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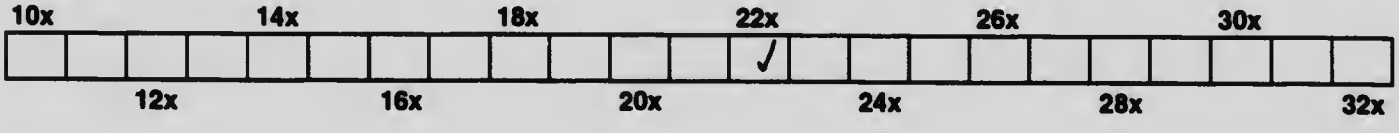

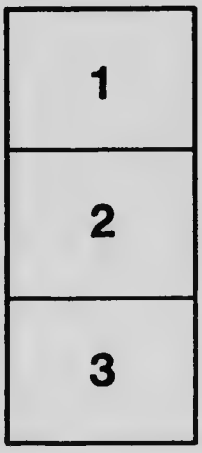

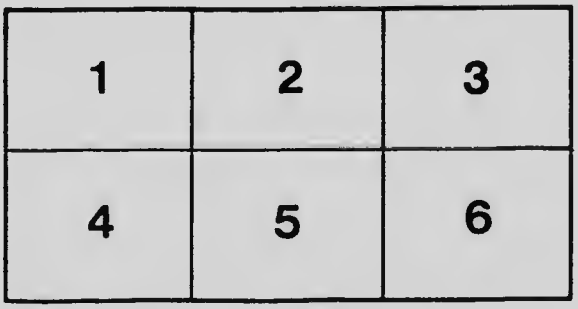

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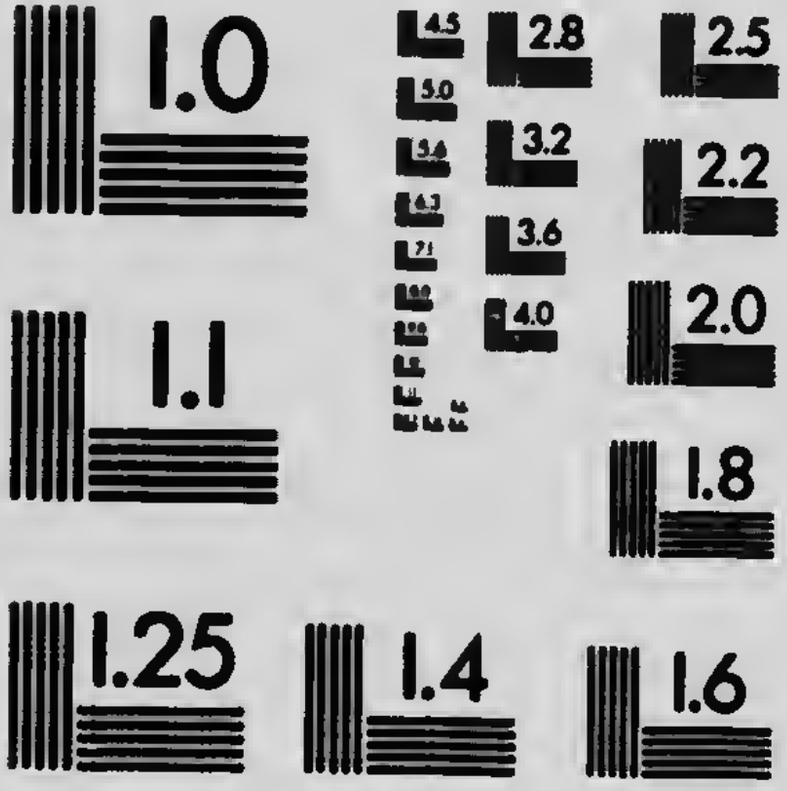

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

THE CODLING MOTH

(*Carpocapsa pomonella*, Linn.)

BY L. CAESAR.

SUMMARY.

The Codling Moth is the most destructive apple and pear insect pest in Ontario, and causes an annual loss of about $2,000,000.

It passes the winter as a larva (worm) in a cocoon in any good hiding place, such as under the loose bark on trees. In May, as a rule, these larvæ begin to transform into pupæ, and soon after the apple blossoms have fallen the moths begin to emerge, and continue to do so until about July 20. The eggs laid by these are placed chiefly on the leaves, and require on an average 9 or 10 days to hatch. Usually it is about 3 weeks after the blossoms fall before the earliest eggs have hatched.

On hatching the young larvæ seek an easy place to enter the apple. This the calyx furnishes, and 75 per cent. or more of these first brood larvæ enter the fruit by this part.

An average of about 25 or 26 days is spent by the larvæ in the fruit. Most of the wormy fruit falls before the larvæ emerge.

All larvæ, after emerging, make cocoons in hidden places. Most of them remain here unchanged till next year, but some of the earliest to emerge transform to pupæ and then to moths and produce a second brood. In the colder parts of the Province, such as Ottawa, only a very rare larva or even none transforms; in districts with a climate like Guelph, Collingwood and Whitby, from 2 per cent. to possibly 8 per cent. do so; in the warmer districts like Niagara a much larger percentage transforms and produces a second brood of larvæ.

First brood larvæ have all, as a rule, entered the fruit by August 1, and the second brood begin to enter about a week or ten days later, and continue to do so up into September, so that larvæ of this brood will

be found in the fruit until the end of the season. About 50 per cent. of the second brood enters by the calyx end.

The Codling Moth can be successfully controlled in any part of Ontario by spraying. One thorough application immediately after the blossoms fall is quite sufficient for any part of the Province, except Niagara and other districts of about the same temperature. In these districts a second application three weeks after the blossoms fall should be given.

The only successful way to combat the second brood is to destroy such a large percentage of the first that not enough will be left to produce more than a very small second brood. This can be done whether the neighboring orchard is sprayed or not.

In spraying, use as good an outfit as you can afford, build a tower on the wagon for tall trees, place an elbow of 45 degrees angle between the nozzle and the spray rod, use rather coarse disc nozzles of the Friend type, hold the nozzles about 2 feet from the calyx and spray directly into it with as high pressure as your machine will give up to 150 or 200 lbs., and never less than 100 lbs. Do not leave the tree till every calyx is thoroughly drenched.

Trees with no fruit may be neglected until the others are done, and then may be given a light spray.

Large trees with much fruit will require from 8 to 15 gals. of mixture each; smaller trees 20 to 30 years old require from 4 to 8 gals.

This application immediately after the blossoms fall is far the most important one. It must be completed before the calyces close, which usually takes place in about a week after the blossoms drop. Do not wait for every blossom to fall, but start to spray when about 90 per cent. of the bloom is off. If the calyx is well sprayed while it is open, when it closes the poison will remain inside all summer and kill any worms entering there.

The best spray mixture to use is 2 lbs. of arsenate of lead to 40 gals. of Bordeaux mixture, or dilute commercial lime-sulphur. The Bordeaux or lime-sulphur is added to control the scab fungus, as this is the most important time to spray for this disease. The Bordeaux must be stronger than the 3-3-40 formula, and the lime-sulphur may be used 1 gal. to 40 gals.

Paris green or arsenite of lime may be used with Bordeaux mixture instead of arsenate of lead, but with lime-sulphur arsenate of lead is the only arsenical poison that is safe.

Do not be too economical with the mixture. Look after the spraying yourself or trust it only to very reliable helpers. Spray thoroughly as directed, and you will get from 75 to 95 per cent. of clean apples the first year and a higher percentage the next.

Spraying alone will give clean fruit and much more of it, but it will not make the fruit large. To secure this the trees must be pruned, the soil well cultivated in the early part of the season, a liberal amount of fertilizer used and sometimes heavily laden trees thinned.

THE CODLING MOTH.

(*Carpocapsa pomonella*, Linn.)

The Codling Moth—the insect which causes nearly all of our wormy apples—is the most destructive insect pest that attacks apples and pears in our Province. There is very little doubt that in most districts this insect does more injury to these fruits than all other insects combined. It is clear, therefore, that apple growers should be well informed about its history and habits and the most up-to-date methods of control.

Accordingly, the object of this bulletin is to set forth these points clearly and simply. All the time that the writer could spare from his other duties during the last two years has been devoted to studying the life-history of the insect, and to spraying orchards for its control. In this work he was much assisted in the season of 1910 by Mr. W. A. Ross, a fourth year student in Entomology at the O.A.C., Guelph. Several

Fig. 1. Adult Coddling Moths, natural size. (After Slingerland.)

points of considerable interest have not been so well investigated as we could wish, and the study of these will be continued.

Wherever our own study of any particular point in the life-history or habits of the insect has not been sufficiently extensive we have consulted the excellent bulletins on this insect by United States Entomologists. The chief writers thus consulted are Slingerland, Simpson, Sanderson, Jenne, Hammar and Quaintance.

Place of Origin and Extent of Spread of the Codling Moth.

References to the Codling Moth in the writings of the ancient Romans indicate that it was a trouble to fruit-growers more than two thousand years ago. Its original home is not definitely known, but is believed by good authorities to have been in South-Western Europe, where the apple originated. From here the insect has spread so widely

that it is found to-day in almost every country where apples are grown. Here and there, as for instance in some valleys in British Columbia, it is still unknown; but there is no doubt that in a few years it will reach even these isolated districts. Entomologists report its presence to-day in almost all parts of Europe, North America, Australia, and New Zealand, and in at least some sections of Asia, Africa, and South America.

Means of Distribution.

The full grown insect, as the name indicates, is a moth and, therefore, can spread from orchard to orchard by flying, and yet it is certain that this method of distribution is slow and does not account for its spread from one district or country to another situated far away, or for its crossing the ocean. A little thought and observation will show that the chief means of distribution is by the shipping of wormy fruit from place to place. Everyone knows that where apples or pears are picked and placed in boxes or barrels for shipping there will be some of the fruit, especially in the poorer grades, that will contain worms. These will be carried wherever the fruit goes, and before it is consumed at least some of the worms will have matured, come out of the apples and spun their cocoons either in the barrels or in some other place nearby. Later on they will emerge as moths, which will lay eggs and start a new colony in the district. It was doubtless in this manner that the Codling Moth came to America from Europe.

How long it has been in Ontario.

In reading up the records of the Codling Moth in Ontario the earliest reference to it I have found is by Rev. C. J. S. Bethune in the first Report of the Entomological Society of Ontario. In this report Dr. Bethune says: "In 1868 the apple crop throughout the Province was very materially diminished by the depredations of this little worm; in some parts of the country fully one-half of the fruit was either completely destroyed or rendered unmarketable. Last year and this year, however, we are thankful to say its ravages have been very considerably diminished."

In the second Report of the same Society under the heading "Addenda to the Report of 1870," Dr. Bethune adds: "The ravages of this horrid creature, which burrows through the fruit and is often found, to the great disgust of the eater, at the core of the apple that he was enjoying, appears to be on the increase in this Province. A few years ago its depredations were very serious; indeed, so much so that at least a third of the yield of the apples was rendered unfit for market."

In the Report of the Society for 1877 Charles Arnold of Paris, Ont., stated that he had scarcely a worm-free apple in his orchard, and attributed this to the smallness of the crop that year—the smaller the crop, the greater the percentage of wormy fruit.

These references show that not only was the Codling Moth in Ontario as early as the year 1868, but that it was almost as abundant then as to-day. From this we must infer that the insect was introduced into the Province many years before that date, otherwise it could not have been nearly so widely distributed and numerous.

Turning to the records of the insect in the United States, Simpson says that in 1819 Burrell reared the first moths from wormy apples, but that it had been present for years before this, though its work had always been mistaken for that of the Plum Curculio. Slingerland says that wormy apples and pears were common around Boston in 1819. He thinks the possible date of the Codling Moth's introduction into America was about 1750—more than 150 years ago. We see, therefore, that this is not a pest of recent introduction into America, but one of the oldest that our fruit-growers have had to combat.

Kinds of Fruit Attacked.

Apples are the favorite fruit, but pears are also severely attacked. In addition to these the insect is frequently found in haws and occasionally in plums, cherries and peaches. A recent bulletin by the Bureau of Entomology, Washington, D.C., shows that in some localities and under favorable circumstances certain varieties of nuts may also be attacked. Very little damage, however, is done to anything but apples and pears.

Amount of Injury Caused.

In trying to estimate the amount of injury caused on an average each year by the Codling Moth we must not forget that it is not enough merely to take account of the percentage of wormy fruit at the time of picking, because throughout the season from about the middle of July up to the time when the last barrel is picked there is a continual dropping of wormy apples. Those that drop early have rotted and disintegrated long before the rest are ready for market. The amount of infestation varies in the different parts of the Province. This is chiefly because in the warmer parts, such as the Niagara district, there is a much larger percentage of second brood worms than in the rest of the Province. In the Niagara district it is not difficult to find unsprayed apple orchards in which 90 per cent. of the fruit has been attacked. In a district like Guelph from 40 to 50 per cent. of the unsprayed fruit is wormy, and this percentage will hold for a good many parts of the Province. From east from about Newcastle to Ottawa the average seems to be about 25 per cent. For the Province as a whole one is probably underestimating the amount of the average yearly injury when he puts it at 45 per cent. of the total crop of apples and 25 per cent. of the pears. In years when the crop is light this percentage will be increased, and again when there is an abundant crop it will be diminished.

In estimating what this loss amounts to in dollars we should deduct a small percentage to make allowance for the number of wormy apples consumed at home in one way or another by the growers or sold for a small sum to the evaporators or to those who cannot afford to purchase good apples. If 5 per cent. be allowed for this we still have 40 per cent. of a dead loss. This means that instead of having about 3,000,000 barrels of No. 1 and No. 2 apples on the average to sell each year the fruit growers would, if it were not for the Codling Moth, have 5,000,000. At the very low price of $1.00 per barrel this would mean an extra sum of $2,000,000 a year. This does not take into consideration the extra amount that would come from pears, which would increase the total considerably.

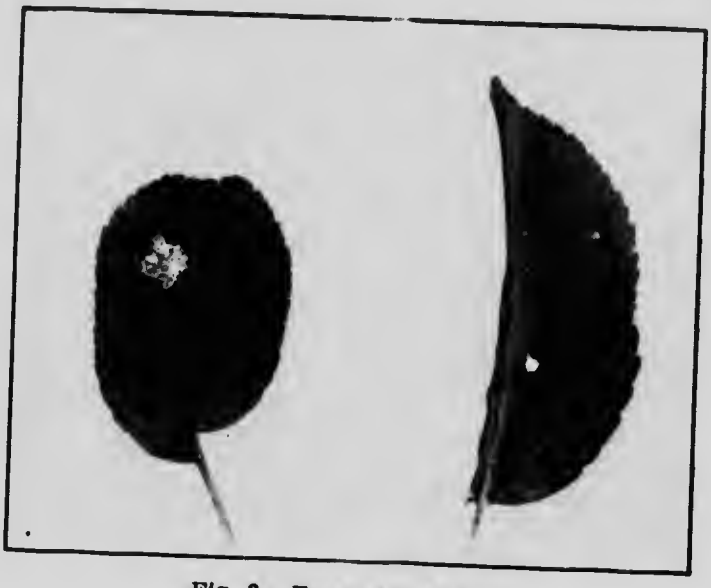

Fig. 2. Eggs, natural size.

It is clear that the pest causes a great loss also in another way; namely, by the amount of discouragement it has given fruit growers, and therefore the influence it has exerted in preventing the setting out of more apple orchards and the greater development of this very profitable industry.

Life History of the Codling Moth.

In order to make what follows clearer, we shall mention here that the Codling Moth, in the course of its life-history, passes through four different stages. There is first the Moth itself, or adult (Fig. 1), which lays the eggs (Fig. 2). These eggs hatch into tiny worms, or as we should more correctly call them larvæ (Fig. 3), which do the damage

to the fruit. When full grown they come out and make little cocoons in sheltered places, and after a time each changes in its cocoon into a brown cigar-shaped creature, called a pupa (Fig. 4).

In what follows we shall not discuss these stages in the order given above, but will start with the stage in which the winter is passed, and then proceed to the other stages in their proper order.

Fig. 3. Full grown larva, about natural size. The dark spots on the body should not be so conspicuous. (Reduced from Simpson.)

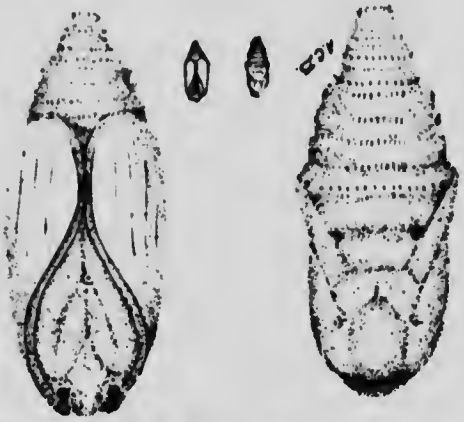

Fig. 4. Dorsal and ventral views of pupae very much enlarged and natural size.

How and Where the Winter is Passed.

If at any time in the winter we were to search beneath the rough bark on the trunks and larger branches of old apple trees, we should find here and there a larva or worm snugly tucked away in a cosy little nest known as a cocoon (Fig. 5). If one of these larvæ is removed from its cocoon and brought into a warm place it will soon begin to move about and leave no doubt in your mind that it is the same creature that causes the wormy apples. Nearly all Codling Moths winter in this manner, but a few of the immature larvæ are still in the fruit when it is picked late in the season and, if it is kept in a cold place, they remain in it over winter.

Where the Cocoons are Placed. Not all the cocoons are to be found under the rough bark, for we often find them in other places. The following are the places in which the writer has found them:

1. Under the rough bark on apple trees.
2. In holes or crevices on apple and other trees near wormy fruit.
3. In clusters of dead leaves under the trees and close to the trunk.
4. In hollows or openings in bones lying on the ground.

5. In a good sheltering crevice in a stone.

6. In apples on the ground that had been attacked by a dry rot, such as the Black Rot (*Sphæropsis malorum,* Pk.).

7. Under old sacks or coarse garments of any kind on or near the trees.

8. In boxes or barrels or similar things near wormy fruit.

9. In cracks or crevices in fruit-sheds or store-rooms where apples have been kept.

10. In similar places to No. 9, both inside and outside of evaporators or jam or cider factories where apples are used. Thousands may often be found around such factories.

Fig. 5. Unopened and opened cocoons on underside of loose bark. In each of the two opened cocoons a larva can be seen.

Fig. 6. Pupa in cocoon on underside of a loose piece of bark. (After Simpson.)

In short, one may say that the larvæ will spin their cocoons wherever they find comfortable hiding places. They do not, however, so far as we have observed, make them in contact with the damp earth, nor have we found them at the roots of grass or under clods, though some state they are occasionally constructed in such places.

The cocoons are usually some distance from each other, but we have found as many as 40 closely crowded together under one small piece of loose bark on an apple tree.

How the Cocoon is Made. The cocoon, as mentioned above, is the little nest or resting place where the larva remains after it has ceased feeding, and where it transforms sooner or later into the pupa. It is composed of silken whitish threads woven together into the desirable form by the larva itself. The silk comes from glands in the larva's body. When ready to make a cocoon the larva sends this silk out through a little spinneret situated just beneath its mouth parts. When the substance issues it is a liquid, but at once on exposure to the air it becomes a solid thread. The power to make at any time a silken thread is used by the larvæ for several other purposes besides the construction of its cocoon; for instance, by means of this it can let itself down from the tree to the ground, or it can make a little covering over the entrance hole when beginning to feed. In making the cocoon sometimes the crevice or place chosen is too cramped for comfort, and in such a case the larva has to use its jaws to enlarge the opening sufficiently.

Changes that Take Place in Spring.

Migration of Larvæ. Though nearly all of the over-wintering larvæ remain in their cocoons until they transform to pupæ and then to moths, a few, possibly because they find their cocoons too much exposed to the sun's rays, desert them and migrate to other places where they make fresh cocoons. This spring on one tree with a tanglefoot band around it 3 larvæ were found caught in the tanglefoot on April 4th, and 3 more on May 23rd and 24th. Previous to each date there was a period of very warm weather. A correspondent who had put fresh bands on trees this spring reported finding more than 50 such migrating larvæ under them.

Pupation. As the weather grows warmer in spring all the living larvæ, whether they have migrated or not, gradually change to the pupal stage, but do not all do so at the same time. In examining bands on apple trees in the early part of the season it was found that the earliest pupæ were regularly found on the south or south-west side of the tree. It is well known that larvæ in storehouses, where it is dark and cool, pupate much later than those outside, where the light and heat can reach them.

These facts show that, as a rule, those that receive the most heat and sunlight pupate first, though there may be a difference of a few days between individuals under the very same external conditions.

The following table shows the date of pupation of 42 larvæ that had wintered under bands:

TABLE I.—SHOWING DATE OF PUPATION, LENGTH OF PUPAL STAGE AND DATE OF EMERGENCE OF MOTHS IN SPRING OF 1910.

Individual.	Date of Pupation.	Date of Emergence of Moth.	Number of days in pupal state.
*1	April 22	May 29	37 or more.
*2	" 22	June 6	45 " "
*3	" 22	" 17	56 " "
*4	" 22	" 18	57 " "
5	May 8	" 15	38
6	" 11	" 25	45
7	" 21	" 21	31
8	" 26	" 23	28
9	" 27	" 22	26
10	" 29	" 23	25
11	" 29	" 23	25
12	" 29	" 25	27
13	" 29	" 25	27
14	" 29	" 27	29
15	" 31	" 21	21
16	" 31	" 22	22
17	" 31	" 25	25
18	June 1	" 25	24
19	" 1	" 25	24
20	" 4	" 24	20
21	" 4	" 27	23
22	" 5	" 27	22
23	" 7	" 27	20
24	" 7	" 27	20
25	" 8	" 25	17
26	" 9	" 27	18
27	" 9	" 25	16
28	" 10	" 27	17
29	" 10	" 29	19
30	" 13	" 28	15
31	" 13	" 29	16
32	" 13	" 29	16
33	" 14	" 28	14
34	" 18	July 5	17
35	" 19	" 6	17
36	" 19	" 7	18
37	" 21	" 8	17
38	" 23	" 12	19
39	" 24	" 9	15
40	" 24	" 10	16
41	July 2	" 18	16
42	" 3	" 22	19

* These four were in pupal state when found (Niagara district).

This table shows that pupation took place in the spring of 1910 at least as early as April 22nd, and continued as late as to July 3rd, and possibly later—a period of more than two months. This was an abnormally warm spring in the early part and very cold later on. The warm weather of the early part hastened the transformation into pupæ. In a normal spring we believe the change would not take place until some time in May. In this connection it is interesting to note that while four pupæ were found at Stoney Creek on April 22, an examination of several bands on trees in an adjoining orchard on May 6 revealed only 9 pupæ, and a further examination in still another orchard nearby on May 13 showed only 4 pupæ. This would suggest that owing to the cold spell of weather in the latter part of April and early in May very few or almost no further transformations into pupæ had taken place from April 22 to May 13. The proportion of larvæ that had transformed up to May 13th was about 5 per cent.

The table also shows that the insect may remain a very long period in the pupal state—the longest period observed being 56 days. As the season advances and the weather becomes warmer, this period rapidly decreases until after the 7th of June the average becomes about 17 days. The shortest time was 14 days. These rearing experiments, except for a few at first in the greenhouse, were conducted in glass vials out-of-doors under the shade of a tree closely approximating to natural conditions of temperature.

Time of Emergence of the Spring Brood of Moths.

It is thought by many persons that the spring brood of Codling Moth adults must all emerge about the time the blossoms are out, and that they lay their eggs in the calyx end shortly after the blossoms fall. Both of these ideas are quite erroneous; for, as will soon be shown, only a rare moth any season emerges before the blossoms fall, and almost no eggs are laid until after the calyces have closed.

The Earliest Moths. In the spring of 1909 the first moth we reared in out-door cages emerged on June 12th and the last on July 25th. In 1910, as Table No. 1 above shows, the first moth emerged on May 29th, the second June 6th, and the last on July 22nd. In order to check our rearing records by a study of the conditions in the orchard we searched carefully for eggs on the leaves. The earliest found in 1910 was one at Guelph on June 15th. This one, as shown by the absence of the red ring, had not been laid more than three days, and the moth that laid it had probably emerged about June 9th or 10th. At Stoney Creek, in the Niagara district, several hours were spent on June 18th searching for eggs in two orchards notorious for the number of wormy apples each year. Only 12 eggs were found in all, and most of these on one tree. Out of the 12 only 4 had been laid more than three days, the rest not having the red ring. These four hatched by June 23rd, and had probably been laid about June 13th. The moths would

therefore have emerged a few days earlier, probably about June 9th or 10th. In 1909 the first eggs found were June 21st, but as three or four freshly hatched larvæ were found on June 25th, it is clear that the eggs must have been laid by June 15th, or possibly a day or two earlier, and the moths have emerged by June 10th at latest. Thus our rearing experiments and orchard observations both indicate that it is a rare moth indeed that emerges before the end of the first week in June. By this time the blossoms in an average year in most parts of the Province are all off and the first spraying is well under way or in some districts completed.

The State of New Hampshire corresponds pretty closely in climatic conditions with Ontario, so that it is interesting to find that Sanderson gives June 9th, 13th and 6th as the respective dates for the emergence of the first moths in the years 1906, 1907, and 1908. These dates correspond very closely with those given above. Hammar gives June 17th for the earliest moth in Northern Pennsylvania in 1907, May 25th in 1908, and June 12th in 1909. (The spring of 1908 in Pennsylvania was unusually early, and the apple trees were out in bloom as early as May 15th.)

The Latest Moths. As mentioned above the latest moth reared in the spring of 1909 emerged July 25, and in 1910 on July 22. When these dates are compared with the earliest dates they show that the moths continue to emerge in spring during a period of about a month and a half. This means the eggs from this brood will continue to be laid, hatch out and the larvæ to enter the fruit for about the same length of time—a very different state of affairs from what is ordinarily supposed to exist.

When the Majority of Moths Emerge. Out of a total of 63 moths of which the date of emergence was kept during the spring of 1910, 35—more than half—emerged between June 20 and 25. This was three weeks or more after the blossoms had fallen. Sanderson gives the date for the majority in New Hampshire in 1906 as about June 14; in 1907, July 2; in 1908, June 20. Hammar gives for Northern Pennsylvania in 1907 about June 24; in 1908, June 10; in 1909, June 25. The average of all these dates is about June 21.

What the Moth Looks Like.

Very few fruit growers have ever seen the moths themselves. Those who wish to rear them can very easily do so if they will put a band of burlap around the trunk of an unsprayed apple tree that is laden with fruit. The band should be put on any time early in July and examined about the end of the first week in August, when both larvæ and pupa will be found underneath it. If the pupæ are taken out without injuring them, put into a glass tumbler in some dry, shady place, and kept covered with cheesecloth to prevent escape, the moths will appear in a few days.

The average adult (as shown in Fig. 1) has an expanse of wing of about three-quarters of an inch. The general color of the front wings is dark gray and of the hind wings light brown. Out near the tip of each front wing, as the photograph shows, there is a well marked brown patch which shows golden when the light falls on it. The presence of this patch is the easiest way to distinguish this moth from many others about the same size and color. The male moths are usually somewhat smaller than the females, and can be distinguished from them by a number of long black hairs situated close together on the upper surface of the hind wing, and by an elongated patch of black scales near the middle of the under side of the front wings. The tip of the abdomen of the two sexes also differs. The majority of moths seem to be males.

Habits of the Moths.

During the day the moths are very seldom seen as they are resting quietly on the leaves, fruit or bark, resembling the latter so much in color that it takes well trained eyes to detect them. Towards evening they begin to fly around and lay their eggs. Many have claimed that they could be trapped by lights and destroyed. We have asked such persons to send us specimens of the moths thus captured, and in every case they have turned out not to be Codling Moths at all, but other small species of about the same size. Professor Slingerland and others have proven that the moths are seldom attracted to lights. The writer has only twice seen a Codling Moth come into a lighted room.

It has been proven that the moths will drink water and are fond of sweet liquid substances. How much they feed in this or any other way does not seem to have been well studied.

How Long the Moths Live.

It is difficult to determine the average length of life of the moths. In our experiments several moths, both of the spring and later brood, lived for 10 days, but most of them died in 3 or 4 days. As only a very few could be got to lay eggs in cages, while most of the free females in an orchard may be expected to do so, it seems clear that the moths did not find their surroundings congenial. A few experimenters have had individual moths live as long as 20 or 25 days. It would seem probable, therefore, that the average length might be 9 or 10 days. Jenne gives the average for the spring brood as about 10 days, and Hammar as 11 days, with about 9¾ days for the males of the later brood and nearly 11½ days for the females.

The Egg.

Its Appearance. The egg, as shown in Fig 2, is nearly circular and small, being less in diameter than the head of a pin. It is almost

flat, is transparent, pearly white or yellowish white in color, and looks like a tiny drop of tallow or of milk. Often it is spoken of as resembling a fish scale glued to the surface on which it is laid. It is always much easier seen when the light is shining on it.

WHERE LAID. The eggs are laid both on the upper and lower surfaces of the leaves, on the fruit and on the twigs. Usually only one is found on each leaf or fruit, though it is not at all uncommon to find two or more. We have made careful estimate for two seasons of the percentage of the first brood eggs laid on the leaves, fruit and twigs respectively, and find it to be approximately 80 per cent on the leaves, only a small proportion of these being on the under surface, and the rest on the upper surface; 18 per cent. on the fruit and 2 per cent. on the twigs. Most entomologists give a higher percentage on the leaves and lower on the fruit. To the second brood eggs we have not given sufficient attention to be able to state what difference there would be from the above proportions. Simpson states that where there are plenty of apples on the tree, 50 per cent. of the second brood eggs are laid on the fruit.

When eggs are laid on the leaves these are usually situated within a few inches of the fruit. though many eggs are laid at some distance from it. We have sometimes found them 6 or more feet away from the nearest apple.

There is some doubt about how many eggs are laid on trees that have no fruit when these are situated near trees with fruit. We have frequently examined such trees and have so far found only two eggs. We, therefore, believe that very few eggs are laid on fruitless trees in Ontario. On the contrary Sanderson seems to imply that the moths readily lay upon them in New Hampshire.

DURATION OF THE EGG LAYING PERIOD OF THE SPRING BROOD OF MOTHS. From what has been said about the length of time during which the first brood of moths continues to emerge we can easily see that freshly laid eggs will be found in the orchard from about June 12 to the end of July. Moreover, just as we have seen that most of the moths of this brood emerge about the end of the third week in June, so we should expect that most of the eggs would be laid a few days later or by July 1st, for the moths begin to lay from 2 to 4 days after they emerge.

AVERAGE NUMBER OF EGGS LAID BY A FEMALE. No definite information can be given on this point. In our cages no moth laid more than 36 eggs, whereas Sanderson in larger cages obtained as high as 136 eggs from one moth, though this was almost twice the number he obtained from any other. He thinks the average should be placed at least as high as 60.

LENGTH OF TIME REQUIRED FOR INCUBATION. This depends very largely upon the temperature, as the warmer the weather the shorter the time required, as a rule. In the early, and again in the later part of the season, the average length of time seems to be about 10 days,

and in the warmest weeks about 7. We have had eggs hatch early in August in 5 days.

CHANGES THAT TAKE PLACE DURING INCUBATION. In two or three days after the eggs have been laid a little red ring appears in them. This can be seen by the naked eye, and is caused by the developing embryo inside. Eggs with this ring are unquestionably fertile. A few days before the eggs hatch this red ring has disappeared, and by examining carefully one can see the young larva within, a black spot indicating the head. After the larva has broken through and escaped the empty shell will often remain for weeks on the leaf or fruit, and is usually easier to see than a freshly laid egg.

THE LARVA.

APPEARANCE. When newly hatched the larva is a tiny whitish caterpillar not more than one-sixteenth of an inch in length, with a black shiny head, and a dark area on the collar (cervical shield) and another just above the tip of the abdomen (anal shield). Scattered over the body are a number of little tubercles that in some specimens are much darker in color than in others, and therefore more conspicuous. By the time the larva is full grown it is about three-quarters of an inch in length and most of them are pinkish or flesh color, while the rest are whitish or cream-colored. Some time before this the head has changed to a glossy brown and the dark area over the collar and above the tip of the abdomen has also become brown. The tubercles are now much less distinct, being of a light brownish color.

It is important that this difference in appearance between the earlier and later stages of the larvæ should be known by fruit growers; because some of them, having become familiar with the brown head and brown cervical and anal shields of the later stage, and then having noticed that many of the side-entering worms in late summer and in autumn had these parts colored black instead of brown are wont to come to the conclusion that these are the larvæ of some new pest equally as destructive as the Codling Moth and not controlled by the ordinary sprayings.

HABITS OF THE YOUNG LARVA. Soon after it has hatched, the young larva, if the egg is laid on the fruit, seeks for an easy place to enter. If it finds any wound or scar it will readily enter by it. Not infrequently it enters where two apples touch or where a leaf is in contact with the fruit. We also find a number entering through the uninjured surface of the side and very occasionally of the stem end. The great majority, however, enter by the blossom end of calyx, as we shall henceforth call it. The little leaflets here give an excellent footing and make entrance easy. After it has worked its way in it feeds for a few days inside the calyx cavity (Fig. 8), and then proceeds to eat a passage to the core, where it seems to delight in the seeds. For some time after its entering at the calyx it is not possible to tell whether the larva is in the fruit or not unless we cut through this part, for no

castings are visible. After a few days, however, it proceeds to enlarge the entrance hole and throw out the castings, thus clearly revealing its presence in the apple. (Fig. 7.)

When the eggs are laid on leaves near the apples, the larvæ, evidently by instinct, make for the fruit, in some cases feeding a little upon the leaves before they reach it. If the eggs are situated at a considerable distance from any fruit it seems evident that most of the larvæ that hatch must perish, for, though we have reared larvæ for three

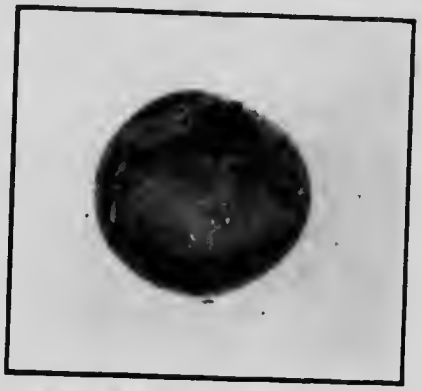

Fig. 7. Castings at calyx end, showing clearly where larva entered the apple.

Fig. 8. Apple cut through the calyx, the dark area showing where the larva usually feeds for a few days before proceeding to the core.

weeks on leaves and twigs in cages, and believe that with extra care we could have brought them through to maturity, we have searched in vain for proof that they feed for any appreciable length of time in this way on the trees.

Percentage of Larvæ of the First Brood that Enter by the Calyx. It is necessary in determining this point accurately to cut doubtful apples through the calyx and examine with a hand lens to see whether there are any traces of the larvæ within. This should be done

towards the end of July, when nearly all the larvæ will have entered the fruit. We have made many counts in this way and found that the average was a little more than 75 per cent. Slingerland places it at about the same figure, Simpson at 81, Petit at 70, Ball at 60, Sanderson at 66, and Quaintance from about 76 to over 80. Pears in our observations were found to have an even higher percentage of calyx entrance than apples, our counts for both 1909 and 1910 showing 90 per cent. entering at this part.

Quite frequently in badly infested orchards one finds apples that have been attacked by several larvæ. We should naturally expect a high percentage of calyces under such circumstances to have been entered. Not nearly sufficient observations have been made to determine what the facts are, but at Stoney Creek on August 17th 100 wormy apples were picked at random from the ground. Most of these apples had been entered by two or more worms. On close examination it was found that 98 out of the 100 had been entered by the calyx.

Length of Time Passed by the Larva in the Fruit. Our average for July and August would indicate that the usual time thus spent is about 26 days. Later in the season in September and October, unless the weather is warm, larvæ will sometimes spend 50 days or more in the fruit. Unfortunately we failed to observe a sufficient number of larvæ from the time of hatching to the time of leaving the fruit to make sure that our average of 26 days was correct. It is interesting, therefore, to compare it with those of other writers. Jenne gives about 24 days for the first brood larvæ in Missouri, and about 24½ days for second brood. Hammar gives 26 days for the first brood in Northern Pennsylvania and 40 days for second brood. Sanderson gives from about 25 to 30 days for the first brood in New Hampshire.

Manner of Leaving the Fruit. When a larva is almost ready to leave the fruit it makes a passage to the outside of the apple, but does not at once emerge; instead, it continues to feed for a short time and then when it has reached the proper stage comes out and at once seeks for a suitable place to make its cocoon. In many cases the exit hole is situated in a different part of the fruit from the entrance. Therefore, the presence of two worm holes in an apple does not necessarily indicate that two larvæ have entered it, but may merely mean that one is the entrance and the other the exit. Not unfrequently, however, the larva does leave by the same hole as it entered by. In such cases it usually makes its way to it by a new passage and avoids working back by the old one.

Proportion of the Larvæ Leaving the Fruit Before and After it Falls.

The greater number of the larvæ remains in the fruit until it falls to the ground, but they do not all do so; a few, but only a few, come out while the apples or pears are still on the trees and let

themselves down to the ground by a silken thread; nearly all, however, of those that emerge before the fruit drops work their way down the twigs and branches towards the trunk in search of good hiding places in which to make their cocoons. To find out what proportion emerged before the fruit fell two trees o clean ground that afforded no hiding places were scraped and banded with two bands of burlap about 20 inches apart and with a band of tanglefoot between. As the larvæ could not work their way over the tanglefoot all those under the upper band must have left the fruit before it fell, while those under the lower must have all left it after it had fallen with the exception of the few that lowered themselves to the ground by a silken thread. From July 26th to September 11th, a total of 621 larvæ were collected from the bands. Of these 566 were under the lower bands and 55 under the upper. This shows that in the case of these two trees ten ti as many larvæ had come up from the ground as had come down the tree. Next year, 1910, we repeated the test on a large Snow apple tree, but as the ground was not so clean and the bark was so rough that scraping did not remove all the hiding places, the test was not so good as the previous year. The total number obtained from August 4th to September 1st was 155, and of these 121 were under the lower band and 34 under the upper, showing that probably four times as many larvæ on this tree had left the fruit after it fell as before. Apparently this high proportion of larvæ leaving the fruit after it falls does not always hold true, because we have seen the reports of tests by other persons in which the percentage of those leaving before and after was given as almost equal. It seems clear, however, that at least 50 per cent., and often a very much higher percentage, are still in the fruit when it drops. This matter is of considerable importance, as we shall see later when we come to consider means of controlling the Codling Moth.

When the Earliest Larvæ Leave the Fruit. Bands were put on three trees at Guelph on July 9th in 1910, and by July 11th 4 larvæ were found beneath them. From this time on fresh larvæ were obtained under these bands daily, a total of 47 being collected by the end of July. In the Niagara district Mr. Peart of Burlington found one larva under a band on July 10, and on July 12th the writer found 20 larvæ and 3 pupæ under two bands at Stoney Creek. (The pupæ were all under the one band.)

In 1909, on July 15th, there was an average of 2 larvæ under bands in the Niagara district, and among them 2 pupæ. At Guelph that year the bands were not put on the trees until July 24th, but up to July 30th only 3 larvæ were found beneath them, the first being July 26th.

The above statements show that at Guelph the earliest larva leaves the fruit somewhere between July 10th and 26th. In Niagara district the date is somewhat earlier, and probably ranges from July 4th to July 10th. If we compare these dates with the date of the emergence of the last of the spring brood moths we find that the larvæ coming from the first eggs laid by the first of the spring brood of moths are full grown,

and in a few cases have left the fruit before the last of this same brood of moths from the over-wintering larvæ have emerged and laid their eggs; for as shown by Table I. the last moth did not emerge until about July 22nd.

What Becomes of the First Brood Larvæ.

By the first brood larvæ we mean all the larvæ that at any time during the season hatch from eggs laid by moths that come from the pupæ of overwintering larvæ. Such moths for convenience may be called the spring brood of moths. These larvæ, as we have already said, begin to emerge at Guelph in some years as early as about July 10th and in other more backward seasons not until about July 26th, whereas in the warmer parts of the Province, like Niagara district, they begin to emerge from about July 4th to July 10th. As we should expect from a study of the dates of emergence of the moths themselves, as shown in Table I., the larvæ will continue to emerge up to September 1st or even later. Our band records for 1909 and 1910 at Guelph show that the largest number of larvæ emerge between August [illegible] and 31st, twice as many having left the fruit in this period as in [illegible] her period of equal length.

All the larvæ, on emerging, [illegible] once seek for a convenient place to make their cocoon. Once the [illegible] made the great majority of them, at least at Guelph, remain here [illegible] without any further feeding or change until next spring; the earliest [illegible]s, however, act very differently, for after remaining a week or so [illegible] larvæ in the cocoon they change into pupæ and then in about two weeks more transform into moths and lay eggs for a second brood of larvæ.

When the Earliest of the New Brood of Moths Emerge.

In 1909 the first moths reared from first brood larvæ and pupæ brought from Niagara district on July 13th emerged on August 2nd. In 1910 from three pupæ and several larvæ brought from the same district on July 12th the first moth emerged [illegible]oth and the second August 1st. The first empty pupal case found under bands on trees at the Experimental Farm, Jordan Harbor, was July 30th. We thus see that August 1st is approximately the date of the earliest emergence of the new brood of moths in the Niagara district.

For Guelph we have not obtained the earliest date for 1909, but in 1910, as the following table will show, the earliest moth appeared August 5th and the second on August 6th. This is just one week later than the earliest from Niagara.

A search for eggs of the second brood at Stoney Creek on August 4th, 1910, resulted in finding only 3, all of which had been recently laid and had not yet got the red ring. This would, therefore, show that our rearing dates agreed with conditions in the orchard.

It is interesting to note that at this date, August 4th, all the first brood eggs had apparently hatched and the last larvæ had entered the fruit. About a week later eggs of the second brood would begin to hatch.

TABLE II.—SHOWING THE DATES AT GUELPH OF EMERGENCE OF THE FIRST BROOD LARVÆ FROM THE FRUIT, OF PUPATION, AND OF EMERGENCE OF MOTHS; ALSO THE NUMBER OF DAYS PASSED IN THE COCOON, FIRST AS LARVÆ AND THEN AS PUPÆ, AND THE TOTAL TIME IN THE COCOON.

Larva left apple.	Pupated	Moth emerged	Days as larva in cocoon	Days as pupa	Total number days in cocoon
July 12.....	July 22.....	Aug. 5 ..	10	14	24
" 12.....	" 20.....	" 6 ..	8	17	25
" 13.....	" 21.....	" 6 ..	8	16	24
" 13.....	" 21....	" 10 ..	8	20	28
" 14.....	" 22.....	" 10 ..	8	19	27
" 15.....	" 24.....	" 10 ..	9	17	26
" 17.....	" 22.....	" 10 ..	5	19	24
" 17.....	" 24.....	" 12 ..	7	19	26
" 21.....	" 27.....	" 16 ..	6	20	26
" 23.....	" 28.....	" 18 ..	5	21	26
" 23.....	" 29.....	" 19 ..	6	21	27
Aug. 2.....	Aug. 13.....	" 30 ..	11	17	28
" 3.....	" 11.....	" 28 ..	8	17	25
" 3.....	" 13.....	" 29 ..	10	16	26
" 5.....	" 16.....	" 30 ..	11	14	25

From this table we see that the maximum time as a larva in the cocoon was 11 days, the minimum 5, and the average 8; the maximum time as pupa 21 days, the minimum 14, and the average nearly 18; and the maximum total time in the cocoon 28 days, the minimum 24, and the average 25 4-5.

Hammar gives for Northern Pennsylvania an average of about one week as larva in the cocoon and of 12 days as pupa. This average would probably be about what we should find in the Niagara district.

WHEN THE LAST LARVÆ OF THE FIRST BROOD CHANGE TO PUPÆ.

At Guelph, as Table II. shows, the last larva pupated on August 5th and emerged August 30th. In the Niagara district, or other warmer parts, the transformations would naturally be expected to continue to take place for some time longer. We have not been able to make sufficient observations to determine exactly how much longer. In 1909, on Sep-

tember 13th, a number of bands that had not been removed for several weeks were examined but no live pupæ were found under them. Supposing that the last moth had emerged on this date, September 13th, and that we take Hammar's average of about 19 or 20 days for the time spent in the cocoon before the moth appears, it is clear that the last larva to pupate must have emerged as early as August 24th or 25th. That the date is earlier than this would appear very probable from the following facts. In 1910 two bands were placed on two trees at Stoney Creek on August 20th, and on September 8th, after an interval of 19 days, these were examined for pupæ but none were found, though as shown above it only requires an average of 8 days even at Guelph for the larva to pupate after entering the cocoon. This, therefore, throws the latest date for 1910 back to at least August 20th. That it is still earlier than this is not improbable, because in Northern Pennsylvania Hammar found that the last larva to transform in his rearing cages had left the fruit on August 14th. If the date in Niagara were August 15th, this would still be 10 days later than at Guelph, so far as one can judge from a single year's test.

Total Time Required for all Stages from Egg to Egg.

If we take the minimum periods given above we get the following: Egg stage 5 days, larva in fruit 20, larva in cocoon 5, pupa 14, moth before laying egg 2, total 46 days. The average time is as follows: Egg stage 10 days, larva in fruit 26, larva in cocoon 8, pupa 18, moth before laying egg 3, total 65 days.

If the stages are counted not from egg to egg but from egg to death of moth we must add about 5 or 6 days to the average, making the total about 70 days.

Percentage of Larvæ of the First Brood that Transform to Moths and Produce a Second Brood of Larvæ.

Between July 11th and September 1st, at Guelph, 438 larvæ were collected from under bands on three trees. This probably does not represent all of the first brood larvæ from these three trees. From these 438 a total of 35 moths emerged, which would mean that almost 8 per cent. of the larvæ had transformed. From the probability that a number of larvæ of the first brood had not left the fruit by September 1st, and from partial records in previous years, we are inclined to think that 8 per cent. is too high a figure for Guelph and other districts of about similar climatic condition. Probably 5 or 6 per cent. would be nearer the average. In the colder apple sections the percentage would be still lower, so that in districts like Ottawa we should expect to find very few larvæ transforming in an average year; in fact Dr. Fletcher stated that there was only one brood at Ottawa. On the other hand in the Niagara and other warmer parts of the Province there is no doubt that a very much higher per-

centage transforms. This we should naturally expect from the fact that the new brood of moths began to appear there in 1910, as shown above, a week earlier than at Guelph and, owing to the longer period of high temperatures, would continue to emerge a week or more after they had ceased to do so at Guelph.

We have not had an opportunity to determine the percentage for these districts, but should not expect it to be much, if any, higher than in Northern Pennsylvania where Hammar found that in 1908 67.7 per cent. of the first brood larvæ transformed and in 1909 23.46 per cent.

Fig. 9. Downy Woodpecker. (Photograph from a poorly mounted specimen.)

Where the Second Brood Larvæ Enter the Fruit.

In well-sprayed orchards nearly all the second brood larvæ enter the fruit from the side. This is because the poison from the spraying is still in the calyx end and kills any larvæ that may attempt to enter there. On unsprayed orchards it is found that a fairly large percentage of this brood enters by the calyx, the average being probably 50 per cent. Quaintance and his assistants in their experiments in Virginia, Arkansas, and Michigan in 1909 found that the proportion of larvæ of the first and second broods combined entering apples by the calyx end was 68.17 per cent.

Remarks on the Number and Destructiveness of the Second Brood Larvæ.

Many fruit growers, especially in the Niagara district, having suffered great loss from the second brood larvæ, think that to produce such a large number, all of the first brood larvæ must transform to moths. A little consideration of this matter will show that if even 25 per cent. of the first brood were to transform this would be sufficient to produce 5 times as many second brood larvæ as first. In proof of this let us start with a single fertile female moth in the spring. According to Sanderson, this moth will probably lay about 60 eggs. Not all of the larvæ from these will reach maturity and leave the apples, but we shall suppose that 40 will do so. If 25 per cent. of these, which would be 10, transform to moths and 5 of these are females we should expect these to lay $5 \times 60 = 300$ eggs.

Fig. 10. Holes made by Downy Woodpecker through rough bark to get at the larvæ beneath. (Cotton wool has been inserted in the holes to make the areas more distinct.)

The moth we started with in the spring only laid 60 eggs; therefore even when only 25 per cent. of the larvæ transform we get 5 times as many eggs and consequently 5 times as many second brood larvæ hatching from them as we had first brood. If 50 per cent. of the first brood transformed we should get 10 times as many second brood larvæ as first, and if only 5 per cent. transformed the two broods would be about equal in number of larvæ. We thus see that to get great numbers of second brood larvæ it is not necessary that all or even a very large percentage of the first brood should transform. But even where the number of the two broods is the same we shall find the second doing more damage than the first in well-sprayed orchards because a much larger percentage of the second

brood enters by the side than by the calyx. Almost all that enter by the calyx at any time in the season will be killed by the poison placed there by the spraying just after the blossoms fall, whereas special sprayings for the side-entering larvæ of the second brood have little effect.

Wherever a second brood occurs we shall find the larvæ in various stages right up to the end of the season.

Having now discussed the life-history of the Codling Moth as fully as seems desirable, we shall pass on to a consideration of how it may be held in check and as leading up to this shall first take up its natural enemies.

Fig. 11. Black Beetle, Tenebroides sp. The drawing on the right is life size; that on the left is enlarged four times.

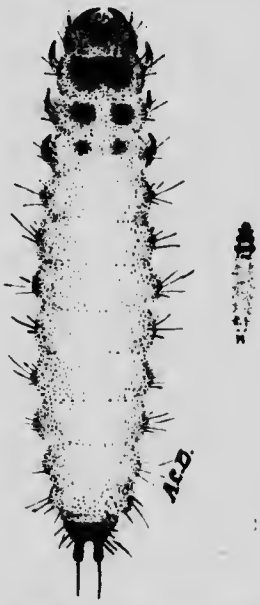

Fig. 12. Larva of the beetle shown in Fig. 11. The drawing on the right is natural size; that on left much enlarged.

Natural Enemies of the Codling Moth.

We have not yet made a thorough study of all the enemies of the Codling Moth in Ontario but, when searching under bands and loose bark for larvæ in the spring, we have been surprised at the very large percentage that had perished during the winter. Sometimes as high as 90 per cent. or more seem to have been destroyed by various causes. The chief of these, so far as we could see, were birds, the grub of a small black beetle (*Tenebroides sp.*) and diseases.

Many birds at one time or another during the year feed upon either the adults or larvæ of the Codling Moth, but during the winter the most useful birds in this respect are the woodpeckers, especially the Downy

Woodpecker (Fig. 9) and the Chickadee. If these two birds are encouraged during winter by hanging bones or pieces of meat on the trees they will often stay in the orchard all year and search every trunk and large branch carefully for larvæ. Fig. 10 shows holes made through the loose bark by the Downy Woodpecker in getting the larvæ of the Codling Moth. It is interesting to see how invariably these birds will find the right place to make the holes and pierce the larvæ and draw them out by means of their barbed tongues.

The grub of the small black beetle mentioned above (Figs. 11 and 12) is whitish and flattened with reddish black to black head, two black spots on the top of each of the first three segments of the body and a pair of stout horn-like projections on the last segment. We have found these grubs under most of the bands. Usually there are two or more to a band. We have observed them attacking both the larvæ and the pupæ, and believe that the total number they destroy in a year is large. The adult beetles are also found under the bands along with the grubs but, while we have frequently suspected them of feeding on the pupæ and larvæ, we have not been able hitherto to prove it, nor have we been able to determine whether this is the same species of beetle referred to by Slingerland as *Trogosita corticalis*, which he found very useful against Codling larvæ in New York State. Prof. Wickham identified it for us as a species of *Tenebroides* (*Trogosita*), stating that it was very difficult to be sure of the species.

In the spring a small proportion, apparently not more than 5 per cent., of the Codling Moth larvæ are found to be dead from disease; a number of them are also destroyed by disease inside the fruit during the growing season.

In addition to the above enemies we have found a small red mite about the size of the head of a pin or smaller feeding upon the eggs of the Codling Moth. All the contents of the egg were eaten and the empty shell left.

In August of 1909 a pupa was found that had been attacked by some species of 4-winged parasite, apparently a Chalcid Fly. The pupa broke when we were removing it and showed the immature parasites inside. We tried to rear them but failed. Efforts have been made to find whether this parasite was at all common but, as none emerged in the glass vials in which we reared the pupæ, it seems probable that it is of rare occurrence.

Slingerland found that the eggs of the Codling Moth were not infrequently parasitized in New York State by a very tiny, almost invisible, 4-winged fly. We have not yet devoted much attention to discovering whether this parasite is in Ontario, but it is natural to suppose that it is.

These are some of the natural foes of the Codling Moth. If it were not for them and for unfavorable weather conditions such as a sudden drop of the thermometer or driving rainstorms that must destroy many eggs and newly-hatched larvæ, the pest would be even more abundant than it is. But the successful fruit-grower cannot depend on these enemies to keep the insect under control and therefore must use devices of his own for combating it.

How the Codling Moth can be Successfully Combated.

Though spraying with a poison will, as we shall show later, thoroughly hold the Codling Moth in check, there are several other means which can in many instances be used to supplement this.

(1) *The destruction of fallen fruit throughout the season.* When speaking of the life-history of the insect we showed that more than half of the larvæ did not leave the fruit until after it fell to the ground. It stands to reason therefore that, whenever it is practicable, it will be very helpful to destroy this fruit the same day as it falls and before the larvæ will have escaped. The easiest way to do this in many districts is to

Fig. 13. Band on tree to catch larvæ.

allow hogs, calves, or sheep to run in the orchard in sufficient numbers to keep it clean of fallen fruit. In a number of cases it will pay to gather the fruit after the first of August and either feed it to the stock or sell it to the evaporators. Such a course is especially desirable after this date in districts where the Apple Maggot or Railroad Worm is prevalent, as the rapid destruction of fallen fruit is the best known remedy for this pest.

(2) *When thinning apples or pears watch for the wormy ones and put them into a bag or basket by themselves and destroy them* by feeding to stock or in other ways. Some good fruit-growers think that if they

throw these small wormy apples on the ground the larvæ will not be able to mature but will die. We have tested this and find that it is a mistaken idea for the larvæ mature just as well as if they were in a large apple. Thinning apples is beginning to be practised in Ontario to a considerable extend. It offers, therefore, to the thoughtful man an excellent way in which to make sure that most of the larvæ of the first brood that the spray has not killed may be destroyed.

(3) *Banding Trees.* For many years the device of trapping larvæ by bands of thick cloth or burlap placed on the trunk of the tree has been used (Fig. 13). These bands should be put on by about the first week in July to make sure of catching the first larvæ that leave the fruit. They ought to be examined about every twelfth day and the larvæ and pupæ destroyed by cutting them through with a knife. The bands need not be

Fig. 14. Blossoms off, calyces open and ready to spray.

wider than 6 or 8 inches and may be held in place by a cord as shown in the photograph or by a small nail or any other simple and handy device. It must not be overlooked that to get the best results from them it is absolutely necessary to scrape all the loose rough bark off the trees before putting the bands on so that these may be the only good hiding-places that the larvæ can find on the trees. As no larvæ transform after about August 20th in any part of the Province, it is not necessary to examine the bands from this date until the end of the season, but when the severe frosts have come and no more larvæ are left to enter beneath them it is very important to make the final round and destroy all that can be found.

(4) *Prevent moths that hatch in fruit-houses from escaping.* The best way to do this is probably to fumigate such places with sulphur, or to cover the windows with cheesecloth and keep the doors fastened.

Spraying.

With the improved methods of spraying of the last few years all doubts about the possibility of controlling the Codling Moth even in the worst infested districts, such as Niagara, have been removed. It is true there are still many growers in these districts who, because they have failed to get good results, think that this is impossible. The explanation in these cases usually is that the work was not done thoroughly. Those who read what follows will understand how easily this can be the case.

When to Spray. We have shown above that as a rule 75 per cent. or more of the first brood larvæ enter the apples by the calyx end. Therefore if we can place poison in this part before the larvæ enter we can kill

Fig. 15. Calyces nearly closed, rather too late to spray.

these before they do any injury. In observing the growth of the young apple we find, as shown in Fig. 14, that for about a week or sometimes ten days the little leaflets that form the calyx remain open, but at the end of this time, as seen in Fig. 16, they close up.

From these facts we see that if we are going to get the poison into the calyx we must begin our spraying at once after the blossoms drop and have it all finished inside of a week or ten days. Then when the calyces do close the poison will be inside and will remain there all through the season, so that any larvæ either of the first or second brood which attempt to enter at any time will be killed.

If the orchard is large and contains many trees which blossom a few days ahead of the others, it will be well to spray these first, but usually one may wait until all the blossoms have fallen from the early varieties and most but not quite all from the others. By this time it will be found that the bees have finished their work so that there will be no danger of the poison doing any harm to these valuable friends.

How Often Must We Spray. In some way not yet fully understood the spray immediately after the blossoms drop and before the calyx closes will, if thoroughly done, kill not only the 75 per cent. that enters by the calyx but also nearly all the remaining 25 per cent. which ordinarily enters by the side or stem end. Therefore, this one application is all that is necessary for the control of the Codling Moth in any district except where there is a large proportion of second brood. In the latter we recommend that a second application be made about three weeks after the blossoms drop because, as the life-history of the insect shows, it is not until about this time that the eggs begin to hatch and the larvæ to enter the fruit. Therefore by covering the apples and leaves thoroughly with poison at this time we shall help to make more certain that almost all the first brood is destroyed.

We are often asked when to spray for the second brood. The answer is: Do the first two sprayings so thoroughly that there will not be sufficient

Fig. 16. Calyces closed; cannot get the poison inside now.

first brood left to produce a second brood that can injure more than a very small percentage of the fruit. Efforts to control the second brood by spraying for it about the end of the first week in August give very poor results and do not pay. In most parts of the United States and in our own Province the most successful apple growers are finding out that the secret of preventing injury from the second brood is just what has been said above: such thorough spraying for the first brood that it is practically annihilated.

Can a Man Control the Codling Moth in His Orchard if His Neighbor's Orchard is Not Sprayed? Our answer to this is YES, The writer has done it himself, and has seen it done even more successfully by others

in the worst infested districts in the Province. It is true that a few trees nearest the unsprayed orchard are likely to be wormier than they would otherwise be but the moths do not fly far as a rule and lay their eggs on the trees near where they emerged.

What Poison Should Be Used.

Almost all over Canada and the United States arsenate of lead is the most popular poison for the Codling Moth. It is not so cheap as arsenite of lime or Paris green, nor does it kill quite so rapidly, but it stays in suspension in the spray tank much better, is much less likely to injure the foliage, and remains on the trees in wet weather much longer. It should be used at the strength of 2 lbs. to 40 gals. of Bordeaux mixture or diluted lime-sulphur. Many claim that 1 lb. is sufficient, but so far as our tests go we prefer 2 lbs., though more than this is unnecessary. If Paris green is used it should be at the rate of ¼ lb. to 40 gals. of Bordeaux. For the method of making arsenite of lime, see Bulletin No. 177, page 43. The strength there indicated is sufficient. When Bulletin 177 was published it was believed that arsenite of lime could be safely used with diluted lime-sulphur, but experiments in 1910 in several orchards showed that in some seasons the mixture causes serious injury to the foliage and occasionally to the young fruit. Therefore *with lime-sulphur the only arsenical that can safely be used is arsenate of lead.* With Bordeaux mixture we may use arsenate of lead, Paris green, or arsenite of lime.

In spraying for the Codling Moth a fungicide, either Bordeaux mixture or lime-sulphur, should be used with the arsenical poison instead of using water alone. This is because the most important time to spray for the Apple and Pear Scab is just after the blossoms drop, and therefore by combining the fungicide with the insecticide we secure a two-fold result. The Bordeaux mixture for this application need not be stronger than 3.3.40, nor the commercial lime-sulphur than 1 gal. diluted to 40 gals. This is because to control the Codling Moth the spray at this time must be applied so thoroughly that a weaker fungicide will suffice.

That the combination of arsenate of lead with lime-sulphur, or of arsenate of lead or arsenite of lime or Paris green with Bordeaux mixture does not lessen the value either of the insecticide or fungicide has now been clearly proven. Arsenate of lead itself is believed to possess considerable fungicidal properties.

Spray Outfits.

Spray Machines. Without a fairly good spray outfit we cannot do good work against the Codling Moth. For orchards of from 2 to 5 acres of trees 25 years old and upwards a good barrel pump will serve the purpose. For 5 to 10 acres we should have a good double-acting pump with a tank holding at least 80 gals. For orchards of more than 10 acres a

strong pump driven by a gasoline engine is very desirable. A good engine soon pays for itself by dispensing with the services of at least one man, and by giving so much more pressure that the work can be done much more thoroughly and quickly.

Machines of any of the above kinds can be purchased from the following companies:

The Spramotor Co., London, Ontario;

The Friend Manufacturing Co., Gasport, N.Y.;

The Bean Spray Pump Co., Cleveland, Ohio; Canadian agent, M. C. Smith, Burlington, Ont.;

The Goulds Manufacturing Co., Seneca Falls, N.Y.; Canadian agent, Robert Thompson, St. Catharines, Ont.

These are at present the best known firms, but doubtless others equally good will soon make their appearance in Ontario.

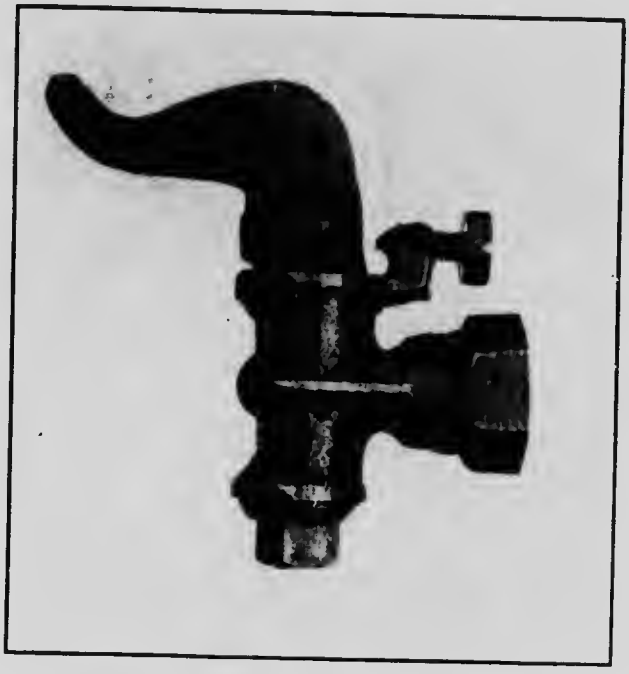

Fig. 17. New type of Bordeaux nozzle.

Hose. It will pay to purchase a good brand of hose, one guaranteed to stand about 300 lbs. pressure, though this much will never be used.

For a barrel pump one line of hose of about 20 feet long is all that will be required. For double-acting pumps, whether driven by hand or by gasoline engines, two lines of hose are necessary, one about 12 or 15 feet long for use on the tower, and the other at least 25 feet long for use on the ground. In order to save the man on the ground from being

drenched by the man on the tower when both are spraying the same tree some use 40 feet of hose for the lower line, and thus the man using this can be spraying the last part of the tree behind when the man on the tower is spraying the nearer side of the next tree.

Extension Rods and Nozzles. The rod for the man on the tower should be about 9 ft. long, and as light as possible, while the one for the man on the ground should not be more than 6 or 7 ft.

The nozzle preferred by many in the West is the new Bordeaux nozzle (Fig. 17). This is a much better nozzle than the ordinary Bordeaux type, but the writer, after testing many different kinds of nozzle, advises the use of a disc nozzle of the Friend type (Fig. 18). For the spray immediately after the blossoms fall he chooses nozzles of this kind that have been used sufficiently to wear the holes a little so that a some-

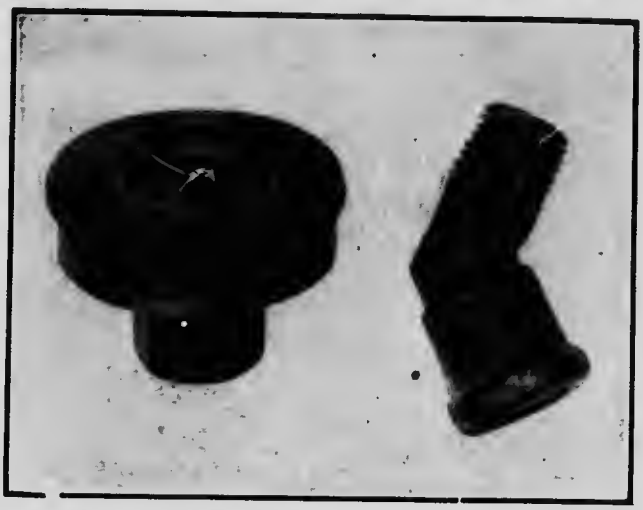

Fig. 18. Friend type of nozzle, and a small brass elbow found very desirable in spraying. Both natural size.

what coarser spray may come out. Each spray rod is equipped with two of these nozzles on a V, each nozzle having an elbow of the type shown in Fig. 18 behind it so that the two may be adjusted in such a way that the cone-shaped spray from the one will extend half-way into that of the other and by this overlapping make much more thorough work. *The elbow device sets the nozzles at an angle of 45 degrees to the spray rod. This is very important,* for with a nozzle in the same straight line with the spray rod it is not possible to control the direction of the spray and send it straight down into the calyx. Some set the nozzles at an angle of 75 degrees or more but this is not so satisfactory as 45.

Tower. For trees 20 years old and upwards a tower on the spray waggon is a necessity (Fig. 19), otherwise the poison cannot be sent into the highest blossoms sufficiently well.

How to Spray.

In spraying for the Codling Moth our object must be to see that every calyx end of the forming fruit is thoroughly covered with the poison before the calyx closes. The deeper the poison is driven into the cavity at this part the more certain will be the destruction of the larvæ trying to enter here. Therefore to accomplish this it is necessary to do very thorough work and to have as high pressure as can be conveniently obtained, never less than 100 lbs. and if possible as high as 150 or even 200 lbs. Endeavor to hold the nozzles about 20 inches or 2 feet away from the blossoms and to send the spray directly into each. Anyone who tries to do this on a tree that has been well covered with bloom will soon see that it requires great care, and before it is accomplished the tree will have been drenched. It is easy to see therefore that the old rule to stop spray-

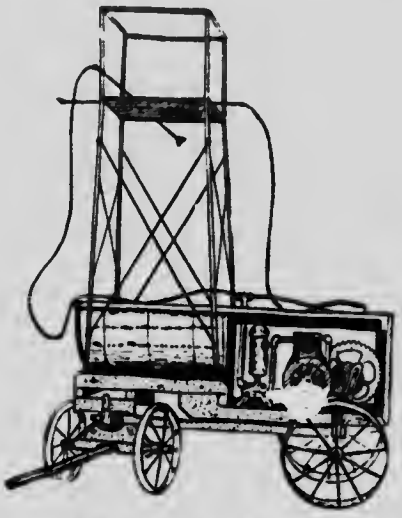

Fig. 19. Tower for spraying tall trees, and spray tank with gasoline engine.

ing when the mixture begins to drip is quite wrong. The rule should be: *Stay at the tree till you have put the poison thoroughly into every calyx but waste no more material than you can help.* From time to time examine the calyces to see if any are being missed. Do the spraying yourself or trust only your best man to do it. A careless man [illegible] spray well.

Large trees may sometimes, if [illegible] have been many blossoms, require as high as from 8 to even 15 gallons, and [illegible]s of 25 or 30 years of age from 4 to 8 gallons. If the tree has only a very few blossoms, look after these carefully and give the foliage a light coat to keep it healthy. If time is pressing the trees that have had no bloom may be left until all the others are done and then touched up.

Of course the spraying should be done with the wind and the stronger the wind the better as it carries the spray more forcibly through the tree. As we can never be sure that the wind will completely change its direction in time to get the other side done before the calyces close it is necessary to spray two-thirds of the tree from the first side. To accomplish this stop the waggon just before it comes to the tree and spray as far in as you can on this side. Then drive directly opposite the tree and spray this part, then drive slightly past and finish as much of this side as can be reached conveniently. If this is done it is very seldom that the wind will not veer sufficiently to enable one to finish the remainder of the tree, though it cannot be so thoroughly done as if the wind were to change directly around.

Where a person has to use a barrel pump and a single line of hose, the sprayer should stand on the tower and with a little extra care he can do the whole tree very thoroughly from this position.

The second spraying for the Codling Moth, which, as we have said above, is only required in very badly infested districts and should be given about three weeks after the blossoms fall, does not require to be so heavy as the first. Nozzles with fresh plates with unworn holes should be used and the mixture should be applied in as fine a mist as possible, the aim being merely to coat every fruit and leaf thoroughly with a very fine covering of poison. If the orchard is free from signs of Apple Scab, and if the weather is dry, the Bordeaux or lime-sulphur may be omitted in this application; otherwise it should be used.

Results Obtained from a Single Thorough Spray for the Codling Moth Immediately After the Blossoms Fell.

Careful experiments have been made in the control of Codling Moth in 1910 by the writer at Guelph, by I. F. Metcalf, Agricultural Representative, assisted by W. F. Kydd, in Simcoe County, and by J. H. Hare, Agricultural Representative in Ontario County. None of the orchards so far as known had been sprayed before, and all except one were composed chiefly of trees varying from 25 to 60 years of age. Two of the outfits were barrel pumps and the third a double-acting pump. The pressure used ranged from 100 to 140 lbs., averaging a little over 100 lbs. The mixture consisted of 2 lbs. arsenate of lead to 40 gals. of commercial lime-sulphur of the strength of 1 gal. to 40 gals. of water. In a few cases the lime-sulphur was used stronger, namely at 1 to 30.

In ten orchards thoroughly sprayed at the right time in these three districts the proportion of worm-free fruit ranged from 80 per cent. to 98 per cent., with an average of 90 per cent. In unsprayed orchards in the same districts nearly all the fruit was unsaleable because of worms and Scab and a large percentage of it dropped off the trees early; whereas in the well-sprayed orchards there was very little dropping until the heavy winds came towards the end of the season, and even then only a small percentage fell.

Scarcely any wormy apples that had been entered by the calyx end could be found in any of these orchards. This should always be the case in well-sprayed orchards.

We believe that another season's thorough spraying of these orchards would give 95 per cent. of clean fruit.

Results in Niagara District from One Thorough Application Immediately After the Blossoms Fell and a Second Three Weeks Later.

In 1909 the writer sprayed 25 acres of apple orchard for Mr. Joseph Tweddle, of Stoney Creek. Two double-acting spray pumps were used, giving an average pressure of about 140 lbs. each. The work was not so thoroughly done, however, as it could have been with a gasoline engine; especially was this the case in one-half of the orchard where the trees were very old and high, making it very difficult to spray them thoroughly. The other half consisted of trees from 30 to 35 years of age and was better done. Very few apples dropped until shortly before picking time. The better sprayed half gave an average of 94 per cent. worm-free apples on the packing tables and the other half 84 per cent. Taking into account wormy apples on the ground the percentages of worm-free apples would be 90 and 75, respectively. Neighboring orchards had from 20 per cent. to 50 per cent. of worm-free apples.

In 1910 the writer sprayed the Jordan Experimental Station orchard in the same way, using Bordeaux (3.3.40) mixture and 2 lbs. arsenate of lead on part of it and commercial lime-sulphur [illegible] 2 lbs. arsenate of lead on most of the rest. One mixture gave just [illegible] good results as the other. From the director's report 85 per [illegible] the fruit was free from all kinds of insect injury. This orchard [illegible] had less than 50 per cent of worm-free apples.

At an orchard demonstration meeting held on the 7th of September, in 1910, at the orchard of M. C. Smith, Burlington, 100 fruit-growers from almost every apple district in the Province saw the results that could be obtained from careful spraying repeated each year for 4 years on an old orchard very hard to spray. At that date there were not more than 2 per cent. of wormy apples and probably not more than 1 per cent. in this orchard, while neighboring orchards had from 50 per cent. to 80 per cent. of wormy apples. Mr. Smith gives two thorough applications each year, following exactly the directions given above. The secret of his success is THOROUGHNESS and good pressure.

Results on Apple Scab.

Almost all of the orchards mentioned above received two sprayings previous to the first spraying for the Codling Moth, and in every case where this was done the Apple Scab was completely controlled even on

Snow apples. There was an average of 99 per cent. of scab-free apples in the orchards sprayed by the writer in 1910, and about as high in those sprayed by Messrs. Metcalf and Kydd, Hare, and Smith, though this was the worst season for Apple Scab that there has been for a long time.

OTHER INSECTS WHOSE WORK IS LIKELY TO BE MISTAKEN FOR THAT OF THE CODLING MOTH.

Lesser Apple Worm. Fig. 20 shows the work of the Lesser Apple Worm. The larva of this insect looks almost exactly like a half-grown

Fig. 20. Work of Lesser Apple Worm. (After Simpson.)

larva of the Codling Moth, except that it is rather a deeper flesh color and tapers a little more towards each end. It has about the same life-history as the Codling Moth. Its native food seems to be haws. There are 2 broods in a year and the last is much the worst. When it attacks the apple, instead of boring into the core, it continues to feed near the surface causing an ugly blotch. It seldom goes deeper than quarter of an inch. As a rule the injury is done at the calyx end but not infrequently it is found at the side or stem end. Occasionally the Codling Moth works somewhat in the same way but seldom makes so large a blotch.

It is difficult without further observations in various parts of the Province to say just how much loss is caused by this insect but it probably does not exceed from 2 to 5 per cent. of all the wormy apples. Around Guelph in neglected orchards the percentage runs higher, in one case over 40 per cent. of the wormy apples on a well-laden tree had been caused by this pest. The same spraying as controls the Codling Moth keeps it fairly well in check.

Plum Curculio. Fig. 21 shows the appearance of the injuries caused to apples after about the middle of August by the Plum Curculio. These are feeding punctures made by the adults, which are little, grayish-black,

Fig. 21. Work of Plum Curculio on apples in late summer and in autumn.

hard-shelled, rough-backed beetles, about quarter of an inch long. They do the injury by cutting a small hole through the skin and then eating out the pulp beneath as far as their rather long beak will reach. Sometimes there will be 20 or more of these holes in a single fruit. Smooth-skinned varieties, like Spys, are generally exempt, while the rougher varieties are often badly attacked. In neglected orchards the Curculio sometimes does as much damage as the Codling Moth.

The best methods of control are: (1) Remove all rubbish, brush and thickets in or around the orchard, because the insects winter in such places.

(2) Cultivate the orchard carefully from as early in spring as the ground is in shape to go on up to as late as is safe. The latter date will be from about June 10th to July 10th, according to the coldness of the district. Do not let weeds grow up until cultivation ceases.

(3) Spray as for the Codling Moth.

BRIEF SUMMARY OF RULES FOR SPRAYING ORCHARDS FOR INSECTS AND DISEASES.

Every pear and apple orchard should be sprayed 3 times each year and in some years 4 times as follows:—

(1) Shortly before, or as the leaf buds are bursting. Use lime-sulphur, either commercial or home-made, corresponding to the strength of the commercial diluted 1 gal. to 10 gals. with water. No poison as a rule is necessary. This application kills San José Scale, Oyster-shell Scale and Blister Mite, and helps ward off Cankers, and Apple and Pear Scab.

(2) Just before the blosoms burst. Use commercial lime-sulphur diluted 1 to 30 or 35, or Bordeaux mixture (4.4.40), and 2 lbs. arsenate of lead to each 40 gals. This application is to destroy all early feeding caterpillars, such as Tent-caterpillars, Case-bearers, Canker Worms and Bud Moths, and to help against Apple and Pear Scab and Cankers.

(3) Immediately after the blossoms fall. Use the same mixtures as for No. 2, but the lime-sulphur need not be stronger than 1 to 40 nor the Bordeaux than 3.3.40. This application is chiefly to control Codling Moth and Apple and Pear Scab, but also helps greatly against Lesser Apple Worm and Plum Curculio.

(4) If a . application is given it should be about 3 weeks after the blossoms 1 with the same mixtures as in No. 3, except that if the season is dr. ne fungicide may sometimes be omitted. This application assists in holding the Codling Moth in check in the warmer parts of the Province and in moist climates is often necessary for the thorough control of the Apple Scab.

N.B.—*Thoroughness is the great secret of success.*

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