ESTIMATION OF LARVAL POPULATIONS OF THE LARCH SAWFLY,

PRISTIPHORA ERICHSONII (HTG.)

by

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INTERIM REPORT

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ABSTRACT

Several minor but important modifications in field sampling and in the handling of insectary-reared material were made in 1959.

The seasonal development of eggs and larvae of the larch sawfly are shown for 1959.

Plotting of cumulative adjusted oviposition curves, numbers of egg scars per sample, and numbers of shoots per sample indicated that disparities between the first two were in part due to differences in numbers of shoots per sample.

The percentages of real mortality estimated from cumulative adjusted population figures were: egg to first instar - 44.9 per cent; first to second instar - 1.2 per cent; second to third instar - 13.9 per cent; third to fourth instar - 2.9 per cent; and fourth to fifth instar - 9.3 per cent. The first three estimates compared favorably with figures derived from alternative methods of estimating mortality. (The last two estimates were unavailable from alternative methods.)

Variation in insect numbers and mortality is discussed briefly.

The technique in its present form is suitable for studying larval populations of the larch sawfly.

1. INTRODUCTION

Work in 1959 on the development of a sampling technique for the estimation of larval populations of the larch sawfly continued along the same lines as in 1958. Several minor but important modifications in the field sampling and in the handling of insectary-reared material were made, but the basic procedures remained the same.

2. METHODS

The heights and crown depths of 200 tamarack trees were measured. Each tree was clearly numbered with three large white cardboard tags, and the large brush removed from the plot. Eight tables for examination of branches were made from painted plywood sheets supported by stakes. These were strategically located near sampling units throughout the plot. The crown of each tree was divided into three equal levels. Twenty pairs of branches were sampled at random from each crown level once a week. Half of the sampling was done on each of two consecutive days. No attempt was made to sample all crown levels from each tree, although this could happen through chance. Pole pruners were used to remove the sample branches. The resulting disturbance of branches up to the level of the uppermost sample branch made it necessary to impose the following restrictions on subsequent sampling: 1) If the upper crown was sampled, the entire tree could not be sampled again until four weeks later; 2) If the middle crown was sampled, the four-weeks sampling restriction was imposed on the middle and lower crown levels, but not on the upper; and 3) If the lower crown was sampled the sampling restrictions applied to this level only.

Field techniques for examination and handling of larvae were the same as in 1958, but a beach umbrella covered with white duck was

used to shade the tables. It had been found that larvae crawling on the plywood sheets were fatally injured by brief exposure to radiant heating on warm sunny days. Shading eliminated this problem.

Insectary rearing was conducted as in 1958, but on a weekly interval. Examination and counting of reared material was synchronized as closely as possible with the time of field collection.

3. RESULTS

3.1 Seasonal Development

The observed and adjusted seasonal distribution of eggs and larvae in 1959 are shown in Fig. 1 and Appendix Table 1. (The adjusted values make allowance for the numbers of insects remaining in or passing through a given stage during the one week interval, see Ives, 1958). The peak oviposition (adjusted values) occurred during the week of June 10 to 17, with a secondary peak July 8 to 15. This bimodality was still noticeable during the first instar, but had disappeared by the third instar.

3.2 Cumulative Oviposition Curves

The numbers of oviposition slits per 60-branch sample, the number of shoots per sample, and the cumulative totals of the adjusted oviposition estimates are shown in Fig. 2 and Appendix Table 2. The agreement is reasonably good if one ignores the July 14 to 15 and August 18 to 19 samples. Examination of reared material in synchronization with time of collection has apparently eliminated the slight bias that was suspected in cumulative adjusted oviposition in 1958. Fluctuation in the numbers of shoots per 60-branch sample suggests that part of the deviation in number of slits per sample on the dates noted was
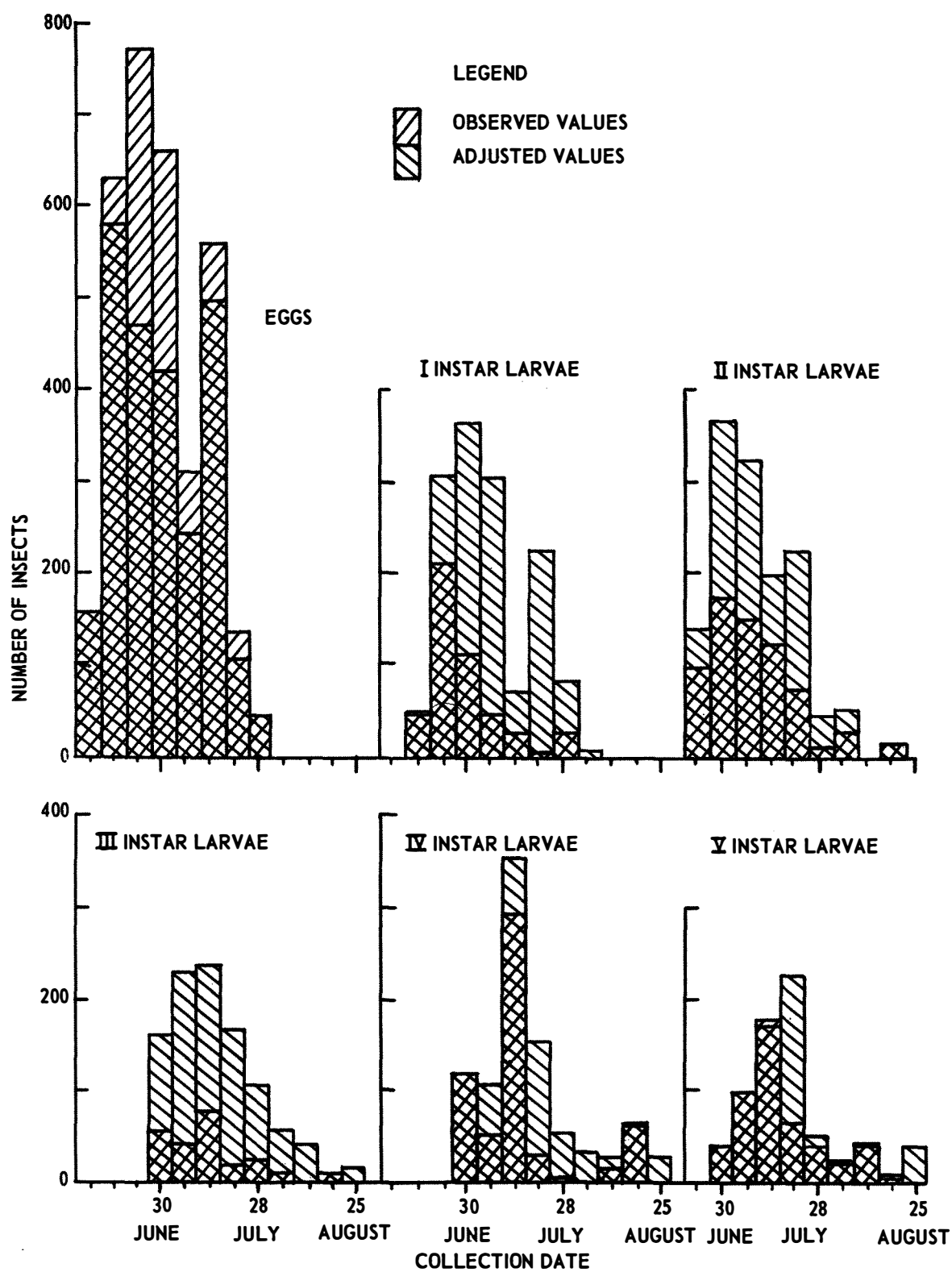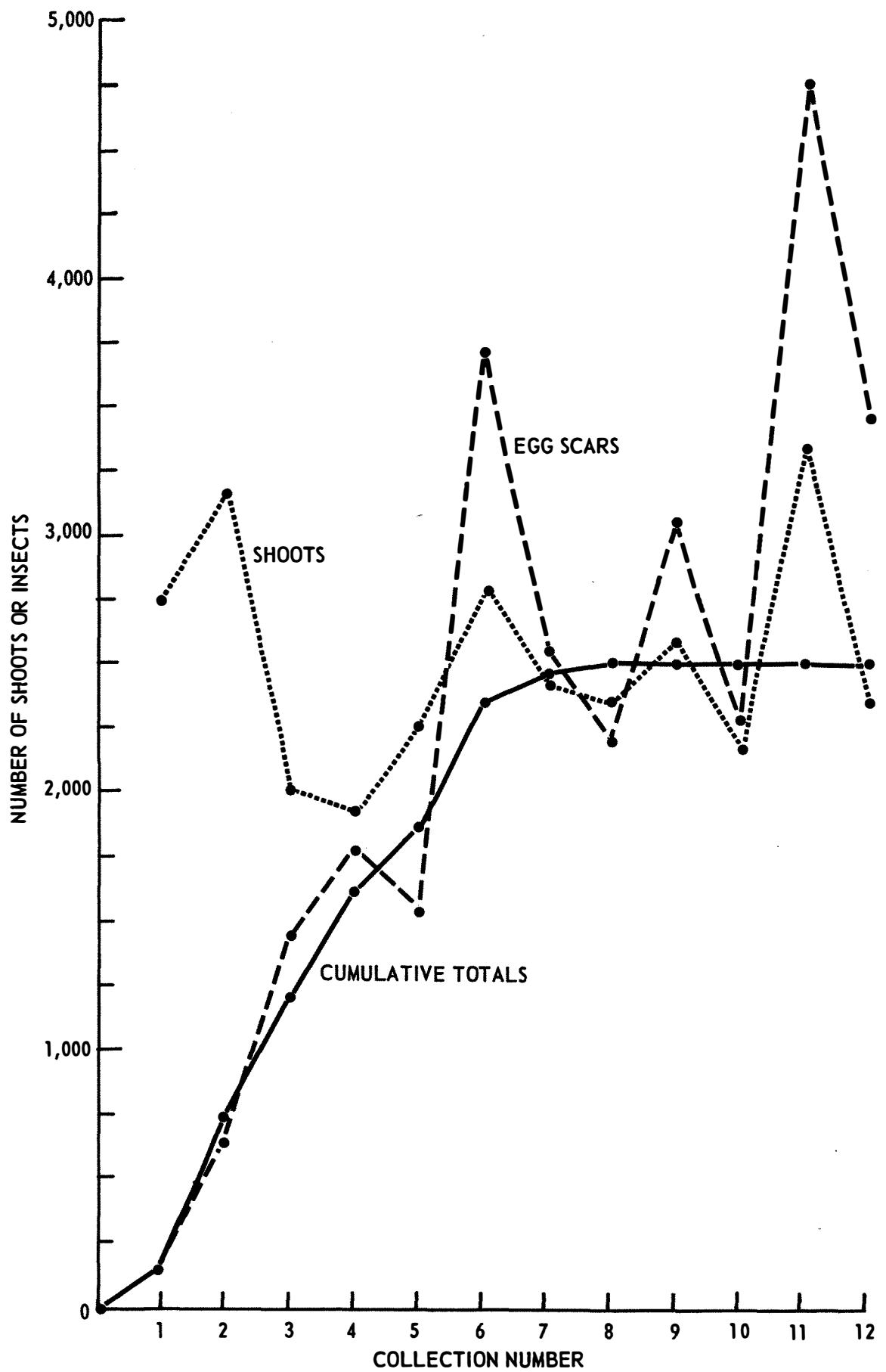
attributable to variation in numbers of shoots. Equal numbers of branches were sampled from each crown level in an attempt to reduce variation in number of shoots per sample. Apparently the stratification was not too successful. Additional stratification on the basis of crown class might also be attempted, but the gain is likely to be small as the trees were very similar in this respect.

3.3 Estimation of Mortality

3.3.1 Cumulative population totals

The adjusted values for eggs and larvae shown in Fig. 1 were added to give the cumulative totals shown in Fig. 3. No overlapping of these curves occurred, indicating that the increased sample size was successful in eliminating the inconsistency noted in 1958. The percentages of apparent mortality were: egg to first instar - 44.9; first to second instar - 2.1; second to third instar - 25.8; third to fourth instar - 7.3; and fourth to fifth instar - 25.1. Corresponding figures for 1958 (second to fourth instar pooled) were 27.0, 1.3, 32.9 and 37.0. The real mortalities for corresponding intervals (with 1958 figures in brackets) were: 44.9 (27.0); 1.2 (1.0); 13.9, 2.9 (23.7); and 9.3 (17.9). Survival in 1959 was 27.8 per cent and 30.4 per cent in 1958.

The real mortality between the egg and first instar larva was nearly 18 per cent greater in 1959 than in 1958, but less mortality occurred between the second and third and between the fourth and fifth larval instars. In both years very little mortality occurred between the first and second or between the third and fourth instars, and the percentage survival was almost identical.
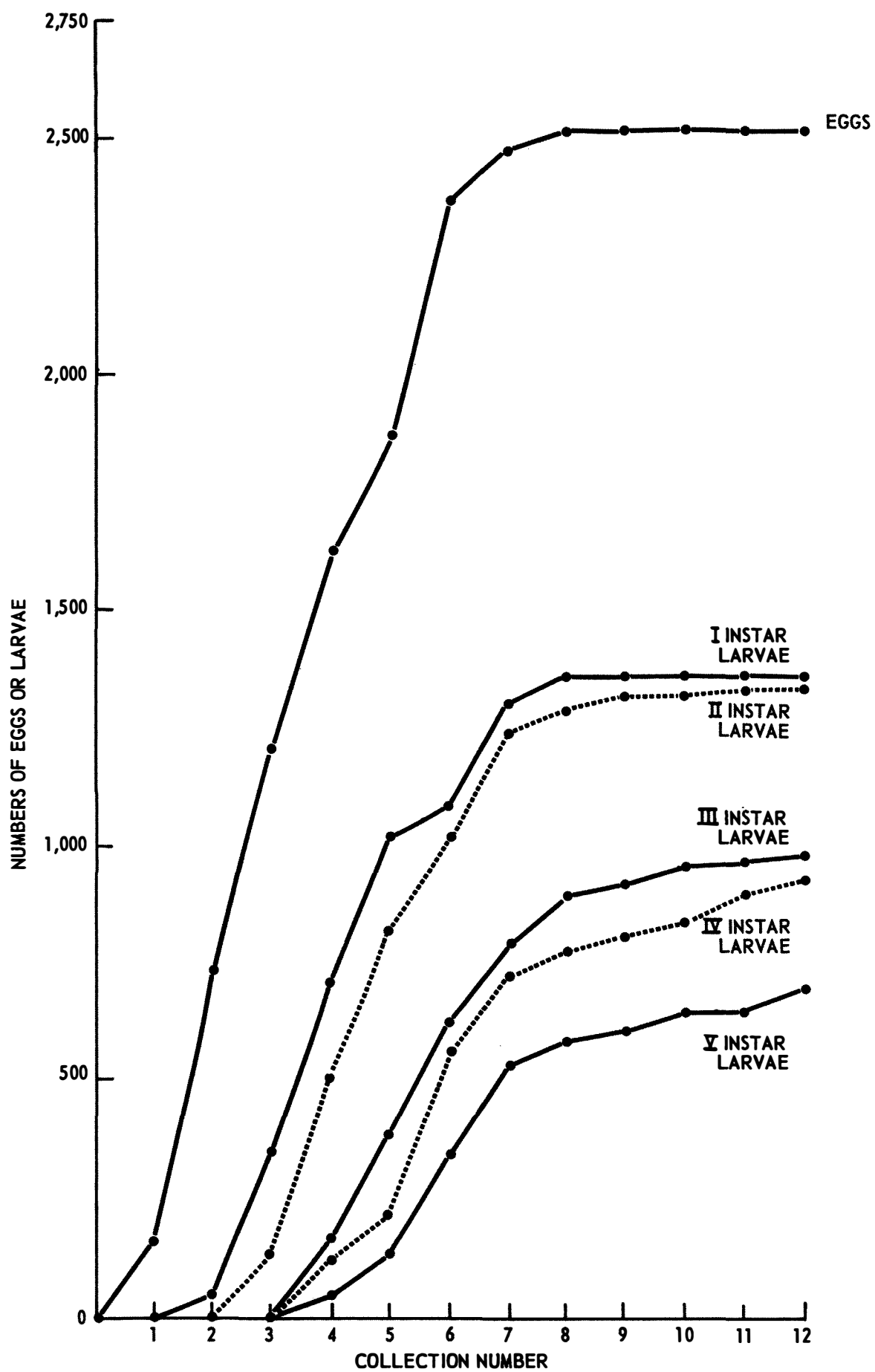
3.3.2 Hatching records

The numbers of eggs in insectary rearings, divided into two groups on the basis of time until hatching, are shown in Appendix Table 3. The percentage of hatch for eggs hatching in seven days or less was 72.2, and 83.8 for those taking longer than this, a difference of 11.6 per cent. The longer period probably represents an estimate of hatching in the absence of most field mortality factors, since exposure in the field would be of relatively short duration. No records were kept on the numbers of shoots in which the eggs had failed to hatch.

The percentage hatch for eggs hatching in four days or less in 1958 was 77.7, and 83.2 for those taking longer than four days. The similarity between the groups taking longest to hatch in 1958 and 1959 suggests that the difference in mortality between the egg and first larval instar in 1958 and 1959 may have been due to increased mortality early in the larval stage in 1959.

3.3.3 Associated larvae and egg scars

The numbers of egg scars and numbers of associated larvae for the first three instars are shown in Appendix Table 4. The percentages of "pseudo-real" mortality[1] were: eggs to first instar - 42.1; eggs to second instar - 45.2; and eggs to third instar - 61.1. The corresponding figures obtained from the total numbers of insects were 44.9, 46.1, and 60.0 per cent. The agreement between the two sets of figures is very good, indicating that relatively few colonies are completely destroyed.

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[1] The mortality has been called "pseudo-real" because it approaches the definition of real mortality, but errs by an unknown amount because the eggs from colonies in which all larvae have been destroyed are not included.

3.4 Reliability of Estimates

3.4.1 Numbers of insects

The estimated numbers of insects for each stage have already been presented, but the reliability of the estimates was not discussed. The within-crown within sampling period sums of squares were pooled for the observed numbers of insects in each stage and for the corresponding adjustments. These two pooled sums of squares were then pooled again to give the estimated variance for each stage. Sampling periods which preceded or followed the occurrence of a given stage were not included in the calculations. The data are summarized in Table 1.

The 95 per cent confidence intervals were wide in relation to the totals for all stages. The one-half confidence interval widths were 34, 31, 28, 28, and 34 per cent of the total numbers for eggs, first, second, third, fourth, and fifth instar larvae respectively. This degree of accuracy is statistically unsatisfactory, but any further increase in sample size is impractical.

Table 1

Pooled variances, numbers of observations, standard deviations
of the total number of insects and 95 per cent con-
fidence intervals on total number.

Stage of insect	Pooled variance (S^2)	Number of observations (n)	Standard deviation of total $(\sqrt{n}.s)$	95 per cent confidence interval on total
Eggs	202.082	960	440.44	$1659 < \mu < 3385$
I Instar	49.127	960	217.17	$963 < \mu < 1815$
II Instar	30.785	1200	192.19	$983 < \mu < 1737$
III Instar	19.132	1080	143.75	$727 < \mu < 1291$
IV Instar	16.032	1080	133.20	$674 < \mu < 1196$
V Instar	13.538	1080	120.91	$463 < \mu < 937$

3.4.2 Survival estimated from association between egg scars and larvae

The variance for the proportion surviving from oviposition to hatching and to each of the first three larval instars was calculated for each stage from the formula given by Cochran (1953):

$$v(p) = \frac{1}{n(n-1)\bar{x}^2} \left[\sum_{i=1}^{n} y_i^2 + p^2 \sum_{i=1}^{n} x_i^2 - 2p \sum_{i=1}^{n} x_i y_i \right]$$

where n is the number of observations in the sample;

x_i is the number of egg scars for the ith observation;

y_i is the number of associated larvae for the ith observation;

$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$ is the mean numbers of egg scars per observation;

and $p = \sum_{i=1}^{n} y_i / \sum_{i=1}^{n} x_i$ is the proportion surviving.

The data are summarized in Table 2.

The confidence intervals for percentages of survival are reasonably satisfactory. It will be noted that relatively few colonies of third instar larvae could be associated with egg scars, which is a basic weakness of this type of mortality estimate. The further the larvae develop, the more difficult it becomes to associate them with the shoot from which they originated. This is due to wandering of the colonies, and consequent intermingling with other larvae. Association becomes especially difficult once fifth instar larvae occur in the population, because they wander considerably while feeding. This often causes colonies of early instar larvae to break up as a result of local food shortages.

Table 2

Summary of statistics on variability for estimates
of survival to different stages.

Survival until:

Statistic	Hatching	I Instar	II Instar	III Instar
Number of observations (n)	148	25	36	15
Number of egg scars $\left(\sum_{i=1}^{n} x_i\right)$	3391	701	1123	416
$\sum_{i=1}^{n} x_i^2$	104341	24533	45519	13690
Number of associated larvae $\left(\sum_{i=1}^{n} y_i\right)$	2596	406	615	162
$\sum_{i=1}^{n} y_i^2$	68336	10258	15977	3234
$\sum_{i=1}^{n} x_i y_i$	79396	15001	25334	5510
p	.766	.579	.548	.389
v (p)	.000694	.002356.	.001536	.006306
95% confidence interval for p	$.714 < p < .817$	$.479 < p < .679$	$.468 < p < .627$	$.219 < p < .560$

4. DISCUSSION

The modifications incorporated into the program in 1959 have overcome most of the difficulties encountered previously. Variability is the one remaining problem, but there seems little that can be done to ameliorate the situation. High variability appears to be a characteristic of the population, and further stratification is unlikely to be very beneficial. Sample size has already been increased to the limit of practicability. The poor accuracy of population estimates will therefore have to be accepted. Even though inaccurate, the data should provide valuable information on mortality if collected for a number of years. No further modifications of the techniques are being contemplated, and the present method will be used in future work.

5. REFERENCES

Cochran, W. G. 1953. Sampling techniques. John Wiley & Sons, Inc. New York.

Ives, W. G. H. 1958. Preliminary studies on the estimation of larval populations of the larch sawfly, Pristiphora erichsonii (Htg.) Interim Report 1958-3. Forest Biology Laboratory, Winnipeg, Man.

6. APPENDIX

APPENDIX TABLE 1

Seasonal distribution of eggs and larvae in 1959 (number per 60-branch sample)

Collection		Eggs		I Instar larvae		II Instar larvae		III Instar larvae		IV Instar larvae		V Instar larvae	
Number	Date	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted	Observed	Adjusted
1	June 9-11	163	163	0	0	0	0	0	0	0	0	0	0
2	June 16-17	631	581	43	44	0	0	0	0	0	0	0	0
3	June 23-24	769	468	210	305	97	140	0	0	0	0	0	0
4	June 30-July 1	661	421	116	362	173	366	54	162	119	119	42	42
5	July 7-8	311	243	43	303	152	324	41	231	48	104	100	100
6	July 14-15	557	496	23	70	125	196	77	236	294	354	176	168
7	July 21-22	134	105	4	223	77	223	15	168	29	155	66	227
8	July 28-29	45	45	22	78	12	40	24	106	3	54	43	50
9	Aug. 4-5	0	0	0	4	33	55	11	45	0	34	20	21
10	Aug. 11-12	0	0	0	0	0	0	2	35	13	26	40	39
11	Aug. 18-19	0	0	0	0	16	16	10	10	60	62	8	4
12	Aug. 24-25	0	0	0	0	0	0	0	16	1	27	0	49

APPENDIX TABLE 2

Number of shoots per sample, number of egg scars per sample
and cumulative totals of adjusted number of eggs
in 1959

Collection number	Collection date	Number of shoots	Number of egg scars	Cumulative adjusted number of eggs
1	June 9 - 11	2802	163	163
2	June 16 - 17	3163	683	744
3	June 23 - 24	2017	1459	1212
4	June 30 - July 1	1921	1791	1633
5	July 7 - 8	2261	1554	1876
6	July 14 - 15	2809	3736	2372
7	July 21 - 22	2456	2560	2477
8	July 28 - 29	2358	2211	2522
9	Aug. 4 - 5	2604	3080	2522
10	Aug. 11 - 12	2183	2296	2522
11	Aug. 18 - 19	3358	4772	2522
12	Aug. 25 - 26	2374	3487	2522

APPENDIX TABLE 3

1959 Hatch Records

Date collected	Hatched in seven days		Not hatched in seven days		Date collected	Hatched in seven days		Not hatched in seven days	
	Scars	Larvae	Scars	Larvae		Scars	Larvae	Scars	Larvae
June 9 - 11	40	33	22	21	June 23 - 24 (cont'd)	26	8	8	8
	15	13	10	8		23	22		
	17	13	11	11		19	19		
	48	46				19	12		
						24	18		
June 16 - 17	17	14	29	28		20	18		
	15	14	46	41		18	13		
	63	61	37	37		35	27		
	15	12	15	15		4	3		
	35	31	10	9		43	39		
	26	26	15	13		18	11		
	52	47	7	7		30	30		
	10	7	19	18		53	31		
	7	7	23	21		18	15		
	8	2				41	36		
	26	26				55	55		
	11	11				14	14		
	15	12				16	15		
	10	10				9	8		
	19	17				26	26		
	18	18							
	31	29			June 30 - July 1	24	2	26	25
	39	37				6	1		
	10	10				15	1		
	30	30				23	10		
						49	5		
June 23 - 24	16	16	25	25		22	22		
	23	22	16	12		25	16		
	3	3	46	36		35	26		
	14	14	16	12		105	82		
	16	16	17	10		23	22		
	45	33	11	10		13	8		
	7	5	25	25		9	9		
	15	13	11	11		5	5		

1959 Hatch Records

Date collected	Hatched in seven days		Not hatched in seven days	
	Scars	Larvae	Scars	Larvae
June 30 – July 1 (cont'd)	34	30		
	41	41		
	20	1		
	17	13		
	32	20		
	15	3		
	19	18		
	13	1		
	9	8		
	30	26		
	14	14		
	13	13		
	22	22		
July 7 – 8	12	2	28	10
	31	28		
	19	15		
	19	19		
	21	21		
	12	3		
	19	14		
	49	48		
	12	10		
	21	20		
	19	16		
	20	15		
	28	23		
July 14 – 15	35	30	34	12
	27	23		
	26	18		
	7	7		
	14	8		
	8	7		

Date collected	Hatched in seven days		Not hatched in seven days	
	Scars	Larvae	Scars	Larvae
July 14 – 15 (Cont'd)	12	1		
	20	1		
	28	28		
	21	11		
	26	20		
	11	9		
	29	26		
	18	2		
	23	8		
	33	2		
	29	8		
	25	24		
	16	1		
	21	2		
	31	7		
	25	22		
	18	14		
	20	2		
	16	11		
	24	8		
July 21 – 22	37	31	–	–
	9	9		
	17	2		
	29	2		
	17	7		
	8	1		
	17	4		
July 28 – 29	15	3	–	–
	30	1		
Totals	2884	2081	507	425