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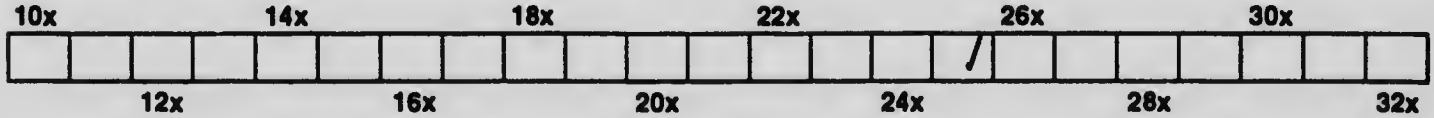

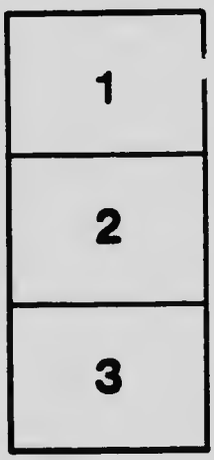

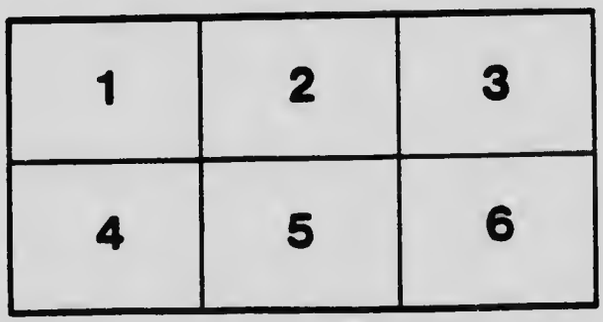

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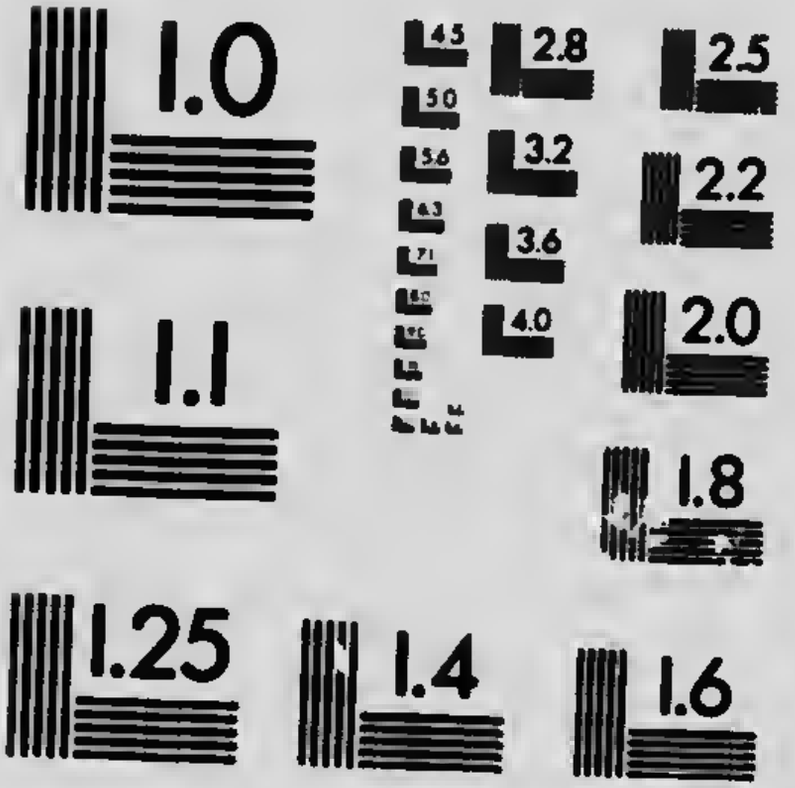

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THE PEAR THRIPS

(*Taeniothrips inconsequens* Uzel)

AND ITS CONTROL IN BRITISH COLUMBIA

BY

A. E. CAMERON, M.A., D.Sc.

AND

R. C. TREHERNE, B.S.A.
Field Officers

BULLETIN No. 15

Published by direction of
Hon. T. A. CRERAR, Minister of Agri. re, Ottawa

OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1918

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ISSUED MAY 8, 1918.

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36197—1

OTTAWA, January 22, 1918.

The Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to submit herewith for your approval Entomological Bulletin No. 15, entitled "The Pear Thrips (*Taeniothrips inconsequens* Uzel) and its Control in British Columbia" which has been written by D. A. E. Cameron and Mr. R. C. Treherne, Field Officers.

In many commercial and other orchards on Vancouver island there has been for a number of years a very serious reduction in the crops of apples, plums, prunes, and cherries owing to a cause which could not be determined. In certain cases, well-cultivated orchards were almost wholly unproductive. In 1915 the pear thrips was discovered in the region in question, and we soon determined that it was the factor responsible for the losses which the fruit growers were experiencing each year. This was the first and only record of the occurrence of this insect in Canada. In view of the losses for which it had already been responsible in the infested region in British Columbia, the serious damage it was causing in the states of California and New York, and the importance of checking its spread in Canada, we immediately undertook an investigation. The life-history, habits, and control of the insect under British Columbia conditions were studied. After determining the most satisfactory spray and suitable methods of application, demonstration work in commercial orchards was carried on. The practical results of this investigation have been of signal and immediate benefit to the fruit growers in the infested region; in one of the orchards the crop was increased tenfold last season by the adoption of control measures.

Notwithstanding the occurrence of this pest in the state of New York, it has not yet been found in any part of Canada other than Vancouver island and the adjacent islands in British Columbia. It is very important, however, that a very careful watch should be kept for its first appearance in any other of the orchard sections of British Columbia or in eastern Canada.

I have the honour to be, sir,
Your obedient servant,
C. GORDON HEWITT,
Dominion Entomologist.

We shall be pleased to hear from any one concerning damage or trouble of any kind due to insect pests. No postage is required on such letters of inquiry when addressed:—

Dominion Entomologist,
Department of Agriculture,
Ottawa, Ont.

Such inquiries should be accompanied in all cases where it is possible by specimens of the insects. The insects should be sent packed with their food plant in a strong wooden or tin box to prevent loss in transit. Packages up to 12 ounces in weight may be mailed free, and every package should bear or contain the sender's name and address, and be accompanied by a letter.

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ILLUSTRATIONS.

THE PEAR THRIPS (*Taeniothrips inconsequens*, Uzel) AND ITS CONTROL IN BRITISH COLUMBIA.

By A. E. Cameron, M.A., D.Sc.
and
R. C. Treherne, B.S.A.
Field Officers.

SUMMARY.

For many years orchardists of Vancouver island have annually experienced a decided reduction in their crops, owing to a "blighting" of the blossom buds, which occurs early in the spring. At first the loss was attributed to spring frosts, to the effects of which certain orchard sections appear to be peculiarly liable. Not all the damage, however, could be ascribed to this cause. In 1915 it was discovered that several orchards were overrun by the pear thrips, *Taeniothrips inconsequens*, and to this insect alone the greater proportion of the damage is now known to be due. The minute, glossy-brown insect measures about one-twentieth of an inch in length, and is usually first observed at the end of March and the beginning of April actively moving around in large numbers on the opening buds, beneath the enveloping scales of which they finally crawl. Previous to this migration to the trees, they have been dormant in the soil for several months.

Life-history.

The emergence from the soil continues up to the middle of April, the maximum number appearing from April 1 to 14. This practically coincides with the time of the bursting of the buds of the various fruit trees on Vancouver island. The buds have barely opened when the adults enter and feed on the young delicate tissue of the developing parts within. Almost as soon as the leaves and blossom pedicels appear, the adults begin to lay their eggs. The first eggs are generally laid about the middle of April, and the last about the middle of May. The period of maximum oviposition usually extends from April 24 to May 7. Eggs are laid in largest numbers on the petioles and midribs of the leaves, on the outer surface of the calyces of the young fruit, as well as on the fruit stems. They require about five to seventeen days to hatch, and it is probable that the great majority hatch in about fourteen days under the conditions prevailing on Vancouver island.

Prunes, plums and cherries, which are more tardy in their development than apples and pears by almost a week, are attacked later by migrating individuals. The damage which is effected on the buds of these first is proportionally greater than what obtains on apples and pears. It is well to bear in mind that the most serious damage to the trees is associated with the buds just after bursting and before blossoming.

The larvæ make their first appearance at the beginning of May, and are to be found on the trees until the middle of June. In great abundance they occur inside the calyx-cup of the blossoms, lacerating its tender tissue and feeding on the nectar. They are also to be found on the back of the leaves, shaded from the sun, busily sucking the leaf-juices. When at rest, they are generally to be found ranged along each side of the midrib and chief veins. When the larvæ

attack the young fruit in numbers, they cause a "russetting" of the skin which is known as "thrips scab." They appear in maximum numbers from May 20 to June 5. The individuals remain on the trees for about three weeks before they are fully fed.

When mature, the larvæ fall to the ground which they enter by any convenient crevice or crack. They may penetrate quite deeply, depending on the character of the soil. In the clayey soils of the Saanich peninsula no larva was found below a depth of 15 inches. The greatest numbers occur nearer the surface, at about 6 to 10 inches. Very few are found to occur in the surface mulch of cultivated orchards. In uncultivated orchards, quite a number of larvæ penetrate no more deeply than the stratum of interlacing grass- and weed-roots. They remain in the soil for three to four months before transforming to prepupæ in their tiny earthen cells.

The prepupal condition lasts for only one week to ten days at the end of September and the beginning of October. The prepupæ transform to true pupæ, the last of which are found in November. The great majority of the pupæ remain as such for six weeks to two months. During November the pupæ become adults, and in this condition they remain in the soil for about five months. At the end of March and the beginning of April of the following year, they emerge from their winter quarters and make their way to the trees.

There is but one brood of the species each year.

Remedial Measures.

As a result of a thorough study of the various remedial measures for the pear thrips undertaken during the springs of 1916 and 1917, it may be confidently stated that this insect can be readily controlled. Spraying offers the only satisfactory means of combating its ravages, and the energies of the orchardists must be concentrated to cope with the adults and larvæ on the trees in the spring. It is primarily essential that the orchardist should learn (1) to recognize the thrips, (2) to watch very carefully for its first appearance on the buds. By following this advice the first step in control will have been accomplished. It has been conclusively shown that spraying against the adult thrips is more important than against the larvæ. Hence, if circumstances demand the application of only two sprays, it is better that they both be applied before blossoming rather than one spray before and the other after. Three sprayings may be arranged for in instances of severe infestation, in which case two applications are made before blossoming and one after. In the case of a moderate degree of infestation, two applications of spray are alone necessary. Both of these should be made at a time when the thrips are observed to be "running" on the outside of the buds. Usually the first application is made on a bright warm day in spring after the buds have just begun to burst. The second may be made in the week preceding the period of maximum bloom. The third spray is directed against the larvæ in the calyx-cups and on the leaves just after the fall of the petals.

It has been demonstrated that for the first application the best results attend the use of miscible oil No. 2 in combination with nicotine sulphate. Whale-oil soap, also combined with nicotine sulphate, is the most suitable and economical for the second and third sprays. Lime-sulphur has been shown to possess very poor penetrative and spreading qualities, hence its potency as a controlling agent for thrips is merely confined to those insects with which it comes into direct contact. Therefore it should only be used to replace the second and third applications of whale-oil soap in cases of light infestation and where it has been found necessary to undertake control measures for "scab." On no account must it be inferred that the first application of miscible oil can be dispensed with. Miscible oil, by reason of its greater powers of penetrating the young buds, has been found to be the best remedial agent in the first spraying. The use of whale-oil soap at this time, whilst often satisfactory, is less effective than the oil.

INTRODUCTION.

The pear thrips, *Taeniothrips inconsequens* Uzel, was discovered on Vancouver island for the first time in the spring of 1915 in an orchard at Royal Oak, four miles north of Victoria. Previous to this, the insect had not been observed in British Columbia. It is probable, however, that it has been present in the province for at least ten years, if not more. In the opinion of prominent orchardists, the characteristic injury caused by the pear thrips to the buds of the various deciduous fruit trees, has existed more or less in their orchards during that period; but the damage was not associated with the presence of this apparently insignificant, but very important, pest until 1915.

The fact that, in the absence of treatment, the average annual loss due to the thrips in the infested areas of California, is computed at over $2,000,000[1] —a figure which would naturally increase with time—has been more than sufficient incentive to an early combating of its activities in the province of British Columbia.

Three separate and badly infested districts were selected in order to prosecute investigations, all situated on the Saanich peninsula of Vancouver island. At Royal Oak, in addition to the general orchard spraying, a small section containing about 200 trees was set apart for the purpose of experiment and demonstration. Here, too, a laboratory was established by the Entomological Branch of the Dominion Department of Agriculture, to facilitate the undertaking of an extensive and intensive study of the life-history and habits of the pear thrips. At the two remaining centres, Keating and Gordon Head, a campaign of experimental spraying was undertaken as at Royal Oak with a view to discovering the most satisfactory and economical means of controlling the pest under local conditions.

It is not possible to give figures with any degree of accuracy illustrating the loss of crop that occurred annually on Vancouver island. It can be quite confidently stated, however, that in the last seven years the prune and pear crops have been a negligible quantity in certain sections. The trees have produced a wealth of blossom and the prospects appeared bright for an excellent return of fruit, which did not, however, materialize. In some cases the fruit buds were destroyed so completely that the blossom never appeared. The same symptoms were apparent in the case of cherries. Only as they are more productive than prunes, generally quite a large percentage of the blossoms set fruit. In pears, some varieties appeared to be more susceptible than others, and the difference of altitude seemed to be directly associated in some cases with lesser or greater infestation of an individual tree. Generally speaking, it was found at Royal Oak, at least, that the pear trees situated on low-lying ground suffered more than those on higher positions. Apples as a whole are more robust in their growth than the other trees just mentioned, and although the infestation on some varieties, notably King and Baldwin, is most severe, they do not appear to suffer to the same extent as the other deciduous trees.

Not only does the thrips levy a heavy toll on the fruit crop each by damage to the fruit buds, but the atrophy of these buds, as well as the foliage buds, caused by the indiscriminate feeding of the insect and its larvæ, tends to check the natural development of the tree. As a consequence, where the control of the pest is neglected, there is a progressive diminution in the yields from year to year.

The purpose of this bulletin is to call attention to the damage caused by this pest in the orchards of Vancouver island, and to the danger of introducing it into those of the mainland of western and eastern Canada, as well as to record the results of experimental spraying in its control. At the same time, new facts concerning the life-history and biology of the species under the conditions prevailing in Vancouver island are set forth.

HISTORICAL.

Known Distribution.

Since the discovery and description of the pear thrips in California in 1904 by Miss S. M. Daniel,[2] the presence of the species in other parts of the American continent has been demonstrated. It was not until the year 1911 that Parrott[3] found the pear thrips (*Taeniothrips pyri*) in New York state, in pear orchards of the Hudson valley around Germantown extending from Stuyvesant in the north to Tivoli in the south. It was also recorded by him from apple buds at Geneva, N.Y.

According to Foster and Jones,[1] the pear thrips was forwarded to them in May, 1912, by Quaintance of the United States Bureau of Entomology. The specimens were taken in six different orchards at northeast Philadelphia, in the state of Pennsylvania.

In the year 1914, Scott[4] recorded the pear thrips from a small Kieffer pear orchard near Baltimore, Md. The insect was also taken on some neighbouring peach and apple trees, though not seriously damaging them.

In Europe, Collinge collected several specimens from plum blossoms at Evesham in Worcestershire, England, which Bagnall[5] identified as *Euthrips* (*Taeniothrips*) *pyri* Dan. Theobald[6] of the South Eastern Agricultural College, Wye, Kent, England, pays particular attention to the species in his Report on Economic Zoology, for 1910. Williams[7] records the occurrence of the species under the name *Physothrips pyri* Daniel, from Histon near Cambridge, England, in 1911 and 1913, and also believes that larvæ sent from Cirencester belong to the same species. This author says there can be no doubt but that the thrips has been present in England for many years, and must occur in many localities. Mokrzecki[8] in his report of 1912, published in 1913, refers to the discovery of the pear thrips on apple and pear trees in the Crimea in March, 1912.

With the exception of these records from the south of England by Bagnall and Williams, and from the Crimea by Mokrzecki, *Taeniothrips inconsequens* had not, up to the time of its discovery in British Columbia in 1915, been found to occur outside the United States. It is very probable that it will yet be recorded from other districts on the American continent, for it seems hardly credible that this insect only exists in localities so widely separated as California and British Columbia on the one side, and New York, Pennsylvania, and Maryland on the other. It is feasible to suppose that this markedly discontinuous distribution can be best explained by the supposition that the insect has been imported from one continent to another and from one state or province to another on nursery stock. It cannot be argued that the insect is indigenous to British Columbia, notwithstanding its discovery on native trees, because it has not so far become established on the mainland. In the districts already named, certain favourable conditions, climatic or otherwise, have caused its rapid multiplication to such an extent that it has overflowed from its cultivated food-plants to native trees where it has assumed, in some cases, an undeniable economic significance. Especially is this true in regard to maples.

By reason of the fact that on this continent the insect was first found in California and on pear trees, it is often popularly designated the "California pear thrips."

Under date of June 6, 1916, a letter was received from Mr. C. B. Williams, in which he states that the pear thrips must in future be known as *Taeniothrips inconsequens* Uzel, as it happens to be identical with an old-known European species. In a paper[9] dealing with British Thysanoptera he suggests the probable introduction of the species into the United States of America from Europe in the larval stage among the soil adhering to the roots of fruit trees.

History Of Species In British Columbia.

In April of 1915, a prominent orchardist, Mr. T. A. Brydon of Royal Oak, B.C., had been engaged in spraying his apple and pear trees with lime-sulphur solution in order to combat "scab", *Venturia pomi* Wint, and *Venturia pyrina* Aderh. His attention was attracted to the scorched appearance of the buds on several trees, and concluding that the injury was the result of the treatment, he at once ceased operations. Later, he observed that both sprayed and unsprayed trees had a similar damaged appearance which seemed to dispel all doubts that the lime-sulphur had caused the blighting of the buds. A communication seeking advice on the subject was straightway sent by the orchardist to Mr. R. M. Winslow, Provincial Horticulturist, who with his assistant, Mr. W. H. Robertson, discovered specimens of thrips in the Brydon orchard. Simultaneously, Mr. E. W. White, Field Inspector, acting under the instructions of the late Mr. Thomas Cunningham, Provincial Inspector of Fruit Pests, also visited this orchard and found the thrips. Specimens were submitted by Mr. White to Mr. R. C. Treherne who tentatively identified them as pear thrips, *Taeniothrips pyri* Dan. This identification was later corroborated by Mr. S. W. Foster of California and Mr. J. Douglas Hood of the United States National Museum, Washington.

Immediately on receipt of this information, the serious nature of the situation was realized. At the suggestion of Mr. Winslow who proved himself very energetic in facing the problem, a series of Farmers' Institute meetings was held in the Saanich peninsula of Vancouver island. Thorough examination of several orchards was made, and in every case the presence of the pear thrips was demonstrated. Growers were quickly notified of the importance of the pest, and advised to busy themselves in preparing for a campaign of attack during the spring of 1916. Only one treatment for the larval thrips was made during the season of 1915, and this was achieved at Mr. Brydon's orchard. In the spring of 1916, another series of Farmers' Institute meetings was held, and plans were fully discussed preparatory to adopting measures for mitigating the injury likely to occur in the following season.

Distribution In British Columbia.

Our investigations have shown that the distribution of the insect is more extensive than was at first supposed. It has practically become established all over Vancouver island and the adjacent islands of the Gulf of Georgia, wherever there are orchards or maple trees. All the orchards of the Saanich peninsula are more or less infested, and reports of its presence on Gabriola island have been verified. Here, too, the maples bordering the shores of the island, showed a great deal of damage when examined on April 27, 1917. The blossoms had been practically killed, and the petioles of the blossoms (fig. 14) were badly scarred by reason of the oviposition of the adults. Later in the season these trees developed a very poor foliage. Even the shade maple-trees in the city of Victoria itself have not escaped, and the few fruit trees which almost every householder possesses are suffering from thrips attack. In a thorough search of the district extending from Victoria in the south to Nanaimo in the north, our efforts were rewarded by the discovery of the insect practically everywhere, there being a particularly heavy infestation in some orchards in the vicinity of Duncan.

It would appear that the species has not so far become established on the mainland of British Columbia. A large number of the orchards in the Fraser valley from Agassiz to New Westminster, including those of Hatzic and Mission, were carefully examined in 1916 and again in 1917, and although an unidentified species of *Frankliniella* was encountered, not a single specimen of the pear thrips was found. Similarly, a close watch for its occurrence in the orchards of the Okanagan has so far proved negative.

When one realizes the comparatively narrow waters which separate Vancouver island from the mainland, and the frequent intercourse that occurs between the two places, it seems difficult to suppose that the species could not be carried to the mainland orchards from the island with nursery stock. Therefore, it will devolve upon the orchardists of the mainland to maintain a careful watch for the species and to report its presence wherever it is found.

SYNONYMY OF THE SPECIES AND ITS SYSTEMATIC POSITION.

Most authors who have dealt with the species have referred it to the genus *Euthrips* Targioni Tozzetti (1881). Hood,[10] however, states that according to the laws of nomenclature this name must be replaced because it was first used to designate a sub-genus substituting the term *Thrips*, itself being employed for a sub-genus of *Thrips* Linné (1758). This author, therefore, decided to relegate the pear thrips to the genus *Taeniothrips* of Amyot and Serville, whilst he distributed the various other species previously assigned to *Euthrips*, among the genera *Scirtothrips* Shull, *Physothrips*, *Odontothrips*, and *Frankliniella*. In this he partly adopted the method of Karny.[11]

Williams,[7] already quoted, originally placed the species in the genus *Physothrips*, but this name has now been discarded.

THE ORDER THYSANOPTERA.

The order Thysanoptera is divided into two suborders, called respectively Terebrantia and Tubulifera. To the former belongs the pear thrips (fig. 7). It is distinguished from the second by the fact that the females possess a saw-like ovipositor, and have the terminal segment of the abdomen conical. The fore wings are broader and stronger than the hind wings, are beset with numerous microscopic spines, and have at least one longitudinal vein reaching from the base to the tip of the wing. Of the two families into which the Terebrantia are divided, this species belongs to the Thripidæ which are distinguished from the Aeolothripidæ in the antennæ being six to eight segmented, wings usually narrow and pointed at the tips, cross veins absent, and the ovipositor of the female down-curved. It is placed in the genus *Taeniothrips* of this family because the body is devoid of reticulation and the abdomen not closely pubescent; the head nearly or quite as long as wide, with a pair of long bristles between the anterior and posterior ocelli; the cheeks swollen, curving abruptly to the strongly protruding eyes; the antennæ eight-segmented, with the last two segments (the style) shorter than the sixth; the maxillary palpi three-segmented, the prothorax very slightly, if at all, shorter than the head, with two long bristles at each posterior angle; the fore tibiæ unarmed; the bristles on the veins of the forewings not equidistant, and the last abdominal segment of the female conical and without a pair of short stout bristles on the dorsal surface.

COMMON NAMES.

The term "thrips" is a general expression assigned to any member of the order Thysanoptera. It is the equivalent of the Greek θρυψ, meaning a wood louse, and is used both in the singular and the plural. Leaf-hoppers such as the Grape leaf-hopper, *Typhlocyba comes* Say—sometimes erroneously called "thrips"—belong to the Hemiptera.

LIFE-HISTORY.

The Egg (fig. 1).

Description.—As might be expected, the egg is minute, measuring 0.75 mm. long by 0.25 mm. broad. It is slightly bean-shaped and somewhat broader anteriorly than posteriorly. It is whitish, colourless, with a very delicate chorion and no evident micropyle. During incubation the egg increases slightly in size.

Period of egg-laying.—Adults were first observed to be engaged in ovipositing about April 18 and continued to lay their eggs up to about May 10, after which date no female was seen to ovipost. Nevertheless, many stragglers and late individuals must continue to do so for several days later, which explains in part the presence of newly-emerged larvæ towards the end of May. The period of maximum oviposition extends from April 24 to May 7, during which time the scars caused by the ovipositor on the petioles of fruit and leaves, and on the midribs and veins of the latter become very apparent. Towards the end of the egg-laying season the under surface of the sepals, especially of apples, receive a goodly quota of eggs. Isolated cases of oviposition on the young fruit and pistils were observed, more particularly on cherries and prunes, but it is improbable that the resulting damage, if any, seriously affects the crop yield.

Fig. 1.—The pear thrips, *Taeniothrips inconsequens*; eggs. X 93. (Original).

Duration of egg-stage.—To determine the duration of the egg-stage a series of experiments was made. Cages of cylindrical mica-chimneys, fitted at each end with sleeves of cotton cloth, were drawn over and enclosed individual twigs of apples, pears, cherries, and prunes. These had previously been examined and determined to be exempt from punctures containing eggs. Closely-woven cheese-cloth serves the purpose better than calico which interferes with free aeration, causing the vapour transpired from the leaves to condense on the walls of the cage and thus rendering observation difficult. In each experiment a single adult thrips was introduced into the cage and retained there for twenty-four hours, the cotton sleeves being tied securely to the twigs, as shown in fig. 2. The adult was then removed, and the larvæ on emerging from the eggs, were likewise removed and counted.

It is conceivable that weather conditions may have some effect in determining the time of hatching, but it is very probable, as Foster and Jones suggest[1], that eggs deposited by the same female on the same day vary as regards their degree of maturity. At least, we can safely assert that some eggs take longer than others to hatch, a fact which conditions of temperature alone will not explain satisfactorily.

The appended table I summarizes the results of the experiments:—

TABLE I.—DURATION OF THE EGG STAGE OF THE PEAR THRIPS, ROYAL OAK, VANCOUVER ISLAND, B.C., 1916.

Experiment No.	Date of		Number of Eggs Hatched.	Duration of Egg Stage in Days.	Average Mean Temperature.	General Weather Conditions.
	Oviposition.	Emergence.				
					F.	
1	April 21	April 30	5	9	51	Changeable.
		May 1	7	10	51	"
		" 3	15	12	52	"
		" 4	2	13	53	"
		" 6	4	15	52	"
		" 7	2	16	52	"
2	April 23	April 28	3	5	52	"
		" 29	7	6	52	"
		May 1	1	8	52	"
		" 3	2	10	53	"
3	April 25	" 1	3	6	52	"
		" 4	4	9	54	"
		" 5	2	10	54	"
		" 9	5	14	52	"
4	April 27	" 7	8	10	53	"
		" 8	1	11	52	"
		" 10	2	13	50	"
		" 12	2	15	51	"
		" 14	1	17	51	"
	April 29	" 13	3	14	50	"
		" 14	5	15	50	"
		" 15	1	16	51	"
	May 1	" 5	3	4	51	Generally fair.
		" 6	15	5	55	"
		" 7	29	6	53	Fair to changeable.
		" 8	24	7	53	"
		" 10	5	9	51	"
		" 11	1	10	50	"
		" 12	4	11	50	"
	May 3	" 10	2	7	49	Changeable.
	" 5	" 11	4	8	48	"
		" 10	5	5	46	"
		" 12	2	7	46	"
	" 7	" 14	1	7	47	Changeable to fair.
		" 16	2	9	49	"
		" 17	1	10	50	"
	" 7	" 16	1	9	49	"
	" 9	" 18	3	9	52	Generally fair.
	" 9	" 15	19	6	49	"
		" 16	5	7	49	"
		" 17	21	8	50	"
		" 18	17	9	51	"

The maximum and minimum temperatures prevailing during the period of incubation of the eggs are given in table II.

TABLE II.—MAXIMUM AND MINIMUM TEMPERATURES DURING THE PERIOD OF INCUBATION OF THE EGGS OF THE PEAR THRIPS AT ROYAL OAK, VANCOUVER ISLAND, B.C., 1916.

Date.	Maximum Temperature.	Minimum Temperature.	Date.	Maximum Temperature.	Minimum Temperature.
	°F.	°F.		°F.	°F.
April 10	58	42	May 1	68	39
" 11	52	42	" 2	72	40
" 12	50	38	" 3	73	51
" 13	62	42	" 4	67	48
" 14	58	44	" 5	64	44
" 15	56	38	" 6	55	38
" 16	60	36	" 7	53	39
" 17	51	42	" 8	55	41
" 18	52	39	" 9	53	38
" 19	54	33	" 10	58	34
" 20	58	38	" 11	60	31
" 21	54	39	" 12	62	32
" 22	55	39	" 13	68	34
" 23	57	39	" 14	74	37
" 24	60	43	" 15	74	41
" 25	65	43	" 16	72	44
" 26	62	46	" 17	67	48
" 27	61	42	" 18	67	43
" 28	59	44	" 19	67	43
" 29	64	40	" 20	63	44
" 30	63	36	" 21	68	33

FIG. 2.—Mica-chimney cage in position on a pear twig as used in oviposition experiments with the pear thrips. (Original).

Egg capacity of adult.—In order to determine how many eggs a single adult pear thrips may lay, a series of experiments was undertaken. Mica cages (fig. 2), fitted at each end with a cotton sleeve, were securely fastened to branches of the trees, enclosing one or more buds. In most cases only a single bud was selected and the others removed. It was found that as the bud developed the thrips had been provided with ample food as well as sufficient surface on which to oviposit. The experiments were commenced and the mica-cages placed in position before the adults had emerged from the soil, thus ensuring that no eggs could be laid by individuals other than those introduced into the cages. Further, the insects used in the experiments were trapped as they emerged from the soil so that could not possibly have commenced oviposition before the experiments .

The varieties of trees used in the experiments included apple, pear, cherry, plum, and prune. In each case the experiment was continued until the death of the adult, when the enclosed blossoms and leaves were carefully examined for eggs with the following results:—

TABLE III.—NUMBER OF EGGS PER INDIVIDUAL ADULT, AT ROYAL OAK, VANCOUVER ISLAND, B.C., MARCH 27 TO MAY 29.

Number of Experiment.	Variety of Tree.	Number of Eggs.	Number of Experiment.	Variety of Tree.	Number of Eggs.
1	Duchess apple	98	20	Olivet cherry	37
2	" "	118	21	" "	7
3	" "	109	22	" "	108
4	" "	42	23	" "	59
5	" "	127	24	" "	42
6	" "	98	25	" "	18
7	" "	91	26	Italian prune	120
8	" "	113	27	" "	125
9	" "	112	28	" "	37
10	Gravenstein "	50	29	" "	45
11	Red Cheek "	4	30	" "	90
12	Bartlett pear	153	31	" "	27
13	" "	128	32	" "	28
14	" "	113	33	" "	93
15	" "	112	34	" "	75
16	Bosc "	63	35	" "	9
17	" "	49	36	Columbia plum	4
18	" "	49	37	" "	27
19	Olivet cherry	120	38	Bartlett pear	32

In almost every case where the bud was a blossom-bud, more eggs were deposited than where the enclosed bud was a leaf one. The pear thrips shows a decided predilection for the blossom pedicels as receptacles for its eggs.

The number of eggs laid by a single individual varies. In the experiment, the highest number laid by any one was 153 eggs, and the lowest was 4. Under favourable circumstances it is probable that the pear thrips is capable of laying about 120 to 150 eggs, but it is not likely that every individual actually lays so many as this. The average, as calculated from the above table, is 73, but this may be considered lower than normal.

Careful dissection of the ovaries of 25 mature specimens was made for the sake of comparison. The ovary is a paired organ consisting of ten ovarian tubes, five on each side, united posteriorly to form the oviduct. The oviducts of each side again unite to form the common oviduct opening to the exterior. Each ovarian tube contains about twenty eggs besides numerous immature germ-cells anteriorly, where the tubes are attached to the walls of the body cavity by delicate fibres of connective tissue. Normally, therefore, the fully mature pear thrips has within its body about 200 eggs at various stages of development.

During the period of oviposition and, indeed, throughout the whole spring the weather on Vancouver island is frequently very uncertain. Temperatures remain low under the influence of the prevailing, cold, southwest winds. Towards the end of April and early in May matters improve considerably, brilliant sunshine prevailing during the day, and the temperature ascending to 70° F.

It will be readily seen on consulting table I on page 14 that no strict correlation seems to exist between the air-temperatures and the times required for the eggs to hatch. Roughly speaking, the period of incubation varies as the rise of temperature but by no means proportionally. It may be that embedded as they are beneath the epidermis in the plant tissue, the eggs are not readily influenced by changes of atmospheric temperature.

The Larva (figs. 3 and 4).

Description.—Foster and Jones[1] have given a complete description of the larva, which is hereafter quoted. The description of the pupa and the adult, which follow later, are also borrowed from the same source.

"First Stage (Larva 1 day old).—Length 0·646 mm; width of head 0·166 mm; width of mesothorax 0·183 mm; width of abdomen 0·15 mm; length of antennæ 0·2 mm; length of antennal segments: I, 20 *u*; II, 40 *u*; III, 45 *u*; IV, 100 *u*. General colour, translucent white; general shape, fusiform. Antennæ, head, and legs large in proportion to the rest of the body, and unwieldy. Antennæ distinctly [illegible]-segmented, first segment short, cylindrical; second segment about twice as long as first, oval, cylindrical; third segment slightly longer than second, urn-shaped; fourth about as long as rest of joints together, acutely conical. A few very fine conspicuous hairs present on all joints, more prominent on segment four. Head subquadrate; eyes reddish brown. Thorax about as long as abdomen, slightly wider. Abdomen gradually tapering, 10-segmented, first eight segments sub-equal, IX and X longer and more abruptly tapering, with a fringe of long, white, nearly inconspicuous hairs. Legs stout, femora and tibiæ nearly equal in length; tarsi one-jointed, ending in a single black claw." In addition it is noticed that a ring of small denticles is provided on the posterio. margin of the ninth segment of the abdomen.

Fig. 3.—The pear thrips, *Taeniothrips inconsequens*; larva recently emerged from the egg, ventral aspect. x 200. (Original).

"Second Stage (full-grown Larva).—Total length 1·833 mm; length of head 0·15 mm; width 0·1083 mm; length of prothorax 0·1833 mm, width 0·2166 mm; length of mesothorax 0·1833 mm, width 0·466 mm. Length of antennæ 0·2833 mm; segment I, 26 *u*; II, 50 *u*; III, 76 *u*; IV, 66 *u*; V, 14 *u*; VI, 16 *u*; VII, 33 *u*. Antennæ: segment I, short, cylindrical; II, obtuse, spindle-shaped; III, spindle-shaped, about as long at I and II together; IV, nearly as long as III, broader than the rest, subconical; V, short, narrow, cylindrical; VI, slightly narrower and longer than V; VII, twice as long as VI, narrower and cylindrical. All joints transversely striated and with a few inconspicuous white hairs. General colour faintly yellowish white, obtusely fusiform in shape. Body longitudinally and laterally faintly striated. Head quadrate; eyes prominent, dark reddish brown, situated a little in advance of the middle; mouth cone broadly rounded, nearly as long as the head, extending to the middle of the prosternum. Prothorax large, slightly wider than long, diverging posteriorly. Mesothorax and metathorax short and broad, twice as wide as long, subequal, in length about as long as prothorax. Abdomen broad, gently rounded, 10-segmented, broadest at segments V and VI; first eight segments subequal; segment IX distinctly longer, tapering to apex, the posterior edge armed with a circle of strong, short, thick, wedge-shaped spines, the two mediodorsal and medioventral ones shorter and smaller; segment X slightly tapering, not quite as long as segment IX. Lateral edges of abdomen finely serrated, also with a few long, inconspicuous white hairs, which are more prominent on segment X. Legs strong; femora and tibiæ about equal; tarsi, one-jointed, ending in a single black claw."

Duration of larval stage.—Appearing first about May 1, when the newly hatched forms begin their activities, larvæ remain on the trees until about the middle of June. Immediately on emerging from the egg the larva begins to move slowly around as if taking stock of its surroundings. After a short interval it pierces the vegetable tissue with its mouth stylets and begins to suck up the liberated plant juices. Consequently, by reason of the comparative transparency of the small individual, one can observe the alimentary canal gradually assuming a green tint due to the imbibition of the green chloroplasts. As the animal feeds it increases in size; the original cuticle proves too small and is shed.

Number of moults.—The first moult occurs, in some cases, two days after birth, but generally the larva is seven to eight days old before this moult takes place. The old skin splits along the dorsal median line, the larva remaining inactive for some time before this happens. The legs and antennæ are gradually withdrawn, and finally the body is extracted from the old sheath. During the

Fig. 4.—The pear thrips, *Taeniothrips inconsequens:* full-grown larva, dorsal aspect. x 90. (Original).

process the original tarsal claws serve as organs of fixation, embedded in the supporting plant tissue and effectively retaining the sloughed-off and effete cuticle. The larvæ of the second stadium are robust and very active. Several individuals, measured just previous to the first moult, had an average total length of 1·29 mm. As will be seen from the description of the second-stage larva, there is a considerable increase in length of the individual after this moult. There is no further moult until they have become fully fed and are ready to transform to the prepupal condition in the ground.

The time required for the development of the larva varies. Normally, the period is about three weeks, but low temperatures such as were experienced during the spring of 1916, and especially from May 6 to May 12, when the mean daily temperature was but 46° F., tend to retard growth by exerting a check on the feeding activities of the larvæ.

When mature, the larvæ, now as large and sometimes larger than the adults, cease to feed and abandon the foliage for the soil, which they enter by any convenient crack or small aperture. The method of transit from tree to ground is rarely, if at all, voluntary. Instead of crawling down the branches and trunk, the larvæ merely fall down. Strong winds and dashing rains remove a goodly number, and many, again, are carried within the old, falling calyces. It is stated, by one authority at least[1], that those individuals which fall off the trees when they have only partially developed, mostly perish, unless they can attain to full growth by feeding on weeds or grasses beneath the trees. Necessarily, such immature larvæ would succumb in cultivated orchards. This appears to corroborate a similar statement made by Moulton.[11] In an examination of a small neglected orchard at Royal Oak, overrun by weeds and grasses, on June 2, several larvæ were found feeding on grasses. They had dropped from the overhanging leaves of cherry and apple trees. This would seem to discredit the idea entertained by some orchardists that it is advantageous to leave orchards in sod because of the difficulty which the larval thrips experience in working their way into grass-covered soil. This view is evidently more imaginary than real, if one will only stop to consider the small size of these insects and the facility with which they can avail themselves of the most minute opening. When, added to this fact, one realizes that weeds and grasses offer sufficient nutriment for undeveloped larvæ to become fully fed, the argument for cultivated orchards seems to be strengthened beyond measure. Further, a series of experiments conducted by Moulton, has demonstrated the value of ploughing and cultivating as partial remedial measures in ridding the top layers of soil of the pupæ. The protecting earthen cells are destroyed, and the contained pupæ are either injured or killed. Since, however, many larvæ penetrate beyond the depth to which deep ploughing can be practically carried out, this means of controlling thrips in orchards is not by any means infallible or absolute. It has been observed, at Royal Oak, that some larvæ will, indeed, penetrate to a depth of 15 to 16 inches. Further, it has been shown that with the class of soil with which we have had to deal, the loose mulch of four or five inches generally contains comparatively few larvæ.

Larvæ, after leaving the trees about the middle of June, remain dormant in the soil until September or October, a period of from three to four months. The prepupal condition is then assumed. In California, the average time of subterranean larval existence is stated by Foster and Jones[1] to be from five to six months, with a minimum of two and a maximum of eight months. Neither of these extremes was experienced on Vancouver island, where no larvæ were found after October 3.

DEPTH OF LARVÆ IN THE GROUND.

After the larvæ have penetrated the soil and found a suitable place in which to rest, they make for themselves a small oval cell, the inner walls of which are smooth and compacted. Doubtless the cell is fashioned by the active, rotatory movement of the abdomen in a manner characteristic of the pupae of many Coleoptera and Lepidoptera. The length of the interior is approximately 2 mm., and the breadth about 1·5 mm. Here the transformations from larva to pupa and pupa to adult occur. The adults continue to occupy their cells in safety until the warmth of spring stirs them into activity.

The distance to which the larvæ descend in the soil depends on the structure and texture of the latter. It is to be expected that in an open, porous soil characterized by thorough breathing, the larvæ will penetrate deeply, whereas in a clayey, compacted soil, the mechanical difficulties to be encountered as well as a diminished circulation of atmospheric oxygen, will tend to confine the larger numbers to the strata just beneath the surface. Again, where the surface is covered over by a thick sod, the thrips may be generally found among the grass roots, not deeper than one to three inches.

During 1916, and again in 1917, measured samples of soil taken from the orchard at Royal Oak, beneath the trees, were examined regularly throughout the summer and autumn from July to November. Very few thrips were found below a depth of 6 to 10 inches, and none at all in the loose surface mulch. The soil is a tenacious clay, and below 10 inches is scarcely penetrable. In the winter, it is characterized by its capacity for retaining moisture and, in the summer, by its tendency to bake hard under the heat of the sun.

The Prepupa (fig. 5).

Description.—"(First stage).—Total length 1·333 mm; length of head 0·1 mm; width 0·116 mm; length of prothorax 0·183 mm; width 0·266 mm; width of mesothorax 0·35 mm; length of abdomen 0·666 mm; width 0·383 mm. Shape similar to adult; colour, translucent white, deeply tinted with brown. Head subquadrate, about as broad as long, eyes dark reddish brown. Mouth-cone broadly rounded, extending to about one-half length of prosternum. Antennæ extending backward on each side of head, apparently four-jointed; first three segments nearly subequal in length, about as broad as long, thick and unwieldy; segment IV about as long as remaining joints, club-like and tapering to an obtuse point. Antennæ with a few inconspicuous white hairs. Prothorax nearly twice as long as the head, broadly rounded posteriorly. Mesothorax broader; wing pads short, those of first pair of wings extending to distal edge of third abdominal segment. Abdomen 10-segmented, widest at III and IV, segments gradually tapering from there posteriorly. First eight segments subequal, IX and X longer, distal end of IX with broad spines somewhat similar to those of second stage larvæ, but shorter and smaller. Legs stout, similar to those of full-grown larva, whole body with sparse, light-coloured, inconspicuous hairs."

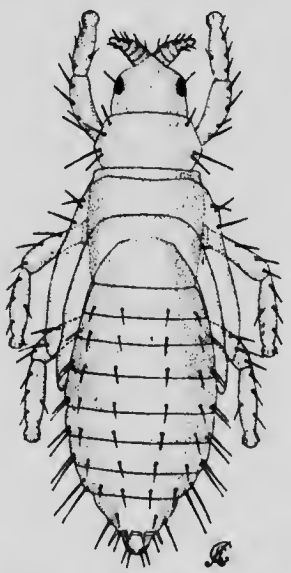

Fig. 5.—The pear thrips, *Taeniothrips inconsequens*; pupa, first stage, dorsal aspect. X 100. (Original).

Duration of prepupal stage.—When the larva is ready to undergo metamorphosis, it sheds its skin and develops into the prepupa which retains certain features of the larva but also assumes some adult characteristics. In colour, it is white like the larva, but there are now two pairs of short wing-pads extending on either side of the body as far as the third and fourth abdominal segments. The antennæ appear to be foreshortened and are carried latero-posteriorly, while the legs are not unlike those of the adult. When removed from its subterranean cell and exposed to the light in a warm room, the prepupa at once becomes active and begins to run about.

In 1917, the first prepupa was found on September 13, and the last on October 10. The average period spent by the individual as a prepupa is about one week to ten days, when the skin is again moulted. The insect then develops into the true pupa.

The Pupa (fig. 6).

Description "(Second stage).—Total length 1·416 mm; length of head 0·183 mm; width 0·166 mm; length of prothorax 0·166 mm; width 0·25 mm; width of mesothorax 0·35 mm; length of abdomen 0·783 mm; width 0·416 mm. Shape similar to adult which is visible beneath the thin transparent shell. Apparently brownish in colour, caused by adult within. Head broader than long; eyes large, dark brown; mouth-cone of adult within extending to posterior edge of prothorax. Antennæ large, cumbersome, laid back on the head and extending past middle of prothorax, four-jointed: I, short; II, elbowed, about twice as long as I; III, short, cylindrical; IV, longer than III, sides uneven as knotted club gently tapering to obtuse apex. Joint I of adult is in joint I of pupa, joint II of adult in joint II of pupa, and III of adult within III of pupa; remaining joints of adult within IV of pupa; three or four white, inconspicuous hairs projecting cephalad from elbow on joint II. Prothorax broader than long. Mesothorax about one and one-half times as broad as prothorax. Wing-pads extending to distal margin of eighth abdominal segment, fore pair not quite so far. Abdomen widest at third and fourth segments, tapering from there to obtuse apex. Posterior edge on ventral side of segment IX with four strong spines resembling a meat fork. This is apparently the cremaster. Legs stout Entire body with numerous, inconspicuous, white hairs".

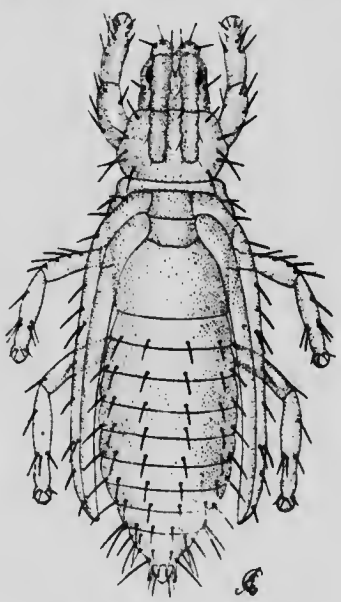

Fig. 6.—The pear thrips, *Taeniothrips inconsequens*; pupa, second stage, dorsal aspect. X 100. (Original).

Duration of pupal stage.—The first pupæ are found about the middle of September and the last about the beginning of November, so that the total period covered by the pupal stage lasts for six weeks to two months. In certain seasons and under unfavourable conditions, it may extend for a longer time than this, but it is interesting to note that there appears to be a much greater uniformity in the duration of the various phases of the life-history in Vancouver Island as compared to California. Foster and Jones[1] state that the earliest pupæ are found in the month of May in the Santa Clara valley, but these they consider as developing from premature larvae, the precocity of which has been determined by infection with some fungous organism. Their latest pupæ are found in December, with the maximum number appearing in October. This latter month also represents the period of maximum pupation in Vancouver island.

It would have been reasonable to suppose that pupation would have been rather later in Vancouver island than in California where the climatic conditions are more equable. Our evidence, however, goes to prove that such is apparently not the case, at least not to any marked extent.

In the middle of June when the larvæ were full-fed and falling from the trees, large numbers were shaken into specially constructed boxes partly filled with finely sifted soil. The larvae burrowed beneath the surface just as they would do in the orchard. The boxes were then buried in the ground, with their tops level with the surface, in the yard adjoining the laboratory. The larvae were thus kept under almost natural conditions. From time to time small samples were taken from these boxes, and table IV shows the comparative number of larvæ, pupæ and adults at Royal Oak during the period July 10 to November 3, 1917.

Fig. 7.—The pear thrips, *Taeniothrips inconsequens*; adult, wings outspread. X 95. (Original).

TABLE IV.—THE COMPARATIVE NUMBER OF LARVÆ, PUPÆ AND ADULTS FOUND IN SOIL SAMPLES, ROYAL OAK, VANCOUVER ISLAND, B.C., DURING JULY TO NOVEMBER, 1917.

Sample numbers.	Dates examined.	Larvæ.		Pupæ.		Adults.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
1 to 8	July 10—Sept. 10	32	100	0	0	0	0
9 to 18	Sept. 13—Oct. 2	33	16	169	84	0	0
19 to 26	Oct. 3—Nov. 3	1	0·7	77	58·8	53	40·5

The Adult (Fig. 7).

Description.—"Length of head 0·13 mm; width 0·15 mm; length of prothorax 0·13 mm; width 0·2 mm; width of metathorax 0·28 mm; width of abdomen 0·31 mm; total length 1·26 mm. Length of antennal segments: I, 33 *u*; II, 45 *u*; III, 63 *u*; IV, 54 *u*; V, 33 *u*; VI, 66 *u*; VII, 9 *u*; VIII, 12 *u*; total, 0·31 mm. Colour dark brown; tarsi light brown to yellow. Head slightly wider than long, cheeks arched, anterior margin angular, back of head transversely striate and bearing a few minute spines

and a pair of very long prominent spines between posterior ocelli. Eyes prominent, oval in outline, black with light borders, coarsely facetted and pilose. Ocelli approximate, yellow, margined inwardly with orange-brown crescents, the posterior ones approximate to, but not contiguous with, light inner borders of eyes. Mouth-cone pointed, tipped with black; maxillary palpi three-segmented; labial palpi two-segmented, basal segment very short. Antennæ eight-segmented, about two and one-half times as long as head, uniform brown, except segment III, which is light brown; spines pale; a forked sense-cone on dorsal side of segment III, with a similar one on ventral side of segment IV. Prothorax about as long but wider than head; a weak spine at each anterior and two large, strong ones on each posterior angle; other spines not conspicuous. Mesothorax with sides evenly convex, angles rounded; metanotal plate with four spines near front edge, inner pair largest. The mesonotal and metanotal plates are faintly striate. Legs moderately long, uniform brown except tibiæ and tarsi, which are yellow. Spines on tip of fore and middle tibiæ weak; several strong spines on hind tibiæ. Wings present, extending beyond tip of abdomen, about twelve times as long as wide, pointed at tips; costa of forewings thickly set with from 29 to 33 quite long spines; fore vein with 12 to 15 arranged in two groups of 3 and 6 respectively, on basal half of wing and a few scattering ones on distal part; hind vein with 15 or 16 regularly placed spines; costal fringe on fore wing about twice as long as costal spines. Abdomen suhovate, tapering abrupty toward the tip from the eighth segment; longest spines on segments 9 and 10; abdomen uniform brown; connective tissue yellow".

In comparing the wings of a large number of adults, it is found that there is a greater variation in the number and disposition of the alar spines than is stated by Foster and Jones in their description above. For instance, the number on the costal vein varies from twenty-three to thirty-two, on the fore-vein from twelve to eighteen. An examination of 100 wings showed that 59 per cent had the basal spines of the fore-vein arranged in two groups of three and six. The first group of three appears to be stable, but the second varies from four to eight. The spines on the hind vein vary from twelve to eighteen.

Duration of adult stage.—The total period of aerial adult activity extends from about two to two and a half months. The numbers increase to a maximum depending on the rapidity with which their emergence from the soil proceeds. Gradually a diminution begins until, after eight to ten weeks, only a few stragglers remain on the trees. This season's records show that the adults first began to appear in the last days of March and to disappear at the end of May, a few remaining over into the first days of June. It is doubtful whether these late individuals lay any eggs. At least, none of them were observed to oviposit. It must be remembered that adults are to be found in the soil for a considerable time previous to their appearance on the trees. Most of the pupæ have probably transformed to the imaginal condition in the autumn and early winter. For a period varying from one to five months, they remain inactive in their subterranean cells until conditions are such as to favor their migration to the upper air.

LONGEVITY OF ADULTS IN CAPTIVITY.

In captivity and with food inside the laboratory, adult thrips do not live longer than four days on an average. Among large numbers thus confined individual specimens have lived as long as eight days and, in one instance, ten days. If supplied with food, some will live as long as twenty days, a result which was repeatedly obtained by confining a number of adults in large glass vials with maple buds, their escape being prevented by a muslin cover which allowed aeration sufficient to obviate the collection of moisture on the walls of the tube. In the field, adults imprisoned in mica-chimneys fixed on the trees lived for as long as four weeks. It may be inferred, therefore, that under natural conditions the duration of the adult's life would probably cover a period of about four to six weeks.

TABLE V.—LONGEVITY OF ADULTS IN CAPTIVITY WITHOUT FOOD: SPECIMENS TAKEN ON EMERGING FROM SOIL.

Number of Experiment.	Number of Specimens.	Date of Confinement.	Date of Death of Last Specimens.	Length of Life of Longest-lived Specimens in Days.
1	50	March 29	April 2	4
2	30	" 30	" 3	4
3	43	" 31	" 6	6
4	53	" 31	" 10	10
5	46	April 1	" 6	5
6	25	" 1	" 10	9
7	119	" 2	" 7	5
8	116	" 2	" 10	8
9	23	" 3	" 10	7
10	76	" 4	" 11	7
11	56	" 5	" 10	5
12	54	" 7	" 12	5

In two experiments with 100 individuals each, the adults on emerging from the soil were confined in tubes covered with muslin and supplied with food in the form of fresh maple-buds. The longest-lived individual in each case survived from April 20 to May 10, a period of twenty days.

MIGRATION OF ADULTS FROM THE SOIL TO THE TREE.

The factor which principally determines the emergence of the adult is sunlight accompanied by the proper degree of warmth. On April 2, 1917, with brilliant sunshine, an air temperature of 52 degrees Fahr., and soil temperature of 45 degrees Fahr. at 3 p.m., the thrips left their subterranean winter-quarters in large swarms, winging their flight confidently in the sunshine. Numbers migrated to the buds, but the great majority after a time appeared to return to the soil, leaving only a very few on the opening buds. These recently-emerged individuals were observed to be of a tawny or flavous yellow colour in distinction to the dark brown colour of older specimens. In many the abdomen is alone flavous, with the head and thorax sepia-coloured, and the reverse often holds good. Before the adults begin to feed in the spring, the abdomen is distinctly contracted so that the wings overlap the distal extremity. The lateral margins are also distinctly flattened dorso-ventrally, the abdomen only becoming round and elongated as the animal feeds and its ovaries develop.

On April 7, and again on April 11 and 12, further large swarms were observed to be migrating from the soil as on April 2, the flight occurring in the afternoon under the influence of warm sunshine. It was noted that the insects could sustain themselves on the wing for long periods, undertaking quite extended and tortuous journeys of 25 yards or more. The general effect of their appearance in the air was that of a shimmering haze rising from the ground, and the constituent individuals of the swarm could be readily followed as they passed between the observer and the sun's light. It is significant to note that where the soil had been stirred by the plough, there was an earlier emergence than from unploughed soil. In distinctly low pockets the emergence of the adults was still further delayed by as much as five to seven days by reason, no doubt, of the lower prevailing temperature. During rainy days there is always a marked diminution in the numbers issuing from the soil, although rain does not cause a complete cessation of their emergence.

Preparatory to taking flight the thrips recurves its abdomen dorsally, and apparently employs the long setæ of the penultimate and ultimate segments in spreading the wings at an angle of 45 degrees with the long axis of the body.

This may be repeated several times before the animal embarks with a spring from the surface on which it is resting. The legs appear to assist in this initial movement of propulsion. As the adults settle after a flight, the wings are immediately tucked in and arranged straight along the abdomen, parallel almost to the mid-dorsal line, the anterior wing of each pair covering the posterior one.

That there is an undoubted migration of thrips from one variety of fruit tree to another is well borne out by facts. Thus, swarming from the soil was practically finished by April 12 at a time when the buds of Duchess, Gravenstein and Red Astrachan apples were in a receptive condition. At this date there were practically no thrips on the King and Wealthy varieties, their buds being as yet tightly closed. Later, as their buds open, the migration becomes more evenly distributed throughout a mixed orchard, indicating a migration from early to late varieties. The same phenomenon applies to pears, of which, in the particular orchard under observation, the Bartlett buds are the earliest to open and are therefore first attacked, followed by the Bosc, Jules Guyot, Rivers' Princess, and Louise Bonne. Of course, the migration takes place from apple to pear in the same way as from apple to apple, or pear to pear.

FIG. 8.—Duchess apple buds, May 3, 1917. Adult pear thrips may be seen on the bud on the right-hand side. (Original).

Prunes, plums, and cherries, in virtue of their later development than apples and pears, are the last to be attacked, and the season is often well advanced before the cherry buds become infested. In the case of prunes and plums, very careful watch is necessary, as the presence of only two or three thrips inside the small and tender buds will often mean their total destruction.

DETERMINATION OF THE DATE OF APPEARANCE OF THE FIRST THRIPS AND THE NUMBERS EMERGING FROM THE SOIL.

The growers make the acquaintance of the pear thrips in early spring, when the adults emerge from their hibernating quarters in the soil and make their way to the bursting buds (fig. 8).

As to the time of their exact date of appearance, this will vary from season to season according as conditions are early or late. Generally speaking, the adults first become evident in any season almost synchronously with the development of the fruit buds. The group of environmental factors which favours the growth of the buds, also stimulates the dormant soil-imprisoned thrips to make their way to the upper air. The factors, then, which determine the time of emergence, are chiefly those of temperature and humidity, whilst the structure and texture of the soil is also of no small importance.

On the Saanich peninsula, in 1916, the first adults began to emerge on March 28 and continued until April 20, with a maximum period of emergence extending from April 7 to April 16. In the spring of 1917, the season was somewhat earlier; but, nevertheless, the first adults were observed in the field only one day previous to that on which they were seen the preceding year, namely, March 27. This was also the date on which the first specimens were taken in the soil trap-cages. Emergence continued until April 27, with a period of maximum emergence lasting from April 2 to April 13.

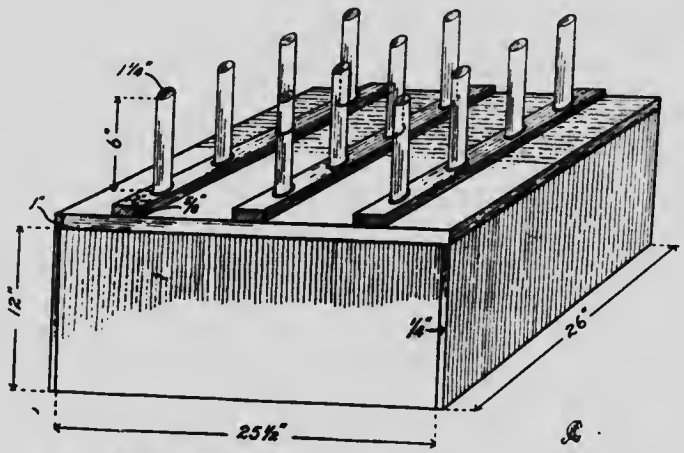

Fig. 9.—Trap emergence-box used in the orchard at Royal Oak, Vancouver island, 1917, for determining the first appearance of pear thrips in the spring and their numbers in the soil. (Original).

The method employed in determining the first appearance of the thrips in the spring, consisted in sinking specially constructed boxes (fig. 9) in the soil beneath the trees. The inside measurement of the boxes was exactly 2 feet square, and the depth was exactly 1 foot. The open top was inverted and sunk in the soil some 6 inches, whilst the closed bottom was re-enforced with three cross slats, 2 inches wide by five-eighths of an inch deep, placed at equal distances of 6 inches apart. Each slat was provided with four holes of 1¼ inch diameter, which also perforated the bottom of the box. Each hole, again, was fitted with a closely fitting cylinder of tin (fig. 10), 1½ inches deep, provided with a narrow flange, one-eighth of an inch broad, to support the cylinder in the hole. Inside this cylinder, a tin cone of the same height was fixed to the basal margin. The apical aperture of the cone was one-quarter of an inch, and the basal aperture 1¼ inch. Lastly, into the cylinder was fitted a glass tube or vial of 1¼ inches diameter. Each box was thus provided with twelve vials, into which the thrips, in their positive reaction to light, found their way and were trapped when they emerged from the soil. It was found that the water-vapour arising from the soil inside the box condensed on the walls of the vials and, collecting between the cone and the cylinder, proved very effective in

nullifying the escape of the thrips once they had reached the tubes. As well as being an accurate index of the period of emergence, the counts obtained by the use of these trap-cages represented the actual number of thrips that were present in the two square feet of soil covered by the boxes.

The average of the numbers emerging in six boxes throughout the orchard represented roughly the degree of infestation of thrips in the soil. As a method of assisting the orchardist in his operations, no better plan than these trap-cages could be employed for determining accurately the first appearance of the thrips at the beginning of the season. Necessarily, the boxes must be stoutly made, and all possibility of cracks, even the most minute, eliminated.

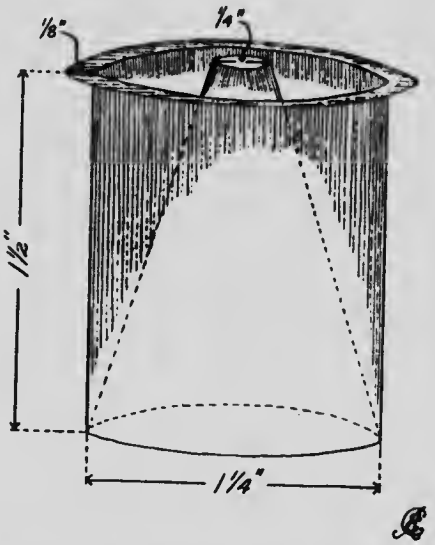

Fig. 10.—Combined trap-cone and cylinder of tin used for holding the glass vials, and fitted into the holes of the soil emergence-boxes, in the orchard at Royal Oak, Vancouver island. X 2. (Original).

A less elaborate apparatus consisting of an inverted, cone-shaped, muslin bag (fig. 11), suspended from an overhanging branch, will be found to provide an excellent indication to the orchardist of the first emergence of the thrips. The lower margin is provided with a circular piece of stout iron wire, which serves to keep the bag extended. Sods are placed firmly around the base in order to keep it in position and to prevent the escape of the insects. The whole apparatus is nothing more or less than an insect-collecting net made of stout, close-meshed muslin. It should be examined every day for the presence of adult thrips, then turned inside out, shaken, and replaced in its former position. Thus the orchardist will obtain a fairly accurate idea of the daily increase or decrease in the numbers emerging, and will be enabled to decide the period of maximum emergence. For obtaining efficient results, these traps should be established in the orchards about the middle of March.

In table VI is represented the actual numbers of thrips emerging from the soil and trapped in each of six boxes distributed through the orchard at Royal Oak, Vancouver island, B.C. It will be readily seen that the largest numbers appeared between the dates of April 2 and April 13.

FIG. II.—Inverted, muslin, bag-net trap in position; a convenient method of determining the dates of emergence of the adult pear thrips from the soil in the spring. (Original).

TABLE VI.—TOTAL NUMBERS OF PEAR THRIPS EMERGING IN TRAP BOXES PARTLY SUNK IN THE SOIL OF THE ORCHARD AT ROYAL OAK, VANCOUVER ISLAND, B.C., UNDER TREES OF APPLE AND PRUNE DURING 1917.

Date.	Number of Thrips Emerging.					
	Box 1.	Box 2.	Box 3.	Box 4.	Box 5.	Box. 6.
March 27	2	1	0	0		
" 28	1	3	0	0		
" 29	0	4	1	17	Trap boxes 5 and 6 not set on these dates.	
" 30	2	18	4	14		
" 31	0	9	0	9		
April 1	4	4	1	9		
" 2	4	47	11	44		
" 3	10	35	8	36		
" 4	29	105	2	29	12	39
" 5	42	190	18	216	72	199
" 6	61	296	4	126	7	35
" 7	110	302	32	339	51	118
" 8	74	115	15	43	9	28
" 9	183	205	47	114	45	47
" 10	54	131	18	34	12	26
" 11	83	43	21	41	18	16
" 12	65	53	9	18	6	12
" 13	13	71	9	9	3	1
" 14	5	13	1	0	1	1
" 15	0	24	2	2	0	2
" 16	5	19	2	0	0	0
" 17	6	12	3	0	0	0
" 18	3	0	1	5	0	0
" 19	5	5	7	0	6	0
" 20	1	1	0	0	0	1
" 21	0	0	0	0	2	0
" 22	0	2	3	1	2	0
" 23	0	0	0	0	0	0
" 24	0	0	0	0	0	1
" 25	0	0	0	0	0	0
" 26	0	0	1	0	0	0
" 27	0	0	1	0	0	0
" 28	0	0	0	0	0	0
" 29	0	0	0	0	0	0

EMERGENCE OF ADULTS IN RELATION TO TEMPERATURE.

The records for the years 1916 and 1917 go to prove that the critical temperatures which determine the emergence of the adults from the soil in the spring, are 45 degrees Fahr. for the soil and 50 degrees Fahr. for the air. Should the temperature at any time fall below these figures after the emergence has actually commenced, the effect will be to delay the process and to give a double or treble maximum to the curve of emergence. On the other hand, should the temperature be maintained above the critical point for some time, a graphical representation of the emergence will show but one maximum.

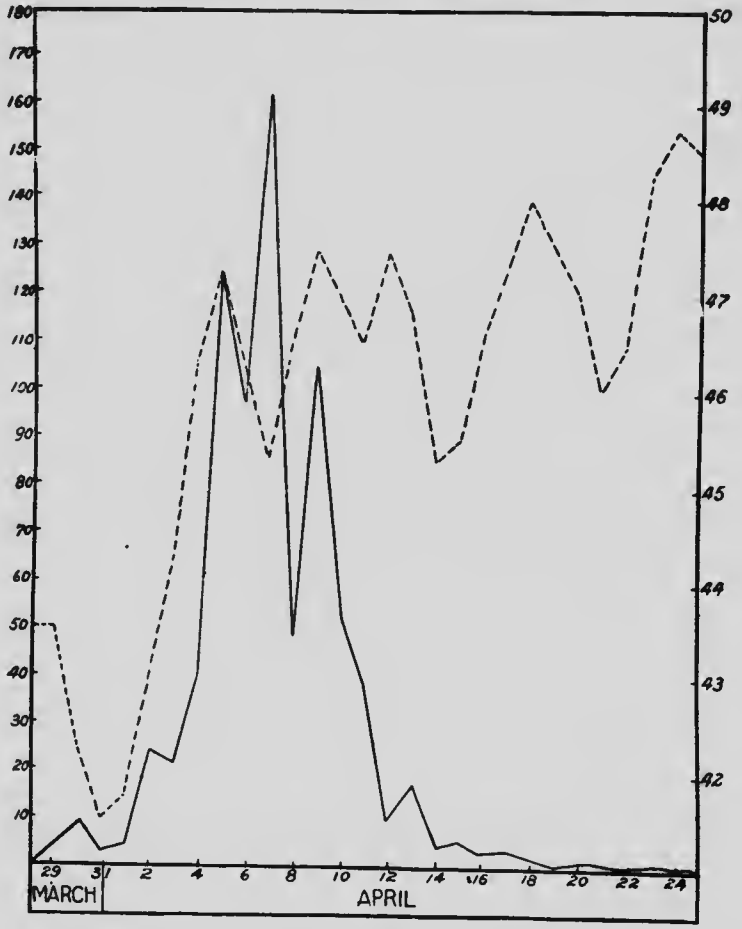

Fig. 12.—Straight-line curve showing emergence of adult pear thrips in trap cages under trees in orchard, Royal Oak, Vancouver island, March 28-April 25. Dotted curve is a graphical representation of the average daily mean soil temperature during the same period. (Original).

It will be observed that the curve of emergence for 1917 at Royal Oak, Vancouver island, B.C. (fig. 12) has three distinct phases, between the dates of March 4 to 10, due to the variations of soil temperature. On March 5, 7, and 9, the emergence was notable by reason of the large numbers which deserted the soil when the temperature rose above the

critical point; but on the intervening dates, March 6, 8, and 10, there was a marked diminution due to the decided fall below 45 degrees Fahr. On the whole, the process was marked by its rapidity, the greatest numbers emerging in a period covering sixteen days from March 29 to April 13, after which there was a gradual tapering off in numbers, until the emergence was completed on April 28. The figures of emergence for 1916 and 1917 were practically identical, a fact which is satisfactorily explained by the similarity of the temperature conditions in the spring in both years. In 1916, the average mean air-temperature between the dates of March 27 and April 30, when most of the adults emerged, was 49 degrees Fahr. For the same period in 1917, it was 49.7 degrees Fahr. The average mean soil-temperatures in 1916 and 1917 covering the same time were respectively 48.8 degrees Fahr. and 46.5 degrees Fahr. It is likely that the emergence for 1916, when no definite figures were kept, would have proved to have been more rapid than was the case for 1917, owing to the two degrees higher average mean soil-temperature. Only, the abnormally high rainfall and snowfall during the early months of the year 1916 might have offset the temperature advantage by exerting a decided retarding influence on the activities of the emerging thrips. It might be argued that any climatic factor, such as low temperature or abnormal rainfall, which will delay the emergence of the adults from the soil, will also be the means of staving off the damage to the trees. Unfortunately, such a factor has generally a retarding influence on the time of blossoming, so that the first appearance of the thrips, depending largely on the same set of favourable conditions, will coincide in most years with the opening of the susceptible buds.

Appended are the mean temperatures, in parallel columns, in the air, in the soil, and on grass from March 27 to April 30, 1916 and 1917, covering the period when the adults were abandoning the soil. The total rainfall and snowfall in inches for the months of January, February, March, and April in both years are also arranged in parallel columns for the sake of comparison.

TABLE VII.—MEAN TEMPERATURES FOR THE PERIODS COVERING THE EMERGENCE OF THE PEAR THRIPS ON THE SAANICH PENINSULA, VANCOUVER ISLAND, MAR. 27 TO APRIL 30, 1916, 1917, AND RECORDS OF RAINFALL AND SNOWFALL BETWEEN JANUARY AND APRIL, 1916 AND 1917.

	1916.	1917
	° F.	° F.
Mean maximum air temperature, Mar. 27–April 30	58·2	60·1
Mean minimum air temperature " "	39·8	39·4
Average mean air temperature " "	49·0	49·7
an maximum soil temperature " "		
minimum soil temperature " "	50·1	47·8
ge mean soil temperature " "	47·6	45·2
	48·8	46·5
Mean maximum temperature on grass " "		
Mean minimum temperature on grass " "	41·0	44·0
Average mean temperature on grass " "	29·0	27·8
	36·5	37·1
Total rainfall in inches for January	1·63	3·1
Total snowfall in inches for January	44·50	17·8
Total rainfall in inches for February	4·73	1
Total snowfall in inches for February	41·00	9·0
Total rainfall in inches for March	6·50	4·7
Total snowfall in inches for March	2·50	
Total rainfall in inches for April	1·32	3·7
Total snowfall in inches for April		

HABITS.

Food Plants—Native and Cultivated.

In addition to being a pest of deciduous fruit trees, the pear thrips has become thoroughly established on many other trees and shrubs on Vancouver island, chief among which are the broad-leaved maple (*Acer macrophyllum*), June berry (*Amelanchier florida*), willow (*Salix scouleriana*), red-flowering currant (*Ribes sanguineum*), choke cherry (*Prunus demissa*), Nuttall's cherry (*Nuttallia cerasiformis*), and also, incidentally, on skunk cabbage (*Lysichiton kamschatkense*), Douglas fir (*Pseudotsuga mucronata*), Oregon grape (*Berberis nervosa*), daisy (*Bellis perennis*), and dandelion (*Taraxacum officinale*). In a nursery, it was found to occur on certain ornamental shrubs and trees such as *Andromeda floribunda*, *Viburnum opulenta*, as well as the Japanese flowering plum.

Fig. 13.—Showing a destroyed blossom-bud and an injured blossom-cluster of the broad-leaved maple, *Acer macrophyllum*, May 8, 1917. Injury caused by the feeding activities of the adult pear thrips. (Original).

It has been fully demonstrated that the species can successfully complete its life-history on the broad-leaved maple, the June berry, choke cherry, and Nuttall's cherry, causing damage exactly parallel to that which it commits on deciduous fruit trees. There is no evidence, however, of its breeding on the others just enumerated. In 1917, the injury to maples was greater than that caused to any kind of deciduous fruit trees, and was widely distributed throughout the Saanich peninsula and southern sections of the island, extending also to the maples of the neighbouring gulf islands. In one marked case, twenty buds of a maple examined at Duncan, V. I., yielded almost one thousand thrips. The buds were seriously retarded in their growth, and many never recovered from the initial check. Late in the summer, when they should have been in full leaf, the trees presented a miserable, bare appearance. The maples skirting the

shores of Gabriola island were all thus seriously affected. Figure 13 represents the type of injury caused to maples. In the photograph, as shown, one bud failed to develop, and the blossom-cluster instead of being short and contracted should have been long and feathery, more in proportion to the size of the leaves at that time of year. Figure 14 also represents injury to maples, the petioles being badly blistered and scarred by the oviposition of the adults and the hatching of the larvæ.

FIG. 14.—Egg-scars on the leaf-petioles of the broad-leaved maple, *Acer macrophyllum*, after eggs of pear thrips have hatched. May 31, 1917. (Original).

Breeding was also quite extensive on the June-berry and choke cherry. When one considers the wide distribution of all these trees on Vancouver island, and their rôle as breeding reserves, it will be readily understood that eradicative measures in regard to the pear thrips are out of the question. As to whether its establishment on native food-plants can be said to support the theory of the indigenous origin of the pear thrips, is open to doubt; but it is significant that the insect has been found on maples 10 miles distant from any orchard. Likewise, it was found to be very common on the native maples on the gulf islands, both inland and along the seashore, often where there were no fruit trees, and sometimes separated from orchards by thick shrub and tall timbers.

Susceptibility of Fruit Trees to Attack and Injury by Adults and Larvæ.

So far as one can judge the relative susceptibility of the different cultivated fruit trees to the effects of the thrips depredations, the palm must be granted to pears among the pome fruits and to prunes and plums among the drupaceous varieties. On the whole, it is probable that the latter, by reason of their smaller and more tender buds, ultimately suffer greater damage than the species and varieties of the congeneric *Pyrus*. It might be well to set forth in detail the various species of cultivated trees attacked.

TABLE VIII –CULTIVATED FOOD-PLANTS OF THE PEAR THRIPS.

Family.	Genus.	Species.	Common Names.	Nature of Fruit.
Rosaceæ	*Pyrus*	*communis* L	Pear	Pome.
		malus L.	Apple	"
	Cydonia	*vulgaris* Pers.	Quince	"
	Prunus	*avium* L, vars.	Cherry	Drupe.
		domestica L, vars.	Plum	"
		domestica L, vars.	Prune	"
		insititia L, vars.	Damson	"
		amygdalus Hook	Almond	"
		armeniaca L.	Apricot	"
		Persica Benth	Peach	"
Juglandaceæ	*Juglans*	*regia* L.	Walnut	Form of drupe

Some of these species are not grown on a commercial scale on Vancouver island, and for this reason the damson, almond, apricot, peach and walnut may be eliminated from our considerations.

They are, nevertheless, with the exception of the walnut, recorded among the principal food-plants of the pear thrips in California[1]. Should the pear thrips by any chance be found in the future to assume economic importance on the mainland of British Columbia, the apricot and peach, at least, which are quite extensively grown there, will probably suffer seriously from its attacks.

Damage to Pears.

The damaged buds of pears are the first to arrest attention in the spring. (fig. 15, A). Working their way in between the opening scales, the adults begin to feed on the tender parts within. As a consequence, the buds begin to "bleed," exuding a sugary sap which crystallizes by evaporation on the exterior of the bud, imparting to it a dull glistening appearance. Where a number of individuals are working on the same bud, it fails to swell and assumes a shrivelled, "scorched" appearance, characteristic of intense infestation. Whole trees may be thus affected. In time the injured buds are attacked by the spores of blue moulds which cause them to turn a bluish-black colour. Some buds will contrive to expand and send forth weakened blossoms in spite of apparent serious injury. The ingress of the mould spores is, however, an effectual check to further development. Toll is levied on all the tender parts within the bud, leaves and their petioles, blossom stems, the developing ovaries, and stamens with their anthers.

B

B, Sweet cherry, showing destruction by the feeding activities of adult pear thrips in early spring. (Original.)

The damage throughout a pear orchard is not always by any means uniform. It is often difficult to tender a satisfactory explanation why, of two trees of the same variety situated side by side, one will have practically all its buds ruined, whilst the other will set a fair amount of fruit. The same phenomenon has also been observed in the case of two adjacent rows of trees of the same variety. In the orchard at Royal Oak, an isolated pear tree of the Sheldon variety surrounded by Bartlett and Rivers' Princess pears was so extensively damaged in the bud stage that, throughout the season of 1916, it contrasted quite strongly with its less stricken neighbours. The only reason which can be assigned for its poor showing is that it develops slightly earlier than the other varieties, and the adults had committed irreparable damage to the buds before attention was called to its condition and a treatment applied. More significant even than this case was that of a Duchess of Angoulême pear grafted upon the variety Rivers' Princess. The graft is a somewhat earlier budding variety than the stock, and the time of swelling of its buds coincided approximately with the maximum emergence of the adults from the soil. It thus laid itself peculiarly open to attack when the closed buds of the stock were as yet tightly closed and protected from injury. In one tree the graft, constituting about one-fourth of the foliage, had its buds almost completely destroyed, in decided contrast to those of the stock which had made comparatively good growth. One is thus forced to conclude that, so far as the pear thrips is concerned, it is unwise to graft an early budding variety on one which develops its buds later in the season. Further, one and the same application of an insecticide will not on this account prove equally efficient in controlling the pest on both varieties. Pears of the Bartlett and Bosc were quite heavily infested by adults; but the timely application of spray solutions reduced the early injury to a minimum. Louise Bonne, Flemish Beauty, and Rivers' Princess, by reason of their later development, did not suffer materially. It must be remembered that the number of adults in a bud is not always a reliable criterion of the damage that is likely to accrue. Ten or twenty adults attacking a young opening bud will often do more to check its future development com- [illegible] than fifty of the species working in a bud which has made greater [illegible] and become strengthened by reason of its growth. Nevertheless, [illegible] measures should be vigorously carried out; for the more inexorable the tr[illegible]ment, the fewer the adults that will persist to lay eggs, harbingers of damage to come. Nor must a truce be called because the numbers of the adults may be diminishing. No matter how carefully the trees of an orchard may be sprayed, there will always be a goodly number of adults which will escape nemesis. Therefore, one must be prepared to make an additional treatment against the larvæ which hatch from the eggs laid by these adults. In this way a crop which may at first appear to be a complete failure, may finally yield a respectable return and amply repay the owner for the labour expended. With an insect so insidious as the pear thrips there can be no relaxation of one's efforts. Half-hearted measures are likely to prove more expensive than none at all. As to the best time for applying insecticides, no hard and fast rules can be drawn up. Seasonal differences may cause an early or late appearance of the thrips, according as the conditions are favourable or otherwise. Under the circumstances, the orchardist must rely to a great extent on his own judgment and decide for himself. There can be no doubt, however, that once the thrips has reached the buds, control measures cannot be undertaken too soon.

B
[illegible] adjacent shoots, showing destruction by the feeding activities of adult pear thrips in early spring. (Original.)

DAMAGE TO APPLES.

On the whole, apples do not seem to be so susceptible to injury as pears. The buds are more robust and appear to be less affected by the activities of the adults. Generally speaking, the three varieties, King, Ribston pippin, and Baldwin, seemed to prove more attractive than Duchess, Red Cheek pippin

Gravenstein, and Wealthy in the orchard at Royal Oak. Of these, the Wealthy is the last to blossom, and at no time was the infestation so heavy as to warrant the expense of making a treatment for the adults, although operations were instituted against the larvæ after the blossoms had been shed. The favourite feeding-ground of the larvæ on apples is the floral receptacle with its nectary. As many as twenty to thirty may be found congregated on a single one, actively

Fig. 16.—Egg-scars on young developing apple-stems, May 20, 1917. Larvæ of pear thrips have emerged, rupturing the tissue and thus accentunting the scars. The pubescence of the stems has been partially removed to show the scars more clearly. Enlarged. (Original).

engaged in imbibing the sweet fluid secreted by the glands. After this has been exhausted they lacerate the tissue, thereby exciting a further flow of sap and causing the appearance of small brown areas. The stamens are also attacked, and becoming brown, they wilt and die. Feeding on the young fruit, the larvæ are responsible for the condition in apples popularly known as "scab," also quite common on misshapen pears. As might be expected, those untreated trees on which adults have been particularly numerous, will experience the greatest larval injury. As the larvæ develop some of them pass from the young fruit to the leaves, where they may be found feeding close to the midrib and the principal veins. The leaves are thus often badly perforated.

In heavy infestations numerous egg-scars will be found on the young fruit pedicels (fig. 16).

DAMAGE TO PRUNES.

The destruction of a prune crop by the pear thrips proceeds with great rapidity after its inception, and, taking tree by tree, the damage is as great as, if not greater than that caused to pears. For ten years there has not been sufficient return from either the prune or plum crop in Vancouver Island to repay the labour of cultivation. As soon as the adults emerge from the soil, they may be seen on the outside of the buds impatient in their efforts to effect an entrance. Once inside, they soon make their presence felt by destroying the most tender parts. As the bud scales are forced apart, the young leaves and blossoms, instead of being fresh and green, appear brown and decayed. The slightest touch will cause these destroyed buds to fall to the ground. One is often surprised by the large number of thrips which are found feeding on the blossom-stems, the tips of the petals, and on the stigma and style of the blossoms before

FIG. 17.—Olivet cherry infested by larvæ of pear thrips May 31, 1917. (Original).

and after they have opened. Year after year the prospects for a heavy crop may appear bright and rosy, only to be repeatedly blasted by the depredations of the pest. It is our conviction that the spray solutions applied at Royal Oak this year would have accomplished much towards saving the crop of Italian prunes, but unfortunately the occurrence of two sharp attacks of frost on May 11 and 12 blighted our expectations and entirely negatived the results. Plums of the Pond's Seedling and Columbia varieties were not so heavily infested as the Italian prunes. It is rather a disheartening spectacle to enter an orchard and see the prune trees presenting a scorched appearance, with an isolated blossom here and there reminding one of the departed glory of the crop. In prunes and plums the scabbing of the fruit caused by the feeding activities of the larvæ may seriously depreciate its market value, if it does not indeed render it quite unsaleable. Were persuasion necessary, nothing could be more stimulating to an energetic campaign of combating the thrips than this story of prune destruction in the Saanich peninsula. As has been previously mentioned, the deposition of eggs in the fruit petioles and their consequent weakening may also account for quite heavy losses in prunes and plums.

DAMAGE TO CHERRIES.

Although cherries are severely attacked by adults, they generally set quite a heavy crop of fruit by reason of their comparatively large productiveness. The thrips first begin to appear in numbers as the buds open up

from their imbricated condition, and later they exact toll of the tender parts of the interior (fig. 15, B). The deposition of eggs in the fruit-stems and leaf-petioles is also responsible for the backward condition of many bud-clusters; for, to some extent, the egg scars interfere with the flow of sap. At Royal Oak in the spring of 1917 it was our privilege to observe how intensive might be the thrips damage to cherries. A section of the orchard which includes nothing but cherry trees of the Olivet variety, presented a most forlorn and cypress-like appearance. In the previous year, bud-clusters had contrived to push out their blossoms and young foliage-leaves. But here development had been seemingly arrested owing presumably to the activities of the adults. The clusters had first browned and then blackened. They remained attached to the branches during the winter, a significant symbol of the neglect of spraying operations. The buds of cherries, as they open up, lend themselves admirably to the effective penetration of the various spraying mixtures, so that there can be little excuse for not controlling the thrips where effective measures are adopted.

Later in the season, the larvæ demonstrate their ability to supplement the adult damage by fenestrating the leaves to such an extent that one might imagine a similar condition arising from the repeated delivery of small shot amongst the foliage. This secondary damage is quite important, and responsible for a decided reduction of the assimilating surface of the leaves, which must be rather detrimental to the growth of the trees.

FIG. 18.—Immature Olivet cherries showing characteristic "russetting" caused by the feeding activities of the larvæ of the pear thrips, May 31, 1917. (Original).

The damage which the thrips may cause to the young fruit was clearly instanced in an orchard at Duncan, Vancouver island. On May 31, 1917, an Olivet cherry-tree was literally swarming with the larvæ, and the cherries, still green, were very badly russetted (fig. 18). Figure 17 will present some idea of the numbers of larvæ that were found feeding on individual cherries.

REPRODUCTION.

OVIPOSITION.

The ovipositor (fig. 19) of the female thrips is quite characteristic. It arises from the eighth and ninth abdominal segments and lies in a groove adapted for its reception by the modification of the ventral sclerites of the two ultimate segments. Four distinct plates enter into its composition, the lower anterior pair originating from the eighth, and the upper posterior pair from the ninth abdominal segment. Curving very gently downward in sickle fashion, it terminates in a very slender sharp point. The egg passes out between the plates which are grooved on their inner faces for its easier exit. By means of a tongue on the lower edge of the upper plates, fitting each into a cham-

on the upper edge of the lower plates, the apparatus is rendered more tensile, while at the same time allowing of a certain degree of sliding play of the upper plates on the lower. Except when actually in use, the ovipositor is hidden in its receptacle, a ventral excavation of the two last segments.

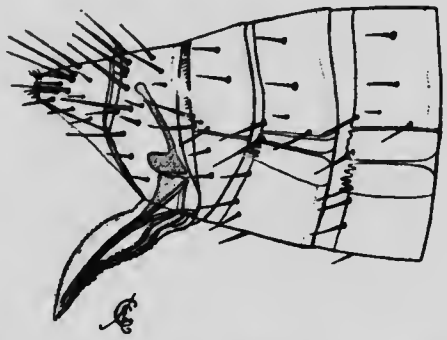

Fig. 19.—The pear thrips, *Taeniothrips incon sequens*. Terminal, abdominal segments of adult to show the ovipositor. X 150. (Original).

The actual time taken by the female in laying an egg varies from two to three minutes. Sometimes the exserted ovipositor is ensheathed too deeply in the plant tissue, and the insect experiences much difficulty in extricating

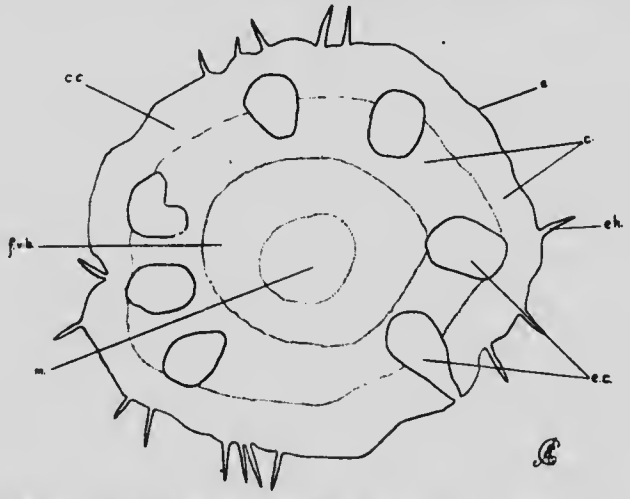

Fig. 20.—Transverse section in outline of fruit-stem of Italian prune to show egg-chambers in the outer layer of cells (*cortex*). Drawn from actual specimen. *e.* epiderm; *c.* cortex; *cc.* chlorophyll layer of cortex; *e. h.* hair; *e. c.* egg-chambers; *f. v. b.* fibro-vascular bundles; *m.* pith. X 115. (Original).

it. On one occasion an individual observed ovipositing in the stipulate leaf of a King apple, was engaged for about thirty minutes in trying to withdraw its ovipositor before success attended its efforts. Numerous cases were recorded of the ovipositor being so securely embedded that the insect was effectively held prisoner and finally succumbed.

The behaviour of the species in the process of oviposition is characteristic. The abdomen is slightly arched, and the ovipositor descends until it lies almost at right angles to the body. The tip of the abdomen is slightly elevated dorsally.

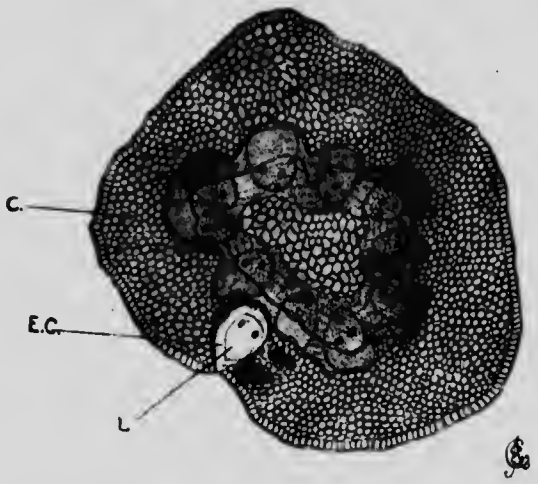

Fig. 21.—Transverse section of cherry stem to show the egg-chamber (*e. c.*) in the outer layer of cells (*cortex*), *c*. Head of larva (*l*) recently emerged in egg-chamber also shown. Drawn from actual specimen. X 65. (Original).

The whole attitude tends to bring pressure to bear on the delicate serrated plates controlled by the muscles of the ninth abdominal segment. Gradually, the toothed valves are inserted up to the hilt at the place selected, when, by

Fig. 22.—The pear thrips, *Taeniothrips inconsequens*. Adult in the act of ovipositing in fruit-stem of apple; ovipositor embedded and represented as evident in the plant tissue. x 126. (Original).

a series of rhythmic contractions of the abdominal muscles, the egg is passed out between the valves and pushed beneath the epiderm. On no occasion, as is sometimes stated, was the insect seen to pierce the epiderm first with its mouth stylets. After the operation is completed, the individual moves actively away and may commence feeding at some other place. The egg

very rarely embedded so deeply as to come into contact with the fibro-vascular bundles of blossom stems, leaf-petioles, and veins, as the case may be (figs. 20, 21). Dessiccation is fatal to the egg, but so long as growth continues it finds a suitable amount of moisture in its chamber among the parenchymatous cells.

Figure 22 shows the insect in the act of ovipositing on an apple fruit-stem. At the point where the ovipositor is embedded the stem is represented as semi-transparent, the better to demonstrate the position of the egg-laying organ.

Parthenogenesis

So far as is known, no specimen of the male of this species has yet been recorded on the American continent. Diligent search for males during the course of our investigations in British Columbia have so far been unrewarded. Similarly, according to the very extensive observations of Moulton[12] and Foster, and Jones[1] in California, nothing but the female was ever taken. Only one solitary male has been recorded, and that in England from plum blossoms, in the district of Evesham, Worcestershire. The specimen was collected by W. L. Collinge, formerly of the Cooper Research Laboratory, Berkhamstead. Bagnall[5] to whom it was submitted, briefly described it as being much smaller than the female, with wings considerably over-reaching the tip of the abdomen. Such a description is evidently rather inadequate.

In the absence of males, the normal method of reproduction is parthenogenetic, but there is no alternation of generations such as prevails among the Aphididæ, the gall-forming Cynipidæ, and some Tenthredinidæ. The significance of the phenomenon is that it secures for the species prolific multiplication. Unlike the parthenogenetic species of Phasmidæ and Aphididæ, the pear thrips produces but a single generation per annum.

CONTROL OF THE PEAR THRIPS.

As a result of two seasons' activities, 1916 and 1917, to determine the effectiveness of suitable control measures against the pear thrips, it may be claimed with every degree of assurance that the insect can be satisfactorily kept in check.

Spraying is the only suitable and satisfactory method of reducing the numbers of adults and larvæ; hence, most consideration will be given to this phase of the subject in the pages that follow.

Spray mixtures consisting of miscible oil No. 2, or whale-oil soap and nicotine sulphate have proved effective as controlling agencies. The provision necessary, however, to ensure satisfactory results rests to a great extent on the timely application of the insecticide. Therefore, in regard to this insect, and probably more so than with many other important orchard pests, it is advisable that the growers should make themselves well acquainted with the form and habits of the thrips so as to decide for themselves the correct time for spraying. It is unsatisfactory to state in other than general terms the approximate dates for applying the spray, inasmuch as no two seasons are absolutely similar in respect to climatic conditions. Further, it would appear that there may be from year to year a decided variation in the degree of infestation affecting the same variety of tree. In view of these facts, it will be readily observed that a great deal depends upon the carefulness and skill of individual growers, and it cannot be too frequently emphasized that the essential features of the life-history of this insect must be clearly understood before control measures can be intelligently undertaken.

During the progress of our work to determine the most effective sprays necessary to effect control, a large amount of data has naturally been obtained. It would only serve to lessen the value of this bulletin and depreciate its usefulness to the orchardist if the details were all included here. Therefore, only the most important points are presented.

SPRAY MIXTURES.

As has already been stated on page 11, a single treatment was made against the larvæ late in the spring of 1915 when the presence of the pear thrips was first revealed. In 1916, a total of 11,569 fruit trees of different kinds, distributed over an area of 138 acres, was sprayed by both power and hand machines. In 1917, a similar campaign of spraying was carried on. In both seasons small blocks of trees were selected to test the efficacy of various strengths of spray-mixtures and the number of spray-applications necessary to ensure the best results. Our work, throughout, was greatly assisted and guided by the results obtained against the pear thrips both in California[13] and New York state[3]. The insecticides chiefly employed during the past two seasons consisted of mixtures containing either whale-oil soap or miscible oil No. 2 in combination with nicotine sulphate and water as a diluent.

Miscible Oil No. 2.

Up to the commencement of this investigation the use of miscible oil in insecticide mixtures was practically unknown among the fruitgrowers of this province. It was understood to have given very excellent results in the control of the pear thrips in California and had received favourable reports in New York state. Information was received from H. F. Wilson, formerly of the Agricultural Experiment Station, Corvallis, Oregon, that oil sprays appeared in some degree to offset the value of later sprays applied for anthracnose, *Neofabraea malicorticis*, a fungous disease affecting apples which is universally regarded as the most serious in the northwest coastal sections of the Pacific. In a letter dated May 19, 1915, he draws attention to this fact: "With regard to oil, I would say that we have received a slight setback here owing to the fact that, following the oil sprays, applications of lime-sulphur or Bordeaux delivered on the trees in the fall for anthracnose will apparently not stick, and for this reason one may have a complication which is liable to interfere with general control measures." Furthermore, we are indebted to S. W. Foster of the General Chemical Company, of San Francisco, Cal., in a letter dated April 30, 1915, for drawing our attention to the possibility of the occurrence of "burning" injury following the application of miscible oil No. 2. To quote his words: "More care is required in the use of oil sprays on apple trees after blooming than on pear trees. The foliage as well as the fruit seems to be more susceptible to injury. Varieties differ somewhat in this regard, but all are really more susceptible than pears and prunes." Dr. E. P. Felt[14] dealing more particularly with the application of miscible oils to sugar maples also issues a warning to orchardists in regard to the later injurious effects of oil.

The points, therefore, on which information appeared desirable were:—

1. The capability of oil in controlling the pear thrips.
2. Its effects on various kinds of fruit trees.
3. Its relation to later applications of lime-sulphur and Bordeaux mixture.

With these in view, therefore, different strengths of miscible oil were tested, their composition varying according to the time of application. For the first, administered at the time when the buds were bursting, 5 gallons of oil were used to every 200 gallons of the mixture.*

*Gallon measure used in this instance and in all other references throughout this bulletin means U.S. gallon.

For the second and third applications the quantity of oil was reduced to 3 and 2 gallons respectively. In some cases, four treatments were made, and the amount of oil used for the fourth was two gallons as in the third.

Several tests were made at different times before the period of blossoming and after, and the results obtained may be briefly stated as follows.

It was found that miscible oil possessed great penetrative power and that buds, even though partially closed, would gradually imbibe the oil beneath their scales with telling effect on the thrips feeding within. This characteristic quality of oil is undoubtedly a great asset for a spraying compound to possess, especially in the section where the work has been carried on, because the months of March and April are usually attended by a slow development of bud growth.

As to the killing-power of miscible oil, there is no doubt whatever that death is almost instantaneous for those thrips which are touched directly by particles of the mixture.

It has been demonstrated that at a strength greater than 2 gallons to 200 of the mixture "burning" may result, especially to apples after the leaves have commenced to appear. Injury of this nature to leaves and fruit was especially noticeable in the Duchess variety. It was observed that the hairs of the leaves assumed a brown appearance and shrivelled up. Their function, which is to regulate transpiration, is thus interfered with. The epiderm, too, and the underlying parenchyma are also affected. In none of the cases, however, under observation, could the burning be termed severe, except in one instance where the tree partially shed its leaves. No specific reason could be advanced in explanation of this occurrence, inasmuch as other trees of the same variety, sprayed on the same day in another section with the same mixture, were not apparently affected at the time of treatment or on the days succeeding. Apart from a temporary retardation in the growth of the more seriously affected trees no permanent injury resulted. In the less severe cases the leaves seemed to revive and resumed their normal healthy appearance.

Efforts were made to determine whether miscible oil caused injury to the trees and their fruit not only in the same year as the application was made but also in the year following. Apart from the set-back to certain trees in the few days immediately following spraying, no sign of injury resulting from oil was apparent either during the season when it was applied or at any time in the succeeding year. This was true in every case, whether the trees received one, two, three or four applications of miscible oil in the strengths before mentioned.

It is customary in the autumn of each year to recommend orchardists on the coast sections of British Columbia to apply Bordeaux mixture to combat the effects of the apple tree anthracnose, *Neofabraea malicorticis*. Applications of Bordeaux mixture were accordingly made to certain trees to test whether or not the earlier one of oil would interfere with its effectiveness. In the following spring an examination of the trees thus treated was made with the result that evidence was obtained that the oil did not in any way interfere with the efficacy of the Bordeaux. In the same way, it may be said with a greater degree of confidence that the oil applications did not nullify the virtue of lime-sulphur sprays in its control of apple scab.

Consequently, it is safe to assert that provided in the first application of oil when the buds are breaking not more than 5 gallons to the 200 are used, and the strengths are reduced to 3 and 2 gallons in the mixtures administered when the blossoms are showing pink and after blossoming respectively, no damage will result.

Furtherm re, its killing-power against thrips is undeniable. Also, no after-effects of an injurious nature to the tree itself nor interferenee with the value of later sprays have been observed.

Whale-oil Soap.

Whale-oil soap has been used for many years in the orchards of British Columbia and on Vancouver island in particular to combat various insect pests. In our experiments we had in view the idea of testing:—

1. Its effect in controlling thrips;
2. Its value as compared to that of miscible oil in combating thrips.

The applications were made in all cases at the rate of 10 pounds of soap to 200 gallons of water. The experiments, however, varied in regard to the number of treatments and to the state of development of the tree.

It was found that whale-oil soap possessed only moderate penetrative powers. In many instances, especially on varieties of fruit trees which have a loose type of bud, the degree of penetration was admirable. In comparison with oil, however, it ranks but second in this respect. More particularly has this reference to the first application in the spring when the buds of many varieties are fairly tightly closed. In later treatments made after the buds have opened and the leaves have begun to develop, the different wetting qualities of the two sprays are not so apparent.

As a killing agent, it was shown that the action of the soap was very rapid in the majority of cases where the insects were directly hit. As compared to oil it was not quite so quick in its effects, but from a practical standpoint it proved eminently satisfactory.

Nicotine Sulphate.

It must be understood that nicotine sulphate, (in the form of Black-Leaf 40.) was always included in the mixtures of oil or soap. In the case of the oil, 1 pint of nicotine sulphate to the 200 gallons was used, and 1½ pints to the same amount of the soap mixture.

Both the oil and the soap individually have an insecticidal action by virtue of their own properties. Along with nicotine sulphate their effectiveness is increased very greatly. In each case they form a film which surrounds the insect and finally causes its suffocation. Further, the adhering and spreading properties of the basic constituents of the mixtures allow the nicotine sulphate to come into close contact with the insect, which finally succumbs to its toxic effects.

Lime-Sulphur.

Inasmuch as lime-sulphur appears at the present time to be essential in the coast sections of British Columbia to combat apple and pear scab in the spring, it seemed desirable to test its efficacy against the pear thrips, and to find whether or not it could be used as an alternative to the oil or soap sprays. Experiments, therefore, were carried out with this aim in view.

In every instance it was shown that it possessed poor wetting and inferior penetrative qualities. It was found to be capable of destroying the adults when it was delivered under considerable pressure and came into direct contact with them. It was frequently observed that adult thrips which had been only partially wetted, survived and quickly escaped from the deleterious effects of the spray. The results against larvæ were more satisfactory, but here again the poor spreading qualities of the mixture detracted from its value. As stated in table X on page 49, it is only recommended for use where the infestation is slight, and where a special spraying with oil or soap would not warrant the expense.

It is perhaps sufficient to remark that lime-sulphur has for many years been applied in certain orchards found to be severely infested by thrips and that the non-reduction of their numbers clearly shows the inability of lime-sulphur to effect a suitable control.

Arsenate of Lead.

Arsenate of lead was incorporated in both the miscible oil and whale-oil mixtures respectively with satisfactory results. It is considered possible that under certain atmospheric conditions the combination of the arsenate with whale-oil soap may cause burning to the foliage of apples. A slight burning

of the foliage, believed to be from this cause, did occur on one occasion in our experiments, but no permanent damage resulted.

Provided the arsenate of lead is mixed in cold water and added directly to the tank, and provided that the strength does not exceed 2 pounds or 2½ pounds to the 40 gallons of the mixture, it is believed to be quite safe to use in combination with either miscible oil or whale-oil soap under the conditions prevailing in the coastal sections of British Columbia.

RESULTS OF SPRAYING.

Method of Recording Results.

A count of the adult thrips present on the trees was made immediately preceding the application of the spraying mixture. The average number in buds and blossoms or on leaves was considered sufficient to indicate, as nearly as one could judge, the degree of infestation. Buds and blossoms were dissected by means of a sharp scalpel and the number of thrips both inside and outside, was carefully recorded. After an interval of 1 to 24 hours had elapsed following the application of the insecticide, a further count was made. A comparison of the figures thus obtained indicated to what extent the spraying mixture had been effective in controlling the pest. It will be readily understood that in dealing with an actively motile organism this plan of recording [illegible]s has its defects, and the experimental error is likely to be considerable. For this reason it is not deemed advisable to present in extended series tabular evidence of the percentage mortality of adults and larvæ. Suffice it to say that the remarks on the preceding pages, under the headings of the different insecticides, have been based upon the interpretation of actual figures obtained in the course of extensive experimentation. The force necessary for the thorough application of the spraying mixture sweeps large numbers of thrips from the trees, and it is thus impossible to obtain comparative figures that are absolutely reliable. In order to determine what happens to those individuals thus swept away, cheesecloth sheets were spread beneath the trees during the progress of the spraying. On examination of the sheets it was shown that the individuals which had fallen from the sprayed trees were undoubtedly killed. This method of rectifying the error of probability, however,—the best that could be devised—was much too crude to provide results that could in any wise be considered exact.

With all due allowance for these difficulties, it can be safely asserted that the percentage mortality among adults caused by oil was 71 for each spraying, and for soap 68·5. With oil, the larvæ suffered a percentage mortality of 85·3 as compared to 84 with soap.

The Value of Two and Four Sprayings Before Blossoming.

Some large Gravenstein apple trees were selected for two treatments with miscible oil—nicotine solution on April 3 and 28 respectively, and an equal number of the same variety was sprayed four times, on March 29, April 3, 12, and 28. After sufficient time had been allowed for the majority of the eggs of the thrips to hatch, these trees were carefully examined in May. The results expressed in terms of 100 calyces and leaves, are rendered as follows:—

TABLE VIII.—GRAVENSTEIN APPLE TREES, SPRAYED TWICE AND FOUR TIMES RESPECTIVELY WITH MISCIBLE OIL No. 2 IN COMBINATION WITH NICOTINE SULPHATE.

Number of Treatments.	Average Number of Thrips per 100 Calyces after Treatment.		Average Number of Thrips per 100 Leaves after Treatment.	
	Adults.	Larvæ.	Adults.	Larvæ.
0	16	341	0	132
2	4	103	0	1
4	10	44	0	1

It will be readily observed that four applications were more effective in controlling the numbers of thrips than two. Nevertheless, the results obtained from two sprayings were quite satisfactory, so much so that in most cases this would be all that would be required.

It is interesting to note the marked difference between the appearance and length of the stamens in the blossoms of the oil-treated trees and those in the controls. In the former, they were fully twice as large as in the latter, white in colour, vigorous, and fairly well spread, thus contrasting readily with the brown, shrivelled stamens of the unsprayed blossoms, which, because of their being deformed by the feeding of the thrips, prevented the rapid penetration of the spraying mixture into the receptacles where large numbers of larvæ were feeding.

The Value of Early and Late Applications.

In order to determine the comparative value of early and late applications, a block of Duchess apple-trees was divided into three sections. The first section received two miscible oil-nicotine sprays, one on April 3 and the other on April 28. Section 2 received a treatment on April 3 and section 3 on April 28. The results were recorded as follows:—

TABLE IX.—RESULTS OF EXAMINATION OF THREE SECTIONS IN A BLOCK OF DUCHESS TREES IN MAY, SPRAYED RESPECTIVELY, (1), ON APRIL 3 AND 28; (2), ON APRIL 3; (3), ON APRIL 28.

Section.	Treatment.	Average Number of Larvæ per 100 Calyces After Spraying.	Average Number of Larvæ per 100 Leaves After Spraying.	Percentage Mortality.
1.....	Sprayed.....	66	2	
	Control.....	347	230	88·1
2.....	Sprayed.....	61	19	
	Control.....	243	70	74·5
3.....	Sprayed.....	132	16	
	Control.....	205	100	51·5

Two sprayings gave the best results, and it is shown that the early application surpassed the later in its effectiveness. From this and other experimental evidence it is concluded that, if circumstances demand the making of but one treatment, it is better that it should be an early than a late one. Fortunately, the adoption of such a course fits in admirably with the later sprayings as suggested in the spraying calendar (p. 49) which has been constructed as a guide to the orchardist for the control of orchard pests and diseases in general. In the above table, contrary to what might be expected, the counts for the block which received two treatments do not differ materially from those of the block which received but a single early application. One would naturally expect to find a lesser number of larvæ in the section twice sprayed. This contradiction can be reasonably accounted for by the fact that there was a constant migration of adults from tree to tree during the season of flight. It is impossible, therefore, to obviate the chances of a re-infestation in the course of field experiments or to confine it to limits which could be considered negligible. The figures as given, however, are both suggestive and significant.

The general results attending the use of the whale-oil-soap-nicotine mixture closely approximate in degree to those of the oil-nicotine mixtures. Consequently, it would be superfluous to make other than this brief mention of them.

Budding Characteristics of Trees.

The gradual growth and development of prunes, apples, and cherries, from the swelling of the buds to the opening of the blossoms, varies considerably in different varieties of fruit trees. The low temperatures which prevail in the early days of the spring, tend to retard the development of the buds. This fact more than any other interferes with the ready control of the thrips. Emergence of adults from the soil takes place from towards the end of March to the middle of April, at a time when the buds of the majority of fruit trees are commencing to burst. The early spring is often accompanied by cold winds and rains. The adults, therefore, which have emerged, are forced to penetrate beneath the imbricated scales of the buds for protection and warmth. Feeding takes place within the bud, and the adults seem disinclined to move very far. When a bright warm day is encountered, the thrips at once assume great activity. However, it has been observed in the respective spring seasons of 1916 and 1917 that a great deal of damage takes place during these cold backward days after the first development of the buds has commenced. The whole crop might be entirely ruined in three or four days of such weather, and this is especially liable to happen with pears. Consequently, it is essential that growers should fully realize this danger and prepare themselves accordingly. They must be careful to note the first appearance of the adults in the spring, and must differentiate between early and late varieties of trees. As has already been remarked, the early bursting buds are most liable to attack in the spring and they should therefore receive the first attention. As a guide to orchardists of Vancouver island, the facts regarding the developmental phases of different varieties of fruit trees have been tabulated as follows:—

TABLE IX.—BUD AND BLOSSOM DEVELOPMENT OF FRUIT TREES IN THE SAANICH PENINSULA, VANCOUVER ISLAND, B.C., IN 1916.

Crop and Variety.	Date.		
	Buds Bursting.	Buds well Open.	Trees in full Bloom.
Pears—			
Kieffer	Mar. 26	April 1	May 3
Bartlett	" 27	" 1	" 4
Flemish Beauty	" 27	" 2	" 4
Bosc	" 27	" 3	" 4
Louise Bonne	" 29	" 1	" 4
Boussock	" 29	" 1	" 4
Jules Guyot	" 29	" 1	" 6
Rivers' Princess	" 29	" 2	" 6
Apples—			
Red Astrachan	Mar. 27	April 5	May 14
Duchess	" 28	" 2	" 4
Gravenstein	" 28	" 6	" 10
King	" 28	" 3	" 16
Red Cheek pippin	" 29	" 5	" 15
Belle de Boskoop	" 29	" 5	" 18
Delicious	April 1	" 9	" 20
Crimea Golden	" 1	" 9	" 18
Wealthy	" 3	" 8	" 19
Ben Davis	" 5	" 8	" 18
Rome Beauty	" 5	" 10	" 20
Northern Spy	" 5	" 10	" 22
Plums and Prunes—			
Italian Prunes	April 10	April 14	April 24
Columbia	" 12	" 16	May 1
Ponds' Seedling	" 13	" 18	" 9
Damson	" 13	" 18	" 1
Cherries—			
Olivet	April 5	April 10	May 4
Bing	" 5	" 10	" 1
Royal Anne	" 5	" 10	" 2

WHEN AND HOW TO APPLY THE SPRAY.

Climatic Factors.

The time at which spraying operations should commence depends on several factors, chief among which are climatic conditions, state of cultivation of the orchard, and bud development.

The adults show the greatest activity on bright, warm, sunny days. In cool, dull, cloudy weather they either seek shelter in the soil from whence they came, or they burrow beneath the protecting scales of the bud. The orchardist should choose, if possible, a warm bright spell of weather after the buds have shown signs of developing in order to make the first application, at a time when the adults are in evidence on the buds. Should the weather remain dull and cloudy for a considerable period, but with a temperature of 50 degrees Fahr. or above, he should satisfy himself by a close examination of the buds as to the activities of the adults. Where it can be shown that the insects have already entered the buds and are lacerating the tissues, immediate spraying operations should commence. It would be courting disaster to postpone taking action in anticipation of bright weather, as the injury to the buds would in all likelihood be irreparable by that time.

Cultivation.

The practice of early spring ploughing, by reason of the fact that the soil is disturbed and therefore warms up readily, determines an earlier emergence of the thrips in ploughed orchards than in those orchards which are left unploughed. The theory that ploughing destroys large numbers of the insect is not at all sound, because the soil cannot be reduced to the fineness of condition requisite to destroy the cells in which they have passed the winter. Further, the adults are merely waiting for the proper degree of warmth in order to escape, and the readier penetration of the atmospheric air into ploughed soil supplies this requirement. It may be that the more rapid emergence of the insects from disturbed soil is of indirect advantage to the orchardist in that the infestation reaches a climax much more rapidly and can therefore be controlled more quickly where the necessary precautions are taken. Here, again, the watchword is careful examination combined with rapidity of action.

Schedule of Applications.

For the sake of convenience the suggested schedule of applications has been drawn up as follows for the spraying of orchards of the Saanich peninsula of Vancouver island:—

TABLE X.—SPRAYING CALENDAR FOR THE GUIDANCE OF ORCHARDISTS COMBATING THE PEAR THRIPS ON VANCOUVER ISLAND.

Number and Times to Spray.	Mixture for Severe Infestation.	Mixture for Light Infestation.
1st Spray; adult thrips in numbers on or in the blossom buds, buds bursting, about April 3–6.	Miscible oil No. 2, 5 gals. nicotine-sulphate, 1 pt. Water, 200 gals.	Whale-oil soap, 10 lbs. nicotine-sulphate, 1½ pts. Water, 200 gals. or Miscible oil, 5 gals. nicotine-sulphate, 1 pt. Water, 200 gals.
2nd Spray; adult thrips in numbers on the trees about a week before blossoms appear, about April 26-May 1.	Whale-oil soap, 10 lbs. nicotine-sulphate, 1½ pts. Arsenate of lead, 8 lbs. Water, 200 gals. or Miscible oil No. 2, 2 gals. nicotine-sulphate, 1 pt. Arsenate of lead, 8 lbs. Water, 200 gals.	Lime-sulphur, 5 gals.-6 gals.* nicotine-sulphate, 1½ pts. Arsenate of lead, 8 lbs. Water, 200 gals.
3rd Spray; larvæ in the calyx cups and on the leaves, petals falling.	Whale-oil soap, 10 lbs. nicotine-sulphate, 1½ pts. Arsenate of lead, 8 lbs. Water, 200 gals.	Lime-sulphur, 5 gals. nicotine-sulphate, 1½ pts. Arsenate of lead, 8 lbs. Water, 200 gals.

*The alternative use of 5 or 6 gallons in this instance is determined by the season as well as by the variety of the apple. The measures indicated in the table are United States, which are related to Imperial in the proportion of 5 to 4.

It must be realized that the suggested dates for the first and second sprayings are merely approximate. They are considered suitable for such seasons as the springs of 1916 and 1917 proved to be, and it will probably be found necessary to vary the times of treatment in after years to suit conditions. The schedule here presented has been drafted to indicate the procedure under two sets of conditions, viz., a heavy and a light infestation of thrips. In cases of a light infestation in an orchard where no material damage has been caused, and in order to circumvent the possibility of the numbers increasing in later years, a single spray of whale-oil soap mixture or miscible oil mixture is considered all that is required for control purposes. The later sprays of lime-sulphur and arsenate of lead are intended to combat apple scab mainly, and other orchard pests. In a heavy infestation it is essential that the orchardist be prepared to expend a great deal of energy in undertaking combative measures. The lime-sulphur sprays for scab must be included as fourth and fifth sprays.

It is considered possible that, if an orchardist endeavours under such conditions of infestation as have been experienced in the Saanich peninsula to combat the thrips thoroughly, he will, possibly in one year, perhaps in two, be able to adopt the spraying schedule recommended for a light infestation.

Preparation of Spraying Mixtures.

In order to dissolve the whale-oil soap warm water is desirable. Consequently, it is advisable to construct a rough, open fire-place at some convenient point in the orchard where water is readily available. When the soap has gone entirely into solution, it is emptied into the tank of the spraying machine which has been filled with the required amount of water. The requisite amount of nicotine sulphate and arsenate of lead is then measured out and added to the solution. It is better to mix the arsenate of lead with water in a separate vessel before adding it to the tank. The agitator is then set in motion, enabling the ingredients to be thoroughly mixed.

With all brands of oil sprays, it is essential that the directions for mixing supplied by the manufacturers be at all times strictly followed, otherwise poor results

may attend the industry of the orchardist. With miscible oil No. 2, the amount requisite for spraying is first placed in a suitable receptacle, and water to the extent of two or three times the volume of the oil is then slowly added. Continual stirring is necessary until proper emulsification is secured, which is indicated by the liquid assuming a creamy-brown colour. The oil thus emulsified is then added to the tank of the spraying machine which has been filled with water. The agitator is then brought into play, and the whole contents of the tank thoroughly mixed. Nicotine sulphate may then be added, followed by arsenate of lead, the latter as in the case of the soap mixture being diluted with water. It is well to remember that the paste form of the commercial arsenate of lead carries with it a certain percentage of water. Consequently, if by any chance the lead arsenate becomes dry, due allowance for this fact must be made in calculating the amount required.

Throughout the campaign of control carried on during the seasons of 1916 and 1917, careful records were kept on the cost of spraying.* It was shown that the cost of the ingredients necessary for making three applications of the soap-nicotine-arsenate mixture by power machines, varied in different orchards from 13 cents to as much as 40 cents per tree. This variation was shown to be due to differences in the size of the trees, to the varying number of trees planted per acre, to differences in the cost of labour, to the accessibility or inaccessibility of water, and to the degree of thoroughness in applying the spray. It was further shown that the cost for labour alone amounted to one to two cents for each minute, whether the power machines were in use or were not actually spraying. Thus, it is important that orchardists should not delay longer than necessary in refilling the tanks or in accomplishing the various operations incidental to spraying.

Types of Machines and Nozzles.

Without enlarging on the recommendations in regard to the kinds of spraying machine considered suitable for use in the control of thrips in an orchard, it may be briefly stated that by far the most satisfactory results attended the employment of high-power, motor-driven outfits capable of generating from 175 to 200 pounds pressure. If hand-power machines developing a lesser pressure than this are used, the most effective results cannot be reasonably expected; and more than one application may be necessary to obtain results comparable to those received where only a single treatment is made under higher pressure, inasmuch as the power machine accomplishes more work in a shorter time and does it more efficiently.

The type of nozzle which has given the best results is one that throws a coarse, driving spray. For later applications, it has been found that nozzles which throw a more spreading form of spray answer the purpose admirably, especially in the case of those made against the larvæ after blossoming is over.

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* *See* "The Agricultural Gazette of Canada," Vol. 4, No. 1, Jan., 191" pp. 13-16.

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