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Recommendations for Control of Curculios on Apple Trees in Connecticut

(1) Arsenate of lead[1] used at $1\frac{1}{2}$ pounds per 50 gallons of spray mixture—applied four times, two applications being subsequent to the calyx period preferably in a pink, calyx, 7-day and 2-weeks or 17-day schedule. Continue until curculios are well under control or if the infestation is small in the beginning, then omit the 7-day application on all except outside rows around the orchard. Apply sprays after calyx at the rates indicated on page 409

(2) Treat interplanted peaches, or peaches in orchards nearby, using lead arsenate as per spray calendar recommendations and cultivate thoroughly up to the trunks during July.

(3) Take care of wild apples or unsprayed trees in immediate neighborhood if possible, either by removal of trees, spraying them at calyx period with lead arsenate and fish oil sticker, or by collection and destruction of early dropped fruits.

(4) Destroy fence rows bordering orchard and remove stone walls if possible.

(5) For trees in the home garden, additional measures such as collection of dropped fruits, may be practised, keeping them picked up and destroyed from the middle of June on—and the destruction of beetles caught by jarring them from the trees onto a sheet.

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[1] $PbHAsO_4$—Acid lead arsenate. Commercial arsenate of lead is commonly sold in Connecticut in this form.

CONTENTS

Control Studies on the Plum Curculio[1] in Connecticut Apple Orchards

Philip Garman and M. P. Zappe

The plum curculio has been recognized as a major enemy of fruits in New England since Colonial days. Records of its occurrence in this country may be found in literature appearing between 1735 and 1750[2], and judging from the amount written since that time it has continued its depredations undiminished in severity, ranking today as one of the most important fruit pests. It is probably a native American insect, which became destructive on the introduction of fruit culture by the colonists.

The studies described in this paper were commenced in 1923, and therefore cover a period of six seasons. Though most of the observations were made at the Station farm at Mount Carmel, the orchard of Mr. C. E. Shepard of the West Woods section of Mount Carmel was placed at our disposal for experimental work. The systematic spraying tests recorded on pages 407-434 represent five seasons' work at the Station farm and four seasons at Mr. Shepard's orchard.

Nature and Extent of the Damage

As the name implies, plums are the favorite food of the curculio and damage to these fruits is always severe. Peaches are likewise attacked and although not seriously in Connecticut, much loss results in some regions. Apricots are about equally preferred to to plums while cherries, nectarines, quinces and pears are sometimes injured. Haws are also said to be infested. Perhaps the most serious damage by the curculio in Connecticut occurs on apples, not necessarily because of the amount of feeding or egg-laying, but because of the importance of the apple crop in the State and the difficulty of controlling it under ordinary conditions.

Injury to Apples

Curculios puncture the fruit of the apple both to feed and to lay eggs. Egg punctures are made during the spring and early summer, whereas feeding punctures may be made at any time. Egg punctures are characteristic for the insect, consisting of small crescentic excavations (Plate IV, a) which may enlarge as the apple grows, often resulting in large arrow-shaped scars (Plate V, a)

[1] *Conotrachelus nenuphar* Herbst.
Order Coleoptera—Family Curculionidae.

[2] See Quaintance and Jenne, 1912, p. 15.

a quarter of an inch or more across. The crescentic excavation usually prevents the destruction of the egg by growth of the fruit, the egg being placed in the flap at the center of the excavation. Feeding punctures consist of small circular holes often excavated around the edges by the feeding of the beetle, the fall punctures being largely of this type (Plate VI, a, b).

The number of punctures per apple varies with the density of the infestation. On trees sprayed with lead arsenate according to the usual schedule, the number varies from one to five, though occasionally more are encountered. On unsprayed fruit, the number frequently reaches 20 or more per single fruit. Where one or two punctures are present, the value of the fruit is not seriously affected except that it should be removed[1] from the highest grade (Fancy). Where 10 to 20 punctures occur, the value is naturally much less. A few external punctures do not, however, impair the keeping qualities and there is no danger of wormy fruit even where more than this occur, since no larvae develop in fruit remaining on the tree. Expanded curculio marks from punctures made early in the season frequently cover a considerable area and may hurt the sale if put on the market in competition with perfect fruit. The greatest damage, however, results from early feeding punctures which deform the fruit and from larvae which partly develop but are later crushed by the growth of the apple (Plate V, b). Such fruit is much reduced in value.

As to the amount of the injury occasioned, it may be said that a large per cent of the fruit is often affected on unsprayed trees, varying with the abundance of the beetles and the size of the crop. Our experience indicates that they may injure as much as 90 per cent of the entire crop, rendering a large part of it unsalable or fit only for cider. On large trees (12 years or more), a medium crop usually shows greater injury than either a very light or heavy one. Ordinarily 50 to 60 per cent of the fruit is damaged in infested orchards where no spraying is done. The following table shows the degree of injury which is found on untreated trees in sprayed orchards, the percentages representing curculio marked fruit:

TABLE 1

	Orchard	1921	1922	1923	1924	1925	1926	1927
				Per Cent				
Milford..............	A	57	67	60	48	..	23–60	..
Expt. Sta., Mt. Carmel	B	..	..	..	64	61	50	55
Shepard's, Mt. Carmel.	C	..	..	..	..	79	26	40

The above figures would not be especially significant unless a comparison were given with fruit from average commercial orchards. Counts were therefore made in a few orchards in order

[1]Public Acts, State of Conn. 1919, Chapter 295, Section 2.

to obtain figures bearing on the amount of damage to fruit as handled by the average Connecticut orchardist.

TABLE 2—RESULT OF SCORES IN COMMERCIAL ORCHARDS—1928

Variety	Location of Orchard	Total Apples	Number Marked by Curculio	Per Cent Marked	Treatment
Baldwin	Cheshire	749	128	17.2	Dormant and pink sprays dusted 7, 14, 30 days after.
Baldwin	Cheshire	661	36	5.4	Same as above plus prepink spray.
Baldwin	Wallingford	1,333	40	3.3	Dormant oil, pink, calyx, dust 10 days later, July 30.
Wagener	Wallingford	749	49	6.5	
Baldwin	Wallingford	1,179	166	14.2	
McIntosh	Cheshire	535	68	12.7	Pink spray, calyx dust (90-10) 7, 14, 30 days later.
Baldwin	Cheshire	749	128	17.4	Same as above.
Baldwin	Cheshire	659	36	5.5	Same as above plus prepink spray.
Baldwin	Cheshire	1,376	228	16.5	Dormant, pink, delayed calyx sprays; dusted afterwards.
Baldwin	Cheshire	554	123	22.2	
Baldwin	Branford	1,421	42	2.95	Dormant, pink calyx and 4 others last on August 1; all sprays.
Baldwin	Branford	945	102	10.7	Dormant, pink, calyx and 3 others; all sprays.

LIFE HISTORY

The life history of the plum curculio is very well known and has been worked out carefully by many investigators. Therefore, it will be unnecessary to extend this phase of the report unduly, but it will be desirable to give a general outline of the life cycle in Connecticut, developing such points as affect control measures.

Eggs are laid in the crescent-shaped punctures already mentioned. On apples, these punctures begin to be noticed shortly after the petals fall when the apples have reached one-fourth to one-half inch in size. After this, there is a period of three to five weeks (Fig. 28) in the field when egg-laying is continued but the peak of oviposition occurs about June 15, dropping off rapidly and being similar to the abundance curve (Fig. 26, b). In insectary cages, egg-laying has been observed to continue until the second week in July or even the last of July while newly made egg-punctures may be observed on apples in the field as late as July 25.

Length of Life Periods 1924–1925

The eggs hatched in an average of seven days according to our observations, varying from five to 16 days. The egg and larval period in the fruit averaged for this locality 22.9 days, varying from 17 to 39 days; while the average time from the entrance of the larvae into the soil to the formation of the adult was 21.2 days varying from 10 to 31 days. Our total period then from deposition of eggs to emergence of adults averaged 53.4, and varied from 31-67 days. The adult was observed to spend some time in the soil after transforming and there seemed to be considerable lack of uniformity in the maturity reached before they came from the soil. This probably accounts for the rather large variation encountered in the total length of the life cycle. There is, however, considerable difference in the length of the life periods in different years and the summer emergence of the adult has varied accordingly. The following records give a general picture of the periods in 1924–1925.

Table 3

	Average (Days)	Range (Days)
Eggs in fruit	7.0	5–16
Larvae in fruit	15.9	12–23
Larvae in soil	11.6	6–16
Pupae in soil	11.0	8–25
Adult in soil	9.8	....
Total	55.4	31–80

Length of Periods under Different Conditions and Cause of the Variations

It seems probable that the total life period given in the preceding table is shorter than actually occurs in the field in some seasons and the following figures bear on this point. Larvae emerging from dropped fruit collected under experimental trees were placed in field cages in 1924–1925, and the time to the emergence of the beetles observed. It will be seen that the average time spent in the ground is 42.2 days which if added to the periods spent in the fruit as egg and larva: namely, 22.9 days, would equal 65.1 days. This, it would seem, more nearly approaches conditions in the orchard. We know, for instance, that the greatest number of eggs laid about June 15 (1923–1924) in Connecticut and the total period of 65 days would bring the period of adult emergence (second brood) to the maximum for August 19. In 1924 and 1925, the curve (see chart on page 389) came to the maximum on September 1, although since that time it has fallen more nearly on the theoretical date, August 15–20 in 1927, and 10–15 in 1928. Another fact which supports the late summer emergence idea is the percentage of fall feeding punctures found on the fruit.

TABLE 4

Number Observed	Average Time Spent in Soil, Days
38	37.8
5	36.0
1	32.0
28	42.6
22	50.1
13	34.3
1	49.0
12	52.0
Total...120	Av. of all observations...42.2 days
	Av. of Averages.........41.7 days

Thus, from the variety Dutchess (unsprayed) examined on August 26, 1927, .09 per cent were marked with this type of feeding punctures; whereas, Russets picked and scored during October ran as high as 2.0 per cent; Greenings scored September 11 averaged 1.4 per cent while Baldwins scored October 27 but picked about one week earlier averaged 6.5 per cent on some unsprayed trees. The greatest amount of fall feeding is thus seen to occur after the first of September and since the adults will begin to feed within a few days after emergence, they could not well have emerged much earlier than this date. On the other hand, during 1928 when there was a very early emergence of adults, few or no feeding punctures were found on early fruit which would tend to contradict the last statement.

LIFE HISTORY IN 1928

Results of rearing curculios in 1928 indicated that there was a much shorter total life period than occurred in 1924 and 1925 and as a direct result an earlier emergence of adults during August, than was experienced during these years. One hundred individuals reared from eggs during 1928 gave an average cycle of 47.9 days and 28 days from emergence from the fruit until appearance above the soil as adults. Larvae placed in the soil on the same dates presumably under identical conditions (placed together in small jars) varied as much as three weeks in their period of emergence. In all cases, a normal emergence curve was produced, the peak of the lots obtained early in the season being approximately 27 days, and those obtained later, about 30 days. The following table shows the results obtained for 1928 in rearing curculios from egg to adult and from larva to adult, the latter being obtained from dropped fruits collected in the orchard at Mt. Carmel.

TABLE 5—LENGTH OF TIME SPENT IN SOIL—1928

Date Entered Soil	Date Emerged	Number Observed	Average	Range Days
June 28	July 25–27	4	28	27–30
July 1	July 25–Aug. 6	107	27	24–36
July 7	July 29–Aug. 21	43	27	22–45
July 8	July 31–Aug. 15	44	28	23–28
July 8	Aug. 4–Aug. 21	119	36	27–44
July 8	July 29–Aug. 10	32	26	21–31
July 9	Aug. 1–Aug. 11	32	27	22–32
July 10	July 21–Aug. 11	95	26	21–31
July 10	Aug. 1–Aug. 24	125	27	21–45
July 11	Aug. 6–Aug. 21	65	31	27–41
July 12	Aug. 4–Aug. 11	91	27	23–30
July 15	Aug. 7–Aug. 19	51	28	23–35
July 16	Aug. 11–Aug. 23	114	32	26–39
July 18	Aug. 10–Aug. 21	64	27	23–34
July 23	Aug. 19–Aug. 26	7	29	27–35
July 24	Aug. 17–Aug. 26	4	29	24–33
July 26	Aug. 19–Aug. 27	10	28	24–36
July 27	Aug. 23–Sept. 3	11	30	27–36
July 29	Aug. 23–Sept. 5	16	30	25–38
July 30	Aug. 21–Sept. 3	6	29	22–33
July 31	Aug. 30–Aug. 31	4	31	30–31
Aug. 3	Aug. 26–Sept. 3	4	26	23–29
	July 21–Sept. 5	1,048	28	21–45

TABLE 6—LENGTH OF LIFE CYCLE FROM EGG TO ADULT—1928

No.	Date Eggs Laid	Date Adult Emerged	Number Beetles	Period Days
1	May 30	July 26	1	57
2	June 12–13	July 26	2	43
3	June 12–13	July 28	2	45
4	June 10–11	Aug. 4	1	54
5	June 15–16	Aug. 4	1	49
6	June 24	Aug. 1	1	38
7	June 24	Aug. 3	1	40
8	June 24–5	Aug. 6	1	42
9	June 24–5	Aug. 7	1	43
10	June 21	Aug. 8	1	47
11	June 26	Aug. 9	1	44
12	June 26	Aug. 15	3	50
13	June 26–7	Aug. 9	7	43
14	June 29	Aug. 15	2	47
15	June 29	Aug. 17	3	49
16	June 29	Aug. 19	2	52
17	June 27	Aug. 14	3	48
18	June 27	Aug. 15	1	49
19	June 30	Aug. 15	2	47
20	June 30	Aug. 19	1	51
21	July 1	Aug. 11	1	41
22	July 1	Aug. 15	1	45
23	July 11	Aug. 24	1	55
24	June 28	Aug. 10	3	43
25	June 28	Aug. 11	1	44
26	June 28	Aug. 13	1	46
27	June 28	Aug. 30	1	63
28	July 5	Aug. 26	2	52

TABLE 6—LENGTH OF LIFE CYCLE FROM EGG TO ADULT—1928—*Concluded*

No.	Date Eggs Laid	Date Adult Emerged	Number Beetles	Period Days	
29	July 5	Aug. 29	1	55	
30	July 2	Aug. 17	1	46	
31	July 3	Aug. 13	1	41	
32	July 3	Aug. 19	5	47	
33	July 6	Aug. 15	2	40	
34	July 6	Aug. 19	2	44	
35	July 4	Aug. 6	1	31	
36	July 4	Aug. 14	1	39	
37	July 4	Aug. 17	1	42	
38	July 4	Aug. 19	4	47	
39	July 7	Aug. 31	1	55	
40	July 11	Aug. 30	1	50	
41	July 11	Aug. 31	1	51	
42	July 11	Sept. 5	1	56	
43	July 8	Aug. 19	1	42	
44	July 18	Aug. 22	1	45	
45	July 18	Aug. 25	1	48	
46	July 8	Aug. 26	4	49	
47	July 9	Aug. 24	1	46	
48	July 9	Aug. 26	3	48	
49	July 12	Aug. 30	1	49	
50	July 12	Sept. 5	2	55	
51	July 10	Aug. 30	1	51	
52	July 10	Aug. 31	3	52	
53	July 14	Aug. 31	3	48	
54	July 14	Sept. 9	1	57	
55	July 22	Sept. 14	2	54	
56	July 22	Sept. 17	1	57	
57	July 19	Sept. 17	1	60	
58	July 22–24	Sept. 17	2	56	
59	July 22–24	Sept. 25	1	64	
Total, average and range			100	47.1	31–64

A chart of the various activities of the curculio during the summer is shown in Figure 23. The first phase showing beetles coming from hibernation often begins in April but is not shown on the chart for lack of space. The peaks and relative abundance at different periods are shown together with the dates when the activity began, when it came to the maximum and finally ceased.

As a rule, the curculio lives longer in the adult stage than in any other. Adults of the second generation emerging from the soil during August and September hibernate and appear during May or June of the following year. Mating occurs in August or September but more often in Spring after coming from hibernation. Beetles sometimes live in captivity until October of the second year, making their total life 13 or 14 months. In most instances, however, beetles hibernating successfully, die before the middle of July and the total period for this stage may be said to vary from a few months (for those that fail to survive the winter) to nine to 13 months. The following chart (Fig. 23) indicates the general course of the life history.

Description

No extended scientific description will be attempted here, since the various stages have been frequently described and are shown in Plates I and II. The larva is sometimes confused with that of the Oriental fruit moth, and it may be said that the main gross

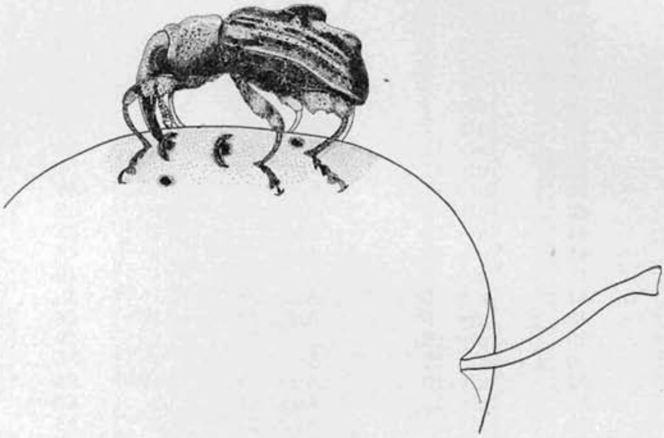


Fig. 21. The curculio beetle, its egg and feeding punctures. Enlarged 5 times.

points of difference lie in the curvature of the body and the color. The curculio almost invariably rests in a curved position while the fruit moth is straighter and more active and when mature is

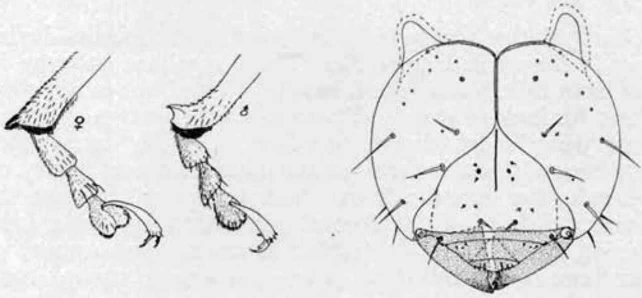


Fig. 22. Structural details of the curculio. Left, hind tibiae and tarsi of adult female and male. Right, head of larva, front view showing punctures and setae.

pink in color. The curculio larva is always white or slightly yellow and possesses no abdominal legs.

There has been some doubt in the authors' minds regarding the number of larval instars, but we have been able to check the statement of Quaintance and Jenne (1912) on p. 56 and find that there are four instars as stated there. The average width of the head capsule of 10-14 individuals of each instar are as follows: first, .28 mm.; second, .45 mm.; third, .69 mm.; and fourth, .96 mm. The larva is shown in Plate I, b and c, the head capsule in Fig. 22.

The pupa, shown in Plate I, d, is without protection except that it transforms in an earthen cell.

Adults, Plate II, a to d, are small brownish gray snout beetles with elevations of different heights on the wing covers, the beetle itself varying in length from tip of snout to end of abdomen from 5 to 7 mm.

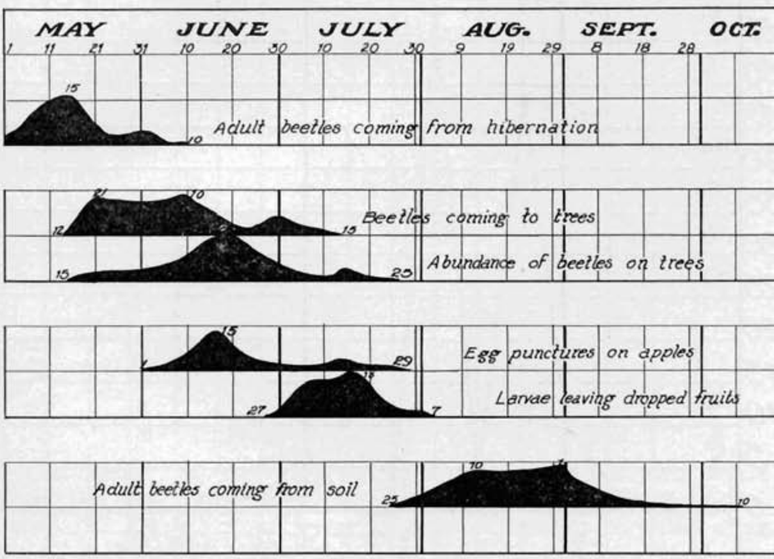


FIG. 23. Chart showing various activities of the curculio. Earliest emergence of hibernating beetles during our experiments occurred April 24. Adult beetles enter hibernation in August and September shortly after emerging from the soil.

When at rest, the adult folds its legs close to the body and if disturbed falls to the ground where it resembles closely a piece of bark or small cinder. The sexes are distinguished by the shape of the hind tibia as shown in Fig. 22.

ABUNDANCE OF THE CURCULIO IN ITS VARIOUS STAGES AND AT DIFFERENT PERIODS OF ACTIVITY

SPRING EMERGENCE OF THE ADULT

Emergence from hibernation begins on the approach of warm weather in the spring. The appearance of beetles depends upon temperature, and apparently upon rainfall in certain seasons. It has been noted by different authorities and observed during these investigations, that there may be an almost complete absence of beetles in the orchard until a given period dependent upon the temperature or other climatic conditions, when they come suddenly in considerable numbers. During the present investigation, records have been kept of emergence of the adults confined in field cages, from which data it appears that they begin to come from hibernation as a rule when the blossom buds of most varieties

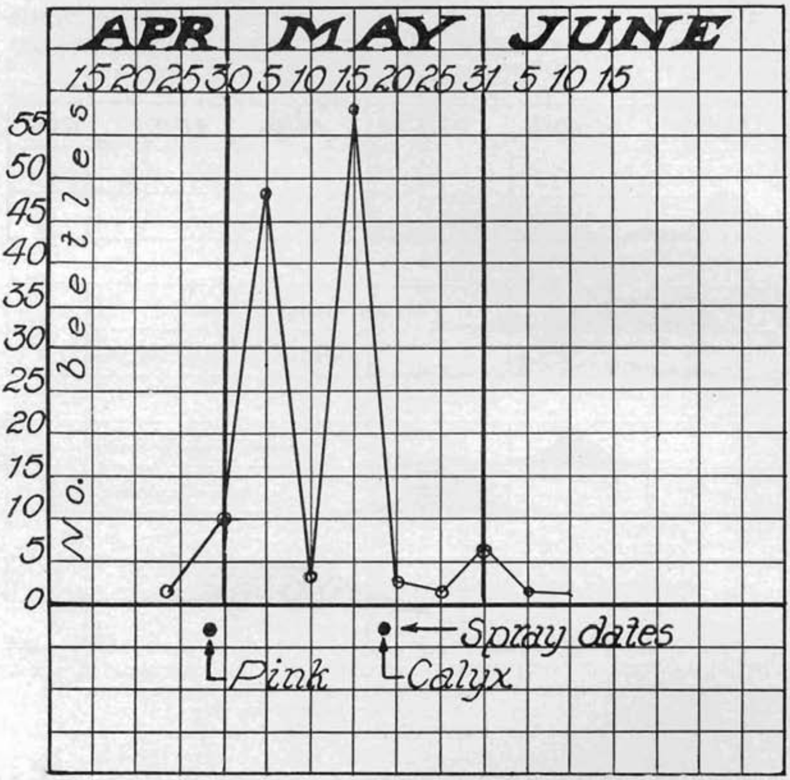


FIG. 24. Emergence of curculio beetles from hibernation in field cages 1925. Varying emergence is probably due to variations in temperature.

are turning pink. The earliest record of emergence thus far obtained is on April 24, 1925, and adults continued to come from the soil until June 12. The best records were obtained in 1925 and 1927 when three distinct waves of emergence were noted probably due to varying temperatures. In 1925, '26, '27 and '28, however, they appeared well on schedule, beginning to appear in numbers when the apple trees had reached the pink blossom bud stage. The data are shown graphically in Figures 23 and 24.

Temperature is, of course, an important factor affecting the time of emergence in spring, and especially the appearance of the beetles on the trees. According to various records (Quaintance and Jenne, 1912, pp. 118-119) the beetles begin usually to be found on the trees after a few days when the thermometer registers 60° F. (mean daily) or above. If the season is dry, the amount of rainfall decidedly affects their emergence from the soil. This is especially true of our observations in field cages where in 1926 the numbers emerging were decidedly increased after heavy rains. In 1927 this condition was not as marked but the following table will show that the greatest emergence occurred after the heaviest rainfall of that period.

TABLE 7—EMERGENCE OF HIBERNATING BEETLES AS AFFECTED BY RAINFALL—1927

Date	Rainfall in Inches	Beetles Emerging in Cages	Temperature, Deg. F.
May 2	tr.	..	.....
3	.05	..	.....
4	....	2	52–62
5	.2	..	.....
7	tr.	1	50–62
10	.2	3	56–62
11	1.05	12	57–71
13	...	..	.....
14	.55	..	.....
15	...	2	53–64
17	.1	..	.....
20	tr.	2	50–64

ABUNDANCE OF BEETLES ON THE TREES

The beetles, however, do not appear on the trees until some time after the first emergence in cages, and the maximum abundance on apple trees is not reached until at least three weeks after the calyx or petal fall spray would normally be applied. On plums, however, their appearance on the trees is somewhat earlier corresponding with the blooming period of some varieties, and the maximum abundance and egg-laying activities do not correspond altogether with the maximum abundance on apples according to our figures. The following charts (Figures 26 and 27) have been prepared to show this phase of the beetles' activities. On apples they begin to appear sometime between the pink and calyx periods, but do not become abundant until later. From the calyx period on, they increase rapidly until about three weeks afterwards when they decrease and gradually disappear, a few stragglers remaining until the middle or even the latter part of July.

EGG LAYING ACTIVITY AT DIFFERENT PERIODS

Extensive observations on the egg laying activities of the curculio in the field were made in 1928, results of fruit examinations being kept during the egg laying period. On apple trees it appears that the danger period in 1928 lay between June 1 and June 22 (calyx spray applied May 28 in our orchard) during which period sprays should be repeated at least twice for trees that are heavily infested. After June 22, there was a long-drawn-out period continuing until August when a few egg scars were made, which suggests the advisability of infrequent applications after the greatest feeding period is past in order to prevent the small amount of damage which occurs at the later time. Ordinarily, however, this has not been found necessary from the control standpoint, but sprays in July recommended for maggot control should play an important part in preventing damage from the late injury described. Figure 28 shows the injury to apples and other fruits resulting from egg punctures, and Plate IV shows typical egg scars.

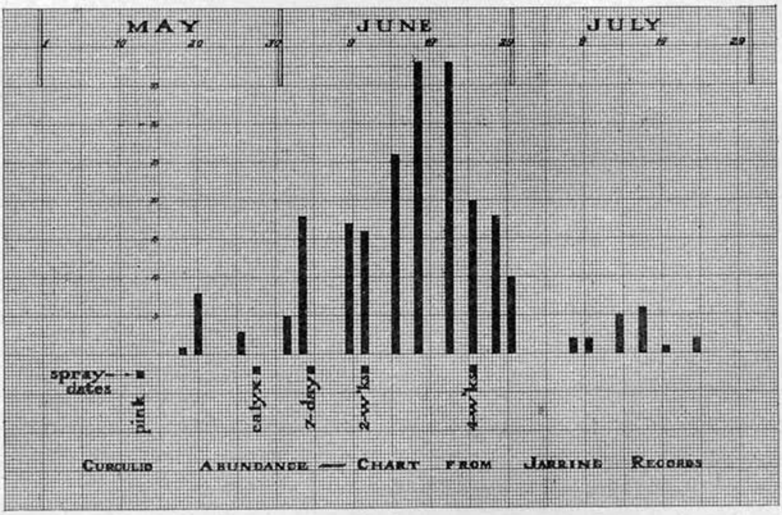


FIG. 25. Curculio abundance on fruit trees constructed from 1926 jarring records, together with spray dates for that year.

It has been thought that some differences might occur in different parts of the State in relation to the earliest egg laying activities. Thus, in 1928, according to the observations of Professor Manter, the calyx spray for apples was begun May 29 at Storrs and on the same date at Mt. Carmel. According to the bioclimatic law[1], there should be a variation of seven days between New Haven and Storrs, Conn., or 11 days between New Haven and Salisbury, while between Mount Carmel and Greenwich there should be no important difference. Such differences must vary from season to season, however, but evidently egg laying at Mount Carmel and Storrs commenced almost simultaneously in 1928.

[1]Hopkins, A. D. The Bioclimatic law and its application to research and practice in Entomology, Jour. Wash. Acad. Sci., 1921; 11: p. 141. According to this law there should be a difference in periodic activity of four days for each one degree of latitude, 5 degrees of longitude and 400 feet of altitude.

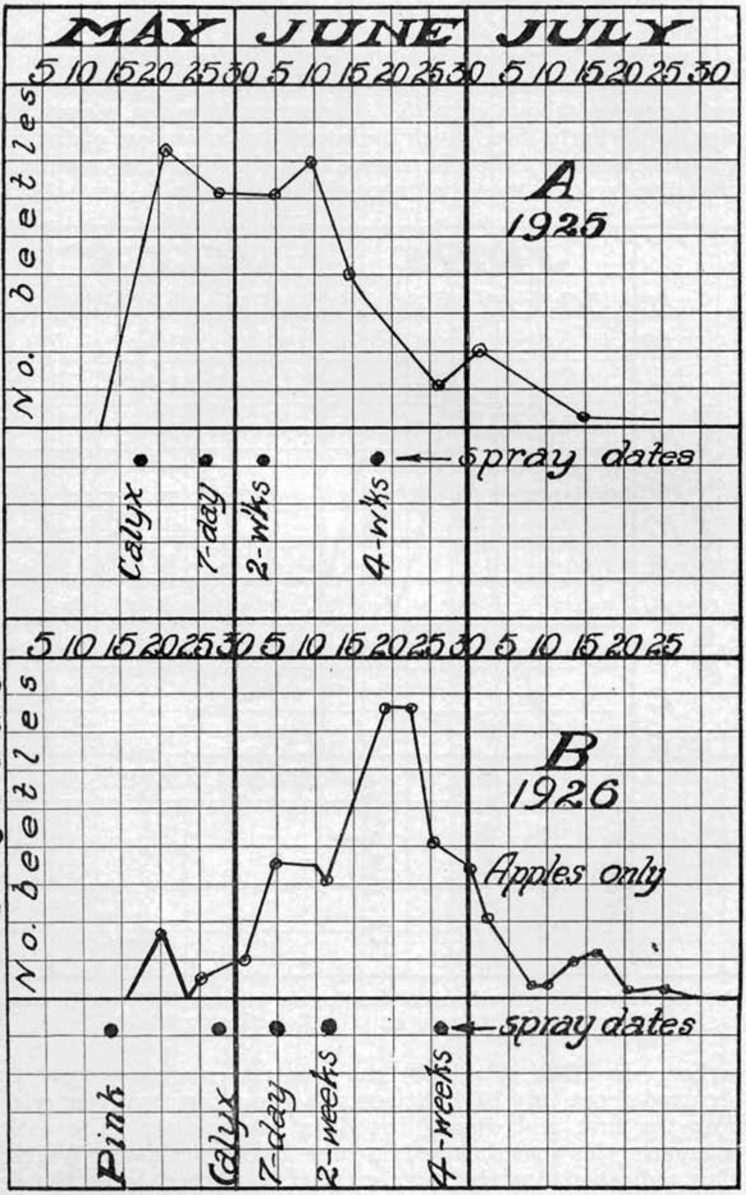


FIG. 26. Chart for comparison of (A) beetles coming to trees from hibernation as determined by removing beetles jarred at frequent intervals and (B) abundance on trees determined by jarring and releasing the beetles after counting.

Larvae Leaving Dropped Fruit

Larvae of the curculio begin to leave the drops in the latter part of June and continue until August. In 1924, the peak was apparently reached about July 15. There was, however, a very sharp rise on the early side, which indicated that that part of the curve was not complete. Similar records kept the following year indicate that the peak of the emergence fell about July 1, some 15 days

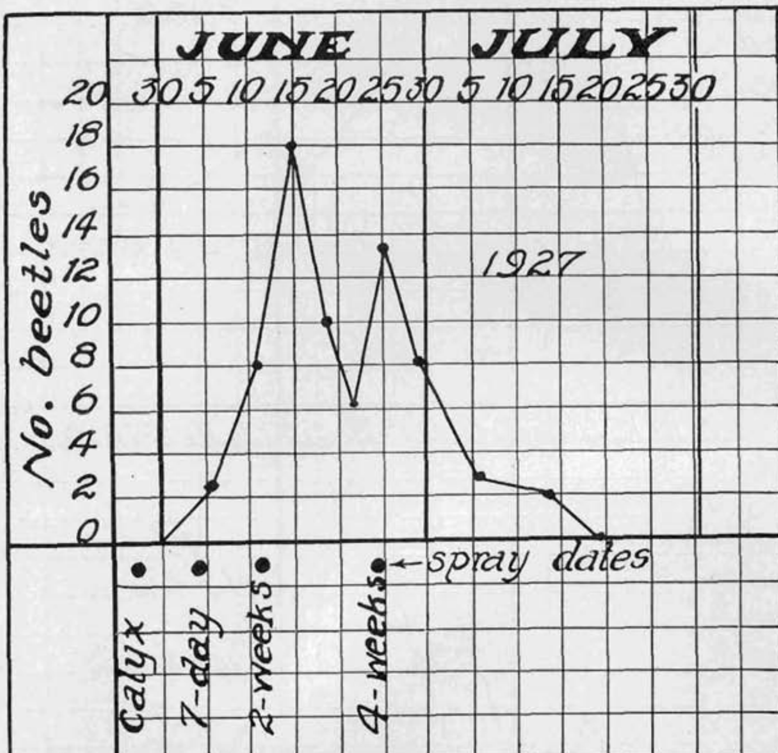


Fig. 27. Showing abundance of beetles on trees in 1927, as determined by jarring and releasing the beetles after counting.

earlier. In 1928, (Table 9) the greatest emergence from fruit occurred about July 10, but there was also a very heavy emergence near the first and during the days intervening. The earliest emergence this year occurred on June 27 and the last on August 7. This indicates that the main part of the brood leave the fruit between July 1 and July 15 or less than a month after the peak of egg laying on apples (Fig. 29). There is some variation from season to season in this phase of the curculios' activity though not so much as might be expected.

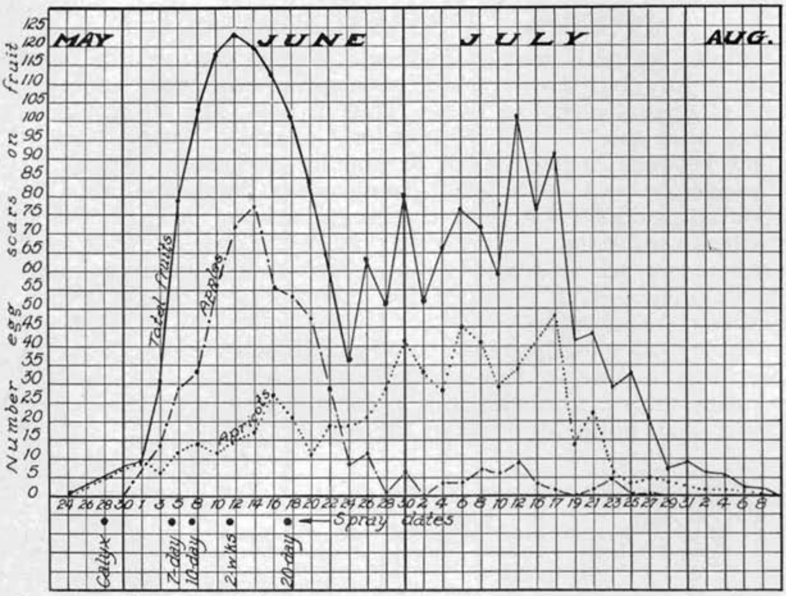


FIG. 28. Abundance of egg scars on fruit of apples, plums and apricots, shown under "total fruits" and apples and apricots separately. The curve for plums was essentially the same as that for apricots. Curves obtained from examination of marked branches every other day.

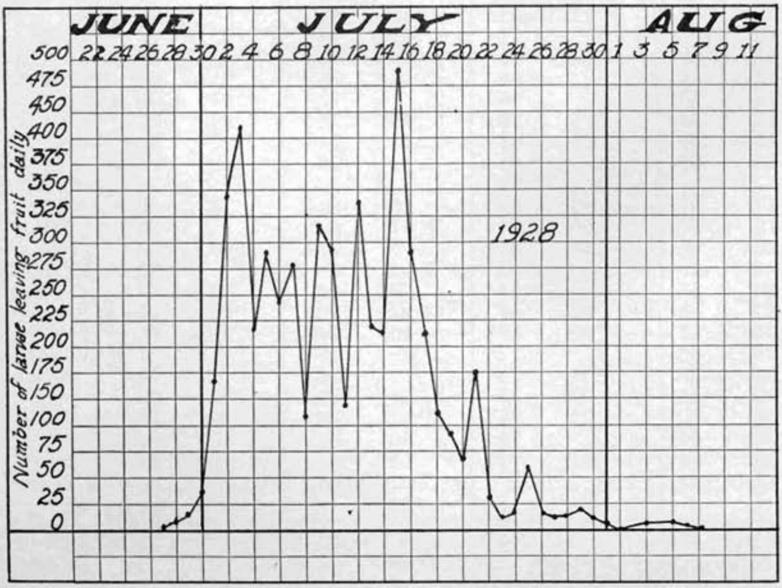


FIG. 29. Chart showing number of larvae leaving dropped fruit daily in 1928.

Emergence of the Second Brood Adults

Adults begin to emerge in insectary cages towards the latter part of July, but few have been obtained in field cages before the first of August except in 1928. Thus in 1924 (Fig. 30), the peak came near the first of September; whereas, during 1926, it came between August 15 and 20, and in 1928, about August 10. The average peak of the adult emergence of the second brood lies about the middle of August, the variation being probably due to weather conditions. In order to predict the exact time of adult peak emergence it would be necessary to obtain temperature data similar to that obtained for the codling moth by Glenn, Shelford and Headlee.

Table 8 shows temperature and rainfall data obtained from the New Haven Weather Bureau for May to August, 1928, the temperature records from this station averaging two or three degrees higher than normally occur in the orchard.

Table 8—Rainfall and Temperature in New Haven—1928

	May		June		July		August	
	Mean Temp.	Rainfall Inches	Mean Temp.	Rainfall Inches	Mean Temp.	Rainfall Inches	Mean Temp.	Rainfall Inches
1	58	.04	66	....	72	Trace	72	.02
2	58	....	72	.34	74	.12	80	....
3	61	....	62		77	....	82	Trace
4	60	....	62	.42	78	.88	85	....
5	58	....	58	1.04	76	1.13	82	.08
6	60	Trace	62	.58	68	1.29	67	.79
7	55	.03	66	Trace	71	....	64	.21
8	51	....	66	....	78	....	71	.05
9	50	.11	64	.49	80	....	78	....
10	56	....	61	....	74	.05	76	.46
11	60	Trace	60	....	75	Trace	75	.24
12	52	....	64	....	78	.01	68	Trace
13	50	....	66	....	72	.24	69	....
14	54	....	70	.45	73	.84	76	....
15	54	....	68	....	74	....	80	....
16	60	....	64	....	76	....	78	....
17	62	....	64	....	78	....	74	.15
18	57	.66	68	.18	82	....	76	.21
19	57	.06	64	1.51	82	....	75	....
20	56	.28	63	....	72	.04	70	....
21	60	....	63	Trace	68	....	72	Trace
22	58	....	58	.20	68	.11	64	.32
23	55	.06	57	Trace	76	.04	64	.56
24	56	.50	66	.19	74	2.40	69	....
25	56	....	72	....	78	....	71	.02
26	59	.36	73	....	73	....	72	.29
27	58	.07	75	.04	74	.02	72	.07
28	60	.02	74	Trace	78	.69	76	.04
29	64	....	69	.50	69	....	82	....
30	64	.07	72	.15	66	....	82	Trace
31	63	....	..	....	68	....	68	Trace
Monthly mean	57.4		65.6		74.3		73.9	
Total precip.		2.26		6.09		7.86		3.51

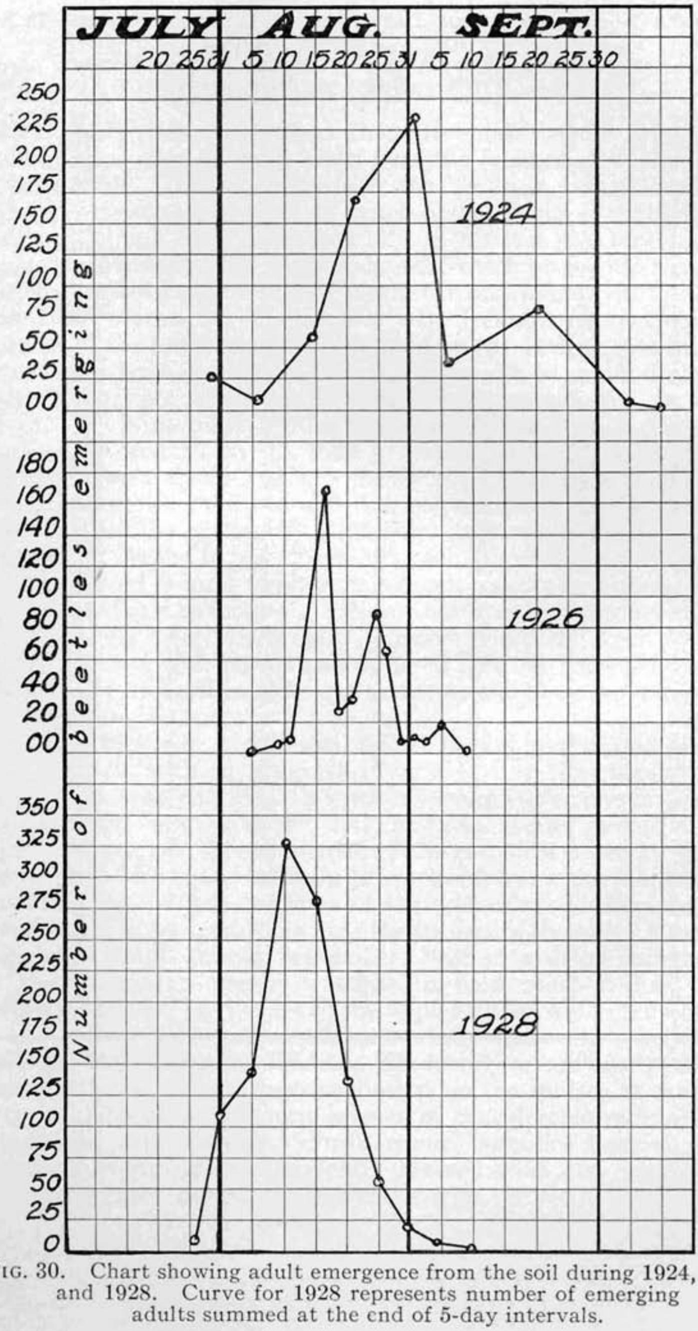


FIG. 30. Chart showing adult emergence from the soil during 1924, 1926 and 1928. Curve for 1928 represents number of emerging adults summed at the end of 5-day intervals.

TABLE 9—EMERGENCE OF LARVAE FROM DROPPED FRUITS—1928

Date	6622 Mixed Plums, Apples and Peach Drops	2779 Peach Drops	1423 Early Apple Drops	3028 Medium Apple Drops	707 Late Drops From Apple	Totals	Apples Only
May 27	1	..	..	..	..	1	..
May 28	6	..	..	..	..	16	..
May 29	14	..	..	..	..	14	..
May 30	..	..	..	..	..	36	..
May 31	..	..	..	..	..	..	..
July 1	170	..	..	..	..	170	..
July 2	349	..	..	..	..	349	..
July 3	417	..	6	..	..	423	6
July 4	214	..	3	..	..	217	3
July 5	170	..	14	2	..	186	16
July 6	227	..	16	2	..	245	18
July 7	224	14	30	8	..	276	38
July 8	73	11	23	4	..	111	27
July 9	156	64	56	43	..	319	99
July 10	135	58	49	49	..	291	98
July 11	67	28	11	39	..	145	50
July 12	146	84	0	100	..	330	100
July 13	80	34	73	36	..	223	109
July 14	84	53	22	59	..	212	81
July 15	130	89	27	241	..	487	268
July 16	88	90	14	119	..	311	133
July 17	41	39	6	126	..	212	132
July 18	20	31	1	67	..	119	68
July 19	14	26	0	54	..	94	54
July 20	12	34	1	13	8	68	22
July 21	11	29	2	70	9	121	81
July 22	3	9	1	7	6	26	14
July 23	0	7	0	4	6	17	10
July 24	0	6	0	3	11	20	14
July 25	3	35	1	10	12	61	23
July 26	2	5	4	3	5	19	12
July 27	1	6	..	3	3	13	6
July 28	4	6	..	2	2	14	4
July 29	1	4	..	2	13	20	15
July 30	0	1	..	2	9	12	11
July 31	2	..	1	1	1	5	3
Aug. 1	0	..	..	..	..	..	..
Aug. 2	0	..	..	..	..	..	..
Aug. 3	1	..	..	..	3	4	3
Aug. 4	0	..	..	..	..	..	..
Aug. 5	0	..	..	..	..	..	..
Aug. 6	0	..	..	1	2	3	3
Aug. 7	1	..	..	1	1	3	2
Total larvae	2,903	763	361	1,071	91	5,189	1,523

HABITS OF THE CURCULIO

Hibernation and Spring Emergence

It is fairly well established that the adult beetles winter in woods, hedge rows or stone walls near the orchard or even in the orchard itself. During the winter, the beetle is very difficult to find and an extended search in peach orchards, apple orchards or woods adjoining may fail absolutely to disclose the hibernating quarters. Probably the most successful attempt to discover the winter quarters is reported by Quaintance and Jenne (1912 p. 130) "At Youngstown, N. Y., in 1905 Mr. Johnson made frequent searches in the fall during October, and on the 14th of that month nine beetles were discovered in a slight depression under an apple tree. They were well covered with closely matted well decayed leaves......Nine more beetles were found in a similar situation in an apple orchard on the 16th......On November 7, six more specimens were taken beneath partly rotted leaves close to the soil. The beetles were wet and dull colored from their surroundings......In the spring of 1905 Mr. Johnson made extended searches for beetles in fence rows, in peach, plum, apple and quince orchards in old stumps in adjoining woods, cracks in fences, under piles of wood and so forth......None, however, was discovered... The following year, 1906, Mr. Johnson found on April 24, 10 beetles covered with leaves and decayed fruit on the surface of a young apple orchard in sod. At this time the blossom buds were just beginning to open."

In spite, however, of the usual failure to find hibernating beetles in or near orchards, it is almost invariably true that beetles first appear in greater numbers on rows adjoining fence rows or woods, and there can be little doubt that they seek shelter in such situations. A search in Connecticut in 1923 and 1924 failed to reveal the whereabouts of the beetle in the orchard, but a single specimen was found in a woods near one of the orchards. This beetle was found under leaves and trash near the surface of the soil. A second beetle was found during September, 1928 in a dried curled leaf on the edge of a nearby woods. In field cages it has been observed that the beetles leave the apples under which they crawl to feed before hibernation and apparently hide under leaves or trash in the immediate vicinity. In spring before emergence, a search in these cages will reveal beetles on the surface of the soil. Shortly afterwards they may appear in considerable numbers on the netting over the cage. Furthermore, curculios bumped from the trees in spring are frequently covered with clay, indicating that they passed the winter in contact with the soil.

Food of the Beetles

Unlike some other insects the adults of the curculio require food. They will feed upon the leaves of peach and apple, and even upon the petals of the flowers (Plate III, b). Confined in cages with fruit blossoms, they often eat through the calyx cup, evidently in search of sweets. In confinement they have been observed to feed also on sugars of various kinds and seem very fond of honey. Much feeding is of course done on young fruits, of all species which the curculio infests. As to varieties of apples preferred either for food or oviposition there seems to be little choice since feeding and egg punctures have been observed on practically all varieties grown in this state. If there is any choice of variety on the part of the beetle, it is the Dutchess variety which seems to be severely injured in most Connecticut localities. The following table shows that the curculio will develop in many varieties. We have attempted to feed them on other fruits besides those in which the larvae develop but without much success except in the case of

Table 10

Variety	No. of Apples	No of Adults Obtained
Baldwin	100	35
Fall Pippin	60	20
Gravenstein	100	90
Hurlburt	100	39
King	100	29
McIntosh	100	18
Russet	70	9
Stark	70	14

oranges, on the peel of which they will feed to some extent. They will also feed on such mixtures as casein and honey, with just enough water added so that it can be rolled into a ball, and they have been observed to feed on a sponge containing sugar with enough citric acid to make it quite sour. Saccharin was not observed to be attractive to the beetles for food.

Moisture Requirements

Adult curculios require considerable moisture during their lives. Not only does moisture or humidity influence their distribution in the United States, but a certain amount seems to be needed for proper functioning of the life activities. Trees with thick, heavy and abundant foliage, providing abundant dampness in the interior are often heavily infested. In cages, they may be frequently seen taking water from any convenient source or they may be trapped in bottles containing only moist blotting paper placed alongside of equally large bottles containing a natural food supply. Such an experiment was performed, using small glass bottles provided with wire funnel traps. Apricots were used as the attracting food. The following results were obtained:

TABLE 11

Date	No. Beetles Used	Beetles in Moisture Bottle	Beetles in Food Bottle	Notes
May 31–June 1...	7	5	2	
June 1–2..........	7	5	2	bottles reversed.
June 2–3..........	6	1	5	pair of beetles put in food bottle before starting.
May 28–9........	6	0	6	check—nothing in moisture bottle.

It is not certain when the beetles take moisture in the field, but it is evident that they are much more active on warm, damp cloudy days than on dry clear ones. One must naturally conclude that moisture or water supply plays a very important role in the biology of the curculio.

Another meteorological factor that affects the curculio is high winds. It is well known that a slight jar is sufficient to make the insect feign death and drop to the ground. It is but natural, therefore, to find them much less abundant on trees, after or during a high wind when the branches are moving about.

NUMBER OF FEEDING AND EGG PUNCTURES

As already noted, the beetles will feed readily upon the fruit. The number of feeding and egg punctures varies in confinement but the following figures will indicate the number usually produced. Quaintance and Jenne give records of individuals making as many as 616 egg punctures although the average for all localities is much lower—101 for Myrtle, Georgia, and 31 for Siloam Springs, Arkansas. The average feeding punctures for these localities is much higher than the number of egg punctures—287 for Arkansas and 161 for Georgia. These figures, however, represent the combined feeding of one pair and indicate that the average feeding punctures per beetle is usually not over 150. Our figures vary from 35-105 egg punctures per female with an average of 79. Feeding punctures per female, however, averaged less than the total number of egg punctures, 46 in number although some individuals fed much more than this.

EGG LAYING AND FEEDING OF ADULTS EMERGING DURING SUMMER

As already mentioned, no eggs are laid in this locality by beetles emerging during the summer. The greatest damage to the fruit lies in the fall feeding punctures (Plates VI and VII, a) which, however, have never appeared to be especially abundant in orchards where our experiments were conducted. The following table shows the relative abundance of this type of feeding punctures on sprayed fruit:

TABLE 12—AMOUNT OF FALL FEEDING OF THE ADULT CURCULIO

Date Scored	Total Fruits	Number with Fall Feeding Punctures	Per Cent with Fall Feeding Punctures	Treatment
August and Sept., 1928....	21,362	44	0.2	Sprayed
August and Sept., 1928....	16,181	51	0.3	Sprayed
Sept. and Oct., 1928......	32,186	112	0.3	Sprayed
Sept. and Oct., 1928......	18,075	151	0.8	Check—no treatment

The actual percentage of fall feeding punctures on sprayed fruit thus seems to be small and may be disregarded as far as preventive measures are concerned. There is often a considerably greater number on dropped mature fruits than on fruit picked from the trees which is thought to be due to beetles seeking hibernating quarters beneath the trees. The greatest amount of damage due to fall feeding of curculios is recorded in our data for 1926, when it averaged 6.5 per cent on unsprayed Baldwins.

TOTAL NUMBER OF BEETLES DEVELOPING IN APPLES AND POSSIBLE MENACE TO FRUIT OF THE FOLLOWING SEASON

In 1924, all dropped fruits were collected from a sprayed orchard containing two rows of unsprayed trees. All picked fruits were counted in scoring so that the relative number developing in the orchard is apparent. By making certain deductions for mortality, and allowing a conservative number of punctures per beetle (below the average in this case) the percentage of the crop which could be injured during the following year may be roughly estimated. While such figures can never be made to represent the actual condition in the field due to many undeterminable and variable factors, they do show that curculios developing in an apple orchard may offer a considerable menace to the crop during the succeeding year. The estimate is a very conservative one and it seems probable that the amount of damage is often considerably greater.

Total number of fruits in 1925..........	144,435
Total larvae from drops in 1924........	2,601
Total adults allowing 85% mortality (50% larval mortality, 70% for adults).....	390
Total punctures allowing 100 per beetle..	39,000
Total apples which could be injured allowing 1.5 punctures per apple.......	26,000
Per cent of total crop which could be injured...........................	18.0

Reaction of Adult Beetles to Insecticides

In confinement the curculio is more or less easily poisoned with various arsenicals. In the field, however, a tree sprayed with the usual strength of lead arsenate will contain no curculios within 24 hours after spraying; whereas, on unsprayed trees in the immediate vicinity they may be very numerous. Experiments along this line were carried out in 1924 with always the same results; namely, the rapid disappearance of beetles after the poison was applied. This was determined by jarring the trees within 24 hours and placing sheets under the trees to catch fallen beetles. None were taken on the sheets. In cages the most rapid kill that we have yet obtained was 100 per cent in four days, which would indicate that some of the beetles at least should be obtained by jarring in 24 hours. No doubt a fatal dose is obtained shortly after the material is applied and the beetles go elsewhere to die. A report published in Bulletin 32 of the Georgia State Board of of Entomology is interesting in this connection. The authors here confined 372 beetles in an enclosed tree sprayed twice with 3-50 lead arsenate. The following day no beetles could be found feeding on the tree but they all died in 10 days. It seems probable that conditions obtaining here are very similar to field conditions although it does not necessarily prove that arsenate of lead as generally applied (where the dosage is smaller) is a repellant. Probably the substance is repellant in action only after the killing dose is obtained. Our tests, however, indicate a rapid disappearance from trees sprayed with 1½ pounds per 50 gallons.

Various other insecticides have been employed in cage tests, including basic lead arsenate, sodium fluosilicate and ferrous arsenate (scorodite) but none have equaled the lead arsenate in killing power. Sodium fluosilicate mixed with four parts of lime showed considerable value but did not quite equal acid lead arsenate. Basic lead arsenate was only partially effective, a fact made further evident by field tests in 1928. To increase the killing power of certain poisons of low toxicity, various compounds such as lead and zinc stearate were added but without success. These are mentioned on page 406.

Reaction of Beetles to Various Supposed Attractive and Repellent Substances

Curculios are very sensitive to odors. It has been shown by Power and Chestnut[1] that the odorous constituents of apples consist of such compounds as acetaldehyde, amyl esters of formic acid and caproic acid and malic, caproic and capryllic acid. A subsequent research[2] indicated the presence of geraniol. Much

[1]Journ. Amer. Chem. Soc. 42: No. 7: pp. 1509–1526: 1920.
[2]Journ. Amer. Chem. Soc. 44: p. 1498: 1922.

time has been given to a consideration of these compounds from the standpoint of attractives and the only ones which could be detected to have much influence on the beetle are acetaldehyde and malic acid. Both the pure acetaldehyde and the acetaldehyde producing acetaldehyde-sodium bisulphite have been used with similar results. However, when used in the field the beetles have not been successfully trapped by any substance. Probably the scarcity of beetles is one factor influencing results, but another important factor is the high volatility, the odor disappearing within a short time after being placed in the open. This is also true of the repellents tried. Laboratory tests were conducted by placing small specimen bottles (capacity 23 cc.) in one end of a box three

TABLE 13—RESULTS OF TESTS WITH VARIOUS ATTRACTIVE MATERIALS USING LONG BOX PLUS TRAP BOTTLES AT END; COMPARED IN EACH CASE WITH NATURAL FOOD

Substance	Kind of Fruit Compared	Number in Fruit Bottle	Number in Test Bottle	Number Beetles Used
Geraniol	apricots[1]	8	0	10[2]
Granulated sugar and and water	apricots	8	0	10
Malic acid plus sugar	apples and	7	2	9
	apricots	6	1	7
Cal. malate Acet. sod. bisulphite	apples and	6	2	8
	peaches	1	6	7
		6	2	8
Acetal., water, cal. malate, sugar	apricots	3	2	5
Acetal.-cal. malate (dry)	apricots	6	0	6
Moist blotting paper	apricots	$2\begin{cases}1\\1\end{cases}$	$5\begin{cases}2\\3\end{cases}$	7
Moist blotting paper	apricots plus geraniol	2	5	7
Moist blotting paper	apricots plus pair beetles	5	1	6
Empty bottle	apricots	6	0	6

feet long by four inches wide by three inches high with openings at both ends. At one end was connected a short upright tube in which was placed a small electric light. This provided enough heat so that there was a gentle current of air through the box, from one end to the other. Each bottle was provided with a wire cone so that beetles could enter but would remain in the bottle. The tests were begun by placing the beetles in the far end of the box and allowing them to remain over night, the number found in each bottle being recorded the following day. The top of the box was provided with heavy red celluloid made for photographic work. It will be seen here that although the light factor is excluded by use of the red screen and the maze construction of the box, there is

[1]Small green fruits.
[2]Two beetles failed to enter trap bottles.

still a disturbing element in the moisture which accompanies the attractive substances. It is also important as noted by others to use beetles at a time when naturally attracted to their native food plants, for if older beetles are supplied especially after most of the feeding and egg-laying are over, conflicting results may be expected. The Y tubes such as have been devised by McIndoo[1] have also been used with air currents from a suction pump. The unevenness of the air current through the tubes precluded consistent results in the few tests that were made with this type of apparatus.

In view of the fact that moisture apparently played such an important part in the above experiments another series was devised comparing equally large squares of blotting paper, one soaked in pure water, the other soaked in the solution of odorous substances to be tested. The paper did not take up such insoluble substances as lime, but some, of course, was deposited on them.

TABLE 14—COMPARISON OF EQUAL SIZE SQUARES OF BLOTTING PAPER CONTAINING WATER WITH VARIOUS SOLUTIONS OF ODORIFEROUS MATERIALS

Substances Compared	Number in Test Bottle	Number in Moisture Bottle	Number Beetles Used
Calcium malate and acetaldehyde.....	8	1	9
Iso-amyl n-capryllate acetaldehyde, malic acid and lime...............	4	2	8
Same..............................	5	2	8

From these results it may be seen that the substances tried had considerable greater attractiveness, yet when we refer to the preceding table it is evident that they do not have nearly as great attractiveness as the natural foods.

The action of repellents was tested in a similar manner except that air was blown through the cage with considerable force with an electric fan. The various substances were placed in the base of the funnel and the fumes blown into the cage with the air. In some of the tests, beetles were first collected on a peach shoot before introduction of the test odor, with the result that they were promptly driven from their natural food to the far end of the box. About 32 substances were tried in this manner with the following results:

TABLE 15

Repellents and Activators	Repellents	Substances Without Apparent Action
Capryl alcohol	Benzaldehyde	Amyl alcohol (Iso)
Iso amyl-n-caproate	Capryl alcohol	Amyl Formate
Iso amyl alcohol	Allyl isothiocyanate	Amyl n-capryllate
Acetaldehyde	Iso-amyl-n-caproate	N.-butyl alcohol
Carbolic acid	Xylene	Anise oil

[1]Journal of Economic Entomology 19: 549–571: 1926.

TABLE 15—*Concluded*

Repellents and Activators	Repellents	Substances Without Apparent Action
Gasoline	Allyl alcohol	Calcium cyanide
Benzaldehyde		Carbon disulphide
Xylene		Chloroform
Allyl iso-thiocyanate		Cider
Allyl alcohol		Clove oil
		Dichloroethane
		Dinitrotoluene
		Ether
		Ethyl alcohol
		Lime sulphur
		Lysol
		Nicotine sulphate
		Octyl alcohol
		Paradichlorobenzene
		Propyl alcohol
		Vinegar

It is worthy of note that such substances as calcium cyanide have little effect, while capryl alcohol and benzaldehyde are strongly repellent. The almost immediate activation of the beetles on the introduction of strong capryl alcohol odor is surprising, the insects running about the cage as if mad.

Application of these apparently repellent substances in the field, however, resulted only in the rapid disappearance of the odor through volatilization, and they consequently had little effect in keeping the beetles from the trees. It is very difficult to select the various repellents in order of their potency and the foregoing list is not intended to convey the impression that one is necessarily more active than another. They have been divided into three lots for convenience. Some of the activator substances were apparently not repellent in the tests conducted and they have therefore been omitted from the repellent list.

There remains the discussion of the protective action of such materials as lime or other non-poisonous material. If we protect a portion of an apple, for instance, with a thick coat of lime, the beetles will feed on the unprotected side. Under natural conditions it is almost impossible to cover completely all sides of an apple unless extremely careful work is done and it is as nearly impossible to maintain this covering over any period of time. It is furthermore difficult to maintain a coat of any thickness so their ultimate value in this regard is doubtful. Lime is sometimes desirable in the spray mixtures, however, for other reasons.

Reaction of Beetles to Light

Confined in cages, the adult curculio beetles are decidedly positive to light, but Quaintance and Jenne have shown that the activities of the female are about equally distributed during the day and the night. The adult beetles have been observed frequently in the field during the day at rest with legs folded, although when disturbed by jarring they may become active and take flight.

Habits of the Larvae

On emergence from the egg, the curculio larva burrows into the center of the fruit where it continues to feed until a cavity of considerable size is excavated. After the apple drops and the larva becomes full grown, it enters the soil, penetrating to a depth of two inches or less. They rarely go more than three inches below the surface and 90 to 100 per cent will be found within the first two inches. Frequent disturbance of the soil by any means destroys the larvae and the value of cultivation in curculio control is therefore apparent. Undersized larvae often desert fruit and burrow in the ground, but it seems probable that these are stunted mature larvae, forced to abandon the fruit before full size is reached.

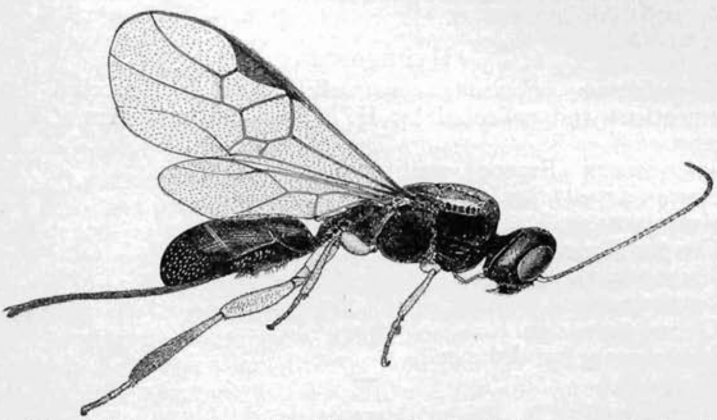


Fig. 31. Adult parasite *Triaspis curculionis* Fitch enlarged about 12 times. Left legs, wing and antenna removed.

PARASITES

Parasites of the plum curculio have not been numerous at any time during this investigation. The most abundant, *Triaspis curculionis* Fitch, (Fig. 31) was observed in 1928 and it parasitized about 18 to 33 per cent of the larvae leaving the fruit July 1. The following table shows the relative numbers of this parasite obtained from a large number of larvae, the average parasitism being 5.0 per cent. The species emerged July 15 to August 21.

The only other parasite observed was the egg parasite *Anaphoidea conotracheli* Girault, found during the summer of 1928. This parasite is reported to kill as much as 85 per cent of the eggs of the plum curculio. Quaintance and Jenne mention nine other

TABLE 16—PERCENTAGE OF PARASITISM BY *Triaspis curculionis* FITCH

Date Larvae Entered Soil	Number Curculio Larvae	Number Parasites Emerging	Per Cent Curculio Larvae Parasitized
June 28	6	2	33.3
July 1	170	31	18.2
July 2	22	7	31.8
July 12	50	1	2.0
July 7	96	1	1.0
July 12	32	0	0.0
July 13	128	0	0.0
July 12	91	1	1.0
July 8	118	1	.9
July 16	125	5	4.0
July 17	114	1	.8
	953	48	5.0

parasites, a number of predaceous insects and other enemies. It will suffice here to list these additional enemies together with a few notes on their Connecticut status.

Hymenoptera

Thersilochus (*Porizon*) *conotracheli* Riley. Reported from Connecticut and collected by H. L. Viereck on flowers of Ribes species.

Microbracon (Bracon) mellitor Say.

Bracon dorsata Say.

Anisocyrta sp.

Pimpla (Epieurus) sp.

Eurytoma sp.

Cataloccus sp.

Cerambycobius sp.

Microbracon lixi Ashmead.

Diptera

Miophasia aenea Wiedemann. Generally distributed over North and South America and probably occurring in Connecticut.

Cholomyia inaequipes Bigot.

Predaceous Enemies

Ants, *Dorymyrmex pyramicus* Roger. We do not have this species in Connecticut although other species no doubt play an important part in destruction of curculio larvae.

Lacewings *Chrysopa oculata* Say and other species present in Connecticut orchards.

Thrips. Reported to destroy eggs of the curculio. Observed frequently in or near egg scars and they had apparently destroyed the eggs present in them.

Carabid or ground beetles. Frequently present in Connecticut orchards.

Chauliognathus pennsylvanicus DeGeer. A small brown beetle frequently present. The larvae of this species is said to attack curculio larvae.

Birds of various species are known to feed on curculios.

Moles destroyed a great many larvae in ground cages in 1924. It was found necessary to protect the bottom of these cages against their entrance.

Diseases

Larvae have been observed frequently to die of disease where the soil becomes very damp, and are frequently covered with a white fungus, probably Isaria or Sporotrichum species. The adult beetles have also been found diseased under similar conditions one of the causes being the green muscardine fungus *Isaria anisopliae* (Metch.) commonly attacking grubs in the soil. (See Pl. II, b.)

CONTROL

Before introduction of the arsenicals as insecticides about 60 years ago, horticulturists used various means for combatting curculios. Cultivation, jarring the trees to capture the beetles, allowing live stock to run in the orchard in order to destroy the larvae in drop fruits are a few of the more successful means of control. Besides these there have been forty or more recommendations and suggestions varying from such means as placing chips under the trees to hanging dead mice therein in order to attract the adult beetles which were thought to lay eggs on such material.

The development of arsenicals as insecticides resulted in a material change in control procedures. Arsenate of lead, developed about 1893, brought a further increase in this means of control. Successful sprays were soon developed for control of the curculio and in late years this method has prevailed almost entirely, though accompanied by orchard sanitation, perhaps the most successful of the older means of control. The development of spray controls during the last 25 years and the trend of present day recommendations is well illustrated in the following summary of literature:

Recommendations of Other Investigators

1905. Crandall, C. S., Illinois Agricultural Experiment Station, Bulletin No. 98. Extensive account of apple and plum curculios with detailed field experiments for control. Spraying operations considered unsuccessful; cultivation recommended.

1906. Crandall, C. S., Ibid., Bulletin 106, pp. 219-231.

1921. Fernald, H. T., In Applied Entomology, pp. 137-139. Control (p. 138). "No one method nor even all the methods of control taken together will give entire freedom from this pest. A combination of the treatments, however, will accomplish considerable in this line." Recommends removal of rubbish and hibernating quarters; (2) pruning trees to allow sunlight to enter; (3) allowing fowls and hogs to run under trees or thorough shallow cultivation from time larvae begin to leave fruit until six weeks later; (4) spraying with arsenate of lead for apples—treatment commonly given for codling moth though similar later applications may also be necessary if the insects are abundant." (5) jarring the trees and collecting the beetles when only a few trees are involved.

1906. Forbes, S. A., Illinois Agricultural Experiment Station, Bulletin 108. Used arsenicals in field tests against the curculio on apples with an average increase of 63 per cent sound fruit over untreated trees.

1914. Headlee, T. J., Report of the Department of Entomology, New Jersey Agricultural Experiment Station for 1913, p. 654. States that where curculio is present foliage must be kept covered with arsenical from time the "creature begins to feed until it disappears." Over-wintering beetles remain in plum orchards about six weeks, in apple orchards for about a month.

1918. Headlee, T. J., Ibid., Report for 1917, pp. 437-438. "Attack seems to have come between blossom-fall and the ten-days-after-blossom-fall spraying." In orchards standing near woodlands or plantings interspersed with old stumps or carpeted with grass, the damage was particularly severe." Recommends clean culture during forepart of season followed by cover crop not producing a dense sod, removal of stumps and cleaning fence rows. Recommends spraying to preserve the coating intact for the first month after blossoms fall.

1919. Headlee, T. J., Ibid., Report for 1918, pp. 212-213. Recommends 7-day spray after calyx. Records two successful cases of control in orchards where curculios were abundant and where crop unsprayed was "ruined by the curculio". Recommends as a schedule for curculio control; "(1) before buds swell; (2) as blossom buds first show color; (3) directly after petals fall; (4) seven days later; (5) 17 days after blossoms fall; (6) June 20 to 30 for all fall and winter varieties. Better results obtained with lime-sulphur and arsenate of lead than with arsenate of lead alone; both have repellent action."

1921. Headlee, T. J., Ibid., Report for 1920, p. 449. Table showing comparison of dust and spray on apples; unsatisfactory control of curculios indicated with dust. Seven to nine per cent injured by curculio.

1923. Headlee, T. J., Ibid., Report for 1922, p. 373. Table showing comparison of dust and spray on apples including curculio records. Dusts do not control curculio as well as sprays.

1924. Headlee, T. J., Ibid., Report for 1923, pp. 274-278, Tables 6, 7 and 8. Results of curculio spraying.

1925. Herrick, Glenn W., In Manual of Injurious Insects, pp. 156-157. "Control measures.—All fence rows, hedge rows and stone walls should be removed from about an orchard. Sunlight on the fallen fruit is fatal to the larvae within, hence judicious pruning to let in the light is useful. Cultivation during late July and early August will destroy pupae in the soil. Thorough spraying with arsenate of lead two pounds to one hundred gallons of water just after the petals fall and again ten days later will be effective if the hibernating places have been destroyed."

1918. Pickett, B. S., Watkins, O. S., Ruth, W. A., and Gunderson, A. J., Illinois Agricultural Experiment Station, Bulletin 206. Contains much valuable information on orchard sprays for the curculio and their results are ably discussed in tables and text. Page 492, under General Summary states: "Codling moth and curculio, as a rule were well controlled by applications of arsenate of lead"; page 493, controls obtained "from 60 to 94 per cent" (in the most successful experiments in 1913) and the least effectively sprayed plats from 32-79 per cent. In 1914 the most effectively sprayed plats showed controls ranging from 81 to 97 per cent and the least effectively sprayed plats from 45 to 87 per cent. In no case did spraying with arsenate of lead fail to exercise a decidedly beneficial effect."

1912. Quaintance, A. L., and Jenne, E. L., U. S. Department of Agriculture, Bulletin No. 103. The most extensive single publication on the plum curculio and its control yet published. Contains summaries of all previous work, data on life history and parasites and accurate studies of control measures. Page 200 under conclusions states: "with a small amount of fruit and abundance of curculios the most thorough spraying will not serve to bring through a satisfactory amount of sound fruit"—"with a large crop of fruit and abundance of insects, results will likewise be disappointing". Recommends four sprays for, apples using dilute fungicide and lead arsenate: (1) as cluster buds are out; (2) as petals fall; (3) three or four weeks after petals fall; (4) nine or ten weeks after petals fall. Secured controls amounting from 19 to 77 per cent increase in sound fruit from sprays tested. The best figures show 91.07 per cent sound fruit as a maximum obtained by the method advocated.

1922. Quaintance, A. L., and Siegler, E. H., U. S. Department of Agriculture, Farmers' Bulletin 1270, pp. 7-10. "Most practical means of control are spraying with arsenate of lead, and cleaning up of trash from the orchards and vicinity as well as thorough cultivation during the summer —the prompt collection and destruction of infested fallen fruit will also aid in reducing this pest." The first spray application to poison the beetles should be applied in pink cluster bud stage, and the second as soon as the petals have dropped, using arsenate of lead at the rate of one pound of powder or two pounds of paste to 50 gallons of water or fungicide. Supplemental treatments are desirable in orchards where the curculio is more than ordinarily destructive.

1914. Slingerland, M. V., and Crosby, C. R., Manual of Fruit Insects, pp. 243-251. Recommends for apples: two sprays as for codling moth just after petals fall and three weeks later—"but where the infestation is severe additional applications will be found necessary." Thoroughness of spraying is essential. Reliance should not be placed on any one method of attack. Clean cultivation, proper pruning, thorough cultivation at proper time are necessary.

1922. Snapp, O. I., Turner, William F., Roberts J. W., U. S. Department of Agriculture, Circular 216. Describes methods used for controlling curculio in the Georgia fruit belt on peaches. Recommends destruction of early drops or disking to destroy pupae and proper orchard sanitation. Jarring the trees also mentioned.

1924. Snapp, O. I., and Alden, C. H., U. S. Department of Agriculture, Bulletin 1205. Dusting and spraying peach trees after harvest for control of the plum curculio. General summary, p. 17 states, "Post-harvest treatments are not advisable except in cases where the curculio infestation has been severe during the peach season". Two applications of 10 per cent lead arsenate and 90 per cent hydrated lime dust are recommended for these treatments.

1928. Sanders, P. D., Trans. Peninsula Hort. Society, pp. 18-23 (Abstr. in Review of Applied Entomology Vol. X. VI: p. 451: 1928.) "Recommendations for control include destruction of overwintering adults by burning woodlands and hedge rows around orchards. Application to peaches of lead arsenate 1-50 or 5 per cent lead arsenate dust, once when petals have fallen and again as shucks are pushing off and cultivation under spread of the tree during second and third weeks after dropping of windfalls.

Besides the literature just quoted, there is considerable published data on the effect of dusts in curculio control with some difference of opinion regarding the merits of the method compared with sprays. Thus Quaintance (1921) p. 224 says "In the case of the plum curculio on apples, dusting compares favorably with spraying where the insect is not especially abundant"...."Under conditions of curculio abundance....dusting is not an effective control and spraying may not furnish the protection desired". The Indiana State report on Horticultural investigations (1919) states that "dusting controlled curculio and codling moth as well as spraying, whereas Cullinan and Baker, Bulletin 283 (1924) of the

Indiana Station state that dusting was inferior to sprays for curculio control in three out of five years work. The work of Stoddard and Zappe at Milford conducted during the years 1920–1924 showed consistent results[1] in favor of spraying although the percentage gain from this method was never great. In addition there are the New Jersey reports comparing dust and spray indicating an advantage for sprays, and in general, opinions favor sprays as better controls.

It is important before discussing any control program to know what conditions surround orchards where most damage is done. A number of typical fruit farms near New Haven were therefore studied. Nearly all Connecticut apple orchards are either cultivated in part or allowed to remain in sod, the orchards in one or the other being about equally divided. Few or no orchardists use clean cultivation. This is due in part to the nature of the land used for this purpose which is often hilly or rolling, and the danger of washing is considerable. There is also much waste or uncultivated land in many localities so that it is almost impossible to locate an orchard without placing it near a wood or within a few rods of numbers of wild apples. Such conditions are primarily responsible for severe infestations commonly found, and it must be recognized that under such conditions heavy infestations of curculio are the rule rather than the exception. Plate VII, b shows a typical wild apple tree.

Conditions Surrounding Ten Representative Orchards

Orchard No. 1. Wallingford. South side of one section near woods reported to be worst; inspection revealed much damage; no wild apples, however, in the vicinity although not far away was an unsprayed orchard; section protected on west by woods. In addition to the woods, a number of peach trees probably supplying many beetles were interplanted with the apples. In another section of the same orchard near a woods on the east side little damage could be seen. This, however, was some distance from the peach trees and the apple orchard mentioned.

Orchard No. 2. Durham. Orchard well in the open though with a fence row on the south. On the north side from a quarter to one-half a mile distant were peach orchards of considerable size.

Orchard No. 3. Middlefield. Large extensive plantings, some of the apples interplanted with peaches. Worst infestations seem to be in these interplanted orchards.

Orchard No. 4. Wallingford. Interplanted orchard, worst conditions in section protected on west by woods, other parts of interplanted orchard said by owner to be less severely injured.

Orchard No. 5. Wallingford. Large plantings some near peach orchards apparently free or with few curculios. No fence rows or woods to protect the orchards although peaches are planted near

[1]Conn. Agr. Expt. Station, Bull. 265; p. 293; 1924.

some of them. The peaches are cleanly cultivated and dusted yearly with arsenate-sulphur-lime dust. Strip cultivations practiced in apple orchards. Plums in bearing near orchard.

Orchard No. 6. Milford. Damage worse on west side adjoining woodland. Orchard in sod or strip cultivation. Fence rows or stone walls around entire orchard, but the worst damage is next the woods as mentioned. Wild apples not far distant.

Orchard No. 7. Branford. Worst damage on outside rows next the woods. Wild apple trees not far distant, but no peaches. Orchard under strip cultivation.

Orchard No. 8. Mount Carmel. Strip cultivation practiced. Worst infestation on west side near fence row, although the latter is low. Young peach orchard also on west side. Other apple trees nearby, but sprayed.

Orchard No. 9. Mount Carmel. Protected on west by fence row and on southwest by wood lot. Wild apples numerous near the orchard. Peach orchards and plum trees to east.

Orchard No. 10. Mount Carmel. About one-fourth mile from No. 9. Not protected on west by fence row, but with bearing peach orchard on south and a few plums on north and west. Damage in this orchard, however, has never been severe for some unknown reason. Orchard in sod. Possibly the plums are sufficiently attractive to draw the beetles away from the apples. Plenty of hibernating quarters nearby.

About the only conclusions which can be drawn from this survey is that the worst damage is done in orchards protected by woods or fence rows on one side (which strange to say seems to be the west side in many of the orchards examined), while those not so protected are not as severely damaged. The presence of peaches in the vicinity seems to have some influence especially if accompanied by woods or fence rows and the presence of wild apples probably has something to do with total number of curculios in an orchard although the survey does not show anything striking in this regard. There is little doubt that beetles develop on these wild fruits since the fruits are abundantly marked and the adults have been jarred from the trees on several occasions. The occurrence of plums or apricots does not seem to influence the severity of infestation as much as peaches.

Preliminary Tests with Various Insecticides

We have already shown that curculios leave the trees shortly after applications of arsenic and it has been well demonstrated that they may be easily killed in confinement when fed on leaves sprayed with the usual dosages. Laboratory tests indicate that the Connecticut curculio is no different in these respects from others, Tables 17-19. It will be noted, however, that death is not immediate and sometimes does not occur until 10 to 12 days after introduction of poisoned food.

TABLE 17—FIVE-DAY TESTS WITH ARSENICALS, FOLIAGE TESTS

Substance Used	Number of Beetles	Date Begun	Number Dead in the Following Days 1	2	3	4	5	% Dead	Notes
Acid lead arsenate 1.2 gm. per 250 cc.	11	June 25	2	8	10		11	100	
Calcium arsenate 1.2 gm. per 250 cc.	8	25	0	5	5		8	100	Beetles excluded from water supply.
Ortho-zinc arsenite 1.2 gm. per 250 cc.	11	25	0	3	4		11	100	
Acid lead arsenate 1.2 gm. per 250 cc. molasses 10 cc....	10	25	1	4	8		9	90	
Ball of casein molasses and lead arsenate............	8	25	2	5	8		8	100	
Check............	10	26	0	0	0		0	00	

These tests were made in jars in the insectary, the twigs being sprayed with the solutions indicated and allowed to dry before placing in the jars with curculios.

TABLE 18—TWELVE-DAY TESTS WITH VARIOUS ARSENICALS

Substance Used	Number Beetles	Date	Dead in the Following Days 1	2	3	4	5	6	7	8	9	10	11	12	Per Cent Dead
Acid lead arsenate 1.2 gm. per 250 cc.	10	Aug. 20	1	1	3	0	3	0	5	0	0	7	0	10	100
Ball of casein with 50 gm. casein, 1 gm. lead arsenate, 10 gm. honey; water to make 125 gm..	9	20	0	0	2	0	0	0	5	0	0	9	0	0	100
Check—no treatment	7	20	0	0	0	0	0	0	0	0	0	0	0	0	00

TABLE 19—LABORATORY TESTS WITH POISON DUSTS TO KILL THE PLUM CURCULIO
(20 beetles used in each jar)

Material	Date Begun	Dead in the following days 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	Aug.																
Scorodite 2 gms. Lead stearate 10 gms............	23	1	0	1	0	0	1	0	2	0	0	3	0	3	0	4	
Scorodite 10 gms. Zinc stearate 5 gms............	23	0	0	0	0	0	2	0	4	0	0	4	0	4	0	4	
Copper fluoride 2 gms. lime 20 gms.	23	1	0	1	0	0	2	0	2	0	0	2	0	3	0	3	
Lead stearate pure.	23	0	0	0	0	0	2	0	4	0	0	5	0	5	0	6	
Zinc stearate pure.	23	1	0	1	0	0	1	0	0	0	0	1	0	1	0	1	2 lost
Magnesium fluoride 20 gms. lead stearate 4 gms..	23	1	0	1	0	0	0	0	1	0	0	3	0	3	0	4	3 lost
Lead peroxide 1 lb. As_2O_5 ¼ oz.....	23	0	0	2	0	0	2	0	2	0	0	2	0	3	0	3	1 lost
Lead arsenate (basic) pure....	23	0	0	2	0	0	6	0	8	0	0	9	0	13	0	14	4 sick
Check............	23	2	0	2	0	0	2	0	2	0	0	2	0	3	0	4	
Sodium fluosilicate 1 lb. Lime 4 lbs.	10	0	0	6	0	10	0	0	0	11	0	0	11	0	12	0	2 escaped
Check............	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arsenate sulfur dust 10% lead arsenate	15	0	0	13	0	0	15	0	0	15	0	0	15	0	0	0	2 escaped
Check............	15	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	

NOTE: Insecticides dusted on fruit and placed in jars containing curculio beetles.

Value of Exposing Drops to Direct Sunlight and Collecting Them from Beneath the Trees

Several ground cages were supplied in 1928 with dropped apples and plums containing egg punctures of the curculio and presumably infested by the larvae. Some of these cages were exposed to direct sunlight; others were protected by cotton sheeting; still others by thick building paper excluding all direct sunlight. The following results were obtained.

Table 20

		Number Beetles Emerging	Number Beetles per 100 Fruits
Protected with cotton sheeting...	(1) 200 apples	75	
	(2) 75 apples	25	36
Exposed to direct sunlight......	(1) 200 apples	25	
	(2) 75 apples	6	11
Protected with building paper...	(1) 75 plums	11	14
Exposed to direct sunlight......	(1) 75 plums	9	12

There is undoubtedly some advantage from exposure of dropped fruits to direct sunlight but control by this means is far from complete in Connecticut. Raking drops into the open is a comparatively simple operation in completely cultivated orchards, but a difficult one in orchards kept in sod. The time required for collecting drops by hand from a 17-year old tree is at least 30 minutes for one man (tree in sod or partly cultivated) and probably one hour for large trees. To obtain the greatest benefit, this operation requires repetition at least twice during the summer and the cost may be figured at 50 cents to $1.00 per tree for $4.00 a day labor. At best, the operation is expensive, although it is fully recognized that the use of such labor often depends upon the value of the crop. At present the feeling among the growers in this section is that the plan is not practical. There is no reason, however, why such a method cannot be employed to advantage where a few trees are involved, though it should be recognized that complete control will not be obtained where there are other infested fruits in the vicinity; neither will the result of this work be evident until the following year.

Spraying Experiments for Curculio Control—1924–1928

In view of the rather wide variation in recommendations for spray control of the curculio on apple and the failure in several instances to obtain satisfactory results in Connecticut with the schedules in use, a program of control experiments was devised and carried out with a view to finding more satisfactory measures than were available at the beginning. It became apparent at once that the 7-day spray advocated by the New Jersey Station offered one solution although a difficult one from the standpoint of many growers with large orchards and limited equipment. If some means could be devised whereby this additional spray might be avoided it would be of considerable advantage. It became desirable to find out, therefore, which sprays, if any, could be omitted and it seemed also worth while to distribute the sprays more evenly throughout the life activities of the adult which as shown by the diagram, Figure 25, do not correspond fully with the pink-calyx-7-day-2-weeks schedule. However, the data obtained in 1928 on the egg-punctures of the beetle seem to indicate that a pink, calyx, 2 weeks, or 17-day schedule, piles up the poison on the trees before the peak of this activity is reached, and the amount of damage occasioned by late feeders, being relatively small, can probably be disregarded in commercial orchards of Connecticut. It also seemed desirable to try addition of such substances as molasses as an attractive food for the beetle or any new arsenical substitute which might come into use, because of the danger of foliage injury from the usual mixtures and the growing belief that the arsenical residue on sprayed fruit at harvest is too large. A comparison of dusts and sprays used in a pink, calyx, 7-day and two weeks schedule was tried out in 1928. Nicotine dust was also tried in 1924 and shown to be worthless for control.

Spray Apparatus and Methods Used

All trees were sprayed at first with 12-foot rods, provided with angle disc nozzles. Sprays were applied in 1924 and 1925 with an Arlington XL sprayer furnishing 150-200 pounds pressure and in 1926, 1927 and 1928 with a Bean sprayer furnishing about 250 pounds. Spiral nozzles of the type shown in Plate VIII, a and b, were used in 1926, 1927 and 1928 and were very effective in furnishing a thorough even coating on fruit and foliage. In 1928 an extension of about four feet was used on one of the rods allowing the operator to reach the tops of the trees more easily. With age, the spiral nozzles became worn through the center and allowed a solid stream to issue at the end. One of our nozzles, however, was used for three years before developing this defect, but it would no doubt last a much shorter time in large orchards where kept in continual use. When operating to best advantage, we were able with this apparatus, using two lines of hose, to apply about 1,000 gallons in the course of an eight-hour day.

The method of spraying consisted of passing completely around each tree, coating as thoroughly as possible all parts thereof. The amount applied to each tree varied with the size of the tree, but from calculations made at Shepard's orchard and that of the Experiment farm at Mount Carmel, the amount applied was approximately one gallon at 7-day and two week periods for every 24 cubic yards.[1] This will mean approximately one gallon or more for every 10 feet of circumference measured around the outer branches of such varieties as Baldwin, McIntosh and Greening, where these varieties are normal in shape and 15-20 years old. The exact amounts as figured would be as follows for the three varieties:

TABLE 21

Circumference, Feet	Baldwin	Gallons Spray Greening	McIntosh
100	16.6	14.1	17.0
80	9.3	6.6	10.4
60	4.7	....	4.8

The volume increases rapidly with circumference, one large Greening tree 125 feet around containing about 760 cu. yards. At the rate mentioned this tree should require about 30 gallons at the 7-day period.

Trees will naturally vary in the number of branches according to the method and amount of pruning and consequently the amount of foliage, but it is believed that the trees experimented upon in two different orchards represent fairly typical conditions for the average Connecticut orchard. The amount applied at the calyx period was about two-thirds the amount of the 7-day because of the smaller amount of foliage, while the pink spray required only one-third of the amount of the 7-day.

The main reason for using the circumference instead of the height in calculating volume lies in the fact that volume seems to be more closely correlated with circumference in our orchards when figured on the formula

$$\nu \text{ (cu. yds.)} \doteq \frac{C}{4\pi \times 27}\left(\frac{0}{2} - .144C\right) = \frac{C}{339.1}\left(\frac{0}{2} - .144C\right)$$

The three varieties mentioned assume a fairly typical shape in middle-aged trees and in older trees if there is plenty of room around each tree. There are cases, however, where the shape of the tree is irregular, due to manner of growth or from being crowded. In the latter cases probably the best method of obtaining the amount of spray would be to rely on careful measurements as suggested by Smith (l. c.) but it is very doubtful whether the orchardist would consider such an operation as practical or even advisable. A certain amount of judgment should always be exercised by the operator, with the aim in view of covering the leaf and fruit surface as completely as possible. A rough estimate of the amounts needed on regular shaped trees can be obtained by

[1]See Smith, Jour. Ec. Ent. 1927. Formula used $\nu\text{(cu. ft.)} = \frac{C_2}{4\pi}\left(\frac{0}{2} - .144C\right)$.

circumference measurements, as a basis for control operations. It should also be stated that the experimental trees were headed low, the outer branches being quite near to or touching the ground.

Dusting was done with a power Niagara duster, covering both sides of the tree as completely as possible at each application.

In the course of these experiments a total of more that 700,000 individual apples were examined, representing 1,400 barrels of fruit.

Materials Used

Materials used throughout these experiments were standard materials sold on the market and consisted of lead arsenate, dry lime sulphur, casein lime and 40 per cent nicotine sulphate. Nicotine sulphate was omitted wherever possible and the experiments at the Station farm were conducted wholly without this material. At Shepard's Orchard it was used in the early sprays (pink and calyx) in 1925 and 1928, but not in 1926 and 1927.

The casein lime was a standard brand consisting of two parts of lime and one part casein analyzed by the Department of Chemistry and reported in 1925, Bulletin 272, p. 149, under analytical number 2475.

Two brands of lead arsenate were used which have also been analyzed by the Department of Chemistry and reported in Bulletin 272, p. 145, under analytical numbers 2474 and 2464. Both products contained approximately 30 per cent arsenic oxide and .18 per cent water soluble arsenic.

The fish oil used in 1926 and 1927 was purchased on the local market as light pressed menhaden oil, but differed considerably from that obtained from Mr. Ashworth in 1928, in being much thicker and heavier. The analysis of our 1928 material follows:

Specific gravity	.9324
Saponification number	187.4
Iodine number	173.3
Free fatty acids as oleic acid	3.46%

The two dusts used were three per cent nicotine dust, and 90-10 sulphur arsenate dust consisting of 90 per cent finely ground sulphur and 10 per cent lead arsenate.

Experiment Station Orchard

Spraying experiments were begun in 1924, using the Experiment Station orchard at Mount Carmel. This orchard consists of a number of varieties arranged in rows running the length of the orchard or part way through. There are 96 trees in all, arranged in six rows. As far as could be determined, the varieties appeared to show about equal infestations, but with a systematic decrease in amount of injured fruit from the outside rows towards the center, and being greater in the lower parts of the orchard to the west. Work during this summer was more or less preliminary and consisted of small tests on 7-14 trees each, taking in entire rows or parts thereof, and scoring all fruit from the orchard. Owing to the variation in degree of infestation in the orchard it was recognized that these results could not be fully relied upon, although giving a general indication of the amount of control. Consequently, the tests were continued in 1925 in different locations which procedure gave a considerably better idea of their value. In 1924, it will be seen that there were fully twice as many punctures on the early drop fruits as on the picked fruit and windfalls harvested later, except on the unsprayed trees where the number was about equal. Tree shaving all sprays had slightly more unmarked fruit than any others. The plot having no 7-day spray, however, averaged 85.5 per cent clean as compared with 86.6 per cent for the complete schedule. None of the remaining treatments averaged as high as these.

It should be mentioned here that several factors influence the abundance of curculios on the trees and have been taken into consideration in evaluating results. They are:

(1) Location of the tree in the orchard—outside trees or trees near fence rows are always more heavily infested.

(2) Number of apples per tree. Very few apples on a large sprayed tree are not usually injured. A medium or light crop, one barrel or less, on a tree normally producing six or seven, is usually injured severely while a maximum crop, well sprayed, usually shows a relatively small percentage of punctures.

(3) Size or volume of the tree itself has influenced results.

TABLE 22—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE—1924.—Detailed Record

Tree Nos.	Total No. Apples	No. Good Apples	No. Marked Apples	Total No. Punctures	Per Cent Marked Apples	No. Punctures per Apple	Kind of Fruit Scored	Treatment
A	664	165	499	1,354	75.0	2.04	Drops	Molasses plus
1– 3,	480	96	384	1,124	80.0	2.34	Drops	lead arsenate
5–12,	669	410	259	654	38.7	0.98	Windfalls	Calyx and 2
14–16	3,409	2,051	1,358	3,238	39.8	0.95	Picked	weeks
	5,222	2,722	2,500	6,370	47.8	1.22	Total	
A 4	275	36	239	622	86.9	2.26	Drops	
and	89	2	87	280	97.7	3.15	Drops	
A 13	154	24	130	432	84.4	2.80	Windfalls	None
	265	60	205	583	77.3	2.20	Picked	
	783	122	661	1,917	84.4	2.45	Total	

TABLE 22—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE—1924—Detailed Record

Tree Nos.	Total No. Apples	No. Good Apples	No. Marked Apples	Total No. Punctures	Per Cent Marked Apples	No. Punctures per Apple	Kind of Fruit Scored	Treatment
B	621	406	215	450	34.6	0.72	Drops	
1– 3,	515	305	210	467	40.7	0.91	Drops	Calyx, 7-day
5–12,	482	404	78	114	16.2	0.24	Windfalls	and 2 weeks;
14–16	4,428	3,756	672	1,199	15.2	0.27	Picked	*No pink*
	6,046	4,871	1,175	2,230	19.4	0.37	Total	
B 4	322	89	233	515	72.3	1.60	Drops	
and	93	10	83	273	89.2	2.93	Drops	
B 13	292	210	82	166	28.1	0.57	Windfalls	None
	315	220	95	208	30.2	0.66	Picked	
	1,022	529	493	1,162	48.2	1.13	Total	
C	2,386	1,471	915	2,017	38.3	0.84	Drops	
1– 3,	1,429	870	559	1,044	39.2	0.73	Drops	Pink, 7-day
5– 8	764	616	148	232	19.3	0.30	Windfalls	and 2 weeks;
	3,301	2,739	562	952	17.0	0.29	Picked	*No calyx*
	7,880	5,696	2,184	4,245	27.7	0.54	Total	
C 4	34	7	27	75	79.4	2.20	Drops	
	133	178	55	84	41.3	0.63	Windfalls	None
	363	135	128	263	35.2	0.72	Picked	
	530	320	210	422	39.6	0.79	Total	
C	2,477	786	1,691	4,135	68.2	1.67	Drops	
9–12,	1,638	307	1,331	4,531	81.2	2.77	Drops	Commercial
14–16	1,336	339	997	3,306	74.6	2.47	Windfalls	nicotine
	4,302	1,270	3,032	9,546	70.5	2.22	Picked	dust
	9,753	2,702	7,051	21,518	72.29	2.20	Total	
C 13	1,766	728	1,038	1,910	58.7	1.08	Drops	
	576	105	471	945	81.7	1.64	Drops	
	521	265	256	488	49.13	.93	Windfalls	None
	2,258	805	1,453	3,114	64.35	1.38	Picked	
	5,121	1,903	3,218	6,457	62.83	1.26	Total	
D	803	669	134	251	16.69	0.31	Drops	
1– 3,	1,030	893	137	230	13.30	0.22	Drops	Pink, calyx
5– 8	990	853	137	210	13.84	0.21	Windfalls	and 2 weeks;
	4,430	3,781	643	672	14.51	0.15	Picked	*No 7-day*
	7,253	6,202	1,051	1,363	14.49	0.19	Total	
D 4	317	107	210	458	66.24	1.44	Drops	
	228	63	165	375	72.37	1.64	Drops	
	294	99	195	448	66.33	1.52	Windfalls	None
	1,129	326	803	2,360	71.12	2.09	Picked	
	1,968	595	1,373	3,641	69.77	1.85	Total	

TABLE 22—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE—1924—Detailed Record

Tree Nos.	Total No. Apples	No. Good Apples	No. Marked Apples	Total No. Punctures	Per Cent Marked Apples	No. Punctures per Apple	Kind of Fruit Scored	Treatment
D	359	87	272	262	75.76	.72	Drops	
9–12,	221	63	158	627	71.5	2.83	Drops	Commercial
14–16	843	286	557	1,957	66.07	2.32	Windfalls	nicotine
	2,160	407	1,753	3,688	81.16	1.70	Picked	dust
	3,583	843	2,740	6,534	76.47	1.87	Total	
D 13	26	9	17	36	65.38	1.38	Drops	
	66	11	55	217	83.33	3.28	Drops	
	145	51	94	207	64.83	1.42	Windfalls	None
	176	37	139	377	78.98	2.14	Picked	
	413	108	305	837	73.85	2.02	Total	
E	207	120	87	205	42.1	0.99	Drops	
1– 3,	238	147	191	256	38.27	1.07	Drops	Pink, calyx
5–12,	328	279	49	93	14.94	0.28	Windfalls	and 7-day;
14–16	2,921	2,607	314	673	10.3	0.2	Picked	*No 2 weeks*
	3,694	3,053	541	1,227	14.66	0.33	Total	
E 4	97	12	85	50	87.5	0.5	Drops	
and	106	34	72	266	67.94	2.5	Drops	
E 13	106	47	59	154	55.6	1.4	Windfalls	None
	1,168	430	738	2,129	63.0	1.8	Picked	
	1,477	523	954	2,599	64.58	1.76	Total	
F	6,320	5,096	1,224	2,266	19.37	0.35	Drops	
1– 3,	2,915	2,302	613	1,514	21.03	0.52	Drops	Pink, calyx,
5–12,	4,561	4,220	341	703	7.45	0.15	Windfalls	7-day and
14–16	10,487	9,433	1,054	1,728	10.05	0.16	Picked	2 weeks
	24,283	21,051	3,232	6,211	13.31	.25	Total	
F 4	1,070	315	655	1,411	61.2	1.32	Drops	
and	319	39	280	798	87.8	2.50	Drops	
F 13	194	91	103	194	52.5	1.0	Windfalls	None
	211	69	142	350	67.3	1.66	Picked	
	1,794	514	1,180	2,753	65.7	1.53	Total	
A, B, C,	3,907	1,404	2,504	5.077	64.1	1.29	Drops	
D, E &	1,610	342	1,268	3,238	78.8	2.01	Drops	Summary of
F,	1,706	787	919	2,089	53.9	1.22	Windfalls	all check
4 & 13	5,885	2,182	3,703	9,384	62.9	1.59	Picked	trees
	13,108	4,714	8,394	19,788	64.04	1.51	Total	
Special	290	148	142	321	48.96	1.10	Drops	Two sprays of lead arsenate
	831	563	268	519	32.3	.625	Picked	with baits.

TABLE 23—SHOWING COMPARISON OF DIFFERENT SPRAY TREATMENTS
EXPERIMENT STATION FARM—1924

Treatment	Per Cent Unmarked Fruit	Kind of Fruit	Total Per Cent of Unmarked Fruit
No Pink Spray Calyx, 7-day and 2 weeks	62.5	Drops	80.57
	83.9	Picked	
No Calyx Spray Pink, 7-day and 2 weeks	61.6	Drops	72.22
	82.5	Picked	
No 7-day Spray Pink, calyx and 2 weeks	85.2	Drops	85.5
	85.6	Picked	
No 2 weeks Spray Pink, calyx and 7-day	60.0	Drops	82.67
	88.8	Picked	
All Sprays Pink, calyx, 7-day and 2 weeks	80.1	Drops	86.69
	90.7	Picked	
Check—no spray	31.6	Drops	35.96
	39.1	Picked	

EXPERIMENT STATION FARM, 1924

Notes:

Trees planted 1911.

Percentage based on counts varying from 3,583 to 24,283 for each treatment.

Peach orchard alongside removed in winter of 1923-24; early drops collected and larvae trapped in cages 1924.

Spray formula used

Lead arsenate	3 pounds
Lime sulphur (liquid)	3 gallons
Casein lime	1 pound
Nicotine sulphate	1 pint
Water	100 gallons

Dates of Spray Applications

Pink	May 13
Calyx	June 2
7-day	June 10
2-weeks	June 16

RESULTS IN 1925

The work was continued in 1925, shifting blocks, and also introducing several new treatments. First a schedule comprising pink, four days after calyx, five days later and two weeks after the five-day spray. (2) use of coated lead arsenate (home made). (3) double the usual strength of lead arsenate and (4) fish oil sticker in calyx spray without lime sulphur. This year the spray containing fish oil plus lead arsenate applied at the calyx period without lime sulphur was slightly better than any other treatment, although the difference between it and the complete schedule was only 0.2 per cent. The "no calyx" treatment stood high in clean fruit indicating that beetles did not get started in the orchard this year until some time after this period. The trees from which the 7-day spray was omitted were low in percentage of clean fruit. In these tests, the complete schedule again stood practically as high as any other, being only .16 per cent less than the highest score.

TABLE 24—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE—1925

EXPERIMENT STATION FARM: DETAILED RECORD

Tree Nos.	Kind of Fruit	Total No. of Apples	No. Marked by Curculio	Per Cent Marked Fruit	Total No. of Punctures	Average No. Punctures Per Apple	Treatment Received
A 1–3	Drops	1,656	808	48.79	1,366	.82	Pink: 6 days after calyx
5–8	Picked	6,509	1,156	17.76	1,814	.28	8 days after 6-day; 2 wks. after 8-day;
	Total	8,165	1,964	24.05	3,180	.39	No lime-sulphur at 6-day
A 4	Drops	56	45	80.35	76	1.35	
	Picked	621	488	78.58	1,069	1.72	Check—no treatment
	Total	677	533	78.72	1,145	1.69	
A 9–12	Drops	2,086	1,506	72.20	2,817	1.35	Pink; 6 days after calyx
14–16	Picked	6,879	1,940	28.20	2,834	.41	with coated lead arsenate; 2-weeks
	Total	8,965	3,446	38.43	5,651	.63	
A 13	Drops	267	264	98.87	650	2.43	
	Picked	416	289	69.47	671	1.61	Check—no treatment
	Total	683	553	80.96	1,321	1.93	
B 1–3	Drops	677	395	58.34	745	1.10	Pink; heavy dose lead
	Picked	7,456	636	8.53	1,080	.14	arsenate at calyx and 2-weeks
	Total	8,133	1,031	12.67	1,825	.22	
B 4	Drops	2,104	1,562	74.23	2,950	1.40	
	Picked	3,579	1,514	42.30	2,616	.73	Check—no treatment
	Total	5,683	3,076	54.12	5,566	.98	
B 9–12	Drops	1,887	83	4.40	122	.06	Pink; calyx with fish
14–16	Picked	1,933	149	7.71	233	.12	oil sticker, no lime-sulphur; 2 weeks.
	Total	3,820	232	6.07	355	.09	
B 13	Drops	309	178	57.60	433	1.40	
	Picked	479	273	56.99	704	1.47	Check—no treatment
		788	451	57.23	1,137	1.44	
C 1–3	Drops	5,596	1,052	18.80	1,591	.28	No 2-weeks;
5–12	Picked	17,708	1,358	7.67	2,228	.12	Pink; calyx; 7-day
14–16	Total	23,304	2,410	10.34	3,819	.16	
C 4 and	Drops	71	41	57.74	97	1.36	
13	Picked	699	365	52.21	784	1.12	Check—no treatment
	Total	770	406	52.72	881	1.14	
D 1–3	Drops	6,545	518	7.91	886	.13	All sprays
5–12	Picked	13,318	720	5.40	1,362	.10	Pink; calyx; 7-day and 2-weeks
14–16	Total	19,863	1,238	6.23	2,248	.11	

TABLE 24—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE—1925—*Concluded*

EXPERIMENT STATION FARM: DETAILED RECORD—*Concluded*

Tree Nos.	Kind of Fruit	Total No. of Apples	No. Marked by Curculio	Per Cent Marked Fruit	Total No. of Punctures	Average No. Punctures Per Apple	Treatment Received
D 4 and 13	Drops	627	365	58.21	816	1.30	
	Picked	1,818	1,369	75.30	4,559	2.50	Check—no treatment
	Total	2,445	1,734	70.92	5,375	2.19	
E 1–3 5–12	Drops	3,556	201	5.65	300	.08	No calyx
	Picked	18,030	1,734	9.61	2,819	.15	Pink; 7-day and 2-wks
14–16	Total	21,586	1,935	8.96	3,119	.14	
E 4 and 13	Drops	1,015	425	41.87	1,112	1.09	
	Picked	2,672	2,039	76.30	6,139	2.29	Check—no treatment
	Total	3,687	2,464	66.82	7,251	1.96	
F 1–3 5–12	Drops	9,620	1,629	16.93	2,929	.30	No 7-day
	Picked	22,592	3,268	14.46	6,075	.27	Pink, calyx and 2-wks
14–16	Total	32,212	4,897	15.20	9,004	.27	
F 4 and 13	Drops	2,709	1,130	41.71	2,337	.86	
	Picked	1,635	1,332	81.46	3,640	2.22	Check—no treatment
	Total	4,344	2,462	56.67	5,977	1.37	
A, B, C, D, E, F,	Drops	7,158	4,010	56.02	8,471	1.18	
	Picked	11,919	7,669	64.34	20,182	1.69	Summary of all checks
4 & 13	Total	19,077	11,679	61.22	28,653	1.50	

Total number apples scored 144,435

Note—"Drops" include early drops collected until about the middle of July.
"Picked" includes fruit taken from tree and also windfalls at time of harvesting crop.

TABLE 25—SHOWING COMPARISON OF DIFFERENT SPRAY TREATMENTS

EXPERIMENT STATION FARM—1925

	Treatment	Per Cent. Unmarked Fruit	Kind of Fruit	Total Per Cent of Unmarked Fruit
1	*No calyx* Pink, 7-day and 2 weeks	94.35	Drops	91.04
		90.39	Picked	
2	*No calyx*: Pink; 6 days after calyx; 8 days later; 2 weeks after 8 day	61.21	Drops	75.95
		82.24	Picked	
3	*No 7-day* Pink, calyx and 2 weeks	83.07	Drops	84.80
		85.54	Picked	
4	*No 7-day* Pink, calyx with fish oil; 2 weeks	95.60	Drops	93.93
		93.30	Picked	
5	*No 7-day*: Pink—heavy dose lead arsenate at calyx; also at 2 weeks	41.66	Drops	88.33
		91.47	Picked	

TABLE 25—SHOWING COMPARISON OF DIFFERENT SPRAY TREATMENTS —*Concluded*

EXPERIMENT STATION FARM—1925—*Concluded*

		Per Cent Unmarked Fruit	Kind of Fruit	Total Per Cent of Unmarked Fruit
6	*No 2 weeks* Pink, calyx and 7-day	81.20	Drops	89.66
		92.33	Picked	
7	*All sprays* Pink, calyx, 7-day and 2 weeks	92.08	Drops	93.77
		94.60	Picked	
8	Check-no spray	43.98	Drops	38.78
		35.66	Picked	

Notes:

Percentages based on counts varying from 3,820 to 32,212 apples for each plot.

Early drops collected 1925.

Amount of spray used 8–14 gallons per tree.

All apples scored by individual examinaion.

Orchard cultivated until 1925 when middle section was left in sod.

Spray Formulas Used

Lead arsenate	3 pounds
Nicotine sulphate	1 pint
Casein lime	1 pound
Lime sulphur (dry)	6 pounds
Water	100 gallons

Fish oil (light pressed menhaden)	1 quart
Lead arsenate	3 pounds (No. 4 only at calyx)
Water	100 gallons

Lead arsenate	6 pounds (No. 5 only at calyx and 2 weeks)
Water	100 gallons

Dates of Spray Applications

Pink,—April 29. Calyx,—May 19. 6-day,—May 25. 7-day,—May 26. 2-weeks,—June 1 and 2. 4-weeks,—June 16.

RESULTS IN 1926.

Coated lead arsenate was tried with a view to eliminating some of the sprays but without success. It should be said, however, that the material used was not the same as the product manufactured later and probably failed for this reason. Colloidal arsenate of lead was used as a substitute for acid lead arsenate with good results. During 1926, the plots treated with lead arsenate and fish oil at the calyx period fell below the complete schedule by 1.3 per cent. The total score of all trees receiving the treatment, however, fell somewhat below this due to the high score of one outside tree. This tree seemed to be so much out of line with the results obtained from the rest that it seems justifiable to omit it from the final figures:

TABLE 26—RESULTS OF FISH OIL—LEAD ARSENATE TEST

Tree No.	Total number apples	Number marked by curculio	Size of tree cubic yards	Per cent marked fruit
B1	2,840	705	330	24.8
B2	3,707	231	318	6.2
B3	1,976	78	286	3.9
B5	4,607	227	345	4.9
B6	2,550	90	400	3.5
B7	1,502	52	343	3.5
B8	735	18	278	2.4
Average marked fruit omitting Bl.				4.6

TABLE 27—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE—1927

EXPERIMENT STATION FARM: DETAILED RECORD

Tree Nos.	Total No. of Apples	No. Marked by Curculio	Per Cent Marked Fruit	Total No. of Punctures	Average No. Punctures Per Apple	Treatment Received
A 1–3 5–8	6,670	1,333	19.9	2,474	.37	No 7-day; pink, calyx with regular lead arsenate (no lime sulphur), 2-weeks
A 9-12 14–16	10,988	1,807	16.4	3,797	.34	No 7-day; pink, calyx with coated lead arsenate (no lime sulphur), 2-weeks
A 4 and 13	1,552	1,207	77.1	4,104	2.64	Check—no treatment
B 1–3 5–8	18,267	1,751	9.6	2,872	.16	No 7-day; pink; calyx with fish oil and lead arsenate no lime sulphur; 2-weeks
C 1–3 5–8	23,169	1,672	7.2	3,213	.14	No 7-day; pink; calyx with fish oil and lead arsenate, no lime sulphur
B 4 and C 4	3,221	871	27.0	1,649	.51	Check—no treatment
B 9–12 14–16	4,816	522	10.8	634	.13	No calyx; pink; 4 days after calyx; 5 days later;
C 9–12 14–16	3,093	232	7.5	363	.12	12 days after 5-day (complete mixture)
B 13 C 13	3,181	1,667	52.4	3,575	1.12	Check—no treatment
D 1–3 5–8	5,965	87	1.46	153	.025	Complete schedule; pink (ferrous ars.); 7-day, calyx Colloidal lead ars.; 2-weeks
D 4	1,820	702	38.86	1,333	.73	Check—no treatment
D 9–12 14–16	4,061	136	3.34	286	.07	All sprays; pink; calyx; 7-day; 2-weeks; complete mixture
D 13	398	113	28.4	264	.66	Check—no treatment
E 1–3 4–12 14–16	2,889	143	4.9	389	.13	No pink; calyx; 7-day and 2-weeks; complete mixture
E 4, 13	853	421	49.3	1,235	1.45	Check—no treatment
F 9–12 14–16	10,664	578	5.4	1,159	.10	No 7-day; pink; calyx and 2-weeks; complete mixture
F 13	66	59	89.4	342	5.18	Check—no treatment
Checks	11,091	5,040	45.44	12,502	1.12	

Notes—Drop fruits were not collected in this orchard in 1926.

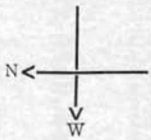
Spray dates: Pink, May 4.
Calyx, May 28
7-day, June 4
2-weeks, June 11
4-weeks, June 24

Formula: Complete mixture and fish oil same as in 1925.
Colloidal and ferrous arsenates at 3 pounds per 100 gallons.
Coated lead arsenate at 8 lbs. paste per 100 gallons.

RESULTS IN 1927

During this year the orchard was divided into three blocks of 24-30 trees each, the plots being sprayed with (1) pink, calyx, 7-day and 2-weeks schedule, (2) pink, calyx, with fish oil and lead arsenate, and 2-weeks sprays, (3) pink, calyx, 2-weeks and 4-weeks sprays. Casein lime was added to plot (2) at the calyx period causing much of the spray to run off the foliage and was thought to be responsible for the poor showing of this plot. The results again showed that the complete schedule (1) was better and on the end row, some 8-15 per cent better than other schedules. The total percentage, however, showed little difference (2-5 per cent), but the considerably improved control of this schedule since 1924 began to be apparent, indicating that the most consistently good results are to be expected from it. A diagram of the orchard with percentages of marked fruit on the count trees is shown below and indicates the variation in percentage of marked fruit in various locations. This year outlying wild apples were sprayed within a fourth of a mile of the orchard.

PLAN AND RESULTS OF EXPERIMENTS AT STATION FARM, MOUNT CARMEL IN 1927



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
F	X	X	11	—	X	34	X	5	—	X	—	X	4	—	X	X
E	X	X	5	7	X	74	X	3	5	X	19	X	3	0	X	X
D	X	X	13	3	X	73	X	2	2	X	44	X	1	6	X	X
C	X	X	—	—	X	—	X	—	2	X	15	X	—	3	X	X
B	X	X	—	8	X	—	X	5	2	X	21	X	0	1	X	X
A	19	15	17	23	—	94	20	15	13	4	24	7	5	5	5	9
Treatments: pink, calyx, 2 weeks, 4 weeks.						check	pink, calyx with fish oil, 2 weeks.				check	pink, calyx, 7-day, 2 weeks.				

Notes:

All percentages referred to nearest whole number; represent fruit marked by curculios.

Trees left blank bore no fruit or so little that the count was worthless.

All picked fruit from count trees scored.

Outlying wild apple trees sprayed with lead arsenate at calyx period.

Drop fruits not collected in 1927.

Row A next a fence row.

Spray dates: Pink—May 6
Calyx—May 26–7
7 day—June 4
2 weeks—June 9
4 weeks—June 23

Formula:
Lead arsenate.................. 3 pounds.
Lime sulphur (dry) .... 6 pounds.
Casein lime.................. 1 pound.
Water......................100 gallons

TABLE 28—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE—1927

EXPERIMENT STATION FARM: DETAILED RECORD

Tree Nos.	Total No. of Apples	Number Marked by Curculio	Per Cent Marked Fruit	Total No. Punctures	Average No. Punctures Per Apple	Treatment
A 1	962	182	18.9	686	.71	Pink, calyx, 2-weeks, 4-weeks
A 2	1,166	176	15.1	296	.25	
A 3	586	99	16.9	208	.35	
A 4	260	60	23.0	139	.534	
A 5	7	0	0.00	0	.0	
B 3	9	0	0.0	0	.0	
B 4	1,424	112	7.8	169	.12	
D 3	171	22	12.9	55	.32	
D 4	1,014	36	3.5	69	.068	
E 3	2,098	102	4.8	163	.077	
E 4	1,261	86	6.8	198	.15	
F 3, 4	4,512	486	10.8	808	.18	
Total	13,470	1,361	10.1	2,791	.20	
A 7	1,586	321	20.2	667	.42	Pink, calyx (with fish oil), 2-weeks
A 8	2,366	357	15.1	601	.25	
A 9	260	33	12.7	44	.16	
A 10	178	7	3.9	10	.056	
B 8	19	1	5.2	2	.105	
B 9	450	10	2.2	16	.035	
C 9	626	16	2.5	29	.046	
D 8	667	12	1.8	16	.024	
D 9	1,452	35	2.4	52	.035	
E 8	2,792	93	3.3	180	.064	
E 9	2,496	118	4.7	205	.082	
F 8	4,543	238	5.2	382	.084	
Total	17,435	1,241	7.11	2,204	.126	
A 12	2,139	156	7.3	288	.13	Pink, calyx, 7-day, 2-weeks
A 13	218	1	.45	1	.04	
A 14	466	22	4.7	36	.077	
A 15	2,004	97	4.8	114	.056	
A 16	3,855	359	9.3	547	.14	
B 14	167	2	1.2	5	.029	
B 13	50	0	0	0	.0	
C 14	5,890	168	2.8	248	.042	
D 13	626	74	1.2	23	.036	
D 14	2,089	118	5.6	197	.094	
E 13	396	14	3.5	36	.091	
E 14	39	0	0	0	.0	
F 13	3,185	139	4.3	159	.049	
Total	21,124	1,150	5.44	1,654	.078	
A 6	292	274	93.8	1,259	4.30	Check—no treatment
A 11	152	36	23.7	69	.45	
B 11	179	37	20.6	51	.28	
C 11	1,491	221	14.8	343	.23	
D 6	1,056	772	73.1	2,031	1.92	
D 11	809	358	44.2	781	.96	
E 6	916	682	74.4	1,869	2.04	
E 11	1,461	276	18.9	412	.28	
F 6	1,860	641	34.4	1,200	.64	
Total	8,216	3,297	40.13	8,015	.97	

RESULTS IN 1928

The same plots were used in 1928 as in 1927, but with one different treatment; namely, a pink, calyx, 10-day, and 20-day schedule. There appeared to be little difference in any of the plots, indicating that they were about equal in curculio control. The pink, calyx, 7-day and two-weeks spray and the pink, calyx, 10-day and 20-day sprays, gave more uniform control. A comparison of several trees of the same variety and the same relative location in the orchard on the other hand, indicates a slight but not significant advantage for the schedule containing fish oil over that omitting it, Table 29. Wild apples in the vicinity of the orchard were sprayed again.

TABLE 29

Variety	Tree No.	Total Apples	Height in Feet	Size cu. yds.	Per cent marked	Treatment
Baldwin	A2	2,179	20	277	13.3	Pink, calyx, 7-day, 2 weeks.
"	A13	2,811	19	274	5.1	pink, calyx with fish oil, 2 weeks.
"	A4	2,294	20	318	8.3	pink, calyx, 7-day 2 weeks.
"	A12	2,125	21	309	7.1	pink, calyx with fish oil, 2 weeks.
Greening	D4	1,318	20	310	7.7	pink, calyx, 7 day, 2 weeks.
"	D13	1,419	19	310	2.1	pink, calyx with fish oil, 2 weeks.
"	D3	1,417	18	233	4.3	pink, calyx 7-day, 2 weeks.
"	D14	1,325	18	312	5.0	pink, calyx with fish oil, 2 weeks.

The total percentage of marked fruit is almost identical on the outside row in the different plots and further indicates that the amount of control was almost the same in all three while mathematical computations indicate no significant advantage of any schedule. This year was a bad year for russeted fruit and scab. No McIntosh trees received the fish oil-lead arsenate spray in 1928, but it is reasonable to expect decreased control of scab when such schedules are used. On trees not scabbing badly results were good, the foliage being better and with less spray burn, due no doubt to decreased amount of spray. Advantages of this schedule lie in its greater economy since one application is omitted, and its greater safety—probable disadvantages in lessened fungous control.

A comparison was also made in 1928 of 90-10 sulphur arsenate dust and spray, both dust and spray being applied on the same schedules—pink, calyx, 7-day and 2-weeks. Results indicate a slightly better control of curculio by spraying although the difference is not great. Thus the per cent of unmarked fruit in the sprayed plot for this year totaled 96.6 per cent while the unmarked fruit on the dusted plot totaled 92.7 per cent. This corresponds in general with results obtained in the Milford experiments of Zappe and Stoddard.

PLAN AND RESULTS OF EXPERIMENTS TO CONTROL CURCULIOS AT EXPERIMENT STATION FARM IN 1928

N

W

	1	2	3	4	5	6	6	8	8	10	11	12	13	14	15	16
F	X	X	2.8	1.7	45	X	X	4.3	3.2	X	X	28	25	2.2	X	X
E	X	X	3.1	4.9	X	20	X	3.5	—	X	9.5	3.1	1.4	1.0	X	X
D	X	X	4.3	7.7	X	33	X	6.0	2.7	X	27	X	2.1	5.0	X	X
C	X	X	3.2	2.2	X	11	X	1.4	3.0	X	22	X	3.5	—	X	X
B	X	X	4.6	5.2	X	9	X	2.3	3.8	X	12	X	4.8	7.4	X	X
A	6.4	13.3	11.7	8.3	9.2	30	8.0	10.7	7.1	10.2	33	7.1	5.1	6.3	17.0	—
Treatments: pink, calyx, 7 day, 2 weeks.						check	pink, calyx, 10 day, 20-day.				check		pink, calyx with fish oil, 2 weeks.			

Notes:

Outlying wild apple trees sprayed with lead arsenate and fish oil sticker at calyx period. No drop fruits collected.

Spray dates: pink—May 8
Calyx—May 28
7-day—June 4
10-day—June 7
2-weeks—June 11
20 day—June 18

Formula— Lead arsenate.............. 3 pounds
Lime sulphur (dry)......... 6 pounds
Casein lime................ 1 pound
Water.....................100 gallons
Fish oil, 1 pint to 100 gallons. (Used in combination with lead arsenate only.)

TABLE 30—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLES

EXPERIMENT STATION FARM—1928

	Total No. of Apples	Number Marked by Curculio	Per Cent Marked Fruit	Total[1] Number Punctures	Average No. Punctures Per Apple	Treatment
A 1	235	15	6.4	36	.15	Pink, calyx, 7-day, 2-weeks
A 2	2,179	290	13.3	450	.21	
A 3	844	99	11.7	136	.16	
A 4	2,294	191	8.3	288	.12	
A 5	3,971	366	9.2	521	.13	
B 3	3,083	143	4.6	186	.06	
B 4	2,308	120	5.2	177	.08	
C 3	3,175	103	3.2	132	.04	
C 4	2,811	61	2.2	73	.02	
D 3	1,417	61	4.3	69	.05	
D 4	1,318	101	7.7	177	.13	
E 3	1,001	31	3.1	52	.05	
E 4	896	44	4.9	66	.07	
F 3	3,914	109	2.8	111	.03	
F 4	2,740	47	1.7	57	.02	
Totals	32,186	1,781	5.53 ± 1.95	2,531	.079	
A 7	4,075	327	8.0	448	.11	Pink, calyx, 10-day, 20-day
A 8	2,747	293	10.7	341	.12	
A 9	3,952	281	7.1	356	.09	
A 10	1,859	189	10.2	275	.15	
B 8	1,699	40	2.3	96	.06	
B 9	2,360	91	3.8	138	.06	
C 8	944	13	1.4	21	.02	
C 9	708	21	3.0	28	.04	
D 8	1,171	70	6.0	112	.09	
D 9	1,498	41	2.7	51	.03	
E 8	676	24	3.5	24	.03	
F 8	234	10	4.3	3	.01	
F 9	3,676	120	3.2	137	.04	
Totals	25,599	1,520	5.93 ± 2.29	2,030	.079	
A 12	2,125	153	7.1	237	.11	Pink, calyx with fish oil, 2-weeks
A 13	2,811	144	5.1	209	.07	
A 14	3,613	228	6.3	295	.08	
A 15	2,233	379	17.0	617	.27	
B 13	2,218	106	4.8	146	.06	
B 14	1,055	78	7.4	128	.12	
C 13	3,204	112	3.5	138	.04	
D 13	1,419	30	2.1	40	.03	
D 14	1,325	67	5.0	100	.07	
E 12	3,185	98	3.1	133	.04	
E 13	1,258	18	1.4	12	.009	
E 14	695	7	1.0	6	.009	
F 13	479	120	25.0	167	.35	
F 14	1,400	31	2.2	47	.03	
Totals	27,020	1,571	5.81 ± 1.87	2,275	.084	
A 6	1,003	302	30.1	602	.60	Check—no treatment
B 6	1,447	130	9.0	170	.12	
C 6	1,690	183	10.8	222	.13	
D 6	1,580	515	32.6	864	.55	
E 6	840	168	20.0	294	.35	
F 5	352	158	44.9	279	.79	
A 11	2,450	818	33.4	1,326	.54	
B 11	2,291	285	12.4	429	.19	
C 11	1,126	242	21.5	393	.35	
D 11	995	255	25.6	495	.50	
E 11	1,149	109	9.5	124	.11	
F 12	3,152	873	27.7	1,235	.39	
Totals	18,075	4,038	22.26 ± 2.28	6,433	.356	

[1] Does not include fall feeding punctures.

TABLE 31—EXPERIMENTS TO CONTROL THE PLUM CURCULIO ON APPLE: SPRAY VERSUS DUST

Tree	Total Apples	Number Marked by Curculio	Per Cent Marked Fruit	Total Number of Punctures	Average Number Punctures Per Apple	Treatment
N 3	380	119	31.3	179	.47	Spray: pink, calyx, 7-day, 2-weeks
N 4	432	60	13.9	87	.20	
N 6	4,042	121	3.0	156	.4	
N 7	2,236	9	.4	8	.003	
N 8	2,034	30	1.4	45	.02	
N 9	1,118	0	0	0	.0	
Totals	10,242	339	3.3±3.3	475	.046	
R 5	1,983	181	9.1	272	.14	Dust: pink, calyx, 7-day, 2-weeks
R 6	896	57	6.4	82	.09	
R 7	1,993	90	4.5	91	.04	
R 8	891	70	7.8	101	.11	
R 9	2,469	127	5.1	143	.06	
S 7	513	6	1.2	6	.01	
S 8	1,242	40	3.2	62	.05	
S 9	3,994	259	6.5	323	.08	
Totals	13,981	830	5.9±1.6	1,070	.076	
N 2	1,068	525	49.2	1,302	.122	Check—no treatment
O 1	202	96	47.5	216	.107	
Totals	1,270	621	48.89	1,518	.119	

EXPERIMENTS AT SHEPARD'S ORCHARD, MOUNT CARMEL; RESULTS IN 1925

This orchard consists of 52 trees of three varieties arranged in six rows. It was divided into two plots with check row through the center. The orchard is provided with abundant sources of infestation, with sprayed and unsprayed apple trees on three sides and a bearing peach orchard on the fourth. In 1925, it received (1) a pink, calyx, 7-day and 2-weeks schedule and (2) a pink, calyx, 2-weeks and five weeks spray. Results favored the condensed schedule (1) by nearly seven per cent.

TABLE 32—RESULTS OF SPRAYING EXPERIMENTS TO CONTROL CURCULIOS: SHEPARD'S ORCHARD—1925

Total Apples	Total Injured	Per Cent Injured	Total Punctures	Average No. Punctures Per Apple	Kind of Fruit Scored	Treatment
						7-day
421	113	26.84	266	.63	Drops	April 29, May 19
11,071	2,295	20.73	4,718	.43	Picked	May 27, June 2
11,492	2,408	20.95	4,984	.43	Total	
						5-weeks
421	113	26.84	266	.63	Drops	April 29, May 19
12,352	3,389	27.43	7,616	.62	Picked	June 2, June 22
12,773	3,502	27.41	7,882	.62	Total	
625	534	85.44	1,574	2.52	Drops	Check—no treatment
3,040	2,369	77.92	8,121	2.67	Picked	
3,665	2,903	79.20	9,695	2.64	Total	

TABLE 33—COMPARISON OF SPRAYS FOR CURCULIO CONTROL: SHEPARD'S ORCHARD—1925

Treatment	Per Cent Unmarked Fruit	Kind of Fruit	Total Per Cent of Unmarked Fruit
7-day April 29, May 19 May 27, June 2	73.26 79.27	Drops Picked	79.05
5-weeks April 29, May 19, June 2, June 22	73.16 72.57	Drops Picked	72.59
Check No Treatment	14.56 23.08	Drops Picked	20.80

Notes:

Trees planted in 1911.

Amount of spray used 5–7 gallons per tree. (Trees bearing most fruit smaller than trees at Experiment Station farm.)

Percentages based on counts varying from 3,665 to 12,773 apples for each plot.

This orchard is very heavily infested; has been in sod, but was sprayed regularly by owner in previous years. Cultivated in part during 1925.

Spray Formula Used.

Lead arsenate	3 pounds
Nicotine sulphate	1 pint
Casein lime	1 pound
Lime sulphur (dry)	6 pounds
Water	100 gallons

RESULTS IN 1926

The two plots were reversed during 1926 and were the same except that schedule Number 2 received a 4-weeks after calyx application instead of a 5-weeks. This year the condensed schedule averaged .5 per cent less than the expanded pink-calyx-2-weeks-4-weeks schedule.

RESULTS IN 1927

Thinking that our 1926 results might have been influenced unduly by some unseen factor the same sprays were repeated on the same plots with the result that the expanded schedule averaged .1 per cent better. The amount of fruit on the two plots was slightly larger both years on the plot receiving the condensed schedule and if influenced by this factor alone the count should have been much better. The systematic increase in injury occurs on the orchard fringe but is greater towards the west side and should influence both plots alike. This infestation is apparently

TABLE 34—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO: SHEPARD'S ORCHARD—1926

Row	Kind of Fruit	Total No. of Apples	Number Marked by Curculio	Per Cent Marked Fruit	Total No. of Punctures	Average No. Punctures Per Apple	Treatment
C 1–4	Drops	2,243	100	4.4	147	.065	Pink, calyx, 7-day and 2-weeks
	Picked	9,325	339	3.6	540	.058	
D 1–4	Drops	5,321	373	7.01	626	.117	
	Picked	10,752	306	2.8	504	.0468	
E 1–4	Drops	3,110	151	4.8	286	.0919	
	Picked	5,681	91	1.6	196	.034	
F 1–4	Drops	2,403	85	3.5	121	.050	
	Picked	8,553	196	2.26	295	.034	
G 1–4	Drops	583	26	4.4	37	.063	
	Picked	3,792	75	1.97	105	.027	
H 1–4	Drops	925	95	10.2	155	.167	
	Picked	2,223	93	4.2	303	.136	
Total	Drops	14,585	830	5.69	1,372	.094	
	Picked	40,326	1,100	2.73	1,943	.048	
Total all fruits		54,911	1,930	3.51	3,315	.060	
C 6–7	Drops	1,261	84	6.6	122	.09	Pink, calyx, 2-weeks and 4-weeks
	Picked	4,546	200	4.4	292	.06	
D 6–8	Drops	2,193	96	4.4	263	.12	
	Picked	6,731	86	1.2	115	.02	
E 6–9	Drops	1,383	190	13.9	360	.26	
	Picked	6,266	148	2.3	254	.04	
F 6–9	Drops	310	9	2.9	14	.04	
	Picked	1,624	33	2.0	66	.04	
G 6–8	Drops	262	13	4.9	18	.07	
	Picked	2,719	129	4.7	231	.08	
H 6–10	Drops	1,127	158	14.0	240	.21	
	Picked	2,239	183	8.2	406	.18	
Total	Drops	6,536	550	8.41	1,017	.15	
	Picked	24,125	779	3.22	1,364	.05	
Total all fruits		30,661	1,329	4.334	2,381	077	
Total CDEFG 5	Drops	3,177	1,398	44.0	2,781	.87	Check—no treatment
	Picked	8,036	2,144	26.7	4,444	.55	
Total all fruits		11,213	3 542	31.58	7 225	.644	

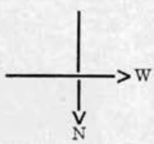
somewhat worse, however, on the northwest corner which falls within the plot receiving the condensed schedule. The only other factor entering the question is the size of the trees. These were measured and it was found that those receiving the condensed schedule are larger. From these facts it becomes apparent that although the count is almost identical, that plot receiving the condensed schedule is in reality better because it controlled equally well with a greater handicap.

TABLE 35—RESULTS OF SPRAYING EXPERIMENTS FOR CONTROL OF PLUM CURCULIO ON APPLE; SHEPARD'S ORCHARD—1927

Tree Nos.	Total No. of Apples	Number Marked by Curculio	Per Cent Marked Fruit	Total No. of Punctures	Average No. Punctures Per Apple	Treatment
D 3	703	23	3.27	36	.051	Pink, calyx, 7-day, 2-weeks
E 3	19	0	0.0	0	.0	
F 3	1,236	38	3.0	56	.045	
G 3	836	38	4.5	66	.079	
H 2	746	160	21.45	361	.484	
D 4	223	7	3.1	9	.040	
E 4	95	1	1.05	2	.021	
F 4	1,645	46	2.8	59	.036	
G 4	868	4	.46	11	.012	
H 4	782	49	6.26	207	.264	
Totals	7,153	366	5.1	807	.112	
D 6	210	3	1.4	3	.014	Pink, calyx, 2-weeks, 4-weeks
E 6	121	2	1.65	2	.016	
F 6	964	55	5.7	117	.121	
G 6	157	99	6.3	94	.598	
H 6	1,704	100	5.86	161	.094	
E 7	346	9	2.6	9	.026	
F 7	1,441	16	1.1	24	.016	
G 7	1,924	42	2.2	64	.033	
H 7	1,308	81	6.2	106	.081	
Totals	8,175	407	4.98	580	.071	
D 5, E 5 F 5, G 5, H 5	1,566	628	40.1	1,073	.68	Check—no treatment

Note—Drop fruits were not collected in this orchard in 1927.

PLAN AND RESULTS OF EXPERIMENTAL WORK IN SHEPARD'S ORCHARD —1927



	A	B	C	D	E	F	G	H	
1	X	X	X	X	X	X	X	X	Pink, calyx, 7-day, 2 weeks.
2			X	X	X	X	X	21	
3			..	3	0	3	4	..	
4			..	3	1	3	.4	6	
5			..	11	26	39	51	55	Check—no treatment.
6			..	1	2	5	8	6	
7			..	..	3	1	2	6	Pink, calyx, 2-weeks, 4-weeks.
8			X	X	X	X	X	X	
9					X	X	X	X.	
10								X	

Notes:

Figures represent percentages of curculio marked fruit. All percentages are referred to the nearest whole number.

All picked fruit from count trees scored.

Trees left blank bore no fruit in 1927.

Spray dates—pink May 6–7
calyx—May 27
7-day—June 4
2-weeks—June 9
4-weeks—June 23

Formula—		
	Lead arsenate..............	3 pounds
	Lime sulphur (dry).........	6 pounds
	Casein lime................	1 pound
	Water....................	100 gallons

RESULTS IN 1928

This year the complete condensed schedule (pink, calyx, 7-day and 2-weeks) was retained on the same plot and compared with the same schedule on the remaining plot, varying only in the substitution of basic lead arsenate for the acid form commonly employed. The basic arsenate apparently reduced the amount of russet on Gravensteins by seven per cent, but did not so affect the McIntosh. On the other hand, canker worms did much more damage in this plot and the total percentage of fruit unmarked by curculio was considerably less—90.9 per cent compared with 94.3 per cent for the acid lead arsenate.

TABLE 36—EXPERIMENTS IN CURCULIO CONTROL; SHEPARD'S ORCHARD—1928

Tree Nos.	Total No. of Apples	Number Marked by Curculio	Per Cent Marked Fruit	Total No. of Punctures	Average No. Punctures Per Apple	Treatment
C 3	2,749	211	7.67	286	.10	Pink, calyx, 7-day, 2 weeks (acid lead arsenate)
D 3	3,148	37	9.8	37	.01	
E 3	4,211	118	2.8	141	.03	
F 3	1,795	20	1.1	24	.01	
G 3	1,182	87	7.36	133	.11	
H 2	1,203	254	21.1	470	.39	
C 4	2,154	216	10.0	328	.15	
D 4	2,528	53	2.1	62	.02	
E 4	2,789	93	3.3	131	.05	
F 4	1,978	88	4.4	129	.06	
G 4	1,421	89	6.3	127	.09	
H 4	800	220	27.5	409	.51	
Totals	25,958	1,480	5.7	2,277	.8	
C 6	1,741	351	20.2	488	.28	Pink, calyx, 7-day and 2-weeks (basic lead arsenate)
D 6	2,140	60	2.8	75	.03	
E 6	2,792	178	6.4	270	.09	
F 6	565	27	4.8	35	.06	
G 6	649	51	7.9	73	.01	
H 6	1,210	289	23.88	434	.36	
C 7	1,894	385	20.32	212	.11	
D 7	3,983	82	2.1	111	.03	
E 7	2,617	109	4.2	147	.05	
F 7	164	13	7.9	18	.11	
G 7	825	31	3.8	42	.05	
H 7	780	183	23.5	294	.37	
Totals	19,360	1,759	9.18	2,199	.11	
$C_5D_5E_5F_5$	4,848	1,435	29.6	2,211	.45	Check, no treatment

PLAN OF EXPERIMENTS AT SHEPARDS ORCHARD, 1928: AND RESULTS OF FRUIT COUNTS FROM DIFFERENT TREES

A	B	C	D	E	F	G	H		
X	X	X	X	X	X	X	X	1	Pink, calyx, 7 day, 2 weeks.
		X	X	X	X	X	21.1	2	Acid lead arsenate.
		7.6	9.8	2.8	1.1	7.3	..	3	
		10.0	2.1	3.3	4.4	6.3	27.15	4	
		4.15	2.21	2.22	56.1	..	..	5	Check—no treatment.
		20.2	2.8	6.4	4.8	7.9	23.9	6	
		20.3	2.1	4.2	7.9	3.8	23.5	7	Pink, calyx, 7-day, 2 weeks.
		X	X	X	X	X	X	8	Basic lead arsenate.
			X	X	X	X	X	9	
							X	10	

Spray dates—Pink—May 10
Calyx—May 24
7-day—May 31
2-weeks—June 7

Formula same as used in Experiment Station Orchard, except for addition of nicotine sulphate at pink and calyx periods.

Assembled Results of Different Sprays for Curculio Control—1924–1928

The following table gives a general summary of the work with sprays conducted between 1924 and 1928 with percentages of fruit unmarked by curculios obtained in the different experiments. Treatments 1-8 were conducted in the orchard of the Experiment Station at Mount Carmel, 9-11 in the orchard of Mr. C. E. Shepard near Mount Carmel. The assembled results show the importance of the 7-day treatment, and the close similarity of the schedule containing fish oil sticker. The unusual uniformity of results obtained in 1928 is probably accidental, but shows that the various schedules employed are about equal in effectiveness; and we believe all of them have considerable merit for control of curculios under Connecticut conditions.

Table 37—Results of Different Sprays for Curculio Control 1924–1928—Picked Fruit Only

	Treatment	Per Cent Clean Fruit 1924	1925	1926	1927	1928
1	*No pink* Calyx, 7-day, 2-weeks...	83.9	....	95.04	....	....
2	*No calyx* Pink, 7-day, 2-weeks....	82.5	90.4	....	....	....
3	*No 7-day* Pink, calyx, 2-weeks....	85.6	85.54	94.6	....	....
4	*No 7-day* Pink, calyx, 2-weeks, 4-weeks...............	....	....	....	89.9	....
5	*No 2-weeks spray* Pink, calyx and 7-day...	88.8	92.3	....	....	....
6	Pink, calyx, 10-day, 20-day	....	....	....	....	94.07
7	*All sprays* Pink, calyx, 7-day, 2-weeks	90.7	94.6	96.65	94.6	94.4
8	*No 7-day* Fish oil plus lead arsenate at calyx; pink, calyx and 2-weeks.........	....	93.30	95.3	92.9	94.19
9	*5-weeks spray* Pink, calyx, 2-weeks, 5-weeks...............	....	72.5	....	....	....
10	*4-weeks spray* Pink, calyx, 2-weeks, 4-weeks...............	....	....	96.78	95.02	....
11	*All sprays* Pink, calyx, 7-day, 2-weeks	....	79.2	97.26	94.9	94.4

Miscellaneous Results

During the experiments conducted at the Experiment Station Farm, it was noted that a gradual reduction in curculio injury took place over that five-year period when the tests were conducted. The following figures are the average of marked fruit obtained from the check trees:

Table 38

Date	Per Cent Marked by Curculio	Notes
1924	64	Drops collected
1925	61	" "
1926	45	" "
1927	40	Wild apples sprayed
1928	22	" "

It seems that continued sprays of the kind employed, together with supplementary controls such as removal of drop fruits (1924-6) and spraying of outlying trees (1927-8) has considerable effect in reducing the total infestation. Also that several years of intensive work results in a steady decline in the total number of curculios in the orchard. It seems reasonable that after a point is reached, similar to 1928, in our spray experiments, that some of the sprays could be safely omitted without seriously influencing the amount of unmarked fruit. The orchardist should then be concerned chiefly with the outside trees of his orchard or the rows nearest the protecting woods if such woods are present.

Cost of Materials

The question will naturally arise as to whether the gain from one extra spray, in decreased amount of curculio damage will pay the cost of the treatment.

Figuring on a cost of materials plus labor employed, and on the basis of our 1928 results it would require at least a five per cent gain in unmarked fruit to pay the cost of the treatment where fruit sells for 12 dollars a barrel, the general market quotation for the highest grade in 1928 (Nov. 25 quotation \$2-\$12). Where the value of the crop drops to \$6 à barrel or \$2, a much higher per cent of gain from curculio must be obtained if the cost of the operation is successfully met from this gain. The greatest differences between a three and a four spray schedule, except on outside rows, has not been over 10 per cent in any year, so that the increased value of the crop does not meet the cost of the application in uninjured fruit except for apples bringing the highest price.

The gain in value of clean fruit may be further offset by the practise of including apples marked by curculios (one to three external marks per fruit) in the higher grades (Grade A)—so that although marked by such punctures the fruit still has considerable value on the market. We have allowed for this condition and assumed for convenience that this fruit will bring 75 per cent of the value of the highest grades although it may and often does bring a much higher per cent.

Regarding the schedule including fish oil sticker it may be stated that although more economical than the other schedules, because of (1) omission of lime sulphur at calyx period, (2) omission of the 7-day application altogether, it cannot be said to control scab except on varieties not especially susceptible. It has, however, been used successfully on Baldwins, Spys, Gravensteins, Wealthys, Suttons, Hurlburts, Greenings and Starks. It may also be added that the European red mite did not become abundant on any of the varieties mentioned during the years when this schedule was used.

Spray Burn

Spray burn being of considerable popular interest at this time, the basic form of lead arsenate was used as noted above in Shepard's orchard. Little or no difference could be seen in the foliage of Gravensteins, Astrachans, or McIntosh, although Gravensteins showed seven per cent less russeted fruit than was present in the plot where acid lead arsenate was used. It is not altogether certain, however, that this difference was due to the spray employed. In our Mount Carmel orchard, the plot where fish oil and lead arsenate were used at the calyx period showed much better foliage than either of the other two spray tests. There was considerable russeted fruit throughout the orchard, most of which was probably due to factors not associated with the spray program.

Arsenical Residue

Analyses of apples sprayed with various combinations were made in 1928, from plots receiving the four-spray schedule, and the three-spray schedule including fish oil sticker at calyx. The latter block contained one Astrachan tree which was picked about August 10. Analysis by Mr. Fisher of the Department of Chemistry, showed .004 grains As_2O_3 per pound of fruit taken from the side of this tree and .006 grains per pound from the top. The tolerance for export fruit is .01 grain arsenic trioxide per pound which is much above that found by Mr. Fisher. Rainfall during July and August averages about four inches per year for each of these months in this locality, but in 1928 the precipitation in July was more than seven inches. Analyses of fruit picked later in the season and also from trees receiving an arsenical spray the tenth of July in addition to the usual schedule (pink, calyx, 7-day and 2-weeks) showed similarly small quantities of arsenical residue, all of them much below the export tolerance. From this it seems that

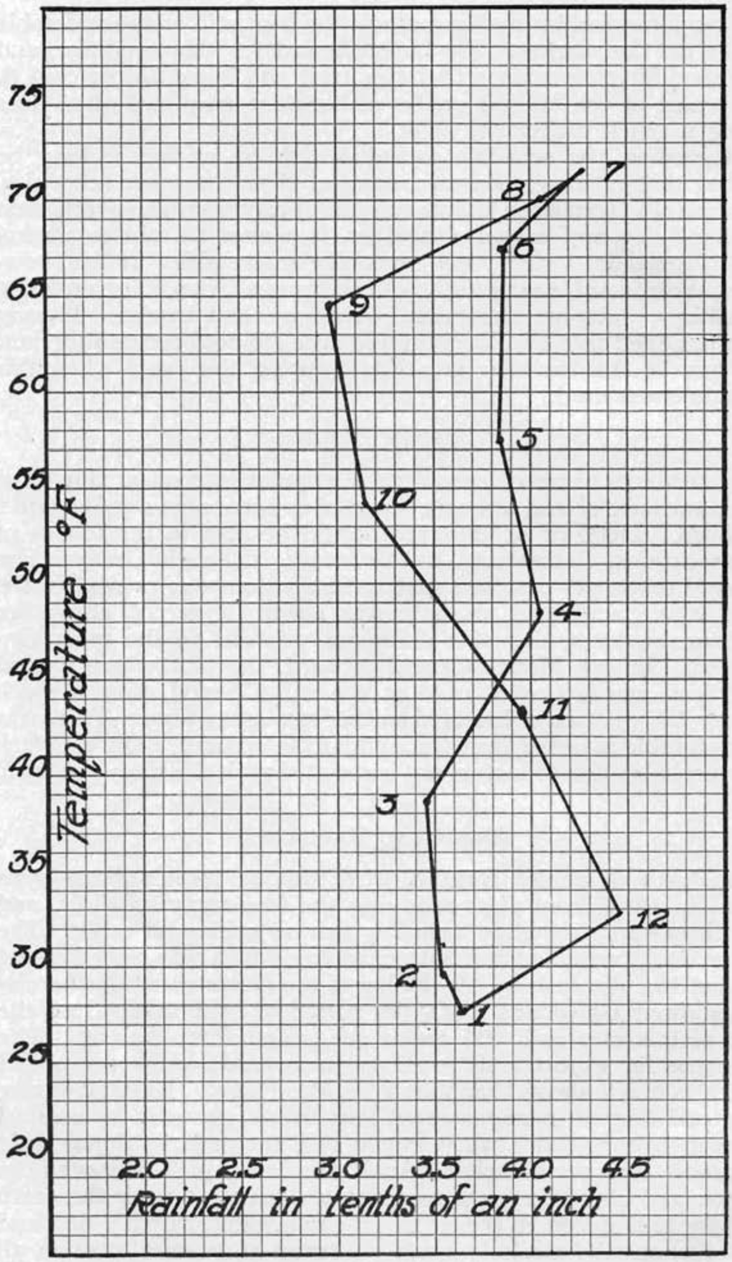


FIG. 32. Climatograph of New Haven district, compiled from U. S. weather bureau records covering the period between 1920 and 1927. The numbers 1, 2, 3, etc., represent the months January, February, March, etc.

there is little danger of harmful residues in Connecticut, especially on those apples picked after September 1, when normally eight or more inches of rain will have fallen. This is also illustrated in Fig. 32 which is a climatograph of the period between 1920 and 1927.

GENERAL CONCLUSIONS

(1) The plum curculio is responsible for much damage to apples in Connecticut.

(2) It is single-brooded and all attempts to produce eggs from beetles emerging during the summer, failed.

(3) The beetles emerge from hibernation near the first of May but do not appear in numbers on the trees till after the blossoms fall.

(4) Beetles come to the trees from outside sources in greatest numbers for a period of about 20 days in Connecticut.

(5) The peak of abundance and egglaying is reached near the middle of June, frequently the 15th, sometimes nearer the 20th.

(6) Beetles developing in dropped apples may offer a serious menace to the succeeding crop.

(7) Sprays applied according to successful schedules outlined in this paper pile up the poison until the June peak of abundance is reached after which there is considerably less danger.

(8) Beetles continue on the trees (apples) in small numbers until the last of July.

(9) All attracting and repelling substances thus far have failed to exert any influence on the curculio in the field. Capryl alcohol is a powerful repellent when confined in cages.

(10) Laboratory tests indicate that the beetles are fond of sweets and may be poisoned in captivity by mixtures containing them.

(11) Effective poisons used in cage tests include, (1) acid lead arsenate, (2) basic lead arsenate, (3) sulphur arsenate dust 90-10, (4) calcium arsenate (5) ortho-zinc arsenite, and (6) sodium fluosilicate lime dust, 1-4.

(12) Parasites are not abundant in Connecticut, the most numerous being apparently *Triaspis curculionis*, which, however, did not kill over 33 per cent of the larvae obtained at any one time.

(13) Spray tests in three different orchards indicate:

(1) That a fair degree of control may be secured with three sprays in Connecticut, but better control with four using a pink, calyx, 7-day and 2-weeks schedule as outlined.

(2) That occasionally a pink, calyx, 2-weeks, and 4-weeks schedule will give good control, while the omission of the 7-day and using fish oil and lead arsenate at the calyx period without lime sulphur closely approximates the results obtained with the four spray schedule but is on the whole less uniform. Such a

schedule should be valuable on trees that burn easily and are not subject to scab infection, besides being more economical than a 4-spray schedule.

(3) That the most consistently good results have been obtained with the 4-spray schedule consisting of pink, 7-day and 2-weeks applications. This resulted in an average of 94.2 per cent unmarked fruit for all tests.

(4) There has been a gradual reduction in injured fruit since 1924, in the orchard where dropped fruits were collected and wild apples in the vicinity sprayed.

(5) Basic lead arsenate compared with acid lead arsenate and used at the same rate per gallon gave less control of curculio than the acid form. It also allowed too much damage from canker worms to be practical at the rate used.

(6) Sprays and dusts used in one field test in 1928 on a full schedule (pink, calyx, 7-day, and 2-weeks) showed the spray slightly superior in control but that dust has merit. This conforms in general with the Milford experiments of Stoddard and Zappe.

(7) Spray residues remaining on the fruit at harvest have been small enough in all cases to conform with the export tolerance.

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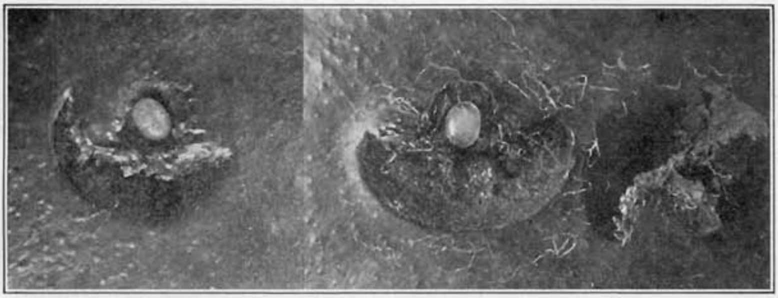
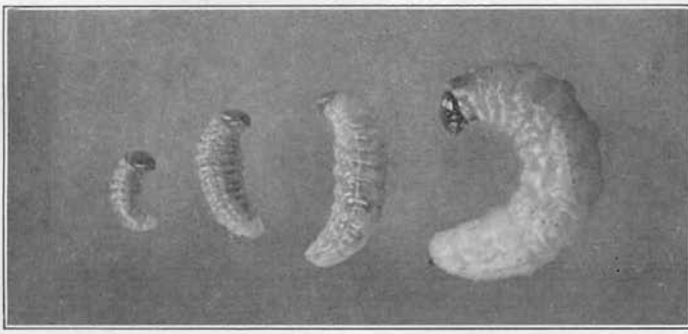
PLATE I

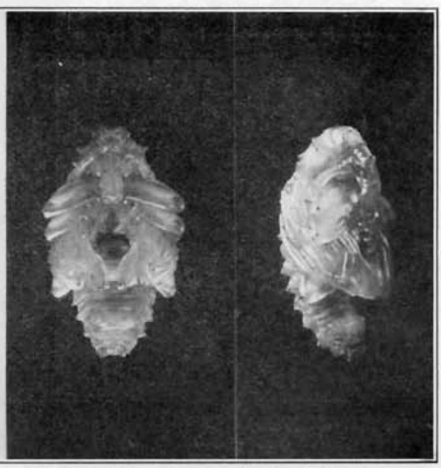


a. The plum curculio egg and crescent shaped egg scars, enlarged nine times.



b. The four larval instars of the curculio, about three times natural size.

c. Full grown larva in peach, natural size.

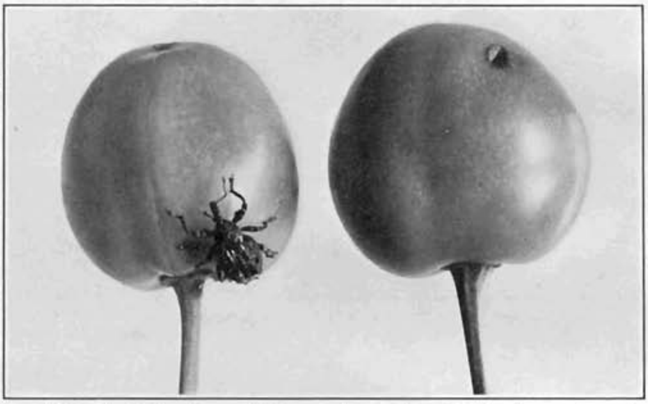


d. The pupa, enlarged about five times.

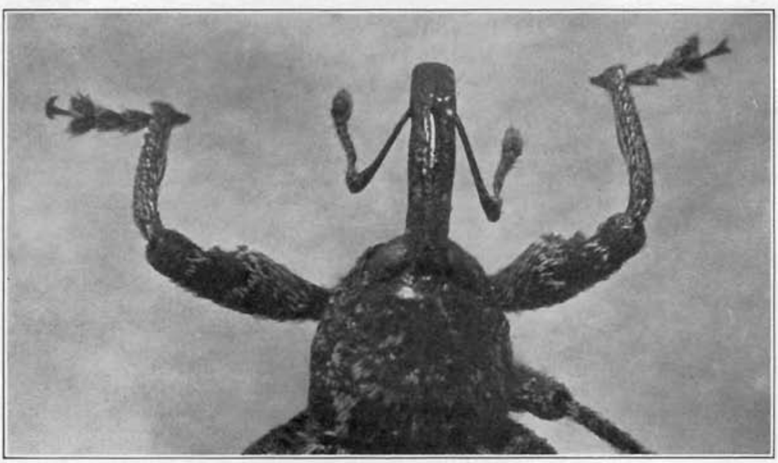
PLATE II

a. The adult beetle curculio, enlarged six times.

b. Beetles attacked by a fungus, *Isaria* sp.

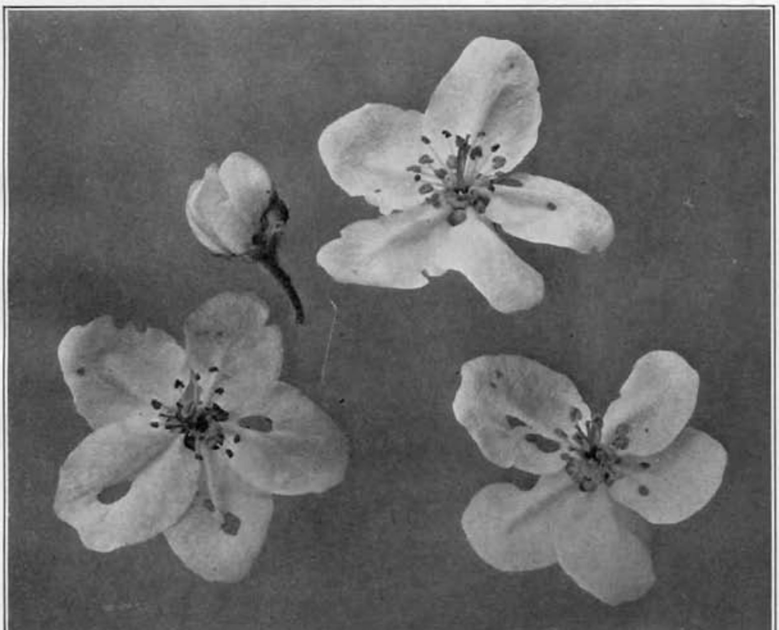


c. The adult beetle and its work on cherries, twice enlarged.



d. The head and beak of the adult curculio, enlarged about 20 times.

a. Jarring beetles from cherry trees in full bloom. Few or no beetles were found at this period.



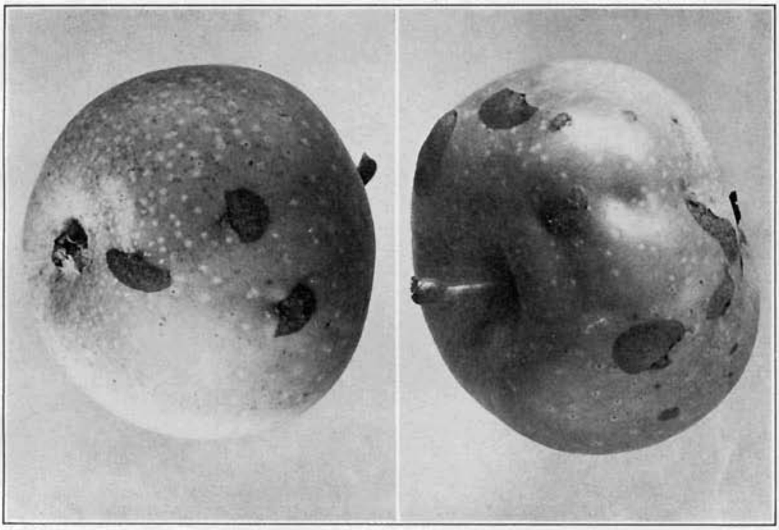
b. Feeding of adult beetles on apple blossoms.

PLATE IV

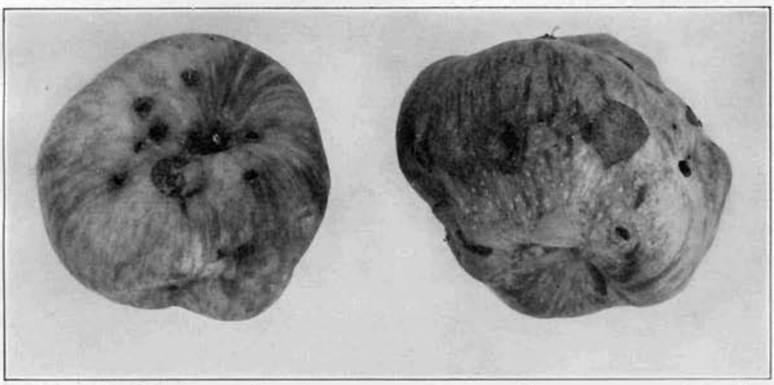
a. Egg scar on apple, enlarged twice.

b. Result of numerous feeding punctures.

c. Size of dropped apples in which curculio larvae frequently develop. Slightly reduced.

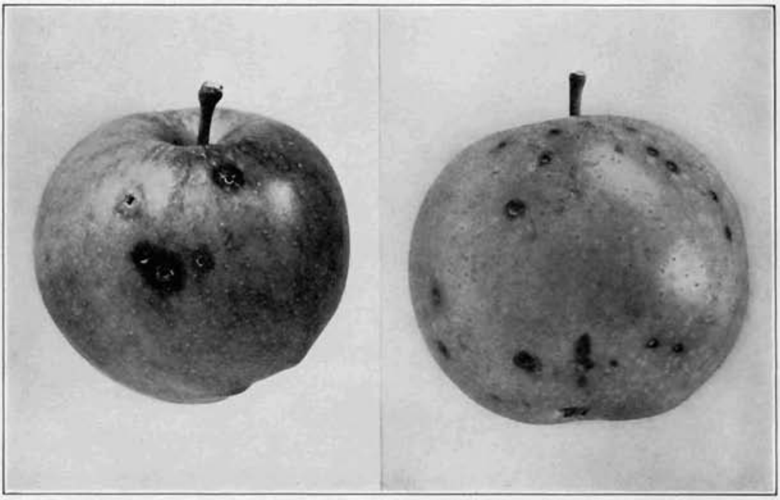


a. Expanded egg scars due to growth of the apple. The eggs or larvae were probably crushed by the growth of the fruit.

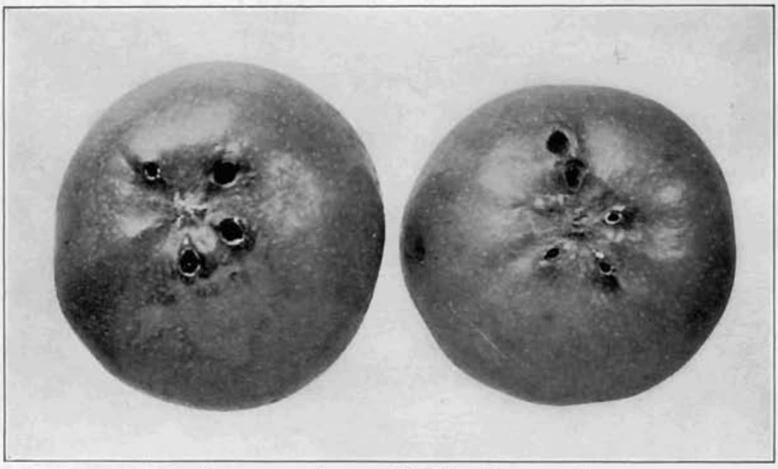


b. Deformed fruit resulting from numerous curculio egg scars and feeding punctures.

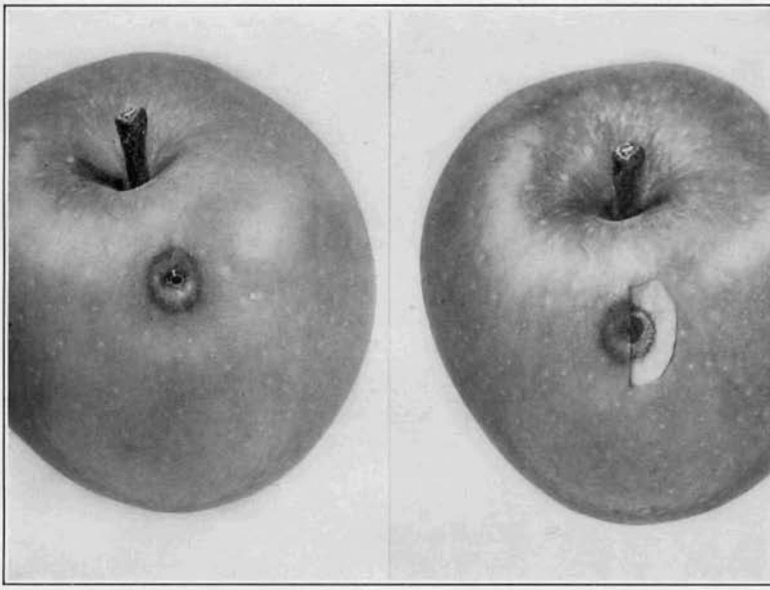
PLATE VI



a. Fall feeding punctures of beetles emerging during the summer.



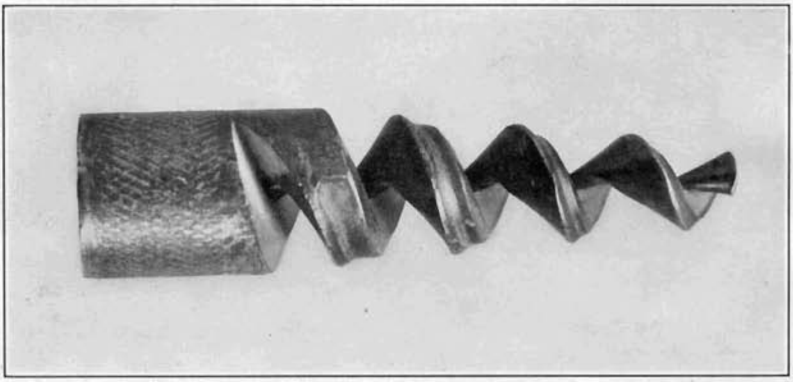
b. A common type of fall feeding puncture.



a. Fall feeding puncture cut away to show how puncture is excavated around the edges.

b. Wild apple tree growing under ideal conditions to promote development of curculios in large numbers. A decided menace if near a commercial orchard.

PLATE VIII



a. Type of spray nozzle used in some of our experiments. There is a graduated hole through the center of the nozzle which furnishes liquid to the spiral surface.

b. Delivery of spray from the nozzle shown in a. Note the solid cone-shaped whirling spray which covers the tree with great rapidity. Absence of projections on the end of the spray rod to catch on branches is a decided advantage. It can be thrust into the center of a tree covering parts not ordinarily reached with the usual spray outfit.