THE APPLE CURCULIO AND ITS CONTROL BY HOGS[1]

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INTRODUCTION

The importance of the apple curculio (*Tachypterus quadrigibbus* Say) has usually been overshadowed by the emphasis given to the plum curculio (*Conotrachelus nenuphar* Herbst). While the latter does not thrive well under the conditions of modern orchard practice, the former seems to be affected very little if at all by spraying, soil cultivation, and pruning.

The destructiveness of the apple curculio in Iowa was first called to the writer's attention by R. M. Clark, manager of the Apple Grove Orchards, south of Mitchellville, Iowa. The plum curculio had been reduced to negligible numbers in this orchard but the manager estimated the loss caused by the apple curculio as at least a thousand dollars a year. This loss was due in part to the added cost of sorting out the unmarketable injured fruit.

The purpose of this paper is to report new observations on the seasonal history and habits of the apple curculio and to describe an effective method of control which can be easily applied over much of the territory in which this insect has proved to be destructive. A description of the stages of its development and many other previously reported facts concerning its life history have been omitted.

REVIEW OF LITERATURE

The first important publication on the apple curculio was by Riley (*7*).[2] He describes and figures the main life stages and describes the punctures made in the green fruit, and the scars on mature pears identified as the early work of the apple curculio. It is evident, however, that his information on the life history is not derived from observations in the orchard. He states that infested apples never fall and that pupation takes place in the apple while it is still on the tree. Gillette (*5*) gives an account of the insect's work on apple and describes its oviposition habits. Crandall (*4*) has made the most complete study of the life history of the apple curculio in connection with his work on the plum curculio. In one respect his observations do not agree with those recorded here. He states that his new generation of beetles fed on the fruit to a very limited extent. Moreover, he describes and figures a type of injury which he ascribes entirely to the plum curculio, but which, in the opinion of the present writer, is more typical of that caused by the late summer feeding of the apple curculio.

The apple curculio has been mentioned as a pest of the apple in a number of widely separated localities. Its injury seems to be most severe in Missouri, Kansas, Illinois, Iowa, Maine, and the Province

[1] Received for publication Dec. 2, 1927; issued April, 1928.

[2] Reference is made by number (italic) to "Literature cited," p. 261.

of Quebec. Brooks (*1*) lists the following fruits as recorded hosts: Hawthorn, wild crab, haw, wild cherry, quince, pear, and apple. Petch (*6*) states that it attacks pear, plum, wild crab, cherry, and hawthorn. Watson (*8*) collected it on cotton in Florida. In northern Colorado it has been reported by List [3] as injuring 100 per cent of the sour cherries in certain orchards.

Control measures recommended for the apple curculio have usually been those found effective against the plum curculio. Such advice seems to be based on the similarity of habits of the two insects rather than on experimental data. Riley (*7*) predicts that the apple curculio can never be controlled by the tree-jarring method and says that the only real remedy is the destruction of infested fruit. Gillette (*5*) suggests arsenical sprays for ordinary infestations, supplemented when severe by jarring and the destruction of windfalls by means of hogs or sheep. Brooks (*1*) recommends the destruction of native host plants, jarring, and arsenical sprays, but says that the last will not prove as effective as against the plum curculio. Crandall's (*4*) discussion of control measures is concerned primarily with the plum curculio. Petch (*6*) states that arsenical sprays and dusts will give good results if applied at the right time and that lime sulphur and sulphur act as deterrents. Two popular reports of the control experiments recorded here have been published by R. M. Clark (*2*, *3*) manager of the orchard where the work was conducted.

NATURE OF THE INJURY

The injury to fruit caused by the apple curculio may be locally severe, but it is not universally present in apple orchards, due in part no doubt to the strange reluctance of the insect to feed on apples of many of the common varieties. In many cases the cause of the injury is not known to the orchardist, or is thought to be the work of the plum curculio.

At the time the beetles are feeding very little injury will be noticed on the surface of the fruit. A few small holes like needle punctures may be observed, or the holes may be concealed by small black pellets of excrement. (Fig. 1, *e*, *f*.) If the holes are cut into toward the center of the apple deeper cavities will be found, which are of two types, large oval cavities and slender cavities more or less the shape of the insect's beak. The former are made for the dual purpose of obtaining food and holding an egg; the latter are feeding punctures only and are made largely by the males. (Fig. 1, *g*–*j*.)

The effect of such punctures is more apparent after considerable growth of the fruit has taken place. The cavity becomes almost completely obliterated within a short time by the rapid growth of the internal tissues of the young apple. This usually results in the destruction of the egg or young grub if the apple remains on the tree. The cavity is closed by the ingrowth of tissue from the sides and bottom, so that a longitudinal section often has the form of an inverted Y. (Fig. 2.) The cavity leaves a lasting imprint upon the growing fruit which becomes evident by the presence of a hardened area extending from the surface toward the core. Growth is inhibited at that point, and as the apple grows a funnel-shaped pit usually develops. (Fig. 1, *o*.)

[3] LIST, G. M. A NEW CHERRY PEST. Rocky Mt. Conf. Ent. Rpt. 4: 5. 1926. [Mimeographed.]

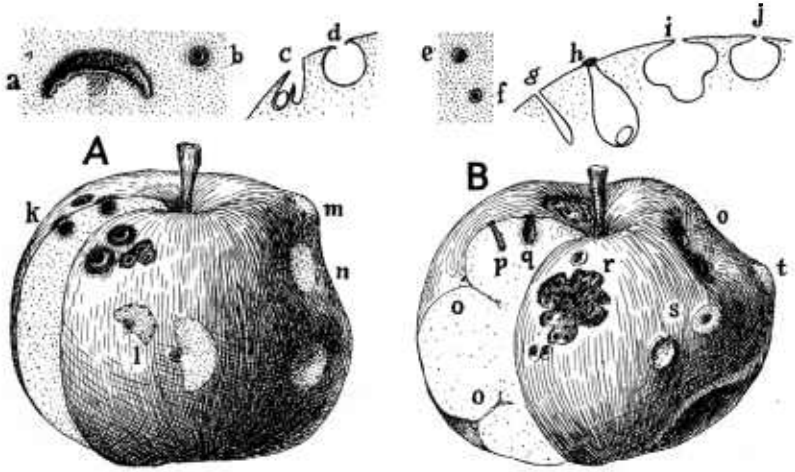

FIG. 1.—A, Injury to apple caused by plum curculio; B, injury to apple caused by apple curculio; *a–j*, recent injury on young fruit, × 3; *k–t*, recent injury on mature fruit and scars resulting from early injury; *a*, crescent cut or egg puncture, surface view; *b*, feeding puncture; *c*, *d*, sections of egg and feeding punctures; *e*, egg puncture plugged with excrement; *f*, same, plug removed; *g*, section of feeding puncture; *h*, section of egg puncture; *i*, *j*, unusual types of punctures; *k*, late summer-feeding punctures, enlarged by drying or rotting; *l*, scars resulting from crescent cuts; *m*, *n*, protruding and sunken scars from early feeding punctures; *o*, pits resulting from egg punctures; *p*, *q*, late summer-feeding punctures; *r*, patch of late summer-feeding punctures resulting in collapse of underlying tissues; *s*, *t*, craterlike and protruding scars resulting from early punctures

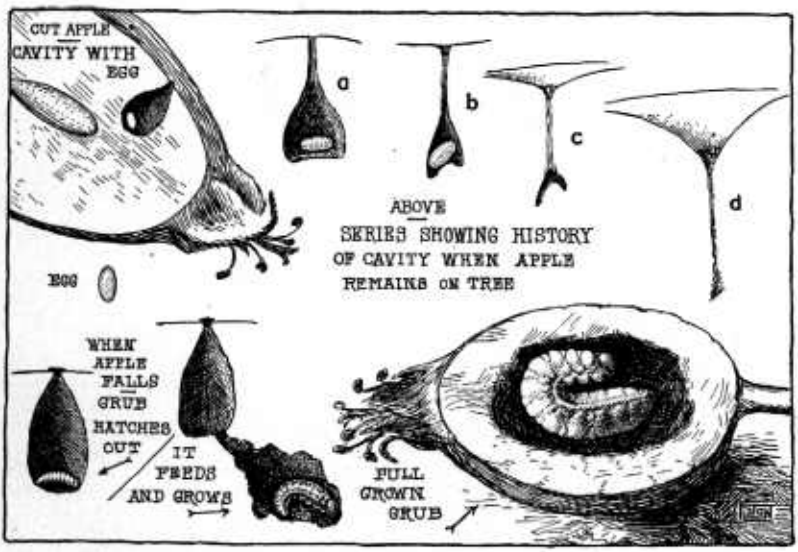

FIG. 2.—Cut apples and sections showing development of apple curculio grub in fallen apples, and history of egg cavities in growing apples

Under some conditions not fully understood the injury may develop as a protruding scar in the form of a rounded bump or a crater. (Fig. 1, *s, t.*) Usually an apple which has been affected at all receives a rather large number of punctures, with the result that as it develops it becomes very much deformed and is entirely worthless as a marketable fruit.

An entirely different type of injury results from the feeding of the new generation of beetles which appear in midsummer. It may be found from the middle of July on. The feeding cavities are like those made in the young apples, but they are not closed over by the growth of the apple. Instead, the portion of the skin undermined dries out, enlarging the opening. If the fruit is still quite green the inner part becomes a hardened scar lining the cavity. If the fruit is nearer maturity the pulp surrounding the cavity tends to dry out and shrink, causing the cavity to enlarge further. Usually a number of holes are located close together near the stem or calyx or under a sheltering leaf. In such cases the whole included area of skin dries and turns brown and the material underneath collapses as a result of the drying, so that no distinct cavities are apparent. All that one sees is a sunken and perforated brown patch on the side of the apple. (Fig. 1, *r*, and fig. 3.) The skin may shrivel and crack open, exposing the dried and discolored pulp. This type of injury has been ascribed to plum curculio, but punctures made by this insect in its late feeding are shallower and usually more scattered.

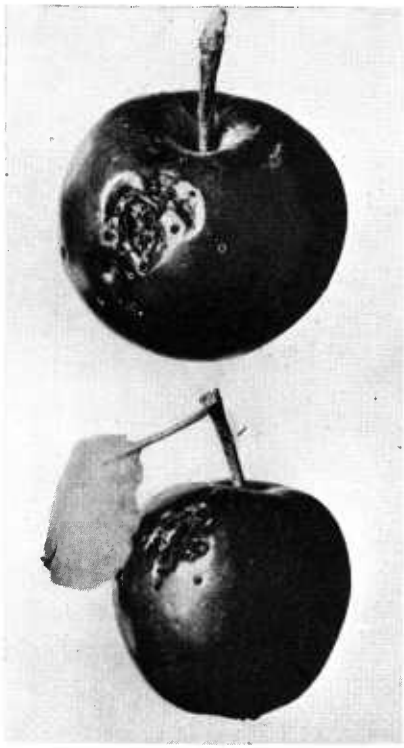

FIG. 3.—Punctures, concentrated under a protecting leaf, made by late-feeding apple curculio

The work of the apple curculio can be distinguished from that of the plum curculio by the greater depth of the cavities formed. In the young fruit while the injuries are still recent the difference is very apparent. The plum curculio's beak is much shorter and broader than that of the apple curculio and the cavity formed is round close to the surface and the hole through the skin is rather large. (Fig. 1, *b, d.*) The egg punctures of the plum curculio are very easily recognized on account of the crescent-shaped cut along one side of the egg puncture proper. (Fig. 1, *a, c.*)

In the mature apples the plum curculio injuries are more apt to develop as spreading scars and usually lack the hardened internal scar tissue extending toward the core. The feeding punctures become rounded scars and the crescent cuts change to semicircles or half

moons. (Fig. 1, *l*.) These scars often occur in depressions but they are seldom deep funnel-shaped pits. In the case of apple curculio injury the pits rarely have more than a small scar at the bottom.

SEASONAL HISTORY

The apple curculio has but one generation a year and passes most of its life in the adult or beetle stage. It comes out of hibernation in the spring and begins feeding on the young apples just after they have set. Egg laying begins while the apples are still quite small. Most of the eggs are deposited before the June drop is complete, but a few beetles continue laying until the apples are nearly half grown. The egg-laying period covers a month or more. Each female deposits a few eggs a day, averaging 60 to 70 during the season.

Normally the apple must drop if the life history of the insect is to be completed. The entire larval and pupal stages are spent within

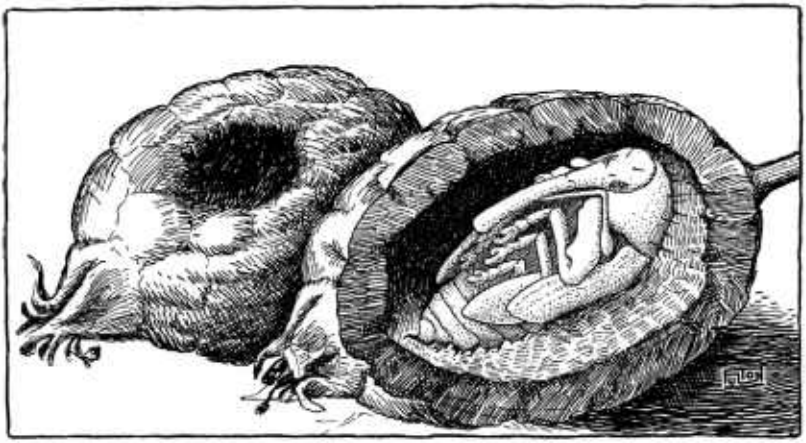

FIG. 4.—Fallen apple from which an adult apple curculio has escaped, and cut apple showing pupa

the dropped apple (fig. 4), which may become dried and mummified before the beetle emerges. Young living larvae were found in some apples picked off the trees in 1926, but none were found in apples picked in 1925. No large larvae have ever been found in growing apples. Evidently the insect is not completely adapted to the cultivated apple and is dependent on the June drop for survival.

A comparison of the percentage of injured fruit on the trees with that on the ground would indicate that the work of the apple curculio has little if any influence on the dropping. Dropped apples collected at several times during 1926 under one group of trees showed an infestation of 37 per cent in a total of 1,073. Counts of injured fruit on the same group of trees taken after the egg-laying season showed 39 per cent injured in a total of 703 apples.

The collecting of beetles and immature stages of the apple curculio has brought out facts concerning the seasonal history which corroborate the results obtained in previous life-history work and which are important in the application of control measures. The adults were found to be present throughout the year but became scarce

early in July because of the dying off of the old generation before many of their offspring had matured. A few of the old generation continued to live and deposited their eggs later in July. In the insectary the last egg was found on July 2 in 1925 and on July 7 in 1926. Eggs were probably deposited in the orchard subsequent to the latter date, for six larvae were collected in fallen apples on August 10, 1926. The transverse diameter of these apples (Ben Davis) was 20, 30, 30, 30, 35, and 38 mm. These larvae were probably from the last eggs deposited that season. Since the apples probably fell soon after the eggs were deposited, their size furnishes an indication of the limits of the egg-laying period. In Crandall's experiments eggs were deposited from May 23 to July 22, a period of over 60 days.

The number of beetles of the new generation leaving the fruit before July 1 must be negligible. The first beetle to be reared to maturity appeared July 3. After the first week in July the beetles began to mature in rather large numbers. By the middle of July 86 per cent had matured from the first dropped apples in 1925 and 100 per cent in 1926. (Table 1.)

TABLE 1.—*Number of dropped and picked apples infested by the apple curculio, and number of curculios in the egg, larva, pupa, and adult stages on different dates in the summers of 1925 and 1926*

Lot No.	Date collected	Date examined	Dropped or picked apples	Apples infested		Curculios in different stages							
						Egg		Larva		Pupa		Adult	
				Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1	June 17, 1925	June 18[1]	Dropped			3	19	13	81				
	do	July 2[1]	do					42	76	13	24		
	do	July 14[2]	do							8	14	51	86
2	do	June 18[1]	Picked			12	92	1	8				
	do	July 14[2]	do					3	17	9	50	6	33
3	June 15, 1926	June 16[1]	Dropped			2	10	18	90				
	do	June 30[1]	do	487	33.0			52	32	110	68		
	do	July 13[2]	do										100
4	July 14, 1926	July 15	Small early drops.	205	39.0			10	15	33	52	21	33
5	do	do	Medium-sized drops.	281	46.0			45	36	79	64		
6	do	do	Recent drops	100	24.0			24	100				
7	Aug. 9, 1926	Aug. 10	Dropped	205	6.8			7	54	4	31	2	15
8	June 15, 1926	June 16[1]	Picked			26	58	19	42				
	do	July 1[2]	do					52	84	10	16		

[1] Part. [2] Remainder.

On account of the extended egg-laying period it is of considerable interest to find out the probable proportion of eggs deposited at different times as the season advances. The heaviest drop of apples comes during a period of a few weeks in June, several weeks after the blossoming period. The proportion of fruit falling during the June drop is quite large except when very few blossoms have set. In 1926 the set of fruit was average or better and the June drop was normal. The apples in lots of 3, 4, 5, 6, and 7 (Table 1) were collected from the same rows of trees and show by the number infested something of the amount of egg laying at the time they fell. Lot 3, which was 33 per cent infested, included the first June drop prior to June

15. Lots 4, 5, and 6 were all collected July 14 and were segregated by size. Lot 4 included the small withered apples which probably fell soon after the middle of June; lot 5 included larger withered apples which probably fell in late June or early July; lot 6 contained only larger fruit which could not have been off the trees much more than a week. The degree of infestation in the three lots was 39 per cent, 46 per cent, and 24 per cent. Lot 7, collected August 9, contained apples which appeared to have fallen so recently that the curculios could not have emerged from them. They were only 6.8 per cent infested.

The percentage of infested apples in lot 6 is still quite high, but the number of apples that dropped in July must have been considerably reduced. The number dropping between the middle of July and August 9 must certainly have been small compared to the June drop. Of the set fruit which falls before the approach of maturity it is probably safe to say that three-fourths drops before the 1st of July in a normal year. Since the degree of infestation is greater before that date it seems probable that 80 per cent of the whole brood of apple curculios are on the ground by July 1. All but a small fraction of the remainder probably appear before the middle of July.

HABITS OF THE ADULTS

On account of the peculiar shape and protective coloration of the beetles, they are extremely difficult to find until the eye has become trained to detect them. They have a habit of posing with beak elevated when anything approaches them (fig. 5), and while standing perfectly motionless they are easily mistaken for a loose bud scale or a cluster of dried petals. If a moving object comes close to them they will drop. The readiness with which they crawl away or take to flight would make a tree-jarring method of control as sometimes used against the plum curculio impractical for this insect.

The adults feed mainly on the fruit, consuming large quantities, especially the females when excavating the egg cavities. To a certain extent the bettles will feed on leaves, making small holes about one-thirty-second of an inch or less. They feed on the cambium of green spurs in much the same way as on the fruit, by enlarging the cavities beneath the surface. This type of feeding was observed in the case of caged insects and its effect can be noted on the orchard trees.

HIBERNATION

An effort was made to find the adult apple curculios in winter to determine where their favorite hibernation quarters are. All search failed of results. Another attempt to solve this problem was made by confining beetles in a large cage under an orchard tree. On August 11, 1926, 80 adult curculios were placed in a cage which contained an old partly decayed apple stump with loose bark, a piece of burlap, dead leaves, matted grass, and a number of apples.

On October 25 the cage was examined and a careful search was made under loose bark, under leaves, and in the upper soil. Fifteen living and two dead curculios were recovered. All were found close to the surface of the ground under matted grass, and most of them were near the door where they had been put in. Apparently they

had not moved about much after August 11. What became of the other 63 beetles is difficult to say, but most of them were probably overlooked in the search. The cage was large, and, as stated before, this insect is difficult to find. None of the apples in the cage had been fed upon.

RESISTANCE OF LARVAE AND PUPAE TO HEAT

One of the control measures usually recommended for the apple curculio is to expose the fallen fruit to sunlight by raking it between the rows or by pruning the trees to let in more sunlight. It was thought advisable to test the effectiveness of sunlight as a killing agent.

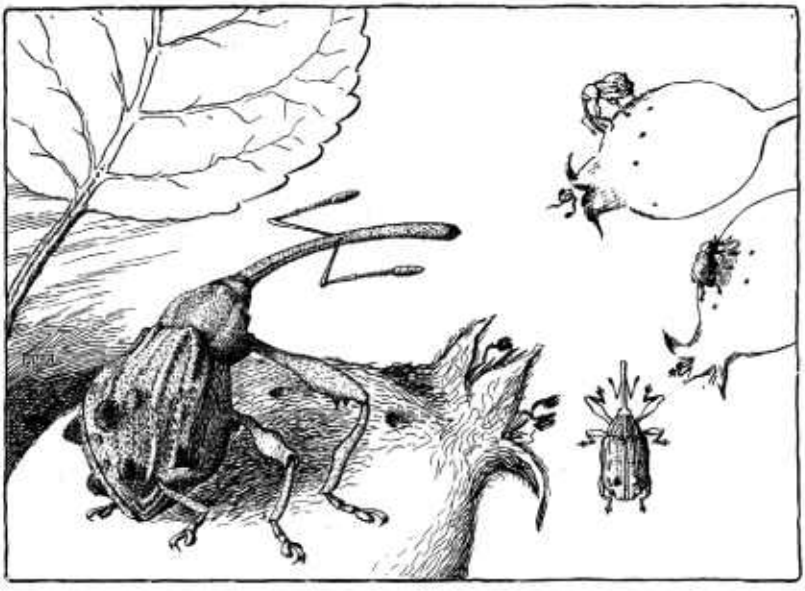

FIG. 5.—Adult apple curculio

On a very hot day a number of infested dropped apples were exposed to the sun by spreading them out in a single layer in a flat pan. The temperature under a tree at the time ranged from 103° to 103½° F. On the surface of the ground in the sun the temperature was 135°; the surface of the pan was 125°–126°, and when the bulb was placed within the cavity of one of the apples the thermometer registered 118° to 120°. The last was probably about the temperature to which the insects were exposed.

After 15 minutes' exposure to the sun, six of the apples were removed and opened. Four larvae were found dead and two alive. After a half hour's exposure another lot was removed and 10 larvae and 5 pupae were found dead. The remaining 9 larvae and 5 purpae were exposed for an hour and all died. As a check, a number of apples from the same lot were examined without exposure to the sun. One dead and apparently parasitized larvae was found among 17 living larvae and 2 pupae.

From this experiment it seems improbable that the insects could live long if the apples were removed from under the trees and exposed to direct sunlight on cultivated ground. Cultivation after the apples have dropped would tend to protect the larvae, however, by shielding them from direct sunlight. Experiments with buried apples showed that the beetles could mature and come out from 2½ inches of loam soil, both loose dry soil and soil that had been water-soaked and dried. Some curculios escaped from 6 inches of soil but ordinary disking probably would not bury apples more than 2 or three inches.

PARASITISM

Parasitism could not have had any marked effect on the degree of infestation of the orchards at Mitchellville. In 1925 only one parasite was discovered in all the material examined. In 1926 the parasites had apparently increased to some extent. In one lot of 235 curculios in various stages, 17 (7.2 per cent) were parasitized. The parasite was a small chalcid fly which was identified by A. B. Gahan as a species of Eurytoma, probably undescribed. The larvae feed externally on the curculio grub. Usually only a withered carcass is found with a full-grown parasite larva. The first adult parasite appeared on July 20, 1926.

CONTROL EXPERIMENTS

Experiments on the control of the apple curculio were all carried on at the Apple Grove Orchards south of Mitchellville, Iowa, or with insects obtained from there. The three orchard plots, separated by intervening field and woods, are described as follows: (1) three acres, 90 per cent Ben Davis variety, woods on three sides; (2) 17 acres, 40 per cent Ben Davis, woods on three sides; (3) main block of 24 acres, 30 per cent Ben Davis, with a spur of 3 additional acres on the southwest corner, 70 per cent Ben Davis. The main block is surrounded by open fields but the spur is directly across the road from a wooded pasture. The apple curculio became severe in orchard No. 2 near the timber about 1915. It spread slowly and by 1925 was most severe in orchard No. 1 and the 3-acre spur of No. 3. The main block of No. 3 remained relatively free but was showing an increase in infestation. The location of the original points of attack would indicate that the curculio came into the orchards from the wood lots, or found more favorable conditions near the woods. The increase in infestation was not due to an overflow of curculios breeding in wild crab apples or hawthorns, however, for such trees had been removed from all woods, except on the north side of orchard No. 1, where the land was under different ownership.

In these orchards the most extensive injury has been done to the Ben Davis variety. A few bearing Delicious in orchard No. 2 have been about as severely injured. Grimes Golden and Willow Twig have been injured to some extent, and Jonathan, Stayman, and Winesap have been slightly injured. Northwestern Greening remained free from injury even when adjacent to the worst infested trees.

Attempts to control the apple curculio by applying an extra lead arsenate spray between the "calyx" and "first-cover" sprays were unsuccessful. The orchards were disked until mid-July, trees were pruned for more sunlight, adjacent fence rows were cleaned up, and

woodland west and north of orchards 3 and 4 were thinned out and pastured. When hogs were available they were turned into the orchard, but this was done only in the spring. These measures resulted in the practically complete elimination of the plum curculio in the orchards but had no lasting effect on the apple curculio. After nine years the latter was more destructive than ever.

In the spring of 1925 an experiment was begun in which hogs were used more intensively. During April and May the orchards were cultivated with a 14-foot extension disk to eliminate as much grass as possible. Pigs weighing from 65 to 90 pounds removed most of the remaining grass under the trees by early June. They then began to feed on the fallen green apples. Until the June drops were well cleaned up in July almost no grain was given them. The number of pigs and the period of pasturage are shown in Table 2 for each orchard.

TABLE 2.—*Number of pigs and period of pasturage in the different orchards in 1925 and 1926*

Orchard No.	Number of acres fenced	Number of pigs pastured in 1925	Period of pasturage in 1925	Number of pigs pastured in 1926	Period of pasturage in 1926
1	3	15	June 25–Aug. 30	0	
2	17	50	June 6–July 20	45	Mar. 1–June 20.
3	3	15	Apr. 1–June 25 and 5 or 6 days in July.		
	24			45	June 20–July 20.

In considering the effect of control measures one must bear in mind that the use of pigs is directed against the new generation of curculios and has practically no effect on the early injury to the fruit. To some extent, then, the amount of injury in the orchard in 1925 could be considered a check on the control obtained for the following year.

The dropped apples were cleaned up very thoroughly in the 3-acre spur of orchard No. 3. Counts of injured and uninjured fruit in this block were made on August 25, 1925. Apples on the lower branches only were counted. On 13 trees there were 1,751 apples. Of these, 1,232 showed injury and 519 showed none; that is, 70 per cent of the fruit was injured. The injury to fruit on individual trees ranged from 40 to 95 per cent.

A very small portion of the injury was caused by the late feeding of the new generation of beetles. This late type of injury had heretofore been quite important in the orchard and added considerably to the total loss.

On July 14, 1926, counts were made in the same part of the orchard. A total of 5,246 apples were examined and of these only 93 (1.77 per cent) showed any injury by apple curculio. The fruit injury of individual trees ranged from 0 to 4.7 per cent.

Orchard No. 1, which had also been thoroughly pastured by hogs in 1925, yielded 500 bushels of apples in 1926, the first paying crop that had been harvested from that block for six years. No counts of injured fruit had been taken in this orchard, but the improvement in the crop was as marked as in No. 3. In 1926 dropped apples containing larvae were scarce, whereas in 1925 an abundance of larvae were obtained by picking up dropped apples at random.

In 1925 orchard No. 2 was only a little less infested than No. 1 and No. 3. A small plot in the southeast corner, separated from the remainder by a gully, was very thoroughly freed from drops in 1925 due to the presence of a wallow in the gully which kept the pigs in that part of the orchard. In 1926 these trees were practically free from curculio injury.

Farther back in the orchard the drops were not so well picked up, and in 1926 the injury in this part was estimated as a check on the figures taken in orchard 3, where the clean-up had been thorough. On August 9, 1926, counts made of injured and uninjured fruit on five trees gave a total of 278 injured and 425 uninjured, or 39 per cent injured. The percentages of injury on the five trees were 16, 28, 32, 43, and 68. Thirty-seven per cent of the dropped apples collected in the same part of the orchard during the season were infested.

The experiments with pasturing pigs were sucessful from a business standpoint. A cost account kept for the two years showed that this method of control was more than economical, for it actually netted a profit. In 1925 each pig returned a net profit of $10 above cost and feed and in 1926 a net profit of $7.65. These figures include the cost of vaccination but not the item of labor in handling or feeding the pigs, nor the cost of fencing, which in his case was small.

A few experiments were tried to determine the possibility of poisoning curculios with arsenical sprays and dusts. Five curculios were caged on a small branch sprayed with calcium arsenate at the strength of 1 pound to 50 gallons of water plus 3 pounds of lime. Five curculios were caged on a second branch sprayed with the same material with the addition of enough molasses to give a slightly brown color. None of the insects showed any sign of poisoning and continued to feed.

On June 5, 1925, 25 curculios were placed in each of three different wire cages over branches of a tree. One branch was thoroughly dusted with calcium arsenate after the cage was in place, so that some of the powder settled on parts of the cage. Another branch was sprayed with the same material at the rate of 1 pound of the poison to 50 gallons of water; the third was untreated. On June 9, the cages were examined but not opened. The one with the dusted branch had 17 dead curculios in the bottom, the one with the sprayed branch had 4 dead, and the check had 1 dead. On June 10 the first two cages were removed. In the cage with the dusted branch 20 curculios were dead and 3 alive, leaving 2 unaccounted for; in the cage with the sprayed branch 4 were dead and 21 alive; in the check cage only 1 was dead. Apples on the check and sprayed branches were riddled with punctures, while those on the dusted branch showed no signs of having been fed upon.

On June 12 the same experiment was repeated in the greenhouse. A small branch was sprayed with calcium arsenate, 1 gm. in 400 c. c. of water, of which about one-fourth was applied. Another branch of similar size was dusted, using 1 gm. of calcium arsenate applied with a small hand duster. Cages were fitted over the branches and 10 curculios were released in each before the sprayed branch was quite dry. On June 15 all curculios were alive and the fruit had many feeding punctures. From the fact that the insects lived so long after the treatment it was apparent that the poison had had little or no effect on them. The success of the dusting in the previous

experiment was possibly due to the large quantity used or to the deposit in the bottom of the cage where the curculios may have crawled about.

As a field experiment, a number of trees were dusted with calcium arsenate, using a rotary fan type of hand duster from a stepladder. On July 2, five days after treatment, the lower branches were shaken over a tarpaulin. The number of cruculios collected from the dusted trees were 0, 1, 2, 4, 8, 2, 9, 0, 0, 3. All except one were alive. Only two untreated trees were shaken, yielding a catch of 2 and 1. A few weeks before, 20 or 30 curculios could have been collected easily from one tree. It seemed evident that the small number taken from the treated trees was not due to poisoning, but to natural dying off at this time. The new generation had not yet come out in quantity.

CONCLUSIONS AND RECOMMENDATIONS

The experiments with the use of poisons, supplemented by the observations of Clark in the orchard, show that there is little hope of controlling the apple curculio with arsenical poisons. Crandall (*4*) reached the same conclusion after feeding apple curculios on fruit treated with Paris green.

The experiment with the use of hogs has shown that five pigs per acre can, if properly handled, clean up the early dropped apples in an orchard and thus control the apple curculio. The critical time for such control, as shown by the seasonal history data, is from the middle of June until about the middle of July. Pigs weighing about 100 pounds are the best size for this purpose since they do not tramp down the low branches. They do not feed from the trees to any great extent if the apples are more than a foot above the ground.

The pigs prefer green apples to grass, and they can find the apples more readily if the orchard is cultivated before the middle of June. No cultivating should be done after the apples begin to drop.

Pigs should be encouraged to frequent parts of the orchard containing the varieties most subject to injury by the apple curculio. This can be done by throwing there whatever extra feed is necessary. The best results will be obtained if the pigs are kept on slightly short rations.

The greatest drawback to keeping pigs in the orchard is that they injure the trees by rooting or by rubbing against the trunks. When small pigs are used for only a month such injury is negligible. Pigs should not be oiled while they are in the orchard, on account of possible injury to the trees from oil rubbed into the bark.

It is sometimes difficult to obtain pigs at the time when the pasturing should be done. The fruit grower should therefore anticipate this need and buy them during the winter and spring whenever they can be obtained most economically.

SUMMARY

Both the early and late injuries to apples caused by the apple curculio show certain characteristics which distinguish them from similar injuries by the plum curculio.

Egg punctures formed by the apple curculio are closed up rapidly by the growth of the apple. Larvae survive and mature only in

apples which drop from the trees. There is no evidence to indicate that the presence of eggs or larvae causes dropping.

Probably 80 per cent or more of the total new brood of curculios likely to survive will be found on the ground in the egg, larval, or pupal stage by July 15. Adults of the new generation begin to emerge about the 1st of July.

Curculios in immature stages in the apples are killed by exposure to sunlight on bare ground.

Adults are able to emerge when apples are buried under a few inches of soil.

The apple curculio can not be readily controlled by arsencial sprays, orchard cultivation, or the destruction of wild host plants.

Dropped apples may be effectively destroyed and severe infestations of the apple curculio controlled by confining a sufficient number of hogs in the orchard during early summer.

LITERATURE CITED

(1) BROOKS, F. E.
1910. THREE SNOUT BEETLES THAT ATTACK APPLES. W. Va. Agr. Expt. Sta. Bul. 126, p. [105]–124, illus.

(2) CLARK, R. M.
[1926]. REPORT OF PROGRESS ON THE CONTROL OF THE APPLE CURCULIO. Iowa State Hort. Soc. Rpt. (1925) 60: 39–42.

(3) ———
[1927]. FURTHER REPORT ON THE CONTROL OF THE APPLE CURCULIO. Iowa State Hort. Soc. Rpt. (1926) 61: 33–35.

(4) CRANDALL, C. S.
1905. THE CURCULIO AND THE APPLE. Ill. Agr. Expt. Sta. Bul. 98, p. 467–560, illus.

(5) GILLETTE, C. P.
1890. THE APPLE CURCULIO. Iowa Agr. Expt. Sta. Bul. 11: 492–494, illus.

(6) PETCH, C. E.
1925. THE APPLE CURCULIO AND ITS CONTROL IN QUEBEC. Canada Dept. Agr. Ent. Branch Circ. 36, 4 p., illus.

(7) RILEY, C. V.
1871. THE APPLE CURCULIO. *In* Third Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri, p. 29–35, illus. Jefferson City, Mo.

(8) WATSON, J. R.
1921. NOTES ON SOME FLORIDA WEEVILS. Fla. Ent. 4: [33]–35.