The Pear Psylla in Oregon

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P. H. Westigard and R. W. Zwick

ABSTRACT

Since its discovery in Oregon in 1946, the pear psylla, *Psylla pyricola* Förster, has become the most serious insect pest of pear. Damage to pear trees include the transmission of pear decline disease which has caused losses of trees, injection of a phytotoxic toxin resulting in tree shock and injury, and secretion of honeydew causing fruit marking. Aspects of pear psylla biology are discussed in relation to the pest's control. Natural enemies are known to exert some suppression of pear psylla populations late in the growing season but the application of insecticides, many of which the pest has become resistant to, is the only means presently available for reducing pear psylla populations to subeconomic levels.

Key words: Pear decline, tree shock, honeydew, biology, control, natural enemies, insecticides, resistance, subeconomic.

INTRODUCTION

Pears are the most valuable tree fruit crop of Oregon. In 1967 the crop was valued at about 43 million dollars, about one-half of which was returned to the grower. The vast majority of production is located in two widely separated areas of the state—the north central section around Hood River and the southwest area in the Rogue River drainage near Medford. About 10 percent of the acreage is located in the Willamette Valley. Of the 22,000 acres planted to pear, the Bartlett variety accounts for approximately 50 percent while the remainder is planted to winter varieties including D'Anjou, Bosc, and Comice. All of the winter varieties and about half of the Bartletts are sold in fresh markets, and therefore the growers are especially sensitive to fruit quality.

The appearance of the pear psylla in the state in 1946 presented a potentially serious threat to pear quality as well as to production itself. Since that time the potential destructiveness has been more than realized, and at the present time the pear psylla must be rated as the number one insect pest of pear.

The purpose of this report is to summarize results of research conducted over a 25-year period which are pertinent to the creation of a rational control program. For the most part, the section on chemical control is taken from data obtained at the Mid-Columbia Experiment Station (Hood River) or the Southern Oregon Experiment Station (Medford). Pertinent information on biology was gathered from numerous sources including Oregon, California, Washington, New York, British Columbia, Nova Scotia, and a few European reports.

SPREAD OF THE PEAR PSYLLA

The pear psylla, *Psylla pyricola* Förster, was first reported in the United States from the state of Connecticut in 1832 (*51*).[1] It is thought that the pest originated in southern Europe or Asia Minor (*11*), and recent data (*12*) involving studies on the relationship between the pear psylla and *Pyrus* species from several countries tend to support this theory. Though the psylla spread rapidly through the pear-growing areas of the eastern United States and Canada (*74*), it was not found west of the Rocky Moun-

[1] Numbers in italics refer to Literature Cited, page 20.

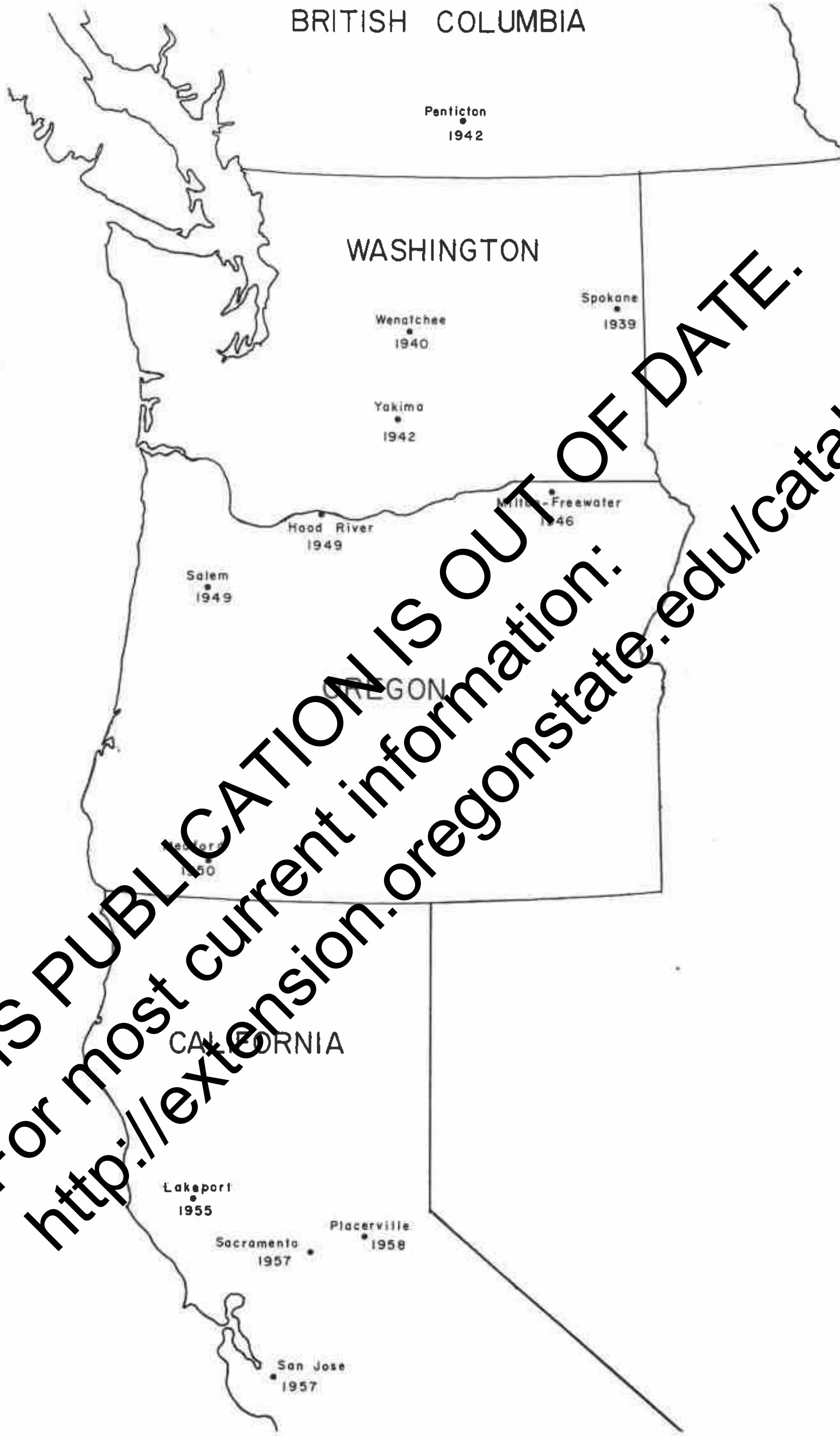

Figure 1. Spread of the pear psylla on the Pacific Coast.

tains until over 100 years later. In the summer of 1939 specimens of *P. pyricola* were detected in Washington near Spokane (*58, 62*), and by 1942 they had spread northward into British Columbia (*73*) and southward to Yakima, Washington (*7*).

In Oregon pear psylla were first discovered in 1946 near Milton-Freewater. No additional infestations were found until September 1949, when the psylla was present in orchards from Milton-Freewater to Hood River. By 1950 all areas of Hood River were infested and the psylla had spread south into the Willamette Valley. In the fall of 1950 two adult psylla were trapped on sticky boards north of Medford, and a year later the pest was found in most Rogue Valley orchards and south to the California border.

The pear psylla spread southward into California, being reported from the most northern counties in 1953 and then from the important pear-growing counties of Lake in 1955, Sacramento in 1957, Santa Clara in 1957, and El Dorado in 1958 (*46*). The spread of the pear psylla is illustrated in Figure 1.

PSYLLA INJURY TO PEAR

Several forms of pear damage are attributable to pear psylla. These include pear decline, injection of toxin, and secretion of honeydew.

PEAR DECLINE

Pear decline disease struck the Pacific Northwest in the late 1940's with affected trees rapidly collapsing (quick decline), as shown in Figure 2, or gradually losing vigor and productivity (slow decline). In 1960 the disease was shown to cause sieve-tube necrosis below the graft union (*1*), resulting in blockage of the conductive tissue. Decline was noted as being more severe on cultivars grafted onto oriental rootstocks such as *Pyrus ussuriensis* and *P. pyrifolia* than on cultivars grafted onto European stocks of *P. communis* (*1, 66, 76*). The pear psylla was first associated with decline in 1962, when a toxin secreted by the psylla was identified as the responsible agent (*31*). Further studies in California have confirmed the role of pear psylla but have shown that the disease was graft-transmissible and therefore most probably a virus in nature (*3, 20, 28, 29, 53, 54*). Most recently, another report has incriminated mycoplasma-like bodies as the responsible agent of decline (*26*).

Losses of trees and production due to pear decline are rather difficult to estimate, but some figures are available. For instance, between 1956 and 1959 the Bartlett pear crop in Washington dropped nearly 30 percent, and this was in large measure attributed to decline (*1*). In California it was estimated that over one million trees had been affected by 1962 (*46*), with production in some areas dropping as much as 50 to 60 percent (*2*).

The major pear-growing areas in Oregon suffered quite differently from

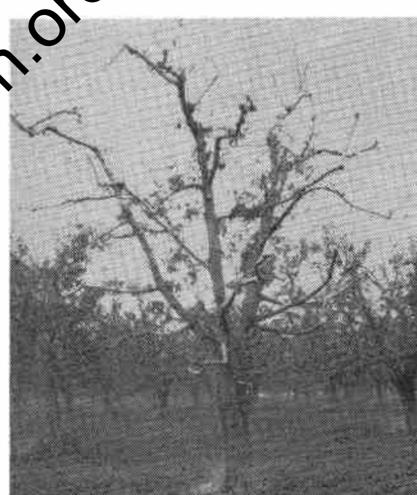

Figure 2. Quick decline symptoms on pear tree in Medford, Oregon (photo courtesy C. B. Cordy)

decline. One of the hardest hit areas was southern Oregon, where pear decline appeared in 1957-1958 (*67*). It has been conservatively estimated that 10 percent of the trees were completely lost, with 10 percent of the remaining trees left as "cripples" (*17*). The most severe losses occurred on the oriental rootstocks (*P. ussuriensis, P. pyrifolia*), with 50 to 60 percent mortality, while 10 to 12 percent of the pears on French roots were lost (*14, 17, 65*). Five to ten percent of the acreage was on these susceptible rootstocks (*65*).

Decline appeared in the Willamette Valley in 1957, with actual loss of about 25,000 trees, or about 15 percent of the total (*14, 50, 65*). Very little decline loss was reported in the Hood River area. This was probably due to the preponderance of decline-tolerant or resistant rootstocks in use (*65*). Pear decline was positively identified in Hood River in 1961 and probably occurred earlier (*50*). Estimates indicate that about 15 percent of trees on *P. communis* root were affected with slow decline (*65*).

Pear decline has now passed through the Pacific Coast, taking with it the most susceptible trees and leaving many weakened "slow decliners," but causing no damage to the majority of trees. From a practical standpoint, the development of resistant rootstocks for use in replanting essentially solved the decline threat (*66*).

PSYLLA TOXIN

Irrespective of its disputed role in producing pear decline, a toxin is secreted by the pear psylla. In the eastern United States, where pear decline has not been reported, psylla feeding has resulted in undersized fruit, wilting of foliage, severe defoliation, reduction in tree productivity, and death to limbs or to entire trees following several years of high infestation levels (*7, 24, 51, 74*). In other work, suppression of pear root growth and general reduction in tree vigor have followed psylla feeding (*13, 34, 75*). The effects of psylla toxin are generally apparent following high psylla levels and have been referred to as psylla shock (*32*). The plant reactions described above are not generally expected from plants fed on by pests which merely remove photosynthate, and are, therefore attributable to a toxicogenic substance.

PSYLLA HONEYDEW

In the process of feeding, psylla nymphs secrete pools of a sticky substance called honeydew (Figure 3). Under conditions of relatively high infestations, especially close to harvest, this sticky material may drip from the leaves onto the fruit and cause a scalding of the surface (Figure 4). In addition, a sooty mold fungus may grow in the honeydew (*11, 58*), leading to further downgrading. Copious amounts of honeydew on foliage at harvest time have resulted in picker complaints and increased harvesting costs.

Figure 3. Pear leaf showing psylla nymphs with typical amounts of honeydew.

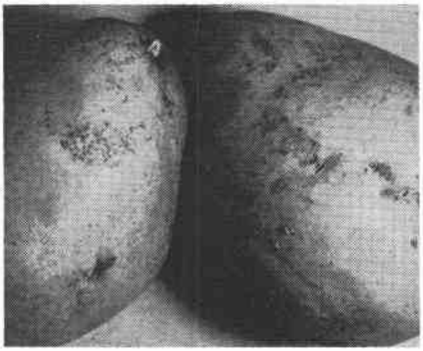

Figure 4. Psylla honeydew marking on D'Anjou fruit.

PSYLLA DENSITIES AND ECONOMIC LOSSES

One of the principles of good pest management states that control measures by use of pesticides should be delayed until the pest densities approach levels that will result in economic losses greater than the cost of treatment (*59*). This density level has been called the economic threshold. It is quite apparent from the description of the various types of psylla injury that there are several economic thresholds for this pest. For example, a grower with pears planted on decline-susceptible rootstocks would expect an economic threshold much lower than if the trees were on resistant roots. Unfortunately, there have been no critical studies to establish injury thresholds for the pear psylla. This will eventually have to be completed if rational control of this pest is to be achieved. Preliminary data in Table 1 show a relationship between psylla densities and damage due to the secretion of honeydew.

Table 1. Discoloration of D'Anjou pears from honeydew at harvest due to various levels of psylla infestation (Hood River, Oregon)

Block	Average no. nymphs per 12 spurs per month					Percentage fruit discolored at harvest
	May	June	July	Aug.	Sept.	
						%
			1970			
1	0	1.5	1.0	10.3	4.0	2.2
2	1.0	0	1.0	1.4	1.0	2.8
3	24.0	[illegible]	[illegible]	35.0	23.0	8.6
			1971			
4	0	3.0	1.2	16.3	4.0	2.3
5	0	0.5	3.4	7.3	4.3	7.5
6	1.0	0	9.5	33.6	69.6	10.4
7	59.0	24.9	77.0	25.3	18.0	29.6

BIOLOGY

LIFE HISTORY

The general life history of the pear psylla in Oregon is similar to that described from other areas (*4, 5, 11, 12, 16, 18, 19, 34, 35, 40, 45, 51, 52, 56, 60, 66, 69, 73, 74*). The insect overwinters in the adult stage, somewhat larger and darker than the summer adult (Figure 5). Both males and females overwinter, and mating apparently does not occur until prior to oviposition in late January or early February. The first eggs laid by the overwintering females are deposited at the base of the unopened fruit or leaf buds (Figure 6) but oviposition continues

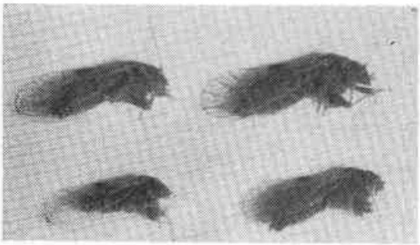

Figure 5. Comparison of overwintering and summer psylla adults. Overwintering (upper), summer (lower).

Figure 6. Eggs of overwintering psylla females laid at base of unopened leaf bud.

until after the fruit buds open. At this time the eggs will be laid on leaf tissue (Figure 7). The interval between oviposition and the appearance of the first instar nymphs (Figure 8) is dependent upon temperature but averages about five weeks in southern Oregon (Table 2) and six weeks in the Mid-Columbia area (Table 3).

The pear psylla passes through five nymphal instars prior to reaching the adult stage. The female psylla attaches the pale yellow egg to the bark by cementing the elongated peduncle so firmly into a crevice that it ruptures if attempts are made to dislodge it. As embryonic development proceeds, the color changes to a deeper yellow-orange, and prior to eclosion two red eye spots of the nymph are visible

Figure 7. Psylla eggs laid along mid-vein of pear leaf.

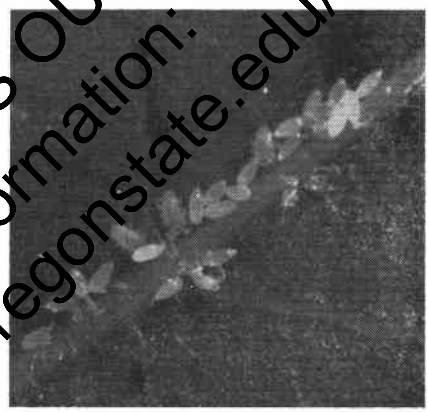

Figure 8. Eggs and first instar pear psylla nymphs.

through the chorion. The first-stage nymphs move to green leaf tissue and insert their stylet mouthparts to feed on the sap of the pear tree. The young nymphs are soon immersed in a pool of honeydew consisting of the sap not utilized in their nutrition. After the first molt, wing pads are external and become more prominent in each succeeding molt, with the body color becoming progressively darker brown or blue-green.

The fifth and last nymphal stage or "hardshell" is dark brown, has prominent wing pads, and is not attached to

Table 2. **Approximate developmental time for first generation pear psylla (Medford, Oregon)**

Year	Date of first egg	Date of first nymph	Eclosion time	Date of first summer adults	Total days (egg to adult)
			days		
1961	Jan. 28	March 15	47	May 3	96
1959	Feb. 12	March 30	46	April 28	75
1957	Feb. 18	March 20	31	April 30	72
1955	March 3	April 4	32	May 9	67
1952	Feb. 14	March 25	40	May 5	81
		Average	39		78

Table 3. Observations on first generation pear psylla egg deposition and hatching (Hood River, Oregon)

Year	Date of first egg	+43° F degree days until first egg found	Date of first nymph	Eclosion time
				days
1971	Feb 11	206	April 5	53
1970	Feb. 17	101	March 24	35
1969	March 12	133	......	......
1968	Feb. 16	148	March 19	32
1967	Feb. 9	211	April 3	53
1966	Feb. 24	124	April 6	41
1964	Feb. 20	204	......	......
	Average	161		42.8

the leaves by its stylets in a pool of honeydew. This stage moves actively about, found most often at the base of leaf petioles or in crevices of the bark of fruit spurs. The length of time required for completion of the first generation nymphal development ranges from 30 to 50 days, with the first summer adults appearing in late April or early May (Figure 9).

NUMBER OF GENERATIONS

In addition to the spring generation described above, there are three summer generations in Oregon, ending with the formation of the overwintering adults in October or November. The approximate duration of the summer generations is given in Figure 9. Thus, there is a total of four psylla generations per year under Oregon conditions. Ontario, Canada, reports as few as two generations (*74*) and California as many as five (*34*). Four generations per year have been reported in Washington (*45*) and parts of British Columbia (*73*) (Table 4).

The appearance of the overwintering adult in the fall is brought about by exposure of fourth-generation nymphs to shortened day lengths (*11, 49, 77*). These adults exhibit a sexual reproductive diapause which continues until exposure to cold temperatures is followed by warmer temperatures (*11, 49, 77*). The overwintering adults also exhibit a tendency to disperse (*11, 25*), a phenomenon not noted in the summer adults. The active dispersal phase accounts for the rapid spread of the species throughout the Pacific Coast states.

HOST RANGE

Although the adult psylla and occasionally the egg stage can be found on other hosts, the insect can complete its development only on pear. Though *Cydonia* is often listed as a host for

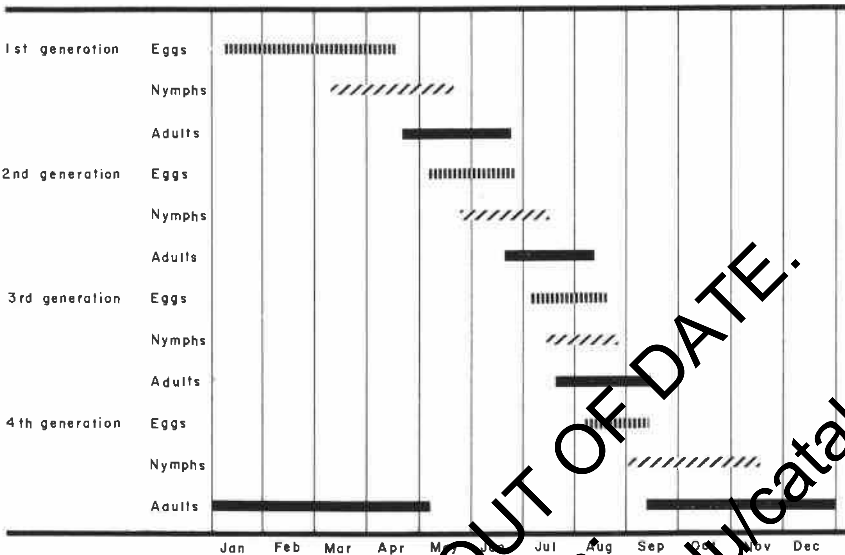

Figure 9. Approximate time of occurrence of the four pear psylla generations in Oregon.

pear psylla (*34, 58*), it has been shown that development on this host is arrested in the early nymphal stages (*30*). Even within the genus *Pyrus*, to which pear belongs, there are species which will not support the completion of psylla development. Generally, pear species of European origin, such as *P. communis*, are more favorable than those from Asia, such as *P. fauriei*, *P. pyrifolia*, or *P. calleryana* (*34, 76*) (Table 5).

Though pear is required for completion of the life cycle, adult psylla, especially of the overwintering generation, can be found on many hosts (*30, 70, 71, 72*). One of these transitory hosts may have served as the original host for the pear decline virus or mycoplasma (*30, 46*).

Table 4. Number of generations of the pear psylla reported from various areas of the United States and Canada

Area	No. generations	Reference
Canada		
Ontario	2–3	74
British Columbia	4–5	73
United States		
Washington	4	45
Oregon (Medford)	4	63
California	5	34

CONTROL

NATURAL CONTROL

In addition to the intrinsic factors, such as reproductive potential, which set limits to psylla numbers, several natural environmental factors favor or discourage increases in densities of this pest.

Table 5. Infestation level of pear psylla on *Pyrus* species (Medford, Oregon)

Test 1. Infestation on caged *Pyrus*

Geographic area	Average no. psylla per 100 sq. in. — Eggs	Average no. psylla per 100 sq. in. — Nymphs reaching maturity
Asia	17	4
Asia Minor	63	30
North Africa	128	81
Europe	99	61

Test 2. Natural infestation on *Pyrus* species collection

Geographic area	Average no. psylla per 25 leaves — Eggs	Average no. psylla per 25 leaves — Nymphs
Asia	27	8.8
Asia Minor	86	48.0
North Africa	44	9.0
Europe	95	49.0

Test 3. Infestation on individually caged *Pyrus*

Geographic area	No. psylla x 10 per sq. in. — Eggs	No. psylla x 10 per sq. in. — Nymphs
Asia	17	4
Asia Minor	23	10
Europe	19	8

Host Plant Condition

Young succulent foliage is preferred by female psylla for oviposition sites (*5, 11, 19, 35*). During the early spring there is generally an abundance of these favorable sites, but the amount of tender forage decreases as stems and leaves begin to harden off and oviposition may be restricted. Nymphs on older leaves or on leaves injured by previous infestations may be unsuited for development (*11*). Fecundity of adults reared from mature foliage may be lower than that of adults from succulent tissue (*42*). Cultural practices such as irrigation and fertilization which influence tree growth pattern will influence psylla densities.

Climatic Factors

Temperature. Though moderate increases in temperatures shorten the developmental time for psylla and favor the increase in the number of generations, excessive summer temperatures cause severe mortality (*5, 11, 35, 41, 68, 73*). Temperatures in excess of 90° F cause reduction in oviposition, and temperatures over 100° F cause mortality to nymphs (*35, 68*). Under conditions of high temperature and low humidity, the honeydew may crystallize and entrap the young nymphs (*11, 35, 41, 73*). Though this phenomenon has been observed under Oregon conditions, it does not appear to play an important role in natural control in this state.

Precipitation. In areas of the country that normally receive heavy amounts of summer rainfall, large numbers of psylla nymphs may be washed from the pear leaves (*25, 73*). However, the Pacific Coast states usually receive little summer rain, and the number of psylla deaths attributable to this factor are small. The installation of overtree sprinklers to provide spring frost protection and summer irrigation recently has become popular in western states, and this may result in increased psylla mortality.

NATURAL ENEMIES

Table 6 summarizes the reports which list the number and kinds of predators and parasites feeding on the pear psylla.

In Oregon's Hood River area the

Table 6. Predators and parasites of the pear psylla reported from North America and Europe

Order	Species	Area	Reference
Hemiptera	*Anthocoris antevolens* White	California	35, 63, 47
		Oregon	63
		Washington	11
	Anthocoris melanocerus Reuter	British Columbia	33, 73
	Anthocoris musculus (Say)	Nova Scotia	52
	Anthocoris nemoralis F.	Europe	6, 44
		British Columbia	44
	Anthocoris nemorum L.	England	18
	Campylomma verbasci (Meyer)	British Columbia	44
	Deraeocoris brevis (Uhler)	British Columbia	44
		Oregon	63
		Washington	11
	Deraeocoris fasciolus Knight	British Columbia	44
	Diaphnocoris provancheri (Burque)	British Columbia	44
	Orius sp.	California	35
Neuroptera	*Chrysopa carnea* Steph.	Oregon	63
		Washington	11
	Chrysopa pacificus Banks	British Columbia	44
	Chrysopa plorabunda Fitch	California	49, 39
	Chrysopa oculata Say	British Columbia	61
		New York	56
	Atractotomus mali (Meyer)	Nova Scotia	52
	Hemerobius angustus (Banks)	California	39
Coleoptera	*Adalia bipunctata* (L.)	New York	56
		Nova Scotia	52
	Adalia frigida Schn.	British Columbia	44
	Anisocalvia quatuordecimguttata (L.)	Nova Scotia	52
	Calvia duodecemmaculata Gebl.	British Columbia	44
	Coccinella transversoguttata Fald.	British Columbia	44
		Oregon	63
		Nova Scotia	52
	Hippodamia quinquessignata Kirby	British Columbia	44
		New York	56
Diptera	*Platypalpus* sp.	British Columbia	44
Hymenoptera	*Asaphes* sp.	British Columbia	44
	Eudopsylla agilis de Meijere	Scotland	27
	Lygocerus sp.	England	18
	Prionomitus mitratus (Dalm.)	British Columbia	44
		Europe	27
		Washington	11
	Psyllaephagus sp.	England	18
	Trechnites insidiosus Crawford	Ontario, Canada	74
		British Columbia	43
		Oregon	63
		California	39
		Washington	11
	Trechnites psyllae Ruschka	England	18

role of natural enemies has not been observed to account for substantial reduction in psylla damage. Heavy introductions of the hymenopterous nymphal parasite, *Trechnites insidiosus* (Crawford), may result in parasitization of over 70 percent of the psylla nymphs on unsprayed trees by mid-August. However, even at this high rate of parasitization, serious foliage damage was evident and over 95 percent of the D'Anjou fruit bore visible discoloration from honeydew secretion. As a result of the frequent insecticide applications necessary to control psylla early in the season in the Hood River area, the rate of parasitization by *Trechnites* and the occurrence of natural psylla predators in commercial orchards have been of minor significance and cannot be depended upon to reduce psylla infestations below economic injury levels.

In southern Oregon the role of predators appears to play an important part in the natural control of *P. pyricola*. Figure 10 presents the population trends of the pear psylla from an orchard left unsprayed for several years but otherwise well cared for (including pruning, irrigation, and fertilization). Population levels of the later generations were lower than those of the spring and early summer. The population trends for some of the predators found in this orchard are given in Figure 11. There appears to be a good correlation between the peaks in predator densities and those of the psylla egg and nymphal stages. One of the most effective predators in southern Oregon is the mirid bug, *Deraeocoris brevis* (Uhler), which can consume nearly 600 psylla eggs

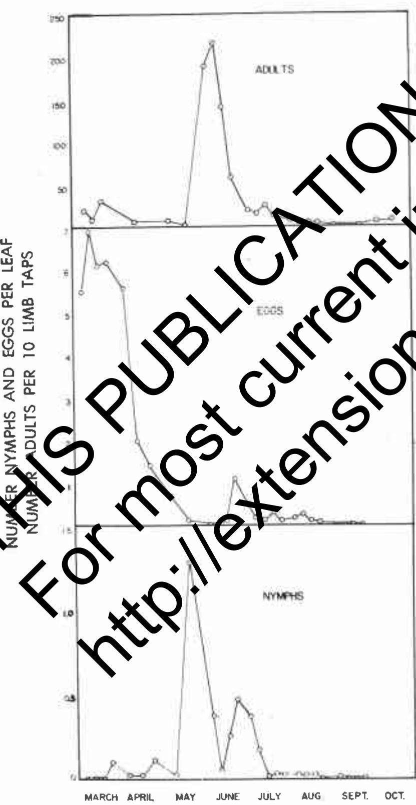

Figure 10. Population trends of pear psylla in an unsprayed Bartlett pear orchard (Medford, Oregon).

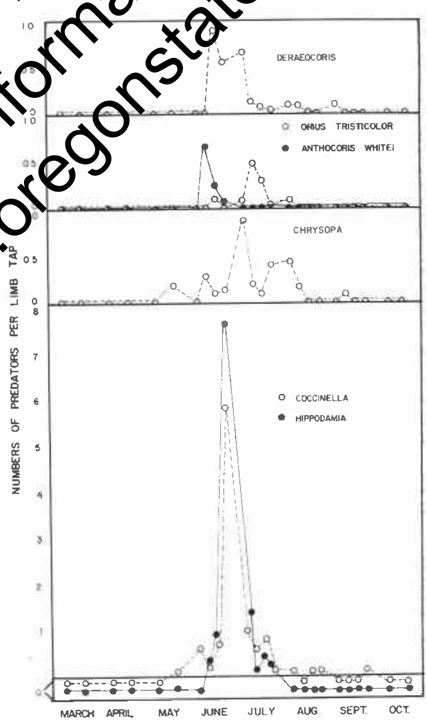

Figure 11. Population trends for psylla predators in an unsprayed Bartlett pear orchard (Medford, Oregon).

and nymphs during its development. The predators belonging to the family Anthocoridae, which have been reported as effective predators in British Columbia and California (*33, 39*), occur only in low numbers in southern Oregon.

CHEMICAL CONTROL

Chemical control still remains the only means of escaping the damage caused by the pear psylla. The chemicals used in control change rather rapidly, primarily due to resistance, and the cost of obtaining economic suppression has risen steadily over the past 10 years. At the present time it is not unusual for growers to apply six to seven sprays aimed primarily at pear psylla. The following section reports on the use pattern of pesticides in Oregon and discusses the various timings which have been found useful in obtaining control.

Dormant Application

The dormant spray is directed against the adult psylla prior to egg laying but after psylla activity begins in mid-to-late winter. Early workers recommended the use of mineral oil sprays at this timing because the sprays were effective on adults and also inhibited egg laying (*21*). More recently (*8*) growers in the Pacific Northwest have resorted to an area-wide program utilizing synthetic pesticide applications aimed exclusively at destruction of the overwintering adults. The need for this special spray was brought about by resistance to many insecticides used during the summer months and the inability of the insecticides to kill all or even most psylla stages. The material that has been most used in the dormant spray is Perthane®, which is active on the adult forms but not on eggs. Resistance by the adult to Perthane now has been reported from Washington and northern Oregon.

The effectiveness of the dormant spray depends not only upon the availability of effective materials but also on critical timing of the application. The correct timing has its origins in the behavior of the overwintering adults and depends on several environmental factors as well. First, following the general dispersal of the fall brood, many psylla will winter outside the pear orchard. The list of transient hosts includes a wide range of plants from which the adults probably require only water in order to survive. Overwintering adults have been found on such diverse plants as alfalfa, apple, and peach.

The percentage of the adult psylla that return to the pear from other hosts is not presently known, but because successful development depends upon the presence of pear, it is probable that many adults find their way back to the pear orchard. Thus, the timing of the dormant spray must be delayed until the return of adult psylla from sources outside the orchard. Until work is done on this aspect, it has to be assumed that most psylla have returned to the pear orchard by the time oviposition begins. The probability of this being correct is strengthened by the past success of the Perthane spray, a material of short residual activity.

A second variable encountered in timing the dormant spray is the availability of the adult psylla within the pear orchard. During much of the winter the adults are found in bark crevices or in other places inaccessible to sprays. They will emerge from these areas when temperatures increase to about 45° F (*11*). Application of sprays should be made when temperatures are expected to reach or exceed this range.

A third variable is the change in susceptibility of the adult to pesticides. In laboratory studies susceptibility to Perthane by the adult decreased in the fall, then increased in midwinter. A second drop in susceptibility was noted in late January (Figure 12).

Two techniques have been used with some success in guiding growers in correct timing of the dormant spray.

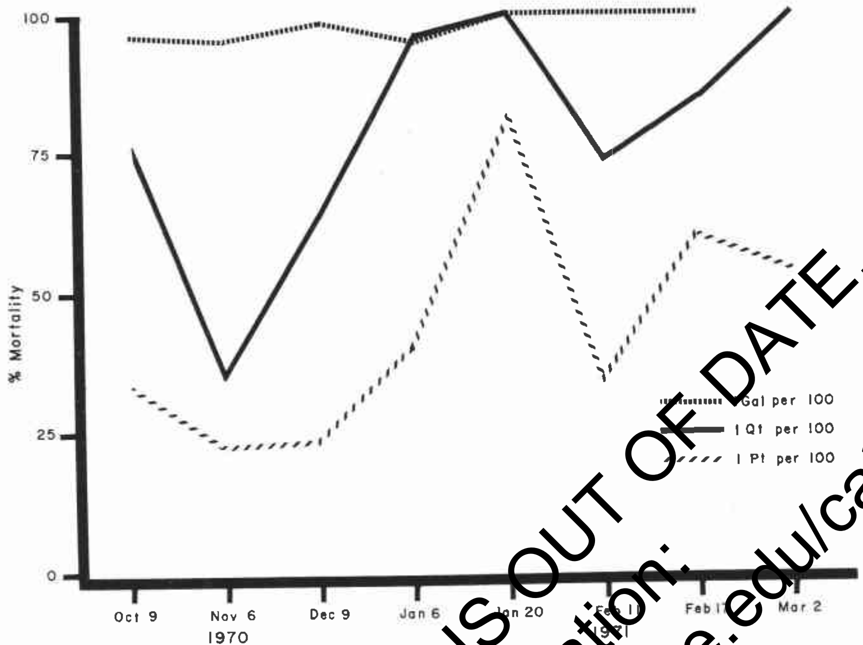

Figure 12. Variation in overwintering adult psylla susceptibility to Perthane over several months' time (Medford, Oregon)

First and best is the dissection of the overwintering females and examination of ovarian development. At Hood River, dissection of females and measurement of egg size has enabled accurate prediction of when egg laying will begin (Figure 13). Several years' dissections have indicated that when 15 to 20 percent of the overwintering female psyllids collected from field samples contain mature eggs in their oviducts, the first eggs can be found on fruit spurs in pear orchards (79).

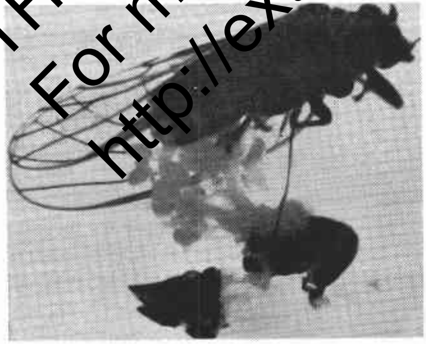

Figure 13. Dissected overwintering psylla female showing egg development.

The second method of estimating correct timing involves accumulating daily maximum temperatures from the first of January and applying the dormant spray when a certain total is reached. This method is quite variable, being more useful in southern Oregon than in the Hood River area (Table 3). In the former area the maximum daily temperatures over 43° F, totaling about 250, usually coincide with the start of egg laying (Table 7). However, because of the variation, dissection of the females is still needed for determining egg maturity.

The future use of dormant spray depends upon the continued availability of materials which both control overwintering adults and are effective at more convenient timings. However, the dormant spray has the advantage of being used at a time when it does not cause destruction of predators or parasites of the pear psylla or of other orchard pests.

Table 7. Egg deposition by overwintering psylla in relation to accumulated degree days over 43° F from January 1 (Medford, Oregon)

Year	Date of first psylla eggs	Date no. of degree days over 43° F = 250
1970	January 27	January 25
1969	February 14	February 26
1968	February 10	February 7
1967	February 8	February 15
1966	February 10	February 19
1964	February 14	February 18
1963	February 11	February 8
1960	January 24	February 6
1959	February 5	February 1
1958	February 9	February 7
1957	February 18	February 18

Table 8. Effectiveness of insecticides in control of pear pests at the delayed dormant timing

Material	Target pest				
	San Jose scale	Rust mite	European red mite	Pear psylla	
				Eggs	Adults
Oil alone	1[a]	3	1	3	2
Oil + lime sulfur	1	1	1	3	2
Oil + organophosphate	1	2	1	3	2
Perthane	3	3	3	3	1
Perthane + oil (6-8 GPA)	1	3	1	3	1
Thiodan	3	1	3	3	2
Thiodan + oil (6-8 GPA)	1	1	1	3	2

[a] 1 = good control expected, 2 = partial control, 3 = poor control.

The insecticides that have been used at the dormant time, along with examples of the degree of control obtained, are given in Tables 8 and 9. A gradual increase in Perthane tolerance in Hood River orchards is shown in these results.

Delayed Dormant Application

The delayed dormant spray is applied from the time of pear bud swell to the opening of the bud and the dropping of the bud scales. Psylla stages at this time generally include overwintering adults and eggs. During this time several of the other important pear pests become active and more susceptible or exposed to chemical treatment. Historically, the delayed dormant spray has been considered as an application directed against such pests as San Jose scale, *Quadraspidiotus perniciosus* Comstock; pear rust mite, *Epitrimerus pyri* Nalepa; and the European red mite, *Panonychus ulmi* Koch. As a result, broad-spectrum chemicals usually are chosen for use at this time.

In Oregon the use of lime sulphur and oil was a standard recommendation for the delayed dormant spray long before the pear psylla was introduced. Use of this combination, as well as the subsequent organophosphate-oil combinations, has generally been less effective on psylla than on the other pests. The lack of effectiveness is due not only to the emphasis given to control of pests other than psylla but to the lack of insecticides which are capable of killing the overwintered adult psylla and their eggs.

Table 9. Dormant sprays for control of overwintering pear psylla adults (Hood River, Oregon)

Date applied	Material	Rate per acre	Method of application	Pre-trmt.	Days after spray 1-2	3-5	6-8	9+
				No. adult psylla per tray				
3-5-66	Perthane EC	1.0 gal.	Helicopter	1	....	0	....	0
3-11-66	Perthane EC	1.0 gal.	Air carrier	2.9	....	....	0.1	0
2-18-67	Perthane EC	1.0 gal.	Air carrier	5.0	....	0	....	0
2-20-67	Perthane EC	1.0 gal.	Helicopter	5.8	....	0.2	0	0
2-24-68	Perthane EC	1.0 gal.	Air carrier	5.4	0	0	....	0
2-25-68	Perthane EC + 70 vis oil	1.0 gal. 1.0 gal.	Fixed wing	9.3	0.8	....	0.1	0
3-12-69	Perthane EC + 70 vis oil	1.0 gal. 1.0 gal.	Air carrier	....	0.2	0.[illegible]	0.4	0
2-20-70	Perthane EC + 143 vis oil	1.0 gal. 3.0 gal.	Air carrier	....	....	3.2	0.7	0.5
2-20-70	Perthane EC + 70 vis oil	1.0 gal. 1.0 gal.	Helicopter	....	....	5.8	5.2	7.3
2-7-71	Perthane EC + 70 vis oil	1.0 gal. 1.0 gal.	Fixed wing	8.1	7.5	4.1	....	....
2-5-71	Thiodan EC	1.0 gal.	Air carrier	7.1	3.7	1.1	2.1	....
2-5-71	Thiodan EC + 70 vis oil	1.0 gal. 1.0 gal.	Fixed wing	15.1	7.8	8.3	....	13.0
2-3-71	Perthane EC + Thiodan EC	0.5 gal. 0.5 gal.	Air carrier	9.1	3.8	1.1	....	....

Psylla eggs are unusually resistant to insecticides applied in the delayed dormant stage. If adults have not been eliminated from the orchard by the dormant spray before they have oviposited significantly, effective ovicidal toxicity cannot be achieved with petroleum oil concentrations which can be used safely during the delayed dormant period (59, 79).

The problems encountered in selecting the most appropriate chemical for use at the delayed dormant time can be seen by examination of Table 8, where it is shown that the available materials are not highly effective against all pests that should be controlled at this timing.

Pink Bud Application

Very few pink bud sprays were applied for control of the pear psylla until the appearance of resistance to organophosphates used during the summer months. The advantage to the pink spray is that the psylla populations are predominantly in the early nymphal stage at this time and are the most susceptible to insecticides. The disadvantages to this timing include wet soil conditions which may exist and the difficulty in covering large acreages in the short period of this stage. In addition, extension of the pink sprays into the bloom period may cause fruit injury or destruction of pollinating insects. A review of the insecticides commonly used in Oregon is given in Figure 14.

Postbloom to Harvest Applications

Because of the overlapping of psylla stages during the postbloom period, the materials used must be active against all stages in order to achieve control with a single spray application. This high degree of control was obtained during the first few years of use of the organophosphate insecticides in the late 1940's and early 1950's. However, as the effectiveness of these materials lessened, it became necessary to decrease the interval between sprays to obtain commercial

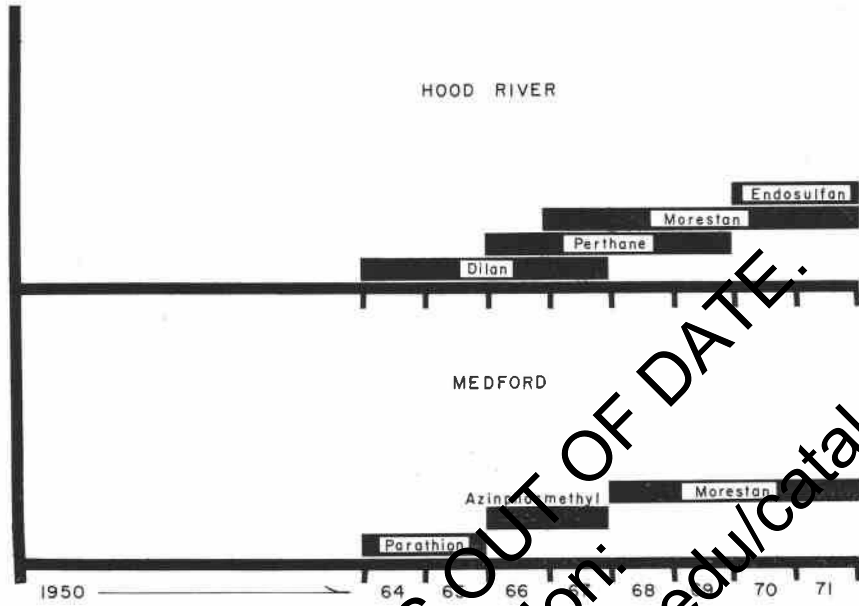

Figure 14. History of insecticide usage for pink bud applications against pear psylla in Oregon.

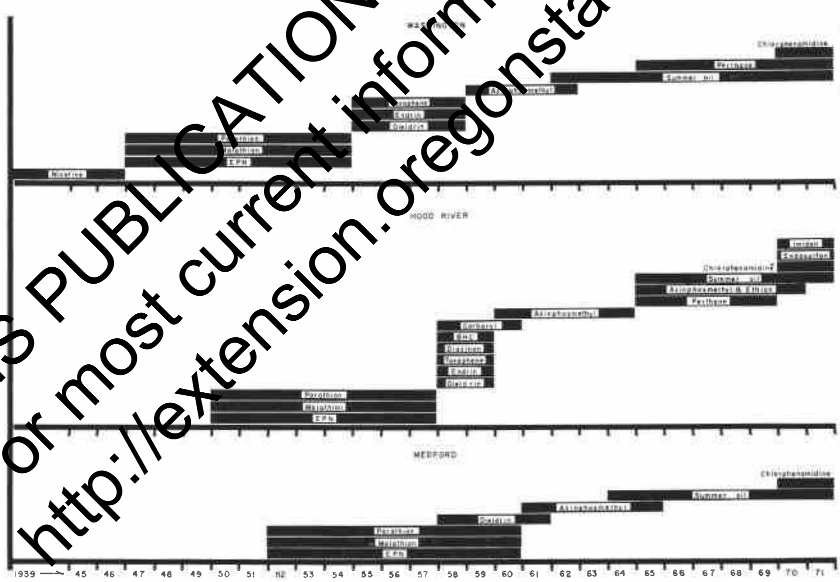

Figure 15. Summer use pattern of pesticides for pear psylla control.

control. The pattern of chemical use and of psylla resistance has been similar in the Pacific Northwest (*9, 10, 11, 15, 22, 23, 45, 48*) and is presented in Figure 15.

As the pear psylla continues to develop resistance to one material after another, the timing of the summer sprays becomes more critical. Generally, the younger nymphs remain the most susceptible and therefore materials should be applied when the majority of the population is in these stages. This will often require a second application 10 days to 2 weeks later, when the unaffected eggs are in the early nymphal stage.

Another development in the chemical control of psylla has been the use of petroleum oils either alone or in combination with other insecticides for increased toxicity. There have been no reported instances of insects, including the pear psylla, developing a tolerance to petroleum oils. The toxicities of several compounds which now give poor psylla control alone due to the development of resistance are increased substantially by addition of superior type oils (*36, 37, 78*). Oils of higher viscosities ($>$ 100 S.S.U.) gave the best control (*36, 78*) and resulted in less foliage injury than lower viscosity ($<$ 100 S.S.U.) oils.

Lenticellular enlargement and proliferation have been observed following the summer use of light dosages of oils (3 to 6 gallons per acre), but the significance of this symptom remains unknown. After 24 dilute applications over seven years at 2 to 3 quarts per 100 gallons of water to D'Anjou trees, no serious effects on tree vigor, growth, bloom, or fruit production are apparent. Under conditions of heavy reinfestation during the growing season, oils applied alone have not been effective in preventing psylla populations from causing defoliation and serious fruit marking from honeydew secretion in an experimental plot.

SUMMARY

1. The pear psylla, *Psylla pyricola* Förster, is the most serious pest of 22,000 acres of commercial pear in Oregon. The pear is Oregon's most valuable deciduous tree fruit crop. The three principal areas of pear culture which have suffered most from the depredations of this pest are Hood River County, the Willamette Valley, and Jackson County.

2. Since its first discovery in northeastern Oregon in 1946, the pear psylla has successively invaded the major pear-growing areas of the state: Hood River in 1949, the Willamette Valley and Medford in 1950.

3. Pear psylla injure pear trees by serving as the vector for pear decline, a serious disease of indeterminate etiology affecting the graft union, especially among cultivars on oriental rootstocks; by injecting a toxin which causes defoliation or "psylla shock"; and by excreting honeydew which burns foliage, discolors fruit, and interferes with harvest.

4. Pear psylla overwinter as mature adults in protected situations in orchards and other vegetated areas. Their winter reproductive diapause is terminated by the warmer temperatures of February when they mate and the females lay their first eggs on the dormant pear buds. The young nymphs hatch during blossom and insert their sucking mouthparts into developing leaves. The five nymphal stages in their life cycle are completed by May and the first adults of the three summer generations emerge to lay their eggs on succulent pear foliage. The summer adults are smaller and lighter-colored and develop from egg to adult in about 30 days. In response to decreasing day length upon fourth-generation nymphs, overwintering adults develop from September to November and disperse widely by flight from the pear orchards in which they developed. Although the adults can derive moisture from and oviposit their eggs on other vegetation, nymphal development to adult is possible only on *Pyrus* species.

5. Although the pear psylla is known to have a number of predators and parasites, populations of these beneficial insects develop too late in

the season to prevent economic damage in commercial orchards. A predaceous bug has been found to reduce psylla populations in unsprayed orchards in Medford.

6. The pear psylla has become resistant to a number of insecticides that were formerly effective in its control. As each new compound became ineffective for control, newer materials have become available. Low rates of superior-type oils in summer cover applications have extended the effectiveness of several insecticides to which psylla have become resistant.

7. A dormant application against overwintering adults before significant egg deposition, followed by pre- and postboom sprays of effective materials at critical stages of psylla development, is presently the only means available for limiting psylla damage to subeconomic levels.

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