AERIAL APPLICATION OF NUCLEAR POLYHEDROSIS VIRUS AGAINST SPRUCE BUDWORM ON MANITOULIN ISLAND, ONTARIO IN 1974 AND A SURVEY OF THE IMPACT OF THE VIRUS IN 1975

by

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ABSTRACT

A 520 ha plot and a 6 ha white spruce plantation infested with spruce budworm were sprayed with nuclear polyhedrosis virus on Manitoulin Island, Ontario in 1974. The application was made using a Grumman Agcat biplane fitted with Micronair spray equipment. The emission rate was 9.4 l/ha, the dosage of virus was 250 billion polyhedra per hectare, and the formulation contained 30 gm/l IMC 90-001 sunlight protectant and 1.25 ml/l Chevron^{R} sticker. At the time of the application larvae were mainly in the fourth instar in the large plot; equal numbers of fourth and fifth instar were present in the white spruce plantation.

The efficacy of the spray was evaluated by population reduction studies, defoliation estimates and microscopic diagnosis of insects to determine the level of virus infection following the spray. Samples were again taken in 1975 to determine the persistence of the virus in the insect population.

In the year of application 58% population reduction was recorded on balsam fir hosts and only 5% on white spruce in the large block. In the year following application virus carryover caused 44% population reduction on balsam fir and 77% on white spruce.

In the white spruce plantation there was 46% mortality. due to virus in 1974 and carryover accounted for 24% in 1975. There was no apparent saving of foliage in 1974 or 1975 in the large plot but beneficial effect was noted in the spruce plantation.

In 1975 nuclear polyhedrosis virus was detected in three check areas close to the large virus block. It is possible that the virus may have spread from the large block and, if this is the case, the potential usefulness of the virus as an agent for biological control is greatly enhanced.

Résumé

Une parcelle de 520 ha et une plantation de 6 ha d'Epinette blanche infestées par la Tordeuse des bourgeons de l'Epinette ont été arrosées de virus de la polyédrose nucléaire en 1974 dans l'Ile Manitoulin (Ont.). On a utilisé à cet effet un biplan Grumman Agcat équippé d'un système de pulvérisation Micronair. Le taux d'émission était de 9.4 ℓ/ha, à raison de 250 billions de polyèdres de virus à l'hectare dans une mixture contenant 30 gm/ℓ de l'agent de protection contre la lumière solaire IMC 90-001 ainsi que 1.27 $m\ell/\ell$ de l'adhésif Chevron®. Au moment de l'application, les larves de la Tordeuse se trouvaient en majeure partie au quatrième stade de développement dans la grande parcelle, et à parts égales aux quatrième et cinquième stades dans la plantation.

L'efficacité de cet épandage a été dans la suite évaluée par étude de la réduction de population, inventaire de la défoliation et examen microscopique des insectes pour y déterminer le niveau de l'infection virale. Des échantillons ont été encore prélevés en 1975 à l'effet de déterminer la persistance du virus dans cette population d'insectes.

Au cours de l'année de traitement la réduction de population enregistrée sur le Sapin baumier était de 58% et seulement 5% sur l'Epinette blanche dans le grand bloc. L'année suivante la persistance du virus réduisait la population d'insectes de 44% sur le Sapin baumier et de 77% sur l'Epinette blanche. Dans la plantation d'Epinette blanche il y avait une mortalité de 46% imputable au virus en 1974 et de 24% à sa persistance en 1975. Il n'y avait pas de préservation apparente du feuillage en 1974 ou 1975 dans la grande parcelle, mais des effets bénéfiques ont été notés dans la plantation d'Epinette.

En 1975 le virus de la polyédrose nucléaire a été détecté dans trois zones de contrôle au voisinage du grand bloc arrosé. Il est possible que le virus se soit disséminé à partir de ce bloc et, si tel était le cas, son utilité potentielle comme agent de lutte biologique se trouverait considérablement renforcée.

INTRODUCTION

Aerial spray trials with spruce budworm nuclear polyhedrosis virus (NPV) have been conducted each field season since 1971 and the results have been summarized by Cunningham et al. (1974). Generally, better control of spruce budworm larvae has been achieved on white spruce hosts than balsam fir hosts. Also early spray applications when larvae are in the second and third instar have given better results in controlling larvae on white spruce. Later sprays when larvae are at the peak of the fourth instar have proved more effective for controlling larvae on balsam fir.

This virus was found to persist from year to year in two spruce plantations near Pembroke sprayed in 1971 (Howse et al., 1973), and it is still present, and having an impact on the spruce budworm population in 1975 (unpublished data). These plantations are isolated and reinfestation probably did not occur.

In 1973, a total of nine plots ranging in size from 13 to 56 ha were sprayed with NPV near Massey and at Aubrey Falls, Ontario. Moderate levels of virus infection and population reduction were recorded in the year of application but carry-over of virus to the

following year was disappointing and did not have the same impact as the applications made in 1971 (Cunningham et al., 1974). These plots were located in large areas of heavy budworm infestation and it is fairly certain that there was considerable movement of adult moths into and out of the plots. It has been postulated that transmission of virus from one year to the next is by diseased cadavers adhering to the foliage over the winter months and, if this is in fact the case, movement of adult moths should have no effect on transmission of the virus.

Bearing in mind these uncertainties, it was decided to find another isolated area and attempt to reproduce the 1971 experiment, or to spray a large area which would buffer and reduce the effect of adult moth immigration and emmigration. As a suitably isolated locality could not be found, the latter policy was adopted in 1974. It was decided to spray all the virus available in a large block and to spray more forest in the same area in 1975.

A wide range of dosages of NPV have been tested ranging from 25 billion polyhedra/ha to 750 billion polyhedra/ha. 750 billion polyhedra/ha was used most successfully in 1971 but this is too heavy to be economically feasible. It is considered that dosages in the range of 125 billion to 250 billion/ha would be economically feasible.

Although results have been consistently better on white spruce hosts, the spruce budworm is a much more serious problem on balsam fir especially in Quebec and the Maritime Provinces and most attention should be given to improving control on this host. After an extensive search a suitable area of 520 ha was found for the 1974 spray trials on Manitoulin Island, Ontario where there was a large flat area of fairly uniform forest type with balsam fir as the dominant species. Not far from this area there were two white spruce plantations, both about 6 ha and it was decided to spray one of them in an attempt to reproduce the results from the plots sprayed in 1971.

Several formulations have been tested over the last 3 years and no definite conclusions can be drawn. The virus is quickly inactivated by the UV in sunlight and there is no doubt that mortality could be greatly increased if the virus would persist in a viable state on the foliage for several days. The highest levels of virus infection obtained in 1973 were in the late spray application with a formulation of IMC 90-001 UV protectant at 30 g/l and Chevron^{R} sticker at a rate of 1.25 ml/l. It was decided to use this formulation in 1974 although the possibility existed that it could be considerably improved.

This report describes the spray application, assess-

ment of the level of virus infection in the population, the population reduction due to the virus and defoliation in sprayed and untreated areas in 1974. Also a similar survey was made in 1975 to determine the effect of virus carry-over from one year to the next. The spray application and determination of the level of virus infection were performed by IPRI personnel and population reduction and defoliation estimates by GLFRC staff.

MATERIALS AND METHODS

Virus production

In the winter of 1973-74, a total of 2.5 million spruce budworm larvae were reared on artificial diet. Of these 1,738,000 survived to fifth instar and were infected with NPV. This yielded 14 kg of freeze dried virus-infected material containing 8 billion polyhedra/g.

Experimental plots

A 520 ha block was selected on Manitoulin Island, Ontario in Robinson Twp., North of Burnt Island (Fig. 1). The stand was composed of about 60% balsam fir stems, 20% poplar stems, 10% white spruce stems and 10% other species. There was no overstory of hardwoods and the dominant balsam fir were 10 to 12 m tall. The area was

flat limestone country with very little soil covering and tree growth was below average.

Two 6 ha spruce plantations, 1.5 km apart, with trees about 6 m tall were located in Dawson Twp. about 10 km from the large block (Fig. 2). One of them was selected as a spray plot and the other left unsprayed as a check.

Two roads ran through the large plot and flight lines 30 m apart were marked on both roads. Trails were marked to the plot corners using red flagging tape and at the time of the spray application red meterological balloons were used to guide the aircraft. Small cylinders filled with helium were carried to the plot corners and balloons put well above the canopy prior to spraying. A balloon was also put on the road on the east side of the plot and moved from one stake to the next to guide the aircraft accurately on each pass it made.

Mixing and formulating the virus

The freeze dried insect powder was weighed into batches of 1,000 g and each batch was put into suspension in 40 l of water using a Kalish^{R} turbo homogenizer. It was then filtered through a 20 mesh sieve and stored in plastic gasolene cans.

IMC 90-001 sunlight protectant[1] was mixed at 10 times

1. Sandoz-Wander Inc., Homestead, Florida 33030.

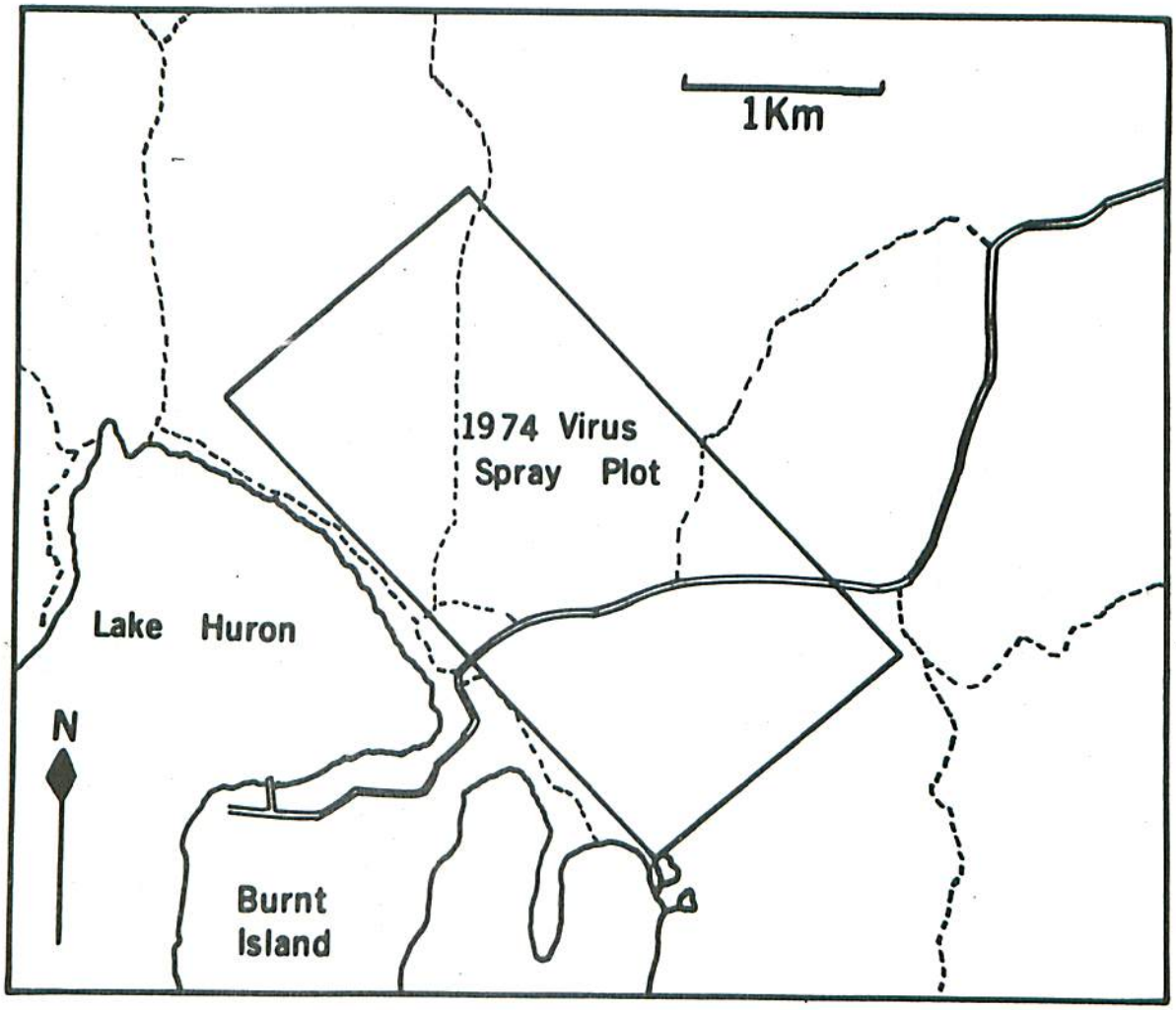

Fig. 1. Location of the 520 ha block sprayed with NPV in 1974 in Robinson Twp., Manitoulin Island, Ontario.

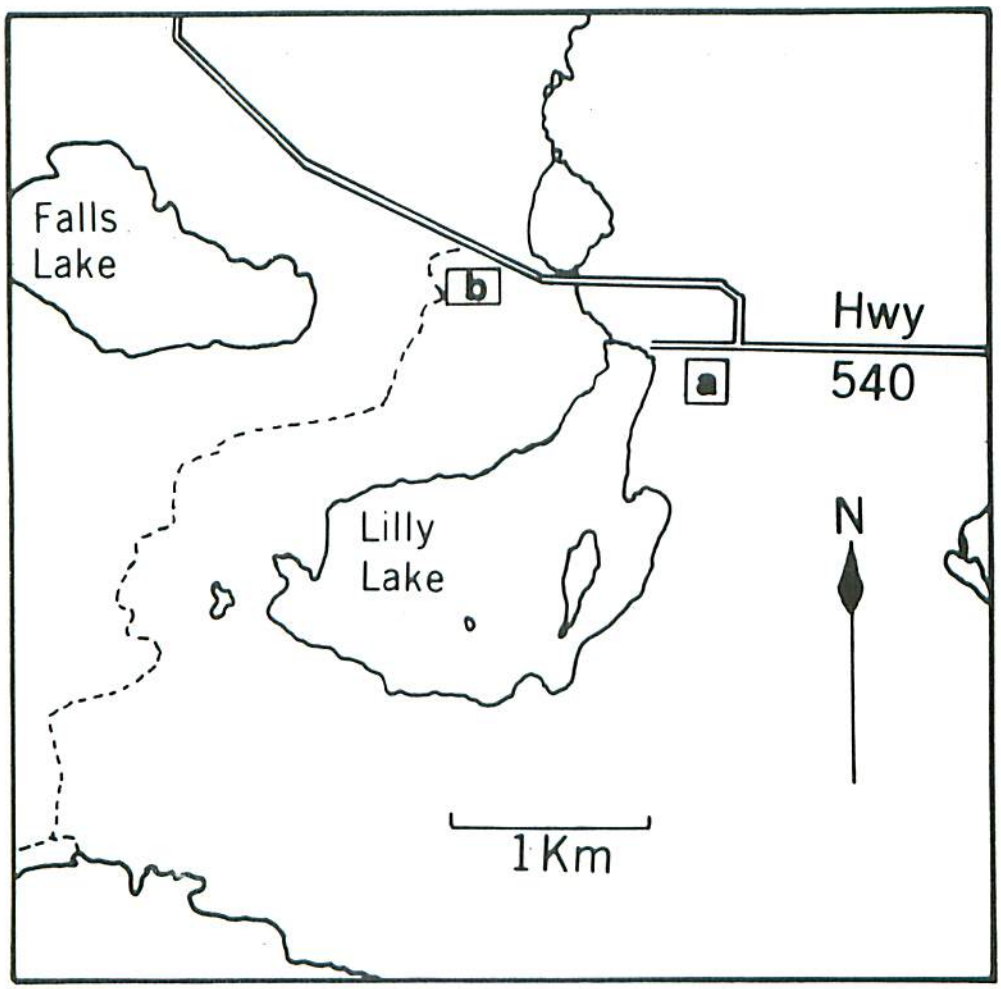

Fig. 2. Location of two white spruce plantations in Dawson Twp., Manitoulin Island, Ontario a) sprayed with NPV in 1974 b) check plot

strength (300 g powder/l) in 160 l drums and it went into suspension without stirring over a period of 2 to 3 hr. The final mixing was done in a 1,600 l animal water trough. Chevron[R] sticker was added at the rate of 1.25 ml/l. The concentrated virus suspension was added directly to the tank in the aircraft and the formulation pumped in to make a total volume of 760 l.

The final concentration of virus was 26 billion polyhedra per litre.

Aircraft and spray application

A Grumman Agcat biplane fitted with 4 Micronair AU 3000 units and owned by General Airspray Ltd. was contracted for the application. Spray mixing and loading was conducted at Gore Bay airport. It was found necessary to remove the pump and line filters in 1972 (Cunningham and McPhee, 1973) and this procedure was repeated. The application rate was calibrated to 9.4 l/ha assuming a 30 m swathe width.

Spraying commenced on the evening of June 12 on the large block, continued on June 13 and finished on the morning of June 14. A total of 7 loads were applied on this plot. The balsam fir buds were fully expanded and starting to flush open and most of the white spruce buds had not lost their caps. Larvae were mainly in the fourth instar.

On June 14 the 6 ha white spruce plantation was sprayed immediately after finishing the large plot. Here bud development and insect development were further advanced than on the large plot; the buds had all shed their caps and there were equal numbers of fourth and fifth instar larvae present.

Monitoring the deposit

Kromekote^{R} spray cards mounted on plywood backing were placed at 15 m intervals along both roads running through the large block and along a fence bordering the edge of the spruce plantation at right angles to the flight lines.

In order to analyse the droplet spectrum, the number of droplets on 5 cm^2 of each card were counted and the diameter of each droplet on 1 cm^2 was measured using a calibrated eyepiece in a dissecting microscope.

Sampling for population reduction studies in 1974 and 1975 and insect counting techniques

As NPV takes at least 10 days to kill spruce budworm larvae in the field pre-spray samples were taken on June 19, 1 week after the start of the operation. Random samples of 100 white spruce 46 cm branch tips and 100 balsam fir branch tips were taken from the large plot and 50 white spruce 46 cm branch tips from the white spruce plantation. Five unsprayed check areas were selected and 25 white spruce and 25 balsam fir 46 cm branch tips collected

from them and 50 branch tips from the white spruce check plot. The same number of samples were collected in a post-spray collection at the time when most of the larvae had pupated.

In 1975, early samples were collected on June 9 from the large virus plot and spruce plantation and from 10 check areas on June 7, 8 and 9. Twenty five white spruce and 25 balsam fir were sampled in the large block, 25 white spruce from the sprayed plantation and the check plantation and 15 white spruce and 15 balsam fir in each of 10 check areas. Pupal samples were collected on July 1, 2 and 3.

Larvae were removed from the foliage and counted using the "drum method" described by DeBoo et al. (1973) and Martineau and Benoit (1973). Pupal samples were hand picked. Abbott's formula (Abbott, 1925) was used to calculate the effectiveness of the two treatments.

Sampling larvae for microscopic examination to determine the level of virus infection in 1974 and 1975.

In 1974, 50 white spruce and 50 balsam fir 46 cm branch tips were randomly collected from the large virus plot on June 30 and again on July 6 (16 days and 23 days post-spray). 50 white spruce samples were taken from the plantation on June 29 and on July 6. The white spruce check plot was sampled on July 6 when 20 random samples were collected, and an area north of the large virus plot was sampled as a check on July 7. Here 10 balsam fir and 10 white

spruce samples were collected.

In 1975, the large virus plot was sampled 3 times, on June 9, June 19 and June 25 when 20 random samples each of white spruce and balsam fir were collected; 20 samples were collected from the white spruce plantation on June 9, 18 and 25. The white spruce check was sampled on the same dates and the same number of samples collected. In 1975, 4 check areas were sampled, 3 in close proximity to the large virus plot and one further away. They were sampled on June 18 and 19 and June 25; from each plot 10 random samples of white spruce 46 cm branch tips and 10 balsam fir 46 cm branch tips were collected.

Microscopic diagnosis

Larvae and pupae were examined microscopically as described by Cunningham et al. (1974) and NPV, cytoplasmic polyhedrosis virus (CPV), entomopoxvirus (EPV) and microsporidia recorded.

Estimates of defoliation

The percent current defoliation was obtained by detailed examination and estimation of the degree of defoliation sustained by the 46 cm branch tips collected for the pupal sample from treated and check plots after spruce budworm had ceased feeding.

RESULTS

Deposit Analysis

The mean number of droplets per cm^2 (with standard deviation) on the large virus plot was 48±22 and on the spruce plantation was 72±29. The percentage of droplets in different size categories is given in table I. It can be seen that in the large plot there were two peaks, one at the 41-120 μ size categories and the other at 201-400 μ category. In the spruce plantation the majority of droplets were in the 201-400 μ category. Coverage was complete on the spruce plantation and on the easterly road in the large plot where the guide balloon was used. However, on the westerly road where cards were placed but no balloon used there was no deposit on the last 180 m of the plot, and due to pilot error, the north west corner of the plot was not sprayed.

Incidence of viruses in the year of application - 1974

The results of the impact of the NPV and levels of microsporidia in the spruce budworm population are given in table II. Higher levels of infection were found in the first sample taken 16 days after the application than in the second sample. No viruses were found in either check area. Maximum levels of 19.0% virus infection of spruce budworm on balsam fir and 11.6% on white spruce were found on the large block and 14.9% in the

white spruce plantation. A total of 2,564 larvae and pupae were examined microscopically from the sprayed plots and check area.

Estimates of population reduction, pupal survival and current defoliation in 1974

The results of the population reduction studies are shown in table III. In the large block 58% population reduction occurred on balsam fir and only 5% on white spruce. In the white spruce plantation, population reduction was calculated to be 46%. In all cases, pupal mortality was higher in the treated areas than the untreated check plots.

Defoliation estimates are also included in table III and it can be seen that the foliage saved by the virus application was negligible.

Incidence of viruses in the year following application - 1975

A total of 2,042 larvae were examined from areas sprayed in 1974 and 1,987 from 5 check areas. Rather low levels of virus were found in the large block with the maximum level of only 2.2% virus infection of spruce budworm from balsam fir in the first of the 3 samples. The highest level of virus infection found in white spruce was in the third sample and was 7.1%. The maximum level of virus infection in spruce budworm in the white spruce plantation was 13.3% and was found in the final sample. The results are shown in table IV.

The levels of virus infection in the four check areas are shown in table V. Check area No. 1 was close

to the check area used in 1974, No. 2 and No. 3 were close to the large spray block and also close to two more plots which were sprayed in 1975 (Cunningham et al., 1975a). Check area No. 6 was 6 km from this area. There were surprisingly high levels of virus infection in check areas No. 1, No. 2 and No. 3 with maximum levels higher than on the large sprayed block. On check No. 1, a maximum level of 4.5% virus infection of insects on balsam fir was recorded and 9.9% was reached on white spruce; on check No. 2, 3.5% on balsam fir and 12.5% on white spruce; and on check No. 3, 1.1% on balsam fir and 9.2% on white spruce. Only 1.1% on balsam fir was recorded in check No. 6. No NPV and 0.6% CPV were found in the white spruce plantation check.

Population reduction, pupal survival and current defoliaton in the year following application - 1975

The results of population reduction and pupal mortality caused by virus which had carried over in the sprayed plots from 1974 to 1975 as well as defoliation in these areas compared to check areas are shown in table VI. In the large virus block there was 44% population reduction on balsam fir and 77% on white spruce caused by virus carry-over. Pupal mortality was higher on the sprayed area than in a check area with similar population density but the amount of foliage saved was again negligible.

In the white spruce plantation, 24% population reduction was attributed to virus carry-over, there was

no effect on pupal emergence and 26% defoliation occurred on the treated plot as compared to 49% in the untreated check.

As NPV had been detected in check areas No. 1, No. 2 and No. 3 which were close to the large spray block it was decided to analyse the data from them as though they were treated areas and compare the early samples and pupal samples to other check areas with similar population densities. The results were most interesting and are shown in Table VII. In these 3 "check" areas population reduction was very similar to the large virus block with 47%, 35% and 11% population reduction on balsam fir hosts in "checks" No. 1, No. 2 and No. 3 respectively and 73%, 81% and 61% on white spruce hosts. The effect on pupal emergence varied in these 3 "check" areas and there was no foliage saved.

Table I

Percentage of droplets on spray cards in different size categories

Plot	Size of droplets in microns							
	up to 40	41-80	81-120	121-160	161-200	201-400	401-600	601-800
Large plot	5.3	23.2	13.7	6.8	11.8	33.8	4.9	0.4
Spruce plantation	0.9	5.2	4.3	12.2	13.0	54.8	8.7	0.9

Table II

Incidence of viruses and microsporidia in plots sprayed with NPV and check plots on Manitoulin Island, Ontario in 1974.

Plot	Sample date	Tree Species	No. of insects examined	Per cent virus infection NPV	CPV	Per cent microsp.
Large block	30 June	bF	452	19.0		8.4
	30 June	wS	790	11.6		8.7
	6 July	bF	350	6.0	0.3	6.9
	6 July	wS	276	4.7		11.2
White spruce plantation	29 June	wS	308	14.9		3.2
	6 July	wS	179	4.5	0.6	2.2
Large block check	7 July	bF	103			3.9
	7 July	wS	31			9.7
White spruce plantation check	6 July	wS	75			4.0

Table III

Population reduction (adjusted for natural mortality) pupal survival and current defoliation in two plots on Manitoulin Island sprayed with NPV in 1974.

Plot	Pre-spray larvae/46cm branch tip		Surviving pupae/46cm branch tip		Percent Population reduction due to NPV Spray		% Successful Pupal Emergence[a]		Percent current defoliation in 1974	
	bF	wS	bF	wS	bF	wS	bF	wS	bF	wS
Large block	26.8	36.8	3.7	3.6	58	5	44	50	71	64
Check	33.8	37.6	11.1	3.9	-	-	66	72	71	67
White spruce Plantation		5.5		1.6		46		57		20
Check		4.5		2.5		-		76		24

a) % Successful pupal emergence = $\frac{\text{Emerged Budworm}}{\text{Budworm alive on sample date}} \times 100$

Table IV

Incidence of viruses and microsporidia in plots sprayed with NPV in 1974 in the year following application on Manitoulin Island, Ontario.

Plot	Sample date	Tree species	No. of insects examined	Percent virus infection NPV	CPV	Percent microsp.
Large block	9 June	bF	322	2.2		17.4
		wS	355	2.5		21.5
	19 June	bF	217	0.9		7.4
		wS	282	0.4		12.1
	25 June	bF	172	0.6		10.5
		wS	168	7.1		15.5
White spruce plantation	9 June	wS	198	2.0		7.6
	18 June	wS	215	4.2		13.0
	25 June	wS	113	13.3	0.9	3.5

Table V

Incidence of viruses and microsporidia in check areas on Manitoulin Island, Ontario in 1975.

Check area	Sample date	Tree species	No. of insects examined	Percent virus infection NPV	Percent virus infection CPV	Percent microsp.
No. 1	19 June	bF	80			10.0
		wS	109	1.8		5.5
	25 "	bF	111	4.5		11.7
		wS	71	9.9		8.5
No. 2	19 "	bF	81			6.2
		wS	159	0.6		10.1
	25 "	bF	85	3.5		11.8
		wS	32	12.5		6.3
No. 3	19 "	bF	172	0.6		
		wS	187	1.1		11.2
	25 "	bF	94	1.1		4.3
		wS	76	9.2		21.1
No. 6	18 "	bF	48			6.3
		wS	85			20.0
	25 "	bF	88	1.1		5.7
		wS	36			25.0
White spruce plantation	9 "	wS	159		0.6	18.2
	18 "	wS	159			8.8
	25 "	wS	155			7.1

Table VI

Population Reduction, Pupal Survival and Current Defoliation in Two Plots on Manitoulin Island in the Year Following Application of NPV Sprays (Sprayed 1974).

Plot	Early Sample Larvae/46cm Branch Tip		Surviving Pupae/46cm Branch Tip		% Population Reduction Due To NPV Carry-over		% Successful Pupal Emergence[a]		% Current Defoliation in 1975	
	bF	wS	bF	wS	bF	wS	bF	wS	bF	wS
520 ha virus plot	21.2	31.7	4.04	2.24	44	77	55	66	85	79
Check	21.6	31.9	7.37	9.87	-	-	76	95	92	80
White Spruce Plantation		21.2		5.08		24		95		26
Check		18.6		5.84		-		97		49

a) % Successful Pupal Emergence = $\frac{\text{Emerged Budworm}}{\text{Budworm Alive on Sample Date}} \times 100$

Table VII

Population reduction (adjusted for natural mortality) pupal survival and current defoliation in three check areas in which NPV was found in 1975 on Manitoulin Island.

Plot	Early sample larvae/46cm branch tip		Surviving pupae/46cm branch tip		% Population reduction due to NPV spray		% Successful Pupal Emergence[a]		% Current Defoliation in 1975	
	bF	wS	bF	wS	bF	wS	bF	wS	bF	wS
1975 Check Plot No. 1	33.3	48.1	4.93	2.27	47	73	97	97	100	95
Check	28.6	49.0	8.00	8.68	--	--	68	85	92	82
1975 Check Plot No. 2	22.1	26.7	6.07	1.73	35	81	70	68	83	82
Check	20.8	29.5	8.87	9.87	--	--	68	95	82	80
1975 Check Plot No. 3	43.0	43.1	7.13	5.60	11	61	79	55	99	94
Check	30.6	35.6	5.73	11.73	--	--	62	86	85	85

a) % Successful Pupal Emergence = $\frac{\text{Emerged Budworm}}{\text{Budworm Alive on Sample Date}} \times 100$

DISCUSSION

The same droplet spectrum was found in the 1974 trials as in 1973 at Massey and Aubrey Falls. The reason for the large number of droplets/cm^2 in the 200-400 μ class is not known but it is possible that, with an application rate of 9.4 l/ha, the Micronair system designed principally for ultralow volume application, is overloaded and very find droplets coalesce to form large ones. The lack of small droplets on the spruce plantation is probably due to the fact that this plot was sprayed about 8 a.m. when the sun had risen. The same phenomenon was noted at Sandbanks Provincial Park during an aerial application of European pine sawfly NPV in an aqueous suspension (Cunningham et al., 1975b).

It is estimated that about 8 ha of the large block was missed in the spray operation due to pilot error. The pilot stated that the corner markers 3.2 km apart could not both be seen at the same time and that the plot was too large for very accurate experimental spraying.

The application was timed to give the best possible infection rate of larvae on balsam fir and in the year of application the level of virus infection and population reduction were markedly better on this host than on

white spruce in that plot. Conversely the timing of the application was poor for white spruce hosts in the large block. It was slightly better on the white spruce plantation where bud development was further advanced and most of the caps were shed. The results on balsam fir were, in fact, the best obtained in 4 years of testing.

The carryover of virus from 1974 to 1975 on the large block was below expectation and the higher levels of virus infection in insects on balsam fir as compared to white spruce were not maintained from one year to the next. The carryover in the white spruce plantation was encouraging with 14.9% insects infected in the year of application and 13.3% the following year. The high levels of virus infection in check areas No. 1, No. 2 and No. 3 was puzzling. On all three checks, the levels of virus infection were higher in insects on white spruce hosts than in the large spray block, and in two of these three check areas levels were also higher in insects on balsam fir. On Manitoulin Island two further plots were sprayed with virus in the vicinity of the large block in 1975 (Cunningham et al., 1975a) and it is not known if the virus in these check areas can be attributed to 1) a natural virus in the spruce budworm population, 2) spread of virus from the large plot sprayed in 1974, 3) drift from the plot sprayed in 1974 or 4) drift from the two plots sprayed in 1975. As drift was closely

monitored on spray cards it is most unlikely that this would have occurred unnoticed. If virus does in fact spread from a sprayed area, this is an ideal situation and greatly increases the potential of NPV for spruce budworm control. When studies are continued in 1976 check areas should be selected in localities well-isolated from the sprayed plots and this phenomenon can be studied more closely.

Too few check samples were examined for naturally occurring virus in 1974 but this problem was rectified in 1975. The lack of check material in 1974 was only recognized when the results were compiled, by which time it was too late to obtain further samples.

Generally, results in 1975 indicated that aside from the 1974 results the control of spruce budworm was better on white spruce hosts than on balsam fir hosts. This situation has been noted consistently during four years of testing and it is probable that the greatest potential use of this virus lies in the control of spruce budworm in white spruce plantations although, unfortunately, the greatest problem with spruce budworm is encountered in stands with a high content of balsam fir.

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