SAMPLING THE EGG STAGES OF THE TWO-YEAR-CYCLE SPRUCE BUDWORM NEAR BABINE LAKE, BRITISH COLUMBIA[1]

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ABSTRACT

Methods of sampling the immature stages of the two-year-cycle spruce budworm, Choristoneura fumiferana *(Clem.), were studied at Babine Lake in west-central British Columbia; this paper deals with the egg stage. At high population levels there was no difference in the number of egg masses per square foot of foliage surface between hosts, study areas, direction or sample size. Significant differences existed between crown levels and trees. Samples from understory trees were not representative of the egg populations from overstory trees. An acceptable estimate of egg numbers may be obtained by sampling one 18-inch branch tip from the mid-crown portion of as many trees as possible. Significant differences between sample areas at low population levels indicate that more localities would have to be sampled to obtain a representative estimate of egg numbers when fewer insects are present.*

INTRODUCTION

The spruce budworm is an important defoliator of coniferous trees in North America. Periodic outbreaks have occurred in British Columbia, and beginning in 1954 an outbreak occurred on white spruce, *Picea glauca* (Moench) Voss, and alpine fir, *Abies lasiocarpa* (Hook.) Nutt., at Babine Lake in west-central British Columbia. The spruce budworm there is the two-year-cycle form. In the even years the eggs are laid on the underside of needles. The eggs hatch and the larvae overwinter as second instars in hibernacula. The following spring the larvae emerge and attack the buds and young shoots. The feeding period is relatively short; the larvae enter hibernation in the fourth instar. The following year the larvae complete their development, feeding on older needles as well as on buds.

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Various methods have been developed for sampling the egg stage of the spruce budworm. Morris (1954, 1955) developed a sequential sampling method using as one sample unit a longitudinal one-half branch selected from the mid-crown of trees. Dowden and Carolin (1950) employed a 15-inch branch tip, and an 18-inch branch tip sample was used by Atwood (1944). The method selected for sampling eggs and larvae of the two-year-cycle spruce budworm in British Columbia was one 18-inch branch sample from the lower or mid-crown level of each of 10 trees in each locality. In 1958 a study was initiated to test the reliability of this sampling method. The egg, first- and second-year feeding, and overwintering stages were sampled. The present paper gives the results obtained for the egg stage.

Methods

The study area was located in a stand of white spruce and alpine fir along the Smithers-Babine Lake road approximately 40 miles east of Smithers. Samples were collected at three locations. Area A was about 7½ air miles from C, and B, located between the other two, was 4½ miles from A. The summarized data on the sample trees, which were representative of the stand, are shown below:

Area	Elevation (ft.)	Tree species	Average height (ft.)	Average D.B.H. (in.)
A	3,400	Alpine fir	39	7.2
		White spruce	39	7.2
		Alpine fir (understory)	9	1.8
B	3,000	" "	47	9.6
C	3,700	" "	40	9.5

The egg stage was sampled in August 1958 and 1960. At each date, sample branches were obtained from eight overstory alpine fir and from four overstory white spruce on Area A and from four overstory alpine fir on each of Areas B and C. In addition, eight understory alpine fir were sampled on Area A.

The branches were removed from the smaller trees using a 20-foot aluminum extension ladder and an aluminum sectional pole pruner. The larger trees were felled and branch samples removed by hand clippers. The trees were sampled as follows. The crown of each overstory sample tree was divided visually into upper, middle, and lower thirds, designated as levels U, M, and L, respectively. Three branches were selected from the centre of each crown level, one each from the north, southwest, and southeast sides. Three branches were taken from the south side of each understory tree at the mid-crown level. The length and greatest width of each entire branch and width of the apical 18-inch portion were measured and recorded in the field and the number of eggs counted.

Populations were calculated as number of egg masses per square foot of foliage. For calculating foliage area the branches were considered to be roughly triangular and the area was determined by multiplying the length by one-half the width.

The data were compared by analysis of variance. The egg mass populations were found to be asymmetrically distributed, being skewed to the right, and showed heterogeneity of variance. Transformation to logarithms was found to have the desired effect of stabilising variance. Tests were made to compare differences between sample locations, tree species, overstory trees, overstory and understory trees, crown sides, crown levels, and whole branch, and 18-inch tip sample sizes.

Results

Number of Egg Masses Per Square Foot of Foliage

The average number of egg masses per square foot are summarized in Table 1. Differences in the numbers of egg masses per square foot of foliage between localities, on trees of the two species, and in different parts of the crown were tested by analysis of variance. The results are listed in Table 2.

TABLE 1

AVERAGE NUMBER OF EGG MASSES PER SQUARE FOOT OF ALPINE FIR AND WHITE SPRUCE FOLIAGE FROM AREAS A, B, AND C

Factor		1958		1960[1]	
		Whole branch	18-inch tip	Whole branch	18-inch tip
Sample area[2]	A	3.8	—	0.8	—
	B	3.0	—	0.1	—
	C	5.3	—	0.0	—
Tree species	alpine fir	3.8[3]	—	0.8	—
	white spruce	6.6[3]	—	1.1	—
Crown sides	N	5.1	6.2	0.7	0.7
	SW	5.4	5.4	0.6	0.6
	SE	5.5	6.3	0.5	0.4
Crown levels	U	8.3	8.4	0.6	0.5
	M	5.7	7.4	0.9	1.0
	L	1.9	2.1	0.3	0.2
Stand level[1, 2]	overstory	6.9	—	0.9	—
	understory	1.0	—	0.0	—

[1]From Area A only, except averages given for B and C in sample area.
[2]Alpine fir only.
[3]From Area A only.

1958 Sampling

Differences between the host species, alpine fir and white spruce, and between localities A, B, and C were not significant. This permitted the combining of the data to strengthen the analyses. There was a significant difference between trees in samples of both species; the standard error of the mean, calculated for 18-inch tip samples at the mid-crown level was 3.77. Student's "t" test showed that the mean number of egg masses

TABLE 2

SUMMARY OF SIGNIFICANCE OF DIFFERENCES IN NUMBERS OF EGG MASSES PER SQUARE FOOT OF FOLIAGE

Factor	1958		1960[1]	
	D.F.	Significance	D.F.	Significance
Sample area	2	n.s.	2	*
Tree species	1	n.s.	1	n.s.
Sample trees	19	*	11	*
Crown sides	2	n.s.	2	n.s.
Crown levels	2	*	2	*
Sample branch size	1	n.s.	1	n.s.
Understory and overstory	7	*	7	*

*Differences significant at least at the 5% level.
n.s. Differences not significant at the 5% level.
[1]Data for all factors except the first from Area A only.

per square foot of foliage on the understory was significantly lower than the mean number on mid-crown overstory samples.

No significant differences were found between the number of egg masses per square foot of foliage taken from the N, SW, and SE sides of the crown. There were significant differences between the numbers of egg masses per square foot on whole branch samples and 18-inch tip samples at level L but not at level M. The data from level U was not analyzed because most of the whole branch samples from that level were less than 18 inches long. Comparing the mean numbers of egg masses per square foot in the crown levels, Student's "t" test showed that whereas levels M and U were not significantly different from each other, level L had a significantly lower number than either level M or level U.

1960 Sampling

The eggs sampled were those laid by moths of the preceding generation sampled in 1958. The population had fallen noticeably. On Area B, egg masses were found only at the mid-crown level and on Area C, no egg masses were found.

As in 1958, there were no significant differences between samples from the two host species and the data were combined to increase the number of trees in the sample and thereby strengthen the analyses. Because differences were found between samples taken from the three localities, data from each locality were analysed separately. Again, differences between trees were significant.

The results of sampling within the crown were similar to those found in 1958. No significant differences were found between the three sides of the crown and no significant differences were found between the two sample branch sizes at any crown level. On Area A, the number of egg masses per square foot was significantly lower on level L (for whole branches, 0.3) than on level M (0.9) but there was no significant difference between U and M (0.6 and 0.9) or between U and L (0.6 and 0.3).

Number Of Eggs Per Mass

The average numbers of eggs per egg mass on alpine fir and white spruce on the three sample areas are summarized in Table 3. The lower number of eggs per mass in 1960 as compared with 1958 suggests that moths which developed from larvae starved because of severe defoliation were incapable of laying as large a number of eggs as those which developed from a healthier 1958 population, or that only the weaker individuals with lower egg laying capacities remained in the area.

TABLE 3

Number Of Eggs Per Egg Mass

Area	Tree species	1958	1960
A	Alpine fir	33.3	18.7
	White spruce	30.8	18.4
B	Alpine fir	51.9	20.2
C	Alpine fir	45.2	0.0

Discussion

The absence of significant differences between host species indicates that both are equally acceptable to the ovipositing moths. Sample could be taken either from alpine fir or from white spruce and populations could be expected to be similar on the species not sampled. Presumably, samples could be taken from both species indiscriminately. Until a larger number of samples at all population levels and at different levels of abundance of both tree species is taken, however, it would be wise to keep data from the two species separate.

The lack of significant differences between sample areas in 1958 indicates that distribution of eggs is uniform throughout reasonably large areas during high population levels. Sampling in 1960 showed greater variation, and samples might have to be taken from a larger number of areas in order to obtain a satisfactory estimate of low populations.

There was considerable variation between individual trees, suggesting that the number of trees sampled per locality should be as large as feasible. In 1958, to reduce the standard error of the mean to 10 per cent of the mean at a probability of 95 per cent it would be necessary to raise the number of trees from which three branch samples were selected from 20, as in the present study, to 230. Because of the difference between understory and overstory samples, only samples from the overstory would be representative of the main population.

Ovipositing moths appear to prefer to lay eggs on the current year's foliage. Therefore, in 1958, the greater abundance of eggs on the upper crown levels was probably due to the higher proportion of the new growth on the upper branches than is usual in the lower crown. Defoliation was severe in 1960, with some tops completely stripped and a considerable amount of top killing. The heavy defoliation could have been responsible for the smaller number of egg masses in the upper crown level. It would be unwise to attribute the change in distribution to the lower population level of that year; this could only be determined by sampling a rising population at which time top defoliation would not be a factor.

The results suggest that the mid-crown of the tree is the most suitable for sampling. Although an estimate of total population would require representative samples from all crown levels, estimates of relative year to year densities could probably be obtained by sampling any one of the crown levels. The mid-crown is more easily reached than the upper third, and has a higher and probably more stable population than the lower third of the crown. Further, as there was no significant difference between whole branch and 18-inch samples at the mid-crown level the smaller sample unit could be utilized. As there was no real difference between crown sides, direction could be disregarded and only one sample would be needed.

It is, therefore, believed that an adequate relative measure of spruce budworm egg masses could be obtained by sampling one 18-inch branch tip from the mid-portion of the crown of as many overstory trees as possible. Either of the two major host tree species could be sampled, and counts from different sample areas averaged for a locality estimate. If, because of inaccessibility it should be impossible to transport a ladder into a locality where tree height makes it impossible to reach the mid-crown with pole pruners, the lower crown level could be sampled, but this should be clearly indicated because of the significant difference between levels.

The difference in the number of eggs per mass found in 1958 and 1960 might be associated with age of the infestation and the vigour of the insects. If so this factor might be utilized in predicting population trends.

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References

ATWOOD, C. E. 1944. The feeding habits of young spruce budworm larvae. Can. Ent. *76*: 64-66.

DOWDEN, P. B. and CAROLIN, V. M. 1950. Natural control factors affecting the spruce budworm in the Adirondacks during 1946-1948. J. Econ. Ent. 43: 774-783.

MORRIS, R. F. 1954. A sequential sampling technique for spruce budworm egg surveys. Can. J. Zool. 32: 302-313.

MORRIS, R. F. 1955. The development of sampling techniques for forest insect defoliators, with particular references to the spruce budworm. Can. J. Zool. 33: 225-294.