SPRUCE BUDWORM ADULT SPRAY TESTS, 1976

by

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Information Report M-X-75

Canadian Forestry Service

Department of Fisheries and the Environment

1977

ABSTRACT

Four insecticides were tested as potential control treatments for spruce budworm adults. The preliminary tests with Sevin-4-oil and Orthene were not encouraging. The best results, a 50 to 60% reduction in egg masses and overwintering larvae, were obtained with three applications of 70 gm of Matacil in 0.73 ℓ of formulation per hectare. However the results were not easily interpreted because of differences in budworm densities on the two hosts, fir and spruce, and female dispersal across the boundaries of small spray blocks.

RESUME

Quatre insecticides furent essayés pour déterminer leur potentiel de réussite dans la lutte contre la Tordeuse adulte des bourgeons de l'Epinette. Les essais préliminaires, avec Sevin-4-huile et Orthène ne furent pas encourageants. Les meilleurs résultats obtenus furent une diminution de 50 à 60% dans les masses d'oeufs et des larves passant l'hiver, fruit de trois applications de 70 gm de Matacil dans 0.73 ℓ de préparation par hectare. Toutefois, les résultats ne furent pas d'une interprétation facile à cause des différences de densités sur les deux hôtes, le Sapin et l'Epinette, puis de la dispersion des femelles à travers les limites des petits blocs aspergés.

INTRODUCTION

The spray tests conducted in New Brunswick in 1976 against the adult spruce budworm (*Choristoneura fumiferana* (Clem)), were primarily aimed at determining the relative effectiveness of four insecticides, Dimecron, Matacil, Orthene, and Sevin-4-oil, and the possible persistence of Sevin-4-oil. The plans also called for testing a new operational technique, the use of ground-based radar to detect and trigger a spray against invading budworm moths. The spray tests were conducted at Dunphy and Acadia but because monitoring was intensive at Acadia, the two operations are reported separately.

ACADIA TESTS: METHODS AND RESULTS

The objective of the Acadia operation was to test the effectiveness of Dimecron and Matacil which were applied at the rate of 0.73 ℓ of formulation per ha. Ten check plots and three treatment blocks (1, 2, 5) were situated within the Acadia Forest Experiment Station and one (Block 4) just outside the eastern boundary. Each block covered about 250 ha. The treatments were as follows:

Block	Insecticide	No. of applications at 70 gm a.i. per ha	Dates and time	Aircraft
1	Dimecron	3	4 July p.m. 6 July a.m. 9 July p.m.	Ag Truck
2	Dimecron	3	4 July p.m. 6 July a.m. 9 July p.m.	Ag Truck
4	Matacil	3	5 July a.m. 7 July a.m. 10 July a.m.	Ag Truck
5	Matacil	2	5 July a.m. 7 July a.m.	Ag Truck

Spruce (black, *Picea mariana* Mill. BSP. and red-black hybrids) was the only host species in Block 2 and the most common species in the check plots and Blocks 1 and 4 as shown by the following cruise data:

	Check plots	Blocks			
		1	2	4	5
Total stems/hectare > 10 cm (> 4 in)	1973	1638	1111	1850	1379
Proportion spruce	92%	88%	100%	88%	46%

The sampling design consisted of five plots within each treatment block and 10 check plots. Where possible, five balsam fir, *Abies balsamea* L. (Mill.), and five spruce trees (one midcrown branch per tree) were sampled in each plot. Budworms were counted in the following stages: pupae, in late June to determine resident densities within plots; pupal cases, in mid-July to determine emerged female densities; egg masses, throughout July from the beginning to the end of the oviposition period; and overwintering larvae (L2), in October.

Resident Female Moth Densities

In mid-July when all adults had emerged, pupal cases were sampled to estimate the densities of the emerged male and female moths. In all, over 1000 pupal cases were counted, of which 44% were females. The mean number of female cases on spruce averaged from 31 to 40 per 10 m^2 in the four treatment blocks and 53 per 10 m^2 in the check plots (Table 1). In general, more female cases were found on balsam fir than on spruce with mean counts ranging from 32 to 130 per 10 m^2 on fir (Table 2). On the average, the ratio of pupal cases on fir versus spruce was 1.68:1.

Density of Moths in Airspace

A ground-based radar was operated nightly from 23 June to 25 July to monitor the aerial densities of moths dispersing over the study area. If more than 12,000 moths per ha were detected on any night in the airspace, a sampling crew was to be alerted to check moths on the ground and if many egg-carrying females were present, a decision would be made to apply a spray treatment against the invaders within 24 hr. However, the highest airborne density of budworm monitored on radar was only 1112, recorded on 6-7 July and therefore treatments against invaders were not necessary. The resident budworm population at Acadia

Table 1. Budworm counts per 10 m^2 on spruce and percent reductions in egg masses and L2, Acadia, 1976

Plot	Counts per 10 m^2				
	Female cases	Egg masses	L2	Masses/female	L2/female
Check	53	380	916	7.17	17.3
Blocks:					
1 Dimecron 3X	39	175(54)[a]	222(76)	4.49(37)	5.69(67)
2 Dimecron 3X	35	241(37)	532(42)	6.89	15.2
4 Matacil 3X	31	98(74)	198(78)	3.16(56)	6.39(63)
5 Matacil 2X	40	238(37)	441(52)	5.95	11.0 (36)

a. Figures in brackets are percent reductions as compared with check plots.

Table 2. Budworm counts per 10 m^2 on balsam fir and percent reductions in egg masses and L2, Acadia, 1976

Plot	Counts per 10 m^2				
	Female cases	Egg masses	L2	Masses/female	L2/female
Check	130	159	973	1.22	7.48
Blocks:					
1 Dimecron 3X	32	206	-[a]	6.44	-
4 Matacil 3X	52	75(53)[b]	281(71)	1.44	5.40(28)
5 Matacil 2X	93	195	412(58)	2.10	4.43(41)

a. - No data.

b. Figures in brackets are percent reductions as compared with check plots.

was supplemented by fewer than 3000 moths per ha throughout the adult season and this had a negligible effect on resident female populations which ranged from about 85,000 per ha in Block 5 to 183,000 per ha in Block 1.

A light trap located in a clearing near the radar site also indicated that few budworm moths invaded the study area. The total seasonal catch in the trap was less than 100 moths.

Female Moth Emergence and Spray Application

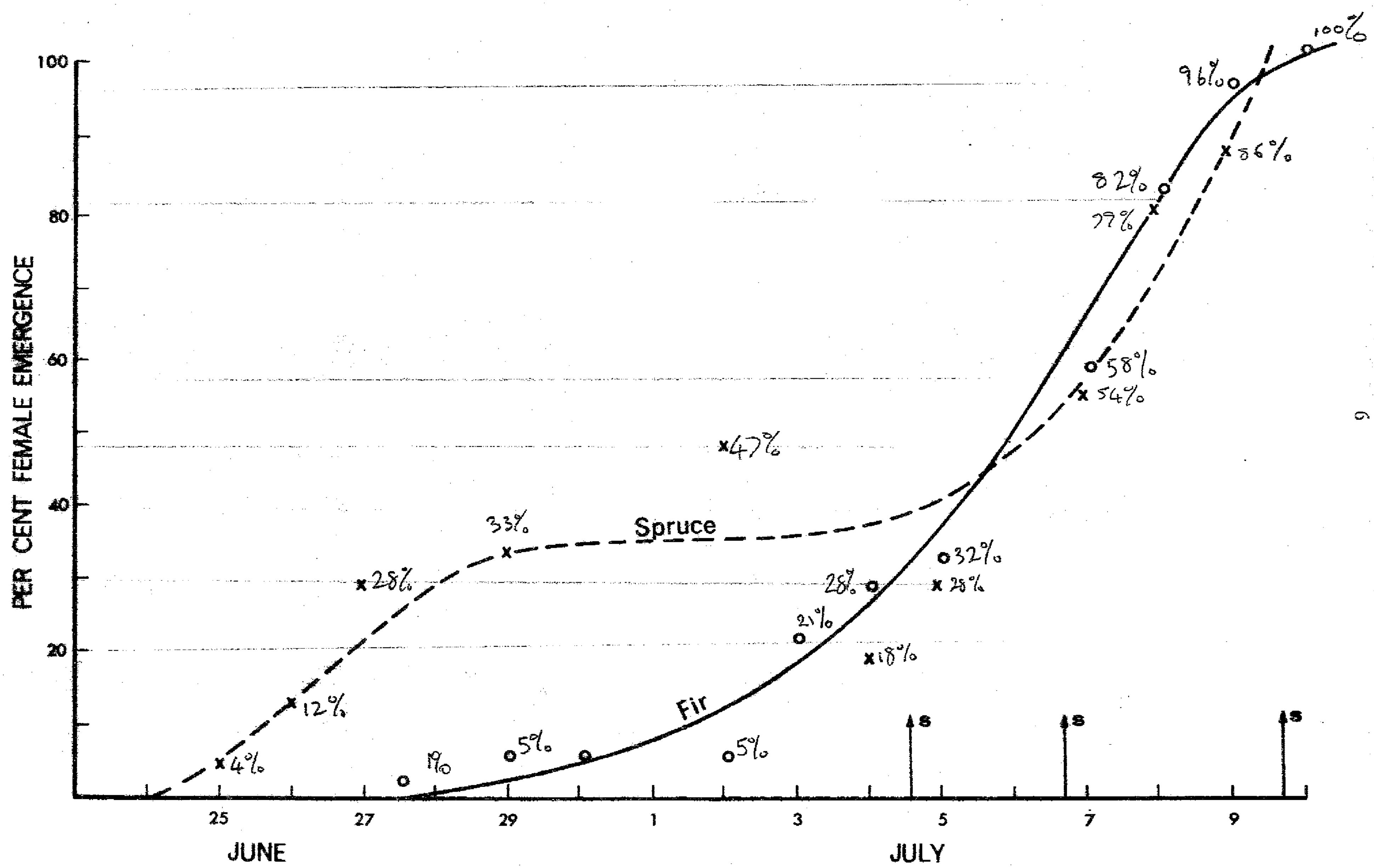
The first empty female pupal cases (adult females) were recorded on 24 June on spruce and on 27 June on balsam fir. The pattern of female emergence on the two host species was quite different. Between 24 and 29 June, about 30% of the females emerged on spruce, but few, on fir (Fig. 1). From 30 June to 3 July the weather was unseasonably cold and wet and the rate of emergence was slow. Emergence increased on 4 July and was complete on both host species by 10 July.

The first sprays were applied to the two Dimecron blocks and the two Matacil blocks when 20-40% of the females and 60-70% of the males had emerged. The second spray was applied when about 60% of the females had emerged, and the third, when emergence had just terminated. Spray aircraft reported good spraying conditions.

Treatment Success Evaluated on Fall-out of Dead Moths

Five collecting trays (0.9 x 1.8 m) per block were set out in the four spray blocks and in two check plots primarily to determine mortality of non-target organisms, particularly parasites and predators,

Fig. 1. Female emergence and spray dates, Acadia, 1976.



but dead moths were also counted (Table 3). A mean number of 99 dead moths per 10 m^2 of tray area was collected on the two check plots but on the spray blocks counts ranged from 179 on the 3X Matacil Block 4 to 661 on a Dimecron Block 1. This comparison of natural and treatment-induced mortality clearly shows that the treatments killed a large number of males and females particularly on 5-6 July. However, it is impossible to translate these data into a percent adult mortality, nor was the sampling precise enough to conclude that three times as many adults were killed on Block 1 as on Block 4. Nevertheless, the counts per day show that mortality occurred for at least 2 days after treatment and late in the season few adults survived in the treatment blocks compared to the check plot.

Treatment Evaluation Based on Egg Counts

About 500 midcrown branches were collected from fir and spruce between 26 June and 10 July to determine the trend in oviposition early in the oviposition period. The foliage was dipped in boiling water for about a minute and the unhatched egg masses were collected from the bottom of the container. (The observed number of egg masses and the rate of female emergence were used in deciding when to apply the first spray.)

The first branches were sampled on 26 June and the first egg mass was found on 27 June on spruce. Branch samples collected from check plots showed that few eggs were laid between 27 June and 5 July, (Fig. 2), most were laid between 6 and 11 July and the time from the

Fig. 2. Seasonal trend in oviposition, Acadia, 1976.

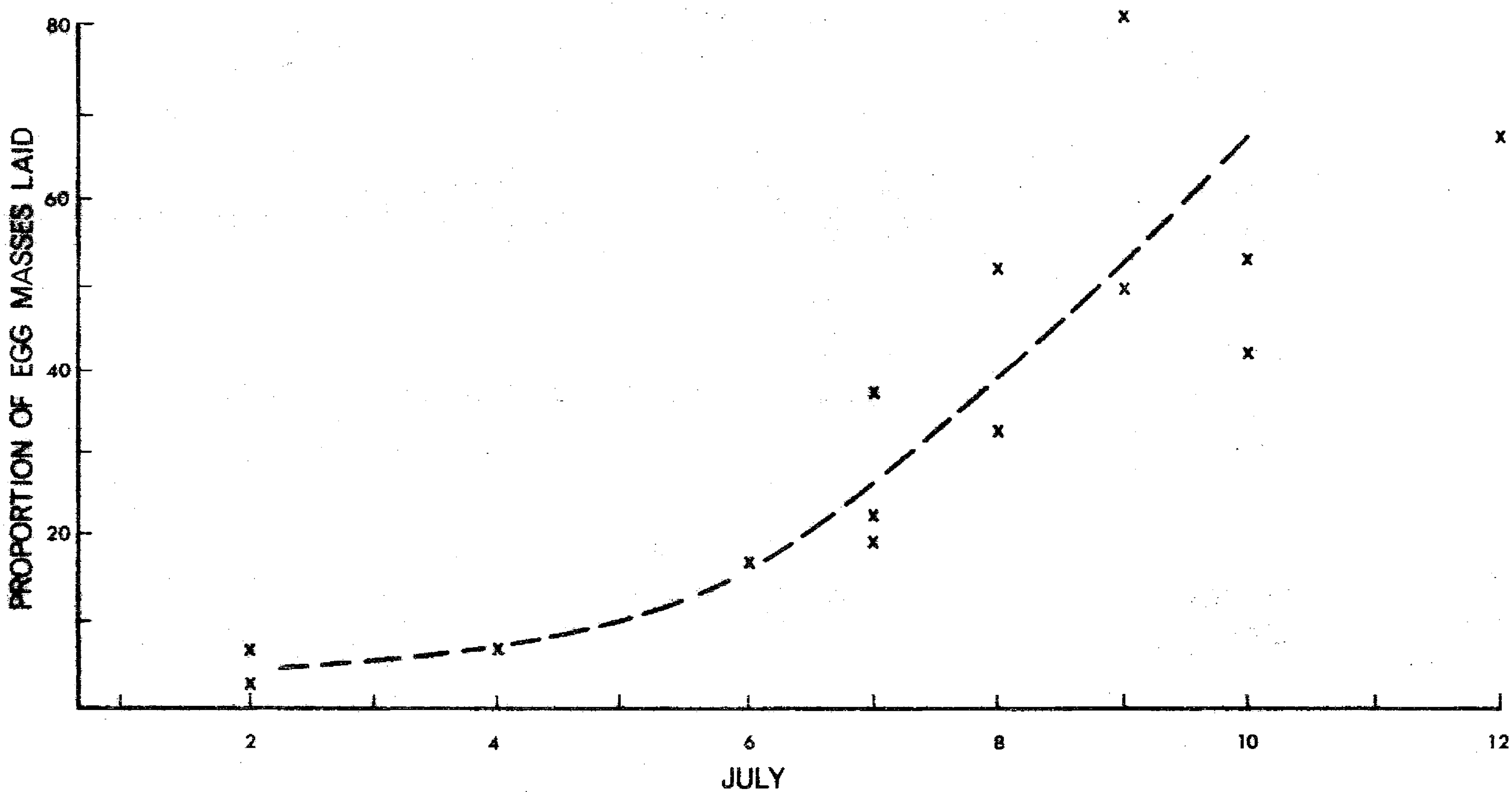


Table 3. Dead adults per 10 m^2 of collecting surface, Acadia 1976

	Check		Block 1		Block 2		Block 4		Block 5	
Date	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
July 4	1.2	0	1.2	0	0	0	1.2	0	-	-
			--- S ---		--- S ---		--- S ---		--- S ---	
5	1.8	0	142	123	28.7	13.2	9.6	0	27.5	9.6
			--- S ---		--- S ---					
6	3.0	0.6	57.5	15.6	13.2	2.4	20.4	2.4	16.8	8.4
							--- S ---		--- S ---	
7	4.2	1.2	46.7	77.8	45.5	19.2	34.7	26.3	33.5	20.4
8	8.4	6.0	18.0	32.3	6.0	9.6	8.4	13.2	6.0	8.4
9	7.2	10.2	16.8	28.7	13.2	37.1	7.2	12.0	7.2	6.0
			--- S ---		--- S ---		--- S ---			
10	8.4	4.2	20.4	64.7	18.0	38.3	13.2	4.8	8.4	18.0
11	8.4	6.0	0	10.8	1.2	6.0	6.0	15.6	1.2	10.8
12	2.4	9.6	0	0	0	7.2	0	3.6	2.4	3.6
13	1.2	4.2	0	3.6	0	1.2	0	0	0	0
14	1.2	0	0	0	0	0	0	0	0	1.2
15	1.2	1.8	0	1.2	1.2	0	0	0	0	0
16	1.2	1.8	0	0	0	0	0	0	0	0
Seasonal Mean	99		661		262		179		189	
Percent females	45		54		51		44		46	

S = Spray date

first egg mass to 50% ovipositon was about 12 days. On the basis of egg deposition, it appears that spray applications (4-10 July) were well-timed to disrupt oviposition.

The mean egg-mass density on the spruce check plots was 380 masses per 10 m^2 (Table 1). Fewer masses were found on all treatment blocks; densities ranged from 98 masses per 10 m^2 on the 3X Matacil block, to 241 masses on one 3X Dimecron block (Table 1). A comparison of these counts suggests that all treatments, but particularly three applications of Matacil, resulted in a significant reduction in eggs laid.

There was also a significant reduction (53%) in egg deposition on fir in the 3X Matacil block (Table 2), which confirms the observations on spruce. But, unlike the counts on spruce, there was no apparent reduction in the number of egg masses on fir on the other blocks. This anomaly arose from the surprisingly low egg-mass counts on fir in the check plots. Both the female counts and overwintering larval counts on fir were high on these plots and we have no obvious explanation for the low egg-mass counts (Table 2).

The treatments were also evaluated on the basis of the calculated egg masses laid per female on the assumption that dispersal of local females was minimal. On the spruce check plots, there were fewer egg masses per female on the 3X Matacil block (56% reduction) and Dimecron block 1 (37% reduction). There was no apparent reduction on the Dimecron block 2 or the 2X Matacil block (Table 1). On fir, the low egg-mass counts in the check plots obscured the analysis of egg masses per female.

Treatment Evaluation Based on Overwintering Larval Counts

All treatments resulted in a pronounced reduction in the number of overwintering larvae on spruce and fir. The largest reduction, 78%, occurred on the 3X Matacil block and the lowest, 42%, on Dimecron block 2 (Tables 1 and 2). The analysis of overwintering larvae per female also showed that the treatments resulted in reductions in budworm abundance but the results were variable (Tables 1 and 2).

Treatment Success Evaluated on Male Adult Counts

A total of 70 traps baited with budworm sex pheromone was set out and checked daily in the four treatment blocks and six check plots. (The traps were constructed from cardboard milk cartons with the ends removed and the inner surfaces covered with tanglefoot.) The number of males caught after spraying was compared to the number caught before the treatment (Table 4). For example, 1096 males were trapped on the 3X Matacil block after the first spray on 5 July compared to 1032 before spraying, or a ratio of 1.06:1 males after spraying (Table 4). On the check plots, the ratio was 9467:2345 or 4.04:1. The difference between these two ratios suggests a 74% kill of males in the 3X Matacil block. These data confirm the analyses of eggs and L2 noted above;- that the most effective treatment was the three applications of Matacil. A significant proportion of males was also killed in all other blocks suggesting that insecticides are particularly effective in disrupting the behavior of male budworm.

Table 4. The number of adult males caught in sex-attractant traps and the apparent kill of males in sprayed blocks, Acadia 1976

Block	First Spray	Males Captured				Apparent Kill of Males (%)
		Mean/Trap/Day	Before Treatment (a)	After Treatment (b)	Ratio (a)/(b)	
1 Dimecron 3X	4 July p.m.	7.59	532	834	1.57	72
2 Dimecron 3X	4 July p.m.	4.70	205	636	3.10	45
4 Matacil 3X	5 July a.m.	11.8	1032	1096	1.06	74
5 Matacil 2X	5 July a.m.	11.4	722	1325	1.84	54
Check Plots		19.8	1780	10,022 (c)	5.63	
			2345	9467 (d)	4.04	

(c) Trapped after 4 July.

(d) Trapped after 5 July.

Treatment Evaluation Based on Canopy Light Trap Catches

A light trap was suspended within the forest canopy in Dimecron block 1 and one check plot from 24 June to 12 July. From 24 June to 3 July 461 moths were taken in the Dimecron block and a similar number, 512, in the check plot (Table 5). On the evening of the first spray (4 July), and the following night, more adults (3993) were caught in the Dimecron block (3993) than in the check plot (3145) indicating minimal spray effect. Furthermore, the average sex ratio of the catches on the 4-5 July, 8% females in the Dimecron block, and 12% in the check plot, failed to show a higher rate of kill among males.

The second spray was applied on 6 July, 0630 hrs. Fewer moths were captured in the spray block than in the check plot on the evening of the treatment and far fewer on the following evening. Thus, the second application caused a marked reduction in moth abundance. Over 50% of the moths caught in the Dimecron block after the second treatment were females (less than 30% in the check) indicating that the males were much more susceptible to the spray than females.

Oviposition Status of Female Moths Killed in Treatment Blocks

Dead female moths collected in the four treatment blocks were examined to determine whether or not they had mated and, if not gravid, what proportion of the eggs had been laid. To check proportion of eggs laid a relationship was developed to predict how many eggs a female had laid on the basis of her dry weight and wing length (A.W. Thomas, In preparation).

Table 5. Spruce budworm moth catches in canopy light traps, Acadia 1976

	Dimecron Block 1				Check Plot			
Night of	Total Budworm	Males	Females	% Females	Total Budworm	Males	Females	% Females
24/25 June	131	129	2	2	65	65	0	0
25/26	1	1	0	0	0	0	0	–
26/27	–	–	–	–	1	1	0	0
27/28	–	–	–	–	3	3	0	0
28/29	167	151	16	10	212	193	19	9
29/30	30	29	1	3	33	33	0	0
30/1 July	15	14	1	7	30	30	0	0
1/2	0	0	0	–	6	6	0	0
2/3	79	79	0	0	146	137	9	6
3/4	38	38	0	0	16	16	0	0
4 July	Spray treatment 2015 hrs							
4/5	2078	1914	164	8	1348	1143	205	15
5/6	1915	1766	149	8	1797	1611	186	10
6 July	Spray treatment 0630 hrs							
6/7	1661	701	960	58	2045	1466	579	28
7/8	750	192	558	74	2774	2125	649	23
8/9	393	35	358	91	1490	1088	402	27
9 July	Spray treatment 2045 hrs							
9/10	26	7	19	73	267	231	36	13
10/11	2	1	1	50	293	231	62	21
11/12	0	0	0	–	123	112	11	9
12/13	2	1	1	50	0	0	0	–

For example, on 5 July, 46 females collected from the check plot (insecticide-treated spruce) were weighed and measured and at least 13 of the 46 (bottom line in Fig. 3) had laid no eggs. In other words, 28% of the female population was gravid. In contrast, only 1 of 51 females collected on 5 July after the first Dimecron spray was gravid (Fig. 4). Again on 9 July, most of the females collected on the Dimecron block had laid 50% or more of their eggs (Fig. 5). These data suggest that gravid females either do not drop out of the tree crowns to the collecting mats, or more likely, that the adult spray kills only the 'active' females that have laid 50% or more of their eggs. Apparently, the less active the female, the less likely she will come in contact with the insecticide.

DISCUSSION

The various evaluation tests showed that three applications of Matacil were the most effective of the three spray treatments and caused a 50 to 60% reduction in egg deposition and density of overwintering larvae. But the overall results of the trials were difficult to interpret because of (a) the unexplained low egg-mass counts on fir in the check plots, (b) the difference in egg-mass counts on fir and spruce in most blocks, and (c) failure to obtain comparable results in the replicated Dimecron treatment. To elaborate, more egg masses were generally found on spruce than on fir in spite of the fact that female densities were higher on fir. With the exception of Block 1, counts of pupae on fir

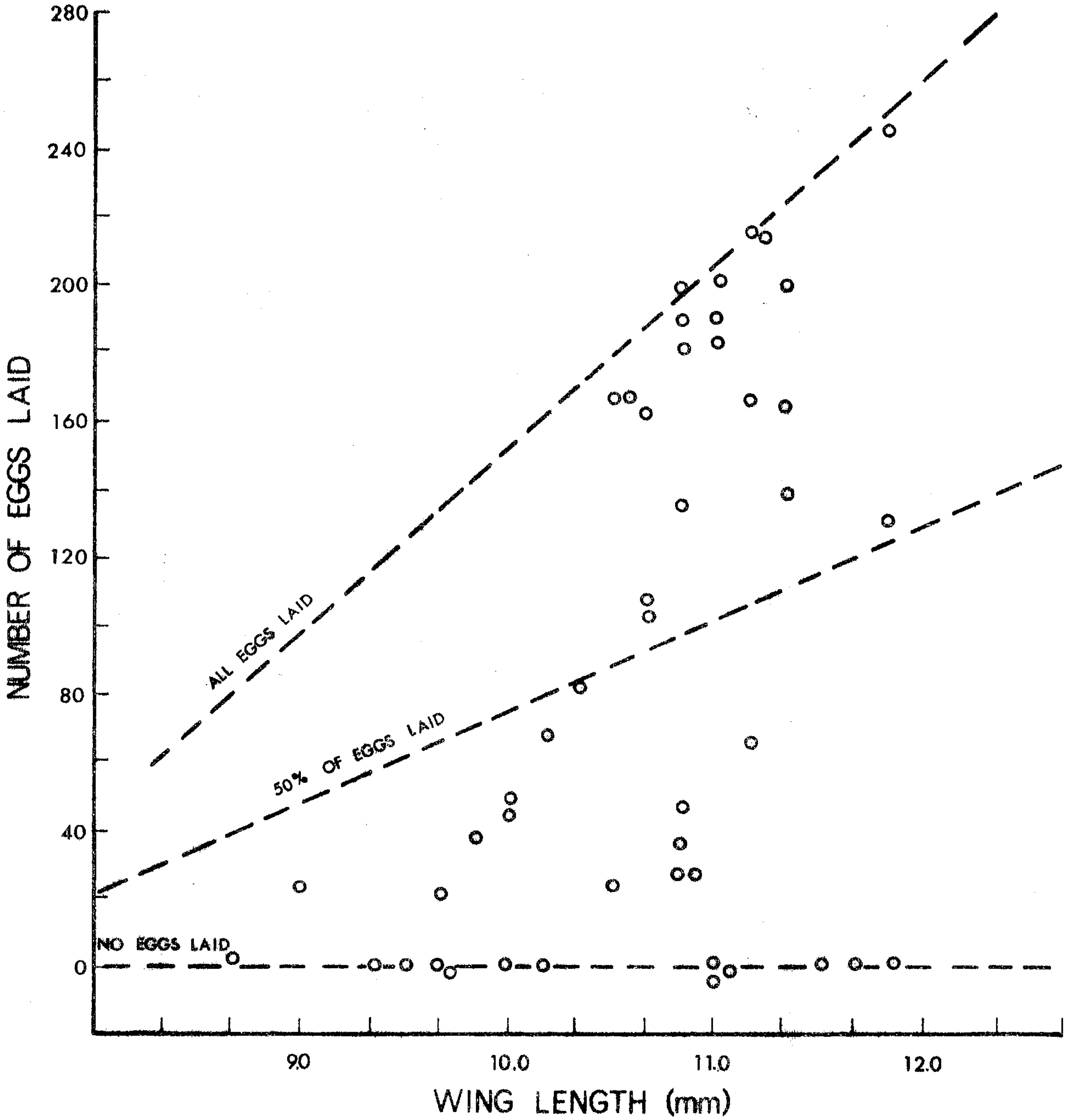


Fig. 3. Oviposition status of 46 females collected from spruce check plot, 5 July. Note the 13 points which represent fully gravid females (bottom line of graph).

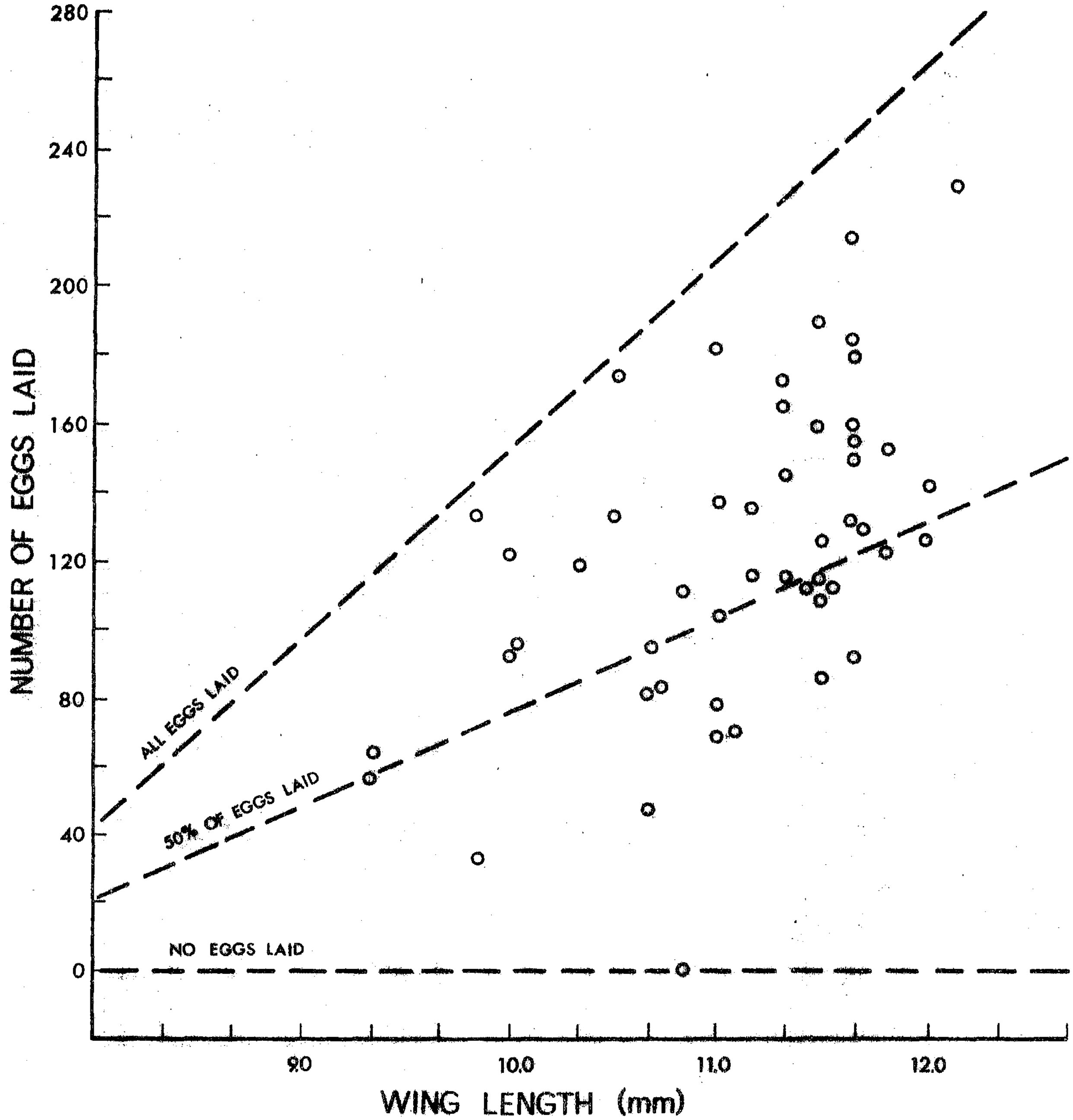


Fig. 4. Oviposition status of 51 females collected on Dimecron blocks after first application. Spray was apparently selective to females that had already laid 50% of their eggs.

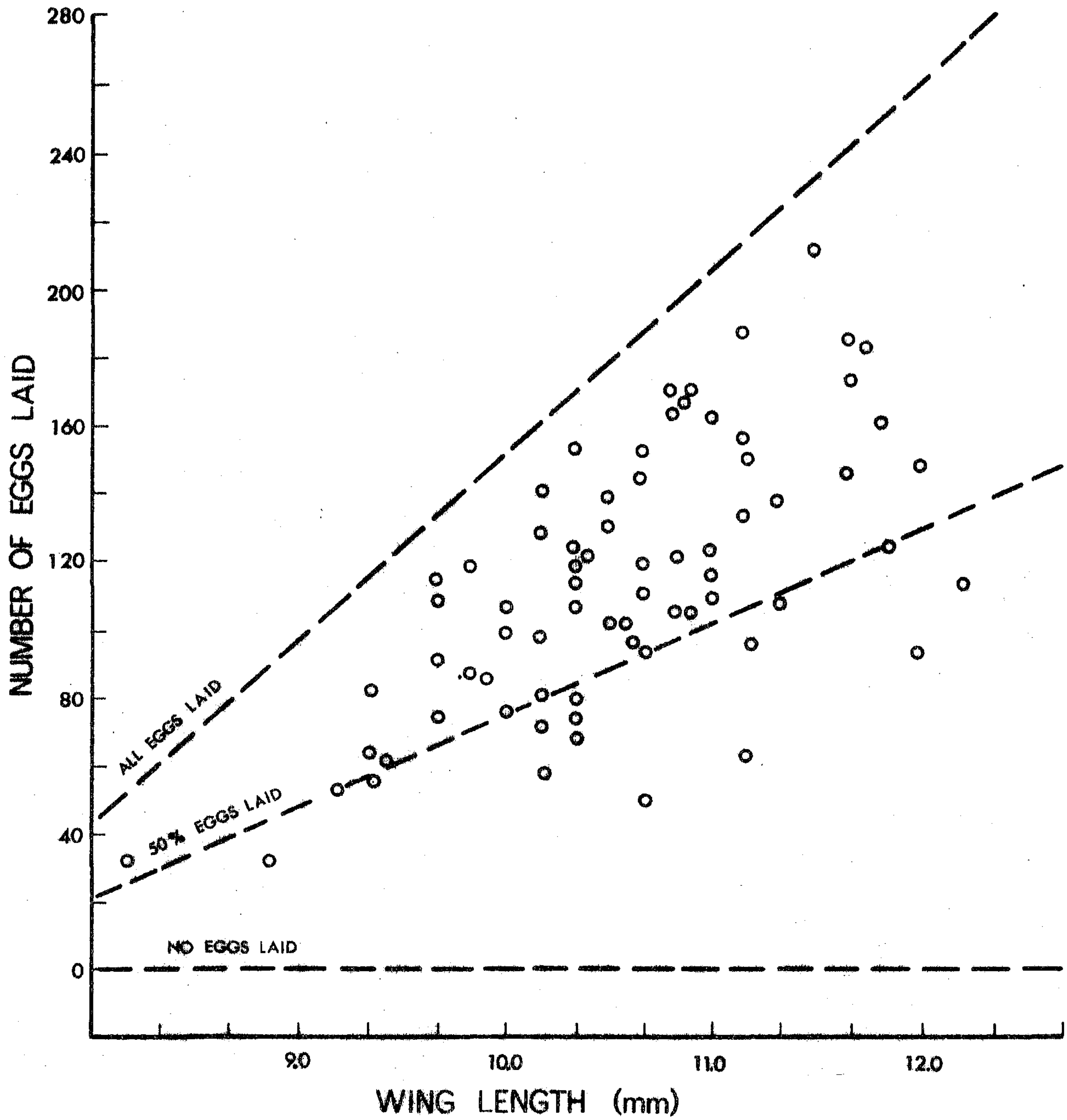


Fig. 5. Oviposition status of 71 females collected on Dimecron blocks after the third spray. Spray was apparently selective to females that had laid 50% of their eggs.

and spruce showed a mean fir/spruce ratio of 1.68:1, while egg-mass counts had a fir/spruce ratio of 0.85:1 and as low as 0.42:1 on the check plots where defoliation of fir was severe. The simplest explanation is that local females preferred to oviposit on spruce possibly because past defoliation was less severe on spruce and the trees may have contained more favorable oviposition sites.

The Dimecron treatment was replicated in Blocks 1 and 2 but the apparent reduction in egg masses and overwintering larvae was much higher on Block 1. The only obvious difference between the two blocks was the 'absence' of fir in Block 2, but this hardly accounted for the experimental differences because fir was not plentiful in Block 1.

On the positive side, two items of information were obtained that will modify future experiments; (a) the 1976 trials suggested that we may have killed far fewer gravid females in pre-1976 tests than expected and (b) it is becoming more obvious after 2 years of testing that adult spray trials cannot be successfully conducted on small blocks of about 300 ha. Large blocks (about 4000 ha) are needed to minimize the confounding effect of local moth dispersal across spray boundaries.

DUNPHY TESTS: METHODS AND RESULTS

The spray tests against adult budworm in the Dunphy area, 1976, were aimed at testing the effectiveness of two insecticides; Sevin-4-oil and Orthene, and the persistence of Sevin-4-oil. The two insecticides were applied to five blocks of approximately 250 ha each.

All blocks were sprayed with 730 ml/ha of formulation in the following manner.

Treatment (gm per ha)	Block number	Dates sprayed	Aircraft
Sevin-4-oil 560 gm + 560 gm	6	3 July, p.m. 7 July, a.m.	AgTruck
Sevin-4-oil 560 gm + 560 gm	10	3 July, p.m. 9 July, a.m.	AgTruck
Sevin-4-oil 1120 gm	7	5 July, a.m.	TBM
Sevin-4-oil 1120 gm	9	5 July, a.m.	TBM
Orthene 280 gm + 280 gm	8	5 July, a.m. 9 July, a.m.	AgTruck

Micronairs were used on the AgTrucks and boom and nozzle on the TBM's.

Resident Budworm Densities and Development

Sample plots were established at five locations in each spray block and in check areas. Five balsam fir were sampled at each location. Pupae and pupal cases (resident populations) were counted on all plots at the peak of the pupal stage and on four occasions during the egg-sampling period. The mean of the latter counts showed pupal densities (female pupal cases) ranging from 2.3 to 93 per 10 m^2 of foliage in the treatment blocks and check plots, respectively (Table 6). This wide variation caused obvious difficulties in the interpretation of spray results.

Table 6. Population counts, Adult spray tests, Dunphy 1976

Block	Treatment	Female emergence (%) at last spray	Female cases/10 m^2	Egg masses/10 m^2	L2/10 m^2	Egg masses per female	Total males trapped
6	Sevin 560 gm + 560 gm	29	47	80	444	1.7	1778
10	Sevin 560 gm + 560 gm	80	4.6	29	97	6.1	1225
7	Sevin 1120 gm	9	56	126	141	2.3	2447
9	Sevin 1120 gm	9	4.5	22	155	4.7	1208
8	Orthene	80	2.3	23	78	10	1038
Check			93	160	319	1.7	3446

Treatment Evaluation

The evaluation of the two insecticides to post-treatment counts was limited to (a) males in sticky traps baited with budworm sex pheromone, (b) egg masses, and (c) L2 in hibernacula.

The nightly catches of males in the sex attractant traps in the check plots showed a peak in seasonal activity on the nights of 6 and 7 July and the first spray applications (3 and 5 July) had little effect on this peak. Fewer males were captured in the treatment blocks compared with the check but the cause could be attributed either to fewer residents or to spraying (Table 6). In the light of other measurements, the latter is the more appropriate interpretation.

Egg masses were sampled throughout the oviposition period but graphs of egg-mass accumulation over time did not show that spraying had a dramatic effect on egg deposition.

The lowest egg-mass densities, 22, 23, 29 per 10 m^2, and low L2 densities were recorded in Blocks 9, 8, and 10, respectively, where resident female densities were also low, being less than 5.0 per 10 m^2 (Table 6). In these blocks, including the Orthene treatment, it is difficult to determine whether the low egg mass counts were the result of low resident female densities or spray treatment but the former is probably the correct interpretation. In Blocks 6 and 7 with relatively high female densities there was little evidence that Sevin-4-oil sprayed early in the season had an effect on the adults. Furthermore, no adults were killed in laboratory experiments in which males and females were caged for 4 days with foliage collected from an area sprayed with 16 oz of Sevin. These results showed that treating adults with Sevin-4-oil has little to recommend it in reducing the accumulation of eggs and the subsequent establishment of second-instar larvae.