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SUSCEPTIBILITY TO SPRAYING MIXTURES OF HIBER-
NATING PEAR PSYLLA ADULTS AND THEIR EGGS.

H. E. HODGKISS.



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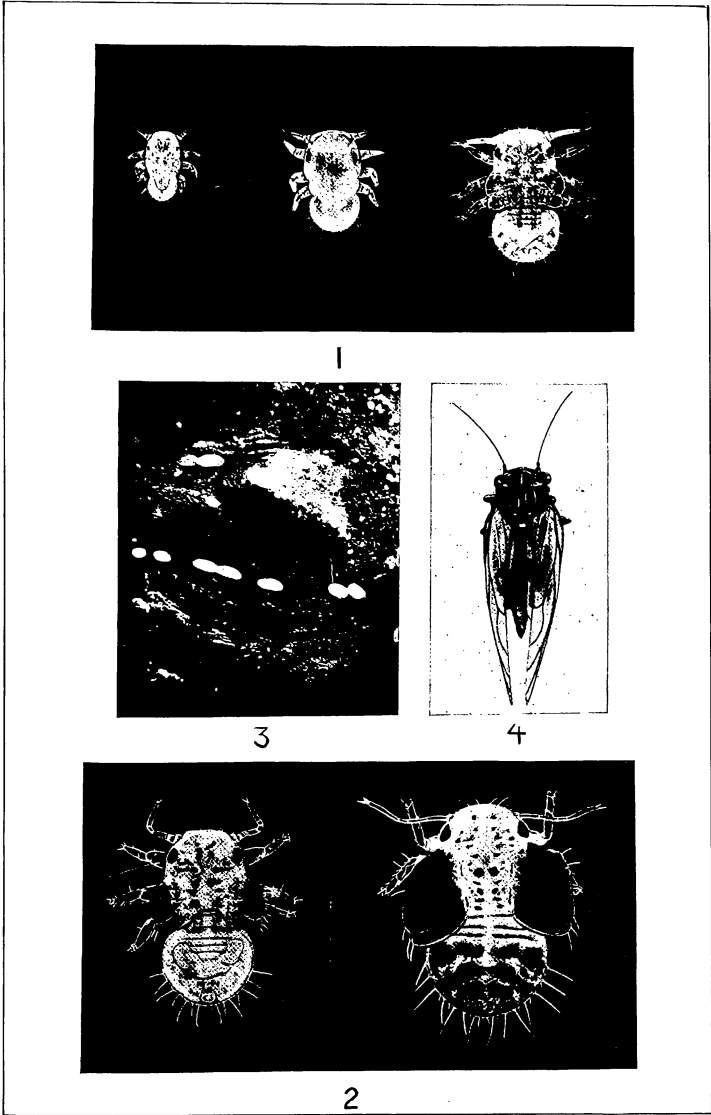


PLATE I.—THE PEAR PSYLLA:
1, Nymphs, stages 1-3; 2, nymphs, stages 4-5; 3, eggs; 4, winter adult.
(All figures much enlarged).!

SUSCEPTIBILITY TO SPRAYING MIXTURES OF
HIBERNATING PSYLLA ADULTS
AND THEIR EGGS.

H. E. HODGKISS.

SUMMARY.

Investigations of failures to control the psylla in pear orchards led the Station to inquire into the susceptibilities of the hibernating adults and their eggs to spray mixtures.

Studies of the seasonal history and habits of the insect showed that the pear psylla passes the winter as an adult or "fly," and that it deposits its eggs in the spring within a short period after its emergence from hibernating quarters. The psylla was observed to winter over on various fruit trees such as apple, cherry, plum and peach, but the largest number of the "flies" sought hibernation in the rough bark of pear trees.

The behaviour of the hibernating "flies" in the fall was quite different from the movements of the insects in the spring. During a period in late fall or early winter when the weather moderated it was observed that few of the "flies" remained in hiding and that they largely clustered in the center of the trees. At such times the adults walked but were sluggish in their movements and rarely attempted to jump or fly. On the contrary, during the spring, as a result of constantly increasing temperatures and the daily effectiveness of sunlight, a few hours of time proved sufficient to induce great activity among the adults. It was not uncommon for them to jump or fly directly after emergence from their winter retreats.

If moderate temperatures prevailed eggs were largely deposited within a few days after the emergence of the hibernating adults in the spring. Oviposition continued for several weeks, especially if the weather was variable, but usually most of the eggs were deposited before the last of April. Some ova were laid on foliage, but it appeared that these normally are comparatively few in numbers and result in little or no serious infestation of the foliage.

The practice of clean culture and the removal and destruction of the rough bark left the "flies" with few opportunities of escape from applications of contact mixtures. Miscible oils, nicotine preparations and soapy solutions were effective sprays against the psylla adults. Homemade oil-emulsions were less satisfactory, which may have been owing to varying percentages of oil in the mixtures, caused by imperfectly prepared emulsions.

The best means of killing the "flies" is spraying during a period of warm weather, preferably in November or December, or during March or early in April. The most satisfactory mixture, from the standpoints of safety to fruit and leaf buds and effectiveness against the insect, is three-fourths of a pint of tobacco extract (40 per ct. nicotine) in 100 gallons of water to which are added from three to five pounds of soap.

Eggs about to hatch and newly emerged nymphs succumb to an application of the lime-sulphur solution. By postponing the dormant treatment for the San Jose scale until the blossom cluster-buds are beginning to separate at the tips, very effective work can be done against the eggs. The lime-sulphur should be used in the proportion of one gallon of the concentrate, 32° B., to eight gallons of water. In some tests of other contact sprays the miscible oils, oil emulsions, weak dilutions of nicotine, and soapy solutions were of small value for the destruction of the eggs. Ova deposited on the twigs after the wood was thoroughly sprayed with the lime-sulphur solution hatched, and the young nymphs were not harmed through contact with the material on the bark of the trees. On the other hand the wash having considerable amounts of sediment (15-20-50 formula) was less destructive to the eggs but the young psyllas which hatched for the most part failed to reach the opening buds and these succumbed to the action of the sediment which became attached to their bodies after leaving the egg shells.

The chief factors which make for efficient work against the hibernating "flies" and their eggs are (1) a knowledge on the part of the grower of the habits of the "flies" and an acquaintance with the eggs; (2) an understanding of the conditions under which these stages are most vulnerable to sprays; (3) thorough work in spraying.

INTRODUCTION.

Failures to control psylla in pear orchards by summer spraying to destroy the nymphs only, have led the Station to inquire into the susceptibility of the insect to spraying mixtures at other stages of its life. Attention has been given especially to the hibernating adults and to the eggs of this brood, for it has seemed on casual observations that these, under certain conditions, might be quite vulnerable to treatment. This conviction was further strengthened by a study of the literature on the species, which has indicated the possibility of protecting orchards by combating the insects in either of these stages, and has emphasized the desirability of experiments along the proposed lines.

HISTORICAL SUMMARY OF SPRAYING FOR ADULTS AND EGGS.

In 1896 Dr. J. B. Smith¹ of the New Jersey Station suggested that "the application of whale-oil soap early in the spring, just as the buds begin to swell, will generally kill the insects (hibernating flies), which are then ready to emerge from winter quarters. Good practice is to scrape all the loose bark from the trees during the winter, and burn it; wash at that time with a potash or strong kerosene mixture, and in the spring use the whale-oil soap at the rate of one pound in one gallon of water, being careful to confine the spraying to the trunk and larger branches. If this is thoroughly done, it forms a film over the trunk which no insect will voluntarily pierce. A liberal application of whitewash is also advantageous * * *"

Prof. M. V. Slingerland² in 1899 recommended that "as these hibernating psyllas are the progenitors of all that will appear on the trees during the following season one can readily see how much it means to kill these over-wintering adults before they begin egg laying in the spring. Drenching the bark thoroughly with a strong kerosene emulsion (1 part emulsion to 4 or 5 of water), whale-oil soap (one pound in three to five gallons of water), or kerosene, using about one part of kerosene to nine or ten parts of water, would be a wise investment."

¹Economic Entomology, p. 138. 1896.

²Proc. W. N. Y. Hort. Soc. 44:71. 1899.

In 1911 Dr. J. B. Smith³ stated "experience has shown that a winter spray of miscible oil, diluted not over ten times, and applied with force enough to penetrate to the bottom of all crevices, produces satisfactory results. I usually recommend that the rough bark be first removed; but if that is done, it is essential that the spraying be done immediately thereafter, and that the scrapings be either burnt at once or thoroughly drenched with the spray. The insects become active enough to crawl at a very moderate temperature, and if scrapings are left lying during an entire sunny day, they may leave them and get among the soil rubbish for a new shelter. On the other hand, the sprayings should not be done at a temperature at or below the freezing point as that impairs the efficiency of the oil."

The eggs of the pear psylla have usually been regarded as quite resistant to sprays which are considered "safe to foliage." Experiments by Slingerland⁴ in 1892 with various insecticides such as kerosene emulsion used full strength, or diluted in three parts of water heated to 130° F., pure kerosene, turpentine emulsion at a dilution of one part of the emulsion to three parts of water, pure turpentine, crude carbolic acid emulsion diluted with ten parts of water, resin wash used triple strength, and heated to 130° F., whale-oil soap and sulphide of potash wash used at double strengths, concentrated potash in the proportion of one pound to one gallon of water, or benzine in undiluted sprays, led him to conclude that it is inadvisable to attempt to combat the pest by spraying to kill the eggs. Subsequent experiments by Marlatt⁵ in 1894 with various oil-emulsions were more successful, but as a varying percentage of the eggs were unharmed he also laid chief emphasis on the importance of destroying the newly hatched nymphs as the most reliable method of control.

With the general use of the lime-sulphur sprays in the East, commencing about 1902, there have been indications that applications of these mixtures have proven of more or less value in the prevention of injuries by this pest. In 1904⁶ some experiments by this Station indicated that these washes had afforded considerable protection

³N. J. Agr. Expt. Sta. Rpt. 31:305-6. 1910 (1911).

⁴Cornell Univ. Expt. Sta. Bul. 44:179. 1892.

⁵*Insect Life*. 7:183-4. 1894.

⁶N. Y. State Agr. Expt. Sta. Bul. 262:62-63; 65-6. 1905.

from the first brood of nymphs. In the spring of 1905⁷ Mr. Fred Johnson of the U. S. Bureau of Entomology was led to believe that the spring application of the lime-sulphur wash was quite effective in destroying the eggs of this insect in Niagara county. On the basis of his observations of pear orchards in the Hudson River Valley, Dr. E. P. Felt,⁸ in 1910, expressed a similar opinion.

In describing conditions in Connecticut during 1904 Dr. W. E. Britton⁹ stated "after spraying pear trees with lime and sulphur mixtures to kill the San Jose scale it was noted that the pear psylla was scarce, though the insect was observed in other localities where it caused more or less injury."

In England, Theobald,¹⁰ while working with a closely related species on apple, doubted the value of most washes in killing psylla eggs, and, while apparently he had not tested the lime-sulphur preparations, he recommends the use of a lime-salt mixture for the prevention of the hatching of the eggs. The application is said to act largely as a mechanical barrier to the escape of large numbers of the young, although he suggests that the salt has some osmotic power "as when the quantity of the salt is increased the action becomes greater."

The experiences of some of the leading growers in New York have borne out the promises of the early experiments with the lime-sulphur wash, and the use of this spray in later years seems to have afforded them almost complete protection against the psylla. On the other hand the results in most plantings have been variable and quite contradictory; and in spite of annual sprayings with lime-sulphur wash before the appearance of foliage the pest has, for several seasons, made serious inroads in pear orchards generally. The true explanation for these differences has been wanting, but the discrepancies appear to have been largely due to habits of the hibernating "flies" as affected by seasonal conditions.

Very little was known of the over-wintering adults or the circumstances of oviposition which would appear to be essential for intelligent action. To these points the Station has devoted much attention for the purpose of determining the best conditions for effective spraying against the adults and the eggs deposited by them.

⁷U. S. Dept. Agr. Yearbook, 1906 (1907). p. 446.

⁸N. Y. State Mus. Bul. 147:45. 1910 (1911).

⁹Conn. State Entomologist. Rpt. 4:213. 1904.

¹⁰Insect pests of Fruit. pp. 160-162. 1909.

STUDIES OF THE HABITS AND OVIPOSITION OF HIBERNATING "FLIES."

TIME OF TRANSFORMATION OF HIBERNATING ADULTS.

The abundance of psyllas during the years 1909-1913 afforded ample opportunity to watch the activities of the hibernating brood of this insect. Transformation to winter adults occurred in late September or October of each year as shown in the accompanying table.

TABLE I.—TIME OF TRANSFORMATION OF PSYLLA ADULTS IN THE FALL.

	1910.	1911.	1912.	1913.
First appearance of "flies" of winter brood	Sept. 28	Oct. 10	Oct. 10	Sept. 29
Average greatest abundance.....	Oct. 16	Nov. 3	Oct. 21	Oct. 20
Latest appearance of nymphs of summer brood.....	Oct. 20	Nov. 12	Nov. 12	Oct. 30

CONDITIONS UNDER WHICH "FLIES" HIBERNATE.

Pear trees of all varieties were equally sought by the adults as food, and sheltered the largest number of these insects. Other kinds of fruits on which hibernating psylla "flies" were often observed were apple, cherry, peach and plum, but the infestation of these fruits was apparently due to their nearness to infested pear plantings. Many adults were also found each year under leaves or other rubbish, and in tufts of grass. In 1912 large numbers of them collected about the "collar" and in some instances in fissures in the soil near the trunks of the trees. Other objects such as fence posts and out-buildings were sometimes found to harbor the "flies" which presumably had crawled to them after having been blown from the trees or having become numbed from the cold and dropped to the ground.

RELATION OF TEMPERATURE TO THE ACTIVITIES OF HIBERNATING "FLIES" IN THE FALL.

The movement of "flies" to winter quarters during the years 1910-1912, of which data are shown in Tables II and III, began with the continued freezing temperatures of October and November. As indicated in Table III this movement was less marked during the

TABLE II.—EFFECTS OF TEMPERATURES ON THE ACTIVITIES OF HIBERNATING PEAR
PSYLLA ADULTS IN THE FALL.

(For 1910 and 1911.)

Activities of adults during 1910.	Daily mean temperatures, 1910.	Date.	Daily mean temperatures, 1911.	Activities of adults during 1911.	
	° F.		° F.		
	51	Oct. 25	48	"Flies" abundant on trees.	
	43	26	46		
	52	27	41		
	42	28	38		
	36	29	42		
	36	30	46		
	45	31	50		
"Flies" abundant on trees.....	42	Nov. 1	41		
"Flies" seek lower bud spurs.....	49		2		30
	39		3		36
	35		4	39	
	39		5	41	
	39		6	39	
	35		7	49	
	34		8	48	
	36		9	43	
	47		10	51	
	38	11	55	Entrance into hibernation.	
	31	12	46		
	32	13	25		
Entrance into hibernation.....	33	14	27		
No "flies" on trees.....	34	15	31		
	32	16	29		
	34	17	28		
	34	18	36		
	31	19	33		
	31	20	32		
	31	21	31		
	37	22	29		
	32	23	31		
	42	24	38		
	39	25	28		
	35	26	35		
"Flies" emerge from bark.....	32	27	42		
	32	28	47		
	35	29	40		
	33	30	30		
	29	Dec. 1	36		
	22		2	34	
	25		3	27	
	27		4	18	
	19		5	32	
	13		6	43	
	15		7	44	
	23		8	43	
	17		9	53	
"Flies" re-hibernate and none emerged until spring.	16		10	53	
	16	11	54		
	16	12	50		
	16	13	37		
	26	14	31		
	26	15	38		
	10	16	38		
	15	17	39		
	26	18	31		
	33	19	25		
				"Flies" emerge in large numbers and remain on bud spurs.	
				"Flies" re-hibernate and none emerged until spring.	

TABLE III.—EFFECTS OF TEMPERATURES ON THE ACTIVITIES OF HIBERNATING PEAR
PSYLLA ADULTS IN THE FALL.

(For 1912 and 1913.)

Activities of adults during 1912.	Daily mean temperatures, 1912.	Date.	Daily mean temperatures, 1913.	Activities of adults during 1913.
	°F.		°F.	
	46	Oct. 25	54	
	46	26	46	
	46	27	48	
	46	28	54	
	51	29	49	
	53	30	43	
	46	31	34	
	54	Nov. 1	35	
	38	2	43	
	34	3	46	
" Flies " abundant on trees	41	4	47	" Flies " abundant on trees.
	54	5	47	
	57	6	47	
	58	7	52	
	43	8	52	
	41	9	51	
	43	10	41	
	54	11	33	
	58	12	38	
	53	13	47	
	53	14	46	
	37	15	37	
Entrance into hibernation	35	16	36	Entrance into hibernation.
	37	17	41	
	34	18	43	
	46	19	56	
	48	20	60	
" Flies " emerge in large numbers.	52	21	57	
	46	22	65	
	41	23	56	
	39	24	42	
	33	25	38	
	34	26	42	
" Flies " re-hibernate	33	27	30	
	27	28	36	
	29	29	40	
	38	30	41	
	31	1	44	
	43	2	44	
	42	3	44	
	38	4	38	
Some " flies " on bud spurs	38	5	45	
	53	6	41	
	36	7	45	
	35	8	37	
	20	9	29	
	46	10	31	
	39	11	25	
	23	12	29	
" Flies " re-hibernate and none emerged until spring	20	13	43	
	33	14	40	
	42	15	33	
	39	16	37	
	33	17	42	
	41	18	33	
	37	19	26	
				" Flies " emerge and remain on lower bud spurs. On coldest days some returned to bark. Final seclusion of adults did not occur until Dec. 29.

autumn of 1913, owing to unusually mild temperatures, and in that year comparatively few "flies" sought protection from the cold before the last days of December.

While the weather was permanently cold during these months the adults remained secluded. In 1910 and 1911 a warm period of several days' duration occurred during the last week of November of each year at which time the unusual warmth during the sunny hours of each day caused myriads of "flies" to leave their hiding places and gather on the bud spurs and tender growth in the center of the trees where they remained although the temperatures at night in the most instances were quite low.

In preparing the tables, the influence of winds, rains and cold storms was not considered, but these factors undoubtedly have obscured the effects of temperature to a considerable extent during some years. It appears from these records that some "flies" after they have once hibernated became active again during the fall or early winter at a mean temperature as low as 32° F., under some conditions, but even at that temperature there was very little activity if colder days had recently occurred. A mean temperature in the fall of about 42° F. usually caused myriads of the "flies" to appear in exposed positions on the trees. Beneath the bark, movement on the part of the insects sometimes was observed at lower temperatures than those indicated in Tables II and III. After the "flies" emerged from shelter they remained semi-dormant on the trees at temperatures less than those at which they emerged from hiding quarters, but it appears from our studies that a mean temperature of at least 40° F., is required to cause the "flies" to leave their shelter during the fall or winter months.

In the spring the susceptibilities of adult psyllas to slight increases in temperature resulted in extensive movements of the insects, very early each season, from their winter quarters to the limbs and smaller branches of the trees. At this period the trees were dormant and the development of the buds had not commenced. Under such conditions the "flies" chose by preference the newer succulent growth within the center of the trees, and the blossom bud spurs about the lower branches. Within a few days, if warmth continued, the "flies" scattered over the trees and disseminated through the orchards. In March, 1910, adults began to jump and fly two days after leaving their hiding places, but during 1911 these activities

TABLE IV.—ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1910.

Date.	Activities of insects.	Condition of trees.	Daily mean temperature.	Weather.	Rain or snow.
			°F.		
March 26	"Flies" appearing.		46	Clear, warm.	
27			42	Cloudy.	
28			59	Clear.	
29			62	Clear.	
30			69	Cloudy.	
31			61	Cloudy.	
April 1			42	Clear.	
2	Eggs being laid.		48	Clear.	
3			56	Clear.	
4	"Flies" most numerous.				
5		Cluster buds breaking.	52	Cloudy.	.08
6			66	Partly cloudy.	
7	Most eggs; ice storm drives flies under bark.	Tips of buds separating.	59	Cloudy.	.02
8			33	Cloudy, ice storm.	.02 ice
9			34	Partly cloudy.	
10			46	Clear.	Trace
11			43	Cloudy.	.04
12			41	Clear.	
13			37	Clear.	
14			37	Clear.	
15			48	Cloudy.	
16	Many eggs collapsing.		60	Cloudy.	.3
17			58	Cloudy.	.09
18		Leaf buds open.	48	Partly cloudy.	.5
19	Eggs hatching.		51	Cloudy.	.06
20	Few nymphs.		43	Cloudy.	.74
21			40	Cloudy.	.11
22		Blossom buds opening.	48	Cloudy, cool.	.07
23			46	Clear.	
24			48	Cloudy.	.33
25	Nymphs dying from cold and rains.		46	Cloudy.	.43
26			47	Cloudy.	.55
27			51	Partly cloudy.	.08
28			47	Cloudy.	Trace
29			41	Clear.	
30	Nymphs most numerous.		51	Cloudy.	.9
May 1			54	Cloudy.	.02
2			53	Cloudy.	.27
3			61	Cloudy.	.4
4	Last flies.	Full bloom.	45	Cloudy.	.52
5			45	Clear.	
6			46	Clear, warm.	
7			48	Clear.	
8			57	Clear.	
9		Blossoms drop.	51	Clear.	Trace
			59	Clear.	.07

commenced within twenty-four hours after emergence. It appeared from these observations that the movements of the psyllas depended entirely on heat influences. In 1910 the mean temperature at the time psylla "flies" became active was 46° F. and the insects spread rapidly over the trees. In 1911 the "flies" emerged at a mean temperature of 52° F. During the following week the warmth decreased to 29° F. and most of the "flies" returned to the shelter

TABLE V.—ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1911.

Date.	Activities of insects.	Condition of trees.	Daily mean temperature.	Weather.	Rain or snow.
			°F.		
Mar. 26	"Flies" appearing		52	Cloudy	.21
27			45	Cloudy	.34
28					
29	"Flies" return to bark		28	Cloudy	.29 snow
30			29	Cloudy	.03 snow
31			29	Cloudy	.29 snow
April 1			27	Partly cloudy	
2			23	Partly cloudy	.02 snow
3			24	Partly cloudy	Trace snow
4			28	Clear	
5			34	Cloudy	.10
6	"Flies" reappear		47	Cloudy	.06
7			50	Cloudy	.21
8			36	Partly cloudy	Trace
9			35	Partly cloudy	.05
10			36	Clear	Trace
11			38	Clear	
12			45	Clear	
13			47	Cloudy	.11
14	Eggs being laid		53	Cloudy	Trace
15		Cluster buds breaking	46	Cloudy	.33
16			38	Partly cloudy	Trace
17			32	Cloudy	Trace
18			34	Cloudy	
19			43	Partly cloudy	
20			47	Cloudy	.52
21			45	Clear	.01
22			38	Cloudy	.01
23			42	Partly cloudy	.03
24			38	Clear	
25			40	Clear	
26			56	Clear	
27			60	Partly cloudy	
28			64	Partly cloudy	
29			63	Cloudy	.03
30	Most eggs		61	Cloudy	.17
May 1		Leaf buds open	54	Cloudy	.52
2	Few nymphs		33	Cloudy	Trace
3			35	Cloudy	Trace
4			40	Clear	
5			44	Clear	
6		Blossom buds opening	49	Clear	
7			55	Clear	
8	Last "flies"		61	Clear	
9	Many nymphs		56	Partly cloudy	.04

of the rough bark. On April 6, 1911, at a mean temperature of 50° F. the "flies" reappeared and did not again seek shelter although on the following day the cold was severe.

A knowledge of the time at which migrations of considerable numbers of the insects may be expected in the spring through a series of years is important since it may serve as a guide to control measures at that period against this stage of the insect. In published accounts of the life history of the pear psylla these activities

TABLE VI.—ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1912.

Date.	Activities of insects.	Conditions of trees.	Daily mean temperature.	Weather.	Rain or snow.
			°F.		
Mar. 26			23	Cloudy	.26
27	"Flies" on bud spurs		38	Clear	
28			37	Cloudy	.35
29			41	Cloudy	.34
30			33	Clear	
31			45	Cloudy	.65
April 1			38	Cloudy	.49
2	"Flies" not active.		31	Cloudy	2.3 snow
3			27	Clear	
4			30	Clear	
5	"Flies" very active.		52	Clear	
6			63	Clear	
7			54	Cloudy	.63 snow
8			30	Partly cloudy	.5 snow
9			38	Partly cloudy	2.5 snow
10	"Flies" under bark.		39	Clear	.10
11	"Flies" out, not active				
12			39	Cloudy	.14
13	"Flies" very active.		36	Clear	.05
14			43	Clear	
15	Eggs being laid.		50	Cloudy	.09
16			63	Clear	Trace
17			61	Clear	
18			45	Partly cloudy	.07
19		Cluster buds breaking	53	Clear	
20			43	Clear	
21			46	Cloudy	
22		Tips of buds separating	48	Clear	
23			58	Cloudy	
24			48	Partly cloudy	
25			48	Partly cloudy	
26			48	Clear	
27	Most eggs		51	Clear	
28			54	Clear	
29	Many eggs collapsing.		39	Clear	
30			40	Cloudy	
May 1			48	Clear	
2			50	Clear	
3			50	Clear	
4	Few nymphs	Leaf buds opening	51	Clear	
5			52	Clear	
6			50	Partly cloudy	Trace
7			62	Clear	
8			63	Partly cloudy	Trace
9			65	Clear	
10	Many nymphs	Blossom buds opening	54	Clear	
			58	Clear	

have been little discussed and for this reason efforts have been made in our work to secure more abundant data concerning the habits of the winter "flies" during the spring months. In 1910 the great spring movement of the "flies" took place on March 26 in western New York and they remained active until a severe rainstorm accompanied with ice caused them to seek the protection of the bark again. In 1911 the psyllas remained dormant until about April 6,

TABLE VII.—ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1913.

Date.	Activities of insects.	Conditions of trees.	Daily mean temperature.	Weather.	Rain or snow.
Mar. 14	"Flies" appear on buds.		°F. 57	Clear.	
15	"Flies" very active.		53	Partly cloudy.	.03
16			35	Cloudy.	Trace snow
17			23	Cloudy.	1.0 snow
18			37	Partly cloudy.	
19			49	Partly cloudy.	Trace
20			54	Cloudy.	Trace
21	Eggs being laid.		51	Cloudy.	Trace
22			45	Clear.	
23			33	Cloudy.	.31
24			40	Cloudy.	1.15
25			49	Cloudy.	1.35
26			44	Cloudy.	.99
27			33	Cloudy.	.36
28			27	Partly cloudy.	Snow
29			38	Clear.	
30			50	Clear.	
31	"Flies" have disappeared.		49	Cloudy.	.15
April 1	Most eggs.		39	Clear.	
2			41	Cloudy.	.11
3			47	Cloudy.	.29
4	Many collapsed eggs.		60	Cloudy.	.13
5			52	Cloudy.	.5 snow
6			34	Partly cloudy.	Snow
7			31	Clear.	
8			36	Clear.	
9			38	Cloudy.	
10	Eggs hatching.	Cluster buds breaking.	38	Cloudy.	.72
11	Few nymphs.		45	Cloudy.	.6
12			49	Partly cloudy.	
13			45	Clear.	
14		Cluster buds separating.	46	Clear.	
15			50	Clear.	
16			52	Clear.	
17			46	Cloudy.	
18			55	Cloudy.	.27
19			52	Partly cloudy.	
20	Many nymphs.		33	Clear.	
21			43	Cloudy.	
22			52	Cloudy.	.3
23			63	Cloudy.	.3
24		Leaf buds opening.	68	Clear.	
25			66	Clear.	
26			69	Clear.	
27			60	Cloudy.	.96
28		Blossom buds opening	51	Cloudy.	.83

and in 1912 few adults were seen until April 11. The earliest extensive migration of which record was obtained in any year occurred on March 14, 1913, but many "flies" were destroyed by storms and extreme cold later in the month. The final emergence of the "flies" in the spring from their winter quarters and their subsequent activities for the four-year period are given in Tables IV-VII.

OVIPOSITION OF THE HIBERNATING BROOD OF "FLIES"

The eggs of the pear psylla are of small size and the act of oviposition is seldom observed owing to the smallness of the insects. At the beginning of oviposition the trees were dormant and the eggs were laid on the wood in crevices in the bark around the bases of the blossom buds or on the stems. The habit of the "flies" of collecting in large numbers on water sprouts often resulted in noticeable quantities of eggs being deposited on such growth and in 1910 they were sufficiently numerous in these locations to attract the attention of orchardists to the infestation. Eggs were the most abundant on the under side of twigs and small branches, which appeared to be due to the protection from cold and winds afforded to the "flies" by these situations.

The young foliage was sought by the "flies" as a place of deposition for their eggs as soon as the buds opened, and as the season advanced belated adults deposited eggs only on foliage. The psyllas seemed to choose by preference the midrib of the leaves and blossom stems for that purpose. Young fruit stems also were selected by them for the lodgment of their eggs. These normally were comparatively few in numbers and resulted in little or no serious infestation of the foliage.

Egg-laying usually began within a few days after the spring migration of adults from winter quarters occurred and extended over a period of several weeks. Most of the eggs, however, were usually deposited within two weeks from the time oviposition commenced. In 1910 a large number of the eggs were laid about April 7. The greatest numbers of eggs in 1911 were seen on April 30, while in 1912 most of the eggs were deposited before April 26. In 1913 they were abundant on April 1 with only a slight increase later in the month.

As to the time required for the hatching of these eggs Slingerland¹¹ states that in 1892 eggs were being deposited on April 7, some of which were taken to his office where they hatched in eleven days. At Geneva some laboratory breedings of psylla eggs were made during 1911, the results of which are presented in the following table.

¹¹Cornell Univ. Expt. Sta. Bul. 44:168. 1892.



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PLATE II.— PEAR TREE BEFORE (1) AND AFTER (2) REMOVAL OF LOOSE BARK. Removal of bark renders tree less attractive to winter adults of pear psylla.



PLATE III.—SPRAYING FOR PSYLLA CONTROL.

Upper.—Unsprayed Kieffer pears defoliated by psylla attacks.

Lower.—Adjoining trees in same orchard sprayed with lime-sulphur solution to destroy psylla eggs.

TABLE VIII.—INCUBATION PERIOD OF FIRST BROOD EGGS OF PEAR PSYLLA UNDER ARTIFICIAL CONDITIONS.

Lot No.	Number of eggs.	Date of deposition.	Date of hatching.	Period of incubation.
I.....	207	Mar. 30	April 10	12 days
II.....	44	April 1	April 11	12 days
III.....	100	April 6	April 18	13 days
IV.....	100	April 8	April 19	11 days
V.....	64	April 13	April 23	11 days
VI.....	45	April 15	April 25	11 days
VII.....	38	April 12	April 19	8 days

The indoor temperatures in these tests were very favorable for early hatching of the eggs. Out of doors in New York the normal temperatures during April are apt to be low and consequently the incubation period of psylla eggs is usually longer. According to Slingerland's¹² observations eggs, of this species deposited on April 7 hatched on May 10. At Geneva some records were obtained on the duration of the egg stage in 1911 under natural conditions which are given in the accompanying table.

TABLE IX.—HATCHING OF FIRST BROOD PSYLLA EGGS UNDER NATURAL CONDITIONS DURING 1910.

Lot No.	Number of eggs.	Date of deposition.	Date of hatching.	Period of incubation.
I.....	354	April 3	April 20	18 days
II.....	238	April 4	April 21	18 days
III.....	578	April 15	May 2	18 days
IV.....	209	April 18	May 4	15 days
V.....	451	April 30	May 11	12 days

From this table it would appear that about eighteen days was the usual incubation period for eggs deposited during the early days of April, 1910, but the time required for the development of the ova became less as the warm days of May approached. In our observations over several years we have noticed that normally psylla eggs hatch in about three weeks but this period is some-

¹²Cornell Univ. Expt. Sta. Bul. 44:168. 1892.

what extended if cold days prevail soon after deposition takes place. On the other hand warm weather seems to hasten the development of the eggs. The retardation and acceleration of the incubation period because of weather conditions perhaps explains the almost simultaneous hatching of psylla eggs which we have observed in orchards in western New York during April or May of the years 1911 to 1913. The records during these years are as follows: 1910, April 19; 1911, May 2; 1912, May 4; 1913, April 10.

INFLUENCES OF NATURAL AGENCIES ON NUMBERS OF HIBERNATING
"FLIES" AND THEIR EGGS.

Fungus disease.—During the spring of 1911, small numbers of the hibernating brood of psylla "flies" died soon after emergence. Dead and inactive adults from orchards in Niagara county showed upon examination the presence of a parasitic fungus, *Empusa* sp. Collections of the "flies" taken at random from the trees showed that about 2.5 per ct. of them were affected by the disease. Casual observations have indicated that the fungus normally has but little influence on the numbers of the psylla.

Egg parasites.—A number of breedings have been made to determine if the eggs of this insect are subject to parasitism, but our studies so far have failed to find evidence of an egg parasite. It would appear that parasites of psylla eggs, if they occur, are unimportant and these observations are included chiefly as a matter of record.

Infertility of eggs.—Numerical counts were made to determine the percentage of hatching of psylla eggs. The eggs used for this purpose were those laid on the bud spurs and they were hatched under natural conditions. The following figures show the number of collapsed eggs as compared with fertile ones in these counts:

TABLE X.—SHOWING RESULTS OF COUNTS AS TO COMPARATIVE NUMBERS OF FERTILE AND INFERTILE EGGS.

Sound eggs.	Collapsed eggs.	Infertile eggs.
<i>No.</i>	<i>No.</i>	<i>Per ct.</i>
2522	175	6.4
685	65	9.0
1628	123	9.8
1000	80	7.4
2763	225	7.6

Weather influences.—Weather greatly affects the activities and numbers of the insect. The influence of temperature in the movements of adults and egg deposition have previously been shown. The following notes are of interest as showing the effects of storms and other conditions upon other habits as well as the numbers of the insect. On March 26, 1910, adults emerged from winter quarters and appeared on pear trees and during the first week of April deposited thousands of eggs. On April 7, 1910, a cold rain occurred at Lockport which coated the trees with ice and on the following day few "flies" were observed upon the trees. A small number of these adults were caught in the ice or dropped to the ground where they perished in the soft earth beneath the trees. Many of them, however, were apparently able to find some protection and on April 20 the trees were reinfested. In 1911 a warm period occurred during the week ending March 9, and "flies" appeared in considerable numbers. During the following night a drenching rain washed thousands of the "flies" to the soft ground where they died. On April 8, 1912, the adult psyllas which were out in full numbers in the tops of the trees were caught by a sudden change of weather and many, numbed by the cold, dropped to the muddy ground beneath from which they were unable to extricate themselves.

In a letter dated March 31, 1913, Mr. F. S. Hayden of Wyoming, N. Y., stated that a cold, freezing rain on March 26 had coated the pear trees in his orchard with ice, and during the warmer days which followed only from one-third to one-fifth of the original infestation of adult psyllas appeared on the trees after the storm. On March 22, 1913, according to Mr. A. B. Buchholz of the State Bureau of Horticulture, a sudden drop in the temperature so numbed the "flies" that they dropped to the ground and later collected in swarms about the "collar" of the trees. In the Collamer orchard at Hilton we have frequently observed in early spring large numbers of the adults under weeds and rubbish beneath the trees or at the "collars" of trees near the surface of the ground. Their presence in these situations we have attributed to the same cause. Mr. L. F. Strickland, also of the State Bureau of Horticulture, reported that in Niagara county a heavy driving rain on March 24, 1913, washed thousands of "flies" from pear trees and in some instances the insects appear to have almost entirely disappeared. The actual

influence of the weather conditions as described must obviously vary greatly according to seasonal conditions, but there is little doubt that ice storms, cold, driving rains, and strong winds do, under certain circumstances, greatly reduce the number of "flies" and thereby lessen the extent of egg deposition.

STATION EXPERIMENTS TO DETERMINE THE SUSCEPTIBILITIES OF HIBERNATING "FLIES" AND THEIR EGGS TO SPRAYING MIXTURES.

FALL AND EARLY WINTER SPRAYING AGAINST HIBERNATING ADULTS.

During 1911, experiments were conducted in the pear orchards of the Middlewood Farms at Varick, Seneca county, to determine the value of the fall spraying as a means of reducing the numbers of "flies" going into hibernation. The plantings comprised about 800 twenty-year-old Bartlett pear trees which had been severely injured by psyllas during the summer. Spraying commenced on December 6, and was continued at intervals, as weather permitted, until December 18, during which period thousands of the insects were clustered on the untreated trees. The spraying mixtures used in these tests were tobacco extract (40 per ct. nicotine), fish-oil soap and lime-sulphur solution, used separately, and each of the latter two in combination with the tobacco extract. The nicotine preparations were diluted at the rate of three-fourths of a pint of tobacco extract (40 per ct. nicotine) to one hundred gallons of water, or lime-sulphur, 32° B., in the proportion of one gallon to eight gallons of water. When the tobacco extract was used alone three pounds of fish-oil soap was added to give spreading and adhering properties. Fish-oil soap was applied in the proportion of one pound to five gallons of water. The concentrated lime-sulphur wash was used at strength for dormant spraying, one gallon of the concentrate to eight gallons of water.

The tobacco preparations and the soap solutions proved very effective. Lime-sulphur wash at dormant strength did not cause marked reductions in the numbers of psyllas, but with the addition of nicotine very effective results were obtained. On warm days which followed the sprayings few "flies" were detected and it was estimated that less than five per ct. of the original infestation of the psylla existed on the trees. During the following spring but

few "flies" emerged and no further applications of sprays were needed to check the operations of the psylla that season. Fall spraying for psylla adults has been repeated in this planting each year since 1911 and is relied on entirely by the owner for the protection of the pear orchard from the pests.

On the basis of the above results a number of experiments along the same lines have been conducted in succeeding years in cooperation with fruit growers. In the main, these later efforts have corroborated the results of the initial tests. Large percentages of the "flies" were invariably destroyed by careful spraying and in isolated orchards, particularly, the work of combating the insect by spring and summer spraying was very much simplified and in some instances was rendered entirely unnecessary. In occasional plantings, because of difficulties due to inclement weather or because of adjoining orchards, these treatments afforded only partial relief and in such cases it was necessary to resort to the usual sprayings the following spring. In none of these tests were miscible or home-made oils applied for fear of damage to the trees. Of the mixtures employed, tobacco extract, soap, and lime-sulphur with tobacco, the tobacco extract (40 per ct. nicotine) has given the most satisfactory results from the standpoints of safeness to the trees and effectiveness against the insects. Applications of soap by a number of growers have given very satisfactory results and have proven somewhat less expensive than the tobacco preparations.

SPRING SPRAYING AGAINST HIBERNATING ADULTS.

During the later days of March, 1910, psylla "flies" appeared in unusual numbers on trees in the orchard of the Collamer Bros. at Hilton. At our suggestion a portion of this planting, comprising about 1530 Bartlett, Kieffer, and Seckel pears of twenty years of age, was sprayed with either kerosene emulsion at the rate of one part of the emulsion to twelve parts of water, or with fish-oil soap in the proportion of one pound of the soap to eight gallons of the water. Applications of these sprays were made during the period of March 21-26 at which time the psylla adults were quite active and had spread over the trees.

The application of the kerosene emulsion did not appreciably lessen the numbers of adults as compared with those on adjoining unsprayed blocks of pears, where there were myriads of the "flies"

clustered on the branches in the lower parts of the trees, which may have been due to varying percentages of oil in the mixtures caused by imperfectly prepared emulsions. The trees subsequently received an application of fish-oil soap which treatment greatly reduced the severity of the infestation, and fewer eggs were deposited in this section than in unsprayed portions of the orchard.

In the spring of 1911 spraying experiments against the "flies" were conducted in the Kieffer pear orchard of Mr. L. B. Wright at Hilton. The rough bark had been removed from the trees during the previous year, which left small opportunity for the protection of the insects from the sprays. As soon as the adult psyllas appeared the trees were sprayed with either miscible oil at dilutions of 1-10 or 1-15, or fish-oil soap in the proportion of one pound of the soap to four or five gallons of water. About 800 trees were used in these experiments and the treatments resulted in large reductions of the numbers of the "flies" in the orchard. Very little difference in the effectiveness of the various dilutions of miscible oil were observed. A slightly greater benefit resulted from the application of the 1-10 dilution, which seemed hardly sufficient to compensate for the added expense of the treatment. Fish-oil soap in the proportions used gave very satisfactory results. A few "flies" escaped from the treatments but no apparent harm was caused to the planting through the natural increase of the insects as the season advanced.

In the spring of 1911 experiments along these general lines were conducted in about twenty-five orchards in cooperation with pear-growers. In these tests miscible oils, homemade oil emulsions, and soapy sprays were used either alone or in combination with tobacco solutions, or these latter solutions were used alone. These later experiments have reaffirmed the results of the initial endeavors. Careful application of the sprays in nearly every instance resulted in freeing the trees almost completely from the insects. In occasional plantings, because of adjoining infested orchards, the treatment afforded only partial relief and in such instances it was necessary to resort to a later treatment. Of the mixtures employed, the soap solutions and the tobacco extract (40 per ct. nicotine) with soap have given the most satisfactory results from the standpoints of safeness to the trees and effectiveness against the psyllas. The homemade oil-emulsion proved to be much less satisfactory as

a spray for the "flies" and orchardists using this spray invariably had to resort to later sprayings in order to control the insects.

BANDING TREES TO TRAP PSYLLA "FLIES."

During the fall of 1910 some experiments were conducted in the orchard of Mr. L. B. Wright of Hilton to determine the practicability of using bands on trees as traps for psylla adults. Forty trees were used in the experiments. Strips of building paper about eight inches in width were fastened around the trees in various positions and some were smeared with either tree-tanglefoot or fish glue. Other bands were not coated with adhesives. The glue dried within a few days and later washed from the paper. A few insects were caught on the bands covered with tree-tanglefoot but this material hardened as the cold increased and proved of little value during the fall. In the spring, as the weather became mild, the gummy material softened and on March 21, 1910, some days after the winter adults had emerged, the sticky bands for about two inches from the upper margin were thickly covered with the "flies." Beneath all the papers there were in March thousands of the dead insects.

The banding of the trees as an adjunct to spraying operations was practised against the psylla "flies" during the fall of 1912 by the Collamer Bros. at Hilton. In this work about 2600 trees were banded with tanglefoot fly-paper, placing the gummy surfaces against the bark. The papers were left on the trees for about three weeks and in November the strips were removed to allow thorough applications of contact sprays to the trees. Many "flies" adhered to the bands but the chief advantage of their use in these orchards seemed to be gained through the providing of a convenient hiding place for the psyllas. Myriads of the insects collected beneath the papers and when the bands were removed the psyllas were easily wetted by an application of a soapy spray.

From these tests it appeared that the employment of adhesives was not essential to the success of the traps, although some "flies" were caught on the sticky surfaces. The paper strips to which no gummy material was applied provided an attractive shelter for thousands of "flies" and it has seemed that bands of that description would lessen the difficulties attending the combating of the "flies" in the fall.

EXPERIMENTS TO DETERMINE THE SUSCEPTIBILITY OF PSYLLA EGGS TO SPRAYING MIXTURES.

In a number of orchards sprayed with lime-sulphur during April, 1910, eggs were observed in considerable numbers on the trees and many of them were discolored and in a collapsed condition. A comparison of sprayed and unsprayed trees led to the conclusion that the unusual appearance of the eggs on the treated trees was due chiefly to the spraying they had received. As it was desirable to have data to corroborate these observations a number of experiments were at once undertaken in pear orchards in the vicinity of Lockport and Medina to test the effects of various contact sprays on psylla eggs which are briefly discussed as follows:

Lime-sulphur sprays: Experiment No. 1.— On April 8, 1910, the homemade wash (15-20-50 formula) was applied to a number of pear trees on which psylla eggs had been laid in abundance. On account of the thickened condition of the spray, the trees and eggs were heavily coated by the application. Daily observations were made in the orchard but no change in condition of the eggs was detected until April 15, or about one week after the trees were sprayed. At this time occasional collapsed eggs were observed on check and treated trees and these increased in numbers until April 20 when nymphs began to make their appearance. The eggs on sprayed and unsprayed trees in the same orchard hatched in considerable numbers, as shown in Table XI, but the nymphs on the trees receiving the lime-sulphur treatment for the most part failed to reach the young leaves, and apparently succumbed to the action of the spray after escaping from the egg-shells. The destruction of the young psyllas was so great that the sprayed trees were comparatively free from psyllas during the remainder of the season while the check trees were badly infested and lost their foliage in midsummer.

Experiment No. 2.— Commercial concentrated lime-sulphur solution, 32° B., diluted with nine gallons of water was sprayed on 21 Bartlett pear trees which were rather thickly covered with psylla eggs. Some adjoining unsprayed pear trees served as checks on the experiment. Applications of the spray were made on April 9, 1910, and on April 16 scattering collapsed eggs were observed on treated and untreated trees. On April 20 a few nymphs appeared on the check trees and their number increased rapidly until all

the eggs had hatched. A few nymphs hatched on sprayed trees but the infestation was slight, and was not sufficient to affect appreciably foliage, yield of pears, or development of the buds for the next year's crop of fruit. The percentage of eggs destroyed by the treatment is given in Table XI.

Experiment No. 3.— During the week of May 2, 1911, 400 Kieffer pear trees were sprayed with the homemade concentrated lime-sulphur solution, 26° B., at a dilution of one gallon of the concentrate to six gallons of water. At this time the cluster buds were separating at the tips and the young leaves were unrolling. In making the application care was used to coat thoroughly, with the spray, the bud spurs and smaller limbs and especially the under sides of the branches, for in these situations the eggs were largely deposited. Some eggs were laid on the trees after the spraying was accomplished and late appearing "flies" continued to oviposit on the trees despite the application of the lime-sulphur wash.

Results on eggs.— The destructive effects of the concentrated lime-sulphur solution on psylla eggs was most strikingly demonstrated in this orchard. Collapsed and discolored eggs were abundant on all the trees within a short time after the spraying operations were completed. Eggs deposited on bud spurs after the trees were sprayed hatched and were apparently not affected by the wash which was upon the trees. The percentage of the eggs destroyed by the treatment in this orchard is given in Table XI.

Effects on cluster buds and foliage.— There was a slight amount of burning on young leaves and fruit stems wherever sediment was used in the lime-sulphur, which resulted in the dropping of occasional young blossom stems. The fruit clusters set full and in June there was no noticeable reduction in the numbers of the maturing pears on the sprayed trees. Applications of the clear solution did not harm the fruit clusters and caused only a slight discoloration of the tips of the leaves. No harmful effects to the trees resulted from these injuries to the young foliage, which made a luxuriant growth, and the trees developed plenty of blossom buds for the following year's crop of fruit.

Experiment No. 4.— A block of about 300 Kieffer pear trees received an application of commercial concentrated lime-sulphur solution, 32° B., in the proportion of one gallon of the concentrate to eight gallons of water. The trees were plentifully stocked with

eggs which had been deposited, for the most part, on the under side of the twigs and smaller branches. The spray was applied during the week of May 2, 1911, at the time when the cluster buds were just beginning to break apart at the tips. The trees were thoroughly drenched with the spray and care was exercised to cover the under sides of the limbs.

Results on eggs.— Few eggs survived the action of the spray. Some nymphs were found on the opening buds but the trees, for the most part, were free from the young insects. The natural increase of psyllas which hatched from eggs not destroyed by the spray was slow and the resulting infestation was inconsiderable. On unsprayed pears an abundance of nymphs hatched from the eggs and the trees were wet with honey dew during the remainder of the growing season.

Effects on cluster buds and foliage.— A slight blackening of the tips of the young leaves occurred which was of small importance. No noticeable injuries resulted to the blossom petioles, and young fruits were numerous. The foliage was healthy during the summer and fruit buds developed in goodly numbers. The crop of pears was not large on treated or untreated plats, which was due primarily to the failure of the trees to form fruit buds during the previous year owing to their weakened conditions from earlier psylla attacks.

Experiment No. 5.— In this experiment 2400 Angouleme pears were sprayed with lime-sulphur solution, 32° B., at a dilution of 1-8. Eggs were very abundant on the trees and the deposition had practically ceased when the spraying operations commenced. The applications were made during the period of April 25-28 at which time the blossom clusters were beginning to separate. The small size of the trees permitted a most thorough coating of the limbs and smaller branches with the spray.

Results on eggs.— The treatment resulted in an almost total destruction of the eggs. Owing to their protected situations a small percentage of the eggs which were not hit by the spray hatched and occasional nymphs appeared on the blossom clusters. These larvæ did not increase in numbers and the few infested fruit spurs were subsequently removed before the nymphal instars were completed and the summer brood of "flies" emerged. In August this planting was quite free from psyllas.

Effects on cluster buds and foliage.— A slight browning of the tips of unopened leaves occurred which caused no noticeable ill effects to the trees or fruit. The trees blossomed full and developed a luxuriant growth of foliage. In midsummer the leaves were green and the fruit buds were strong and gave promise of an excellent crop during the following season. The crop of fruit which set was large and the pears were clean, of excellent size and free from the gummy, blackened appearance which ordinarily accompanies the work of the psylla on pear trees.

During the spring of 1911 cooperative spraying experiments for the control of the psylla in the egg stage were conducted in twenty-five pear orchards. In these experiments lime-sulphur solution was the only spray applied since this had proven the most efficient of all the materials used in the previous tests on psylla eggs. Applications of the mixture in the different orchards were made during the last week in April or the first week in May, as the cluster buds were separating at the tips. The results bore out the promises of the earlier tests and in the majority of the orchards all of the eggs, so far as could be determined, were destroyed. In occasional plantings where lack of care was exercised in making the applications of the lime-sulphur a small percentage of the eggs hatched and summer treatments were made to protect the pear trees from injuries by the summer broods. Pear-growers who sprayed carefully were highly pleased with the results obtained from the work and these orchardists have come to depend on the lime-sulphur solution for psylla control in their pear plantings. Other fruit-growers who are each year required to spray for the psylla have adopted this means of control for the insects; and these men, through careful spraying and attention to the egg-laying habits, and to the development of the buds, have secured results which have given them much satisfaction. Pear-growers generally are able through this single spraying for the eggs to protect their crops of pears from the work of the insect during the growing season and insure a good development of the succeeding year's fruit buds.

Tests with other spraying mixtures.— A number of experiments to test the effects of other insecticides in comparison with lime-sulphur were made during the spring of 1910. The additional materials were kerosene emulsion, fish-oil soap, and nicotine prepara-

tions, which were applied in varying dilutions. The effects of the sprays on psylla eggs are given in the accompanying table.

TABLE XI.—EFFECT OF VARIOUS INSECTICIDES ON PSYLLA EGGS.

TREATMENT.	Dilution of spray.	Bud spurs counted.	EGGS COUNTED.		Eggs killed.
			Sound.	Col- lapsed.	
					<i>Per ct.</i>
Lime-sulphur	(Concentrate 1-8) . . .	90	39	2,082	98
Lime-sulphur	(Concen' rate 1-6) . . .	75	18	339	94
Lime-sulphur	(Formula 15-20-50) . . .	102	1,806	564	*24
Fish-oil soap	(1-5)	100	232	20	8
Kerosene emulsion	(1-8)	100	900	52	5.6
Miscible oil	(1-15)	100	800	45	5.9
Black leaf extract	(1-30)	100	824	64	7.2
	(1-40)	100	920	48	5
Black leaf 40	(1-1000)	100	810	61	7
Checks	Unsprayed	100	2,522	175	7

* The small percentage of eggs destroyed in this test was presumably due to the lower amount of sulphur in solution in the wash.

In these tests the lime-sulphur solution was the only spray that functioned in any marked degree as an ovicide. Oils and soapy solutions appear not to have caused a decrease in the development of the eggs. The percentage which did not hatch in these instances apparently represented about the normal decrease for that season due to infertility, as shown by the checks.

DISCUSSION OF RESULTS.

Efforts to control the psylla in pear orchards through applications of contact sprays during the summer months have, on the whole, proven unsatisfactory in most plantings. These failures have been due chiefly to the great activity of the adults, the resistance of the old nymphs, and the protection afforded to the nymphs in the more advanced stages by secretions of honey-dew with which they are usually surrounded. There is, moreover, an intermingling of the "flies," eggs and nymphs of the summer brood which render it exceedingly difficult to make much headway against the insects with control measures during those months, since all of these stages of this pest are not susceptible to a single spray mixture which can safely be employed on foliage.

The experiments which the Station has conducted have conclusively shown that the numbers of the psylla can be reduced to insignificant proportions through the adoption of spraying practices against the "flies" or the eggs. In most cooperative efforts orchardists have been able by one thorough application of a spray made against either of these stages to destroy a large part of the infestation, which has resulted in comparative freedom of the trees from the insects during the remainder of the season. In cases of severe infestations other pear-growers have found it advisable to make sprayings for both the "flies" and the eggs. But through attention to the habits of the psyllas and care on the part of the orchardists in making the applications a single treatment has usually proven sufficient for the control of the insect in either of these stages.

The control of the pear psylla through spraying for the hibernating adults and their eggs is accomplished with comparative ease in isolated orchards or small plantings. In localities where orchards adjoin or are somewhat closely situated the control of this pest is usually attended with greater difficulties. Very often a neglected plantation in the neighborhood of well-sprayed orchards serves as a source of infestation. Such a situation provides conditions under which individual orchardists may fail to secure good results from spraying. This difficulty can best be overcome by cooperation among the growers affected, who should act as a unit in carrying out repressive and remedial measures. The chief factors which make for efficient work against hibernating "flies" and their eggs are (1) a knowledge on the part of the grower of the habits of the "flies" and an acquaintance with the eggs; (2) an understanding of the conditions under which these stages are most vulnerable to sprays; (3) thorough work in spraying.

METHODS OF TREATMENT.

SPRAYING MIXTURES AND FORMULAS.

FORMULA 1. TOBACCO EXTRACT.

Tobacco extract (40 per ct. nicotine).....	$\frac{3}{4}$ pt.
Water.....	100 gals.
Soap.....	3 to 5 lbs.

FORMULA 2. FISH-OIL SOAP.

Fish-oil soap.....	20 lbs.
Water.....	100 gals.

These are recommended for fall or spring spraying to destroy the "flies."

FORMULA 3. MISCIBLE OIL.

Miscible oil	7-8 gals.
Water	100 gals.

This is a rather dangerous spray and should be used only in the spring as buds are swelling and never after buds begin to show green at the tips.

FORMULA 4. LIME-SULPHUR MIXTURE.

Lime-sulphur solution (32°-34° B.)	1 gal.
Water	8 to 9 gals.

To be applied just as the blossom cluster-buds separate at the tips to destroy psylla eggs a.out to hatch and newly-emerged nymphs.

DIRECTIONS FOR SPRAYING FOR THE WINTER "FLIES" AND EGGS OF THE PEAR PSYLLA.

1. *Spraying for hibernating or winter "flies."*— Especial pains should be taken to destroy the pest in this stage, as effective work greatly reduces the number of eggs deposited on the trees and simplifies subsequent spraying operations. The best means of killing the "flies" is spraying during a period of warm weather, *preferably* in November or December, or during March or early in April. A



FIG. 1.—TOO EARLY FOR MOST EFFECTIVE PSYLLA CONTROL

rise in temperature induces the insects to emerge from their hiding quarters and creep to the portions of the trees exposed to the warm rays of the sun and protected from a cold wind. While the insects are able to crawl they are very sluggish in their movements and do not fly. This habit makes them very vulnerable to treatment and the grower should take full advantage of it by so spraying that none of the insects be allowed to escape. To kill the "flies" it is essential to wet thoroughly all portions of the trees, and especial pains should be taken to force the liquid under the loose bark and into all the cracks and crevices in the bark. The experiments have shown the wisdom of spraying one tree thoroughly before proceeding to another. In balmy weather the "flies" may dodge quickly to the opposite side of the tree. By spraying the entire tree they are unable to avoid wetting by the spraying mixture. Treatment late in the fall or winter is especially recommended, as the influence of steadily

decreasing temperatures at this season on the movements of the "flies" makes them especially vulnerable to spraying. In planning for this work select days when there is no danger of the spraying mixture freezing on the trees. The most satisfactory spray from the standpoints of safety to fruit and leaf buds and effectiveness against the insects is three-fourths of a pint of tobacco extract (40 per ct. nicotine) to one hundred gallons of water to which are added from three to five pounds of dissolved soap. (Formula 1).

2. *Spraying for eggs of winter "flies."*— The eggs about to hatch and the newly-emerged nymphs succumb to an application of the lime-sulphur mixture. In this lies a hint to the fruit-grower for an effective use of this spray against the psylla as well as the scale. The eggs of the psylla are laid principally during April and commence to hatch early in May or when the blossom cluster-buds are beginning to separate at the tips. (Fig. 1.) Most growers spray much earlier than this for the San Jose scale, but by postponing the treatment of pear orchards until the blossom clusters are well advanced (Fig. 2) one may deal an effective blow against the psylla and with the same treatment successfully combat the scale. The lime-sulphur solution, testing 32° to 34° B., should be diluted in the proportion of one gallon to eight or nine gallons of water. (Formula 4.) The spray should be used in liberal quantities and pains should be exercised to wet all portions of the tree, especially the fruit spurs and the under sides of the young wood, where most of the eggs are laid.



FIG. 2.—BEST STAGE FOR SPRAYING TO DESTROY PSYLLA EGGS

CLEAN CULTURE AND THE REMOVAL AND DESTRUCTION OF ROUGH BARK.

While the adult psyllas seem to prefer to spend the winter under the loose bark of the trees, they may, nevertheless, seek shelter under any waste which affords chances to hide. Matted weeds, tufts of grass leaves, or rubbish on or about the trees present ideal

conditions for hiding places for the insects. Attention to the disposal of such accumulations will greatly aid pear-growers in the spraying for the "flies" especially, through the fewer opportunities offered for the adults to secrete themselves from the sprays.

The rough bark not only provides a shelter for the psyllas during the winter but it also constitutes the chief obstacle to thorough spraying during the dormant season to kill the hibernating "flies." Its removal is desirable for two reasons: first, to render the trees less attractive to the adults for the purposes of hibernation during late fall, winter and early spring; and, second, to facilitate a more thorough spraying of the trunks and lower portions of the larger limbs. The loose bark should be removed by a dull hoe or floor scraper, preferably during a wet period, as the bark is then more easily detached. Care should be taken not to cut into the live tissues as the wounds may become infected with disease. If many psyllas are hiding on the trees the bark should be collected and burned to kill the insects which are attached to the scrapings.

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