RESULTS OF THE AERIAL APPLICATION OF FENITROTHION ON A HEMLOCK LOOPER INFESTATION IN SOUTH BROOK VALLEY, NEWFOUNDLAND.

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INTRODUCTION

The epidemic of eastern hemlock looper in Newfoundland that began in 1966 required extensive aerial spraying operations in 1968 and 1969. The spraying was planned by a Task Force comprised of representatives from the principal forest agencies of the Island and was conducted by Forest Protection Limited of New Brunswick. The Canadian Forestry Service undertook surveys to delineate outbreak areas for spraying and to determine the effectiveness of the insecticide in reducing looper numbers. The Task Force requested that a study be undertaken in a specific spray area to give a more precise assessment of the effects of spraying than was possible from the survey spot-checks. It was recognized that there were a number of severe limitations in interpreting the results obtained from areas sprayed during a commercial operation. Some of the limiting factors were lack of untreated controls, no opportunity to evaluate the effect of one application of insecticide versus two or more applications, and the inability to control the time of spraying. However, despite the limitations the project was undertaken and this report describes the methods and results.

METHODS

Study Area

The study plot was located in a 12,500 acre spray block in the South Brook Valley, near Corner Brook. Forest stands in the valley were composed primarily of 40 year old balsam fir, averaging about 25 to 30 cords to the acre. They were severely infested with the looper and had a high priority for protection.

Spraying Operation

The insecticide, fenitrothion, was applied by a team of three Grumman Avengers (T.B.M.) fitted with boom and nozzle spray equipment and directed by two pointer aircraft. The area was treated in two applications of 1/8 lb. per acre at a 7-day interval and a third application of 3/16 lb. per acre, 15 days following the second spray. During the first application one of the aircraft flew out of formation, probably because of the difficult flying conditions imposed by the rough terrain in the valley, resulting in an incomplete spray coverage over the plot. During the second application flying appeared normal and spray coverage was good. The third treatment was not scheduled in the original plan but was considered necessary because of the partial spray coverage during the first application, early defoliation, and the high value of the stand.

Estimating Spray Deposit

Spray deposit was monitored by the evidence of droplets on spray assessment cards*. A card was placed on the tip of a lower branch of each of 100 trees, and an additional card was placed in the open on the ground near each tree; making a total of 200 cards per spray. Cards were positioned immediately prior to and collected one-half hour after the sprays on July 2 and July 10. The amount of spray received was not measured; spray was indicated as present or absent only.

Estimates of Looper Population Levels

Larval numbers were estimated from beating 1 cubic yard of foliage (Sippell, 1969) on 200 (6 ft. to 10 ft. high) balsam fir trees. The sample trees were randomly grouped in units of 10 to accommodate 20 samples taken at 2-day intervals as follows: two pre-spray samples; three samples after the first spray; and 15 samples after the second spray. No samples were collected on spray days and trees were only sampled once. Larvae were segregated by instar and recorded as living or dead; living larvae were forwarded to the laboratory at St. John's for rearing. Two pre-spray samples were collected, one on June 28 and the other on June 30. The second sample was taken two days before spraying and contained the higher number of larvae, as expected at this stage of larval development. The effect of the spray was expressed as the percent reduction in looper numbers from the latter sample and the number obtained in each post spray sample.

Estimates of Larval Mortality

Mortality, attributed to treatment, was estimated from numbers of dead and living larvae collected in larval drop trays. These trays were constructed from unbleached cotton squares, 1 yard by 1 yard, with a 4-inch wide barrier of tanglefoot applied around the edges to prevent larvae from escaping. The trays were placed 12 inches above ground under each of 10 trees randomly selected from the 200 sample trees. It should be noted that beating samples were collected from the opposite side of the trees used for sampling with drop trays. Larvae were collected from the drop trays at 2-day intervals following spraying for a total of 16 collections (Table 2). Larvae were recorded as living or dead by instar, and larval mortality was expressed as a percentage of the proportion of the dead larvae in the sample.

*Kromekome white

Reproductive Potential

Larvae from both the pre- and post-spray samples were fed untreated balsam fir foliage in the laboratory to determine if they might survive and if the reproductive potential of the looper population was impaired by the insecticide. The larvae were placed in covered 1-pint glass jars (10 per jar) and the foliage changed at 2-day intervals. Rearing room conditions were maintained at 70% RH and 70°F. Emerging adults were placed in 16 oz. jars (3 pairs per jar) for mating and oviposition. Eggs were separated for viability by color; viable eggs are brown, non-viable are green.

RESULTS AND DISCUSSIONS

Spray Deposit

Only 188 cards were recovered following the first spray and 182 following the second spray. These cards were checked in the laboratory for the presence of spray droplets and the results are expressed as the percentage of cards receiving spray droplets as follows:

	No. of cards recovered		% of cards having spray droplets	
Treatment	From branches	From the open	From branches	From the open
1st spray	94	94	35.1	52.1
2nd spray	87	95	70.1	92.6

Results show, as expected, that fewer cards on branches received spray than those in the open. Part of the spray obviously settled on the branches above the location of the spray cards. Only 52.1% of the cards in the open showed spray deposits from the first treatments, and 92.6% showed spray from the second treatment. This low deposit indicates poor coverage of the sample plot during the first application of insecticide. However, spray coverage was good during the second treatment.

Effect of Spray on Larvae

Data from beating samples showed that larval numbers averaged 44.8 per tree (a reduction of 16.2%) 2 days after the first spray, and 6.6 per tree (a reduction of 87.5%) 6 days after the second spray (Table 1).

Numerous sluggish and motionless larvae were observed hanging from their silken-thread, 2 days after the first spray. Although there were no dead larvae in the larval drop trays, 4.4% of the larvae in the beating samples were dead 4 days after the first spray (Appendix I). Data from the larval drop trays show that more than 90% of the larvae were dead by July 14, the 4th day following the second spray (Table 2). This high larval mortality indicates the reason for the large reduction in numbers of living larvae obtained from the beating samples during the same period. The percentage of dead larvae decreased after July 16 until the third spray when dead larvae again made up over 90% of the samples. However, larval numbers (living and dead) did not exceed an average of 4 per larval drop sample after July 16 and corresponding low numbers were recorded from the beating samples. No dead larvae were collected after August 4 and no living or dead larvae were collected after August 10 (Appendix II). Pupation began about the end of July.

Results of the study show that two applications of fenitrothion reduced looper population levels by 87.5%, 6 days after the second spray, and by 96.5% on the 12th day. This compares favourably with the average of 93% reduction calculated from data collected by the Forest Insect and Disease Survey from stands treated across the Island. It should be noted that even three treatments did not eradicate the looper in the experimental plot.

Data shown in Appendix I and II indicate that most larval mortality from the insecticide occurred during the first and second instars. However, about 10% of the population had reached the third instar prior to the first spray, and 40% of the population had reached the 3rd instar by the 4th day following the second spray, when larval mortality reached 90% in the larval drop trays. Studies have shown that most defoliation occurs when larvae are in the 3rd and early 4th instars (Carroll, 1956). Consequently, some defoliation was expected in the sprayed block. Examination of the sample trees showed damage to new shoots and subsequent aerial surveys showed light to moderate defoliation throughout the area.

Effect of Spray on Reproductive Potential

The laboratory reared population contained 55.9% females; similar to that reported by Carroll (1956) in unsprayed areas (55.1%). The highest number of eggs produced in this experiment (an average of 24.3 per female) was much lower than that recorded by De Gryse and Schedl, 1934 (av. 100 eggs/female) and Carroll, 1956 (av. 67 eggs/female). Results of laboratory rearings show the viability of eggs was much lower from adults reared from larvae collected after the second and third sprays (48.9%) than from those reared from earlier collections (78.0% and 76.9%) (Table 3).

Table 1. Percent reduction in larval numbers after spray over a 40-day sampling period.

Date	Av. no. of living larvae per tree (n = 10)	Percent reduction	No. days after sprays
June 30	53.2	-	Last pre-spray sample
July 2	First spray		
July 4	44.8	16.2	2
July 6	35.3	33.6	4
July 8	31.7	40.4	6
July 10	Second spray		
July 12	23.4	56.8	2
July 14	12.8	75.8	4
July 16	6.6	87.5	6
July 18	4.8	91.0	8
July 20	5.7	89.0	10
July 22	1.9	96.5	12
July 25	Third spray		
July 27	3.8	92.5	2
July 29	2.4	95.0	4
July 30			Beginning of pupation
July 31	1.1	98.0	6
August 2	1.4	97.0	8
August 4	0.4	99.0	10
August 6	0.5	99.0	12
August 8	0.4	99.0	14
August 10	0.1	99.8	16
August 12	0	-	18

Table 2. Larval mortality estimated from drop trays

Date	Av. no. of larvae per drop trays	Percent dead in sample	No. of days after spray
July 2	First spray		
4	35.7	-	2
6	24.8	-	4
10	Second spray		
12	65.4	86	2
14	20.8	91	4
16	3.3	91	6
18	2.5	60	8
20	1.9	63	10
25	Third spray		
27	3.4	91	2
29	3.1	93	4
31	0.6	17	6
August 2	-	-	8
4	0.3	67	10
6	0.3	-	12
8	0.1	-	14
10	-	-	16
12	-	-	18

Although the spraying did not appear to change the sex ratio of the looper the decrease in the number of eggs laid and in the percentage of eggs hatched indicates that repeated applications of fenitrothion may severely reduce the reproductive potential of this insect.

Table 3. Viability of the laboratory reared hemlock looper eggs

Larval collection	No. of larvae received for rearing	No. pupated	No. of adults mated		Av. No. of eggs per female	
			Male	Female	Viable	Non-viable
Before 1st spray	610	204 (33.4%)	79	96	13.0 (78.0%)	3.7 (22.0%)
After 1st spray	1,016	348 (34.3%)	127	166	12.5 (76.9%)	3.8 (23.1%)
After 2nd spray	360	207 (57.5%)	88	112	11.9 (48.9%)	12.4 (51.1%)

Observation on the Incidence of Disease in the Sprayed Area

It is interesting to note that a fungus disease, Entomophthora sp., was found on dead 3rd and 4th instar larvae collected after the second spray. Hemlock looper larvae surviving a sub-lethal dose of fenitrothion, may have become susceptible to this disease. It is known that stress factors tend to increase the susceptibility of insects to pathogens. However, the disease was also found on larvae at Serpentine Lake and McIvers; areas that were not treated with insecticide. Therefore, it cannot be stated with certainty that the chemical treatment induced the disease in the South Brook Valley.

SUMMARY AND CONCLUSIONS

Results of the study showed that the distribution of the spray was considerably better during the second treatment than during the first; the unscheduled third spray was not monitored.

The data do not provide information on the effect of one application of insecticide. Two applications of fenitrothion killed about 90% of the larvae by the 4th day following the second spray; late instar larvae were more resistant than early instar larvae. Even three treatments did not eliminate looper larvae from the experimental plot.

Although the insecticide treatment did not appear to change the sex ratio of the looper, laboratory mating and rearing experiments indicate that repeated applications of fenitrothion may adversely affect the reproductive potential of this insect.

An aerial survey in the fall showed light to moderate defoliation in the 12,500 acre spray block. Records of looper development have shown that this defoliation might have been avoided if the insecticide had been applied 5 days earlier when about 30% of the larvae had reached second instar. Results of this study suggest that insecticides would provide the most effective control if applied during this critical period and they should be applied twice if a short residual chemical is used. Results of this study also show that spot checks conducted by the Forest Insect and Disease Survey are adequate to monitor the effect of the commercial application of insecticide on the hemlock looper. Both methods show that the spray operation was largely successful in protecting infested stands.

LITERATURE CITED

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Appendix I. The number of hemlock looper larvae collected by beating*

Sample	Date	State/ Instar	1	2	3	4	Total	% living and dead	Av. No. of larvae/tree	S.D.
				Pre-spray collection						
1	June 28	Living	246	139	4	-	389	100	38.9	28.83
		Dead	-	-	-	-	-	-	-	-
2	June 30	Living	267	217	48	-	532	100	53.2	33.23
		Dead	-	-	-	-	-	-	-	-
	July 2			First spray application						
				Post-spray collection						
1	July 4	Living	155	273	30	-	448	100	44.8	25.41
		Dead	-	-	-	-	-	-	-	-
2	July 6	Living	46	164	143	-	353	89	35.3	21.04
		Dead	17	20	7	-	44	11	4.4	2.84
3	July 8	Living	72	164	81	-	317	85	31.7	21.95
		Dead	12	31	11	-	54	15	5.4	4.01
4	July 10			Second spray application						
				Post-spray collection						
1	July 12	Living	5	79	150	-	234	80	23.4	18.02
		Dead	31	21	5	-	57	20	5.7	3.74
2	July 14	Living	-	34	94	-	128	57	12.8	10.32
		Dead	31	57	4	-	92	43	9.2	9.21
3	July 16	Living	-	11	51	4	66	80	6.6	7.68
		Dead	-	16	1	-	17	20	1.7	1.49
4	July 18	Living	-	2	30	16	48	89	4.8	4.10
		Dead	-	4	3	-	7	11	.7	.67

Appendix I (Cont'd)

Sample	Date	State/ Instar	1	2	3	4	Total	% living and dead	Av. No. of larvae/tree	S.D.
5	July 20	Living	-	3	32	22	57	98	5.7	6.45
		Dead	-	1	-	-	1	2	.1	.32
6	July 22	Living	-	-	10	9	19	86	1.9	1.10
		Dead	-	3	-	-	3	14	.3	.48
	July 25			Third spray application						
7	July 27	Living	-	-	2	36	38	76	3.8	4.64
		Dead	-	10	1	-	11	24	1.1	.99
8	July 29	Living	-	-	8	16	24	47	2.4	1.78
		Dead	-	21	6	-	27	53	2.7	2.45
	July 30			Beginning of pupation						
9	July 31	Living	-	-	-	11	11	100	1.1	2.13
		Dead	-	-	-	-	-	-	-	-
10	August 2	Living	-	-	-	14	14	45	1.4	1.65
		Dead	-	17	-	-	17	55	1.7	1.49
11	August 4	Living	-	-	-	4	4	100	.4	.52
		Dead	-	-	-	-	-	-	-	-
12	August 6	Living	-	-	-	5	5	100	.5	.85
		Dead	-	-	-	-	-	-	-	-
13	August 8	Living	-	-	-	4	4	100	.4	.70
		Dead	-	-	-	-	-	-	-	-

Appendix I (Cont'd)

Sample	Date	State/ Instar	1	2	3	4	Total	% living and dead	Av. No. of larvae/tree	S.D.
14	August 10	Living	-	-	-	1	1	100	.1	.32
		Dead	-	-	-	-	-	-	-	-
15	August 12	Living	-	-	-	-	-	-	-	-
		Dead	-	-	-	-	-	-	-	-

*Based on 10 trees per sampling dates.

Appendix II. The number of hemlock looper larvae collected by drop trays*

Sample	Date	State/ Instar	1	2	3	4	Total	% living and dead	Av. No. of larvae/tree	S.D.
	July 2		First spray application							
			After first spray							
1	July 4	Living	159	175	23	-	357	100	35.7	19.22
		Dead	-	-	-	-	-	-	-	-
2	July 6	Living	65	130	53	-	248	100	24.8	14.73
		Dead	-	-	-	-	-	-	-	-
3	July 8	Missing								
	July 10		Second spray application							
			After second spray							
1	July 12	Living	2	38	51	-	91	14.0	9.1	6.35
		Dead	37	450	76	-	563	86.0	56.3	22.01
2	July 14	Living	-	6	13	-	19	9.1	1.9	1.91
		Dead	32	113	44	-	189	90.8	18.9	5.49
3	July 16	Living	-	-	3	-	3	9.0	.3	.67
		Dead	2	10	18	-	30	91.0	3.0	1.63
4	July 18	Living	-	2	8	-	10	40.0	1.0	.67
		Dead	1	4	10	-	15	60.0	1.5	1.35
5	July 20	Living	-	1	6	1	8	37.0	.8	.92
		Dead	-	1	10	-	11	63.0	1.1	1.20
6	July 22	Missing								
	July 25		Third spray application							

Appendix II. (Cont'd)

Sample	Date	State/ Instar	1	2	3	4	Total	% living and dead	Av. No. of larvae/tree	S.D.
7	July 27	Living	-	-	1	2	3	9.0	.3	.48
		Dead	-	7	18	1	31	91.0	3.1	1.60
8	July 29	Living	-	-	1	1	2	7.0	.2	.63
		Dead	-	13	16	-	29	93.0	2.9	1.52
	July 30		Beginning of pupation							
9	July 31	Living	-	-	4	1	5	83.0	.5	.71
		Dead	-	-	1	-	1	17.0	.1	.32
10	August 2	Living	-	-	-	-	-	-	-	-
		Dead	-	-	-	-	-	-	-	-
11	August 4	Living	-	-	-	1	1	33.0	.1	.32
		Dead	-	-	2	-	2	67.0	.2	.42
12	August 6	Living	-	-	3	-	3	100	.3	.67
		Dead	-	-	-	-	-	-	-	-
13	August 8	Living	-	-	-	1	1	100	.1	.32
		Dead	-	-	-	-	-	-	-	-
14	August 10	Living	-	-	-	-	-	-	-	-
		Dead	-	-	-	-	-	-	-	-
15	August 12	Living	-	-	-	-	-	-	-	-
		Dead	-	-	-	-	-	-		

*Based on 10 trays per sampling dates.