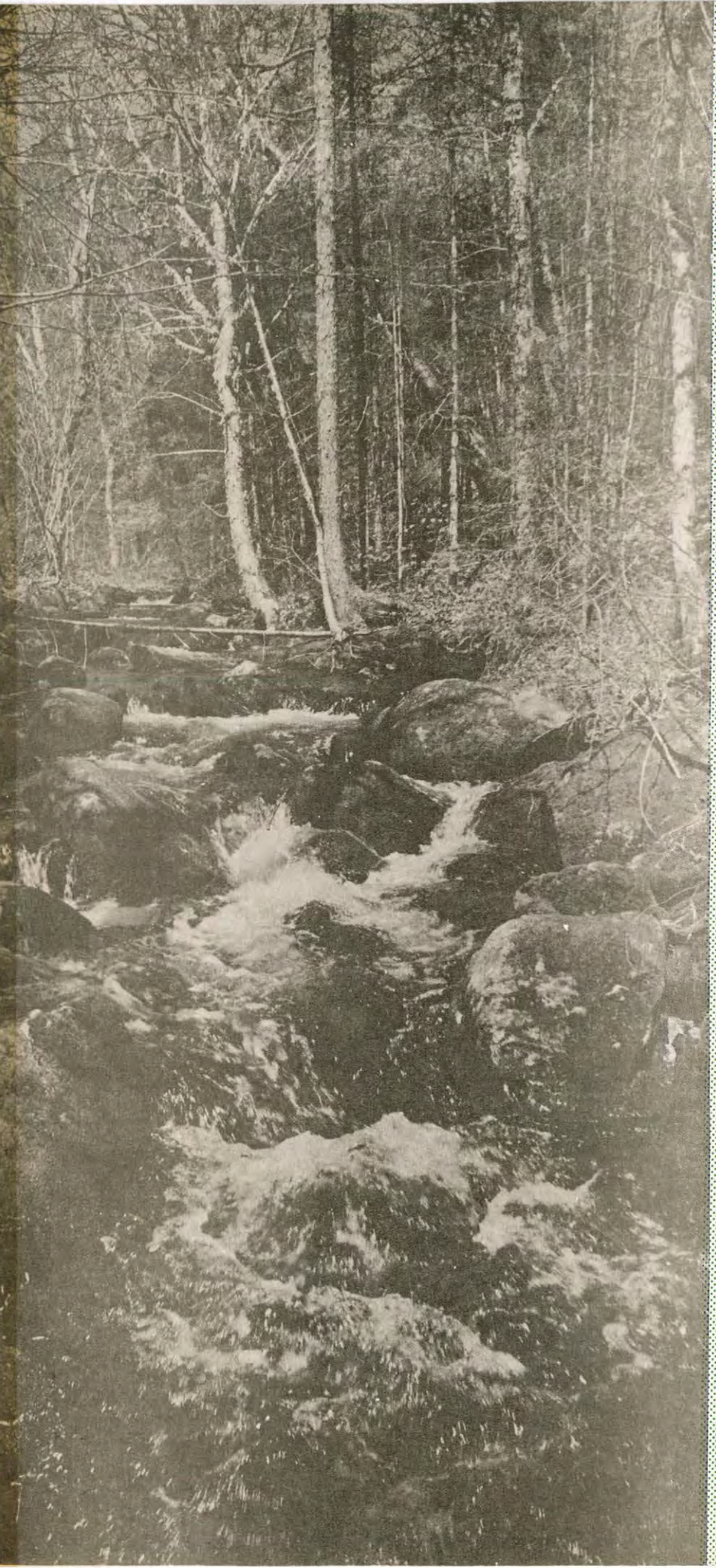

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TOXICITY OF AMINOCARB TO INSECTS IN A WOODLAND STREAM

BY
D. C. EIDT

MARITIMES

MARITIMES FOREST RESEARCH CENTRE

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D.C. Eidt

Maritimes Forest Research Centre

Fredericton, New Brunswick

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ABSTRACT

A stream was injected with aminocarb and the effects on aquatic arthropods were noted. Neither the commercial oil solution emulsified and injected into a stream at 4.7 µg/L for 1.5 h followed 1.5 h later by 13.7 µg/L for 1 h nor an emulsifiable concentrate injected at 2.5 µg/L for 1.5 h followed 1 h later by 15.8 µg/L for 1.25 h was enough to affect survival or drift of aquatic invertebrates. Although the dosage in streamwater that causes mortality is unknown, there is no evidence of hazard to stream benthos from aerial sprays up to 88 g/ha nor from two consecutive sprays at 70 g/ha.

RESUME

Un ruisseau fut traité à l'aminocarb et les effets sur les arthropodes aquatiques furent notés. Ni la solution d'huile commerciale, émulsifiée et infectée dans le ruisseau à raison de 4.7 µg/L durant 1.5 h, suivie 1.5 h plus tard de 13.7 µg/L durant 1 h, ni une concentration émulsifiable, injectée à raison de 2.5 µg/L durant 1.5 h, suivie 1 h plus tard de 15.8 µg/L durant 1.25 h, n'ont suffi à affecter la survie ou la dérive des invertébrés aquatiques. Bien que la dose mortelle dans le ruisseau soit inconnue, il n'existe aucune preuve de danger pour les organismes vivant au fond du ruisseau, du fait d'arrosages aériens jusqu'à une dose de 88 g/ha d'insecticide, ou de deux arrosages consécutifs à raison de 70 g/ha.

DOSIS SOLA FACIT VENENUM

Aminocarb (Matacil®) has been found to be effective in aerial sprays against the spruce budworm, Choristoneura fumiferana (Clem.). In the doses used (85 g or less/ha), it presents no apparent hazard to birds, fish, or small mammals, and except for spiders, its effects on terrestrial and aquatic invertebrates are generally light (Varty 1978). Subsequent observations by Varty[1] indicate toxic effects on certain parasitic Hymenoptera. Aminocarb was used in field experiments in New Brunswick on 1000 ha in 1970 and on 23 500 ha in 1971, and operationally on approximately 62 000 ha in 1975, 289 000 ha in 1976, 525 000 ha in 1977, and 600 000 ha in 1978. It was used operationally in Quebec in all years from 1973 to 1978, and in Newfoundland in 1978. Some monitoring of effects on aquatic invertebrates was done in treated areas in New Brunswick, Quebec, and Newfoundland but the concentrations in water were usually unknown.

During the first New Brunswick field trial in 1970, Penny (1971a) monitored aquatic invertebrates in the Big Eskedelloc River, Northumberland County. About 6 of 18 km of the stream passed through a block sprayed twice with aminocarb at about 85 g/ha. Using five 0.09 m^2 Surber samples at least once a week from late May to mid-August, he was unable to detect any differences from a control stream, in numbers at the order level or in total biomass, that were attributable to the insecticide. However, his methods may have been inadequate; according to Rosenberg and Snow (1977), "It is notoriously difficult to provide adequate measures of invertebrate standing crop using low numbers of Surber samples".

In 1971, Penny (1971b) monitored aquatic insects in two streams passing through experimental blocks sprayed with aminocarb at 103 g/ha. Again he used five Surber samples on each sampling date and identified the insects to order. He concluded, evidently by comparing the means of all pretreatment samples with the means of all post-treatment samples, that there were reductions in numbers of some orders in both streams and of biomass in one, and he attributed this to the insecticide. He did not use spatial controls and the data, which are plotted on graphs as means of five samples without variances, are not very persuasive.

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[1]Varty, I.W. Pers. Comm., Marit. For. Res. Cent., Fredericton, N.B. E3B 5P7.

Buckner et al. (1975) also monitored aquatic invertebrates in a stream or part of a stream in a block sprayed operationally twice with aminocarb at 52 g/ha in 1974. They concluded with some uncertainty that numbers of stonefly nymphs were reduced by the treatment; their data are expressed as mean number of organisms/0.1 m^2 Surber sample with standard deviations that exceed the means. They did not sample before the first treatment, but their control stream yielded equally variable low numbers of insects and they saw no distressed insects. The same data and conclusions are given by Buckner and Sarrazin (1975). Buckner et al. (1975) found no effect on bottom fauna in a shallow pond exposed to aminocarb applied from the air at 70 g/ha.

G.F. Gillis (Montreal Engineering Co. Ltd., 1976) monitored drift in 1976 in New Brunswick streams sprayed with fenitrothion at 210 g/ha followed by two applications of aminocarb, each at 70 g/ha. He found no significant effect of aminocarb on drift, using both temporal and spatial controls, whereas the fenitrothion induced statistically significant increases in both dead and live drift.

These conflicting reports leave some doubt as to whether kills of aquatic invertebrates resulting from forest spraying with aminocarb have ever been observed. Simply because aminocarb is a broad spectrum insecticide, there should be a concentration at which it kills stream insects. However, it is difficult to determine the concentration of aminocarb in stream water despite Eichelberger and Lichtenberg's (1971) claim of a minimum detectable concentration of 0.1 µg/L. My experiments were therefore designed to introduce a known amount of aminocarb into a stream and observe the effects on aquatic invertebrates. The object was to determine a dose that would kill stream insects and to determine if caged insects were safer when buried in the stream bed.

METHODS

A stretch of Manzer Brook, New Brunswick, (46°20'N, 67°01 W) was selected for the experiments. Manzer Brook has not been characterized but it is a cold clear permanent stream draining a wooded area

with some recently clear-cut areas. The general climate, soils, and forest characteristics of the area are described in a brochure published by the Nashwaak Experimental Watershed Project (Anon [1976]). The Manzer Basin is adjacent to the Hayden Basin of the Nashwaak Project.

The stream was first treated with aminocarb in the oil-based formulation supplied to Forest Protection Limited for forest spraying. An emulsifier was added to disperse the insecticide. In two subsequent experiments, increasing concentrations of aminocarb were added until it became impossible to maintain an emulsion and properly dispense the pesticide. To overcome the dispensing problem, the Chemagro Corporation supplied an emulsifiable concentrate.

Four field experiments, numbered I to IV, were performed 15 June 1977, 6 July 1977, 15 June 1978, and 12 July 1978. A laboratory test was also done to estimate effective field application rates for the emulsifiable concentrate. The experiments are described in chronological sequence because the design of each is conditioned by the antecedent experiments.

Field Experiment I

A stretch of Manzer Brook was treated with aminocarb 15 June 1977. The water temperature rose from 10°C to 11.5°C during the experiment. The stream discharge was 253 L/sec and the greatest of several water speeds at two-thirds stream depth was 100 cm/sec, measured with a propeller-type flowmeter.

The experimental procedure was similar to that of a field experiment with fenitrothion done earlier the same year on a neighboring stream (Eidt 1978). A barrier net was installed to prevent upstream drift from entering the test stretch. Insecticide was injected 52.3 m above the barrier net as measured along the meanderings of the midstream flow. Various stations, where drift would be sampled, insects caged, and water sampled for insecticide analysis, were established above and below the injection site (Table 1).

Because of high stream discharge 15 June, it was necessary to brush the barrier net regularly to prevent drifting detritus from blocking the apertures and the stream from overflowing the net or washing it out.

Drift was sampled at five sampling stations (Table 1). All net sets were for 15 min at 30-min intervals. The catches were washed and placed in untreated water in sealed jars and held in the stream to keep them cool. Between 8 and 24 h after collection, all samples were sorted according to living or dead, preserved in alcohol, and retained for identification and counting.

Table 1. Distance (m) from dosing site to barrier net, caged insects, and drift and water sampling stations, field experiment I, 15 June 1977. Four cages and four water samples were clustered within ±1.8 m of the location indicated

	Drift		Cages		Water	
Barrier net	Station	Distance	Station	Distance	Station	Distance
	1	-14.6				
52.3						
	2	58.5				
	3	71.6			1	65.4
			1	73.7		
			2	99.0		
	4	100.6				
			3	141.7		
	5	145.0				
					2	149.3
			4	179.5		

Insects used for bioassay were nymphs of Leuctra spp. stoneflies that had been collected in Manzer Brook using drift nets the night before the experiment. They were caged and placed on or buried in the stream bed as described by Eidt (1978). The cages were installed 2 days before treatment on the stream bed and at planned depths of 10, 20, and 30 cm below the stream bottom at each station, and were removed 1 day after treatment.

The stream was treated with aminocarb in the formulation supplied to Forest Protection Limited to spray budworm-threatened forest in New Brunswick. The formulation supplied by the manufacturer (Chemagro) in 1977 was 19.5% aminocarb, 50.5% nonyl phenol, and 30% No. 2 fuel (diesel) oil by weight, giving a concentration of 180 g/L. Mir liquid dishwashing detergent was used with the concentrate in the ratio 0.55:1 to form an emulsion with stream water.

The insecticide was injected at midstream from a mariotte bottle, a device that maintains a uniform rate of flow from the dispensing nozzle. The stream discharge was determined with a propellor-type flowmeter, then the concentration of the emulsion in the bottle was adjusted to give the desired concentration in the stream. The insecticide was injected between 0800 and 1030 h Atlantic Standard Time (AST) to give a calculated concentration of 2.2 µg/L active ingredient. The insecticide mixed well, and on the basis of a visual test with rhodamine WT, was uniform across the width of the stream by the time it reached the barrier net.

Water samples for aminocarb anaylsis were collected at intervals of 30 min, 1, 2, and 4 h after treatment began. Surficial water samples were taken at midstream by moving the collecting vessel between the surface and the bottom of the stream. Interstitial water samples were obtained from these depths in the stream bed using siphons in the manner described by Eidt (1977). Water was collected in jars with aluminum cap liners and kept in a spring at 10°C until the field work was completed. They were taken to Fredericton, sorted, and stored overnight in a cold room at 2°C, then taken to the Water Quality Laboratory, Environmental Management Service, Environment Canada, Moncton, N.B. They were analyzed, 10 to 21 weeks later, by G. Brun, using a nitrogen-specific electrolytic conductivity detector without preparing an aminocarb derivative.

Field Experiment II

The same stretch of Manzer Brook as in field experiment I was treated 6 July 1977. The stream discharge was 141 L/sec and the greatest water speed in the measured transect at two-thirds stream depth was 92 cm/sec.

The experimental procedure was similar to that of experiment I, with the same injection and barrier net sites, but only drift stations 1, above the injection site, and 3, below, were used (Table 2). Caged Leuctra spp. stonefly nymphs were placed on the stream bed only, at three sites, then removed the day after the experiment.

The aminocarb concentrate was diluted with No. 2 fuel (diesel) oil in the same proportions as used for spraying by Forest Protection Ltd: 28.5% aminocarb concentrate to 71.5% oil. Atplus 526 was used as an emulsifier and rhodamine WT 20% solution in methyl alcohol as a tracer. The mix in the mariotte bottle was: aminocarb concentrate, 153 mL; No. 2 fuel oil, 383 mL; rhodamine WT, 76 mL; Atplus 526, 201 mL; and stream water, 6474 mL.

The mariotte bottle was fitted with two nozzles so that a higher rate could be used if the lower one was ineffective. The smaller nozzle was used between 0825 and 0955 h AST to give a calculated concentration of 4.7 µg a.i./L, the injection was stopped for 1 h 30 min, then the larger nozzle was used between 1125 and 1225 h AST to give a calculated concentration of 13.7 µg a.i./L.

Only surficial water samples were taken during experiment II; samples for aminocarb analysis were taken at intervals of 25 min, 1 h 35 min, and 2 h 05 min after treatment began at the lower rate. They were analyzed for aminocarb as in experiment I.

Table 2. Distance (m) from dosing site to barrier net, caged insects, and drift and water sampling stations, field experiment II, 6 July 1977. Two cages were placed at each site

	Drift		Cages		Water	
Barrier net	Station	Distance	Station	Distance	Station	Distance
	1	-14.6				
52.3					1	52.3
			1	53.8		
	3	71.6				
					2	73.4
			2	74.4		
			3	103.3	3	103.3

Additional water samples were taken in small brown bottles at 15-min intervals to be subsequently examined in a fluorometer for the concentration of rhodamine WT. Knowing the relative concentrations injected, the rhodamine WT concentration was used as an indicator of the aminocarb concentration. The method ignores any differential behavior of the two chemicals in the 103-m stretch between the injection and sample stations.

Field Experiment III

The same stretch of Manzer brook was again treated 15 June 1978. The stream discharge was 130 L/sec, the pH of the stream water was 6.3, and the water temperature was steady throughout the experiment at 10°C. The barrier net was placed 49 m below the injection site and drift was sampled 26 m below the barrier net using 30-min consecutive net sets until 3 h 40 min after treatment ended. Drift was not sampled above the injection site because only gross effects were sought. The stream was treated at a calculated mean rate of 33.69 µg/L for 2 h 40 min between 1445 and 1725 h (AST). The mixture used was 390 mL of technical aminocarb (19.5% aminocarb, 50.5% nonyl phenol, and 30% solvent oil 585, by weight), 53 mL Atlox emulsifier, 100 mL Mir liquid detergent, 195 mL rhodamine WT 20% solution in methyl alcohol, and 8362 mL stream water. Separation of the pesticide mixture occurred in the mariotte bottle, and the intended dose was not achieved. Stream water samples were taken four times during and after injection, then handled and analyzed as before. No use was made of the rhodamine dye.

Laboratory Toxicity Test

To estimate the dosage of emulsifiable concentrate that should be used in the field experiments, insects were exposed for 3 h to 0, 1, 10 and 100 µg/L aminocarb in Mason jars of continuously aerated stream water in a controlled-environment cabinet. Temperature was controlled between 16 and 18°C and two 15 W fluorescent tubes were programmed to go out between 2100 and 0500 h AST. In another series of jars, insects were exposed to equivalent concentrations of a "blank", which contained the solvents and emulsifiers. All treatments were replicated twice. The insects were collected in drift from the Middle Branch Nashwaaksis Stream after dark 5 July 1978 and acclimatized to the incubator temperature

overnight. (Water used was from this same stream). Each jar was stocked with at least 9 Baetis spp. mayfly nymphs between 0800 and 0830 h AST, 6 July. Baetis spp. were chosen for their availability in the Nashwaaksis Stream; Leuctra spp. would have been preferred for consistency with field experiments and for an assumed greater sensitivity to aminocarb, but they were scarce in Nashwaaksis Stream. In all jars, the water was replaced with clean stream water, without rinsing, 3 h later. The dead and living insects were counted about 24 h after the experiment began.

Field Experiment IV

Manzer Brook was treated with the emulsifiable concentrate 12 July 1978, beginning at 1200 h. The stream discharge was 70 L/sec and water temperature was about 15°C. The rate of injection was 2.48 µg/L for 2 h 30 min, a rate established on the basis of results from the laboratory experiment. Treatment was discontinued for 1 h then resumed at 15.84 µg/L for a further 2 h 15 min. The barrier net was placed 49 m below the injection site and drift was sampled 28.2 m below the barrier net using 30-min consecutive net sets from 30 min before treatment began until 1 h 15 min after it ended. Drift was not sampled above the injection site because only gross effects were sought. Water for chemical analysis was collected 30.6 m below the barrier net. It was handled and analyzed as in experiment I, with additional "clean up" procedures to remove the solvents and emulsifiers.

RESULTS

Field Experiment I

Aminocarb concentrations found in the stream water on 15 June 1977 are given in Table 3. The background concentration in the stream water was assumed to be zero because no aminocarb was used operationally in southern or central New Brunswick in 1977. Although the calculated concentration was 2.2 µg/L, the highest concentration detected in water samples was just half that much. This may have been due to a combination of sorption, of downstream dispersion, and of loss by various means in the samples which were not analyzed until 75 days after their collection. The data in Table 3 clearly show a drop in insecticide concentrations after dosing ceased.

Because of the difficulty of burying siphon tubes at the planned depths of 10, 20, and 30 cm in the stoney stream bed, the depths were remeasured when the tubes were removed. At station 1 they were 10, 15, and 25 cm deep and at station 2 they were 10, 20, and 28 cm deep. As was found with fenitrothion (Eidt 1977), it is not possible to conclude from the data (Table 3) that there was any change in aminocarb concentration with depth in the stream bed.

The numbers of drift organisms were essentially uniform throughout (Table 4). The mean number of dead arthropods at the four stations below the injection site varied from 1 to 3.5. These means were higher than the numbers at the station above the injection site at the same times, due to the nature of the upstream station. There were no temporal differences in either living or dead arthropods at any of the downstream stations that could attributed to the treatment.

When cages were removed the day after the treatment, the depths of the cages on remeasurement were 10, 19, and 21 cm at station 1; 10, 20, and 21 cm at station 2; 11, 25, and 25 cm at station 3; and 10, 20, and 24 cm at station 4. The cages each contained from 3 to 11 Leuctra spp., which were about 90% L. tenella Provancher, about 10% L. ferruginea Walker, and probably some L. tenuis (Pictet). A few specimens were dead, but were apparently injured in handling. The rest were healthy as were one nymph of the stonefly Amphinemura wui Claassen and two of Paraleptophlebia spp. mayflies.

Field Experiment II

The results of the analysis of aminocarb samples taken 6 July 1977 are shown in Table 5. Using the results of the fluorometer reading for the same samples, the approximate relationship between the fluorometer readings (Y) and the aminocarb concentrations (X) was determined by regression to be $Y = 0,5335X - 0.0221$ ($r^2=0.81$). The data on fluorescence due to the added rhodamine WT were then plotted as aminocarb concentrations (µg/L) (Fig. 1). Concentrations during the treatment at the low rate differed from station to station and diminished gradually throughout the treatment period at station 2. During the treatment at the high rate, the concentrations at the three sampling stations were

Table 3. Aminocarb concentrations in stream water, field experiment I, 15 June 1977

Station (m below injection)	Lapsed time (h:min) after Dosing began	Lapsed time (h:min) after Dosing ended	Aminocarb (µg/L) Surface water	Aminocarb (µg/L) Interstitial water (depth in streambed)		
Station 1 (65.4)				10 cm	15 cm	25 cm
	0:30	-2:15	0.8	0.5	<0.5	0.5
	1:00	-1:45	<0.5	<0.5	0.6	0.6
	4:00	1:15	<0.5	<0.5	<0.5	<0.5
Station 2 (149.3)				10 cm	20 cm	28 cm
	0:30	-2:15	0.5	0.9	0.6	-
	1:00	-1:45	1.1	0.5	0.8	-
	2:00	-0:45	0.9	<0.5	<0.5	0.7
	4:00	1:15	<0.5	<0.5	<0.5	<0.5

Table 4. Aquatic insects and mites in 15-min drift samples from Manzer Brook, field experiment I, 15 June 1977. L=living, D=dead. Distances are from injection site

Starting time of net set (AST)	Station 1 -14.6 m L	1 -14.6 m D	2 58.5 m L	2 58.5 m D	3 71.6 m L	3 71.6 m D	4 100.6 m L	4 100.6 m D	5 145.0 m L	5 145.0 m D	Sta. 2-5 Mean D
0745	8	2	19	1	9	6	6	4	3	1	3.0
	Aminocarb (2.2 µg/L) injection began 0815 h										
0815	4	1	8	3	1	3	1	3	8	3	3.0
0845	4	1	5	1	4	1	5	1	4	1	1.0
0915	4	0	-	-	4	4	6	1	4	3	2.7
0945	7	0	10	1	1	0	3	3	9	2	1.5
1015	4	1	1	0	2	1	2	3	2	1	1.3
	Aminocarb injection ended 1030 h										
1045	8	2	4	2	5	2	1	6	3	3	3.3
1115	7	2	4	4	4	4	1	3	6	3	3.5
1200	2	2	14	1	7	3	10	1	3	6	2.8
1300	10	0	6	1	6	1	6	1	2	6	2.3
1400	-	-	-	-	3	3	-	-	-	-	-

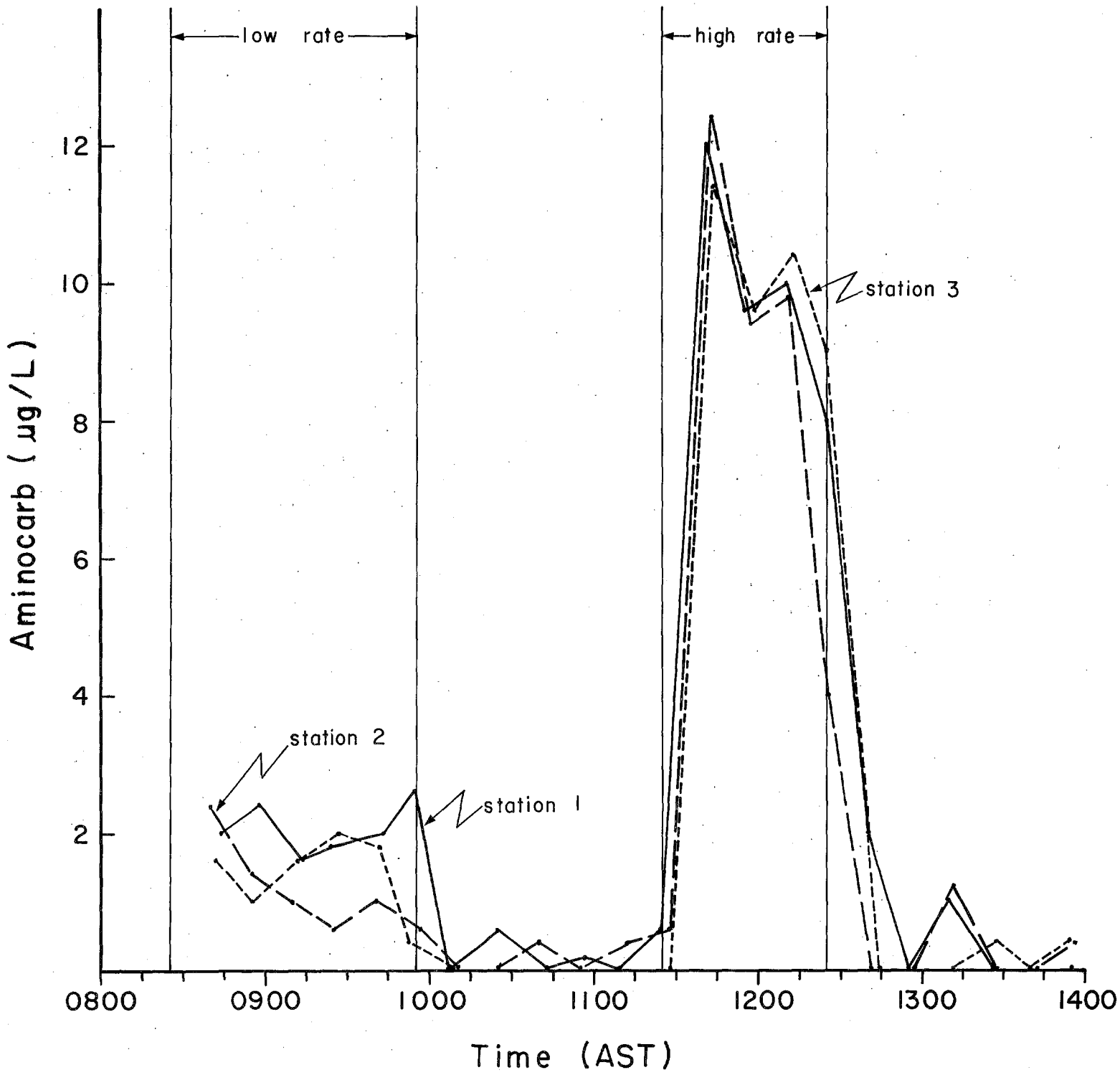

Fig. 1. Aminocarb concentrations at three sampling stations, field experiment II, 6 July 1977, based on fluormetric analysis of tracer rhodamine WT. Aminocarb injection: Low rate = 4.7 µg/L; high rate = 13.7 µg/L.

similar. Concentrations rose and fell quickly as treatment began and ended, as would be expected considering the high water speed. The overall average concentration for the low rate at all stations was 1.54 µg/L (0.4-2.6), as compared with the calculated concentration of 4.7 µg/L based on the amount injected. The overall average concentration for the high rate at all stations was 9.6 µg/L (4.0-12.4) as compared with the calculated concentration of 13.7 µg/L. The difference was not explained but would be due in part to the inability of the aminocarb analysis to account for all the insecticide. In most such analyses including that of experiment I, insecticide is lost in many ways, including degradation during sample storage.

There were no changes in numbers of living or dead arthropods that suggest any differences among pretreatment, during treatment, and post-treatment drift (Table 6). In general, more arthropods were collected in drift above the injection site than below it.

Again, as in experiment I, there was little mortality of caged insects; all could be attributed to handling injuries. In addition, two living nymphs of A. wui and two living larvae of Rhyacophila sp. a carnivorous caddisfly were found in cages.

Field Experiment III

During the 15 June 1978 field experiment, the insecticide mixture could not be maintained in the mariotte bottle. The oil came to the top and it was assumed that the aminocarb remained in the oil and thus little entered the stream. Because of this separation, no use was made of the rhodamine WT dye to infer insecticide concentrations. Aminocarb concentrations determined by chemical analysis of the water samples were:

Time (AST)	Concentration (µg/L)
14:45 (injection began)	
15:15	5.9
16:15	6.5
17:15	5.7
17:25 (injection ended)	
18:45	1.0

Table 5. Aminocarb concentrations in stream water, field experiment II, 6 July 1977

Station (m below injection)	Lapsed time (h:min) after Dosing began	Lapsed time (h:min) after Dosing ended	Aminocarb (µg/L)
Station 1 (52.3)	0:19	-1:11	2.1
	1:30	0:00	1.5
	2:00	0:30	0.2
Station 2 (73.4)	0:15	-1:15	1.9
	1:27	-0:03	1.0
	1:55	0:25	<0.5
Station 3 (103.3)	0:17	-1:13	1.9
	1:28	-0:02	1.0
	1:57	0:27	<0.5

Table 6. Aquatic insects and mites in 15-min drift samples from Manzer Brook, field experiment II, 6 July 1977. L=living, D=dead. Distances are from injection site

Starting time of net set (AST)	Station 1 -14.6 m L	Station 1 -14.6 m D	Station 3 71.6 m L	Station 3 71.6 m D
0810	8	13	3	0
Aminocarb (4.7 µg/L) injection began 0825 h				
0840	3	1	5	0
0910	6	6	3	4
0940	–	–	4	5
Aminocarb injection ended 0955 h				
1010	2	5	0	1
1040	–	–	2	2
1110	7	5	2	1
Aminocarb (13.7 µg/L) injection began 1125 h				
1140	–	–	7	3
1210	4	2	3	0
Aminocarb injection ended 1225 h				
1240	–	–	2	1
1310	9	1	2	0
1340	–	–	7	1

This implies, from previous experience, a concentration of about 6 µg/L for 2 h 30 min and lingering traces afterwards. There was no effect on invertebrate drift (Table 7). Increases in living animals in the last two net sets are normal increases associated with nightfall.

Laboratory Toxicity Test

The results of the toxicity test (Table 8) indicate that the aminocarb emulsion is highly toxic, as just one Baetis nymph survived even at 1 µg/L. This nymph was obviously sluggish and a second nymph, classed as dead, was twitching. The blank did not differ from the controls at 1 µg/L equivalent, but only half the insects survived at 10 µg/L equivalent, and none at 100 µg/L equivalent.

Field Experiment IV

Aminocarb concentrations determined by chemical analysis of the water samples taken 12 July 1978 were:

Time AST	Concentration (µg/L)
1300 (injection at low rate began)	
1330	1.2
1400	1.0
1500	1.0
1530 (injection ended)	
1630 (injection at high rate began)	
1700	6.3
1840	10.0
1845 (injection ended)	

This implies from previous experience a concentration of about 1 µg/L for 2 h 30 min, none or a trace for 1 h, then an average of 8 µg/L or more for 2 h 10 min, and lingering diminishing amounts afterwards. There was no effect of the emulsifiable concentrate on drift of aquatic invertebrates in Manzer Brook (Table 9).

Table 7. Aquatic insects and mites in 30-min drift samples, 26 m below the barrier net in Manzer Brook, field experiment III, 15 June 1978

Net Set (AST)	Living	Dead	Total
1415 - 1445	2	5	7
Aminocarb (33.69 µg/L) injection began 1445 h			
1445 - 1515	1	4	5
1515 - 1545	1	4	5
1545 - 1615	4	5	9
1615 - 1645	4	7	11
1645 - 1715	4	9	14
1715 - 1745	2	5	7
Aminocarb injection ended 1725 h			
1745 - 1815	4	11	15
1815 - 1845	5	12	17
1845 - 1915	2	6	8
1915 - 2115 (30 min mean)	3.5	6.3	9.8
2115 - 2145	28	8	36
2145 - 2215	17	5	22

Table 8. Survival of Baetis spp. nymphs exposed to various concentrations of aminocarb emulsion and equivalent concentrations of a blank. Bracketed numbers are larvae of other mayflies, stoneflies, and black flies

Treatment	Concentration (µg/L)	Living	Total	Survival (%)
Control	0	8 (5)	10 (5)	80.0
Control	0	12 (1)	14 (1)	85.7
Aminocarb	1	1 (2)	11 (3)	9.0
Aminocarb	1	0 (1)	13 (6)	0
Aminocarb	10	0	10 (1)	0
Aminocarb	10	0	10	0
Aminocarb	100	0	10 (2)	0
Aminocarb	100	0	12 (2)	0
Blank	1	7 (2)	9 (2)	77.8
Blank	1	12	13	92.3
Blank	10	5 (2)	12 (2)	41.7
Blank	10	6 (2)	12 (2)	50.0
Blank	100	0	13	0
Blank	100	0	15 (2)	0

Table 9. Aquatic insects and mites in 30-min drift samples 28.2 m below the barrier net in Manzer brook, field experiment IV, 12 July 1978

Net set (AST)	Living	Dead	Total
1220 - 1300 (40 min)	4	1	5
Aminocarb (2.48 µg/L) injection began 1300 h			
1300 - 1330	3	3	6
1330 - 1400	2	1	3
1400 - 1430	1	2	3
1430 - 1500	2	3	5
1500 - 1530	4	2	6
Aminocarb injection ended 1530 h			
1530 - 1600	1	2	3
1600 - 1630	2	0	2
Aminocarb (15.84 µg/L) injection began 1630 h			
1630 - 1700	4	1	5
1700 - 1730	3	0	3
1730 - 1800	4	0	4
1800 - 1830	2	0	2
1830 - 1900	0	0	0
Aminocarb injection ended 1845			
1900 - 1930	2	0	2
1930 - 2000	3	2	5

DISCUSSION

None of the field treatments had any observable effect on aquatic invertebrates in the study stream. Since an objective of the study was to determine the concentration of aminocarb that would kill some benthos, this was disappointing. However, the highest concentration used, 15.8 µg/L, can be compared with fenitrothion at 47.5 µg/L since fenitrothion is normally applied at three times the rate of aminocarb; concentrations of fenitrothion over 40 ppb have been found only three times in stream waters (Hall *et al.* 1975; Flannagan 1975; L.W. Coady 1977[2]). Peak concentrations in the field are transitory and do not take exposure time into account. Using the CT statistic of Eidt (1978)

[2]Coady, L.W. Pers. Comm., Environmental Protection Service, St. John's Newfoundland.

the comparison is more meaningful. On 12 July 1978, the CT (µg/L x h) based on the calculated injection rates was 42 which is comparable to 42 x 3 = 126 for fenitrothion, a level at which substantial kill of aquatic insects is expected. Even if the concentrations determined by water analysis are used, and these are always below actual concentrations for various reasons, the CT is 21 which is comparable with a fenitrothion CT of 63.

The original objective was to inject a concentration high enough to determine the level lethal to at least the more sensitive species. This was not achieved in 1977. Nonetheless the concentration used was well above any that might usually result from an operational spray. The oil solution used in operational spraying might be expected to remain on the water surface, thus keeping the aminocarb away from bottom-dwelling organisms. In 1978, even though an emulsifiable concentrate was used so the aminocarb would mix with the water and reach the bottom organisms, no effects were noted.

Elsewhere, benthos was studied during operational sprays in the Gaspé, Québec, in Newfoundland, and in New Brunswick. André Gengras, (1978)[3], saw a small increase in the drift of certain aquatic invertebrates in a Gaspé stream after an aminocarb spray at 70 g/ha in 1977. The aminocarb spray followed two of fenitrothion, each at 280 g/ha. He could not separate the effect on drift of the spray from the effects on drift of spates or other factors. L.W. Coady, 1978[1] found no effects on aquatic invertebrates in Newfoundland when monitoring experimental sprays at 2 x 70 g/ha in 1978. G.F. Gillis (1978)[4], was unable to show any effect on living or dead drift of aquatic invertebrates in three north central New Brunswick streams following aminocarb at 70 g/ha in 1977.

CONCLUSIONS

There is little or no hazard to stream benthos of aerial sprays of aminocarb at 70 g/ha. The dosage in water that will cause mortality

[3]Gengras, Andrés. Pers. Comm., Ministère du Tourisme, de la Chasse et de la Pêche, Québec.
[4]Gillis, G.F. Pers. Comm., Montreal Engineering Company Ltd., Fredericton, N.B.

remains unknown, but it is greater than the 4.7 µg/L for 1 h 30 min plus 13.7 µg/L for 1 h as used in the 1977 field experiment with the oil solution and greater than 2.48 µg/L for 2 h 30 min plus 15.84 µg/L for 2 h 15 min as used in the 1978 field experiment with the emulsifiable concentrate. It is recommended that further field experiments be conducted to determine the lethal dosage, and thus the margin of safety.

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