Periodical Cicadas, *Magicicada* Spp., as Pests in Apple Orchards

D. W. HAMILTON, Entomology Research Division, Agric. Res. Serv., U.S.D.A., Vincennes, Ind.[1]

Introduction

Studies pertaining to periodical cicadas, *Magicicada* spp., date back to 1666 when Henry Oldenburg reported on their occurrence and damage. They are a native North American species that have attracted the attention of entomologists, other scientists, and nonscientists alike because of their comparatively large size, long subterranean life, and regular periodical appearances. The most complete account of periodical cicadas known to the author is one prepared by C. L. Marlatt in 1907. At that time Marlatt referred to *Magicicada septendecim* (L.) as, "undoubtedly the most anomalous and interesting of all the insects peculiar to the American continent."

Three excellent papers on periodical cicadas have been presented before this group in the past decade—Deay (1953), Jacobs (1954), and Young (1958). The object of this paper is to report on studies and observations of this pest and its control in apple orchards and to present evidence that the feeding of the nymphs on the roots of apple trees reduces the ability of the roots to function normally to the detriment of the development of the trees. The studies and observations reported herein were made in Orange and Duchess Counties, New York, in 1945 (Brood 2), Knox County, Indiana, and Lawrence County, Illinois, in 1950 (Brood 23), Brown and Fountain Counties, Indiana, in 1953 (Brood 10), and Brown County, Indiana, in 1957 (Brood 14).

Broods Occurring in Indiana

Marlatt (1907) brought together all available information on the different occurrences of periodical cicadas and classified them as representing 30 broods. Marlatt (1907), Deay (1953), and others have pointed out the existence of two races, *septendecim*, which takes 17 years to complete its life cycle, and *tredecim*, which takes 13 years. Marlatt placed broods 1 through 17 in the *septendecim* race and broods 18 through 30 in the *tredecim* race. The 17-year race of the cicada is generally confined to the States in the northern area of infestation and the 13-year race to the southern area. Some workers ascribe the difference in the longevity of broods to differences in temperatures. Young (1958) and others showed that there were also other plausible explanations for the difference in the life cycle of the two races. Both races have been recorded from Indiana. Seven of the Indiana broods have been credited to the 17-year and two to the 13-year race. At least two of them are probably no longer present in

---

1. Acknowledgements are made to J. L. Brann, Jr., New York Agricultural Experiment Station, who cooperated in the experiments during 1945 in New York. J. M. Ferris, Purdue University, for sampling and determining the abundance and species of nematodes present in the Dixie Orchard soil, J. R. Shay and Zofia Maciejowska, Purdue University, for making the studies reported under the section pertaining to root rots and viruses, and D. L. Shankland, Purdue University, for determining the weights and oxygen consumption of the nymphs.

Indiana. A publication in press by Alexander and Moore (1962) shows that the former identification of periodical cicada as a single species (*Magicicada septendecim* (L.)) with the two races, *septendecim* and *tredecim*, is erroneous and that six different species may be involved. Three of these have a 17-year cycle and three have a 13-year cycle.

Types of Injury to Apples

In the past reports of injury by periodical cicadas have been confined to the direct and indirect effects of the slits made by the adult females during the egg-laying process. These effects include splitting of the branches, breaking off of bearing wood, stunting and loss of vigor of effected trees, and weakening of trunks and scaffold limbs on young trees (Marlatt 1907). Peach, pear, and apple trees and grapevines have been reported as being damaged more than forest or shade trees. Young trees usually suffer more damage than old trees. However, the act of oviposition is not confined to any special species of plant or type of wood. In the Hudson Valley in 1945 unprotected young apple and pear trees up to 7 years old were a complete loss. In many instances 22-year-old trees had more than 95 percent of their terminals ruined. An injured terminal generally broke off 1 to 1½ feet from its tip. Cherry trees were less affected than apple trees. In one nursery oviposition punctures were noticed in the stems of annual lilies, and on one farm the handle of a pitchfork bore several oviposition marks extending down from the apple limb against which it was standing. The severity of attack is not readily appreciated prior to seeing a heavily infested orchard at the peak of adult activity. Adult emergence holes in one orchard near Vincennes, Indiana, averaged 20,000 under each apple tree in 1950.

Prior to the emergence of adults near Vincennes in 1950 and Nashville, Indiana, in 1953, it was observed that mature apple trees in certain orchards, especially in the Dixie and Bessire orchards, where heavy infestations of cicada nymphs were present, were not responding to heavy fertilization or other practices that stimulate growth and assure vigor in apple trees. They appeared to be in poor physical condition. Although it was suggested that the cicada nymphs feeding on the rootlets were responsible for this condition, positive evidence was not available. The symptoms were those characteristic of starving trees and could have been due to any one or more of several causes. For example, trees injured by the tile-horned prionus, *Prionus imbricornis* (L.), have been observed to show similar symptoms. Nematodes could have been present in sufficient numbers to have had a similar effect. Examination of the roots of the apple trees showed the presence of galls, which could be attributed to the woolly apple aphid, and the absence of root hairs that help feed the trees. Large numbers of cicada nymphs were present. The trees in the Dixie and Bessire orchards recovered from their decline in 1950 and 1953, respectively, following the emergence of the adult cicadas, but tree decline was apparent again by 1957 in the Dixie Orchard and in 1959 in the Bessire Orchard, especially in the latter. Adult populations in the Dixie Orchard were partially killed off with TEPP sprays prior to their egg laying in 1950, so that the subsequent nymph population was not as large as previously. However, another block in the Dixie Orchard that was unsprayed was showing severe decline.

In order to definitely prove the exact cause of the tree decline, scientists representing different disciplines worked as a team. These included the author, representing entomology, J. M. Ferris, a nematologist, and J. R. Shay and Zofia Maciejowska, plant pathologists, to whom the author is grateful for their valuable assistance in determining whether or not root rots or viruses were present.

Determination of Nematodes Present

In order to determine whether plant parasitic nematodes could be the cause of the tree decline in Dixie Orchard No. 5, Vincennes, Indiana, soil samples were collected within the branch-drip area of six Rome apple trees. A 500-cc. aliquot of soil from each sample was processed. Nematodes of the genera, *Paratylenchus*, *Pratylenchus*, *Heliocotylenchus*, *Tylenchorhynchus*, and *Xiphinema*, were found in the samples. The numbers of *Xiphinema americanum* recovered varied from 15 to 130 per sample with an average of 32. *Pratylenchus* spp. were found in numbers ranging from 0 to 20, with an average of 6 per sample. As none of the known or suspected plant-parasitic nematodes were obtained in consistently high numbers from the samples, it was concluded that nematodes were probably not the primary cause of the tree decline.

Investigations for Root Rots and Viruses

Removal of the block of Rome apple trees in the Dixie Orchard in May, 1960, made it possible for a team of plant pathologists to make a careful examination of the root system from approximately 100 mature trees.

All of the downed trees were examined for evidence of root rots, for xylem and phloem streaking in both the fibrous feeder and large transport roots, and for pitting in the bark of the seedling root portions and in the scion top that might indicate the presence of a virus. No evidence of root or lower stem abnormalities that might indicate the presence of a fungus or a virus disease as the cause of the general debility of the trees was found.

It was the pathologists' conclusion that the debility of the trees was due to some cause other than a root-attacking pathogen or a known virus.

Other Injury Present

Numerous nodules of the woolly apple aphid, *Eriosoma lenigerum* (Haus), were present on the roots in both orchards, but this injury was no more abundant than on the roots of normally growing, similarly aged apple trees in other orchards in the area.

Periodical Cicada Nymphs Present

Whenever diggings were made in the soil under the trees in these orchards during the 3 years covered by this study, large numbers of cicada nymphs were found in the area 2 to 18 inches below the surface. A study of the burrows in a plowed area in a portion of the Dixie Orchard where trees had been removed because of their severe decline showed that periodical cicada nymphs were concentrated in patterns that followed the root system of the trees. Decline in both orchards was more evident the seventh to eighth year after the nymphs had hatched, a period that coincides with the completion of the fourth and final-growth instar for the

nymphs and a time when their feeding would be the greatest. Nymphs from these diggings varied in size. Most of this variation was attributed to the presence of both the large and dwarf *(cassinii)* forms of the cicada (Deay 1953) since the history of adult emergence did not indicate an overlapping of broods. Weights of the larger nymphs ranged between 0.461 and 0.748 grams each. Their average oxygen consumption rate was 607 cubic millimeters of oxygen per gram per hour at 28 degrees C. This is a relatively slow rate for respiration when compared with the average 1370 cubic millimeters of oxygen per gram per hour for insects, worms, and spiders that inhabit the forest soil (Krogh 1941).

Diggings were made under the apple trees to determine the density of the nymph population. Digging was done by removing cores of dirt 6 to 8 inches in diameter with a tiling spade. Three cores were removed from under the branches of each tree. In June 1959, 30 nymphs per square foot of soil surface were found under the apple trees in the Dixie Orchard, or about 21,000 feeding on the roots of each tree. The largest number of cicadas taken under a square foot of soil was 64. In November 1960, 104 nymphs per square foot were found under trees in the Bessire Orchard at Nashville, or about 72,800 under the spread of each tree. The largest number of cicadas taken under a square foot of soil was 122. Dean (1959) reported 70 nymphs per square foot feeding on apple roots in Ulster County, New York, where tree decline was present. Banta (1960) investigated conditions that were causing severe orchard decline in Ohio and found as many as 45 cicada nymphs per square foot. Soil and leaf analyses did not show any specific element deficiency. Examination of the roots showed all small rootlets smaller than a pin to be brown or dead; no healthy ones were found. Older portions of the roots were white and alive. These reports substantiate the findings in Indiana.

It can be concluded from these studies that the nymphs of the periodical cicada feeding on the roots of apple trees cause severe tree decline that reduces growth and length of life of the trees, and the yield and size of apples produced. Since the nymphs feed underground and the symptoms are those of starvation, the damage they do has oftentimes been improperly attributed to other causes.

Control Investigations

Adults

The author's first attempt to control this pest was in 1945 in eastern New York where large-scale tests of DDT, ferbam, phenothiazine, aluminum sulfate with lime, ryania, and lead arsenate insecticides were applied for control of the adults (Hamilton 1953). No practical control was obtained. Cutright and Parks (1949) reported control with TEPP. Tests made in 1950 by Hamilton (1953) substantiated these findings and also indicated that Metacide (mixture of 6.2% parathion, 24.5% methyl parathion, and 2.7% related organic phosphates) was partially effective. However, it was found that TEPP had to be applied almost daily to be effective, partly because of continued emergence and migration of adults into the orchards from neighboring trees and woods. The Bessire Orchards are relatively narrow and lie along the ridge of hills surrounded by the Yellow Wood Forest. In 1953 laboratory tests of high concentrations of endrin, dameton, Strobane (terpene polychlorinates (65% chlorine)),

methyl parathion, Metacide, and pyrethrins were made to control the adults. Sprays were applied directly to the insects. Only the pyrethrins were considered effective enough for field use. In tests in the Bessire Orchard, a 2-percent formulation of pyrethrins at 8 ounces in 100 gallons of spray was ineffective. Adults knocked down recovered rapidly. TEPP (40 percent) at ⅓ pint and (20 percent) at 10 ounces in 100 gallons was effective in knocking down the adults, but others moved into the trees rapidly. Mr. Bessire failed to obtain satisfactory control in a 50-acre block in which he applied about 10 gallons of TEPP spray per tree. The most reliable method of protecting young trees from injury continued to be a covering made of cheesecloth or netting during the egg-laying period.

Graham and Krestensen (1957) have reported that Sevin (1-naphthyl *N*-methylcarbamate) is effective against the adults. A single application gave control for as long as 1 week. Sevin has not been used in Indiana since no major emergence of adults has occurred since it has been available.

Nymphs

No practical measures for control of the nymphs appear in the literature. Large-scale soil treatments, with phorate granules and sprays, Nemagon (1,2-dibromo-3-chloropropane), Phosdrin (1-methoxycarbonyl-1-propen-2-yl dimethyl phosphate), American Cyanamid 18133 (*O,O*-diethyl 0-2-pyrazinyl phosphorothioate), dimethoate, and Dow M-712 (1,2-dibromo-3-chloropropane) were made in May 1959. After the surface of the soil had been culticut, materials were applied with a high-pressure spray and then watered in, with 500 gallons of water for each 700 square feet treated. Nymph counts made June 24 showed that none of the materials used gave satisfactory control.

In 1960 and 1961 soil treatments were applied to trees in the Bessire Orchard that covered an average of 700 square feet. In 1960 Sevin was applied at the rate of 5 pounds per tree, as follows: (1) A 10-percent granular formulation was hoed into the soil and (2) an 85-percent wettable powder was mixed in 100 gallons of water and injected to a depth of 12 to 24 inches at the rate of 5 gallons in each of 20 locations. Application was made with an injector described by Cleveland (1960). Some injections were also made 6 inches deep and 6 inches apart with a commercial injector (Fumigum),[2]

In 1961, by means of the injector described by Cleveland, 20 ounces 47.5-percent phorate emulsifiable concentrate, 20 pounds 50-percent Sevin wettable powder, and 25 million DD-136 nematodes[3] in 100 gallons of water per tree were applied to the soil beneath the spread of branches, each to a single tree on May 18. The nematode-treated tree and an additional tree each received a nematode treatment on June 27 that contained 53 million nematodes in 121 gallons of water. In addition, one tree received a surface application of 25 million nematodes in 100 gallons of water on May 18. Diggings made on three occasions after application showed that phorate injections killed more periodical cicada nymphs than the other

2. Mention of this proprietary product does not necessarily imply its endorsement by the U. S. D. A.

3. The DD-136 nematodes used in these investigations were reared and supplied by S. R. Dutky, Entomology Research Division, ARS, U. S. D. A.

test treatments; however, none of the treatments were sufficiently effective to warrant recommendation.

Marshall (1962), in a manuscript presented at this meeting, reported substantial control of the nymphs with demeton.

Literature Cited

ALEXANDER, R. D., and T. E. MOORE. 1962. The Evolutionary Relationships of 17-year and 13-year Cicadas, and Three New Species (Homoptera: Cicadidae: *Magicicada*). Misc. Publ. Mus. Zool. Mich., (in press).

BANTA, ELDON S. 1960. Apple Orchard Decline. Proc. Ohio State Hort. Soc., 113th Annual Meeting: 88-90.

CLEVELAND, MERRILL L. 1960. Soil Injection as a Means of Applying Systemic Acaricides to Fruit Trees. Jour. of Econ. Ent. 53(1): 144-146.

CUTRIGHT, C. R., and T. H. PARKS. 1949. Combatting the Periodical Cicada with Insecticides. Jour. Econ. Ent. 42(2): 359.

DEAN, R. W. 1959. Weekly Report of Insects, Diseases and Crop Development. Ext. Serv. Dept. of Entomology and Plant Pathology. Cornell University, Ithaca, New York, June 8: 60.

DEAY, HOWARD O. 1953. The Periodical Cicada, *Magicicada septendecim* (L.) in Indiana. Proc. Ind. Acad. Sci. 62: 203-206.

GRAHAM, COSTELLO, and ELROY R. KRESTENSON. 1957. A Residual Spray for Control of the Periodical Cicada. Jour. Econ. Ent. 50(6): 713-715.

HAMILTON, D. W. 1953. Notes on the Activity and Control of the Periodical Cicada, 1945 and 1950. Jour. Econ. Ent. 46(2): 385.

JACOBS, M. E. 1954. Observations on the Two Forms of the Periodical Cicada. *Magicicada septendecim* (L.). Proc. Ind. Acad. Sci. 63: 177-179.

KROGH, A. 1941. The Comparative Physiology of Respiratory Mechanism. Phila. Univ. Press.

MARLATT, C. L. 1907. The Periodical Cicada. U. S. D. A., Bur. of Ent., Bul. 71:1-181.

MARSHALL, G. EDWARD. 1962. Studies on the Control of the Periodical Cicada in Apple Orchards. Proc. Ind. Acad. Sci. for 1961. 71: 114.

OLDENBURG, HENRY. 1666. Some Observations of Swarms of Strange Insects and the Mischiefs Done by Them. Philos. Trans. London 1(8): 137.

YOUNG, FRANK N. 1958. Some Facts and Theories About the Broods and Periodicity of the Periodical Cicadas. Proc. Ind. Acad. Sci. 68: 164-170.