BULLETIN 252 DECEMBER, 1923

# Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

# The European Red Mite

PHILIP GARMAN

Figure 1. European Red Mite, greatly enlarged.

CONTENTS

# CONNECTICUT AGRICULTURAL EXPERIMENT STATION

## OFFICERS AND STAFF

**December, 1923.**

---

### BOARD OF CONTROL.

His Excellency, Charles A. Templeton, *ex-officio, President.*

James H. Webb, *Vice-President*.....Hamden
George A. Hopson, *Secretary*.....Mount Carmel
Wm. L. Slate, Jr., *Director and Treasurer*.....New Haven
Joseph W. Alsop.....Avon
Charles R. Treat.....Orange
Elijah Rogers.....Southington
Edward C. Schneider.....Middletown

### STAFF.

E. H. JENKINS, PH.D., *Director Emeritus.*

**Administration.**
W. L. SLATE, JR., B.Sc., *Director and Treasurer.*
MISS L. M. BRAUTLECHT, *Bookkeeper and Librarian.*
MISS J. V. BERGER, *Stenographer and Bookkeeper.*
MISS MARY BRADLEY, *Secretary.*
WILLIAM VEITCH, *In Charge of Buildings and Grounds.*

**Chemistry.**
**Analytical Laboratory.**
E. M. BAILEY, PH.D., *Chemist in Charge.*
R. E. ANDREW, M.A.
C. E. SHEPARD
OWEN L. NOLAN
HARRY J. FISHER, A.B.
} *Assistant Chemists.*
FRANK SHELDON, *Laboratory Assistant.*
V. L. CHURCHILL, *Sampling Agent.*
MISS MABEL BACON, *Stenographer.*

**Biochemical Laboratory.**
T. B. OSBORNE, PH.D., SC.D., *Chemist in Charge.*

**Botany.**
G. P. CLINTON, SC.D., *Botanist in Charge.*
E. M. STODDARD, B.S., *Pomologist.*
MISS FLORENCE A. MCCORMICK, PH.D., *Pathologist.*
G. E. GRAHAM, *General Assistant.*
MRS. W. W. KELSEY, *Secretary.*

**Entomology.**
W. E. BRITTON, PH.D., *Entomologist in Charge; State Entomologist.*
B. H. WALDEN, B.AGR.
M. P. ZAPPE, B.S.
PHILIP GARMAN, PH.D.
} *Assistant Entomologists.*
JOHN T. ASHWORTH, *Deputy in Charge of Gipsy Moth Work.*
R. C. BOTSFORD, *Deputy in Charge of Mosquito Elimination.*
MISS GLADYS M. FINLEY, *Stenographer.*

**Forestry.**
WALTER O. FILLEY, *Forester in Charge.*
A. E. MOSS, M.F., *Assistant Forester.*
H. W. HICOCK, M.F., *Assistant Forester.*
MISS PAULINE A. MERCHANT, *Stenographer.*

**Plant Breeding.**
DONALD F. JONES, S.D., *Geneticist in Charge.*
P. C. MANGELSDORF, M.S., *Assistant.*

**Soil Research.**
M. F. MORGAN, M.S., *Investigator.*

**Tobacco Sub-station at Windsor.**
C. M. SLAGG, M.S., *in Charge.*

---

THE WILSON H. LEE CO.

# The European Red Mite in Connecticut Apple Orchards.

*Paratetranychus pilosus* Can. & Fanz.

By Philip Garman, Ph.D.

Brown foliage, a result of the feeding of the European red mite, was first noticed on apples in Connecticut in 1920, when a block of Baldwins in a large commercial orchard near Branford became discolored. Since that time the trouble has increased rather than decreased in the State, and the mite now seems to be well established, threatening serious damage in some sections every year. What can be done to hold it in check has been asked from time to time, and we are now able to offer what seems to be a practical remedy, together with facts about habits and life history of the mite which should enable the orchardist to gain control.

## History.

The European red mite was described in 1876 from Italy: it has been noticed in several countries of Europe having been given considerable attention as a pest in Sweden. In America it has been present for many years, but has been confused with other species, notably, the clover mite (*Bryobia pretiosa* Koch) and the common red spider (*Tetranychus bimaculatus* Harvey) from both of which it is distinct. On the Pacific coast it has passed under the name of citrus mite and apparently others, and has done serious damage in that locality. It was noted in Canada in 1915,[1] by Frost in Pennsylvania[9] in 1919, was found in Connecticut in 1920,[10] and since then has been reported from Maryland, New York and Ohio. The mite was recognized as present in California by Essig[4] in 1922, though it has probably been there much longer.

## Nature of the Injury.

A heavy infestation of red mites turns leaves of apple trees brown early in June, and if continued gives them a dead appearance in July. This results in undersized and poorly colored fruit and affects the vitality and set of fruit for the following season. On plums and apples, a little later, there is considerable defoliation. A moderate infestation leaves the trees with sickly foliage and prevents growth of fruit the latter part of the summer, a condition

often unnoticed by the orchardist, but very conspicuous as compared with trees free of mites.

## Distribution.

The red mite is present in Connecticut, Massachusetts, New Jersey, New York, Maryland,[12] Pennsylvania, West Virginia and Ohio. It has also been reported from Canada. In the west, Oregon and California consider it worthy of attention and it will probably be found in many other localities where perhaps it is not numerous enough at present to invite attention.

In Connecticut it is well distributed, having been seen in, or received from, Fairfield, Hartford, Middlesex, New Haven and New London Counties. The most serious damage seems to have been done in the southern part of the State and little complaint has been heard from the more northern counties.

## Host Plants.

The species has been found by the author on rose, pear, peach, plum, cherry, apple and elm. It is reported to infest prune trees in Pennsylvania,[2] and is known to infest almond, prune and citrus fruits in California.[3] Most damage is done to apples and plums in Connecticut, though occasionally peach trees in the vicinity of infested apples have been injured.

## Habits and Life History.

Examine an infested tree in winter after the leaves have fallen and you will note on branches the size of a lead pencil (sometimes on those as much as two inches in diameter) a coating of small red eggs, which if numerous enough will not require magnification to see them. They are dark red in color and are most abundant around bud scars and in crevices—resembling a coating of red brick dust. Wise orchardists know the signs and know that trouble may be in store—and act accordingly. These are the winter eggs, which carry the pest over from season to season. Watch carefully and you will find them hatching about the middle of April or first of May; or, in terms of the development of the apple tree, at the time when the blossom buds of most varieties begin to show pink; better still when the leaves are about an inch long. From the twigs the young mites make their way to the leaves and begin to feed, completing their development in two weeks, but sometimes requiring longer if a cold spring is at hand. By the first of June, conditions being favorable, they begin to multiply rapidly, passing the entire cycle in three weeks or shorter if the weather is warm. The life period is such that an overlapping of broods now begins for the following reasons. The egg develops in 6–13 days or an average of nine days, and the mites require

about as long to complete their development, or long enough to begin laying eggs (nine days more). If we now allow 15 days as the average life of the adult during which time the eggs are laid, not all at one time but a few each day, then at the end of 15 days under favorable conditions the first eggs of the particular female will have hatched and will be well along to maturity, giving two different generations on the leaf at one time. This apparently takes place shortly after the first of June in Connecticut, making it impossible to apply separate sprays for different broods during the summer. In all, considering the length of the cycle, some six generations might easily occur in a single summer, but it is not always safe to figure natural laws or processes by such simple mathematics. The number of generations in this case is of minor importance, but our experience indicates that most damage is done in June and early July when multiplication is most rapid, and before enemies become numerous.

The female is not a great egg layer, but is capable of laying as many as 34 eggs, at the rate of one or two per day. By the middle of August, many eggs are laid on the twigs and in the calyx and stem cavities of the fruit, and by September 15 the winter eggs are being laid rapidly. The adults die shortly after and show no tendency to hibernate in this climate.

The time required for development in each stage is shown in the following tables:

TABLE 1—LENGTH OF INCUBATION PERIOD.

| Eggs Laid | Eggs Hatched | Period, Days | Mean Temp., F. |
|---|---|---|---|
| May 16 | May 29 | 13 | 63.2 |
| May 18 | May 29 | 11 | 64.2 |
| May 21 | May 29 | 8 | .... |
| May 21 | June 1 | 10 | 67.2 |
| June 24 | June 30 | 6 | .... |
| June 24 | June 30 | 6 | .... |
| July 11 | July 17 | 6 | 73.1 |
| Aug. 6 | Aug. 14 | 8 | .... |
| Aug. 8 | Aug. 16 | 8 | .... |
| Aug. 8 | Aug. 17 | 9 | .... |
| Aug. 29 | Sept. 6 | 8 | .... |
| Aug. 16 | Aug. 30 | 14 | 65.5 |
| Aug. 17 | Aug. 30 | 13 | 66.4 |
| Sept. 3 | Sept. 9 | 6 | 72.0 |

TABLE 2—PERIOD FROM EGG TO ADULT.

| Egg Hatched | Adult Obtained | Period, Days | Mean Temp., F. |
|---|---|---|---|
| May 29 | June 5 | 7 | 66.6 |
| June 1 | June 8 | 7 | .... |
| June 9 | June 19 | 10 | 65.1 |
| June 10 | June 17 | 7 | .... |
| July 11 | July 16 | 5 | 77.1 |
| July 25 | Aug. 1 | 7 | 72.9 |
| July 25 | Aug. 3 | 9 | .... |
| Aug. 30 | Sept. 9 | 10 | .... |
| Aug. 14 | Aug. 23 | 9 | 65.4 |

TABLE 3—PREOVIPOSITION PERIOD OF ADULT FEMALE.

| Female Emerged | First Egg Laid | Period, Days | Mean Temp., F. |
|---|---|---|---|
| June 7 | June 10 | 3 | 61.0 |
| July 8 | July 9 | 1 | 71.3 |
| July 16 | July 19 | 3 | 79.2 |
| July 16 | July 19 | 3 | 79.2 |
| Aug. 6 | Aug. 8 | 2 | .... |
| Aug. 10 | Aug. 17 | 7 | 71.8 |
| Sept. 9 | Sept. 11 | 2 | .... |

TABLE 4—LENGTH OF LIFE OF ADULTS.

| Adult Emerged | Adult Died | Period, Days | Mean Temp., F. |
|---|---|---|---|
| June 7 | June 21 | 14 (female) | .... |
| June 9 | June 30 | 21 | .... |
| July 8 | July 22 | 14 (female) | 79.0 |
| July 16 | July 22 | 6 (female) | 82.2 |
| Aug. 10 | Aug. 29 | 19 (female) | 68.1 |
| Aug. 3 | Aug. 17 | 14 (male) | 74.8 |
| Aug. 6 | Aug. 19 | 13 (female) | .... |

TABLE 5—EGGS LAID BY ADULT FEMALES.

| First Egg | Adult Died | Total Number |
|---|---|---|
| June 10 | June 21 | 18 |
| July 9 | July 22 | 22 |
| June 10 | June 21 | 16 |
| June 9 | June 30 | 34 |

TABLE 5a—LIFE HISTORY OF EUROPEAN RED MITE.†

| Eggs Laid | Eggs Hatched | Adult Obtained | Eggs from Adult | Total Period, Days |
|---|---|---|---|---|
| May 21 | May 29 | June 5 (male) | ..... | 15 |
| May 21 | ..... | June 7 | June 10 | 20 |
| July 5 | ..... | July 16 (male) | ..... | 11 |
| July 7 | ..... | July 16 | July 19 | 12 |
| July 21 | ..... | Aug. 3 (male) | ..... | 13 |
| July 19 | July 25 | Aug. 1 (male) | ..... | 13 |
| Aug. 6 | Aug. 14 | Aug. 23 | ..... | 17 |

Early stages feed mostly on the underside of the leaf, but as the leaf becomes crowded, many adults move to the upper surface and feed there. Very little web is spun at any stage, the larvae and nymphs spinning more than the adults.

## METHODS OF SPREAD.

Wind is the most important agent in local distribution of the red mite. Many spin down from the leaves on short threads and if a strong wind is blowing, are probably carried for a considerable distance. Distribution of infested nursery stock is probably responsible for spread of the mite since the eggs are small and easily overlooked. Probably many are carried on the fruit, especially winter apples, which sometimes contain eggs in calyx and stem cavities.

† Continuous records of single individuals.

## The Different Stages.

The European red mite passes through the following stages:—egg: active larva—quiescent larva: active first nymph—quiescent first nymph: active second nymph—quiescent second nymph: adult male or female. During quiescent periods the mites are inactive and no food is taken. The male usually emerges shortly before the female and awaits the emergence of the latter. Eggs are laid within a few days after emergence of the adult female. There is no difference in the number of immature stages of male and female.

## Description.

Adult females are dark velvety red in color, the nymphal stages and the male dark brown or green. Winter eggs are dull red, summer eggs usually brown.

*Egg*—Slightly flattened above, radially grooved and with a short stalk arising from the center, the stalk being longer than the vertical diameter of the egg. Transverse diameter of egg .15 mm.

*Larva*—Nearly orange in color when recently hatched, later turning dark green or brown; mite with three pairs of legs; length .16–.18 mm.

*Protonymph*—Very dark green or brown in color; with four pairs of legs, the latter quite pale; length .19–.25 mm.

*Deutonymph*—Very dark green or brown; legs paler; length .25–.30 mm.

*Adult, female*—Color dark velvety red or brown with conspicuous white dots on dorsum at base of setae; 26 setose dorsal bristles in all; tarsi provided with a single claw widest at the mid point and with apparently five (there are probably six) appendiculate spurs projecting at right angles (Fig. 2, 4); four tenent hairs with hooked tips arise from the base of the claw and exceed it considerably in length; collar tracheae consisting of a single tube (Fig. 2, 3) dilated at tip to form a spherical chamber; maxillae consisting of four segments, the last tipped with a short spatulate body, probably representing an additional segment; next to the last segment with a strong hook, and the last with five setae (two apical, two basal on the dorsum, and one lateral) and a clavate hair between the two dorsal pairs; length of adult, .28-.31 mm.

*Male*—Much smaller than the female, the tip of the abdomen being much more pointed and the color usually brown, never red; genitalia as in Fig. 2, 5; length .26–.28 mm.

## Difference from Other Economic Species.

There are abundant differences between the European red mite and the common red spider, *Tetranychus bimaculatus* Harvey. The dorsal setae are smaller in the latter species and the collar tracheae are much different, being hooked and segmented (see Fig.

2, 8). The eggs are spherical, usually pale, and without grooves or stalk.

*Bryobia pretiosa* Koch,† the clover mite, is distinguishable at sight, being considerably flatter and wrinkled above and with a number of flat scalloped plates around the margin of the body of the adult. There are two claws on each tarsus instead of one and the front pair of legs is much longer than any of the others. The eggs are red but are larger, usually measuring .19–.20 mm. in diameter, and lack the radial grooves and the dorsal stalk present in *P. pilosus*.

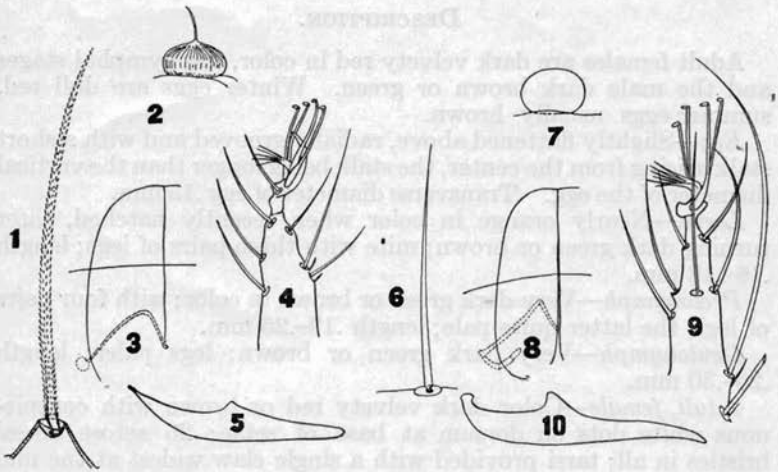



Figure 2. Structures of European red mite, *Paratetranychus pilosus* Can. and Fanz. and common red spider, *Tetranychus bimaculatus* Harvey.

1, *Paratetranychus pilosus*, seta of dorsum 846 times enlarged; 2, egg, 14 times enlarged; 3, collar tracheae and mandibular plate, 714 times enlarged; 4, tarsus of first pair of legs of female, 921 times enlarged; 5, penis, 1400 times enlarged.

6, *Tetranychus bimaculatus*, seta of dorsum, 846 times enlarged; 7, egg, 14 times enlarged; 8, collar tracheae and mandibular plate, 714 times enlarged; 9, tarsus of first pair of legs of female, 921 times enlarged; 10, penis, 1400 times enlarged.

## Number of Mites Necessary to Produce Browning.

Some varieties of apples withstand much more of an infestation without showing the effects than others. Spy and Wealthy trees were browned in 1923 by 12 to 33 mites per leaf, estimated from the number of cast skins found after browning was noticed. Hurlbut trees with 55 to 133 per leaf suffered severe browning.

† *Bryobia pratensis* Garman.

## Varietal Preferences.

Greening trees rarely have as many mites per leaf as other varieties, and no instances have been observed in Connecticut where severe injury has been done to this variety. Baldwin is perhaps the most commonly injured, but Hurlbut, York Imperial, McIntosh, Wealthy, Northern Spy and Fall Pippin have been injured, in some cases severely. Thin leaved varieties are most susceptible.

## Natural Enemies.

Some of the most puzzling features of the appearance and disappearance of the red mite are connected with the occurrence of predaceous enemies. An orchard may, for instance, be heavily infested one season and show almost no mites the following year, although no spraying has been done in the meantime. This is often, though not always explained by the presence of enemies which in Connecticut seem able to conquer and almost eradicate the mite once every two or three years. Thus in 1922, a heavy infestation at North Branford was reduced almost to the zero point and no outbreak occurred the following year. In 1923, thrips, coccinellids, and small Hemiptera such as *Triphleps insidiosa* were numerous in orchards, and greatly checked the mite in several places.

Three species of thrips† were found, a small bug‡, a lady beetle§, a predaceous mite‖, and a small undetermined Neuropteron. All of these destroyed eggs of the red mite with relish, one thrips being observed to eat 19 eggs in twenty-four hours, while an adult *Stethorus* on being observed took six eggs and three mites within five minutes.

Enemies of the red mite are most numerous in July and August and when numerous enough keep the pest in check in spite of its rapid multiplication at this time of year. One or two thrips per leaf are apparently enough to keep in advance of an infestation because of their enormous appetite for mite eggs, and their habit of attacking mites themselves when eggs are scarce. They often leave the foliage and twigs with empty transparent egg shells, having sucked out their contents and departed.

## Weather Conditions Affecting Abundance.

Adverse weather conditions are responsible for subsidence of outbreaks in some cases, but it is sometimes difficult to say whether this or the abundance of enemies is the cause. Conditions favorable to the mite may be favorable to development of the enemies or vice-versa. It has been reported that bad outbreaks have followed a very severe winter and the great numbers of mites in 1920 and

† *Leptothrips mali* Fitch, *Scolothrips 6-maculatus* Pergande and *Haplothrips* sp.; determined by Dr. A. C. Morgan.
‡ *Triphleps insidiosa* Say.
§ *Stethorus punctum* Leconte.
‖ *Seius pomi* Parrott.

1923 certainly followed abundan snows and cold weather. However, a serious outbreak occurred in 1922 after a ratl er mild winter, and the infestations in 1923 did not become serious until midsummer, whereas if cold weather had much effect this should have begun more promptly. Heavy rainfall or better a series of showers at frequent intervals in summer is successful in keeping an infestation from gaining headway, as witnessed in this State in 1922. This is due to the fact that many mites are washed from the leaves and are unable to regain the tree. It is quite possible that a rainy period in September would decidedly affect the abundance of the mite the following season, though no cases of this sort have been observed. In 1923, the prolonged dry period from the middle of June to September favored development and several orchards were damaged severely.

## Control Measures.

Owing to the uncertainty that weather and enemies will produce a balance in favor of the orchardist, treatments for control must be considered and a regular schedule adopted. There are periods when the mite is especially vulnerable and a thorough spray is of much value; and it is a good policy to learn to know the mite in its different stages so that damage may be anticipated and prevented. As with many insects the best time to concentrate efforts is in early spring and sprays at this time should go far towards a control for the entire season, especially in this climate. It is well, therefore, to keep a sharp lookout for winter eggs when the annual pruning is done and not to wait until the leaves turn brown before considering treatment.

## Sprays for the Winter Eggs.

The first attack should be on the overwintering eggs which may be reached with sprays and largely destroyed. Laboratory tests were conducted in 1920-21 with a view to finding the most effective treatments for this purpose. Some of the tables are given below together with tests of several other compounds reaching us since these were made.

In the tables, the names of a number of proprietary compounds appear, and the following explanation in regard to their general composition and source is necessary. Such compounds as lime-sulphur, and Scalecide are too well known to need comment.

"*Jarvis Compound.*"— A miscible oil containing phenol; manufacturer J. T. Robertson; obtained from Apothecaries Hall Co., Waterbury, Conn.

"*Kero-spray.*"—A commercial kerosene emulsion; manufacturer, Kero-Spray Co., 198 9th St., Jersey City, N. J.

"*Keresol.*"—An oil spray containing 70 per cent. kerosene; obtained from Mr. A. A. Claasen, Mascher and Turner Streets, Philadelphia, Pa.; effect of spray on trees unknown.

*"Sulco V. B."*—A spray containing fish-oil and small per cent. phenol; manufactured by Cook & Swan Co., 148 Front St., New York; obtained from Apothecaries Hall Co., Waterbury; effect on apple trees unknown, probably safe.

*"Wormol."*—A miscible oil recommended for use against peach borers by the General Chemical Company; obtained from General Chemical Company, 25 Broad St., New York, N. Y.; effect upon apple trees unknown.

*"B. T. S."*—Barium tetrasulphide, a lime-sulphur substitute; a General Chemical Company product.

*"Sunoco Spraying Oil"*.—A miscible mineral oil; apparently safe on apple trees; sold by Sun Oil Company, Philadelphia, Pa.

*"Target Brand Scale Destroyer."*—A miscible oil containing phenol; sample submitted by the Interstate Chemical Company, Jersey City, N. J.

TABLES SHOWING RESULTS OF TREATING EGGS OF EUROPEAN RED MITE WITH DIFFERENT INSECTICIDES.

TABLE 6.

| Exp. No. | Treatment | Total Number of Eggs Used | Number Hatched | Per Cent. Hatched | Date Treated | Date Examined |
|---|---|---|---|---|---|---|
| 1. | Kerosene emulsion (10 per cent. kerosene) | 660 | 402 | 60.9 | Mar. 16 | Apr. 29 |
| 2. | Kero-spray 1 part-25 parts water | 298 | 166 | 56.0 | " | " |
| 3. | Sulco V. B. 1 part-25 parts water | 502 | 255 | 50.7 | " | " |
| 4. | Keresol 1 part-18 parts water | 442 | 265 | 59.9 | " | " |
| 5. | Jarvis Compound 1 part-15 parts water | 104 | 6 | 5.7 | " | " |
| 6. | Scalecide 1 part-15 parts water | 237 | 22 | 9.2 | " | " |
| 7. | Lime-sulphur 1 part-9 parts water | 652 | 253 | 38.8 | " | " |
| 8. | Dry lime-sulphur 12 lbs.-50 gals. water | 418 | 125 | 29.9 | " | " |
| 9. | B. T. S. 12 lbs.-50 gals. water | 349 | 162 | 46.4 | " | " |
| 10. | Scalecide 1 part-25 parts water | 341 | 115 | 33.7 | " | " |
| 11. | Check no treatment | 265 | 151 | 56.9 | — | " |
| 12. | Scalecide 1 part-15 parts water | 150 | 8 | 5.3 | April. 7 | Apr. 29 |
| 13. | Scalecide 1 part-15 parts water | 669 | 9 | 1.3 | " | " |
| 14. | Scalecide 1 part-35 parts water | 838 | 53 | 6.3 | " | " |
| 15. | Scalecide 1 part-25 parts water | 744 | 68 | 9.1 | " | " |
| 16. | Scalecide 1 part-50 parts water | 462 | 47 | 10.1 | " | " |
| 17. | Check no treatment | 253 | 164 | 65.0 | — | " |
| 18. | Check no treatment | 100 | 45 | 45.0 | — | " |

TABLE 7.

| Exp. No. | Treatment | Total Number of Eggs Used | Number Hatched | Per Cent. Hatched | Date Treated | Date Examined |
|---|---|---|---|---|---|---|
| | Lime-sulphur 1-9 | | | | | |
| 1. | Nic. Sulphate 1-500 | 649 | 189 | 29.1 | Dec. 29 | Feb. 23 |
| 2. | " " " | 2,166 | 544 | 25.1 | Feb. 8 | Mar. 2 |
| | Lime-sulphur | | | | | |
| 3. | 1 part-9 parts water | 403 | 45 | 11.1 | Apr. 5 | Apr. 15 |
| 4. | " " " | 378 | 18 | 4.7 | Mar. 12 | Mar. 28 |
| 5. | " " " | 773 | 268 | 34.6 | Dec. 29 | Feb. 23 |
| | Lime-sulphur 1-9 | | | | | |
| 6. | Nic. Sulphate 1-500 | 165 | 80 | 48.4 | Apr. 13 | Apr. 28 |
| 7. | " " " | 221 | 54 | 24.4 | Apr. 13 | Apr. 29 |
| | Lime-sulphur | | | | | |
| 8. | 1 part-9 parts water | 526 | 351 | 66.7 | Dec. 29 | Apr. 28 |
| 9. | " " " | 652 | 253 | 38.8 | Mar. 16 | Apr. 29 |
| 10. | " " " | 449 | 132 | 29.4 | Feb. 17 | May 3 |
| 11. | " " " | 299 | 83 | 27.7 | Mar. 10 | May 2 |

*Notes.*

Table 6. Eggs in tests 1-11 were taken from the same branch. Those in 12-18 were from another branch. All eggs dipped in the different solutions, not sprayed.

Table 7. Nos. 1-5 were kept indoors after treatment; 6-11 outdoors. Nos. 5 and 6 were sprayed, other dipped.

TABLE 8.

| | | | | | | |
|---|---|---|---|---|---|---|
| | Dry lime-sulphur | | | | | |
| 1. | ½ oz.-1 pint water | 302 | 114 | 37.7 | Apr. 5 | Apr. 15 |
| 2. | " " " | 274 | 6 | 2.1 | Mar. 12 | Mar. 28 |
| 3. | " " " | 197 | 74 | 37.5 | Mar. 4 | Mar. 25 |
| 4. | " " " | 418 | 125 | 29.9 | Mar. 16 | Apr. 29 |

TABLE 9.

| | | | | | | |
|---|---|---|---|---|---|---|
| | B. T. S. | | | | | |
| 1. | ½ oz.-1 pint water | 1,047 | 368 | 35.2 | Feb. 8 | Mar. 2 |
| 2. | " " " | 374 | 124 | 33.2 | Apr. 5 | Apr. 15 |
| 3. | " " " | 438 | 35 | 7.9 | Mar. 12 | Mar. 28 |
| 4. | " " " | 234 | 34 | 14.5 | Mar. 4 | Mar. 25 |
| 5. | ½ oz.-1 pint water | 349 | 162 | 46.4 | Mar. 16 | Apr. 29 |
| 6. | B. T. S. ½ oz.-1 pt. water N.S. 1 part-500 part water | 282 | 126 | 44.6 | Apr. 5 | Apr 29 |

TABLE 10.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Scalecide 1-15† | 773 | 27 | 3.5 | Dec. 29 | Feb. 23 |
| 2. | " 1-15 | 1,078 | 0 | 0.0 | Feb. 8 | Mar. 2 |
| 3. | " 1-15 | 412 | 0 | 0.0 | Apr. 5 | Apr. 15 |
| 4. | " 1-15 | 67 | 0 | 0.0 | Mar. 12 | Mar. 28 |
| 5. | " 1-25 | 173 | 0 | 0.0 | Mar. 16 | Apr. 4 |
| 6. | " 1-50 | 356 | 11 | 3.0 | Mar. 16 | Apr. 4 |
| 7. | " 1-15 | 119 | 0 | 0.0 | Mar. 4 | Mar. 25 |
| 8. | " 1-15 | 409 | 135 | 33.0 | Dec. 29 | Apr. 28 |
| 9. | " 1-15 | 104 | 6 | 5.7 | Mar. 8 | Apr. 29 |

† Proportions of Scalecide to water.

TABLE 10—*Continued.*

| Exp. No. | Treatment | Total Number of Eggs Used | Number Hatched | Per Cent. Hatched | Date Treated | Date Examined |
|---|---|---|---|---|---|---|
| 10. | Scalecide 1-25 | 341 | 115 | 33.7 | Mar. 9 | Apr. 29 |
| 11. | " 1-50 | 150 | 8 | 5.3 | Apr. 7 | Apr. 29 |
| 12. | " 1-15 | 669 | 9 | 1.3 | Apr. 7 | Apr. 29 |
| 13. | " 1-25 | 744 | 68 | 9.1 | Apr. 7 | Apr. 29 |
| 14. | " 1-35 | 838 | 53 | 6.3 | Apr. 7 | Apr. 29 |
| 15. | " 1-50 | 462 | 47 | 10.1 | Apr. 7 | Apr. 29 |
| 16. | " 1-15 | 326 | 55 | 16.8 | Feb. 17 | May 3 |

*Notes.*

Table 8. Nos. 1-3 kept indoors, 4 outdoors.

Table 9. Nos. 1-4 kept indoors, 5 and 6 outdoors.

Table 10. Tests 1-7 were kept indoors after treatment; 8-16 were kept outdoors. Numbers 10-15 were sprayed, others were dipped in spray solutions.

TABLE 11.

| Exp. No. | Treatment | Total No. of Eggs Used | No. Hatched | Per Cent. Hatched | Date Treated | Date Examined |
|---|---|---|---|---|---|---|
| 1. | Sunoco spraying oil 1-15 | 233 | 4 | 1.7 | Feb. 1 | Mar. 8 |
| 2. | Sunoco spraying oil 1-15 | 262 | 1 | .4 | Mar. 15 | Apr. 15 |
| 3. | Sunoco spraying oil 1-25 | 180 | 6 | 3.3 | Mar. 15 | Apr. 15 |
| 4. | Sunoco spraying oil 1-50 | 325 | 56 | 14.1 | Feb. 3 | Mar. 8 |
| 5. | Lime-sulphur, 1-6..... | 297 | 68 | 22.8 | Feb. 3 | Mar. 8 |
| 6. | Lime-sulphur, 1-9..... | 224 | 77 | 29.4 | Feb. 3 | Mar. 8 |
| 7. | Target brand scale destroyer, 1-15..... | 357 | 3 | .8 | Feb. 3 | Mar. 8 |
| 8. | Target brand scale destroyer, 1-50..... | 265 | 37 | 13.9 | Feb. 3 | Mar. 8 |
| 9. | Red engine oil 1% emulsion with fish oil soap.. | 299 | 0 | .0 | Mar. 15 | Apr. 15 |
| 10. | Red engine oil 2% emulsion with fish oil soap.. | 322 | 2 | .6 | Mar. 15 | Apr. 15 |
| 11. | Scalecide 1-15..... | 252 | 4 | 1.5 | Mar. 15 | Apr. 15 |
| 12. | Check, no treatment.... | 200 | 143 | 71.5 | ——— | Mar. 8 |
| 13. | Check, no treatment.... | 175 | 136 | 77.7 | ——— | Apr. 15 |
| 14. | Lime-sulphur 1-8..... | 666 | 148 | 22.2 | Apr. 11 | May 15 |
| 15. | Scalecide 1-15..... | 644 | 2 | .3 | Apr. 11 | May 15 |
| 16. | Sunoco spraying oil 1-15 | 573 | 2 | .3 | Apr. 11 | May 15 |
| 17. | Red engine oil 2% emulsion with fish oil soap.. | 646 | 31 | 4.8 | Apr. 11 | May 15 |
| 18. | Check, no treatment.... | 361 | 127 | 35.1 | ——— | May 15 |

TABLE 12 (CHECKS).

| Exp. No. | Total Number of Eggs Used | Number Hatched | Per Cent. Hatched | Date Obtained | Date Examined |
|---|---|---|---|---|---|
| 1. | 1,956 | 345 | 17.6 | Dec. 29 | Feb. 23 |
| 2. | 527 | 263 | 49.9 | Feb. 9 | Mar. 4 |
| 3. | 60 | 45 | 75.0 | Feb. 10 | Mar. 4 |
| 4. | 2,421 | 1,477 | 61.0 | Feb. 8 | Feb. 23 |
| 5. | 334 | 326 | 97.6 | Apr. 5 | Apr. 15 |
| 6. | 359 | 324 | 90.2 | Apr. 8 | Apr. 28 |
| 7. | 208 | 185 | 88.9 | Mar. 4 | Mar. 25 |
| 8. | 402 | 223 | 55.4 | Mar. 10 | Mar. 28 |
| 9. | 403 | 333 | 82.6 | Mar. 11 | Mar. 28 |
| 10. | 430 | 342 | 79.7 | Mar. 12 | Mar. 28 |
| 11. | 255 | 209 | 81.9 | ——— | Apr. 4 |

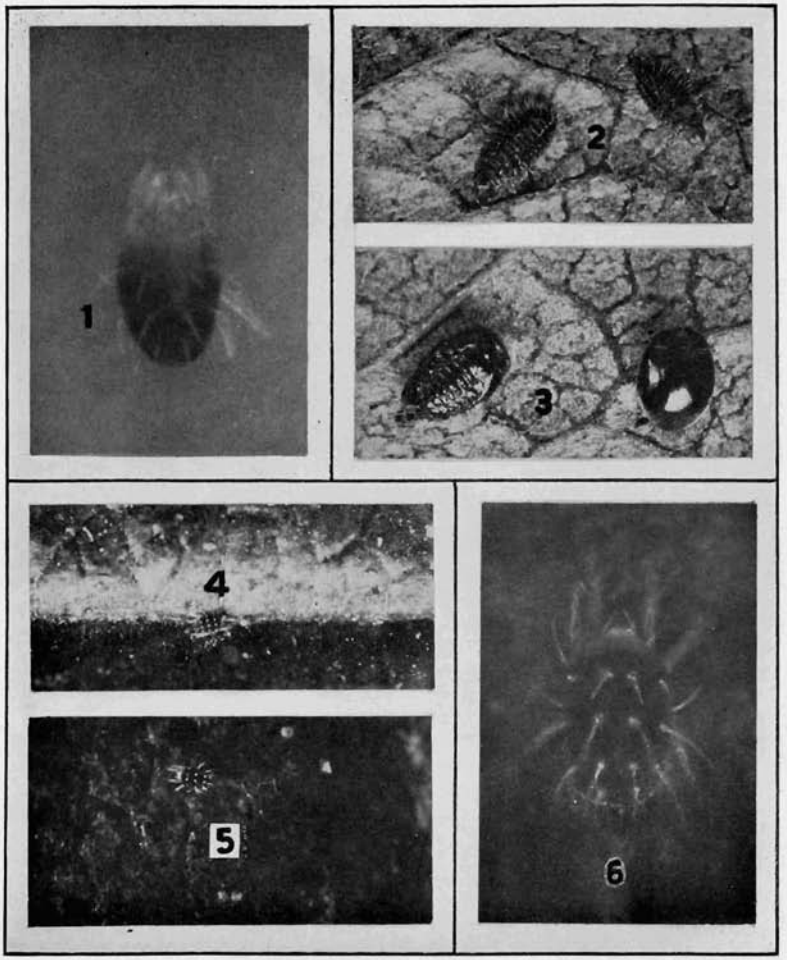
TABLE 12 (CHECKS)—*Continued.*

| Exp. No. | Total Number of Eggs Used | Number Hatched | Per Cent. Hatched | Date Obtained | Date Examined |
|---|---|---|---|---|---|
| 12. | 421 | 181 | 42.9 | Dec. 29 | Apr. 28 |
| 13. | 265 | 151 | 56.9 | Mar. 16 | Apr. 29 |
| 14. | 253 | 164 | 64.8 | Apr. 7 | Apr. 29 |
| 15. | 100 | 45 | 45.0 | Apr. 7 | Apr. 29 |
| 16. | 162 | 109 | 67.3 | Apr. 13 | Apr. 28 |
| 17. | 120 | 20 | 16.6 | Apr. 4 | Apr. 28 |
| 18. | 155 | 85 | 54.8 | Apr. 5 | Apr. 29 |
| 19. | 531 | 337 | 63.4 | Feb. 17 | May 3 |
| 20. | 188 | 114 | 60.6 | Mar. 10 | May 2 |

COMPARATIVE MORTALITY OF TREATED EGGS OF EUROPEAN RED MITE, KEPT OUTDOORS AND INDOORS AFTER TREATMENT.

TABLE 13.

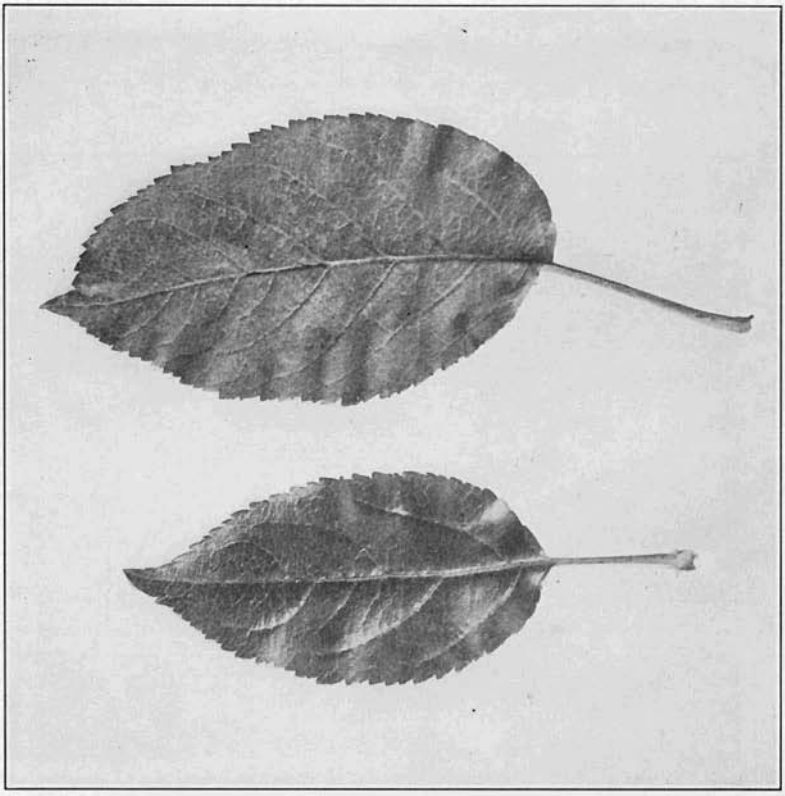
| Treatment | Hatched Per Cent. | Possible Kill Per Cent. | Number of Eggs Used | |
|---|---|---|---|---|
| Check, no treatment | 61.0 | 0 | 7,355 | Indoors |
| | 54.9 | 0 | 2,195 | Outdoors |
| Kero-spray | 86.5 | 0 | 445 | Indoors |
| | 55.7 | 0 | 298 | Outdoors |
| Sulco V. B. | 49.9 | 18.6 | 879 | Indoors |
| | 48.0 | 12.5 | 958 | Outdoors |
| Keresol | 34.2 | 44.0 | 385 | Indoors |
| | 59.9 | 0 | 442 | Outdoors |
| Linseed oil emulsion | 56.0 | 8.4 | 841 | Indoors |
| | 26.1 | 52.5 | 352 | Outdoors |
| B. T. S. | 26.7 | 56.3 | 2,093 | Indoors |
| | 45.6 | 16.8 | 631 | Outdoors |
| Lime-sulphur; liquid 1-9 | 22.1 | 63.8 | 3,596 | Indoors |
| | 43.1 | 21.4 | 2,515 | Outdoors |
| Lime-sulphur; dry | 25.0 | 59.0 | 773 | Indoors |
| | 29.9 | 45.5 | 418 | Outdoors |
| Kerosene emulsion | 31.6 | 48.2 | 227 | Indoors |
| | 60.9 | 0 | 660 | Outdoors |
| Wormol, 1 part in 15 parts water | 5.4 | 91.1 | 419 | Indoors |
| | 14.7 | 73.2 | 292 | Outdoors |
| Scalecide | 1.2 | 98.1 | 2,978 | Indoors |
| | 9.9 | 81.8 | 4,043 | Outdoors |
| Jarvis Compound | 0 | 100 | 792 | Indoors |
| | 6 | 89.1 | 104 | Outdoors |



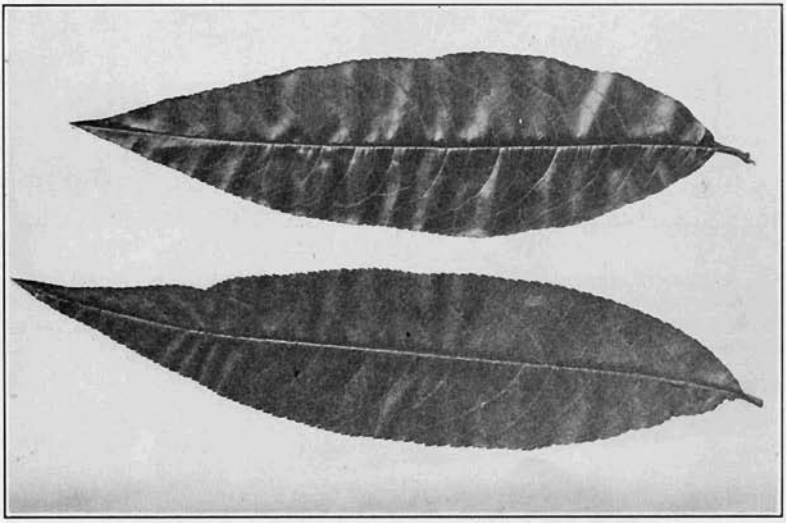

1. Quiescent nymph of European red mite, enlarged 80 times. 2. Larvae of predaceous enemy (*Stethorus punctum* LeConte). 3. Pupa and adult of same, enlarged 10 times. 4 and 5. Adult females of European red mite, enlarged 13 times. 6. Adult female, enlarged 80 times.

**EUROPEAN RED MITE.**

PLATE VI.



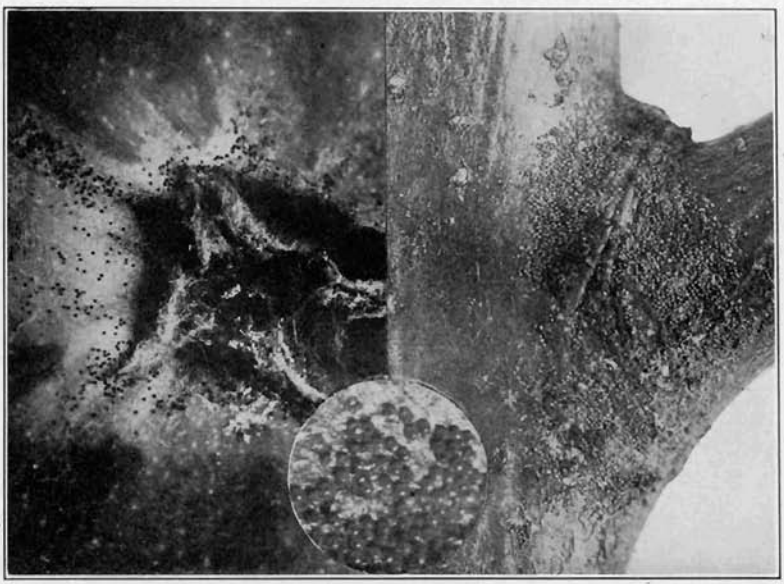
a. Apple leaves, showing leaf injured by European red mite (above), uninjured (below).



b. Peach leaves, showing leaf injured by European red mite (below), uninjured (above).

**EUROPEAN RED MITE.**

[a.] Infested apple tree which has lost much foliage from the attacks of the mite.



b. Eggs on calyx end of apple, and on twig, three times enlarged; insert, same from twig, enlarged about ten times.

**EUROPEAN RED MITE.**

PLATE VIII.

a. View in orchard of Smith T. Bradley, North Branford, showing untreated trees partially defoliated by mite.

b. View in same orchard showing trees which were sprayed with linseed oil emulsion.

**EUROPEAN RED MITE.**

*Notes.*

Table 12. Eggs listed here were not treated with any insecticide. Numbers 1-11 were kept indoors in moist jars; 12-20 outdoors.

Table 13. The percentages in the column headed "possible kill" were obtained by comparing each with the check hatch, obtaining the actual hatch, and subtracting this number from 100, thereby obtaining the per cent. killed. Where the per cent. hatched is higher than the check it is obvious that the insecticide has no killing power.

SUMMARY OF VARIOUS TREATMENTS.

TABLE 14.

| Exp. No. | Treatment | Hatched Per Cent. | Possible Kill Per Cent. | Number of Eggs Used |
|---|---|---|---|---|
| 1. | Check, no treatment | 55.2 | 0 | 9,550 |
| 2. | Kero-spray | 74.1 | 0 | 743 |
| 3. | Sulco V. B | 49.2 | 10.9 | 1,837 |
| 4. | Keresol | 47.9 | 13.3 | 827 |
| 5. | Linseed oil emulsion | 46.3 | 16.2 | 1,193 |
| 6. | B. T. S | 31.1 | 43.7 | 2,724 |
| 7. | Lime-sulphur (liquid) | 30.8 | 44.3 | 6,111 |
| 8. | Lime-sulphur (dry) | 26.3 | 52.4 | 1,191 |
| 9. | Kerosene emulsion | 12.9 | 76.7 | 887 |
| 10. | Wormol | 9.2 | 83.4 | 711 |
| 11. | Scalecide | 7.6 | 86.2 | 7,021 |
| 12. | 2% Red engine oil emulsion | 4.8 | 91.3 | 646 |
| 13. | Jarvis compound | .6 | 99.0 | 896 |
| 14. | Sunoco spraying oil | .3 | 99.5 | 573 |

Different authorities have claimed that dormant or delayed dormant sprays of lime-sulphur either killed the mites before hatching, prevented them from reaching the leaves, or killed them by continued action after reaching the leaves. Although lime-sulphur will kill some of the eggs as shown in the tables, it has been our experience (see Table 15) that it does not prevent them from reaching the leaves or kill them off in appreciable numbers after they begin to feed. It is in fact a much less efficient ovicide for the red mite than miscible oils. A fairly convincing example of this is found in the table below, which gives the results of a test conducted at the Experiment Station Farm in 1923.

TABLE 15—EFFECT OF FIELD TREATMENTS ON THE WINTER EGG.

| Treatment | Number of Fruit Spurs Examined | Number with Live Mites on Leaves | Per Cent. Infested |
|---|---|---|---|
| Scalecide 1-15 | 978 | 56 | 5.7 |
| Lime-sulphur 1-9 | 975 | 972 | 99.6 |
| Check, no treatment | 1,000 | 1,000 | 100.0 |

Examination of the trees during the winter indicated a nearly equal infestation of all blocks. Sprays were applied at the latest possible date considering the development of the trees. Nearly a thousand fruit spurs in each block of about 20 trees were examined, every twig included having eggs on it or at its base. It

will be seen that lime-sulphur checked their development little or none, while the miscible oil used was considerably more effective.

This condition continued well into the summer and trees receiving lime-sulphur alone as a delayed dormant spray were in practically the same condition as those receiving no spray, that is, in the amount of infestation on the leaves. What virtue there is in lime-sulphur seems to rest mainly with early summer sprays and not so much with the delayed dormant. Early summer sprays at 1.5–50 or 1–50 have been successful in three different experimental orchards in keeping the mite in control—and this without any dormant or delayed dormant spray whatsoever. This, together with the information in Table 15, indicates that lime-sulphur dormant or delayed dormant sprays are of little value in red mite control.

It will be noted in Tables 7, 9 and 10 that there is a general reduction in percentage of hatch after treatments as the season advances from December to April or May. This is probably due to embryonic development, but the membranes do not split as in the case of aphids. The outer membrane, however, does loosen up and may be peeled off with a needle several days before the mite hatches. These facts were corroborated in practical experience at the Conyers Farm orchard at Greenwich, in charge of Mr. G. A. Drew. Fall spraying in this orchard with miscible oil killed a very small per cent., while spring applications were quite effective.

Scalecide is the only miscible oil which has been given a field test, and it is shown to be effective. There are other oil emulsions, however, which should do the work, and some, notably the home-made lubricating oil emulsions, apparently are causing no damage.[8] There is an element of danger in using them, and it is well to observe some precautions in applying.

1. Make sure that all of the oil emulsifies, leaving none floating on the surface of the water in the spray tank. This condition will often follow the use of old material which has been on hand for a year or more. In most cases it is best to have fresh stock.
2. Do not drench the trees; spray lightly, covering the outer twigs and smaller branches.
3. Do not spray in weather so cold that the spray freezes.
4. Apply before the buds break, as a late dormant spray. This usually falls several weeks before the *delayed dormant spray*.
5. Do not use at all unless red mite eggs are very numerous, or unless you expect a serious outbreak; an application of miscible oil once every three years should be sufficient when the mite is once in control.

### Summer Sprays.

Different substances have been tested on the mites themselves for killing power, and the results are given below in Table 16. Such tests are not so satisfactory as similar tests for the eggs, be-

cause of the fact that the mite is susceptible to changes in temperature and also to condition of the food plant. At any rate, there is considerable more variation in the results obtained, though they indicate in a general way the effectiveness of soaps, lime-sulphur solutions, and oil emulsions.

TABLE 16—RESULTS OF LABORATORY TESTS TO CONTROL MITES.

| Exp. No. | Insecticide Used | No. Dead | No. Alive | Per Cent. Dead | Temp. of Air F | Dates |
|---|---|---|---|---|---|---|
| 1. | Ivory soap flakes 2 lbs. —50 gals..... | 67 | 12 | 84.8 | | May 20–22 |
| 2. | Ivory soap 2 lbs.—50 gals. plus Melrosine 1 part to 100..... | 71 | 14 | 83.5 | | May 20–22 |
| 3. | Ivory soap flakes 2 lbs. —50 gals..... | 409 | 2 | 99.5 | 73 | May 13–18 |
| 4. | Ivory soap flakes 2 lbs. —50 gals..... | 406 | 4 | 99.0 | 80.5–82 | May 13–18 |
| 5. | Lux 2 lbs.—50 gals... | 107 | 1 | 99.0 | 73 | May 13–18 |
| 6. | Lux 2 lbs.—50 gals... | 164 | 3 | 98.1 | 80.5–82 | May 13–18 |
| 7. | Potash fish oil soap 10 lbs.—50 gals..... | 12 | 14 | 46.1 | | May 23–25 |
| 8. | Fish oil soap 5 lbs.— 50 gals..... | 13 | 41 | 24.0 | | May 23–25 |
| 9. | Fish oil soap 10 lbs.— 50; sulphur 16 lbs. 50 gals..... | 16 | 93 | 14.6 | 80.5–82 | May 27–31 |
| 10. | Borax soap 4 lbs.—48 gals. water..... | 128 | 26 | 83.1 | 60–79 | Aug. 17–18 |
| 11. | Linseed oil emulsion 1 part—20 parts water | 81 | 5 | 94.1 | 70–74 | Aug. 17–18 |
| 12. | 40% nicotine sulphate ¾ pt.—50 gals..... | 114 | 5 | 95.7 | | July 28–30 |
| 13. | Borax soap 6 lbs.—50 gals..... | 141 | 6 | 95.9 | | July 28–30 |
| 14. | Fels naphtha soap 4 lbs.—50 gals..... | 15 | 0 | 100 | | July 28–29 |
| 15. | Star soap 4 lbs.—50 gals..... | 23 | 2 | 92 | | July 29–30 |
| 16. | Dusted with sulphur.. | 22 | 59 | 27.1 | 73 | May 12–18 |
| 17. | Dusted with sulphur.. | 101 | 2 | 98.0 | 80.5–82 | May 12–18 |
| 18. | Lime-sulphur 1—40 nicotine sulphate 1 —500..... | 36 | 2 | 95.0 | 60–79 | Aug. 15–16 |
| 19. | Lime-sulphur 1—40; nicotine sulphate 1 —500..... | 141 | 18 | 88.7 | 60–79 | Aug. 17–18 |
| 20. | Ace-Hy 1—400† ..... | 108 | 254 | 29.8 | | June 31–July 1 |
| 21. | Ace-Hy 1—200† ..... | 40 | 2 | 95.2 | | Aug. 29 |
| 22. | Lime-sulphur 1—43¼ gals..... | 79 | 28 | 73.8 | | July 28–30 |
| 23. | Check, no treatment.. | 4 | 53 | 9.5 | 73 | May 12–18 |
| 24. | Check, no treatment.. | 22 | 31 | 41.7 | 80.5–82 | May 12–18 |
| 25. | Check, no treatment.. | 12 | 70 | 14.6 | | May 20–22 |
| 26. | Check, no treatment.. | 2 | 84 | 2.3 | 60–79 | Aug. 17–18 |

† An insecticide no longer on the market; containing cyanide (CN) as the active ingredient.

Sulphur dusts are variable, both in laboratory and in the field, but at least one factor influencing their effectiveness is found in the temperature of the atmosphere as shown in the two following charts, giving the killing power of sulphur dust and a dust containing 88 per cent. sulphur and 10 per cent. lead arsenate.

"Pomodust"† is now on the market and was apparently effective in controlling the red mite under the weather conditions experienced in 1923. The totally different action of sulphur dusts in

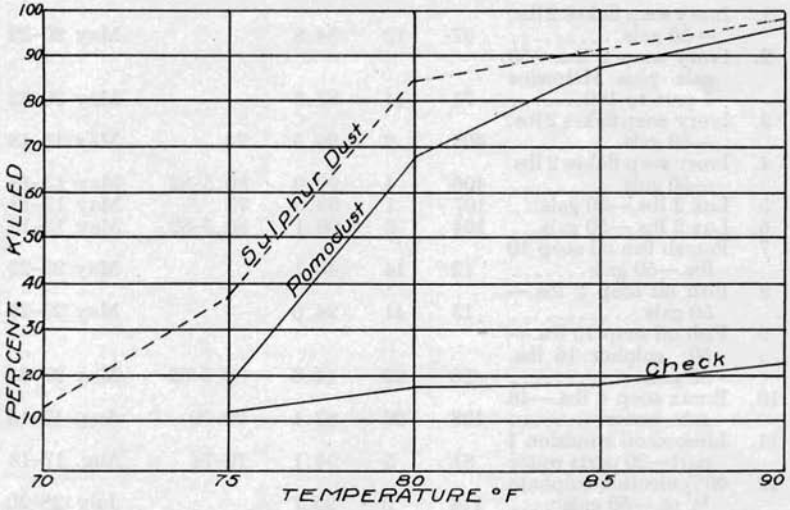



Chart 1. Showing kill obtained with sulphur dust and "Pomodust" at different temperatures; exposure in each case 24 hours.

1922 may be explained by the lack of excessive heat, and the dry weather which doubtless influenced the results in 1923.

Field tests have been conducted in five different orchards in Connecticut. The first were carried out at the Plant Brothers orchard in Branford in 1920. Soap, soap and nicotine sulphate, and sulphur-arsenate-nicotine dust were tried, but results were inconclusive due to the lateness of the applications. In 1921, no field tests were conducted but in 1922 serious outbreaks occurred and experiments were undertaken in three different orchards. Good control was secured with linseed oil emulsion, soaps, and a lime-sulphur-lead-arsenate-nicotine mixture. Tests at the Bradley orchard showed good control with linseed oil emulsion and with fish oil soap. Good control, however, was obtained with borax soap and lime-sulphur-lead-arsenate-nicotine combination in the

† Chemical analysis by the Connecticut Station, Department of Chemistry, showed that it contains sulphur 87.79 per cent., lead arsenate 9.80 per cent., and a trace of iron; water soluble arsenic .24 per cent.

Milford orchard of F. N. Platt. Counts were not made in the Milford orchard, but from a practical standpoint results were good, since the foliage continued green throughout the summer.

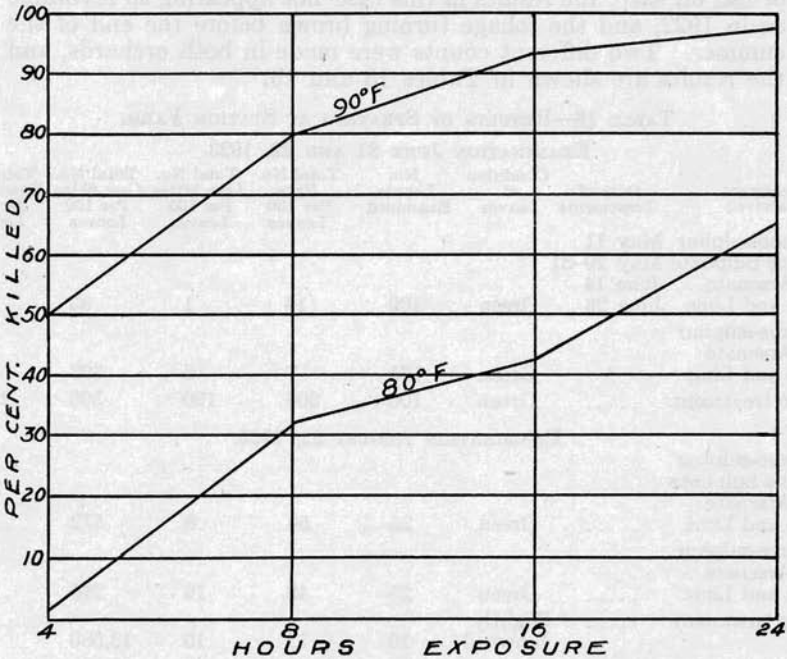



Chart 2. Showing kill obtained with "Pomodust" at different temperatures and different lengths of exposure.

TABLE 17—RESULTS OF FIELD TESTS WITH SOAPS, LINSEED OIL EMULSION AND SELF-BOILED LIME-SULPHUR IN BRADLEY ORCHARD.

| Insecticide Used | No. Alive | No. Dead | Per Cent. Dead | No. of Leaves Examined | No. of Twigs Examined | Date of Treatment | Date of Examination 1922 |
|---|---|---|---|---|---|---|---|
| Linseed Oil 1 gal.† Ivory soap 1½ lbs. Water 100 gals... | 718 | 1,524 | 67.9 | 80 | 10 | June 2 | June 6 |
| Ivory soap 6 lbs. Water 200 gals... | 1,743 | 779 | 30.8 | 60 | 9 | June 2 | June 6 |
| "Kerospray" 1 gal. —100 gals..... | 916 | 381 | 29.5 | 50 | 6 | June 2 | June 6 |
| Fish oil soap 14 lbs.—200 gals.. | 691 | 655 | 48.6 | 54 | 6 | June 2 | June 7 |
| Self-boiled lime-sulphur (8-8-50) Kayso 2½ lbs.— 200 gals..... | 951 | 356 | 27.2 | 64 | 8 | June 2 | June 8 |
| None..... | 1,592 | 278 | 14. | 65 | 7 | ——— | June 8 |

† Prepared according to directions in Mass. Agr. Exp. Sta. Bull. 179, pages 175-6, except that flakes were used instead of bars of soap.

Continued experimentation in 1923 in the orchard at the Experiment Station Farm and in the orchard at Conyers Farm, Greenwich, substantiated the results in 1922 except for the use of fish oil soap, the results in this case not appearing so favorable as in 1922, and the foliage turning brown before the end of the summer. Two different counts were made in both orchards, and the results are shown in Tables 18 and 19.

TABLE 18—RESULTS OF SPRAYING AT STATION FARM.

EXAMINATION JUNE 21 AND 22, 1923.

| Treatment Received | Date of Treatments | Condition of Leaves | No. Leaves Examined | Total No. Eggs Per 100 Leaves | Total No. Live Mites Per 100 Leaves | Total No. Cast Skins Per 100 Leaves | Total No. Dead Mites Per 100 Leaves |
|---|---|---|---|---|---|---|---|
| 1. Lime-sulphur Nicotine Sulphate Lead Arsenate.. Kayso and Lime | May 11 May 29–31 June 14 June 26 | Green | 100 | 16 | 1 | 33 | 14 |
| 2. Lime-sulphur Lead Arsenate Kayso and Lime | " | Green | 125 | 7 | 6 | 303 | 43 |
| 3. No treatment | ..... | Green | 100 | 606 | 190 | 306 | 281 |

EXAMINATION AUGUST 22, 1923.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. Lime-sulphur Nicotine Sulphate Lead Arsenate Kayso and Lime | ..... | Green | 25 | 54 | 8 | 572 | ... |
| 2. Lime-sulphur Lead Arsenate Kayso and Lime | ..... | Green | 25 | 48 | 16 | 240 | ... |
| 3. No treatment | ..... | Slightly browned | 10 | 12 | 10 | 13,580 | 4 |

TABLE 19—RESULTS OF SPRAYING AT CONYERS FARM.

EXAMINATION JUNE 12, 1923.

| Treatment Received | Date of Treatments | Condition of Leaves | No. Leaves Examined | Total No. Eggs Per 100 Leaves | Total No. Live Mites Per 100 Leaves | Total No. Cast Skins Per 100 Leaves | Total No. Dead Mites Per 100 Leaves |
|---|---|---|---|---|---|---|---|
| 1. Lime-sulphur 1—50 | May 2 May 24 June 26 | Green | 225 | 3 | 2 | 130 | 3 |
| 2. Lime-sulphur followed by linseed oil emulsion | May 2 May 24 June 26 | Green | 100 | 39 | 61 | 71 | 88 |
| 3. Check, no treatment | ..... | Turning brown | 50 | 286 | 1,220 | 1,094 | 258 |
| 4. Lime-sulphur plus nicotine sulphate | May 2 May 24 June 26 | Green | 160 | 3 | 6 | 178 | 16 |
| 5. Lime-sulphur plus Kayso and Sulphur | " | Green | 210 | 11 | 26 | 227 | 25 |
| 6. Fish Oil Soap and Sulphur | " | Green | 200 | 25 | 29 | 196 | 38 |

TABLE 19. RESULTS OF SPRAYING AT CONYERS FARM—*Continued.*

EXAMINATION AUGUST 2, 1923.

| Treatment Received | Date of Treatments | Condition of Leaves | No Leaves Examined | Total No. Eggs Per 100 Leaves | Total No. Live Mites Per 100 Leaves | Total No. Cast Skins Per 100 Leaves | Total No. Dead Mites Per 100 Leaves |
|---|---|---|---|---|---|---|---|
| 1. Lime-Sulphur 1—50 | ..... | Green | 25 | 212 | 44 | 592 | 40 |
| 2. Lime-sulphur 1—50 followed by linseed oil emulsion | ..... | Green | 25 | 328 | 168 | 5,590 | 120 |
| 3. Check, no treatment | ..... | Brown | 25 | 20 | 25 | 18,300 | 4 |
| 4. Lime-sulphur plus nicotine sulphate | ..... | Green | 25 | 140 | 44 | 3,476 | 16 |
| 5. Lime-sulphur plus Kayso and Sulphur | ..... | Green | 25 | 32 | 8 | 1,562 | 0 |
| 6. Fish oil soap and Sulphur | ..... | Brown | 25 | 1,648 | 544 | 10,300 | 280 |

*Notes.*

Table 18. Insecticides used at the following strengths in all tests. Lime-Sulphur 1.5 gal. to 50 gals.; nicotine sulphate .5 pint to 50 gals.; Lead arsenate 1.5 lbs. to 50 gals.; Kayso .75 lb. to 50 gals.; hydrated lime 1.5 lbs. to 50 gals.

Table 19. Insecticides used at following strengths. 2.—One per cent. linseed oil emulsion. 4.—Lime-sulphur 1 gal. to 50 gals., nicotine sulphate 6 oz. to 50 gals. 5.—Lime-sulphur .5 gal. to 50 gals., Kayso .75 lbs. to 50 gals., sulphur 5 lbs. to 50 gals. 6.—Potash fish oil soap 5 lbs. to 50 gals., sulphur 5 lbs. to 50 gals.

Cast skins left upon the leaves gave a reliable index of the efficiency of a spray in 1923, the total number found indicating how many mites had been present. Thus at the Experiment Station Farm, examination August 22, check trees showed twenty to fifty times as many cast skins per leaf as in the case of trees sprayed with lime-sulphur. At the Conyers orchard the check trees had from six to thirty times as many casts as could be found on trees sprayed with lime-sulphur. This seems to be more reliable than judging the foliage greenness, which may be affected by a number of causes. It will also be seen that no conspicuously greater control was obtained with lime-sulphur to which nicotine alone was added than with lime-sulphur combinations containing no nicotine. Lime-sulphur combinations thus far have not failed in a single instance under our observation to control the red mite successfully if applied according to spray calendar recommendations, especial attention being given to early summer sprays.

Mineral oil and linseed oil emulsions are very effective in killing mites—apparently more so than lime-sulphur if the count is made shortly after the spray is applied. They have given uniform results of this kind in every instance and there is no reason why linseed oil emulsion (or other safe spraying oil) cannot be used to advantage on trees unable to stand commercial lime-sulphur. For

apples their use seems to be needless in view of more efficient fungicidal effects of lime-sulphur. Soaps are likely to vary, and while their combination with sulphur may be effective at times, even this combination may fail to give good results. Probably their continued effect is dependent upon heat as with sulphur dusts already mentioned. A field test of three oil emulsions is shown in Table 20.

TABLE 20. EUROPEAN RED MITE CONTROL AT CONYERS ORCHARD.†

SPRAYED JUNE 25, 1923.

| Exp. No. | Insecticide Used | Number Live Mites. | Number Dead. | Per Cent. Dead. | Possible Kill Per Cent. |
|---|---|---|---|---|---|
| 1. | Sunoco spraying oil 1 part in 100 parts water..... | 6 | 395 | 98.5 | 98.1 |
| 2. | Linseed oil emulsion 1 gallon linseed oil 1¼ lbs. Ivory soap 100 gallons water | 30 | 177 | 85.5 | 82.5 |
| 3. | Schnarr's insecticide 1 part in 100 parts water..... | 28 | 412 | 93.5 | 92.6 |
| 4. | None ..... | 241 | 61 | 20.1 | 0.0 |

*Notes.*

Trees in experiments 1 and 3 sprayed with hand pump and rod, 2 with gun and power outfit.

## SPRAY BURN RESULTING FROM SPRAYS CONTAINING LIME-SULPHUR.

The main objection to the use of lime-sulphur solution has been due to burning of the foliage. Severe spray burn was noticed in different sections of Connecticut in 1923 and notes upon the probable cause are timely. As the spray formula consists of several compounds, the following possibilities arise:

1. The cause of the spray burn may be the lime-sulphur solution—due to composition or strength.
2. It may be due to lead arsenate alone—due to high water soluble arsenic content.
3. It may be due to nicotine sulphate—especially combination products with other insecticides.
4. It may be due to a combination of all of these materials resulting in other compounds or altered original compounds which cause burning.
5. Weather conditions noticeably affect the degree of spray burn.
6. The particular variety may be susceptible to spray injury.

† Leaves collected immediately after treatment and examined the following day.

Considering these causes in order, with precautions necessary to avoid injury, it seems advisable:

1. To reduce the strength of lime-sulphur on tender varieties such as Baldwin from 1½ to 50 gallons to 1 to 50 or even 1 to 75 in the later applications.

2. To obtain a guarantee that the lead arsenate used shall contain no more than .75% of water soluble arsenic. If large quantities are purchased have the material analyzed for water soluble arsenic at the Experiment Station or elsewhere.

3. Omit nicotine sulphate unless aphids are present in the orchard.

4. Combine your sprays in the following order:

1. Lead arsenate
2. Nicotine sulphate
3. Casein lime
4. Lime-sulphur.

Do not allow sludge to collect in the bottom of the spray tank; clean frequently.

5. Do not spray when the temperature or humidity is high. It is best to stop when the temperature reaches 90 degrees.

6. Be particularly careful with Baldwin and other thin leaved varieties. If the trees continue to be burned, use formula[3] containing lime-sulphur, casein lime and sulphur as follows:

| | |
|---|---|
| Water | 100 gallons |
| Lime-sulphur | 1 gallon |
| Finely ground sulphur | 5–10 lbs. |
| Casein lime | 1 lb. |

## Summary and Recommendations.

1. The European red mite passes the winter in the egg stage upon smaller twigs and branches. Eggs hatch in April or May at the time fruit buds are turning pink.

2. The incubation period of the summer egg varies from six to thirteen days, and the adult develops in five to ten days. The preoviposition period lasts from one to seven days, but eggs are usually laid within a few days after emergence. Adults lived six to nineteen days and adult females laid a total of sixteen to thirty-four eggs during their lives. Winter eggs are sometimes laid in August; usually however during September and early October. Winter eggs are dark red, summer eggs, brown.

3. This mite is easily distinguished from other species in adult and egg stage.

4. An infestation of 50 to 100 mites per leaf is sufficient to cause leaves of apple trees to turn brown. Baldwin is the variety most commonly injured.

5. Enemies become numerous in July and August and are often responsible for the disappearance of the red mite.

6. Dry weather in summer favors their development and a wet period with frequent showers keeps them in check.

7. A definite spray schedule should be adopted in orchards where mites are numerous.

8. Lime-sulphur delayed dormant spray is not effective because of the late hatching of the egg.

9. Miscible oils are effective dormant sprays, and with care are reasonably safe in orchard work. Fall sprays of miscible oil are apparently ineffective.

10. Lime-sulphur, summer strength, sprays should be applied early beginning with the pink spray, which should be followed by at least two others containing lime-sulphur, the latest being applied the last of June or first of July.

11. Nicotine sulphate is unnecessary in the spray mixture so far as mite control is concerned.

12. Soaps, miscible oils and linseed oil emulsion are very effective summer sprays, but needless and apparently less efficient in control of fungous diseases than lime-sulphur.

13. Care should be exercised in applications of lime-sulphur and the precautions noted on page 123 carefully observed.

## ACKNOWLEDGMENTS.

In the course of the work outlined in the present paper, several persons have aided materially. Dr. W. E. Britton, and Messrs. M. P. Zappe, B. H. Walden, E. M. Stoddard and G. E. Graham have given invaluable service. The use of orchards belonging to the Plant Brothers at Branford, S. T. Bradley of North Branford, F. N. Platt of Milford, as well as the Conyers orchard at Greenwich, managed by Messrs. G. A. Drew and H. B. Reed, has increased the scope of the work immeasurably. Thanks are due to all persons in charge of orchards, without whose aid orchard field work would have been impossible; and to those who have given personal service and advice throughout the period of these investigations.

## LITERATURE.

1. Caesar, L.
1915. *In* Canadian Entomologist, 57-58.
2. DeLong, D. M.
1923. Results of Spraying and Dusting for the Control of the Red Spider (*Paratetranychus pilosus*).
*In* Journ. Econ. Ent. 16: 88-90.
3. de Ong, E. R.
1922. The Control of Red Spider in Deciduous Orchards.
Cal. Agr. Exp. Sta. Bull. 347.
4. Essig, E. O.
1922. The European Red Mite.
*In* Mo. Bul. Cal. State Dept. Agr. 11: 409-411.

5. Ewing, H. E.
1912. The Occurrence of the Citrus Red Spider *Tetranychus mytilaspidis* Riley on Stone and Citrus Fruit Trees in Oregon.
*In* Journ. Econ. Ent. 5: 414-415.
6. .....
1914. The Common Red Spider or Spider Mite.
Ore. Agr. Exp. Sta. Bul. 121.
7. Fernald, H. T. and Bourne, A. I.
1922. Injury to Foliage by Arsenical Sprays.
Mass. Agr. Exp. Sta. Bul. 207.
8. Flint, W. P.
1923. Shall we Change our Recommendations for San José Scale Control?
*In* Journ. Econ. Ent. 16: 209-212.
9. Frost, S. W.
1919. *In* Journ. Econ. Ent. 12: 407.
10. Garman, Philip.
1921. The European Red Mite, *Paratetranychus pilosus* Can. & Fanz., in Connecticut.
*In* Journ. Econ. Ent. 14: 355-359.
11. .....
1920. *In* Rept. Conn. State Entomologist, 184–189.
1921. " " " " 146–152.
1922. " " " " 333–338.
12. Hamilton, C. C.
1922. Univ. Md. Extension Service Information Card No. 6.
13. Houser, J. S.
1923. Proc. Fifty-sixth Ann. Meeting Ohio Sta. Hort. Soc., 56-59.
14. McGregor, E. A.
1919. The Red Spiders of America and a Few European Species Likely to be Introduced.
Proc. U. S. Nat. Mus. 56: 641-679.
15. Stratford, G.
1920. Control of Red Mite on Apple Trees.
*In* New Zealand Journal of Agriculture XX: 176-178.
16. Tragardh, Ivar.
1915. Bidrag Till Kannedomen Om Spinnkvalstren (Tetranychus Duf.).
Med. nir. 109, fr. Cent. f. fors, pa jordbr. Entom. avdel. n: r 20.
17. Quayle, H. J.
1912. Red Spiders and Mites of Citrus Trees.
Cal. Agr. Exp. Sta. Bul. 234.
1913. Some Natural Enemies of Spiders and Mites.
*In* Journ. Econ. Ent. 6: 86-88.
18. Vinal, Stuart C.
1917. The Greenhouse Red Spider Attacking Cucumbers and Methods for its Control.
Mass. Agr. Exp. Sta. Bul. 179.