Under the conditions of the present study, the fungus appears to act as a parasite whose pathogenicity is closely related to temperature.—J. S. Maini and B. W. Dance.

Mortality in Artificial Populations of Spruce Budworm under Field Conditions.—The extremely low populations of the spruce budworm, *Choristoneura fumiferana* (Clem.), encountered in recent studies in the Black Sturgeon Lake area of Ontario (Fye R.E. Bi-Mon. Prog. Rept. 19(1): 2-3, 1963) have encouraged investigations of factors responsible for maintaining the populations at endemic levels. Eggs of the spruce budworm were introduced on seven white spruce and six balsam fir trees. The eggs were from female budworms reared from larvae collected in the collapsing localized outbreak at Plammes Lake in the Port Arthur District of Ontario. The study trees were 10 to 15 ft. in height and all competitive vegetation was removed. In July 1964, the trees were searched thoroughly and all spruce budworm and naturally occurring defoliating larvae of other species were removed from the trees and subsequently reared in the insectary.

The number of eggs introduced and the pertinent results are shown in Table 1. Additional data concerning eggs exposed in a similar manner in a 12 × 12 × 12 ft. cage covering a white spruce and a balsam fir tree are included for comparison.

TABLE 1

Results of exposure of introduced spruce budworms. Black Sturgeon Lake, Ontario, 1963–1964

Host tree	White Spruce	Balsam Fir	Total	Caged
No. of eggs exposed July 1963	641	479	1120	754
No. of late instar larvae removed July 1964	19	36	55	106
Per cent survival to late instars	3.0	7.5	4.9	14.1
Number of larvae parasitized	5	4	9	0
Per cent parasitized[1]	26.3	11.1	16.3	0
Number reaching adult stage	8	12	20	59
Per cent adults[1]	42.1	33.3	36.4	55.7

[1]Based on late instar larvae removed.

Inspection of the egg masses after an appropriate hatching period indicated that the number of sterile eggs in the introduced masses was negligible. One hundred and twenty-eight or 11.4% of the eggs exposed on the open trees were lost to predators. The total loss to predators was undoubtedly higher since occasionally whole masses were missing and could have been lost either to predators or through adverse weather. However, the inspection indicated that 856 or 78.1% of the eggs hatched.

Obviously, mortality is high in the young larvae since only 4.9% of the original egg population reached the late larval stage on the study trees. Some of the larvae were undoubtedly lost during the spring period of "ballooning" on finely spun threads (Rose, A. H. and Blais, J. R. Can. Entomol. 86: 174-177. 1954). However, in the cage where the ballooning was minimized by confinement of the larvae and some protection from the extreme winter weather and predation was afforded, the survival to the late larval instars was 14.1%. Also noteworthy is a higher survival to the adult stage of the late instar larvae in the cage. Since the eggs introduced into the cage were from the same female budworms as those exposed on the open trees, and presumed to have the same genetic qualities, we may speculate that the cage protected the larvae from undetermined environmental stress whose lethal effects were not manifested in the uncaged larvae until the late larval instars or pupal stage.

A higher survival was noted in larvae placed on the balsam fir trees than those on the white spruce. Unpublished data indicate that generally larger populations of predators inhabit the white spruce and these may appreciably reduce the populations of eggs and small larvae. That 95 of the 128 eggs known lost to predators were eliminated from white spruce and only 33 from balsam fir tends to corroborate this suggestion.

Parasites moved readily into the introduced populations of larval budworms also. The parasites reared included two specimens of *Exochus* sp. nr. *albifrons* Cr., two of *Apanteles*, n. sp. nr. *murinanae* C. and Z., four of *Elachertus cacoeciae* How. and one unidentifiable specimen. Further study will be necessary to determine the sources of these parasites but the extremely low level of the spruce budworm in the surrounding area suggests that alternate hosts and not the natural populations of the spruce budworm are the source.

Natural populations of *Acleris variana* Fern., *Zeiraphera* spp. and *Pulicalvaria piceaella* (Kft.) on the study trees harbored several parasites including *Scambus decorus* Wly., *Trathala* sp., *Diadegma* sp., *Meteorus pinifolii* Mason, *Apanteles californicus* Mues., and *Apanteles* n. sp. nr. *murinanae* C. and Z., of which *Scambus decorus* Wly., members of the genus *Diadegma*, and *Apanteles* n. sp. nr. *murinanae* C. and Z. are known parasites of the spruce budworm. However, only *Apanteles* n. sp. nr. *murinanae* C. and Z. attacked the artificially planted budworm populations.

Thus the early data from this study suggest that the progeny from the females of the endemic population of the spruce budworm are effectively suppressed by predation, parasitism, and other environmental factors and that a relaxation of one or more of these factors may permit population expansion to epidemic levels.

Grateful appreciation is expressed to the staff of the Canada Department of Agriculture, Entomology Research Institute, for the identification of the parasites obtained in this study, and to Mr. K. C. Hall, Forest Insect Laboratory, for supplying the material from which the eggs were collected.—R. E. Fye.

BRITISH COLUMBIA

The Balsam Woolly Aphid in British Columbia, 1964.—Population and tree mortality surveys of the balsam woolly aphid, *Adelges piceae* (Ratz.), initiated in 1959, and the predator release program, begun the following year, have been continued. Previous studies were presented in an earlier report (Silver *et al.* Bi-Mon. Prog. Rept. 18(3), 1962). The present report summarizes the results of the 1962, 1963, and 1964 work.

The known range of the balsam woolly aphid, in the southwest corner of the Province, has continued to increase each year since it was first discovered in 1958. On the mainland, it is present in valleys draining into Sechelt Inlet, Howe Sound, Burrard Inlet, and the Indian Arm and is probably responsible for heavy balsam mortality from Jervis Inlet eastward to Garibaldi Park and the Pitt River Valley. On southern Vancouver Island, several new infestations were discovered. In 1963, gouted *Abies* were discovered at a private home near Mt. Tolmie. In 1964, stem-attack was recorded just north of Victoria and at Mt. Douglas Park and the aphid was found on twig collections from Esquimalt Lagoon, and Mill Bay near Sidney. A considerable enlargement of the Thetis Lake Park infestation also became apparent. A 62 × 1 chain strip in the Park revealed 8 stem-attacked, 32 gouted, and 366 uninfested trees. Except for two infested ornamental *Abies* found in a garden at Duncan, the infestation is currently believed to be within an area of approximately 140 square miles eastward from a line drawn from Mill Bay south to Goldstream Park and southwest to Esquimalt Lagoon.

On the mainland, amabilis fir, *Abies amabilis* (Dougl.) Forb., is the principal host while on Vancouver Island, grand fir, *A. grandis* (Dougl.) Lindl. is the host most commonly attacked. The more susceptible amabilis fir occurs north of the present limits of the infestation on Vancouver Island.

Ten trend plots established in 1961 and 1962 in Howe Sound and Burrard Inlet drainages were re-examined in 1964 and results are summarized in Table 1. Plots at Cypress, Raffuse, and Brittania creeks were lost to logging. The number of gouted trees declined slightly on most plots and one to five more stem-attacks were noted on four plots. The death of between one and five trees on all but one plot, in which no mortality occurred, was attributed to aphid attack.

TABLE 1

Condition of amabilis fir on balsam woolly aphid study plots, 1961–1964.

Location of plot and area (in acres)		No. of stems						
		Healthy		Gouted		Stem-attacked		Killed by b.w. aphid
		1961	1964	1961	1964	1961	1964	1961–1964
Cypress Cr.	(0.6)	36	33	14	12	0	0	1
Grouse Mtn.	(1.2)	31	23	16	11	0	1	5
Rainy R.	(1.2)	46	35	14	13	0	0	2
Indian R.	(0.3)	37	24	0	13	13	15	0
Seymour R.	(0.3)	39	41	10	4	0	0	1
Seymour R.	(0.4)	46	36	3	7	1	6	2
Woodfibre Cr.	(0.4)	43	45	6	2	0	0	1
Dakota Cr.	(0.6)	48	45	2	1	0	0	1
McNair Cr.	(1.2)	8	9	13	9	0	0	5
Parkdale[1]	(2.4)	50	41	5	7	4	5	1

[1] First record in 1962, not 1961.

Five sample strips were run in the Vancouver North Shore and Sechelt areas where aphid damage was heavy (Table 2). The percentage of amabilis fir varied from 26.0 to 60.8. An average of 9.1% of the amabilis fir trees had been killed, 13.3% showed definite gout, and 5.2% had stem-attack. The heaviest mortality occurred on Mt. Seymour where 23% of the trees were killed and another 25% showed signs of stem-attack. Cypress Creek suffered the greatest volume loss because a large number of mature trees had died. Analysis of the data by diameter classes showed that stem-attack was most prevalent on pole-sized trees and gout was most severe on larger mature trees.

Annual aerial surveys in which red-topped tree tallies by drainages were made. There was an increase in the number of red-topped trees in 1962 and 1963. However, the numbers in the western half of the surveyed area decreased slightly in 1964; the eastern half of the area was not surveyed. Areas of heaviest tree mortality have been Ashlu Creek, Cypress Creek, Capilano River, Seymour Mountain, Mamquam River, Indian River, and Pitt River.

TABLE 2

The degree of attack in balsam woolly aphid sample strips, 1964

Location of strip	Total no. stems	% amabilis fir					
		In stand	Healthy	Stem-attacked	Gouted	Killed by b.w. aphid	Killed by other causes
Mt. Seymour	266	27.2	41.0	25.0	8.0	23.0	3.0
Lynn Creek	230	36.1	69.6	0.0	22.6	7.4	0.4
Cypress Creek	282	30.3	55.3	0.0	29.4	12.8	2.5
Mt. Elphinstone	441	60.8	97.3	0.0	1.5	0.5	0.7
Port Mellon	144	26.0	71.5	2.8	12.5	6.9	6.3

From 1959 to 1964, 55 balsam woolly aphid stem-attacked trees were examined to determine what insects and other organisms were associated with the aphid on the trunks of infested trees. A number of native predators were found, all of which occurred only occasionally. Two mites, *Allothrombium mitchelli* Davis and *Anystis* sp. were the most common predators on the mainland. Predaceous larvae of the syrphids *Metasyrphus aberranti* (Cn.), *Neocnemodon rita* (Cn.), and *Dasysrphus amalopis* (O. S.) were also found. At Thetis Lake the principal native predator was an undescribed species of *Leucopis*.

Another aphid, *Pineus abietinus* Underwood and Balch, was found at Kitimat and Smithers to the north beyond the balsam woolly aphid infestation but its significance is not known. A scolytid, *Pseudohylesinus grandis* Sw., attacked trees infested by the aphid at the Mt. Seymour study area but seldom attacked uninfested trees. Most of the heavily infested trees showed attack by *P. grandis* and bore fruiting bodies of *Dasyscyphus agassizii* (Berk and Curt.) Sacc., a fungus known to be saprophytic and indicative of areas of dead bark.

In 1962 and 1963 the following predators imported from Germany were released at Seymour Mountain: *Aphidecta obliterata* (L.)—2,800; *Aphidoletes thompsoni* Moehn—800; *Laricobius erichsonii* Rosenh.—4,900 *Pullus impexus* (Muls.)—1,400. No releases were made in 1964.

Only *L. erichsonii* was recovered after having overwintered. It is now established on the release site but has not dispersed more than 1 mile. Heavy feeding on aphids occurred where predators were present; the waxy "wool" on boles was loosened by the foraging of the larvae, and aphid populations had noticeably declined.

While the balsam woolly aphid is known to be well established in southwestern British Columbia around Vancouver, the extent of the infestation may be delineated more precisely as new methods of detecting its presence now being developed are introduced. Mortality of amabilis fir on the mainland has been heavy in some areas and aphid populations, based on numbers of stem-attacked trees, are not declining. All ages of *Abies* are susceptible. Mortality of grand fir on Vancouver Island has been negligible to date but may increase. The presence of the pest in nurseries near Victoria and on ornamentals in private gardens has demonstrated one method by which it is spread to other areas. One predator species has been established on the mainland but it is too soon to determine its effectiveness in reducing balsam woolly aphid populations.

Further predator releases and studies will be made. The survey program will be continued to point out areas where tree mortality is heavy and where it may be expected in the future. Such areas could be given priority in logging plans.—J. W. E. Harris.

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