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Biology and Control of the Apple Redbug

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Apples Injured by the Apple Redbug

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ABSTRACT

TWO species of insects, *Heterocordylus malinus* and *Lygidea mendax*, were originally described as pests of apple in western New York orchards and given the common name of apple redbugs. Of these, only *Lygidea mendax* is of general economic importance and distribution and this bulletin is concerned exclusively with this species.

The injury induced is caused by the feeding of the bugs on the fruit and foliage. Injury to foliage is slight and takes the form of red or brown stippling. Injured fruits exhibit russeted areas of variable extent and may also be badly deformed. The amount of injury varies widely from tree to tree and from orchard to orchard. The insect is widely distributed but only occasionally occurs in destructive numbers thruout an entire planting.

The winter is passed in the egg stage in the bark and wood of twigs and watersprouts. The nymphs hatch out while the trees are blooming and grow thru five immature stages before becoming adults. Egg laying occurs during June and July, with the adults dying by the end of the latter month. There is one generation a year.

Control may be effected by killing the eggs with petroleum oil sprays applied in the dormant or delayed dormant stages, or by means of contact sprays or dusts applied at the calyx stage, or shortly thereafter, to kill the nymphs before they commence feeding on the fruit.

Control by natural enemies is slight. The most common parasite found was one which attacked less than 2 per cent of the eggs.

BIOLOGY AND CONTROL OF THE APPLE
REDBUG

R. W. DEAN AND P. J. CHAPMAN¹

INTRODUCTION

Two species of insects, commonly known as apple redbugs, were originally reported to cause injury to the fruit in New York State orchards (6).² One of them, the so-called dark apple redbug, *Heterocordylus malinus* Reut., was later found to be of minor importance as a pest. During the 14 years' investigations conducted in the Hudson Valley area and 7 years' in western New York here reported, it has seldom been found and then only on wild hosts or neglected apple trees where it usually was associated with much larger numbers of the more common species, *Lygidea mendax* Reut. This latter insect is responsible for most, if not all, of the "redbug damage" in commercial orchards of the State. Formerly known as the "false apple redbug" or "light apple redbug", its present approved common name of "apple redbug" (14) indicates its precedence over the dark species as a pest. The biology and control of *Lygidea mendax* is the subject of this bulletin.

Redbug injury had been observed as early as 1896 by Slingerland working in western New York, altho the first report on these insects and their control was given in 1911 by Crosby and Wilson (6). Within a few years, the "false" apple redbug was found in Connecticut (2), Pennsylvania (9), and Ohio (11). Its occurrence is general thruout the eastern states and it is said to be most destructive in New York, New England, and southeastern Canada (13).

Under New York conditions, the apple redbug is widely distributed but varies greatly in abundance, some orchards being uninfested while others show injury ranging from light to severe. It may be confined

¹The writers were assisted at various times during these investigations by J. F. Schadt, Kieth H. Kelly, and Orion Clark. Thanks are due to the following fruit growers in whose orchards tests were conducted: P. M. Cornell, Poughkeepsie; A. T. Ogden, Kinderhook; Charles S. Wilson and Bruce P. Jones, Hall; Albert Bowman, Albion; and Ray Snyder, Albion.

²Refers to Literature Cited, page 41.

to certain orchards on a farm or even to a few trees within an orchard. The injury to untreated check trees in the experimental orchards used in our studies in the Hudson Valley from 1932 to 1944 (Table 1) has varied from 2.04 per cent to 29.68 per cent, with a 12-year average of 11.04 per cent. The most severely attacked orchard examined in that period was estimated to have 75 per cent of the fruit injured. There is

TABLE 1.—VARIATION IN PERCENTAGE OF INJURED FRUIT ON CHECK TREES IN HUDSON VALLEY EXPERIMENTAL ORCHARDS, 1932-1944.

YEAR	LOCATION	PERCENTAGE OF FRUIT INJURED	
		Average	Range
1932.....	Poughkeepsie	14.12	7.87-25.31
1933.....	Poughkeepsie	14.95	
1934.....	Poughkeepsie	19.33	13.22-24.09
1935.....	Poughkeepsie	8.24	3.85-32.14
1936.....	Kinderhook	5.62	1.62-20.85
1936.....	Kinderhook	2.16	0.17- 4.56
1937.....	Kinderhook	4.52	1.07- 9.10
1937.....	Poughkeepsie	8.78	7.07-10.18
1938.....	Kinderhook	29.68	12.75-46.47
1939.....	Kinderhook	9.85	6.23-18.67
1940.....	Poughkeepsie	13.45	0.44-27.10
1941.....	Poughkeepsie	3.86	0.00-16.90
1943.....	Poughkeepsie	17.98	11.17-28.93
1944.....	Poughkeepsie	2.04	0.35- 9.92
Average.....		11.04	

considerable variation from tree to tree within an infested orchard. Thus, individual check trees in the experimental plots have ranged from zero to 46.47 per cent fruit injury. The individual fruits exhibit scars which vary from some so few and so slight as scarcely to throw the apple out of grade to those involving the entire fruit and so deforming it that it is unmarketable. Fruit on the average infested tree shows all degrees of injury, but the very light scarring is relatively scarce, the bulk of the injury being the more severe type. (See frontispiece.)

During the course of these studies, the only host plant considered was the apple. The original host of the apple redbug, according to Cushman (8), appears to have been wild crab, *Pyrus* sp., and that of the dark apple redbug hawthorn, *Crataegus* sp. No variety is immune to attack, altho some, like Rome Beauty and Red Delicious, seem to be less affected than others, such as Northern Spy, Rhode Island Greening, and McIntosh. Most of our experimental work was done on McIntosh. In different orchards, different varieties may be at-

tacked, and there is some evidence of variation from year to year. Hence, varieties which may be lightly affected in one planting may be considerably injured in another.

INJURY

The injury induced by the redbug is caused by the feeding of the nymphs and adults on the fruit and foliage. The newly hatched bugs seek out the opening leaf buds and work their way down between the unfolding leaves to feed on the tender growing tissues. The terminals of the twigs are favored locations. The mouthparts of the redbug are of the sucking type, consisting of a slender beak composed of four bristle-like structures enclosed in a heavy sheath. The bristle-like parts together form a slender tube which pierces the succulent plant tissue and thru which the juices are sucked up. Apparently, a salivary secretion is introduced into the plant at the time of feeding, for a bright reddish dot forms around each feeding puncture within a few hours so that as the leaf develops, it exhibits a characteristic spotted appearance (Fig. 1). After the leaf reaches full size, the reddish areas die and turn brown. Part of the dead tissue may drop out, leaving numerous small, irregular holes in the affected leaf (Fig. 2). The injury to the foliage is never of a serious nature, but the appearance of the typical spotted terminal leaf clusters offers conspicuous evidence of the presence of the bugs. Counts of the number of infested terminals on treated and untreated trees have been used, in some tests, as the basis for determining the effectiveness of dormant or semidormant insecticidal treatments.

At about the time the insects are one-third grown and the small fruits have reached a diameter of $\frac{1}{4}$ inch, some bugs begin feeding on them. There is



FIG. 1.—REDDISH STIPPLING ON TERMINAL GROWTH CAUSED BY REDBUG FEEDING.

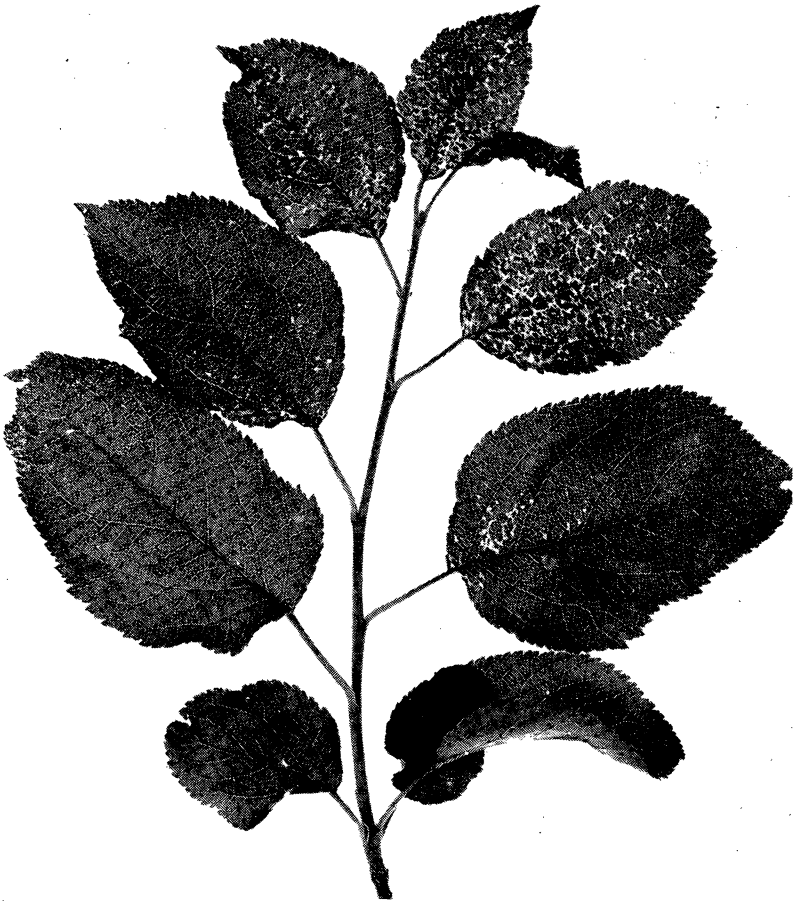


FIG. 2.—APPEARANCE OF RED BUG FEEDING ON OLDER LEAVES.

no indication that the fruits are deliberately sought out for attack, but bugs that had been feeding on the foliage of fruit clusters transfer their attentions to the growing apples. The first evidence of injury to the fruit is the development of brownish areas, having a "water-soaked" appearance, on the surface. The flesh of the apple shows no injury but, a little later, the skin exhibits shallow cankers where the brown areas first appeared, the epidermis dying and the surface of the cankered area becoming very rough (Fig. 3). Fruits which do not attain a diameter of at least $\frac{1}{4}$ inch are seldom attacked, but fruits which

do reach that size but which later fall in the June drop may be fed upon. There is no evidence that redbug injury causes normal McIntosh fruits to drop. All June drops in the 1938 experimental block were collected and examined. A total of 59,550 drops were picked up, of which 5,068, or 8.51 per cent, were injured by redbug. Of these, 23, or 0.04 per cent of the total, were apparently normal developing fruits. Similar data were obtained in 1939. In a total of 21,000 June drops, 881, or 4.20 per cent, were injured. Only five, or 0.02 per cent of the total, were apparently fertile injured fruits, comprising 0.57 per cent of the injured drops.

On the mature fruit the injury appears as brown, russeted areas with distinct margins, varying in size from small, more or less round spots, about 1/16 inch in diameter, to irregular areas covering more than half of the fruit (Fig. 4). The russeting is commonly accompanied by more or less gnarling which results from suppression of growth of the tissues around the feeding punctures (Fig. 5). The depressions vary from small, funnel-shaped dimples to deep irregular pits.

Another type of scarring found on the apple at harvest takes the form of irregularly shaped, more or less continuous russeted areas, not depressed or deforming the fruit (Fig. 4). Knight (12) attributes this type of injury to late feeding, while gnarling is supposedly caused by early feeding on the apple. This was not borne out by observations made on a test conducted in 1938 in which trees were sprayed at 2- to 3-day intervals from the time redbugs began hatching until the adults had disappeared. Theoretically, the trees sprayed early in the season should have shown a lower proportion of the "late" feeding injury and, the later the spray was applied, the greater the amount of shallow surface scarring there should have been. Actually, there were peaks of "late" injury on the trees sprayed April 29, May 13, 16, and 27, and July 8, and the amount of "late" injury was generally greater



FIG. 3.—YOUNG FRUITS SHOWING FEEDING INJURY (A) 10 DAYS AFTER CALYX AND (B) A FEW DAYS LATER.

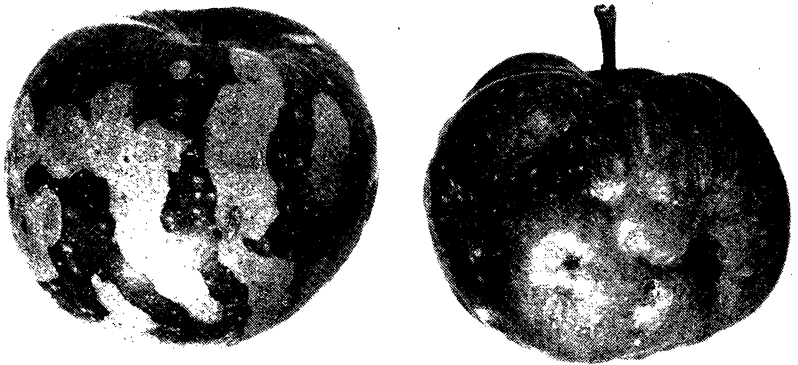


FIG. 4.—REDBUG INJURY TO MATURE APPLES.

Left, so-called "late feeding" scars confined to the surface of the fruit; *right*, deep scars attributed to "early feeding".



FIG. 5.—EXTREME DISTORTION OF A MCINTOSH FRUIT RESULTING FROM SEVERE REDBUG ATTACK.

than the average on trees sprayed before May 28 and less than average on those sprayed after that date. It seems more probable that the surface-russetting type of scarring simply represents a lighter type of injury. Both types of scars frequently occur on a single apple.

During some seasons, injury to the leaves may be out of all proportion to fruit injury. The insect is able to complete its development in a normal manner on trees bearing no fruit by feeding on the foliage or terminal twig-growth. Under certain conditions it may follow this practice to a large extent on fruited trees with the result that fruit injury is low altho the bug population is high. The factors which bring about this condition are not known, but it is probable that succulence of vegetative growth has some influence.

THE LIFE CYCLE

The observations on the life history of the apple redbug here presented have largely been incidental to control studies. The redbug does not lend itself readily to the rearing methods usually employed in

studying the life cycle of an insect, so our information was obtained in the following manner. A large cloth sheet was placed on the ground beneath a tree so as to cover the entire spread of the branches. The tree was then heavily oversprayed with nicotine sulfate or pyrethrum to knock down as many bugs as possible onto the sheet, from which they were collected and later counted to determine the relative numbers of the developmental stages present. By spraying a different tree every 2 or 3 days, as was done in 1938, the development of the insect thruout the season could be followed in considerable detail. Fairly extensive observations of this sort were also made in 1937 and more limited data were obtained in other years.

The apple redbug develops from an egg thru five immature, or nymphal, instars to the adult stage in from 5 to 6 weeks' time. There is but one generation a year. The rate of development seems to be determined to a considerable extent by temperature. In 1938, an "early" season, temperatures during the egg-to-adult period were low, averaging 58.3° F between April 26 and June 8 (Fig. 7), and the length of time spent in each instar was greater than under the more normal temperatures occurring in 1937 (Fig. 6). In that year, the average temperature during the developmental period, May 3 to June 8, was 63.6° F.

The winter is passed in the egg stage. The white, elongated, slightly curved eggs, about $\frac{1}{16}$ inch long, are laid in the bark of smaller branches and waterspouts, usually in pairs, with the tips just showing at the surface. Lenticels are favorite sites for egg laying. Most eggs are deposited in wood of the current season's growth. Of a total of 505 eggs examined in March, 1944, 83.3 per cent were found in the past season's growth, 15.3 per cent in growth originated in 1942, and 1.4 per cent in growth started in 1941. The eggs are inserted into the bark, with the enlarged and rounded inner ends frequently imbedded in the underlying woody tissue (Fig. 8, bottom). They diverge as they enter the twig. Externally, their presence is indicated by a slight swelling of the bark and a pair of minute white specks which are the exposed egg caps in the lenticel (Fig. 8, top). Hatching begins in late April or early May, at the time when McIntosh fruit buds are in the pink stage, and is usually completed before full bloom.

The tiny, active first instar nymphs, less than $\frac{1}{20}$ inch long, which hatch from the overwintering eggs are, at first, orange colored, but they soon turn a characteristic bright tomato-red. They feed on the unfolding leaves, especially near the growing tips, and do not seem

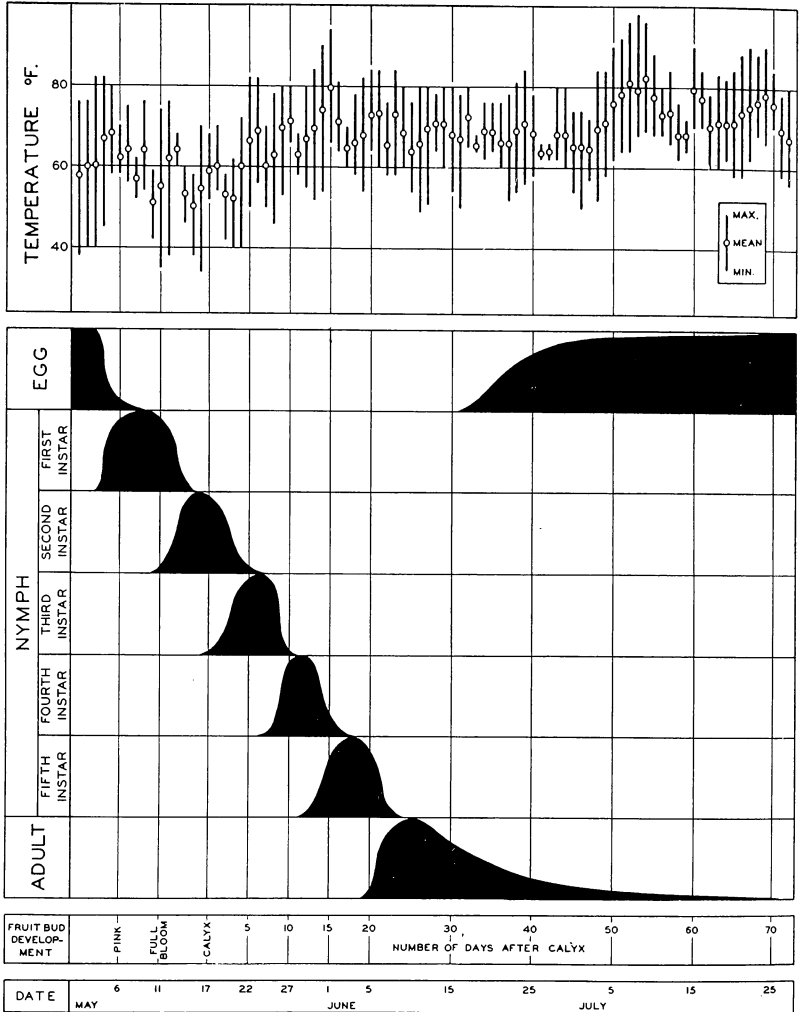


FIG. 6.—SEASONAL DEVELOPMENT OF APPLE REDBUG AT POUGHKEEPSIE, N. Y., 1937.

to be particularly attracted to fruit buds at that time. They crawl down into the opening buds, inserting their mouthparts into the tender leaf tissue but, when disturbed, run rapidly back along the twig toward the tree. The rate at which the nymph develops is apparently determined by temperature conditions, and varies from year to year. In 1937 and 1938, the average length of the first nymphal instar was

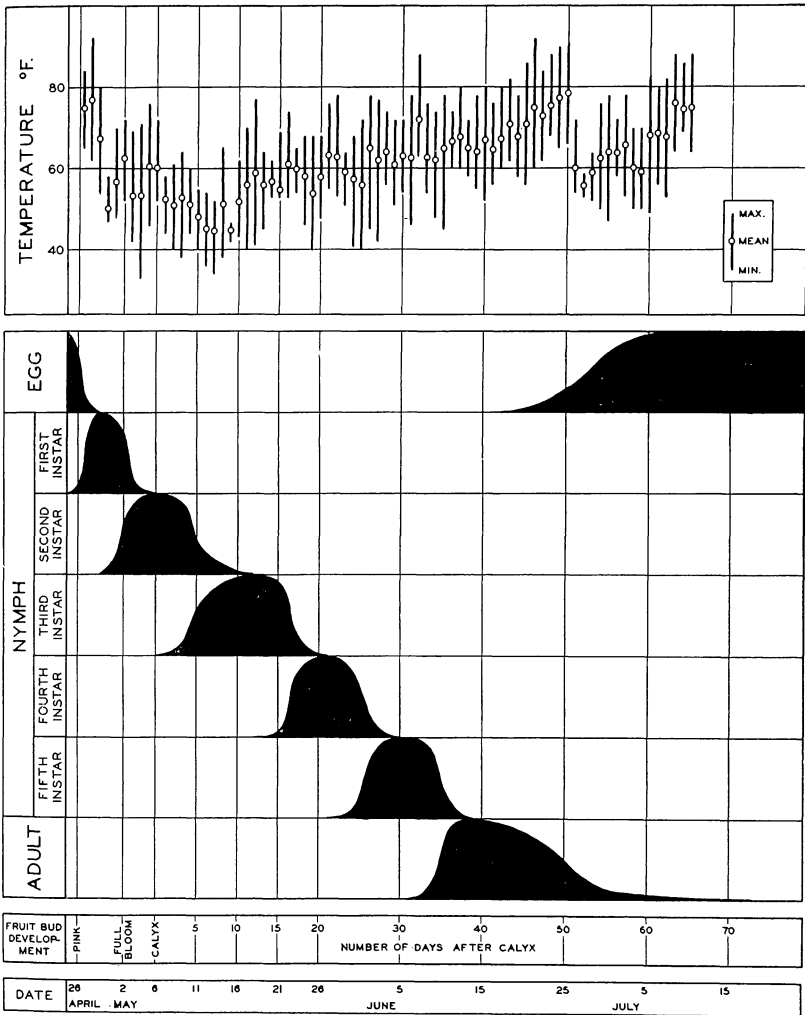


FIG. 7.—SEASONAL DEVELOPMENT OF APPLE REDBUG AT KINDERHOOK, N. Y., 1938.

about 7 days. The full-grown, first-instar bug is approximately $\frac{1}{16}$ inch long, bright red in color, with dark legs, antennae, and beak, and with the body sparsely clothed with fine, dark hairs (Fig. 9a).

Upon molting to the second instar, the body of the nymph is only slightly greater in length, but much broader and the appendages are considerably longer. As the bug grows, the body elongates. The color

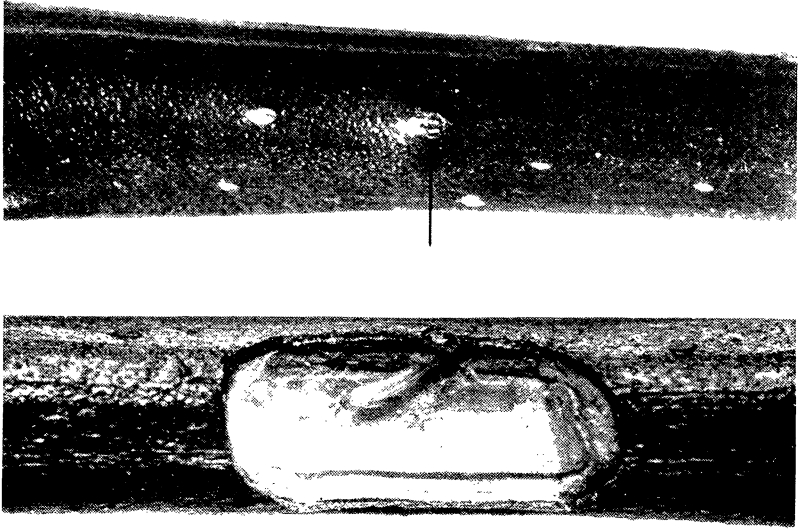


FIG. 8.—EGGS OF THE APPLE REDBUG.

Top, surface view showing tips of two eggs (arrow) in a lenticel; *bottom*, bark cut away to show egg in position in twig.

remains the same. When newly molted, the legs are lighter colored, but they darken with age. Feeding is still confined to the leaf buds in this instar. Its duration is variable. In 1938, the average was 12 days, nearly all of the bugs being in the second instar when McIntosh fruit buds were in the calyx stage. In 1935, more than 16 per cent were still in the first instar 2 days after the calyx stage, the rest having reached the second instar. The fully grown, second-instar nymph is $\frac{1}{10}$ to $\frac{3}{32}$ inch long (Fig. 9b).

The third instar lasted about 7 days in 1941, 9 days in 1938, and 10 days in 1935. On the third day after the calyx stage, in 1941, 98.2 per cent of the redbugs were in the third instar. At this same stage, in 1938, only 8.3 per cent were in the third instar. By the time the third-instar bugs become abundant, the developing fruits have reached a diameter of $\frac{1}{4}$ inch and some of the nymphs now begin feeding on the small apples. When full grown, the third-instar nymph is about $\frac{1}{8}$ inch long (Fig. 9c). The general appearance is similar to that in the preceding instar, except for the wing rudiments which first become apparent at this stage.

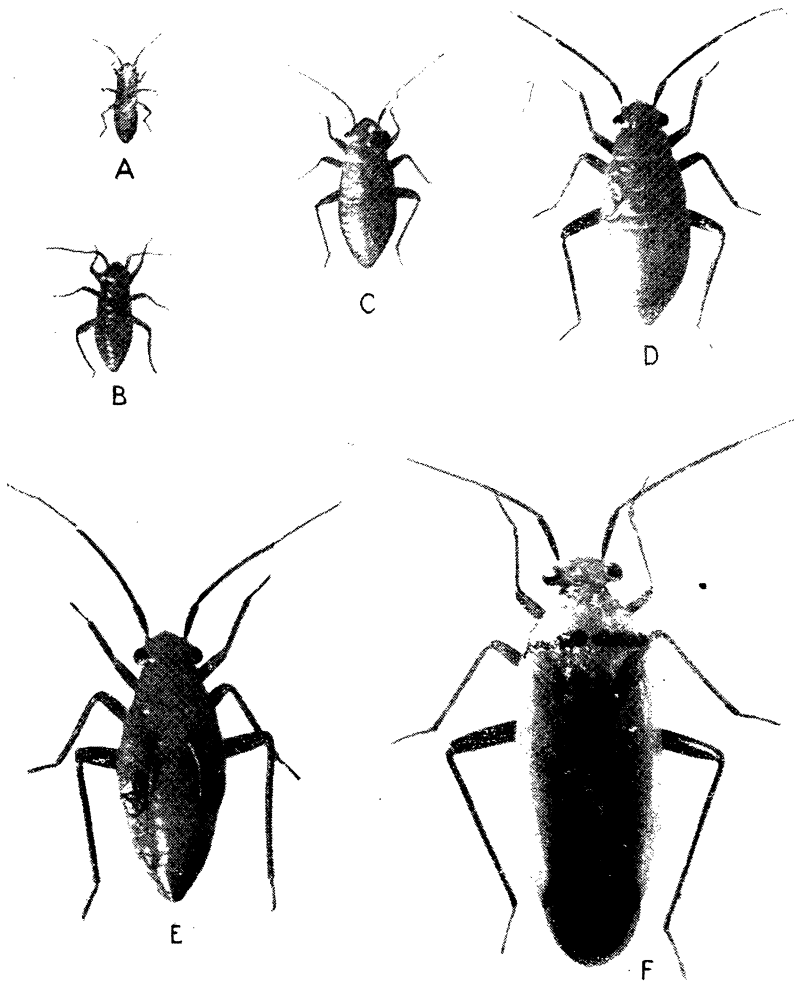


FIG. 9.—NYMPHAL AND ADULT STAGES OF THE APPLE REDBUG.

A, first-instar nymph ; B, second-instar nymph ; C, third-instar nymph ; D, fourth-instar nymph ; E, fifth-instar nymph ; F, adult. About $8\times$ natural size.

Fourth-instar bugs show quite definite wing-pads. These organs are much more conspicuous in this instar than in the preceding one. In 1938, the fourth instar lasted, on the average, about 9 days, the first such bugs appearing 14 or 15 days after the calyx stage, and 98.7 per

cent of the nymphs being in the fourth instar 1 week later. In 1937, nearly all bugs were in the fourth instar 10 or 11 days after the calyx. Feeding on both fruit and foliage continues. As the developing leaves unfold, the characteristic red stippling, which has already appeared on the terminal cluster, becomes very conspicuous. The full-grown, fourth-instar nymph is $\frac{3}{20}$ inch long (Fig. 9d).

The wing-pads in the fifth instar are quite large and the tips are dark. In 1937 and 1941, bugs in this instar appeared 14 days after the calyx; in 1935, 2 days later; while, in 1938, individuals in the fifth instar did not appear until 23 days after the calyx stage. The instar averaged only 5 to 6 days in length in 1935, as compared with 8 days in 1937, and 10 days in 1938. When full grown, the nymph is $\frac{1}{5}$ inch long (Fig. 9e).

The adult is fully winged and appears darker in color than the immature stages because of the dusky color of the wings. These are margined with red, but darker—almost black—in the center, and the tips are dark-colored and membranous. The mature insect is slightly more than $\frac{1}{4}$ inch long (Fig. 9f). The adults feed in the same manner as the nymphs. They are strong fliers, but usually attempt to escape danger by running rather than flight. Their flight is short, usually between adjacent trees, and it is probable that there is little spread from orchard to orchard by means of flying adults. The insect exhibits little tendency to spread. The usual experience has been that foci of infestation remain year after year in approximately the same places. Adults appeared about 20 days after the calyx in 1937, but not until 33 days following that stage in 1938. A few adults were taken on July 26, 1937, 70 days after the calyx and 50 days after the appearance of the first adult. In 1938, adults were found 63 days after the calyx (July 8), and were probably still present in the orchard for a week afterward. In 1936, 73.6 per cent of the bugs captured on the twenty-fourth day following the calyx stage were adults and, by the forty-fifth day only a few bugs, all adults, were found. Limited rearing experiments in 1945 indicate that the period of adult life is 25 to 35 days for the female and 20 to 30 days for the male.

The ratio of females to males in 1936, 1937, and 1938 was 1.09, 1.64, and 1.14 to 1, respectively. The sexes may be distinguished by the appearance of the ventral surface of the tip of the abdomen (Fig. 10). The male exhibits a complicated set of clasping structures associated with the external reproductive organs, while the female abdomen shows a longitudinal slit within which the ovipositor is concealed. This last

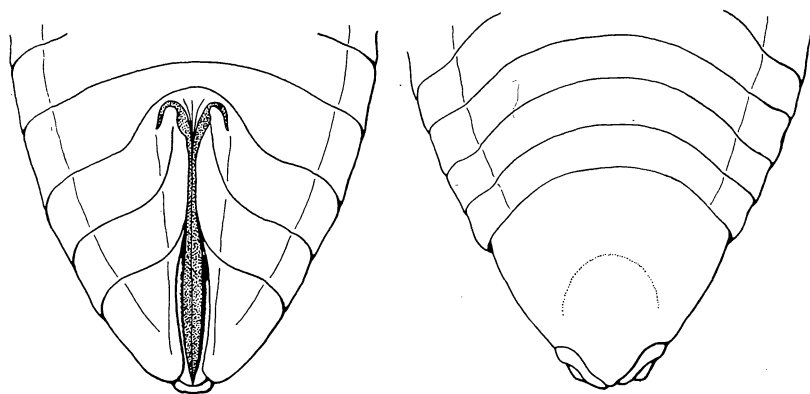


FIG. 10.—EXTERNAL REPRODUCTIVE ORGANS OF FEMALE (LEFT) AND MALE (RIGHT) REDBUGS.

About 25× natural size.

organ is an amber-colored, horny structure consisting of four stout, curved blades. It is hinged at the anterior end so as to swing down out of the groove in the abdomen when in use.

In ovipositing, the female bends the abdomen forward and beneath her so that the ovipositor is directed more or less downward when extended from its sheath (Fig. 11). It is thrust deeply into the bark of twig or branch, thru a lenticel, and an egg deposited. Another thrust is then made in the same lenticel, but diverging from the first, and another egg laid. The number of eggs laid by a female under natural conditions is not known. In cages, a single female redbug has deposited 45 eggs, of which 39 were viable. The average under such artificial conditions is considerably less, many bugs refusing to oviposit at all altho, upon dissection, they were found to contain fully developed eggs. It is probable that the female lays about 50 eggs in the course of her lifetime. The female

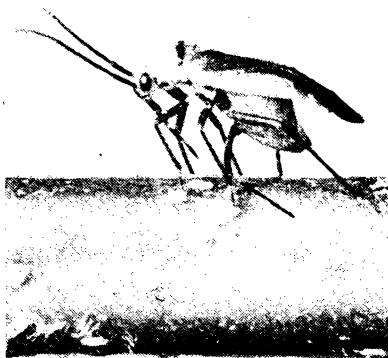


FIG. 11.—ADULT FEMALE LAYING EGGS.

The tip of the ovipositor (arrow) has just been inserted into the twig. About 5× natural size.

undergoes a period of further internal development, after molting from the fifth nymphal instar, before laying eggs. This pre-oviposition period was not more than 14 days long for most bugs in 1936, and 21 days after the appearance of the first adult there were still some sexually immature individuals. In 1937, the pre-oviposition period was between 9 and 12 days long, and 16 days after the first adult was found, all females examined contained ripe eggs. Twelve days after adults appeared in 1938, females containing ripe eggs were found and, 9 days later, all females examined were sexually mature. In general, the pre-oviposition period seems to be about 10 days in length.

CONTROL

A considerable number of orchard control tests have been conducted in the period of 1932 to 1945. Investigations have been directed along two lines, *viz.*, tests of dormant and delayed dormant sprays to kills the eggs, and tests of sprays and dusts containing contact insecticides to kill the nymphal stages. Standard orchard spraying and dusting equipment was used to make the insecticide applications. The size of the experimental block varied from a relatively small group of trees to a whole orchard. Both solid and randomized plots have been used, containing from 1 to about 25 trees.

Results were measured in several ways. In some tests of dormant and semidormant applications, as already mentioned, counts were made of the numbers of injured terminals on treated and check trees. Results of a few tests with contact sprays were determined by counts of the numbers of nymphs knocked down on a large cloth sheet spread beneath the tree, first by the test material and then by an excessive application of a strong nicotine sulfate spray. In most of the experiments, the control obtained was determined by examination of the fruit, including June drops in some instances and later drops in all tests. No attempt was made to score the fruit for degree of injury, all apples which showed evidence of redbug feeding being classified as injured. The percentage of injured fruit on treated trees, as compared with the percentage of injury to fruit on untreated check trees, was used to calculate the percentage control efficiency, using Abbot's (1) formula.

DORMANT AND SEMIDORMANT OIL SPRAYS

The possibility of controlling the apple redbug by means of oil sprays directed against the egg stage was first advanced by Frost (10)

who reported on the use of delayed dormant applications of petroleum oils for this purpose. It would seem, at first thought, that the egg of the redbug is beyond the reach of spray applications, being protected by the bark and wood in which it is laid, but apparently, the small amount of the egg surface which is exposed, plus the penetration of oil thru the oviposition slit in the bark, is sufficient to make it vulnerable to such treatment.

Experiments with oil sprays were begun in 1932. During that season and for several years later, testing was limited to the use of oils at 5 and 6 per cent strengths in the dormant period and 3 per cent in the delayed dormant stage. The oil sprays were prepared in the spraying machine employing, prior to 1940, either lignin pitch (*Goulac*) or bordeaux mixture as the emulsifying agent. Results of these tests are given in Table 2.

In 1941, Chapman, Pearce, and Avens (4) reported that the amount of oil deposited on a tree in spraying is determined by the concentration of oil in the spray, the thoroughness of spraying, and the kind and amount of emulsifying agent used. Insect control, in turn, was shown to be rather directly related to the quantity of oil deposited regardless of how it became deposited. Pearce, Chapman, and Avens (17) in 1942 brought out further that oils currently being used as spray oils varied in their effectiveness as insecticides. Products derived from paraffinic base crude oils were reported to be more effective than those originating from asphaltic or naphthenic base crudes.

To determine whether or not these principles applied to the use of oils to control the apple redbug, tests were conducted with oil sprays prepared with different emulsifiers and with oils differing in their fundamental composition. These tests showed that properly formulated sprays of lower oil content gave as good or better control of the redbug than the stronger concentrations first employed (Tables 2 and 3).

Improvement in control was first obtained by substituting blood albumin for emulsifiers formerly used, particularly lignin pitch (*Goulac*), which resulted in a heavier deposition of oil. Later work disclosed that effectiveness was related to the "paraffinicity" of the oil. Best results were obtained with the highly paraffinic oils and poorest results with the naphthenic oils, with the products derived from mid-continent fields and usually classified as being intermediate in paraffinicity generally falling in an intermediate position in effectiveness. The composition of oils used in redbug control experiments is given in

TABLE 2.—CONTROL OBTAINED IN THE HUDSON VALLEY WITH TANK-MIXED PETROLEUM OIL SPRAYS APPLIED IN THE DORMANT PERIOD, 1932-1943.

YEAR	LOCATION	MATERIALS AND AMOUNTS USED IN 100 GALLONS*		No. OF TREES IN TEST	TREE SIZE	FRUIT INJURY, PER CENT		CONTROL EFFICIENCY, PER CENT
		Oil	Emulsifier			Unsprayed	Sprayed	
1932	Poughkeepsie	A1-H, 6 gals.	Bordo, 1 1/2-4-100	3	Large	14.12	1.78	87.4
1932	Poughkeepsie	Red Engine, 6 gals.	Bordo, 1 1/2-4-100	5	Large	14.12	1.76	87.5
1932	Poughkeepsie	Sunoco Spray, 6 gals.		5	Large	14.12	3.26	76.9
1936	Kinderhook	A1-H, 6 gals.	Goulac, 1/2 lb.	10	Large	5.51	1.58	71.3
1937	Kinderhook	A1-H, 6 gals.	Goulac, 1/2 lb.	9	Large	4.09	0.94	77.0
1938	Kinderhook	A1-H, 6 gals.	Goulac, 1 lb.	5	Medium	29.68	1.76	94.1
1939	Kinderhook	A1-H, 6 gals.	Goulac, 3/4 lb.	5	Medium	9.85	2.19	77.8
1939	Kinderhook	A1-H, 5 gals.	Goulac, 3/4 lb.	5	Medium	9.85	5.43	44.9
1940	Poughkeepsie	A1-H, 6 gals.	Bl. Alb., 2 oz.	5	Medium	13.45	1.42	89.4
1940	Poughkeepsie	A1-H, 5 gals.	Bl. Alb., 2 oz.	5	Medium	13.45	2.69	80.0
1943	Poughkeepsie	A1-H, 4 gals.	Bl. Alb., 2 oz.	9	Medium	17.98	8.48	52.8
1943	Poughkeepsie	A3-H, 4 gals.	Bl. Alb., 2 oz.	9	Medium	17.98	0.56	96.9
1943	Poughkeepsie	A3-H, 3 gals.	Bl. Alb., 2 oz.	9	Medium	17.98	1.37	92.4
1943	Poughkeepsie	E2-H, 4 gals.	Bl. Alb., 2 oz.	9	Medium	17.98	8.44	53.1

*Bl. Alb. = Blood albumin. A product containing 75 per cent filler was used; the amount shown is the actual blood albumin present. Bordo = Bordeaux mixture. Goulac = Lignin pitch. Sunoco Spray = A 'petroleum soap'.

TABLE 3.—CONTROL OBTAINED IN WESTERN NEW YORK WITH TANK-MIXED PETROLEUM OIL SPRAYS APPLIED IN THE DORMANT PERIOD, 1940 AND 1944.

YEAR	LOCA-TION	MATERIALS AND AMOUNTS USED IN 100 GALLONS*		No. OF TREES IN TEST	TREE SIZE	AV. NO. INJURED TERMINALS PER TREE		CONTROL EFFICIENCY, PER CENT	OIL DEPOSIT, MGS. PER SQ. IN. †
		Oil	Emulsifier			Unsprayed	Sprayed		
1940	Hall	A1, 5 gals.	Bl. Alb., 2 oz.	6	Large	2,500.0	54.3	97.8	1.80
1940	Hall	A1, 5 gals.	IN-181, 2 oz.	3	Large	2,500.0	94.3	96.2	1.41
1940	Hall	A1, 5 gals.	T.E.O., 56 cc.	4	Large	2,500.0	217.9	91.3	1.94
1940	Hall	A3, 5 gals.	Bl. Alb., 2 oz.	3	Large	2,500.0	44.3	98.2	1.80
1940	Albion	A1, 4 gals.	Bl. Alb., 2 oz.	2	Large	541.0	11.0	97.9	2.03
1940	Albion	A3, 4 gals.	Bl. Alb., 2 oz.	1	Large	541.0	7.0	98.7	1.71
1944	Hall	A3, 2 gals.	Bl. Alb., 2 oz.	3	Large	415.7	59.3	85.7	1.15
1944	Hall	A3, 3 gals.	Bl. Alb., 2 oz.	3	Large	415.7	19.0	95.4	1.63
1944	Hall	A3, 4 gals.	Bl. Alb., 2 oz.	3	Large	415.7	9.0	97.8	2.09
1944	Hall	D1, 4 Gals.	Bl. Alb., 2 oz.	3	Large	415.7	123.3	70.3	2.56
1944	Hall	D1, 6 gals.	Bl. Alb., 2 oz.	3	Large	415.7	74.7	82.0	3.14

*Bl. Alb. = Blood albumin. A product containing 75% filler was used, the amount shown is the actual blood albumin present. IN-181 = A proprietary compound containing sodium lauryl sulfate. T.E.O. = Triethanolamine oleate.

†Determined by G. W. Pearce and A. W. Avens of the Division of Food Science and Technology of this Station.

Table 4. This superiority of paraffinic oils was not always demonstrated in orchard tests. Variations in redbug infestation from tree to tree and in spray coverage as influenced by tree size and wind force may account for such apparent inconsistencies. In all tests where the various oils could be compared on the basis of oil known to be deposited on the test trees, paraffinic oils were clearly shown to be superior to the naphthenic types.

Some commercially prepared concentrated emulsions and emulsible oils have given results comparable to those obtained with tank-mixed emulsions of known composition (Table 5). It is difficult to predict in

TABLE 4.—PHYSICAL PROPERTIES OF PETROLEUM SPRAY OILS USED IN WESTERN NEW YORK CONTROL TESTS.*

OIL NO.	SAYBOLT VISCOSITY AT 100°F	KINEMATIC VISCOSITY INDEX ASTM	GRAVITY ° A.P.I. AT 60°F	DENSITY d 20° d 4°	ANILINE POINT, °C
D1	121	-4	22	0.9189	67
E2	104	2	22	0.9175	65
D6	206	16	22	0.9207	—
A1	105	63	28	0.8842	83
A3	100	115	34	0.8502	104

*Determinations were made by G. W. Pearce and A. W. Avens of the Division of Food Science and Technology of this Station. Oils used in Hudson Valley tests (A1-H, D1-H, etc.) were similar, but were not from same lots as those listed above.

TABLE 5.—CONTROL OBTAINED WITH COMMERCIALY PREPARED OIL SPRAYS IN THE DORMANT PERIOD, ALBION, 1940.

LOT NO.*	OIL IN STOCK, PER CENT	ACTUAL OIL USED, PER CENT	CONTROL EFFICIENCY, PER CENT†	OIL DEPOSIT MGS. PER SQ. IN.‡
1a	66	4	50.3	1.23
6a	83	4	72.1	1.82
2b	83	4	73.7	1.28
3b	83	4	83.1	1.31
5	83	4	73.7	1.71
7c	83	4	93.3	1.85
9c	95	4	99.8	1.97
8	99	4	93.3	1.92
11	99	4	98.3	2.13
12e	98.5	4	93.3	2.51
13e	83	4	93.3	3.38
14	83	4	96.5	3.38
Tank-mixed..	100	4	97.9	2.03

*Paired lots (1a and 6a, 2b and 3b, etc.) were supplied by same manufacturer and reported to be the same oil, differing only in the emulsifier used. In the tank-mixed lot, oil 1a was used with blood albumin as the emulsifier.

†Based on number of infested terminals. Control trees had an average of 541 infested terminals.

‡Determined by G. W. Pearce and A. W. Avens, Division of Food Science and Technology of this Station.

advance how effective such a product may be, short of trial and error, unless one is provided with information on the type oil employed and the oil deposition characteristics of the emulsifier used. Attention is called to the general relationship illustrated by the data in Table 5 between oil deposit and control, particularly between the paired lots where presumably the same oil was present.

Oil sprays applied at the delayed dormant stage have been limited to 3 per cent strength or weaker for reasons of tree safety. Such treatments are commonly used to destroy scale insects and the eggs of the European red mite. As will be seen in Tables 6 and 7, 3 per cent concentrations of intermediate (A1) and naphthenic (D1, D6 and E2) type oils give an inadequate degree of control whether used at the dormant or delayed dormant stage. However, the highly paraffinic oils, typified by oil A3, have given good results at both stages when used at 3 per cent strength. Oils of this type are not only more efficient as insecticides but have also proved safer to use on trees after leaf growth has started than older types of dormant spray oils. Altho insect eggs are thought to be more susceptible to treatment as the hatching period approached, no definite evidence was found that this is true in the case of the redbug. Thus, dormant and delayed dormant applications of the same oil gave nearly equal control where the oil deposit in each case was the same or nearly so. (See 1944 tests for western New York, Tables 3 and 7).

The various toxicants added to dormant oil sprays did not increase the kill of redbug eggs (Tables 8 and 9). Tar oil emulsions and tar-lubricating oil combinations gave poorer control than petroleum oil emulsions. Dinitro compounds alone had no value and when added to oil did not increase control. In some instances in which dinitro paste was added to an oil emulsion, the control was reduced, probably because the wetting agent in the dinitro material decreased the amount of oil deposited by the spray.

For practical purposes, 4 gallons of a Mid-Continent paraffin oil, as typified by oil A1, emulsified in 100 gallons of water with 2 ounces of blood albumin ($\frac{1}{2}$ pound of the usual blood albumin emulsifier) is recommended for control of apple redbug in the dormant period. Three gallons of a highly paraffinic oil, such as oil A3, emulsified in 100 gallons of water with 2-4-100 bordeaux mixture may be employed as a delayed dormant spray with good results if thoroly applied.

TABLE 6.—CONTROL OBTAINED IN THE HUDSON VALLEY WITH TANK-MIXED PETROLEUM OIL SPRAYS APPLIED AT THE DELAYED DORMANT STAGE, 1932-1943.

YEAR	LOCATION	MATERIALS AND AMOUNTS USED IN 100 GALLONS*		No. OF TREES IN TEST	TREE SIZE	FRUIT INJURY, PER CENT		CONTROL EFFICIENCY, PER CENT
		Oil	Emulsifier			Unsprayed	Sprayed	
1932	Poughkeepsie	A1-H, 3 gals	Bordo, 3-9-100	6	Large	14.12	3.81	73.0
1932	Poughkeepsie	Red Engine, 3 gals	Bordo, 3-9-100	6	Large	14.12	3.27	76.8
1932	Poughkeepsie	Sunoco Spray, 3 gals.		6	Large	14.12	12.34	12.6
1934	Poughkeepsie	A1-H, 3 gals.	Bordo, 1-3-100	2	Large	19.33	3.52	81.8
1938	Kinderhook	A1-H, 3 gals.†	Bordo, 2-4-100	5	Medium	29.68	7.90	73.4
1943	Poughkeepsie	A1-H, 3 gals.†	Bl. Alb., 2 oz.	9	Medium	17.98	2.51	86.0
1943	Poughkeepsie	A3-H, 3 gals.†	Bl. Alb., 2 oz.	8	Medium	17.98	3.05	83.0
1943	Poughkeepsie	E2-H, 3 gals.†	Bl. Alb., 2 oz.	9	Medium	17.98	3.23	82.0

*Bl. Alb. = Blood albumin. A product containing 75 per cent filler was used; the amount shown is the actual blood albumin present. Bordo = Bordeaux mixture. Sunoco Spray = A. petroleum soap.

†Plus nicotine sulfate, 1 pint.

‡Plus Fermate, 1½ lbs.

TABLE 7.—CONTROL OBTAINED IN WESTERN NEW YORK WITH TANK-MIXED PETROLEUM OIL SPRAYS APPLIED AT THE DELAYED DORMANT STAGE, HALL, 1943 AND 1944.

YEAR	MATERIALS AND AMOUNTS USED IN 100 GALLONS		NO. OF TREES IN TEST	TREE SIZE	AV. NO. INJURED TERMINALS PER TREE		CONTROL EFFICIENCY, PER CENT	OIL DEPOSIT MGS. PER SQ. IN.*
	Oil	Emulsifier†			Un-Sprayed	Sprayed		
1943	A1, 3 gals.	Bordo, 2-4-100	7	Large	1,251.3	368.4	70.5	—
1943	A3, 3 gals.	Bordo, 2-4-100	8	Large	1,251.3	56.5	95.5	—
1943	D1, 3 gals.	Bordo, 2-4-100	8	Large	1,251.3	466.6	62.7	—
1943	D6, 3 gals.	Bordo, 2-4-100	8	Large	1,251.3	620.0	50.4	—
1944	A3, 1 gal.	Bordo, 2-4-100	3	Large	702.0	416.0	39.9	0.38
1944	A3, 2 gals.	Bordo, 2-4-100	3	Large	702.0	128.3	81.7	0.90
1944	A3, 3 gals.	Bordo, 2-4-100	3	Large	702.0	31.0	95.6	1.64
1944	D1, 4 gals.	Bordo, 2-4-100	3	Large	702.0	181.7	74.1	1.87

*Determined by G. W. Pearce and A. W. Avens, Division of Food Science and Technology of this Station.

†Bordo = Bordeaux mixture.

CONTACT SPRAYS AND DUSTS

The first experiments reported on the control of the apple redbug (6) established the susceptibility of the insect to nicotine sprays, and subsequent investigations corroborated this (3, 9, 18); altho, for some time, there were differences of opinion as to the amount of nicotine necessary and the most suitable time for making the application. Most workers soon came to recognize that 1 pint of nicotine sulfate (40 per cent nicotine) in 100 gallons of spray was necessary for satisfactory control, as was originally recommended by Crosby and Wilson (6). These investigators, being more concerned with the dark apple redbug, *Heterocordylus malinus*, which develops somewhat earlier than *L. mendax*, recommended that two applications be made, the first at the pink stage and the second at the calyx stage of fruit bud development. They recognized the fact that the calyx application was the more important for the control of *L. mendax*, but this seems to have been overlooked by others, and, for a time, two applications were recommended in some localities. When it became known that only one species, *L. mendax*, was causing most, if not all, of the injury, the use of nicotine sulfate for redbug control was standardized at 1 pint per 100 gallons of the calyx spray. This is still a recommended method of control.

Nicotine in dust applications was found to be effective. Crosby (7) reported that dusts containing from 25 to 40 per cent tobacco killed

TABLE 8.—CONTROL OBTAINED IN THE HUDSON VALLEY WITH COMBINATION SPRAYS AND DINITRO MATERIALS APPLIED IN THE DORMANT PERIOD, 1934-1940.

YEAR	LOCATION	MATERIALS AND AMOUNTS USED IN 100 GALLONS*	NO. OF TREES IN TEST	TREE SIZE	FRUIT INJURY, PER CENT		CON-TROL EFFI-CIENCY, PER CENT
					Un-sprayed	Sprayed	
1934	Poughkeepsie	Tar oil emulsion, 4½ gals.†	2	Large	19.33	12.39	35.9
1938	Kinderhook	Tar-lubricating oil emulsion, 5¼ gals.†	5	Medium	29.68	18.37	38.1
1934	Poughkeepsie	Oil A1-H, 2 gals. + cresylic acid, 1 gal. + Bordo 1-3-100	2	Large	19.33	16.42	15.0
1938	Kinderhook	Dinitro oil A, 4 gals. + Goulac, 10 oz.‡	5	Medium	29.68	2.06	93.1
1939	Kinderhook	Dinitro oil A, 3 gals. + Goulac, 10 oz.‡	3	Medium	9.85	2.44	75.2
1940	Poughkeepsie	Dinitro oil A, 3 gals. + Bl. Alb., 2 oz.§	5	Medium	13.45	2.57	80.9
1939	Kinderhook	Dinitro oil A, 2 gals. + Goulac, 10 oz.‡	3	Medium	9.85	5.31	46.1
1939	Kinderhook	Dinitro oil emulsion B, 3 gals.¶	3	Medium	9.85	4.94	49.8
1940	Poughkeepsie	Dinitro oil emulsion B, 3 gals.¶	5	Medium	13.45	8.28	38.5
1939	Kinderhook	Dinitro oil emulsion C, 3 gals.¶	3	Medium	9.85	3.84	61.0
1940	Poughkeepsie	Oil A1-H, 5 gals. + Bl. Alb., 2 oz. + dinitro powder, 1 lb.**					
1940	Poughkeepsie	Oil A1-H, 5 gals. + Bl. Alb., 2 oz. + dinitro paste, 1 qt.††	5	Medium	13.45	1.39	89.7
1938	Kinderhook	Dinitro paste, 2 gals.††	5	Medium	13.45	3.83	71.5
1938	Kinderhook	Dinitro paste, 2 gals.††	5	Medium	29.68	28.70	3.3

*Bl. Alb. = Blood albumin. A product containing 75 per cent filler was used. The amount shown is the actual blood albumin present. Bordo = Bordeaux mixture. Goulac = Lignin pitch.

†Tar oil 90 per cent.

‡Tar oil 37 per cent; lubricating oil 46 per cent.

§Petroleum oil 96 per cent; dinitro-o-cyclohexyphenol 4 per cent.

¶Petroleum oil 75 per cent dinitro-o-cyclohexyphenol 2 oz. per gallon.

||Petroleum oil 75 per cent; dinitro-o-cyclohexyphenol 2 per cent.

**Containing dinitro-o-cyclohexyphenol 37.5 per cent (6 oz. per pound).

††Containing sodium dinitro-o-cresylate 22% (6.9 oz. dinitro-o-cresol per quart).

TABLE 9.—CONTROL OBTAINED IN WESTERN NEW YORK WITH COMBINATION OIL AND DINITRO SPRAYS APPLIED IN THE DORMANT PERIOD, 1940 AND 1941.

YEAR	LOCAL- TION	MATERIALS AND AMOUNTS USED IN 100 GALLONS*	NO. OF TREES IN TEST	TREE SIZE	AV. NO. TERMI- NALS INJURED		CON- TROL EFFI- CIEN- CY,	OIL DEPOSIT, MGS. PER SQ. IN. †
					Un- sprayed	Sprayed		
1940	Hall	Oil A1, 3 gals. + Bl. Alb., 1 oz. + dinitro paste, 1 gal. †	3	Large	2,500.0	1,014.6	59.4	0.98
1940	Hall	Oil A1, 4 gals. + Bl. Alb., 1 oz. + dinitro paste, ½ gal. †	3	Large	2,500.0	336.3	86.5	1.25
1940	Hall	Oil A1, 4 gals. + Bl. Alb., 2 oz. + dinitro powder, 2 lbs. §	3	Large	2,500.0	218.3	91.3	1.29
1940	Hall	Oil A1, 5 gals. + Bl. Alb., 2 oz. + dinitro powder, 1 lb. §	2	Large	2,500.0	92.0	96.3	2.21
1941	Albion	Oil A1, 4 gals. + Bl. Alb., 2 oz. + DNOCHP, 6 oz.	4	Medium	882.0	40	95.5	1.65
1941	Albion	Oil A1, 4 gals. + Bl. Alb., 2 oz. + sodium salt of DNOCHP, 6 oz.	4	Medium	882.0	59	93.3	1.62
1941	Albion	Oil A1, 4 gals. + Bl. Alb., 2 oz. + DNOC, 6 oz.	4	Medium	882.0	57	93.5	1.69
1941	Albion	Oil A1, 4 gals. + Bl. Alb., 2 oz. + sodium salt of DNOC, 6 oz.	2	Medium	882.0	24	97.3	1.65
1941	Albion	Oil A1, 4 gals. + Bl. Alb., 2 oz. + ammonium salt of DNOC, 6 oz.	2	Medium	882.0	31	96.5	2.23
1941	Albion	Oil A1, 4 gals. + Bl. Alb., 2 oz. + guanidine salt of DNOC, 6 oz.	2	Medium	882.0	44	95.0	1.88

*Bl. A.b. = Blood albumin. A product containing 75 per cent filler was used. The amount shown is the actual blood albumin present. DNOC = Dinitro-o-cresol. DNOCHP = Dinitro-o-cyclohexylphenol.

†Determined by G. W. Pearce and A. W. Avens. Division of Food Science and Technology of this Station.

‡Containing sodium dinitro-o-cresylate 22 per cent (27.6 oz. dinitro-o-cresol per gallon).

§Containing dinitro-o-cyclohexylphenol 37.3 per cent (6 oz. per pound).

redbug nymphs or knocked them out of the trees so that they subsequently died. Extensive tests were conducted by Parrott, Glasgow, and MacLeod (15), using nicotine-sulfur-lead arsenate dusts. They concluded that, ".....apple red bugs may be effectively controlled by thoro dusting with sulfur and arsenate of lead containing 0.50, 1.0, and 2.0 per cent nicotine". Zappe and Stoddard (20) also found that a nicotine-sulfur-lead arsenate dust containing 2 per cent nicotine gave good control.

The purpose of such treatment is to kill the redbug nymphs after all of the eggs have hatched but before the insects start to feed on the fruit. Referring to the life cycle, it will be seen that, at the pink stage, hatching is not yet completed. Hence, a volatile contact insecticide, like nicotine, applied at this time cannot kill all of the bugs. Hatching may be completed by a late pink stage, or not until after the trees have started to bloom. Spraying during bloom is objectionable for several reasons, so that the first regular application that occurs after the completion of hatching is the calyx spray. Extensive feeding on the fruit begins about 10 to 15 days after the calyx stage. There is, therefore, a period extending from bloom to about 10 days or even 2 weeks after petal-fall during which, theoretically, the insect can be controlled to best advantage. In actual practice, the optimum period has been somewhat shorter than this. Tests conducted in 1935 and 1938 show that the application should be made within 5 or 6 days after the calyx stage in order to obtain adequate control (Table 10).

Even when properly timed, the control obtained with nicotine sulfate sprays varies because of other factors (Table 11). One commonly accepted reason for poor results is that the application was made at too low a temperature, and the nicotine was not volatilized. A minimum temperature of 65° to 70° F is thought to be necessary before the nicotine spray is effective. The evidence of these tests does not bear this out. In 1937, the calyx spray was applied when the average temperature was 75.8° F and redbug control was 74.2 per cent. The 1941 calyx application was made at an average temperature of 56.6° F and the control obtained was 93.0 per cent. Part of the calyx spraying in 1943 was done when temperatures ranged from 70° to 78° F and part when the temperature averaged 55° F. In the first instance, the control obtained varied from 79.2 per cent to 91.5 per cent; in the second, it was 92.5 per cent. It would seem, therefore, that temperatures as low as 55° F do not have a marked adverse effect on the action of nicotine sulfate sprays for redbug control.

TABLE 10.—CONTROL OBTAINED WITH NICOTINE SULFATE SPRAYS AT VARIOUS STAGES OF FRUIT BUD DEVELOPMENT, 1935 AND 1938.*

YEAR	LOCATION	TIME OF APPLICATION	NUMBER OF TREES IN TEST	TREE SIZE	FRUIT INJURED, PER CENT		CONTROL EFFICIENCY, PER CENT
					Unsprayed	Sprayed	
1935	Poughkeepsie	Pink	2	Large	8.24	2.04	75.2
1935	Poughkeepsie	Calyx	2	Large	8.24	1.25	84.8
1935	Poughkeepsie	6 days after calyx	2	Large	8.24	1.38	83.2
1935	Poughkeepsie	10 days after calyx	2	Large	8.24	22.59	0.0
1935	Poughkeepsie	16 days after calyx	2	Large	8.24	31.31	0.0
1935	Poughkeepsie	20 days after calyx	1	Large	8.24	31.98	0.0
1938	Kinderhook	Pink	5	Medium	29.68	7.03	76.3
1938	Kinderhook	Calyx	5	Medium	29.68	1.80	93.9
1938	Kinderhook	5 days after calyx	3	Medium	29.68	1.42	95.2
1938	Kinderhook	10 days after calyx	3	Medium	29.68	3.02	89.8
1938	Kinderhook	15 days after calyx	3	Medium	29.68	17.41	41.3

*Proprietary solution containing 40 per cent nicotine. The calyx spray in 1935 consisted of liquid lime-sulfur 2 gals., lead arsenate 3 lbs., hydrated lime 3 lbs., Gouliac 1 lb., and nicotine sulfate 1 pint in 100 gallons. All other applications consisted of hydrated lime 3 lbs. and nicotine sulfate 1 pint in 100 gallons. The pink and calyx sprays in 1938 consisted of liquid lime-sulfur 2 gals., lead arsenate 3 lbs., hydrated lime 3 lbs., nicotine sulfate 1 pint in 100 gallons. All other applications consisted of hydrated lime 2 lbs. and nicotine sulfate 1½ pints in 100 gallons.

TABLE 11.—CONTROL OBTAINED WITH NICOTINE SULFATE, 1-800, IN CALYX SPRAY.*

LOCATION	DATE	OTHER MATERIALS IN 100 GALLONS OF SPRAY	NUM- BER OF TREES IN TEST	TREE SIZE	WIND VELOCITY	TEMPER- TURE, °F	INJURED FRUIT, PER CENT		CON- TROL EFFI- CIENCY, PER CENT
							Un- sprayed	Sprayed	
Poughkeepsie	May 20, 1932	LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs.	6	Large	Moderate	69.7†	14.12	1.51	89.3
Poughkeepsie	May 16, 1933	Lime, 3 lbs.	3	Large	Moderate	57.3†	14.95	0.64	95.8
Poughkeepsie	May 16, 1934	Lime, 10 lbs. (nico- tine sulfate 1-600)	4	Large	Moderate- strong	57.3†	19.33	0.92	95.2
Poughkeepsie	May 18, 1935	LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs. + Goulac, 1 lb.	2	Large	Calm	62.0†	8.24	1.25	84.8
Poughkeepsie	May 23, 1937	LS, 2 gals.	3	Large	Calm	75.8†	8.78	2.26	74.2
Kinderhook	May 6, 1938	LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs. + WS paste, 8 lbs. + LA, 3 lbs. + lime, 3 lbs.	5	Medium	Calm	65.3†	29.68	1.80	93.9
Kinderhook	May 26, 1939	WS paste, 8 lbs. + lime, 3 lbs.	3	Medium	Calm	73.7†	9.85	3.10	68.5
Hall	May 24, 1939	WS paste, 8 lbs. + lime, 3 lbs.	10	Large	Calm	74.0	19.79	0.25	98.7
Poughkeepsie	May 27, 1940	LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs.	6	Large	Calm- light	66.0†	13.45	4.60	65.8
Hall	May 28, 1940	WS paste, 8 lbs. + lime, 3 lbs.	2	Large	Calm	68.0	36.39	1.95	94.6
Poughkeepsie	May 12, 1941	Lime, 3 lbs. + NNO, 1 pint	16	Medium	Moderate	56.6†	3.56	0.25	93.0
Poughkeepsie	May 9-12, 1941	Lime, 3 lbs.	17	Medium	Moderate	58.6-56.6†	3.56	0.38	89.3

Poughkeepsie	May 22-23, 1943	WS, 6 lbs. + LA, 3 lbs. + lime, 3 lbs.:							
		a. Sprayed in one operation with one gun	9	Medium	Calm-light	55	17.98	1.36	92.5
		b. Sprayed in one operation with one gun	12	Medium	Calm-light	73	17.98	3.74	79.2
		c. Sprayed half of tree at a time	11	Medium	Calm	70-73	17.98	1.94	89.2
		d. Sprayed in one operation with two guns	10	Medium	Light	76-78	17.98	1.53	91.5
		e. Sprayed from rig	17	Medium	Light	76-78	17.98	17.65	21.7

*Proprietary solution containing 40 per cent nicotine; Goulac = Lignin pitch. LA = Lead arsenate. Lime = Hydrated spray lime. LS = Liquid lime sulfur.

NNO = Proprietary wetting agent containing mannitan monolaurate. WS = Dry wettable sulfur. WS paste = Wettable sulfur.

†Average temperature 8:00 a.m. to 6:00 p.m.; others shown are actual temperatures at time of application.

Wind velocity records taken at the time of spraying are not extensive enough to allow hard and fast conclusions to be drawn. Generally, the most favorable time was selected, but, occasionally, it was necessary to spray when moderate to strong winds were blowing. Such conditions prevailed at the calyx application in 1934, together with a low average temperature. The control with nicotine sulfate at $1\frac{1}{2}$ pints to 100 gallons of spray was 95.24 per cent. Moderate wind velocities during the application of the calyx spray in 1932 and 1941 do not appear to have caused serious reduction in control, but, in 1944, nicotine-containing calyx sprays applied under calm conditions at temperatures of 60° to 71° F gave 72.5 per cent and 74.6 per cent control, respectively, whereas when the wind velocity was 4.57 m.p.h., altho the temperature was 82° F, the control dropped to 49.0 per cent.

Wind conditions may have an indirect effect on control by affecting spray coverage, as may any other factor bearing upon it. Thus, in tests conducted in 1943 and 1944 on methods of spraying, where the tree was sprayed from the ground, both the inside and the outside being covered, good control was obtained. When all spraying was done from the rig, and from the outside only, poor control resulted. Thoro spray coverage is essential, but it is not necessary to spray the entire tree in one operation. In the 1943 tests, a standard nicotine sulfate calyx application was made in which the entire tree was sprayed from the ground, inside and out, in one operation using one gun. The control varied from 66.9 to 91.5 per cent, with an average of 79.2 per cent. When each half of the tree was sprayed separately from the ground, inside and out, with a time interval of $\frac{1}{2}$ hour between applications, the control varied from 87.3 to 91.1 per cent, with an average of 89 per cent. Spraying the entire tree in one operation from the ground, inside and out, using two guns so as to cover the tree in the shortest possible time, resulted in control ranging from 86.9 to 95.9 per cent, the average being 91.5 per cent. It is probable that, with modern spraying equipment, coverage may be obtained at a fast enough rate so that the redbug, active as it is, is unable to outrun the spray. In the length of time which usually elapses between treating the two halves of the row, when spraying only half of each row on either side of the rig, there is not enough migration of bugs to affect control. If the interval becomes several days, as it might when spraying from only one direction, with the wind, the result would probably be less satisfactory.

If the bugs could be killed at the time of hatching, there would be no possibility of injury to the fruit and, at this stage of its life cycle,

the insect would, supposedly, be highly susceptible to the action of an insecticide. Since the hatch occurs over several days during the blooming period, no one spray of a volatile contact insecticide could be expected to give complete control, while several sprays during bloom would be both expensive and inadvisable from the standpoint of their effect on pollinating insects. The fixed nicotine compounds would seem to offer a possible solution to the problem since the nicotine which they contain is released at a relatively slow rate, and one application made at the pink stage of fruit bud development might persist thruout the period of redbug hatching. Tests of such sprays are summarized in Table 12. Promising results were obtained with two of the three fixed nicotine compounds used, the control being a little better than that resulting from nicotine sulfate in the calyx spray and decidedly better than that given by nicotine sulfate in the pink spray. The cost of the nicotine material, however, was approximately twice as great.

Redbug control with nicotine sulfate, or any other contact sprays, depends upon actually hitting the insect with the spray material. Any condition which interferes with this will lower control regardless of the insecticide or the concentration used. Thus, thick, unpruned trees, full of sucker growth offer ideal conditions for the redbug by furnishing an abundance of twig growth suitable for egg laying as well as being difficult to wet with spray (Fig. 12).

Nicotine sulfate is relatively expensive and, to some spray operators, it is quite poisonous. One purpose of these investigations was to find a substitute without these objectionable features. The most promising material tested prior to the testing of DDT in 1944 was pyrethrum. Excellent control of apple redbug nymphs with a 30 per cent pyrethrum dust, used at the rate of 90 pounds to the acre, was reported by Patterson (16).

Pyrethrum was first used in sprays in the form of ground flowers. The control obtained is shown in Table 13. The results with pyrethrum powder containing 0.6 to 0.9 per cent pyrethrins, when used at the rate of 3 pounds in 100 gallons in the calyx spray, were at best only fair. Two applications, at the pink and calyx stages, gave control comparable to that obtained with nicotine in the calyx spray. It was apparent that the combination of pyrethrum powder with liquid lime-sulfur was less effective than pyrethrum and neutral wettable sulfurs. Variable results were obtained with extracts of pyrethrum. When used in a spray containing wettable sulfur (dry or paste form), lead

TABLE 12.—CONTROL OBTAINED WITH FIXED NICOTINE COMPOUNDS IN THE PINK SPRAY AND WITH NICOTINE SULFATE IN THE PINK AND CALYX SPRAYS. POUGHKEEPSIE, 1935-1943.

YEAR	MATERIALS AND AMOUNTS USED IN 100 GALLONS*	TIME OF APPLICATION	NUM-BER OF TREES IN TEST	TREE SIZE	INJURED FRUIT, PER CENT		CON-TROL EFFI-CIENCY, PER CENT
					Unsprayed	Sprayed	
1935	Nicotine bentonite B, 6 lbs. †	Pink	2	Large	8.24	0.83	89.9
1935	Nicotine sulfate †, 1 pint + lime, 3 lbs.	Pink	2	Large	8.24	2.04	75.2
1935	Nicotine sulfate †, 1 pint + LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs.	Calyx	2	Large	8.24	1.25	84.8
1940	Fixed nicotine ‡, 6 lbs. + MS, 6 lbs. + skimmilk powder, ¼ lb. + LA, 3 lbs.	Pink	5	Large	13.45	13.01	3.3
1940	Nicotine sulfate †, 1 pint + LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs.	Calyx	6	Large	13.45	4.60	65.8
1943	Nicotine bentonite C ¶, 4½ lbs. + MWS, 6 lbs.	Pink	9	Medium	17.98	1.56	91.3
1943	Nicotine sulfate †, 1 pint + MWS, 6 lbs. + LA, 3 lbs. † lime, 3 lbs.	Calyx	42	Medium	17.98	2.25	88.1

*LA = Lead arsenate; Lime = Hydrated spray lime; LS = Liquid lime-sulfur; MS = Micronized dusting sulfur; MWS = Micronized wettable sulfur.

†Proprietary compound containing 7 per cent nicotine.

‡Proprietary solution containing 40 per cent nicotine.

¶Proprietary compound containing 14 per cent nicotine.

§Proprietary compound containing 4.8 per cent nicotine.



FIG. 12.—SUCKER GROWTH AROUND THE TRUNK OF A TREE PROVIDES BREEDING PLACES FOR APPLE REDBUG AND MAKES CONTROL DIFFICULT.

arsenate, and lime, the control obtained was less than when the quantity of solids was reduced. It is possible that the pyrethrum was absorbed by the additional bulk of solid materials and, consequently, did not come in contact with the insects. Under normal conditions, pyrethrum powder is less expensive than nicotine sulfate, but the extracts are not.

Both nicotine and pyrethrum were used in dust applications. The results of some of these tests are shown in Table 14. One and 2 per cent nicotine-lime dusts gave variable results, the control obtained ranging from 35.8 to 92.5 per cent. Apparently, weather conditions play a more important role in the success or failure of nicotine dust treatments than is the case with nicotine sulfate sprays. The best control was obtained at higher average temperatures and under calm conditions. The poor results obtained in the 1943 test are due to adverse wind conditions, for the average temperature was the highest at which nicotine dusts were applied, but wind velocities were also at the maximum for these tests.

TABLE 13.—CONTROL OBTAINED WITH PYRETHRUM IN CALYX SPRAYS, 1937-1940.

YEAR	LOCATION	MATERIALS AND AMOUNTS USED IN 100 GALLONS	NUM- BER OF TREES IN TEST	TREE SIZE	INJURED FRUIT, PER CENT		CON- TROL EFFI- CIENCY, PER CENT
					Un- sprayed	Sprayed	
1937	Kinderhook	S, 5 lbs. + LA, 3-12 lbs. + lime, 1 lb. + soybean flour, 1 lb. + pyrethrum powder, 2 lbs.†	11	Large	4.09	2.49	39.1
1937	Kinderhook	LS, 2 gals. + LA, 0-6 lbs. + Goulac, ¾ lb. + pyrethrum powder, 2 lbs.†	7	Large	4.09	2.96	27.6
1937	Poughkeepsie	WS, 5 lbs. + pyrethrum powder, 2 lbs.†	3	Large	8.78	3.05	65.2
1937	Poughkeepsie	LS, 2 gals. + pyrethrum powder, 2 lbs.†	3	Large	8.78	3.39	61.3
1938	Kinderhook	S, 5 lbs. + LA, 3 lbs. + lime, 3 lbs. + soybean flour, 1 lb. + pyrethrum powder, 3 lbs.†	6	Medium	29.68	8.73	70.6
1938	Kinderhook	S, 5 lbs. + LA, 3 lbs. + lime, 3 lbs. + soybean flour, 1 lb. + pyrethrum powder, 3 lbs.†	5	Medium	29.68	5.87	80.2
1938	Kinderhook	LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs. + pyrethrum powder, 3 lbs.†	5	Medium	29.68	12.09	59.3
1939	Kinderhook	WS paste, 8 lbs. + LA, 3 lbs. + lime, 3 lbs. + pyrethrum extract-spreader, 1 pint§	3	Medium	9.85	4.26	56.8
1939	Hall	WS paste, 8 lbs. + pyrethrum extract-spreader, 1 quart§	7	Large	19.79	0.05	99.7
1939	Hall	WS paste, 8 lbs. + pyrethrum extract in acetone, 1 quart¶	9	Large	19.79	1.22	93.8
1940	Poughkeepsie	MS, 6 lbs. + LA, 3 lbs. + skim milk powder, ¼ lb. + pyrethrum extract-spreader, 1 quart§	5	Large	13.45	6.92	48.6
1940	Poughkeepsie	MS, 6 lbs. + LA, 3 lbs. + skim milk powder, ¼ lb. + pyrethrum extract in acetone, 1 quart¶	4	Large	13.45	2.67	80.1

*Goulac = Lignin pitch; LA = Lead arsenate; Lime = Hydrated spray lime; LS = Liquid lime sulfur; MS = Micronized dusting sulfur; S = 325-mesh dusting sulfur; WS = Dry, wettable sulfur; WS Paste = Wettable sulfur paste.

†Pyrethrin content 0.365 per cent.

‡Pyrethrin content 0.6 per cent.

§Pyrethrin content 1.125 per cent.

¶Pyrethrin content 0.9 per cent.

TABLE 14.—CONTROL OBTAINED WITH CALYX DUST APPLICATIONS, 1938-1943.

YEAR	LOCATION	COMPOSITION OF DUST MIXTURE*	NUM- BER OF TREES IN TEST	TREE SIZE	WIND VELOCITY	TEMPERA- TURE, °F	INJURED FRUIT, PER CENT		CON- TROL EFFI- CIENCY, PER CENT
							Un- sprayed	Sprayed	
1938	Kinderhook	Nicotine sulfate, 1 pint + lime, 50 lbs. †	3	Medium	Moderate	59.5	29.68	11.02	62.9
1940	Poughkeepsie	Nicotine sulfate, 1 quart + lime, 50 lbs. †	9	Large	Calm	66.0	13.45	1.00	92.5
1943	Poughkeepsie	Nicotine sulfate, 1 quart + lime, 47½ lbs. §	23	Medium	Moderate- strong	70-72**	17.98	11.55	35.8
1938	Kinderhook	S, 40 lbs. + LA, 10 lbs. + clay 30 lbs. + Dry Pyrocid, 10 lbs. ¶	3	Medium	Moderate	59.5	29.68	2.52	91.5
1940	Poughkeepsie	S, 50 lbs. + LA, 10 lbs. + Pyrax ABB, 30 lbs. + Dry Pyrocid, 10 lbs. ¶	9	Large	Calm	62.3	13.45	0.46	96.6

*Clay = Bancroft clay dust diluent; Dry Pyrocid = Proprietary dry dust concentrate containing 2 per cent pyrethrins; LA = Lead arsenate; Lime = Hydrated spray lime; Nicotine sulfate = Proprietary solution containing 40 per cent nicotine; Pyrax ABB = Proprietary pyrophyllite dust diluent; S = 325-mesh dusting sulfur.

†Nicotine content of finished dust 0.97 per cent.

‡Nicotine content of finished dust 1.90 per cent.

§Nicotine content of finished dust 2.0 per cent.

¶Pyrethrin content of finished dust 0.22 per cent.

||Pyrethrin content of finished dust 0.20 per cent.

**Actual temperature at time of application. Other temperatures shown are 8 a.m. to 6 p.m. averages.

Results with pyrethrum dusts were less variable than those given by nicotine-lime applications. Again, wind velocity affected results, but there is less evidence of a temperature effect. Variations in the composition of the dust mixture and in the pyrethrin content also account for different degrees of control. A dust containing 0.1 per cent pyrethrins (5 per cent *Dry Pyrocide*) failed to give control, while dusts with 0.15 to 0.2 per cent pyrethrin contents (7½ to 10 per cent *Dry Pyrocide*) were effective. Complete dusts, composed of sulfur, lead arsenate, and the pyrethrum-containing material, plus such fillers as clay or pyrophyllite, were less effective than those including only the pyrethrum material and a filler. This is due to the physical characteristics of such dust mixtures. The complete dusts were heavier and tended to cake in the hopper of the type of duster used, while the straight pyrethrum dusts exhibited much more satisfactory dusting properties. It is advisable to make a special application of either the pyrethrum dusts or the nicotine-lime dusts within 4 or 5 days after the calyx spray, rather than to attempt to substitute a dust containing fungicide, arsenical, and contact insecticide for the calyx spray application.

Several other materials have been tested for toxicity to the apple redbug, usually in the calyx application. The results of these tests are summarized in Tables 15, 16, and 17. Some of the rotenone-containing compounds gave fair control, but none were as effective as nicotine sprays or dusts or pyrethrum dusts. The aliphatic thiocyanate gave poor control, even when combined with nicotine alkaloid. Stock dip sprays, which some growers have reported to give excellent redbug control, gave poor results in our tests. A summer dinitro material gave poor control and, in any event, is not considered safe to use at this stage of tree development. The new insecticide, DDT (dichloro diphenyl trichloroethane), in limited tests in 1944 and 1945, showed much promise. Calyx sprays containing 0.4 pound of actual DDT in 100 gallons and 5 per cent DDT dust applied a few days after the calyx stage gave a high degree of control. Until more is known about the place of DDT in horticultural sprays, however, no recommendation of its use for apple redbug control can be made.

NATURAL CONTROL

The apple redbug is remarkably free from attack by insect parasites and predators. The bugs are alert and very active, running rapidly when alarmed and dodging quickly to the side of the twig opposite

TABLE 15.—CONTROL OBTAINED WITH MISCELLANEOUS INSECTICIDES APPLIED IN THE CALYX SPRAY, 1938-1943.

YEAR	LOCATION	MATERIALS AND AMOUNTS USED IN 100 GALLONS*	NO. OF TREES IN TEST	TREE SIZE	INJURED FRUIT, PER CENT		CON-TROL EFFI-CIENCY, PER CENT
					Un-sprayed	Sprayed	
1938	Kinderhook	S, 5 lbs. + soybean flour, 1 lb. + powdered cube root, 3 lbs.†	3	Medium	29.68	7.79	73.7
1940	Poughkeepsie	MS, 6 lbs. + skim milk powder, ¼ lb. + LA, 3 lbs. + rotenone extract, ½ gal.‡	5	Large	13.45	5.90	56.1
1943	Poughkeepsie	MWS, 6 lbs. + LA, 3 lbs. + rotenone-pyrethrum extract, 1½ pints§	8	Medium	17.98	9.82	45.4
1939	Kinderhook	WS, 8 lbs. + LA, 3 lbs. + lime, 3 lbs. + organic thiocyanate, 1 quart¶	4	Medium	9.86	6.01	39.0
1943	Poughkeepsie	MWS, 6 lbs. + LA, 3 lbs. + nicotine-thiocyanate spreader, 1 pint	1	Medium	17.98	7.58	57.8
1939	Kinderhook	WS, 8 lbs. + LA, 3 lbs. + lime, 3 lbs. + stock dip and disinfectant, 1 quart**	3	Medium	9.86	3.88	60.6
1940	Poughkeepsie	LS, 2 gals. + LA, 3 lbs. + lime, 3 lbs. + stock dip and disinfectant, 2 quarts**	5	Large	13.45	9.68	28.0
1943	Poughkeepsie	MWS, 6 lbs. + LA, 3 lbs. + summer dinitro spray, 1¼ lbs.††	1	Medium	17.98	11.58	35.6

*LA = Lead arsenate; Lime = Hydrated spray lime; MS = Micronized dusting sulfur; MWS = Micronized wettable sulfur; S = 325-mesh dusting sulfur; WS paste = Wettable sulfur paste.

†Rotenone content 5.3 per cent.

‡Proprietary compound containing 2.5 per cent rotenone and 5 per cent other cube resins, plus a spreading and wetting agent.

§Proprietary compound containing 0.3 per cent pyrethrins, 1.5 per cent rotenone, and 4.5 per cent other cube resins, plus a spreading and wetting agent.

¶Proprietary compound containing aliphatic thiocyanates 24 per cent, phthalic anhydride glycerol alkylid resin 16.3 per cent, pine oil 20.3 per cent, and petroleum oil 39.4 per cent.

**Proprietary compound containing 12 per cent nicotine alkaloid and 12 per cent organic thiocyanate in a glyceride oil base.

††Proprietary compound of unknown composition.

‡‡Proprietary compound containing 20 per cent of dicyclohexylamine salt of dinitro-o-cyclohexylphenol.

TABLE 16.—KNOCK-DOWN OF FOURTH- AND FIFTH-INSTAR NYMPHS WITH MISCELLANEOUS INSECTICIDES, POUGHKEEPSIE, 1939.

MATERIALS AND AMOUNTS USED IN 100 GALLONS*	No. OF TREES IN TEST	TREE SIZE	NUMBER NYMPHS KNOCKED DOWN		CON- TROL EFFI- CIENCY, PER CENT
			By test spray	By nicotine spray†	
Nicotine sulfate, 1 pint+lime, 2 lbs.	1	Small	90	10	89.5
Pyrethrum extract-spreader, 1 pint . . .	1	Small	44	37	52.1
Organic thiocyanate, 1 quart	1	Small	76	202	23.9
Rotenone extract spray, 1 quart	1	Small	63	28	67.8
Stock dip and disinfectant, 2½ quarts	1	Small	36	134	17.4
Stock dip and disinfectant, 1 quart + nicotine sulfate, 1 pint	1	Small	69	8	89.1
Water only (control)	1	Small	6	126	—

*Applied two weeks after calyx stage. Lime = Hydrated spray lime; Nicotine sulfate = Proprietary solution containing 40 per cent nicotine; Organic thiocyanate = Proprietary compound containing aliphatic thiocyanates 24 per cent, phthalic anhydride glycerol alkyl resin 16.3 per cent, pine oil 20.3 per cent, and petroleum oil 39.4 per cent; Pyrethrum extract-spreader = Proprietary compound containing 0.365 per cent pyrethrins in a glyceride oil base. Rotenone extract spray = Proprietary compound consisting of a vegetable and petroleum oil solution of rotenone and other derrick extractives. Stock dip and disinfectant = Proprietary compound of unknown composition.

†Nicotine sulfate 1-600 plus lime. Applied 24 hours after test spray.

that from which danger threatens, so that it is probable that the attacks of natural enemies are thus largely avoided. Only when molting between instars are they quiescent,

A single instance of a parasitic grub, presumable a hymenopterous larva, emerging from a fourth-instar redbug nymph being held in the laboratory was recorded. An attempt to rear the parasite to the adult stage was unsuccessful.

While collecting redbugs in an orchard, one instance of predatism by an unidentified species of spider was observed. The predator was one of the so-called jumping spiders which capture prey without benefit of a web. The victim was a fifth-instar nymph.

The eggs are attacked by an insect parasite, probably a hymenopteron. Attempts to rear the species have been unsuccessful and it is known only from larvae found in the host egg. It is not abundant. Out of a total of 505 eggs examined, 8, or 1.6 per cent, were found to be parasitized.

Such a meagre record of natural enemies does not explain the rather abrupt decreases in redbug abundance which sometimes occur from one season to the next. It would seem that other controlling factors must be operating, but their nature is unknown.

TABLE 17.—RESULTS OF PRELIMINARY TESTS WITH DDT FOR CONTROL OF APPLE REDBUG, POUCHKEEPSIE, 1944-1945.

YEAR	TIME OF APPLI- CATION	MATERIALS AND AMOUNTS USED IN 100 GALLONS*	NUM- BER OF TREES IN TEST	TREE SIZE	FRUIT INJURED, PER CENT		CON- TROL EFFI- CIENCY, PER CENT
					Unsprayed	Sprayed	
1944	Pink	Wettable spray powder (20% DDT), 2 lbs.	8	Moderate	2.04	0.61	70.4
1944	Calyx	Wettable spray powder (20% DDT), 2 lbs. + WS paste, 10 lbs.	8	Moderate	2.04	0.16	91.9
1945	Calyx	Wettable spray powder (40% DDT), ½ lb. + MWS, 6 lbs. + LA, 3 lbs.	6	Small	Av. No. bugs found after treatment†	Reduction over control, per cent	94.8
1945	Calyx	Wettable spray powder (40% DDT), 1 lb. + MWS, 6 lbs. + LA, 3 lbs.	6	Small	1.5	97.8	100
1945	Calyx	Wettable spray powder (40% DDT), 2 lbs. + MWS, 6 lbs. + LA, 3 lbs.	6	Small	0	100	100
1945	Calyx	Dust (5% DDT)	9	Small	0	100	96.6
1945	Calyx	Nicotine sulfate, 1 pint + MWS, 6 lbs. + LA, 3 lbs. + lime, 3 lbs.	6	Small	0.3	99.5	94.8
1945	Calyx	Control—MWS, 6 lbs. + LA, 3 lbs. + lime, 3 lbs.	8	Small	1.5	97.8	—
					67.0	—	—

* DDT = Dichloro diphenyl trichloroethane, technical grade; LA = Lead arsenate; Lime = Hydrated spray lime; MWS = Micronized wettable sulfur; Nicotine sulfate = Proprietary solution containing 40 per cent nicotine; WS Paste = Wettable sulfur paste.

† Sprayed one month after calyx with nicotine sulfate plus lime.

SUMMARY

The apple redbug, *Lygidea mendax*, occurs in many New York State orchards, sometimes causing extensive damage. The dark apple redbug, *Heterocordylus malinus*, is reported from western New York but has been found only rarely in the Hudson Valley area, and then never in commercial orchards.

In feeding, the bugs cause a reddish stippling of leaves on the terminals of branches that is not of economic importance, and a gnarling and russetting of the fruit which, in extreme cases, may affect three-fourths of the crop. No evidence was found that they cause excessive drop of small McIntosh apples.

The apple redbug is a small, very active, tomato-red bug about $\frac{1}{4}$ inch long when full grown. The winter is passed in the egg stage, the eggs being laid singly or in pairs in the bark and wood of twigs and small branches and watersprouts. They hatch in the spring during the blooming period of McIntosh. There are five nymphal instars before the winged adult stage is reached in early June. Both the nymphs and adults feed on developing foliage and fruit, the latter not being attacked until it has reached a diameter of about $\frac{1}{4}$ inch. Approximately 10 days after reaching the adult stage, the female begins to lay eggs and continues to do so until mid-July, or later.

The insect can be controlled by (a) a petroleum oil spray applied during the dormant or delayed dormant periods, or (b) a contact spray or dust applied at the calyx stage or within 5 days of the calyx period. The dormant oil spray should contain 4 per cent of a paraffinic base oil; the delayed dormant, 3 per cent of a highly paraffinic product. Blood albumin, 2 ounces in 100 gallons of water, or its equivalent in oil-depositing properties, is advised as the emulsifier for dormant sprays, and bordeaux mixture 2-4-100 for the delayed dormant. Nicotine sulfate, used at the rate of 1 pint in 100 gallons in the calyx spray, is the standard recommendation for controlling the pest in the nymphal stage. Two per cent nicotine-lime dust and dusts containing 0.15 to 0.2 per cent pyrethrins gave excellent control when applied within 5 days after the calyx stage. The dusts were adversely affected by wind to a greater extent than the nicotine sulfate spray, and the nicotine-lime dust did not give as good control at lower temperatures. No temperature effects were noticed in the case of pyrethrum dust, while temperatures as low as 55° F did not decrease the effectiveness of a nicotine sulfate calyx spray application.

Tar oils and dinitro materials were ineffective against the eggs, and stock dips, aliphatic thiocyanates, and a dinitro material for summer use did not control the nymphs. Rotenone-containing sprays gave fair control of the redbug. DDT sprays and dusts show much promise, but more information is needed before they can be recommended.

The redbug is remarkably free of natural enemies. An insect parasite, supposedly a hymenopteron, was found to attack a small percentage of the eggs. A parasitic hymenopterous larva was reared from one fourth-instar redbug nymph, and the capture of a fifth-instar bug by a small spider was witnessed. The nature of other controlling factors, which apparently exist, is not known.

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