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ADELGES PICEAE (RATZ.),
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INTRODUCTION

The balsam woolly aphid, Adelges piceae (Ratz.) (Homoptera: Adelgidae), continued to be one of the most important forest pests in the province during 1965. In February and March a foliage sampling survey was done by the Forest Insect and Disease Survey on Vancouver Island. In April the B. C. Forest Service Protection Division in co-operation with the Department of Forestry began a more intensive survey for the aphid, principally on Vancouver Island. This survey is still under way. Throughout their field season, from May to October, Forest Insect and Disease Survey rangers across the province were directed to look for signs of the aphid and to make specific collections around the known boundaries of the infestation. Detection procedures principally consisted of examining the bark of the lower six feet of the bole and 18-inch branch samples collected from the upper half of the crown. Collections of branches from the lower half of the crown and from understory regeneration (trees up to 12 feet high) usually revealed aphid only when populations were high.

On Vancouver Island the balsam woolly aphid was found to occur principally on grand fir, Abies grandis (Dougl.) Lindl., along the east coast from Victoria north to Nanaimo. Late in the year, however, one collection was taken from amabilis fir, Abies amabilis (Dougl.) Forb., near Duncan. On the mainland the infestation, principally on amabilis fir, continued heaviest around Howe Sound, Burrard Inlet and Indian Arm but extended eastward as far as Coquitlam Lake and westward to the headwaters of Salmon Inlet.

Two additional, similar-appearing aphids were found, necessitating microscopic identification of collections. Pinus abietinus Underwood and Balch, a native balsam adelgid apparently causing little damage to its hosts, was found to be widespread throughout the balsam woolly aphid infestation area and was also collected at a number of widely scattered localities around the province: at Kitimat, Smithers, Burns Lake, and Christina Lake. It was found on grand fir, amabilis fir, and alpine fir, Abies lasiocarpa (Hook.) Nutt. Adelges nusslini C. B., reported to be associated sometimes with Adelges piceae in Europe, was found in

^{1/} Respectively, Research Officer and Forest Research Technicians, Forest Insect and Disease Survey, Victoria, B. C.

three nurseries in Vancouver and Victoria and at one private home in Burnaby. In the nurseries about two dozen newly infested four- to six-foot Nordmann fir, Abies nordmanniana (Steven) Spach., were involved, some of which were badly damaged. The tree in Burnaby was not identified. The significance of Adelges nusslini to native Abies species is not known.

An experimental program of biological control involving the release of imported predaceous insects was continued in 1965, with releases of several species near Victoria.

MAINLAND INFESTATION

Deterioration of amabilis fir increased during 1965 in the southwestern mainland portion of the Vancouver Forest District. Aerial and ground surveys indicated an increase in the number of attacked trees and in tree mortality in the infested area which extended over approximately 672,000 acres (Map 1).

Persistent poor visibility caused by overcast weather and smoke haze in 1964 prevented completion of the intended survey in that year using a "Beaver" fixed-wing float plane. Flying conditions in 1965 were even worse and it was decided, therefore, to use a helicopter. It proved to be markedly superior to the fixed-wing craft in manoeuvring through cloud-obscured valleys. The aerial survey involved about 14 hours of flight time and extended from the east side of Sechelt Inlet to Pitt Lake including the Ashlu Creek Valley and the North Shore drainages of Burrard Inlet (Map 2). The terrain was rough, with numerous short creeks and rivers and well-defined valleys. A tally of amabilis fir showing appreciable red or brown foliage indicating current damage was made by drainages (Table 1). In addition, areas of significant old mortality were delineated. It was not possible, however, to determine the cause of mortality from the air, and areas were ground-checked or designated for future ground checks to determine if the aphid was a factor. Heaviest areas of damage were found at Rainy, Capilano, Seymour, and Indian rivers, Grand Creek, and the Cypress Creek - Hollyburn Ridge area.

Ground-checks were made within the known aphid-infested area and beyond including Toba Inlet, Texada Island, and the Lower Fraser River Valley to Hope and Boston Bar. Fifty-nine specific examinations involving checks of over 500 trees were made but no infested areas beyond those known in 1964 were discovered.

A number of previously established permanent sample plots were examined and several new plots were established. A summary of balsam woolly aphid attack and tree mortality found in 11 previously established plots is shown in Table 2, along with data from a new plot (No. 14) established on Mt. Seymour. The number of stem and gout attacks both more than doubled over 1964. Stem attacks were found for the first time in the Rainy River Valley. The greatest increase in attack was in the plots at Seymour Dam, Port Mellon Road, and Rainy River. During 1965, 21 plot trees died, bringing the total dead to 83, of which 23 were attributed primarily to the balsam woolly aphid and 60 to other causes such as suppression and blow-down. In

the new 610-tree Mt. Seymour plot, 226 trees showed gout symptoms, 114 were stem attacked, and 235 showed no visible damage. Of 36 heavily stem-attacked trees on Mt. Seymour under observation since 1959, 14 were dead when checked in December 1965.

On Mt. Seymour, cards coated with sticky "Tree Tanglefoot" replaced at two-week intervals from June to November, trapped small numbers of wind-blown aphid crawlers throughout this period. Snow on the cards prevented later collections.

VANCOUVER ISLAND INFESTATION

Prior to 1965, routine examinations by Forest Insect and Disease Survey rangers had revealed the aphid at several localities on and adjacent to the Saanich Peninsula at the southern tip of Vancouver Island. In February and March 1965 a special survey was undertaken to define further the extent of the infestation. The entire Victoria ranger staff, four rangers from the Vernon sub-laboratory, two men contributed by industry and one temporary employee of the Department were involved. Branch samples were taken and examined for the dormant overwintering stage of the aphid. A mobile elevating platform (Skyworker) was used to obtain the samples up to 50 feet from the ground. Of 172 localities sampled south of Qualicum Beach, the aphid was found at 28 points, all south of Nanaimo. The majority of the aphid-infested samples were from the Saanich Peninsula, although infestations were also located on Gabriola and Salt Spring Islands. Two major nurseries were found to have balsam infested by Adelges piceae.

Beginning in April and continuing throughout the remainder of the year, a B. C. Forest Service Protection Division crew, under the direction of forester Mike Zachary and involving up to 12 people, undertook an intensive survey for the aphid. As a result, the boundaries of the main infestations were more clearly defined and a number of spot attacks on Vancouver Island were delineated and trees felled to slow spread of the aphid.

Little grand fir mortality was noted during a three-hour aerial survey of southern Vancouver Island north to Nanaimo in November using a Cessna 172 fixed-wing aircraft (Map 3). Infested areas could not be distinguished from uninfested areas from the air.

Cards coated with sticky "Tree Tanglefoot" trapped aphid eggs and crawlers throughout the period they were set out near Victoria from mid-May 1965 to January 1966. One trap, consisting of a 5 x 8 inch card set out three feet from a heavily stem-attacked tree, captured as many as 145 crawlers and 50 eggs between examinations at one-week intervals. There were three periods of peak abundance--in late May, late July, and late October. The lowest recorded temperature, in mid-December, was 27° F., although temperatures were above freezing at most times during the winter.

BIOLOGICAL CONTROL

To date, no effective methods of controlling this pest are known. Balsam in some infested areas has been cut to reduce spread of the aphid

and to salvage deteriorating timber. No practical method of chemical control in forest stands has been developed. Biological control in which predators or parasites are encouraged to search out and destroy pest populations, is one of the possible solutions to this problem. Several species of predators, already present when the balsam woolly aphid arrived in British Columbia some time prior to its discovery in 1958, have been found but these have not affected satisfactory control. Since 1933, attempts have been made to establish in North America predators of the aphid, largely imported from Europe, but there has been as yet no instance of satisfactory control. Experimental introductions are continuing with a variety of species, however, in the hope that a complex of predators may become established that will hold aphid populations below a level at which they can cause significant tree damage.

Between 1960 and 1963, 18,053 predaceous insects of five species imported from Germany and Australia were released at Mount Seymour Provincial Park near Vancouver on the B. C. mainland (Harris et al., 1964). No releases were made in 1964.

Studies up to 1964 showed that the only species successfully established was Laricobius erichsonii Roseh. (Coleoptera: Derodontidae). Larvae and adults of this species were recovered in appreciable numbers on the release area and on trees sampled 0.7 and 1.1 miles away. Some stem infestations showed signs of heavy feeding by Laricobius but damage to the trees by the aphid and by secondary enemies, particularly the bark-beetle, Pseudohylesinus grandis (Coleoptera: Scolytidae), caused continued tree mortality.

In 1965 sixteen trees on the mainland (Map 4) and four trees in Thetis Lake Park on southern Vancouver Island were checked for predators at approximately three-week intervals. The bole was examined with the aid of a hand lens from ground level to six feet. All trees with the exception of three at Thetis Lake had been examined the previous year and had at that time a moderate to heavy stem attack (over 10 adult aphids per square inch) on the lower bole. In 1965, however, many of the trees had been severely weakened by aphid attack and four on the mainland died during the summer. Consequently, aphid populations on some trees examined were dying off because of host deterioration.

The only predators of a released species found on a sample tree in 1965 were two Laricobius larvae. This tree was about 1 mile from the release area. Several other larvae, however, were found on bark collected from a nearby tree on which there was a large population of healthy aphid. Laricobius thus continues to be established at the release site in 1965 although it was not found on trees, even those with healthy aphid populations, farther than one mile away.

Releases in 1965 were confined to Thetis Lake Park near Victoria. The species imported and released are shown in Table 4. In addition, 20 Aphidecta oblitterata (L.) from the first importation were caged on two 5 ft. Nordmann fir heavily infested with Adelges nusslini, and 154 adult progeny were released at Thetis Lake Park on July 13.

Native predators were found infrequently during examinations of stem-attacked trees and were judged to have little effect on aphid populations. The most frequently found native predator, as in previous years, was a mite, Allothrombium mitchelli David (Acarina: Trombidiidae). Both larvae, nymphs and adults of this species were predaceous on nymphs other than the first instar, and adults of Adelges piceae. Another mite, Anystis sp. (Acarina: Anystidae), was also occasionally found. Neuroptera, Leucopis sp. (Diptera: Chamaemyiidae), and several Serphidae (Diptera) species were also found relatively frequently. The fungi Cephalosporium sp.; Penicillium sp. and an unknown species were found parasitizing adult Adelges on one tree near the Seymour dam in early December. O. Morris of the Laboratory noted that these fungi are pathogenic on insects and have not been reported before on aphids.

DISCUSSION

The balsam woolly aphid infestation on the mainland appears, at least for the present, to be confined to the area indicated in Map 1. These apparent limits of spread may be the result of such physical barriers as the surrounding high mountainous terrain running from 4,000 to 8,000 feet elevation, above the elevation where aphid has been found to date, broad inlets such as Sechelt Inlet, and lowland or logged areas lacking Abies species. Valleys adjacent to the infestation, however, have considerable volumes of overmature amabilis fir similar to those currently suffering heavy mortality within the infestation and the aphid may be expected to continue to spread.

The infestation on Vancouver Island is confined currently almost entirely to populated areas containing scattered grand fir which, to date, have suffered little mortality and which are of low commercial value. These trees, however, are a persistent source of infection. Immediately to the north and west are high value stands of the more susceptible amabilis fir.

Insufficient is known yet about the aphid to predict properly the movement of infestations. The aphid is transported by wind and also probably by animals. Cutting infested trees may help prevent such spread. All possible precautions, however, need to be taken to prevent or retard its spread by human agencies. Infested logs or nursery stock should not be transported from infested to uninfested areas. The possibilities of inadvertent transport of the aphid on machinery and clothing should be borne in mind and a particular watch on stands kept in areas frequented by people.

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TABLE 1

Amabilis Fir Suspected of Aphid Damage Within or Adjacent to
Balsam Woolly Aphid-Infested Areas as Determined by
Aerial Surveys in the Vancouver Forest District (Mainland)

Area	Number of defective amabilis fir		
	1963	1964	1965
Chapman Cr.	12	11	- ^{1/}
Gray Cr.	0	6	-
Thornhill Cr.	-	20	-
Clowhom R.	56	27	120
Bear Cr.	4	3	17
Tzoonie R.	5	12	-
Jervis Inlet (N. end)	0	26	-
Ashlu Cr.	203	52	169
Mill Cr.	17	11	26
Woodfibre Cr.	5	3	50
Sechelt Cr.	40	5	3
McNab Cr.	9	22	315
Rainy R.	19	1	335
McNair Cr.	12	14	125
Cypress Cr.	86	30	425
Phyllis Cr.	-	-	41
Hesketh Cr.	-	15	149
Andrews Cr.	-	10	18
Capilano R. (Upper)	0	0	8
Enchantment Cr.	0	13	75
Eastcap Cr.	51	13	187
Seymour Mtn.	80	-	25
Seymour R. (Below Dam)	141	-	82
Seymour Lake	66	-	256
Seymour R. (Above Lake)	170	-	134
Indian River (Upper)	90	-	49
Meslillooet Cr.	36	-	10
Indian River (Lower)	17	-	50
Grand Creek	10	-	200+
Coquitlam R. (Lower)	-	-	13
Coquitlam Lake (E. side)	71	-	159
Coquitlam R. (Upper)	4	-	31
Boise Cr.	-	-	15
Corbold Cr.	-	-	0
Vickers Cr.	-	-	8

^{1/} Not surveyed.

TABLE 2

Summary of Balsam Woolly Aphid Attack on Amabilis Fir
on Permanent Sample Plots, 1963 to 1965, Vancouver Forest District (Mainland)

Plot No. and location	No. of trees															Total
	Healthy ^{1/}			Gouted ^{2/}			Stem attacked ^{2/}			Dead (b.w.a.) ^{3/}			Dead (o.c.) ^{4/}			
	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965	
2 Grouse Mtn.	28	23	12	7	11	10	3	1	0	5	5	5	5	8	21	48
3 Rainy River	44	35	11	14	13	28	0	0	3	1	2	2	2	10	12	61
4 Cypress Cr.	33	33	29	12	12	15	0	0	0	1	1	2	3	3	3	49
5 Indian R.	29	24	19	7	13	22	15	15	20	0	0	1	2	3	2	50
6 Raffuse Cr.	48	-	47	0	-	0	0	-	0	0	-	0	2	-	3	50
8 Seymour R.	42	41	38	4	4	7	0	0	3	1	1	1	3	4	4	50
9 Seymour Dam	34	36	10	6	7	34	9	6	13	2	2	3	1	1	1	50
10 Woodfibre Cr.	47	45	46	1	2	1	0	0	0	1	1	1	1	2	2	50
11 Dakota Cr.	45	45	46	1	1	0	0	0	0	1	1	1	2	2	2	49
12 McNair Cr.	9	9	7	10	9	11	0	0	0	5	5	5	2	3	3	26
13 Port Mellon Rd.	45	41	17	6	7	22	5	5	24	0	1	2	4	7	7	60
Total	404	332	282	68	79	150	32	27	63	17	19	23	27	43	60	543
14 Seymour Mtn.	-	-	235	-	-	226	-	-	114	-	-	-	-	-	51	610

^{1/} Living trees without visible balsam woolly aphid symptoms.

^{2/} Some trees are both stem attacked and gouted.

^{3/} Figures cumulative. b.w.a. = balsam woolly aphid.

^{4/} Figures cumulative and include all other causes of mortality.

TABLE 3

Summary of Balsam Woolly Aphid Attack on Grand Fir on Permanent Sample Plots,
October 1965, Vancouver Forest District (Vancouver Island), near Victoria

Plot location	No. of trees			Dead	Total
	Healthy ^{1/}	Gouted ^{2/}	Stem attacked ^{2/}		
Burnside Road	97	17	57	12	173
Thetis Lake A	14	5	19	6	42
Thetis Lake B	35	14	17	1	61

^{1/} Living trees without visible balsam woolly aphid symptoms.

^{2/} Some trees are both stem attacked and gouted.

TABLE 4

Predator Releases in British Columbia in 1965. Thetis Lake Park, Victoria

Date	Release number	Source	Species	Number liberated
22 April	65-10	Czechoslovakia	<u>Aphidecta obliterated</u> (L.) (Coleoptera:Coccinellidae)	660
6 May	65-14	Pakistan	<u>Tetrachleps abdulghanii</u> Ghuri (Homoptera:Anthocoridae)	133
11 May	64-17	Pakistan	<u>Tetrachleps abdulghanii</u> (Homoptera:Anthocoridae)	1,124
15 May	65-21	Germany	<u>Laricobius erichsonii</u> Rosenh. (Coleoptera: Derodontidae)	612
5 June	65-35	Germany	<u>Aphidoletes thompsoni</u> Moehn (Diptera:Itonididae)	800
5 June	65-35	India	<u>Tetrachleps</u> sp.	19
30 June	65-42	Germany	<u>Pullus impexus</u> (Ws.) (Coleoptera:Coccinellidae)	1,949
30 June	65-42	Germany	<u>Aphidoletes thompsoni</u>	112
7 July	65-44	Germany	<u>Pullus impexus</u>	448
13 July	65-53	Germany	<u>Aphidoletes thompsoni</u>	168







