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Preliminary Report on the Codling Moth in the
Yakima Valley.

By Eldred Jenne

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* Deceased, February 9th, 1905.

Preliminary Report on the Codling Moth in the Yakima Valley.

BY ELDRED JENNE.

INTRODUCTION:—The following notes are taken from the writer's report on the work done on the Codling Moth during the summer of 1903, in the vicinity of North Yakima and Zillah. The work was carried on by the State Experiment Station at Pullman, and was particularly outlined and directed by Prof. C. V. Piper, then of the Station staff.

The plan of the work was to follow closely, in the orchard and in breeding cages, the life history and habits of the Codling Moth during the season, and also to gather data regarding the means at present in use for combating the pest. In short, the object was to study *existing conditions* in regard to the Codling Moth in the Yakima valley, with the end in view of later carrying out spraying experiments based upon these observations. The work will probably be continued during the next season, after which the intention is to publish in full the results of both years' work. Meanwhile a few of the results of the work of 1903 which may be of use to orchardists in combating the Moth during the coming season are published herewith.

Life History of the Codling Moth.

The plan followed in studying the life history of the Codling Moth was to follow its development in one particular orchard as closely as possible, this work being checked by observations made from time to time in as many other orchards as possible. The orchard of Mr. W. L. Wright, near North Yakima, was selected as headquarters, and here all the breeding cage work was done, this forming the basis of the life history studies. The results ob-

tained from the breeding cage work were checked by constant observations in the orchard.

A summary of the data obtained on the life history of the Codling Moth is shown graphically in the accompanying diagram.

Number of Broods.

One of the principal aims of the life history studies was to determine the number of generations or "broods" which the insect produces in a season, as this has been a much disputed point with observers. The results are given briefly below.

At least two generations or "broods" undoubtedly occur, as represented in the accompanying diagram, separated by a period of about twenty days. The gap was observed in the orchard between the two broods of eggs, between the times when freshly stung apples were found, and in the record of worms caught from banded trees. The two generations were also bred in cages. Part of the band record is given below.

Part of daily record of worms caught from 24 banded trees in the orchard of W. L. Wright, showing gap between the first two broods:

DATE	NO. WORMS	DATE	NO. WORMS	DATE	NO. WORMS
July 17.....	16	July 26.....	4	Aug. 4.....	2
" 18.....	10	" 27.....	5	" 5.....	2
" 19.....	18	" 28.....	0	" 6.....	2
" 20.....	16	" 29.....	2	" 7.....	2
" 21.....	8	" 30.....	2	" 8.....	6
" 22.....	9	" 31.....	2	" 9.....	6
" 23.....	7	Aug. 1.....	3	" 10.....	12
" 24.....	4	" 2.....	1	" 11.....	13
" 25.....	4	" 3.....	0	" 12.....	11

As shown here the gap between the first two broods at the time of the worms leaving the apples occurs between July 20 and August 10, (1903), indicated by the few worms appearing under the bands between these dates. The same gap is shown graphically in the curve below.

Curve representing the band record for the season. The height of the curve above the base line represents the number of larvae caught at any one time.

Late Pupae. (Third Generation.)

As soon as the sudden decrease (July 20) in the number of worms appearing under the bands was noticed, all the worms caught each day were kept in cages so as to determine the per cent. which would pupate and the per cent. to pass the winter as larvae.

The results are given in the following table:

Worm Appeared Under Band	No. Pupating	No. Wintering
July 24-27.....	12.....	0
" 27.....	5.....	1
Aug. 2.....	3.....	1
" 4.....	5.....	1
" 5.....	3.....	0
" 6.....	9.....	1
" 9.....	5.....	0
" 10.....	14.....	5
" 11.....	12.....	6
" 12.....	7.....	3
" 13.....	10.....	1
" 15.....	3.....	2
" 17.....	9.....	3
" 18.....	12.....	8
" 20.....	12.....	9
" 21.....	4.....	5
" 23.....	2.....	22
" 26.....	2.....	19
" 28.....	0.....	19
" 29.....	0.....	16
Aug. 1-Aug. 21...103.....	59	
" 1- " 28... 85.....	115	
" 21-Sept. 3.... 20.....	207	
" 28- " 3... 0.....	51	

From the above table it will be seen that the first larva destined to pass the winter as such appeared under the band on July 27. No more were caught which did not pupate until Aug. 2, but from then on until Aug. 20 the proportion which did not pupate gradually increased. It should be noticed, however, that the *actual number of those which pupated also increased* and up till Aug. 21 exceeded those which did not pupate. But about Aug. 21 pupation declined abruptly and after another week all the worms which left the apples went into winter quarters, the last worm to pupate appearing under the band Aug. 26. It should be noticed that the dates given in the table above are those on which the worms appeared under the bands, the dates of pupation for those which did pupate being a week or ten days later at this season of the year. The last pupa appeared Sept. 4 from a worm which appeared under the band on Aug. 26. At Zillah, Mr. F. Walden removed the bands from his orchard of 3000 trees on Aug. 24 and again on Sept. 5. A rough count was kept of the number of pupae caught when the bands were removed the last time, and it was estimated that 500 pupae were taken from the 3000 trees. No pupae appeared in this orchard after Sept. 5. In general it may be said that for a season like the one of 1903 *pupation practically ceases by Sept. 1st*. This date is important to those who use bands for trapping the worms, because after pupation has ceased it is not necessary to remove the bands again until the crop is harvested.

Evidence of a Third Brood.

Since the Codling Moth always passes the winter as a larva it is evident that if some of the second generation of larvae could be proved to pupate, it would be beyond a doubt that at least some of the insects pass through three generations. Now from the band record it will be seen that most of the first brood of worms had left the apples by July 1, and as during this time of the year the worms do not remain in the apples much over twenty days, all of the first brood of worms should have left the apples *at least* by Aug. 1. It therefore seems certain that those worms which left the apples and pupated *after* Aug. 1 and as late as *Aug. 26* must have been of the second generation, the resulting moths being a third generation of moths.

Again it will be seen from the table given above that the actual number of worms which pupated *increased* from Aug. 1 to Aug. 21, whereas if only larvae of the first brood pupated the number should have steadily decreased during this time, not only in proportion to the number which did not pupate, *but also absolutely*.

Another reason for believing that these late pupae belong to a third generation is that both band record and orchard observations show a distinct gap of about twenty days between the two broods, while if the late pupae are taken as belonging to the second brood of pupae it would indicate an overlap of more than twenty days between the broods; an overlap from the time the first wintering larva appeared, July 27, to the time when the last worm appeared under the band to pupate, Aug. 26.

It will be noticed from the table given above that pupation declined abruptly about Aug. 20. Now a temperature record was kept during the summer and it shows that after Aug. 22 the temperature was decidedly lower than before. From Aug. 10 to 20 the average temperature from 7 to 9 p. m. was about 73 degrees, while from Aug. 20 to 30 it was 65 degrees. This dropping of the temperature at about the time when pupation ceased suggests the idea that it may depend much upon the temperature at the time whether or not a worm will pupate or live over winter. In 1903 not more than a very small proportion of the worms of the second brood pupated, but it would be expected that this proportion would vary in different years according to the fall temperature and might in a favorable season become of considerable importance, perhaps so much so as to make necessary an extra spraying during September.

CODLING MOTH CALENDAR—Showing graphically the life history of the Codling Moth as observed during the summer of 1903.

Relation of Life History to Spraying.

It is evident that to get the greatest possible benefit from spraying, it should be done just before the worms enter the apples, except possibly in the case of the first spraying of the season, which many prefer to give immediately after the blossoms have fallen so that some of the poison will be inclosed within the calyx lobes when they close. In orchards where from seven to ten sprayings are used there is no doubt that some of them could be profitably left out; but the trouble comes in deciding which ones to leave out. This, of course, depends upon the time when the young worms enter the apples. It has commonly been supposed among orchardists that from the time when the first worms enter in the spring until late in the fall, there is an unbroken procession of young worms going into the apples. This is true to some extent, but this work and also the observations of several orchardists have shown that at one place there is an almost complete break of about twenty days in the procession, and that there are other fluctuations. In other words the great majority of the worms enter the apples at more or less definite times. Thus in 1903, as shown in the diagram, the first brood of larvae entered during the month of June. Then a break occurred from the last of June to about July 20; then between July 20 and the last of August the greater part of the second brood of worms entered the apples. From the last of August till the first of October there was a gradually diminishing line of stragglers entering the apples. These stragglers may be accounted for partly as members of a partial third brood and partly as late members of the second brood delayed by the lower temperature of the fall. The time during which the worms entered the apples during 1903 is shown by the following diagram. A rough idea of the comparative numbers entering at any one time is given by the height of the curve above the base line.

If the time shown in the above diagram were the same for all years, the problem of spraying at the right time would apparently be a simple one; but the difficulty comes in determining the variation for different seasons. Now, the time when the first worms will enter the apples may always be reckoned from the date of blooming of the apple trees, the first worms entering in three weeks or a little less after the blossoms fall. Then if the orchard was sprayed while the calyx cups were open, the second spraying should be about *two weeks* later in order to catch the first worms. These two sprayings should suffice for the first brood, and if fewer than the five sprayings indicated on the diagram were to be given during the year it is likely that one of these sprayings could best be left out, especially if the crop is heavy, as apples stung by the first brood almost always fall off while small, and thus a natural thinning takes place. As for the second brood it seems that three sprayings applied at the times indicated on the diagram should be sufficient. *(It should be remembered that these suggestions as to the time of spraying are based solely upon the life history of the Codling Moth as determined during the season of 1903, and not upon actual syraying experiments, as none have yet been undertaken.)*

In deciding when to spray for the second brood, the date of blooming of apples would be of no help as the season is by this time so far advanced that weather conditions meanwhile might considerably change the date of appearance of the second brood. So in this case orchardists must for the present depend upon their their own observation and judgment. It is on account of this uncertainty that many orchardists prefer to spray at regular intervals throughout the season rather than take the chances of leaving out a spraying at the wrong time.

Methods of Spraying Now in Use.

It is supposed by some orchardists that Paris Green spray loses its insecticidal properties in from 10 to 14 days after being applied, and that it therefore needs to be renewed that often. The fact is that Paris Green is a stable chemical compound and would keep indefinitely as far as chemical change is concerned. The only things which make renewal of the spray necessary are: first, the

removal of the spray by mechanical means, such as rain; and second, the thinning out of the coat of spray on the apples, caused by the growth of the apples. As rain is almost entirely lacking in the Yakima valley, about the only way in which the spray is removed is by the rubbing together of leaves or apples, caused by wind. If plenty of lime is used in the spray, it is not hard to tell when it needs renewal. The number of sprayings used by different orchardists varies greatly according to the different opinions held by each. Some spray at regular intervals of from two to four weeks, giving in all six to ten sprayings during the year. Others spray irregularly at such times as they think necessary. Most of the latter class use only three to six sprayings during the year. Some spray while the calyx cup is open, while others think this spraying unnecessary, although it is undoubtedly effective. Complete data in regard to the treatment for the Codling Moth and the results of each were collected in twelve of the largest orchards of the valley, but the space is not sufficient to give them here.

Spraying Machinery.

A notion prevails among a few more or less inexperienced orchardists that when Paris Green is once thoroughly "dissolved," the spray is poisoned and that no further attention is necessary. The fact is that Paris Green is insoluble in water and cannot be dissolved as sugar or salt will dissolve, but is simply held in suspension, like dust in water, and being heavy, will quickly settle to the bottom if the spray is not kept constantly stirred. Hence the importance of having a good agitator in the spraying machine. If the agitator is not effective the trees will be sprayed with practically nothing but water and the hose and nozzles will constantly become clogged and after each barrellful of spray is used, a greater or less portion of the Paris Green will be found as a residue in the bottom of the barrel. With a good agitator it should only occasionally be necessary to clean out the machine, and then only lumps of lime etc. should be found. Next after the agitator the most important thing is to get as great pressure as possible.

Two main types of nozzles are in general use: those which throw a fan-shaped spray (Bordeaux and San Jose), and those which give a cone-shaped spray (Vermorel.) The Vermorel type

gives the finest spray and is most often used with hand pumps, although many prefer the Bordeaux. In the case of power spraying machines, which on account of the greater pressure produces a finer spray than hand pumps, the Bordeaux nozzles are more used.

Most of the orchards in the Yakima valley are too small to warrant the purchase of expensive power spraying outfits. A few are in use, however, and have proved profitable. Their chief advantage is in the greater pressure which they furnish and in their greater capacity, requiring fewer refillings. A power sprayer is effective in a wind that would stop any hand pump, and the finer spray which they give on account of the great pressure produces a more even coating over the trees and the spray does not have so great a tendency to collect into large drops and fall off.

Sprays.

Paris green is practically the only insecticide used against the Codling Moth in the Yakima valley. It is the intention of some of the orchardists to test other arsenites and spraying compounds in the future. The amount of paris green used to 100 gallons of water varies with different orchardists from three-fourths of a pound to one and one-half pounds and the amount of lime from four to sixteen pounds, the usual amount being from four to ten pounds. Where a large amount of lime is used the object usually is to make the spray show up well when dry, so as to be able to tell when it needs renewal. The main purpose of the lime is to prevent burning of the trees by the free arsenic in the paris green. To do this it is necessary to use only a few ounces of lime to a pound of paris green, the extra lime being for the purpose of making the spray more conspicuous. It may be that an excessive amount of lime would impair the action of the paris green.

Banding.

The practice of banding the trees in order to catch the worms which cocoon under them has been pretty generally abandoned throughout the Yakima valley, although a few orchardists still use the bands. In the orchard of Mr. F. Walden, near Zillah, where the banding system is still used, the cost of removing the