ENVIRONMENTAL EFFECTS OF A DOUBLE APPLICATION OF AZAMETHIPHOS ON SELECTED TERRESTRIAL AND AQUATIC ORGANISMS

by

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ABSTRACT

Two consecutive applications of 0.070 kg AI/ha azamethiphos were studied to assess the impact of this compound on several components of the forest ecosystem. A general knockdown of terrestrial invertebrates was noted following each application. Apart from large increases in the drift of caddisfly larvae of the family Philopotomidae, the effect on aquatic invertebrates was minimal. Analysis of brook trout stomach contents indicated that, although some changes in the composition of the diet occurred, overall availability of food was not significantly reduced. Forest songbird populations were unaffected with no significant disruption of breeding activities.

RÉSUMÉ

Les auteurs ont étudié les effets de deux applications consécutives d'azamethiphos afin d'évaluer l'impact de ce composé sur plusieurs éléments de l'écosystème forestier. Un abattement général a été observé chez les invertébrés terrestres à la suite de chaque traitment. Sauf d'importantes augmentations de la migration des larves de moucherons de la famille des Philopotomidées, les invertébrés aquatiques n'ont subi qu'un effet minime. L'analyse du contenu de l'estomac des truites de ruissaeux a montré que, malgre certaines modifications de la composition de leur menu, la présence des aliments généralement ingurgités n'était pas significativement réduite. Les populations d'oiseaux chanteurs forestiers n'ont pas été affectées et on n'a obervé aucune perturbation significative de leurs activités d'accouplement.

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INTRODUCTION

Large scale spray operations using chemical insecticides are conducted annually over Eastern Canadian forest regions in order to reduce the damage caused by the spruce budworm, *Choristoneura fumiferana* (Clemens). The search for more effective and environmentally acceptable forest insecticides is a cooperative venture involving both private enterprise and agencies of the federal and provincial governments. Laboratory screening trials conducted at the Forest Pest Management Institute (FPMI) in 1978 and 1979 showed azamethiphos to exhibit sufficient contact toxicity to spruce budworm larvae to warrant its use in aerial field trials. These trials were carried out during May and June by personnel of the Forest Pest Management Institute in the vicinity of CFB Gagetown, New Brunswick. In conjunction with the efficacy trials, field trials to determine the effects of this compound on selected components of aquatic and terrestrial environments were conducted near St Donat-de-Montcalm, Quebec. These studies were carried out by FPMI in cooperation and with support from Ciba-Geigy Canada Ltd.

SITE SELECTION

Environmental impact studies were conducted in a 50 ha spray block located approximately 2½ km south of the town of Notre-Dame-de-la-Merci, Quebec. The block was bounded on the west by the right-of-way of Highway 18 and on the east by a 2½ km section of Ruisseau Castor (Figure 1).

Terrestrial studies were carried out in a 4 ha forest plot typical of the spray block, where diversity of habitat indicated a healthy resident avifauna population. Selective cutting in the area had left a fairly open stand of predominantly black spruce, *Picea mariana* (Mill.) BSP, speckled alder, *Alnus rugosa* (DuRoi) Spreng., honeysuckle, *Lonicera* sp. L., balsam fir, *Abies balsamea* (L.) Mill., aspen, *Populus tremuloides* Michx., and larch *Larix laricina* (DuRoi) K. Koch. Approximately half of the plot was upland, falling off sharply to lowland, boggy conditions near the stream.

A 4 ha control bird plot was set up approximately 2½ km north of Notre-Dame-de-la-Merci, along the west side of Highway 18. The forest cover was similar to the treatment plot, but more dense, with aspen, beaked hazel, *Corylus cornuta* Marsh., honeysuckle, balsam fir, black spruce, white birch, *Betula papyrifera* Marsh., and speckled alder the predominant species.

Aquatic studies were conducted in Ruisseau Castor. Within the spray block Ruisseau Castor is a fairly small stream between 3m and 4 m in width and generally less than 1 m in depth. Flow measurements taken on 19 June and 10 July were 0.18 and 0.15 m^3/sec respectively. The upper half of the treated portion of this stream

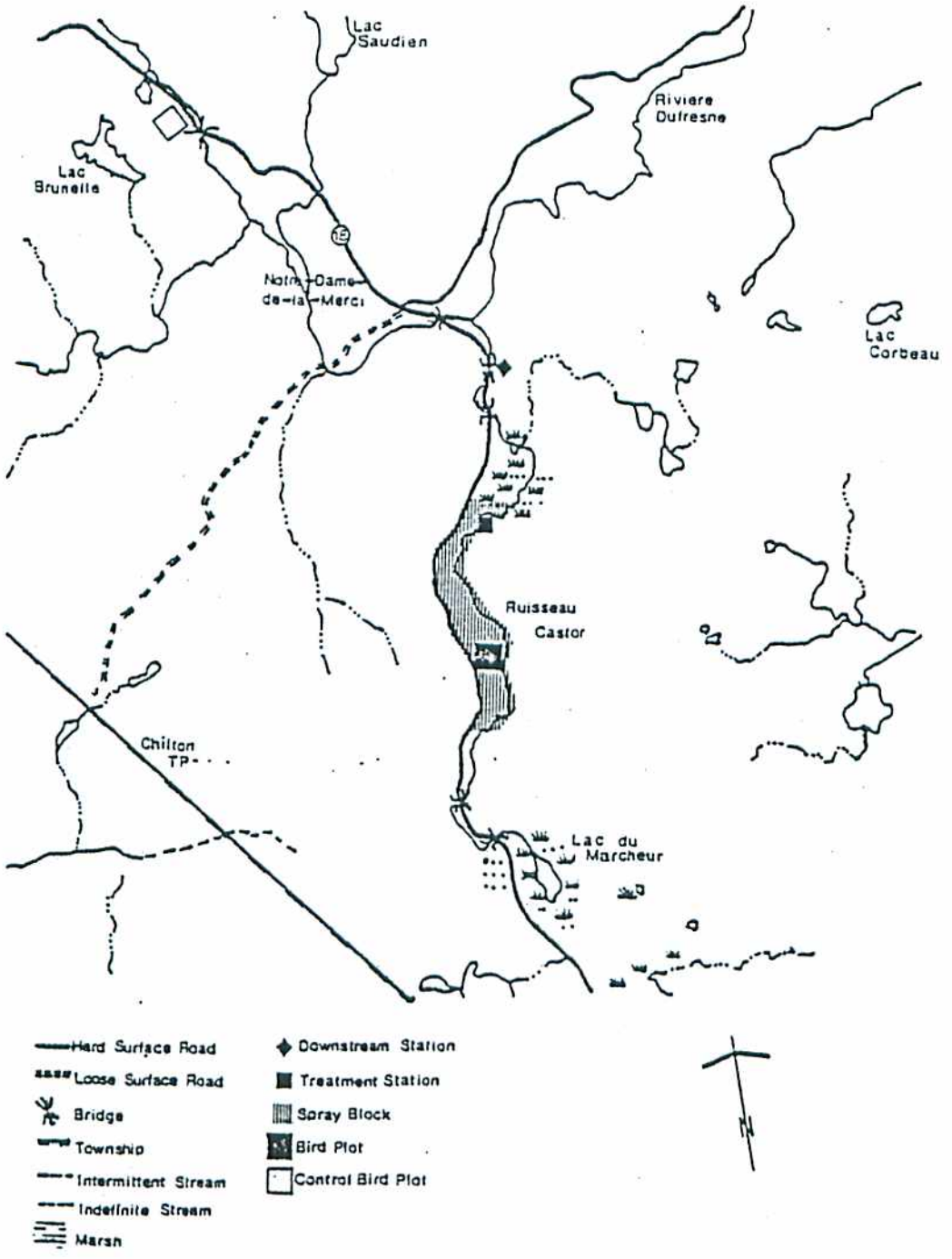

Figure 1. Location of spray block and sampling areas

is relatively slow with occasional riffle areas and large pools. The bottom type is predominantly coarse gravel and sand covered with silt and organic debris. The area around the stream is low and open and provides very little stream cover. Bank vegetation is primarily larch, speckled alder, willow, *Salix* sp. L., dogwood, *Cornus* sp. L., bayberry, *Myrica* sp. L., *Spiraea* sp. L., grasses and sedges. The lower half of the treated portion of this stream flows through mixed forest and is much faster and more turbulent with a boulder, rock and gravel bottom. Bank vegetation is primarily white spruce, *Picea glauca* (Moench) Voss, white birch, balsam fir, mountain maple, *Acer spicatum* Lam., larch, cherry, *Prunus* sp. L., speckled alder, willow, and beaked hazel, and provides abundant stream cover. A downstream sampling station was located about 2 kilometers downstream from the spray block where Ruisseau Castor crosses Highway 18 (Figure 1). Just below the spray block Ruisseau Castor flows through a large, open bog, but from about 500 m above the downstream station to its confluence with Riviere Dufresne, the stream gradient increases and the bottom is primarily boulder, rock and gravel.

A small unnamed stream which crosses Highway 18 approximately 5½ km south of the town of St-Donat-de-Montcalm, Quebec, was used as a control for the aquatics studies. This stream is between 3 m and 5 m wide, is generally less than 1 m deep, and has a boulder, rock and gravel bottom. The flow is fairly fast with many riffle areas and small pools. Flow measurements taken on 19 June and 10 July were 0.22 and 0.13 m^3/sec respectively. The most common tree and shrub species along the stream are sugar maple, *Acer saccharum* Marsh., mountain maple, white birch, balsam poplar, *Populus balsamifera* L., ironwood *Ostrya virginiana* (Mill.) K. Koch., mountain ash *Sorbus* sp. L., speckled alder, willow and beaked hazel.

METHODS

SPRAY APPLICATION

Azamethiphos was applied twice to the 50-ha spray block and a 2.5 km section of the treatment stream, with a six day interval between applications, at a dosage rate of 0.070 kg active ingredient/ha. Application was carried out by a Cessna 185 aircraft equipped with a Micronair® spray emission system calibrated to deliver the formulation at the rate of 1.46 l/ha. A small amount of automate "B" red dye was added to the preformulated spray mixture to facilitate deposit assessment. The composition of the spray mixtures were as follows:

First treatment	1.51 ℓ automate "B" dye[1]	(2% by volume)
	42.17 ℓ Cellosolve[2]	(55.7% by volume)
	32.02 ℓ Alfacron[2]	(42.3% by volume)

Second treatment	0.98 ℓ automate "B" dye[1]	(1.3% by volume)
	42.47 ℓ Cellosolve[2]	(56.1% by volume)
	32.25 ℓ Alfacron[2]	(42.6% by volume)

At 0705 EST on 29 June 1979, the plane made its initial pass down the treatment stream. Subsequent swaths were north-south along parallel lines, 60 m apart, starting at the highway and progressing east toward the stream. The last pass was at 0718 EST. The second application began at 0425 EST and ended at 0439 EST on 5 July 1979. The same basic flight plan was followed.

Meteorological measurements taken at the St. Donat airport on the mornings of spray application are presented in Table 1.

DEPOSIT MEASUREMENT

Deposit samplers consisted of two stainless steel plates, one plate covered with a 100 cm^2 Kromekote® paper card. The samplers were placed in fairly open areas along the centre line of the bird plot and on stakes in the water and along the banks of the treatment stream. Samplers were also put out close to the highway near the downstream station to measure atmospheric drift of the spray products.

A NCR microcard reader was used to size and count droplets deposited on the Kromekote® cards. Spread factors were calculated for each size class of spray droplet, and deposit was estimated after the method of Hurtig et al. (1953). Droplet densities (drops/cm^2) for each size class were totalled to give a drop density value for the entire spray card.

Deposit on the plates not covered by Kromekote® cards was estimated by colorimetry. The plates were washed with a small volume of toluene and the quantity of dye rinsed off them was measured using a Bausch and Lomb Spectronic 100 spectrophotometer. This was compared with the amount of dye in a reference standard taken from the original spray formulation.

TERRESTRIAL STUDIES

Terrestrial Invertebrate Knockdown

Terrestrial invertebrate knockdown was monitored by collecting invertebrates from 39 cm x 33 cm x 15 cm plastic wash buckets. Sixteen buckets (8 treatment; 8 control) were placed under typical coniferous cover (balsam fir and white spruce) in the bird plots. Treatment buckets were located at stations along the centre line of

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[1] Morton Williams Ltd., Ajax, Ontario

[2] Ciba-Geigy Ltd., Cambridge, Ontario (Cellosolve and Alfacron received pre-mixed by this supplier).

Table 1
Weather conditions at the St. Donat-de-Montcalm airport
for the first and second azamethiphos applications
29 June and 5 July 1979

Date	Time	Temp. (°C)	R.H. (%)	Wind Speed (kph)	Wind Direction (°Mag)	Cloud Cover	Comments
29 June 1979	0430	8.5	100	0.0 - 1.5	330		Heavy fog
	0645	13.5	98	0.0 - 1.5	330		
	0700	14.5	94	0.0 - 1.5	330		
	0715	15.0	94	0.0 - 1.5	330		
5 July 1979	0400	5.0	100	3.5 - 7.0	330	10/10	
	0424	5.5	98	5.0 - 7.0	330	10/10	
	0440	4.5	95	7.0 - 14.0	330	10/10	Wind increasing
	0455	5.0	95	8.5 - 10.0	340	10/10	Starting to drizzle

the plot, perpendicular to the spray lines, so that each swath was sampled. An additional 12 buckets (6 treatment; 6 control) were placed under typical stream cover (Table 2) along Ruisseau Castor and the untreated control stream. Invertebrates were collected each evening and preserved in a 30% methanol solution.

Birds

Forest songbird population impact studies were carried out on 4 ha plots utilizing a singing-male breeding territory mapping technique similar to that described by Kendeigh (1947). Bird populations were censused each morning shortly after dawn, commencing five days prior to the initial application and continuing throughout the experimental period, terminating five days after the last treatment. Each singing or sighted bird was recorded on a plot map while the censor slowly traversed the plot along parallel lines established 40 m apart. All birds were identified to species, sex and type of activity at time of record (singing, foraging, flying etc). All male birds vocally defending a territory were assumed to be mated and recorded as two birds, all others (sighted, non-singing, etc.) were recorded as one.

Daily census maps were compiled covering the pre-spray and post-spray periods to delimit breeding territorial boundaries. The number of birds observed during each census was used to indicate activity trends and relative abundance on that plot.

AQUATIC STUDIES

Water Chemistry

Water temperature, dissolved oxygen, pH, alkalinity and hardness were measured periodically at each station using a Hach Kit, Model AL-36B.

Drift

Numbers of drifting aquatic invertebrates in the study streams were monitored by drift netting before and after the two azamethiphos applications. At the treatment and control stations, drift samples of measured duration were taken twice daily, morning and evening, using a standard 0.47 m x 0.32 m drift net with a No. 54 mesh (363 micron opening). A drift net fitted with a metal restrictor to reduce the size of the opening to 0.48 m x 0.025 m was used for 12-hour nocturnal and diurnal drift sampling at the downstream station. In both cases drift nets were placed in the stream to sample a column of water from surface to bottom including the surface film. Current velocity was measured at the opening to each drift net halfway between the surface and bottom using a

Table 2
Tree and shrub species sampled for Terrestrial Invertebrate Knockdown along streams, Montcalm County, Quebec.
20 June to 9 July 1979

Ruisseau Castor Treatment Stream

Bucket Number	Species
1	speckled alder, cherry, mountain maple
2	speckled alder
3	balsam fir, beaked hazel
4	balsam fir, willow
5	speckled alder
6	white spruce, beaked hazel, speckled alder

Untreated Control Stream

Bucket Number	Species
1	speckled alder
2	balsam poplar, willow
3	balsam fir, mountain maple
4	balsam fir, mountain ash
5	balsam fir, sugar maple, beaked hazel
6	ironwood

Teledyne Gurley No. 625 Pygmy Current Meter. Using the above information, the following could be calculated:

depth at station (m) x width of drift net opening (m) x current velocity (m/sec) x duration of drift sample (sec) = m^3 of water in drift column

Drift samples were either picked immediately and preserved in a 30% methanol solution or preserved in their entirety in a 10% solution of formaldehyde. In the laboratory, invertebrates were counted and identified to order or family and the results expressed as:

number of invertebrates/10 m^3 of water in drift column

Terrestrial organisms were separated from the aquatic drift samples, counted, identified and recorded as number of invertebrates per 100 m^2 of surface area of drift column, calculated as follows:

$$\frac{\text{number of invertebrates} \times 100}{\text{width of drift net opening (m)} \times \text{current velocity (m/sec)} \times \text{duration of drift sample (sec)}}$$

Bottom Fauna

Bottom fauna populations were sampled periodically at each station using a standard 0.093 m^2 Surber sampler (Surber 1936). Organisms collected from four randomly chosen rocks (approximately 20 cm in diameter) at each station were used to supplement the population study. Samples were picked and identified in the same way as drift samples. For each sampling date, results were expressed as mean numbers and standard deviation of aquatic organisms of a particular group collected in four Surber samples or from four rocks.

Caged Invertebrates

Aquatic insects from two taxonomic groups were held in small, submerged holding cages at the treatment and control stations at the time of the second spray application.

	Number of Invertebrates	
	Treatment	Control
Trichoptera:Limnephilidae	11	8
Plecoptera	18	10

The cages consisted of 30 cm lengths of 10 cm diameter ABS tubing, screened at both ends, and fitted with a hinged door. Several plastic baffles were located inside the tube to break up the current. Insects were counted and transferred into the cages three days before the spray and the cages were placed in the streams in a position that allowed the current to flow through the ends. Cages were checked periodically for mortality up to two days after the spray.

Fish Diets

Fish for stomach content analysis were collected either by electrofishing or angling. Total length, fork length, weight and sex were recorded for each fish caught. Stomachs were excised and preserved immediately in a 10% solution of formaldehyde. In the laboratory, the volume of the stomach contents was measured and the composition of food items determined. In measuring the volume of the stomach contents, the amount of indigestible material present was estimated and the measured volume corrected accordingly so as to represent actual volume of food items.

RESULTS

DEPOSIT

Deposit measurements for the first and second applications are summarized in Tables 3 and 4 respectively. Because of the problems involved in determining volume by the spot counting method (e.g., loss of the most volatile fraction of the formulation from descending spray droplets through evaporation; inability of the spot counting method to account for droplets smaller than 20 μ in diameter), volume as determined by colorimetry probably gives a truer indication of actual volume deposited.

Deposit on the bird plot was similar for both applications. At the aquatic sampling station, however, a much better deposit was achieved from the second spray than from the first, and for both applications there was a heavier deposit on the mid-stream samplers than the stream bank samplers.

Some drift of spray products was measured at the downstream station for both applications. During the second spray, a malfunction developed in one of the spray plane's Micronair® units. A small amount of spray product continued to leak from this unit after the plane had completed each south to north pass of the spray block and made its turn over the downstream station in preparation for a north to south run. This may partially explain the higher deposit measured at the downstream station for the second spray. There is a very large discrepancy between deposit as measured by

Table 3
Deposit assessment summary from the
Azamethiphos Treatment Plot* sprayed 29 June 1979,
Montcalm County, Quebec.

			Colorimetry		Spot Counting	
	Number of deposit samplers	Mean Drop Density (Drops/cm^2)	Mean Volume Deposited (l/ha)	Mean Percent of Emitted Volume Recovered	Mean Volume Deposited (l/ha)	Mean Percent of Emitted Volume Recovered
Bird Plot	6	12.77	8.67×10^{-2}	5.94	4.76×10^{-2}	3.26
Treatment Stream						
Mid-stream samplers	5	10.31	4.80×10^{-2}	3.29	3.08×10^{-2}	2.11
Stream bank samplers	5	1.88	1.20×10^{-2}	0.82	1.21×10^{-2}	0.83
Downstream Station	5	<0.01	4.00×10^{-3}	0.27	4.00×10^{-6}	<<0.01

* spray emission rate 1.46 l/ha (20 fl. oz./acre)

Table 4
Deposit assessment summary from the
Azamethiphos Treatment Plot* sprayed 5 July 1979,
Montcalm County, Quebec.

	Number of deposit samplers	Mean Drop Density (Drops/cm^2)	Colorimetry: Mean Volume Deposited (l/ha)	Colorimetry: Mean Percent of Emitted Volume Recovered	Spot Counting: Mean Volume Deposited (l/ha)	Spot Counting: Mean Percent of Emitted Volume Recovered
Bird Plot	6	12.20	10.33×10^{-2}	7.08	3.25×10^{-2}	2.23
Treatment Stream						
Mid-stream samplers	5	20.20	9.20×10^{-2}	6.30	5.88×10^{-2}	4.03
Stream bank samplers	5	7.42	4.00×10^{-2}	2.74	2.03×10^{-2}	1.39
Downstream Station	5	0.02	3.00×10^{-2}	2.06	7.54×10^{-5}	<0.01

* spray emission rate 1.46 l/ha (20 fl. oz./acre)

spot counting and colorimetry however, and it is possible that in the latter case the spectrophotometer was measuring something other than dye.

TERRESTRIAL INVERTEBRATES

Forest Plot

On the days of application (29 June and 5 July) terrestrial invertebrate knockdown in treatment buckets was nine times that of control (Appendix I, Tables 1 and 2), a sixteen-fold increase over the average pre-spray daily totals (20-28 June) prior to the first spray, and a six-fold increase over the average (1-4 July) prior to the second spray.

Diptera, Homoptera, Hymenoptera and Araneida were affected by both applications, but Coleoptera and Acari responded to the first treatment only (Figures 2 and 3). All groups were affected immediately except Araneida which exhibited a one day delayed response. Peak numbers of Homoptera and Hymenoptera were observed two days after the second application.

Recovery was observed two days after the first application, but effects of the second application were still evident in all groups up to the conclusion of the study five days after the second spray application.

Stream bank

A significant knockdown of terrestrial invertebrates was observed in the first and second post-spray samples (3 and 5 times the pre-spray average respectively) following the first azamethiphos application (Appendix I; Table 3) Adult Diptera and Hymenoptera were affected immediately. Increased numbers of Acari, Araneída, Collembola and Coleoptera:Staphylinidae did not show up in the buckets until the day after application (Figure 4). By two days after application numbers had returned to normal.

Collembola were knocked down immediately by the second spray. Increases in numbers of Acari, Hemiptera and adult Diptera were not observed until two days after application (Figure 4).

Numbers at the control station fluctuated relatively little over the course of the study (Appendix I, Table 4; Figure 5).

Drift

Significant increases in the drift of terrestrial forms of Araneida, Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Hymenoptera, Formicidae and Diptera were observed at the treatment station within two hours of the first spray application, but numbers

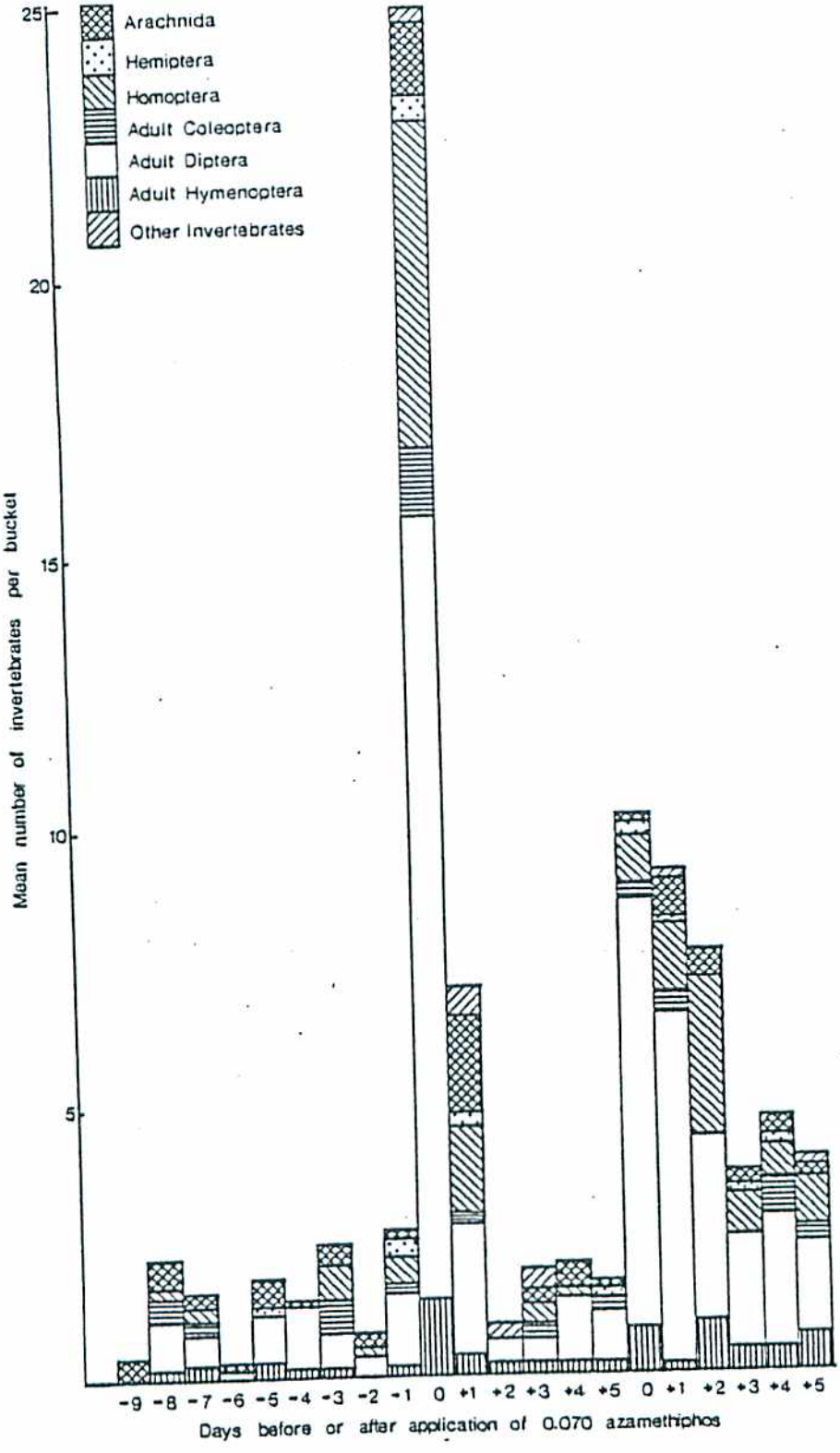


Figure 2. Terrestrial invertebrates collected from buckets placed in treated forest plot.

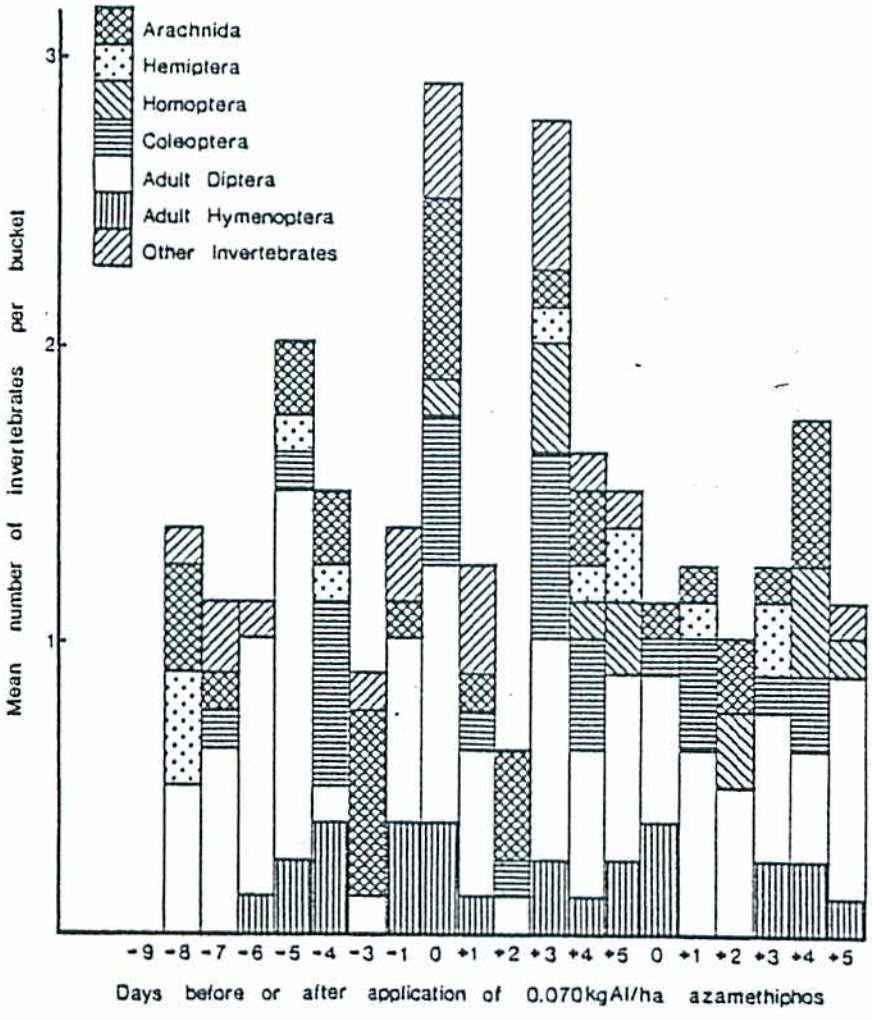


Figure 3. Terrestrial invertebrates collected from buckets placed in control forest plot

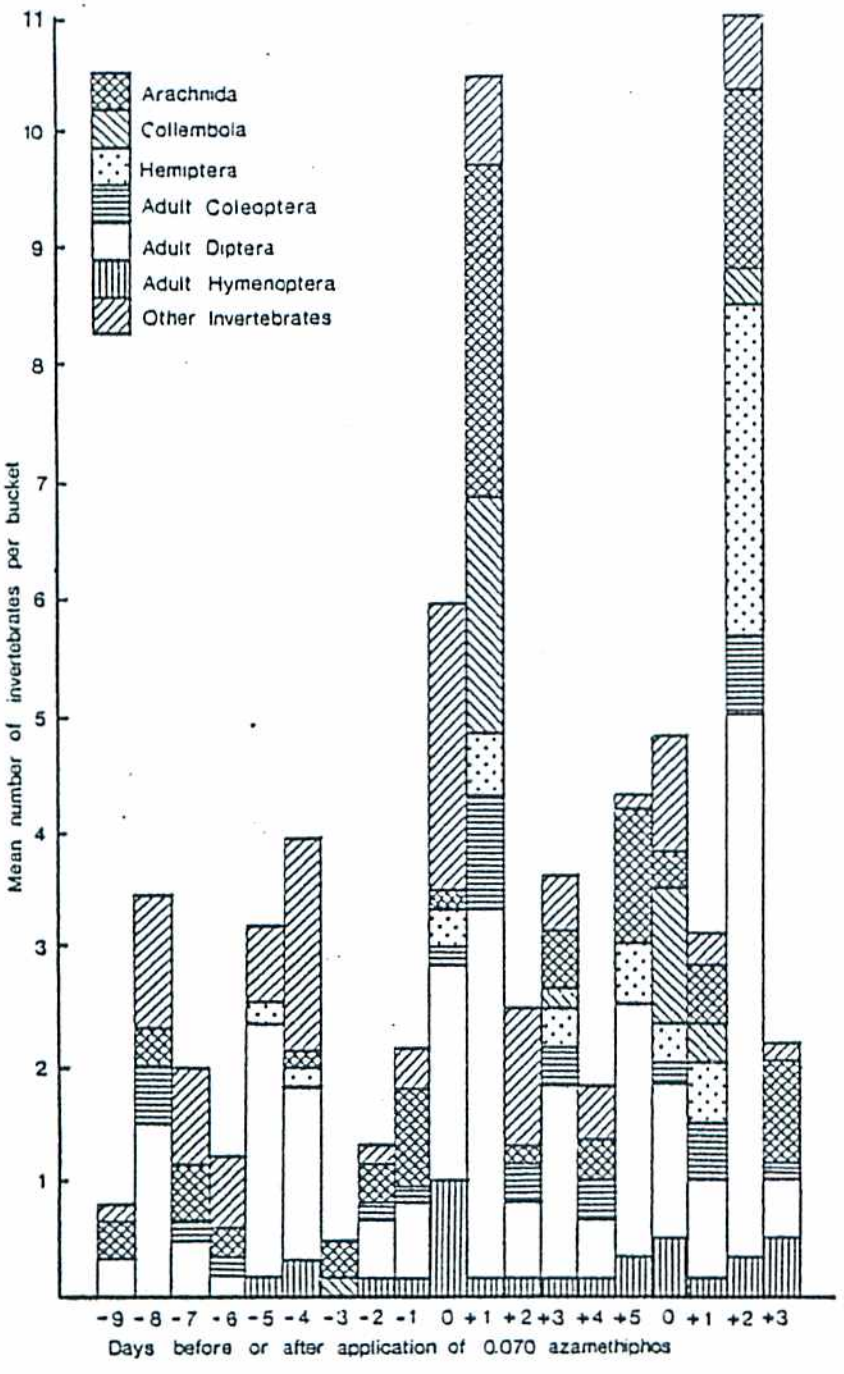


Figure 4. Terrestrial invertebrates collected from buckets placed along the treatment stream

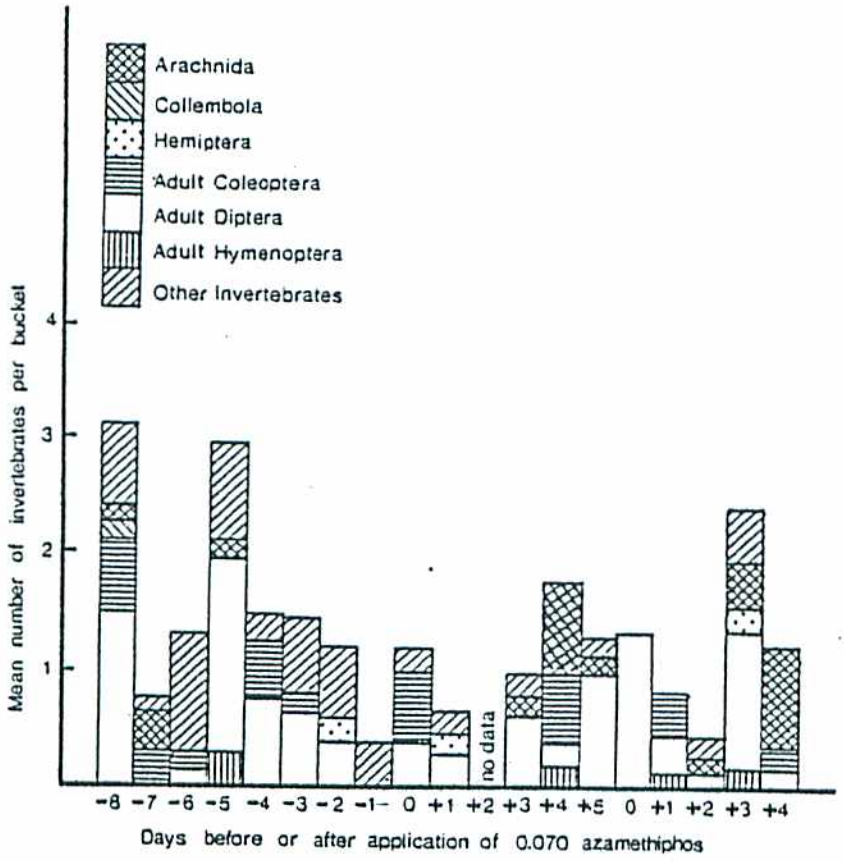


Figure 5. Terrestrial invertebrates collected from buckets placed along the control stream

had returned to normal by that evening (Appendix I, Table 5; Figure 6). No similar increases in terrestrial invertebrate drift were noted at the control station at this time (Appendix I, Table 7; Figure 6). Diptera and Hymenoptera appeared to be the most severely affected. No significant knockdown was recorded at the downstream station for the first spray or at either Ruisseau Castor station for the second spray (Appendix I, Tables 5 and 6).

BIRDS

The population structure of forest avifauna on the treated and control plots was similar (Appendix II; Tables 1-4). A total of 33 species representing 11 families were recorded on the treated plot and 33 species representing 15 families on the untreated control plot. Populations of Parulidae, Fringillidae and Turdidae, the predominant families in both areas (Appendix II; Tables 1 and 2) remained relatively stable through the study (Figure 7).

Insectivorous bird species such as the Nashville warbler, *Vermivora ruficapilla* (Wilson), the magnolia warbler *Dendroica pensylvanica* (Linnaeus), the common yellowthroat, *Geothlypis trichas* (Linnaeus) and the American redstart, *Setophaga ruticilla* (Linnaeus) were not affected by the treatment (Appendix II, Tables 3 and 4; Appendix III, Figures 1-4. The number of alder flycatchers *Empidonax alnorum* (Brewster), declined significantly on the treatment plot following the first application, however, and their territories remained unoccupied for the rest of the study. The control plot did not support a population of alder flycatchers, but eastern phoebes, *Saynoris phoebe* (Latham), a similar species, continued to defend their territories in the control plot, suggesting no natural abandonment of flycatcher territories at this time (Appendix II, Tables 3 and 4; Appendix III, Figure 5).

The breeding territories of representative species of Turdidae and Fringillidae were not disturbed (Appendix III, Figures 6-8). The ruby-crowned kinglet, *Regulus calendula* (Linnaeus), small pesticide sensitive species, continued to actively defend their territories throughout the study (Appendix III, Figure 9). Plot searches following each application did not detect any dead birds or birds exhibiting signs of pesticide stress (bill wiping, tremors or other erratic behaviour).

AQUATIC STUDIES

Water Chemistry

The water chemistry parameters for each aquatic sampling station are summarized in Table 5. Although stream water temperatures were fairly high (14.5-20.0°C) at the time of the study, dissolved oxygen content did not drop below 8 ppm.

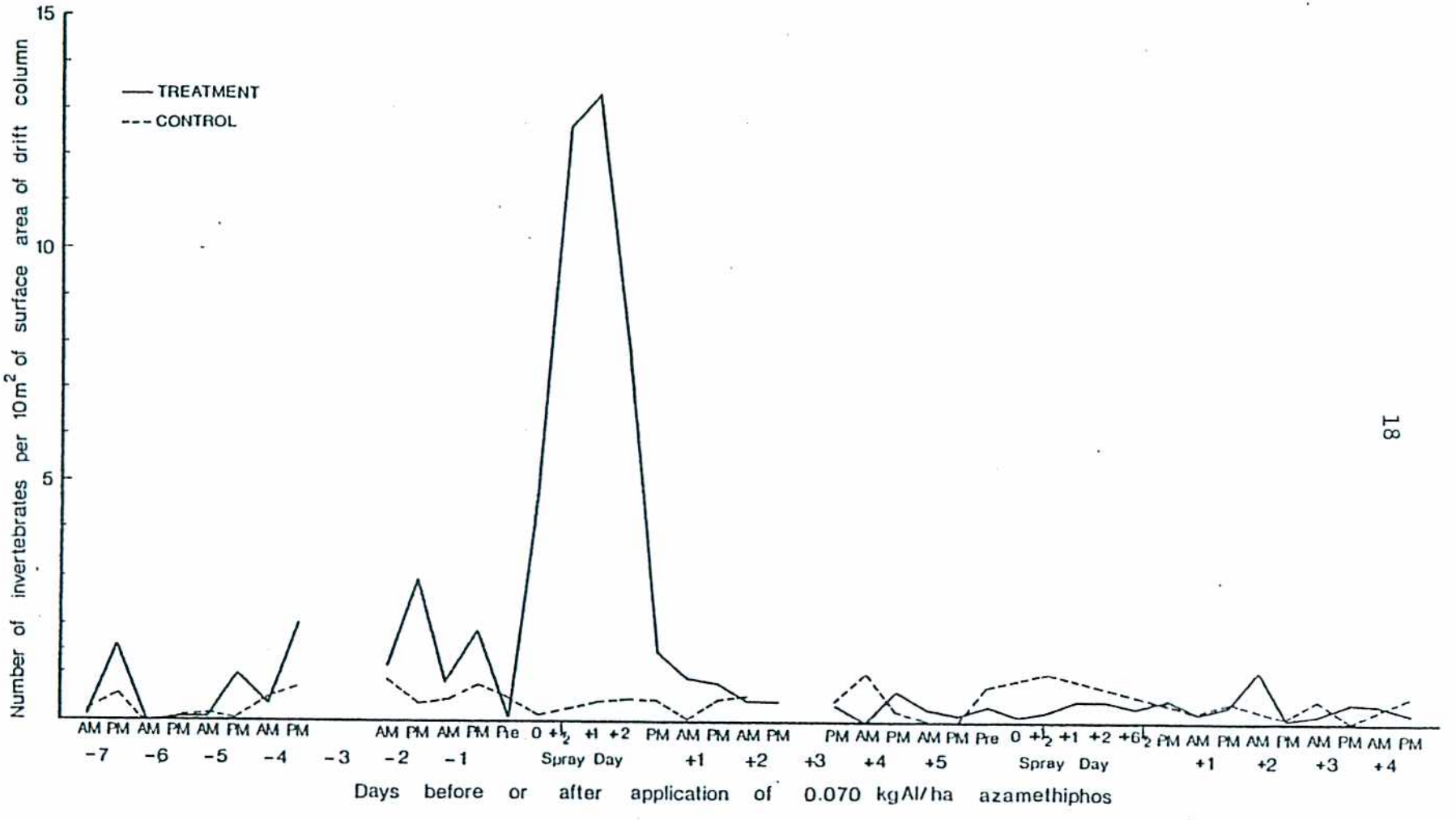
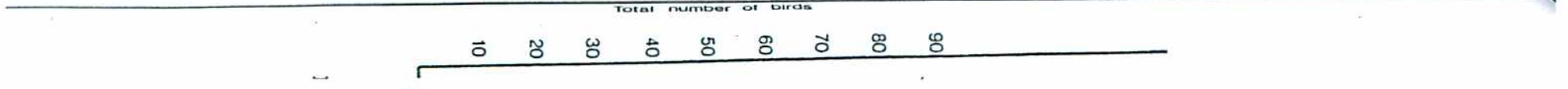


Figure 6. Terrestrial invertebrates collected in drift net sets at the treatment and control stations



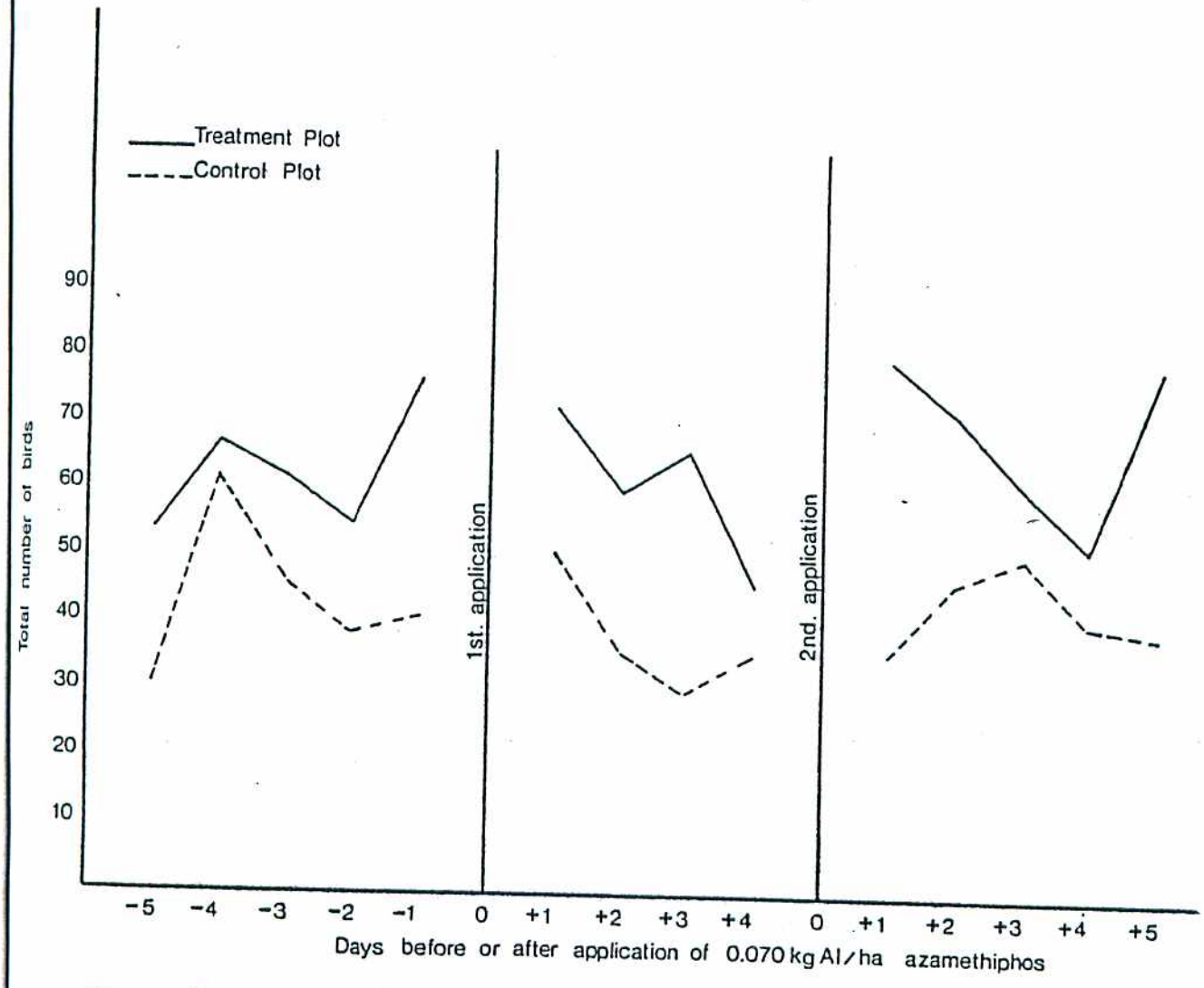


Figure 7. Comparison of bird activity on treatment and control plots

Table 5
Water quality parameters in study streams,
Montcalm County, Quebec.
16 June to 31 August 1979

Sampling Station	Date	Temperature (°C)	pH	Dissolved O_2 (mg/1)	Hardness (gpg $CaCO_3$)	Alkalinity (gpg $CaCO_3$)
Control	16/6/79	19.0	6.5	9	2	2
	3/7/79	17.0	7.0	9	2	1
	9/7/79	17.0	7.0	8	2	2
	28/8/79	18.0	7.0	8	3	1
Ruisseau Castor	16/6/79	20.0	7.0	9	3	2
	3/7/79	15.0	7.0	10	7	1
	9/7/79	17.0	7.5	8	3	2
	31/8/79	15.5	7.0	8	3	1
Ruisseau Castor Downstream	17/6/79	17.0	7.0	8	4	2
	3/7/79	14.5	6.5	8	2	1
	9/7/79	18.0	7.0	8	3	2

Aquatic Invertebrates

The results of drift netting and bottom fauna sampling are summarized in Appendix IV; Tables 1-9. Numbers of most groups of aquatic invertebrates were too low and too variable to make any certain statements regarding changes in population levels resulting from the two azamethiphos applications. Since heptagenid mayfly nymphs (Ephemeroptera:Heptageniidae), baetid mayfly nymphs (Ephemeroptera:Baetidae), and caddisfly larvae (Trichoptera) were among the most abundant groups present at all three stations, and since these groups are usually good indicators of insecticide effects, their changes in abundance over the course of this study have been illustrated in Figures 8 and 9.

A severe regional storm which began on the evening of 1 July, two days after the first azamethiphos application, and continued throughout the night and most of the next day, resulted in extremely high water levels and increased current speeds at all three study stations (Table 6). The first post-spray bottom fauna samples could not be taken until water levels had receded enough to allow crews to work in the study streams, and even then sampling was still extremely difficult. Because the flood occurred between spray day and the first post-spray bottom fauna sample, it is impossible to separate which changes in abundance of aquatic invertebrates were due to the insecticide application, and which to flood effects and poor sampling conditions.

Sometime after the 30 July sample date, construction began to widen Highway 18 south of Notre-Dame-de-la-Merci. This construction had significant effects upon the Ruisseau Caster watershed. By the time of the two month post-spray sample on 31 August, heavy siltation was evident along the entire length of the treatment stream as a result of earth moving and heavy equipment traffic. In addition, the section of stream including the downstream station had been re-channeled to facilitate bridge construction.

Ruisseau Castor Treatment

There was a very significant increase in the number of caddisfly larvae (Trichoptera) caught in the drift net set on the evening of the first application (almost 300 times the average number caught in pre-spray drifts) (Appendix IV; Table 1). A much smaller increase (< one order of magnitude) in drifing water striders (Hemiptera:Gerridae) was observed in the + 1 hr and + 2 hr drifts on spray day. This increase is significant, however, because up until this time only one water strider had been caught in six days of pre-spray drift netting. The increases in the drift of baetid mayfly nymphs and chironomid larvae (Diptera:Chironomidae) recorded on the evening of 1 July were probably the result of flash flooding.

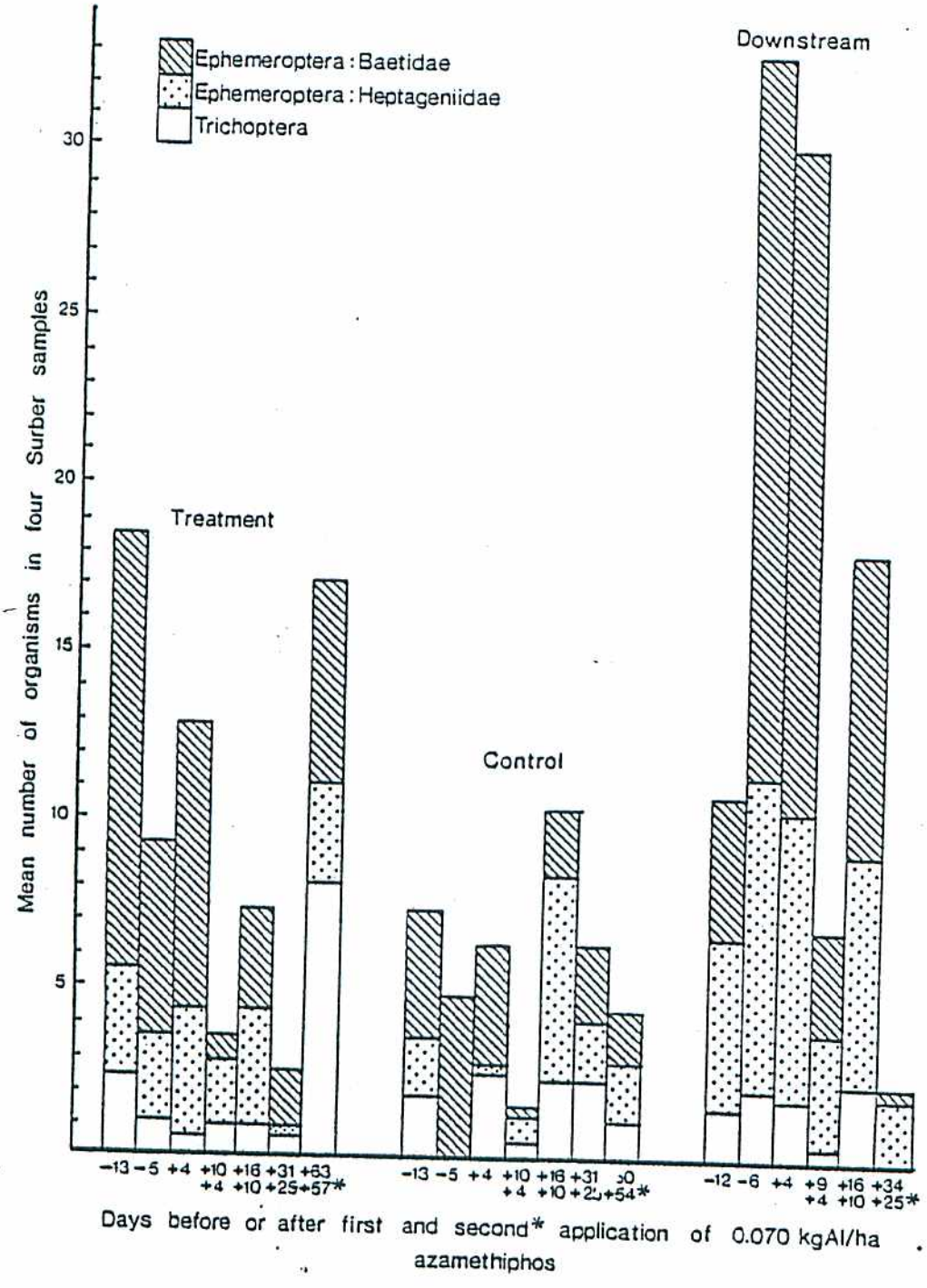


Figure 8. Changes in abundance in selected groups of aquatic invertebrates from Surber samples

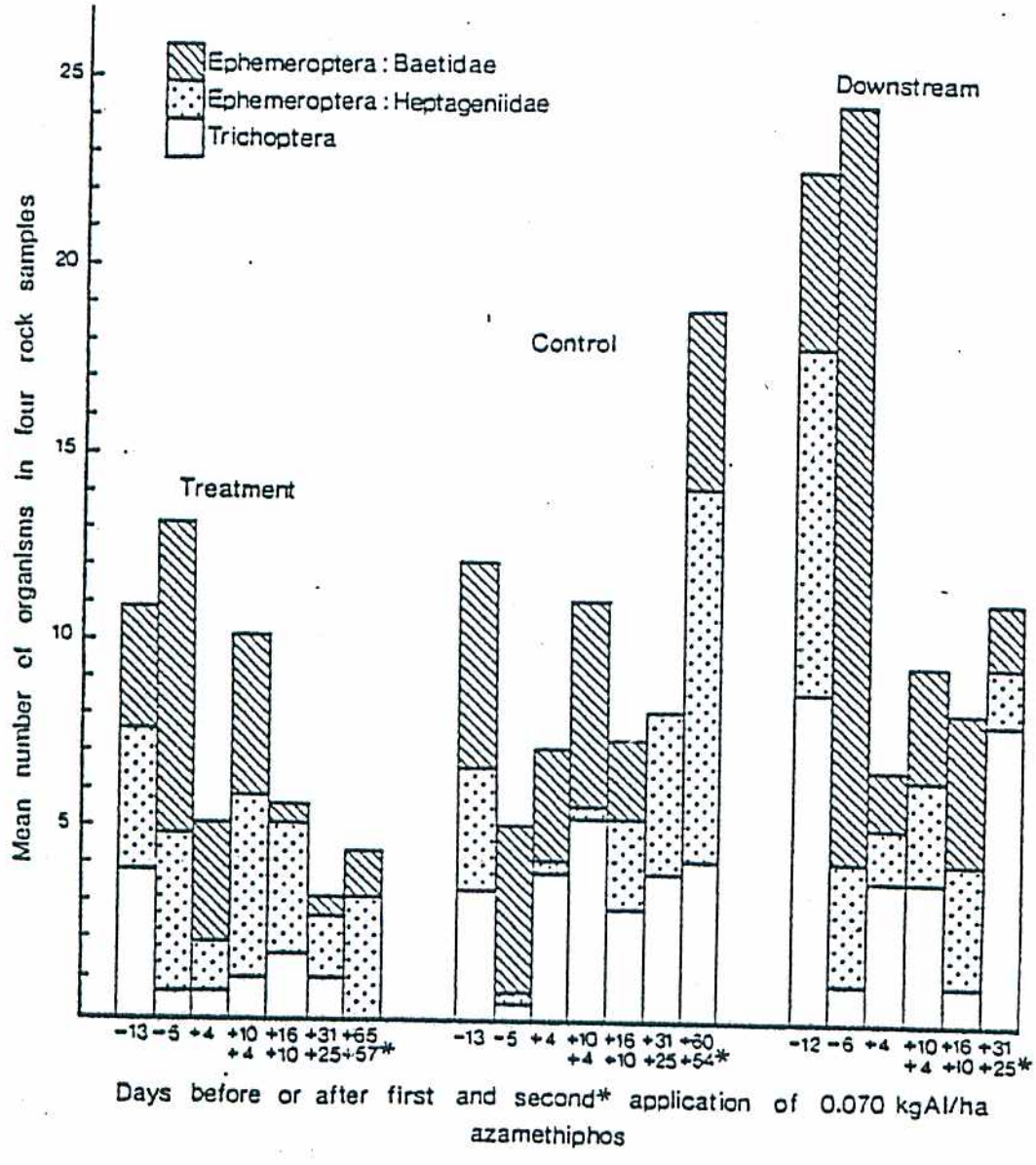


Figure 9. Changes in abundance in selected groups of aquatic invertebrates from rock samples

Table 6
Change in water level and flow* of Ruisseau Castor and Untreated Control Stream as a result of 1 - 2 July 1979 regional storm.

Date		Ruisseau Castor Treatment		Ruisseau Castor Downstream		Untreated Control	
		depth (m)	current velocity (m/sec)	depth (m)	current velocity (m/sec)	depth (m)	current velocity (m/sec)
30 June	am	0.22	0.36	0.16	0.21	0.22	0.39
	pm	0.22	0.30	0.15	0.33	0.22	0.24
1 July	am	0.21	0.30	0.16	0.30	0.18	0.12
	pm	0.47	0.69	--	--	--	--
2 July	am	>0.50	--	0.48	0.96	--	--
	pm	0.50	0.63	0.47	0.69	0.70	0.48
3 July	am	0.50	0.57	0.40	0.54	0.70	0.36
	pm	0.40	0.45	0.36	0.51	0.58	0.42
4 July	am	0.40	0.51	0.30	0.45	0.53	0.45
	pm	0.37	0.45	0.27	0.39	0.53	0.48
5 July	am	0.37	0.30	0.23	0.36	0.52	0.44
	pm	0.31	0.36	0.20	0.36	0.47	0.39

* measurements taken at drift stations

Other than a slight increase in springtails (Collembola) there were no significant changes in the drift pattern at the treatment station following the second azamethiphos application.

Immediately following the first application a reduction (< one order of magnitude) in the number of caddisfly larvae in Surber samples was observed at the treatment station, but not at the control station. By four days after the second spray, numbers had returned to close to the pre-spray level. A reduction (< one order of magnitude) in the population of baetid mayfly nymphs at the treatment station immediately following the second application was accompanied by a reduction of similar magnitude at the control station.

Numbers of most groups of aquatic invertebrates collected from rocks at both the treatment and control stations decreased immediately following the first spray and then increased again after the second spray. There are two probable explanations for this, both of which are related to the effects of the 1 July flood:

1) Organisms living on the surface of rocks and exposed to the current were washed off during the flood and later recolonized.

2) Water levels were still high at the time of the first post-spray bottom fauna sample and organisms were washed off the rocks as they were brought to the surface.

Numbers of caddisfly larvae and pupae, many of which firmly anchor themselves to the substrate, remained essentially unchanged over this period at the treatment station, but increased at the control station.

There was no mortality of caged caddisfly larvae or stonefly nymphs at either the treatment or control station.

Ruisseau Castor Downstream

In general, more organisms were caught in nocturnal than in diurnal drift net sets. Following the first application there were no apparent changes in the drift pattern at this station. There was a significant increase in the number of caddisfly larvae caught in the first nocturnal drift sample taken following the second application (> 4 times the number in the nocturnal drift from the day before) (Appendix IV; Table 2). No corresponding increase was noted at the control station.

A very slight reduction in numbers of stonefly nymphs (Plecoptera) collected in Surber samples was observed immediately following both the first and second azamethiphos applications. By ten days after the second spray, however, numbers were back to the

pre-spray level. Over this period, the population in the control stream remained at a fairly constant, low level. Although a significant reduction in the population of riffle beetle larvae (Coleoptera:Elmidae) following the first spray is indicated at this station, this is probably due to variability in sampling since these insects seem to appear and disappear randomly over the course of the study at all three stations. Heptagenid and baetid mayfly nymphs and caddisfly larvae all decreased in abundance at the downstream station after the second spray. At the control station a similar decrease was noted for baetid mayfly nymphs and caddisfly larvae, but heptageniid mayfly nymphs increased in abundance.

Aquatic invertebrates collected from rocks at the downstream station exhibited the same general trends in numbers as those at the treatment and control stations.

Fish Diets

Brook trout for stomach content analysis were collected on five occasions between 21 June and 31 August. Over this period the ratio of volume of stomach contents/body weight steadily increased to a peak on 9 July after which it dropped off, and the composition of the diet changed significantly (Appendix V, Tables 1 and 2).

Two dietary changes of particular interest were noted (Figure 10):

1) Caddisfly larvae were an important item in the diets of brook trout up until 9 July (an average of 22.7 percent of the volume) after which they became of minor importance (< 10 percent). Conversely, chironomid larvae were of little importance in the first part of the study (5 percent of the volume or less) but were eaten in significant numbers after 9 July (an average of 25.2 percent).

2) Baetid mayfly nymphs made up a large part of brook trout diets (an average of 25.7 percent of the volume) in all but the 9 July sample (5.5 percent).

   In this sample flying Diptera were by far the most important food source (61.6 percent of the volume).

Most other invertebrate groups eaten were of minor importance throughout the study except terrestrial Homoptera and Lepidoptera, which were important in the 21 June pre-spray sample (25.5 and 17.5 percent of the volume respectively), and burrowing mayfly nymphs

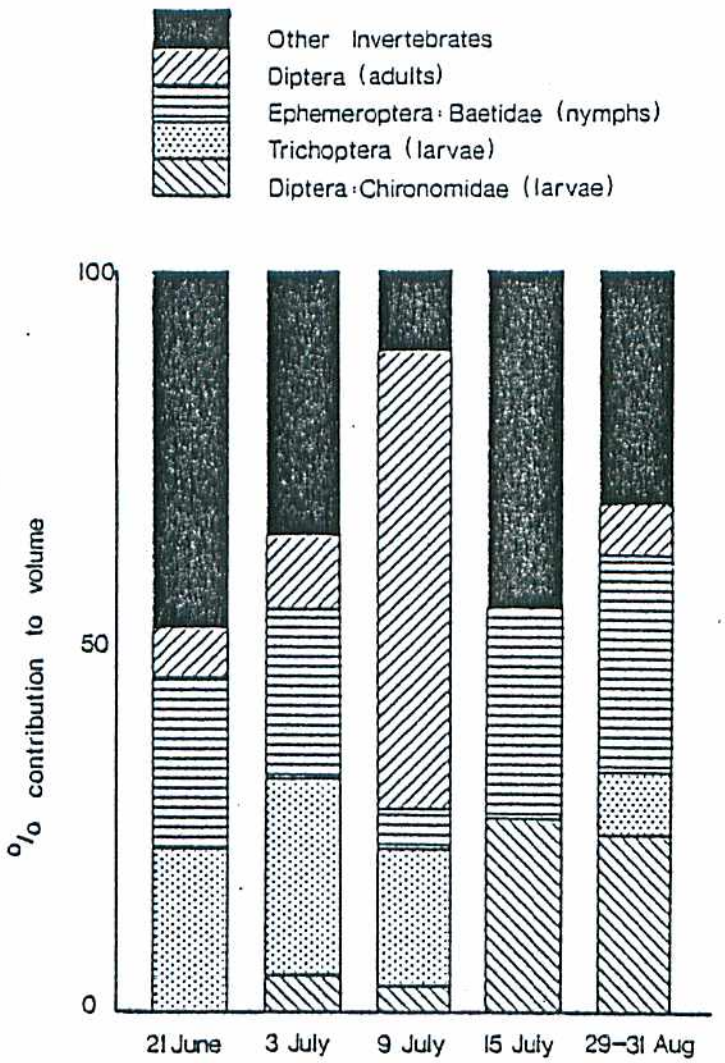


Figure 10. Dietary changes in brook trout sampled from the treated portion of Ruisseau Castor

(Ephemeroptera:Ephemeridae) which appeared in the 3 July sample (two individuals making up 15.5 percent of the volume).

DISCUSSION

DEPOSIT

Deposit for the two applications (0.27% to 5.94% of the emitted volume by colorimetric analysis in the first and 2.06% to 7.08% in the second) was much lower than expected considering the type of spray aircraft used and the near perfect weather conditions at the time of both treatments. Using the same aircraft and spray emission system, Kingsbury and Kreutzweiser (1979) measured deposits on mid-stream sampling units of from 3.4% to 59.2% of the emitted volume by colorimetric analysis (permethrin oil soluble concentrate in insecticide diluent "585"). In the latter study the insecticide formulation was applied at a rate of 4.68 l/ha, however, as compared to 1.46 l/ha in the present study. One possible explanation for the low deposit measured is that in most cases deposit samplers were positioned under some type of cover, and that overhanging vegetation filtered out a large proportion of the spray droplets before they reached the ground or the water surface.

TERRESTRIAL EFFECTS

Azamethiphos had an immediate broad spectrum effect on terrestrial invertebrates, but delayed and extended effects would seem to indicate that this insecticide continues to be toxic in the environment for up to five days or longer depending on weather and spray conditions.

Although deposit on the bird plot was similar for both applications, knockdown results were very different. Three days of precipitation immediately following the first application may have washed insecticide residues from the vegetation, limiting the knockdown effect. No precipitation occurred during the post-spray period for the second application, however, allowing the chemical to remain in the environment longer, and resulting in a prolonged knockdown effect.

Weather conditions at the time of application will also influence invertebrate activity and hence the likelihood of individuals physically contacting the pesticide. Warm temperatures at the time of the first spray were probably at least partly responsible for the especially large knockdown observed on 29 June. Less of an impact was observed for the second treatment which was applied at an earlier time in the morning when temperatures were cooler (5°C), and invertebrates less active.

In general, litter inhabiting fauna appeared to be unaffected, possibly because they were protected from the effects of a direct

spray by the forest canopy and underbrush. Although stream bank buckets were fairly successful in collecting springtails and staphylinid beetles, overall, numbers of litter inhabitants sampled were quite low, which may reflect limitations of this method as a true indicator of pesticide effect for this group.

Delayed increases in the knockdown of Homoptera and Hemiptera, plant feeders, and of insect predators such as Araneida and Acari, may be due to ingestion of the chemical through contaminated food. Despite the fact that there was a considerable impact on most terrestrial invertebrate groups, there was no observed effect on Lepidoptera.

During the nesting season, arthropods are more critically a necessary food source for birds. Adults expend a greater amount of energy in foraging, in order to fulfill brood requirements. At this time, adults have been shown to diversify both foraging area and method of predation, which enables them to exploit alternate resources (Root 1967). Feeding studies prove that a change in food supply will evoke a change in foraging behaviour (Hartley 1953). Therefore, it would seem probable that a temporary depletion of arthropods, such as the knockdown experienced in this program, would trigger natural adaptations to fluctuations of arthropod populations.

Owing to their specialized mode of feeding, flycatchers are potentially the most vulnerable to a knockdown of flying insects. Reports on stomach content vary, but Bent (1942) listed Hymenoptera, Coleoptera and Diptera as the major food sources of the Alder flycatcher (41%, 18% and 14% respectively). The fact that the documented knockdown was largely of these groups, suggests that territorial abandonment by the alder flycatcher may have been due to a depletion of their food source. With constant emergence and immigration of insects, any localized depletion should have been shortlived however, and individuals may have foraged outside the block until insects were again available in that area.

As mentioned above, three days of rain occurred immediately after the first application. These adverse weather conditions pose a potentially greater threat to the food supply than pesticide knockdown, by increasing energy costs to maintain body heat, while decreasing insect activity and hence, availability of food.

Another possible explanation for the disappearance of alder flycatchers may be the natural breakdown of territories after nesting. Data for the alder flycatcher in this area is not available, but in areas where egg dates for both the eastern phoebe and the alder clycatcher are recorded, the eastern phoebe nests earlier. Despite this, the eastern phoebe was observed to be in territory after the alder flycatcher. This may have represented a second brood however, as the eastern phoebe has been reported to produce two broods per season under favourable conditions.

AQUATIC EFFECTS

Fredeen (1962) and Fredeen et al. (1953) found that control of blackfly larvae in Western Canada with DDT and heptachlor was most effective when the water was turbid or if the insecticide was introduced in a formulation containing diatomaceous earth. It was assumed that the toxin became adsorbed on to the suspended particles in the water which were trapped and consumed by the blackfly larvae. It was also noted that the treatments had less effect on other aquatic insects which do not normally feed on small particles suspended in water.

On the evening of the first spray, 241 of the 245 caddisfly larvae (98.4%) caught in the drift at the treatment station belonged to the family Philopotomidae. Similarly, 29 of the 31 caddisfly larvae (93.6%) caught in the first nocturnal drift net set at the downstream station following the second application were also Philopotomidae. This family of Trichoptera is roughly classified by Pennak (1978) into a group called "net filter feeders" according to their method of obtaining food; i.e., they "construct fine nets that strain particulate material from the water; the larvae may eat the whole net and its contents periodically, or they may remove the particles from the net".

Lipophilic molecules with low solubility in water, such as azamethiphos, adsorb readily onto sediments and suspended particulate materials in an aqueous environment. Azamethiphos, adsorbed onto particles trapped in a caddisfly larva's food net, or onto the proteinaceous net itself, when ingested, would act as a stomach poison. This method of feeding may explain why only this particular family of caddisfly appeared to be affected by the application, and also why in both cases the response was delayed by several hours.

Caged caddisfly larvae of the family Limnephildae were unaffected by the second spray. Members of this family are "grazers", which feed on algae, fungi, detritus and very small invertebrates picked up at random from the substrate (Pennak, 1978) and do not remove suspended particulate matter from the water.

It is interesting to note that the increase in drift of caddisfly larvae at the downstream station following the second spray corresponds to an unusually high measured deposit of spray products at this station as a result of the malfunction in one of the spray aircraft's Micronair units described earlier.

A slight increase in the drift of water striders was noted immediately following the first spray. These insects inhabit the surface film of water, and in streams prefer areas with little or no current. By virtue of their habitat requirements, these semi-aquatic hemipterans are likely to occasionally come in direct contact with either the spray cloud or an insecticide-carrier oil

slick on the water surface, and in this respect are more like terrestrial insects. As noted previously terrestrial Hemiptera were knocked down by both spray applications.

Although there was some indication from Surber sampling that stonefly nymph populations may have been reduced at the downstream station, no mortality of caged stonefly nymphs was noted.

The fact that brook trout are basically opportunistic feeders complicates the analysis of the effects of insecticide applications on their diets. Dietary changes reflect only changes in availability of food items and do not necessarily indicate population reductions of a particular benthic group.

Baetid mayfly nymphs were of significantly less importance in the 9 July sample not only because of a temporary reduction in the population level, but also because knocked-down terrestrial Diptera became a more easily obtainable food source at this time. Similarly, a decrease in importance of caddisfly larvae after 9 July reflects both a decrease in abundance of this group plus an increase in abundance of chironomid larvae and baetid mayfly nymphs.

Although the overall composition of the diet changed significantly over the course of the study, there is nothing to suggest that availability of food became a limiting factor to the trout population of Ruisseau Castor.

CONCLUSION

A double application of 0.070 kg AI/ha azamethiphos, at the deposit levels measured in this study, had no obvious harmful effects on forest songbirds or native fish. Territorial abandonment by alder flycatchers following the first application could not be positively attributed to the treatment, and may have occurred naturally as a result of termination of breeding activities. Other than a fairly large impact on one family of caddisfly larvae (Philopotomidae), no significant overall effects on aquatic invertebrates were noted. Toxicity to terrestrial invertebrates was extensive with residual knockdown effects documented up to five days after the spray.

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APPENDIX I

Terrestrial invertebrate knockdown in treated and control areas.
Montcalm County, Quebec. 1979.

Table 1
Terrestrial Invertebrate Knockdown,
Azamethiphos Treatment Plot,
Montcalm County, Quebec.
20 June to 10 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos*		-9	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	0	+1	+2	+3	+4	+5
Gastropoda					1							1	1					1				
Arachnida																						
Phalangida		3				2		1				1										
Acari											3											
Araneida			4	2	1	2	1	2	2	1	8	13		2	4	1	1	6	4	2	3	2
Collembola								1						1								
Orthoptera																						1
Hemiptera						1				3	3	2				1	2	1	2	1	1	
Homoptera																						
Cicadellidae											2											
Other	adults		1	2				5	1	4	46	12		3	1		7	10	21	6	5	7
Coleoptera																						
Carabidae			1	1				1														
Staphylinidae			1					2		1	2			2		2	2	2				2
Elateridae			1					1														
Other	adults		1	1				1			8	2						1			5	
Trichoptera											1											
Lepidoptera																						
Microlepidoptera												2										
Other	larvae			2			1	1				1	1	2								
Diptera																						
Tipulidae			2	2		1			1		1											
Culicidae				1										1		1	1		1	2		
Chironomidae			1			1	2	1	1	1	24	8	1			2	7	21	8	3	3	2
Simuliidae						1		1		3	8	2	1		2	1	17	2	6	9	9	6
Sciaridae				1		1	2			1	1		1			1	4	2	4		5	
Muscoidae											3	2		3				1		1		
Other	adults		4		1	3	5	3	1	6	77	7	1		8	3	34	25	8	2	3	6
Hymenoptera																						
Formicidae				1																		
Other	adults		1	1		2	1	1		1	11	3	1	1	1	1	6	1	7	3	3	5
	larvae										1											
Total terrestrial invertebrates		3	17	14	3	14	12	21	6	21	199	56	7	15	16	13	81	73	61	29	37	31

* application at 7:05 am on 29 June 1979 and
again at 4:25 am on 5 July 1979

Table 2
Terrestrial Invertebrate Knockdown,
Azamethiphos Untreated Control Plot,
Montcalm County, Quebec.
20 June to 10 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos*		-9	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	0	+1	+2	+3	+4	+5
Gastropoda					1					1	2	3		2	1							
Arachnida																						
Phalangida														1								
Acari								1	1		1									1		
Araneidae			3	1		2		1	4	1	4	1	3		2		1	1	2		4	
Collembola										1	1											
Plecoptera														1								
Hemiptera			3			1		1						1	1	2		1		2		
Homoptera																						
Cicadellidae															1	1					1	
Other	adults										1			3		1			2		2	1
Coleoptera																						
Carabidae											1									1		
Staphylinidae								2			1			3				1				
Elateridae				1											2						1	
Other	adults					1		3			2	1	1	2	1		1	2			1	
Lepidoptera																						
Other	larvae		1	1					1					1		1						1
Diptera																						
Culicidae			1	1																		
Chironomidae						1				1	1									1		
Simuliidae			1	2		1				1		2	1	2	1	1	1					
Sciaridae										1	1			1		1			1			
Muscoidae				1		1								1								2
Other	adults		2	1	7	7		1	1	2	5	2		2	3	3	3	5	3	3	3	4
Hymenoptera																						
Formicidae														1		1					1	
Other	adults				1	2		3		3	3	1		1	1	1	3			2	1	1
	larvae			1																		
Total terrestrial invertebrates		0	11	9	9	16	--	12	7	11	23	10	5	22	13	12	9	10	8	10	14	9

* application at 7:05 am on 29 June 1979
and again at 4:25 am on 5 July 1979

Table 3
Terrestrial Invertebrate Knockdown*,
Ruisseau Castor Treatment Stream,
Montcalm County, Quebec.
20 June to 8 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-9	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	0	+1	+2	+3
Gastropoda					0.40							0.16	0.33							
Arachnida																				
Phalangida				0.33			0.16							0.33	0.16					
Acari								0.16		0.66		1.17				0.66		0.33	1.16	0.66
Araneida		0.33	0.33	0.16	0.20			0.16	0.33	0.16	0.16	1.67	0.16	0.16	0.16	0.50	0.33	0.16	0.33	0.16
Collembola								0.16				2.00		0.16			1.16	0.33	0.33	
Ephemeroptera	adults			0.66		0.50	0.83			0.33		0.16	0.33		0.33		0.16			
Plecoptera	adults	0.16	0.16			0.16					0.33	0.16					0.33		0.16	0.16
Psocoptera	adults											0.16	0.33					0.33		
Hemiptera						0.16	0.16				0.33	0.50		0.33		0.50	0.33	0.50	2.83	
Homoptera																				
Cercopidae			0.16																	
Others			0.33	0.16	0.20				0.16		0.66			0.16						
Coleoptera																				
Carabidae	adults		0.16		0.20					0.16									0.16	
Staphylinidae	adults								0.16			0.83	0.16				0.16	0.16	0.50	0.16
Elateridae	adults		0.16															0.16		
Other	adults		0.16	0.16							0.16	0.16	0.16	0.33	0.33			0.16		
	larvae										0.16									
Trichoptera	adults												0.16		0.16					
Lepidoptera																				
Microlepidoptera	adults											0.16								
Macrolepidoptera	adults																		0.16	
Other	larvae		0.50								0.16			0.16					0.16	
Diptera																			0.16	
Tipulidae	adults		0.66				0.66				0.66	0.16		0.16			0.16			
Culicidae	adults		0.16																	
Chironomidae	adults											0.16	0.16						0.33	
Simuliidae	adults		0.16				0.50		0.16	0.33	0.50	0.33				0.16	0.16	0.16	0.16	
Sciaridae	adults	0.16		0.16			0.50						0.16	0.66						
Tabanidae	adults				0.20											0.16				
Muscoidae	adults						0.16					0.50								
Other	adults	0.16	0.50	0.33		2.17	0.66		0.33	0.33	1.67	2.00	0.33	1.00	0.50	1.83	1.50	0.66	4.00	0.50
Hymenoptera																				
Formicidae											0.16					0.16				
Other	adults					0.16	0.33		0.16	0.16	1.00	0.16	0.16	0.16	0.16	0.33	0.50	0.16	0.33	0.50
Total terrestrial invertebrates		0.81	3.44	1.96	1.20	3.15	3.96	0.48	1.30	2.13	5.95	10.44	2.44	3.61	1.80	4.30	4.79	3.11	10.93	2.14

* expressed as mean number of invertebrates per bucket

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 4

per bucket

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 4
Terrestrial Invertebrate Knockdown*,
Untreated Control Stream,
Montcalm County, Quebec.
21 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+3	+4	+5	0	+1	+2	+3	+4
Gastropoda				0.50							0.16								
Arachnida																			
Phalangida														0.16					0.60
Acari													0.20					0.20	
Araneida		0.16	0.33		0.16							0.16	0.60				0.16	0.20	0.20
Collembola		0.16																	
Ephemeroptera	adults			0.50	0.50			0.20											
Plecoptera	adults		0.16		0.16	0.25	0.16	0.40	0.20										
Hemiptera								0.20			0.16							0.20	
Homoptera																			
Cercopidae		0.33																	
Other					0.16							0.16		0.16				0.20	
Coleoptera																			
Carabidae	adults		0.16	0.16			0.16									0.16			
Staphylinidae	adults					0.50							0.40						0.20
Elateridae	adults	0.16																	
Other	adults	0.50	0.16							0.60			0.20			0.16			
	larvae	0.16															0.16	0.20	
Lepidoptera																			
Microlepidoptera	adults						0.16												
Other	larvae									0.20									
Diptera																			
Tipulidae	adults	0.33			0.16		0.16				0.16	0.16		0.33	0.33				
Culicidae	adults																	0.20	
Chironomidae	adults	0.16			0.50														
Simuliidae	adults				0.16		0.16								0.33	0.33			
Sciaridae	adults	0.16						0.20										0.40	
Tabanidae	adults											0.16							
Muscoidae	adults							0.20		0.20									
Other	adults	0.83		0.16	0.83	0.75	0.33			0.20	0.16	0.33	0.20	0.66	0.66		0.16	0.60	0.20
Hymenoptera																			
Formicidae		0.16					0.33		0.20										
Other	adults				0.33								0.20			0.16		0.20	
Total terrestrial invertebrates		3.11	0.81	1.32	2.96	1.50	1.46	1.20	0.40	1.20	0.64	0.97	1.80	1.31	1.32	0.81	0.48	2.40	1.20

* expressed as mean number of invertebrates per bucket

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 5
Terrestrial organisms caught in drift net sets*,
Ruisseau Castor Treatment Station,
Montcalm County, Quebec.
22 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-2 am	-2 pm	-1 am	-1 pm	Pre	Spray Day 0 hr	Spray Day +⅓ hr	Spray Day +1 hr	Spray Day +2 hr	+1 pm	+1 am	+1 pm	+2 am
Current velocity (m/sec)		0.58	0.30	0.36	0.30	0.33	0.27	0.24	0.24	0.30	0.32	0.33	0.30	0.27	0.27	0.27	0.27	0.27	0.24	0. 6	0.30	0.30
Surface area of drift column (m^2)		245.3	126.9	152.3	126.9	139.6	114.2	101.5	101.5	126.9	135.4	139.6	126.9	114.2	114.2	114.2	114.2	114.2	161.5	152.3	126.9	126.9
Arachnida																						
Araneida			1.58													1.75	4.38	3.50				
Diplopoda													0.78									
Ephemeroptera	adults				0.79		0.88		0.98	1.58	0.74			0.88	0.88	2.63	3.50	3.50	1.24	1.31	1.58	0.78
Anisoptera	adults							0.98								0.88						
Plecoptera	adults										1.48			0.88	0.88	3.50	2.63	0.88			0.78	1.58
Hemiptera									0.98							2.63			0.62			
Homoptera													0.78									
Trichoptera	adults					0.72									1.75	1.75						
Lepidoptera	larvae						0.88										0.88			0.66	0.78	
Hymenoptera																						
Formicidae																						
Other	larvae								0.98							0.88	5.25	2.63				0.78
	adults								0.98						0.88		0.88	0.88				
Coleoptera															4.38		4.38	3.50				
Staphylinidae	adults														0.88				0.62			
Lampyridae	adults										0.74											
Other	adults																0.88	3.50	0.62			
Diptera	adults	1.22	14.18				7.88	2.96	16.75	10.24	26.60	7.88	17.34		38.53	111.20	110.32	61.29	11.76	6.57	4.73	1.58
Total terrestrial invertebrates		1.22	15.76	0.00	0.79	0.72	9.63	3.94	20.69	11.82	29.55	7.88	18.91	1.75	48.16	125.21	133.09	79.68	14.86	8.54	7.88	4.73

* expressed as number of organisms/100 m^2 of surface area of drift column

** application at 7:05 am on 2 June 1979 and again at 4:25 am on 5 July 1979

Table 5 (cont'd)
Terrestrial organisms caught in drift net sets*,
Ruisseau Castor Treatment Station,
Montcalm County, Quebec.
22 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		+2 pm	+3 pm	+4 am	+4 pm	+5 am	+5 pm	Pre	Spray Day 0 hr	+½ hr	+1 hr	+2 hr	+6½hr	pm	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Current velocity (m/sec)		0.69	0.63	0.57	0.45	0.51	0.45	0.30	0.30	0.30	0.30	0.30	0.54	0.36	0.33	0.27	0.30	0.30	0.27	0.27	0.30	0.24
Surface area of drift column (m^2)		291.9	88.8	80.4	63.5	71.9	63.5	84.6	84.6	84.6	84.6	84.6	152.3	101.5	139.6	114.2	126.9	126.9	114.2	114.2	126.9	101.5
Arachnida																						
Araneida		0.34	1.13														0.78					
Diplopoda																						
Ephemeroptera	adults	0.68											1.31				2.36			0.88	0.79	
Anisoptera	adults																					
Plecoptera	adults	1.03				1.39					1.18			0.99								
Hemiptera		1.37											0.66							0.88		
Homoptera															0.72							
Trichoptera	adults				1.58																0.79	0.99
Lepidoptera	larvae		1.13									1.18										
Hymenoptera																						
Formicidae											1.18	1.18			0.72							
Other	larvae													0.98	0.72		0.78	0.79				
	adults	0.34						2.36				1.18		0.98			0.78		0.88			
Coleoptera																						
Staphylinidae	adults																					
Lampyridae	adults																					
Other	adults																					
Diptera	adults	1.03	1.13		4.73	1.39	1.58	1.18	1.18	2.36	2.36	1.18	1.31	1.97		2.63	6.30		0.88	2.63	2.36	0.99
Total terrestrial invertebrates		4.80	3.38	0.00	6.30	2.78	1.58	3.55	1.18	2.36	4.73	4.73	3.28	4.92	2.15	2.63	11.03	0.79	1.75	4.38	3.94	1.98

* expressed as number of organisms/100 m^2 of surface area of drift column

** application at 7:05 am on 2 June 1979 and again at 4:25 am on 5 July 1979

Table 6
Terrestrial organisms caught in drift net sets*,
Ruisseau Castor Downstream Station,
Montcalm County, Quebec.
24 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-5		-4	-3		-2		-1		Spray Day		+1		+2
		Diu.	Noc.	Diu.	24 hr	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	24 hr
Current velocity (m/sec)		0.24	0.36	0.30	0.27	0.24	0.36	0.27	0.21	0.24	0.27	0.12	0.21	0.33	0.30
Surface area of drift column (m^2)		237.6	412.0	294.3	579.6	291.6	332.1	277.4	206.3	203.4	290.0	164.9	159.1	420.3	389.7
Arachnida															
Araneida								0.36							
Ephemeroptera	adults									0.98				0.95	
Plecoptera	adults									3.44		4.25		0.48	
Hemiptera															0.26
Homoptera															
Trichoptera	adults			0.34				1.08	0.97	1.47		0.61		0.24	0.51
Lepidoptera	larvae											0.61			
Hymenoptera															
Formicidae															0.51
Coleoptera															
Staphylinidae	larvae														0.26
	adults														1.03
Other	larvae														0.26
	adults														
Diptera	adults		0.97		0.69	0.69	0.30	3.60	2.91	6.88				0.71	
Total terrestrial invertebrates		0.00	0.97	0.34	0.69	0.69	0.30	5.05	3.88	12.78	0.00	5.46	0.00	2.38	2.82

Diu. - Diurnal drift (from about 7:00 am to 7:00 pm)
Noc. - Nocturnal drift (from about 7:00 pm to 7:00 am)

* expressed as number of invertebrates/100 m^2 of surface area of drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 6 (cont'd)
Terrestrial organisms caught in drift net sets*,
Ruisseau Castor Downstream Station,
Montcalm County, Quebec.
24 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		+3		+4		+5		Spray Day		+1		+2		+3		+4
		Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.
Current velocity (m/sec)		0.96	0.69	0.54	0.51	0.45	0.39	0.36	0.36	0.42	0.36	0.36	0.30	0.42	0.30	0.36
Surface area of drift column (m^2)		722.9	790.7	526.5	493.4	515.0	361.5	429.3	469.8	387.4	443.9	312.1	402.8	337.0	388.8	324.5
Arachnida																
Araneida				0.19			0.28									0.31
Ephemeroptera	adults			0.08	1.22	0.19	1.38			1.29		0.32			0.26	
Plecoptera	adults			0.76		0.78	1.11	0.93	0.21	0.77		0.64	0.74	0.30	0.26	
Hemiptera																0.31
Homoptera																0.31
Trichoptera	adults									0.26				0.30		0.31
Lepidoptera	larvae			0.19		0.78										
Hymenoptera																
Formicidae				0.19						0.26						
Coleoptera																
Staphylinidae	larvae	0.14									0.23					
	adults															
Other	larvae															
	adults								0.21							
Diptera	adults			0.95	1.22	1.75	1.38	1.16	4.26	0.52	0.23					
Total terrestrial invertebrates		0.14	0.00	2.66	2.43	3.50	4.15	2.10	4.68	3.10	0.45	0.96				

Diu. - Diurnal drift (from about 7:00 am to 7:00 pm)
Noc. - Nocturnal drift (from about 7:00 pm to 7:00 am)

* expressed as number of invertebrates/100 m^2 of surface area of drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 7
Terrestrial organisms caught in drift net sets*,
Untreated Control Stream,
Montcalm County, Quebec.
22 June to 1 September 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-2 am	-2 pm	-1 am	-1 pm	Spray Day 4 am	5 am	6 am	7 am	8 am	9 am	5:30 pm	+1 am
Current velocity (m/sec)		0.42	0.24	0.15	0.39	0.44	0.48	0.24	0.18	0.30	0.24	0.24	0.27	0.33	0.33	0.33	0.33	0.33	0.33	0.36	0.39
Surface area of drift column (m^2)		177.7	101.5	63.4	165.0	186.1	203.0	101.5	76.1	126.9	101.5	101.5	114.2	139.6	139.6	139.6	139.6	139.6	139.6	152.3	165.0
Arachnida																					
Araneida														0.71				0.71		0.65	
Ephemeroptera	adults		0.98											2.14		0.71				0.65	0.61
Plecoptera	adults		0.98				0.49								0.71				0.71		
Hemiptera									1.31						0.71						
Homoptera																			0.71		
Trichoptera	adults																	0.71			
Lepidoptera	larvae												0.88						0.71		
Hymenoptera																					
Formicidae										2.36								1.43	0.71	1.31	
Other	larvae								1.31												
	adults					0.54			1.31	0.78							0.71			0.65	
Coleoptera																					
Staphylinidae	adults							0.98		1.57						0.71					
Other	adults	0.56	0.98							0.78				0.71						0.65	
Diptera	larvae							0.98													
	adults	1.68	2.96		0.61	1.07	0.49	2.96	3.94	3.15	3.94	4.92	7.00	1.43	0.71	1.43	0.71	1.43	2.14	0.65	
Total terrestrial invertebrates		2.25	5.91	0.00	0.61	1.61	0.98	4.92	7.88	8.67	3.94	4.92	7.88	5.02	2.15	2.87	1.43	4.30	5.02	4.60	0.61

* expressed as number of invertebrates/100 m^2 of surface area of drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 7 (cont'd)
Terrestrial organisms caught in drift net sets*,
Untreated Control Stream,
Montcalm County, Quebec.
22 June to 1 September 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		+1 pm	+2 am	+3 pm	+4 am	+4 pm	+5 am	+5 pm	4 am	5 am	6 am	pm	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm	+58 am
		Spray Day																			
Current velocity (m/sec)		0.24	0.12	0.48	0.36	0.42	0.45	0.48	0.48	0.48	0.48	0.39	0.42	0.39	0.39	0.30	0.24	0.24	0.36	0.39	0.66
Surface area of drift column (m^2)		101.5	50.8	67.7	50.8	59.2	63.4	67.7	67.7	67.7	67.7	110.0	177.7	165.0	165.0	126.9	101.5	101.5	152.3	165.0	186.1
Arachnida																					
Araneida					1.97								1.12								
Ephemeroptera	adults	3.94								2.96									1.31		
Plecoptera	adults			1.48	3.94				2.96	5.91							0.98				
Hemiptera		0.98																			
Homoptera			1.97									1.82		0.60							
Trichoptera	adults									1.48									0.66		0.54
Lepidoptera	larvae			1.48																	
Hymenoptera																					
Formicidae																0.78					
Other	larvae																			0.60	
	adults																				
Coleoptera																					
Staphylinidae	adults													0.60							
Other	adults				1.97												0.98			1.81	
Diptera	larvae																				
	adults		3.94	1.48	1.97	1.68			4.43			1.82	1.12	2.42	2.42		2.96		1.31	3.03	1.08
Total terrestrial invertebrates		4.92	5.91	4.43	9.85	1.69	0.00	0.00	7.39	10.34	0.00	3.64	2.25	3.64	2.42	0.79	4.92	0.00	3.28	5.46	1.61

* expressed as number of invertebrates/100 m^2 of surface area of drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

APPENDIX II

Population structure of bird communities
on treatment and control plots.
Montcalm County, Quebec. 1979.

Table 1
Forest bird population census,
Azamethiphos Treatment Plot,
Montcalm County, Quebec,
24 June to 10 July 1979.

Family	Pre-spray 1st application						Post-spray 1st application					Post-spray 2nd application					
	June 24 -5	June 25 -4	June 26 -3	June 27 -2	June 28 -1	Daily avg.	June 30 +1	July 1 +2	July 3 +4	July 4 +5	Daily avg.	July 6 +1	July 7 +2	July 8 +3	July 9 +4	July 10 +5	Daily avg.
Tetraonidae	0	0	0	1	0	0.2	0	0	0	0	0.0	0	5	0	1	0	1.2
Picidae	0	0	1	0	0	0.2	0	0	2	0	0.5	1	0	0	0	0	0.2
Tyrannidae	4	6	0	0	2	2.4	0	0	2	0	0.5	0	0	0	0	2	0.4
Corvidae	0	0	0	0	0	0.0	4	0	1	0	1.3	0	0	0	0	0	0.0
Paridae	0	0	0	0	1	0.2	0	0	4	1	1.3	1	1	0	2	3	1.4
Sittidae	0	0	2	0	0	0.4	0	0	0	0	0.0	2	0	0	2	0	0.8
Turdidae	6	15	11	9	18	11.8	14	13	12	9	12.0	22	23	15	17	22	19.8
Sylviidae	6	6	4	4	6	5.2	6	6	2	0	3.5	2	2	0	1	2	1.4
Bombycillidae	3	1	1	0	3	1.6	3	1	4	4	3.0	6	2	4	0	2	2.8
Parulidae	16	30	25	28	34	26.6	28	26	26	18	24.5	25	25	22	21	25	23.6
Fringillidae	18	9	17	12	12	13.6	17	13	12	13	13.8	20	14	19	8	22	16.6
Total Birds	53	67	61	54	76	62.2	72	59	65	45	60.3	79	72	60	52	78	68.2

Table 2
Forest bird population census
Azamethiphos Untreated Control Plot
Montcalm County, Quebec
24 June to 10 July 1979

Family	Pre-spray 1st application						Post-spray 1st application					Post-spray 2nd application					
	June 24 -5	June 25 -4	June 26 -3	June 27 -2	June 28 -1	Daily avg.	June 30 +1	July 1 +2	July 3 +4	July 4 +5	Daily avg.	July 6 +1	July 7 +2	July 8 +3	July 9 +4	July 10 +5	Daily avg.
Tetraonidae	0	1	1	0	0	0.4	0	0	0	0	0.0	0	0	1	0	0	0.2
Picidae	0	0	0	0	1	0.2	0	0	0	0	0.0	0	0	0	0	0	0.0
Tyrannidae	0	0	0	0	0	0.0	0	0	0	0	0.0	3	0	2	0	2	1.4
Corvidae	1	1	0	3	0	1.0	0	0	0	0	0.0	1	3	1	2	0	1.4
Paridae	0	0	1	0	0	0.2	0	0	1	0	0.3	0	0	2	2	3	1.4
Sittidae	0	2	2	0	0	0.8	0	0	0	0	0.0	0	0	2	0	0	0.4
Mimidae	0	0	2	2	2	1.2	2	0	0	0	0.5	2	2	0	2	0	1.2
Turdidae	4	8	7	7	2	5.6	10	4	0	3	4.3	2	10	8	2	4	5.2
Sylviidae	2	2	4	0	2	2.0	2	2	0	2	1.5	0	0	0	2	0	0.4
Bombycillidae	2	1	0	0	0	0.6	1	3	1	1	1.5	2	3	1	2	3	2.2
Vireonidae	2	4	4	4	4	3.6	2	0	0	2	1.0	0	4	4	4	2	2.8
Parulidae	12	29	19	18	18	19.2	22	18	16	19	18.8	19	20	22	19	19	19.8
Icteridae	0	4	4	0	6	2.8	4	2	4	5	3.8	0	1	0	1	1	0.6
Thraupidae	0	0	0	0	0	0.0	0	0	0	0	0.0	2	0	0	0	0	0.4
Fringillidae	7	9	2	4	6	5.6	7	6	7	3	5.8	4	4	7	5	4	4.8
Total Birds	30	61	46	38	41	43.2	50	35	29	35	37.3	35	47	50	41	38	42.2

Table 3
Forest bird population census
Azamethiphos Treatment Plot
Montcalm County, Quebec
24 June to 10 July 1979

Family	Species	Pre-spray 1st application						Post-spray 1st application					Post-spray 2nd application					
		June 24 -5	June 25 -4	June 26 -3	June 27 -2	June 28 -1	Daily avg.	June 30 +1	July 1 +2	July 3 +4	July 4 +5	Daily avg.	July 6 +1	July 7 +2	July 8 +3	July 9 +4	July 10 +5	Daily avg.
Tetraonidae	Ruffed Grouse	0	0	0	1	0	0.2	0	0	0	0	0.0	0	5	0	1	0	1.2
Picidae	Common Flicker	0	0	1	0	0	0.2	0	0	0	0	0.0	1	0	0	0	0	0.2
	Yellow-bellied Sapsucker	0	0	0	0	0	0.0	0	0	2	0	0.5	0	0	0	0	0	0.0
Tyrannidae	Alder Flycatcher	4	6	0	0	2	2.4	0	0	0	0	0.0	0	0	0	0	0	0.0
	Olive-sided Flycatcher	0	0	0	0	0	0.0	0	0	2	0	0.5	0	0	0	0	2	0.4
Corvidae	Blue Jay	0	0	0	0	0	0.0	4	0	1	0	1.3	0	0	0	0	0	0.0
Paridae	Black-capped Chickadee	0	0	0	0	1	0.2	0	0	4	1	1.3	1	1	0	2	3	1.4
Sittidae	Red-breasted Nuthatch	0	0	2	0	0	0.4	0	0	0	0	0.0	2	0	0	2	0	0.8
Turdidae	American Robin	0	1	0	0	1	0.4	0	0	1	1	0.5	4	2	0	2	4	2.4
	Wood Thrush	2	2	0	0	2	1.2	0	0	0	0	0.0	2	2	0	2	2	1.6
	Hermit Thrush	0	1	0	0	0	0.2	1	0	3	1	1.3	0	1	2	0	1	0.8
	Swainson's Thrush	4	7	5	5	5	5.2	8	7	3	1	4.8	7	6	5	6	3	5.4
	Veery	0	4	6	4	10	4.8	5	6	5	6	5.5	9	12	8	7	12	9.6
Sylviidae	Ruby-crowned Kinglet	6	6	4	4	6	5.2	6	6	2	0	3.5	2	2	0	1	2	1.4
Bombycillidae	Cedar Waxwing	3	1	1	0	3	1.6	3	1	4	4	3.0	6	2	4	0	2	2.8
Parulidae	Black-and-white Warbler	0	0	0	0	0	0.0	2	0	2	0	1.0	0	2	0	0	0	0.4
	Tennessee Warbler	0	2	0	0	0	0.4	0	0	0	0	0.0	0	0	0	0	0	0.0
	Nashville Warbler	2	4	8	6	8	5.6	9	8	6	4	6.8	6	6	8	8	6	6.4
	Magnolia Warbler	4	4	4	8	4	4.8	2	4	2	7	3.8	4	3	4	6	6	4.6
	Yellow-rumped Warbler	2	0	4	2	4	2.4	3	2	0	0	1.3	0	0	0	0	0	0.0
	Blackburnian Warbler	0	4	0	0	0	0.8	0	0	0	0	0.0	1	2	2	2	0	1.4
	Chestnut-sided Warbler	4	4	6	4	6	4.8	4	6	4	4	4.5	4	6	2	2	0	2.8
	Ovenbird	0	0	0	0	0	0.0	0	0	0	0	0.0	2	0	2	0	2	1.2
	Mourning Warbler	0	2	0	0	0	0.4	0	0	0	0	0.0	0	0	0	0	0	0.0
	Common Yellowthroat	2	4	2	4	8	4.0	6	2	8	3	4.8	6	2	2	0	5	3.0
	Canada Warbler	0	2	1	2	2	1.4	0	2	0	0	0.5	0	0	0	0	0	0.0
	American Redstart	2	4	0	2	2	2.0	2	2	4	0	2.0	2	4	2	3	6	3.4
Fringillidae	Rose-breasted Grosbeak	4	2	4	4	0	2.8	2	0	2	0	1.0	2	0	0	0	0	0.4
	Purple Finch	2	0	0	2	2	1.2	0	0	2	4	1.5	0	0	2	0	2	0.8
	Pine Siskin	0	0	0	0	0	0.0	0	0	0	0	0.0	4	0	0	0	0	0.8
	White-winged Crossbill	0	0	0	0	0	0.0	0	0	0	0	0.0	2	4	4	0	4	2.8
	Dark-eyed Junco	2	0	2	0	0	0.8	2	0	0	2	1.0	1	0	0	0	0	0.2
	White-throated Sparrow	10	7	11	6	10	8.8	13	13	8	7	10.3	11	10	13	8	16	11.6
Total Birds		53	67	61	54	76	62.2	72	59	65	45	60.3	79	72	60	52	78	68.2

Table 4
Forest bird population census
Azamethiphos Untreated Control Plot
Montcalm County, Quebec
24 June to 10 July 1979

Family	Species	Pre-spray 1st application						Post-spray 1st application					Post-spray 2nd application					
		June 24 -5	June 25 -4	June 26 -3	June 27 -2	June 28 -1	Daily avg.	June 30 +1	July 1 +2	July 3 +4	July 4 +5	Daily avg.	July 6 +1	July 7 +2	July 8 +3	July 9 +4	July 10 +5	Daily avg.
Tetraonidae	Ruffed Grouse	0	1	1	0	0	0.4	0	0	0	0	0.0	0	0	1	0	0	0.2
Picidae	Common Flicker	0	0	0	0	1	0.2	0	0	0	0	0.0	0	0	0	0	0	0.0
Tyrannidae	Eastern Pheobe	0	0	0	0	0	0.0	0	0	0	0	0.0	3	0	2	0	2	1.4
Corvidae	Blue Jay	1	1	0	3	0	1.0	0	0	0	0	0.0	1	3	0	2	0	1.2
	Common Raven	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	1	0	0	0.2
Paridae	Black-capped Chickadee	0	0	1	0	0	0.2	0	0	1	0	0.3	0	0	2	2	3	1.4
Sittidae	Red-breasted Nuthatch	0	2	2	0	0	0.8	0	0	0	0	0.0	0	0	2	0	0	0.4
Mimidae	Catbird	0	0	2	2	2	1.2	2	0	0	0	0.5	2	2	0	2	0	1.2
Turdidae	American Robin	0	0	0	0	0	0.0	2	0	0	2	1.0	0	5	3	2	3	2.6
	Hermit Thrush	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0	1	0.2
	Swainson's Thrush	2	4	3	2	0	2.2	7	3	0	0	2.5	2	4	5	0	0	2.2
	Veery	2	4	4	5	2	3.4	1	1	0	1	0.8	0	1	0	0	0	0.2
Sylviidae	Ruby-crowned Kinglet	2	2	4	0	2	2.0	2	2	0	2	1.5	0	0	0	2	0	0.4
Bombycillidae	Cedar Waxwing	2	1	0	0	0	0.6	1	3	1	1	1.5	2	3	1	2	3	2.2
Vireonidae	Solitary Vireo	0	0	2	2	2	1.2	0	0	0	0	0.0	0	0	0	2	0	0.4
	Red-eyed Vireo	2	4	2	2	2	2.4	2	0	0	2	1.0	0	4	4	2	2	2.4
Parulidae	Black-and-white Warbler	2	0	0	2	0	0.8	0	2	0	2	1.0	2	2	0	0	0	0.8
	Nashville Warbler	0	1	0	0	2	0.6	2	2	2	0	1.5	2	0	6	2	0	2.0
	Magnolia Warbler	0	6	2	2	0	2.0	8	2	2	2	3.5	2	2	1	2	0	1.4
	Black-throated Blue Warbler	0	2	0	0	2	0.8	2	0	0	0	0.5	0	0	0	0	0	0.0
	Yellow-rumped Warbler	2	3	2	0	0	1.4	0	0	2	0	0.5	0	0	0	0	0	0.0
	Black-throated Green Warbler	0	2	0	0	0	0.4	0	0	2	2	1.0	0	0	0	0	2	0.4
	Blackburnian Warbler	2	0	0	0	0	0.4	0	0	0	0	0.0	0	0	2	0	0	0.4
	Chestnut-sided Warbler	0	0	0	0	0	0.0	0	0	0	0	0.0	1	1	0	1	1	0.8
	Ovenbird	2	6	6	6	6	5.2	6	6	6	4	5.5	6	4	8	6	4	5.6
	Common Yellowthroat	2	2	4	4	4	3.2	4	6	2	4	4.0	4	4	2	2	6	3.6
	Canada Warbler	2	5	3	4	4	3.6	0	0	0	4	1.0	1	5	0	4	4	2.8
	American Redstart	0	2	2	0	0	0.8	0	0	0	1	0.3	1	2	3	2	2	2.0
Icteridae	Red-winged Blackbird	0	4	4	0	6	2.8	4	2	4	5	3.8	0	1	0	1	1	0.6
Thraupidae	Scarlet Tanager	0	0	0	0	0	0.0	0	0	0	0	0.0	2	0	0	0	0	0.4
Fringillidae	Rose-breasted Grosbeak	4	4	2	2	4	3.2	2	2	0	0	1.0	0	0	0	2	2	0.8
	Chipping Sparrow	0	0	0	0	0	0.0	0	0	2	0	0.5	2	2	0	0	0	0.8
	White-throated Sparrow	3	5	0	2	2	2.4	5	4	5	3	4.3	2	2	7	3	2	3.2
Total Birds		30	61	46	38	41	43.2	50	35	29	35	37.3	35	47	50	41	38	42.2

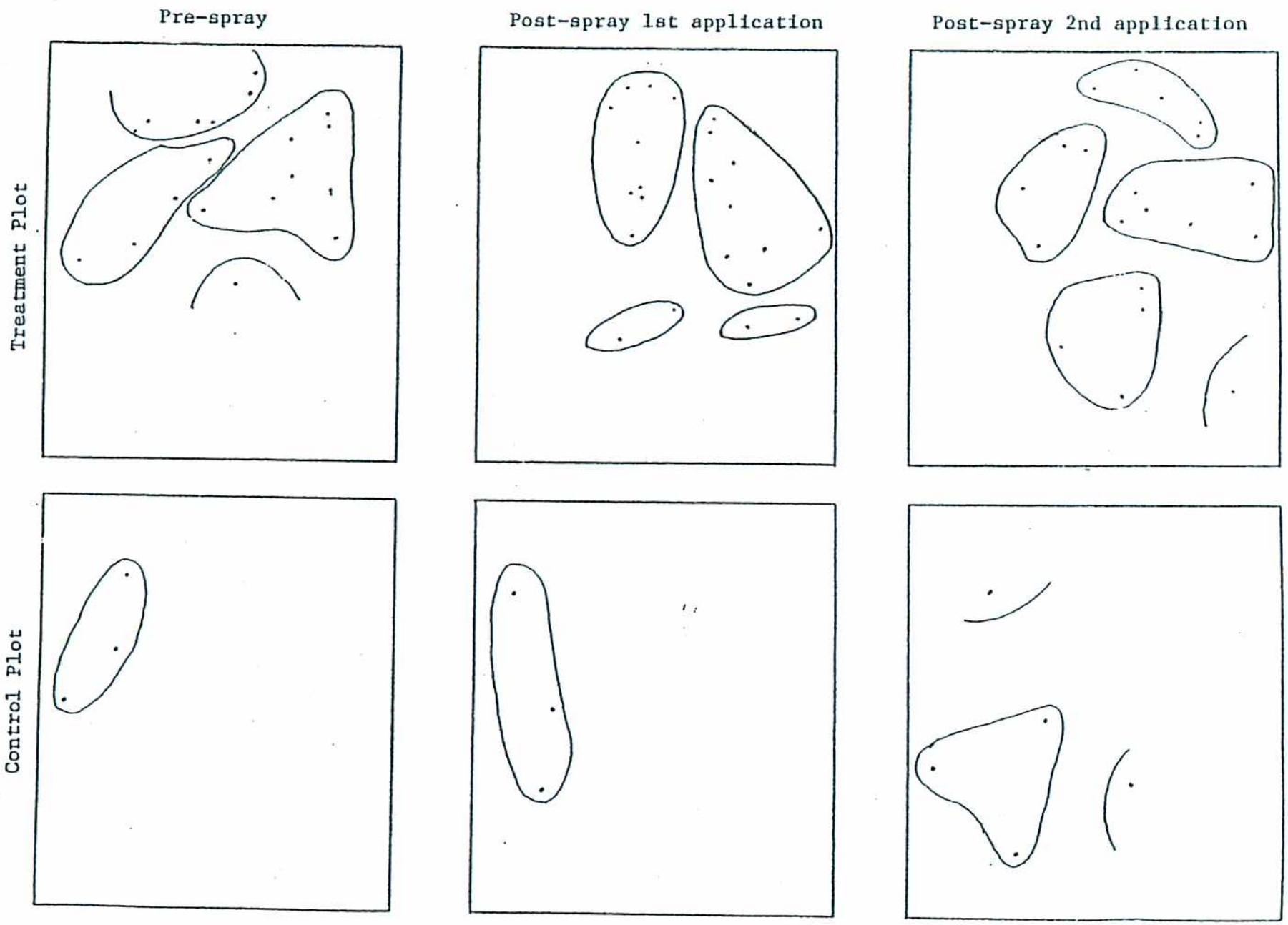


Figure 1. Breeding territories of the Nashville warbler, *Vermivora ruficapilla* (Wilson)

Figure 1. Breeding territories of the Nashville warbler, *Vermivora ruficapilla* (Wilson).

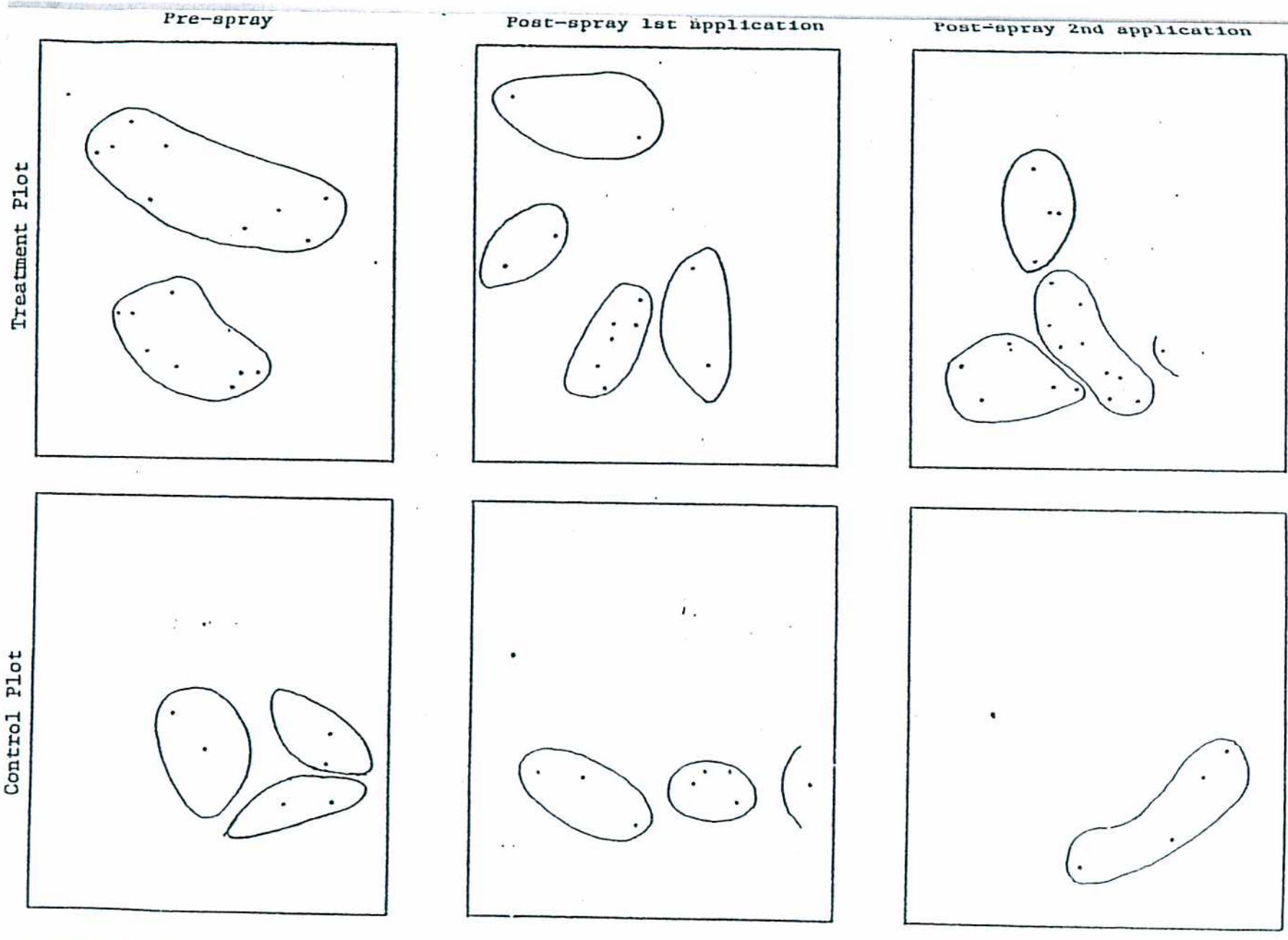


Figure 2. Breeding territories of the Magnolia warbler, *Dendroica magnolia* (Wilson)

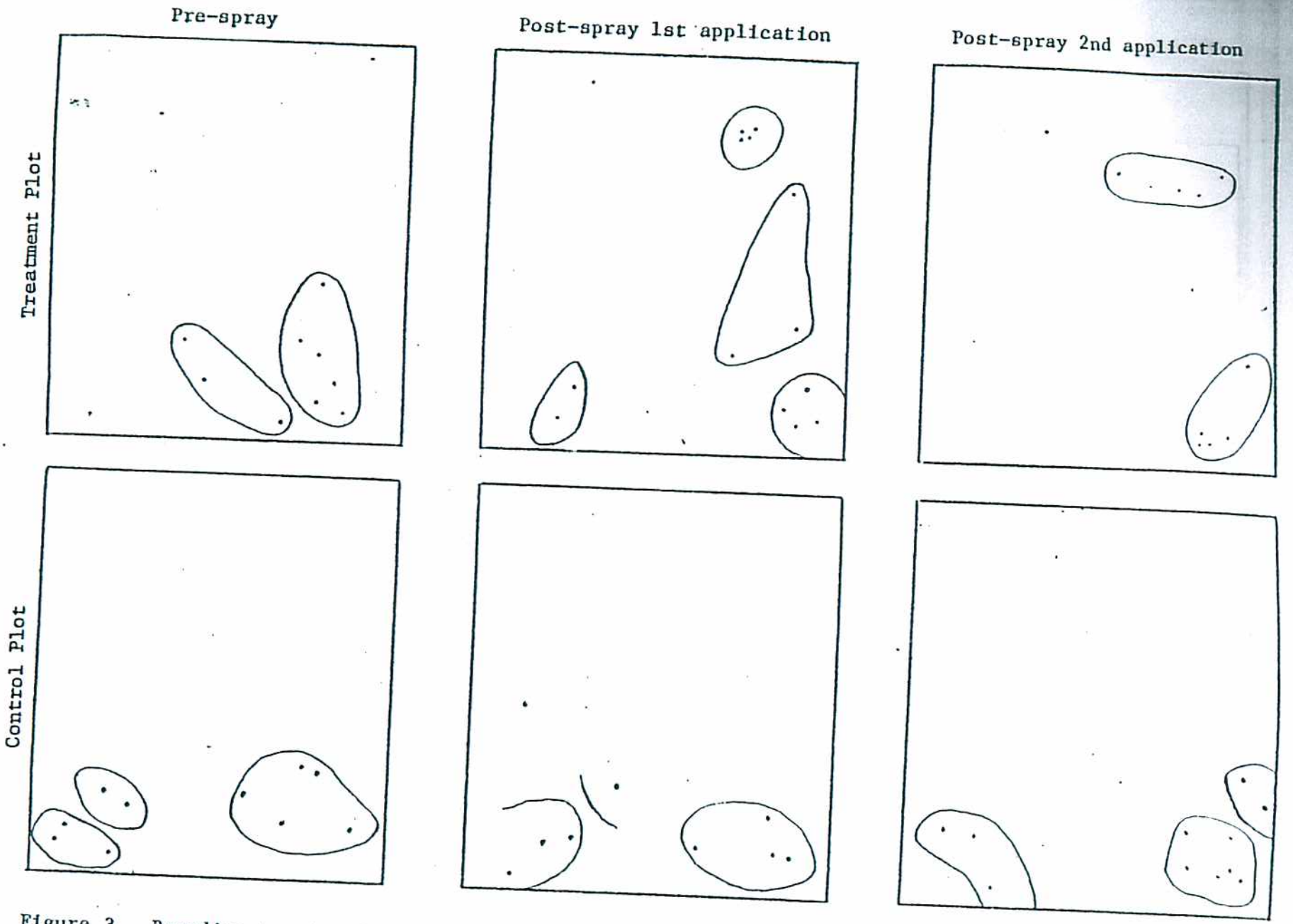


Figure 3. Breeding territories of the Common Yellowthroat, *Geothlypis trichas* (Linnaeus)

Figure 3. Breeding territories of the Common Yellowthroat, *Geothlypis trichas* (Linnaeus)

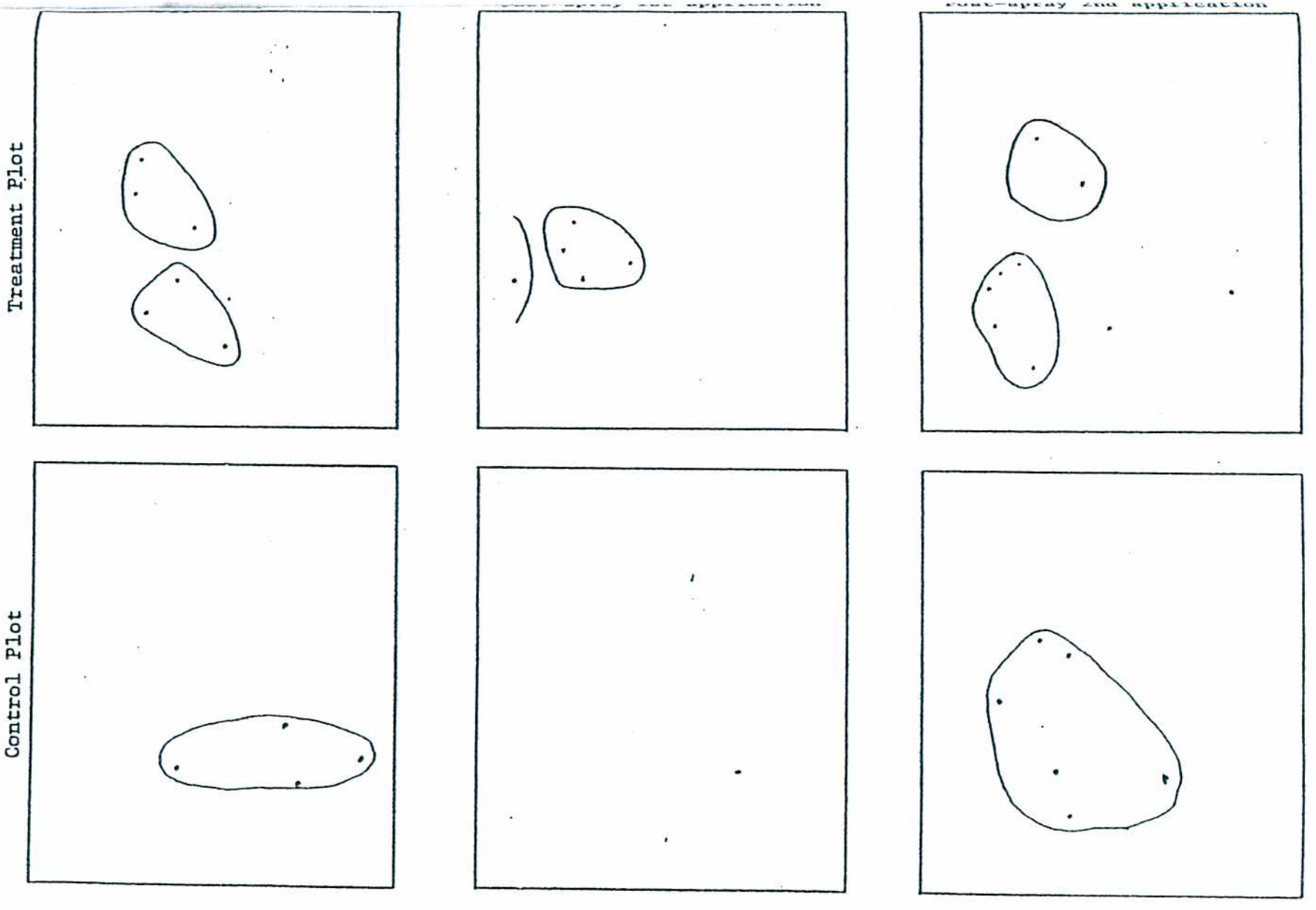


Figure 4. Breeding territories of the American Redstart, *Setophaga ruticilla* (Linnaeus)

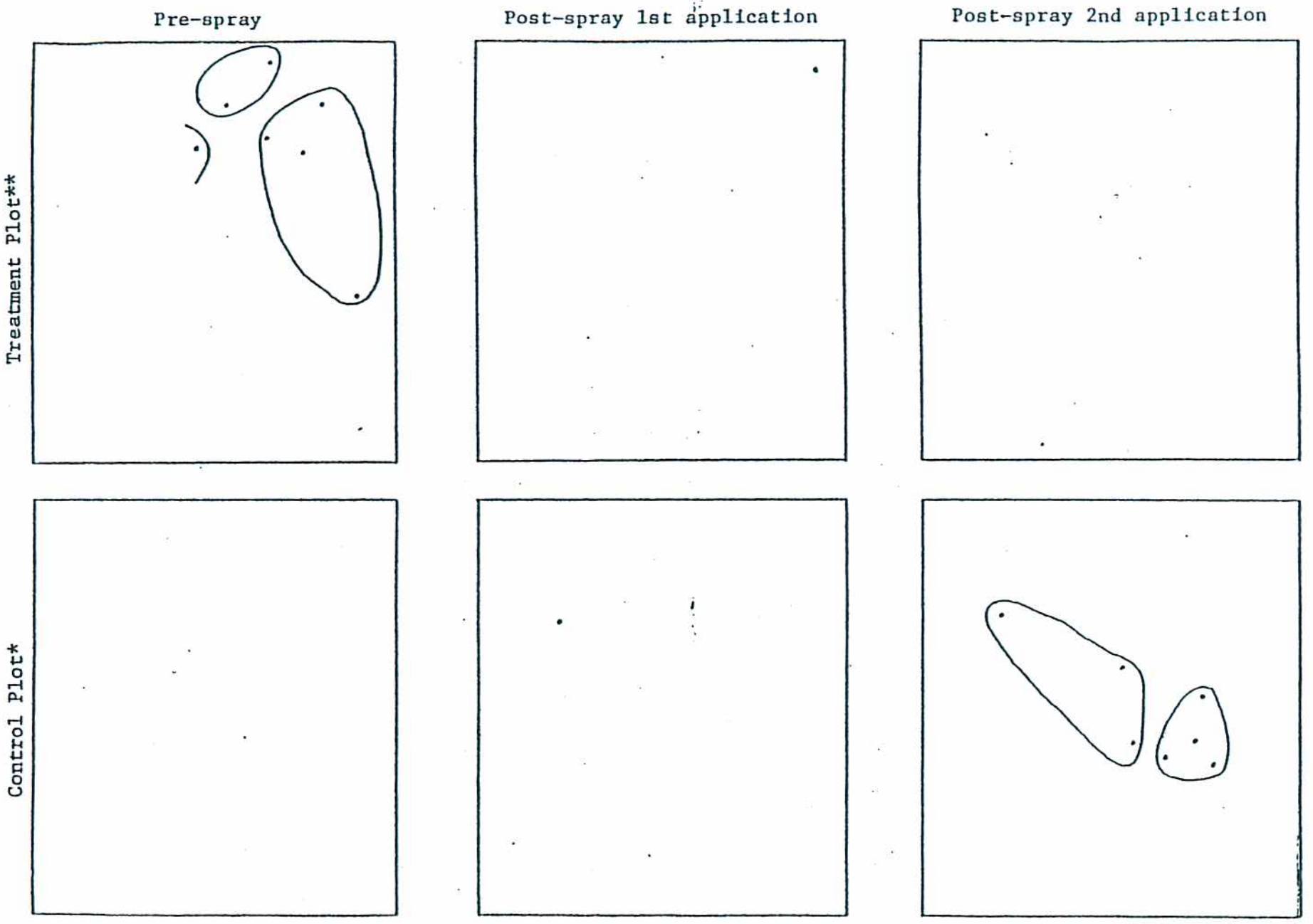


Figure 5. Breeding territories of the Eastern phoebe*, *Sayornis phoebe* (Latham), and the Alder flycatcher**, *Empidonax alnorum* Brewster

Figure 5. Breeding territories of the Eastern phoebe, Sayornis phoebe (Latham) Alder flycatcher**, *Empidonax alnorum* Brewster

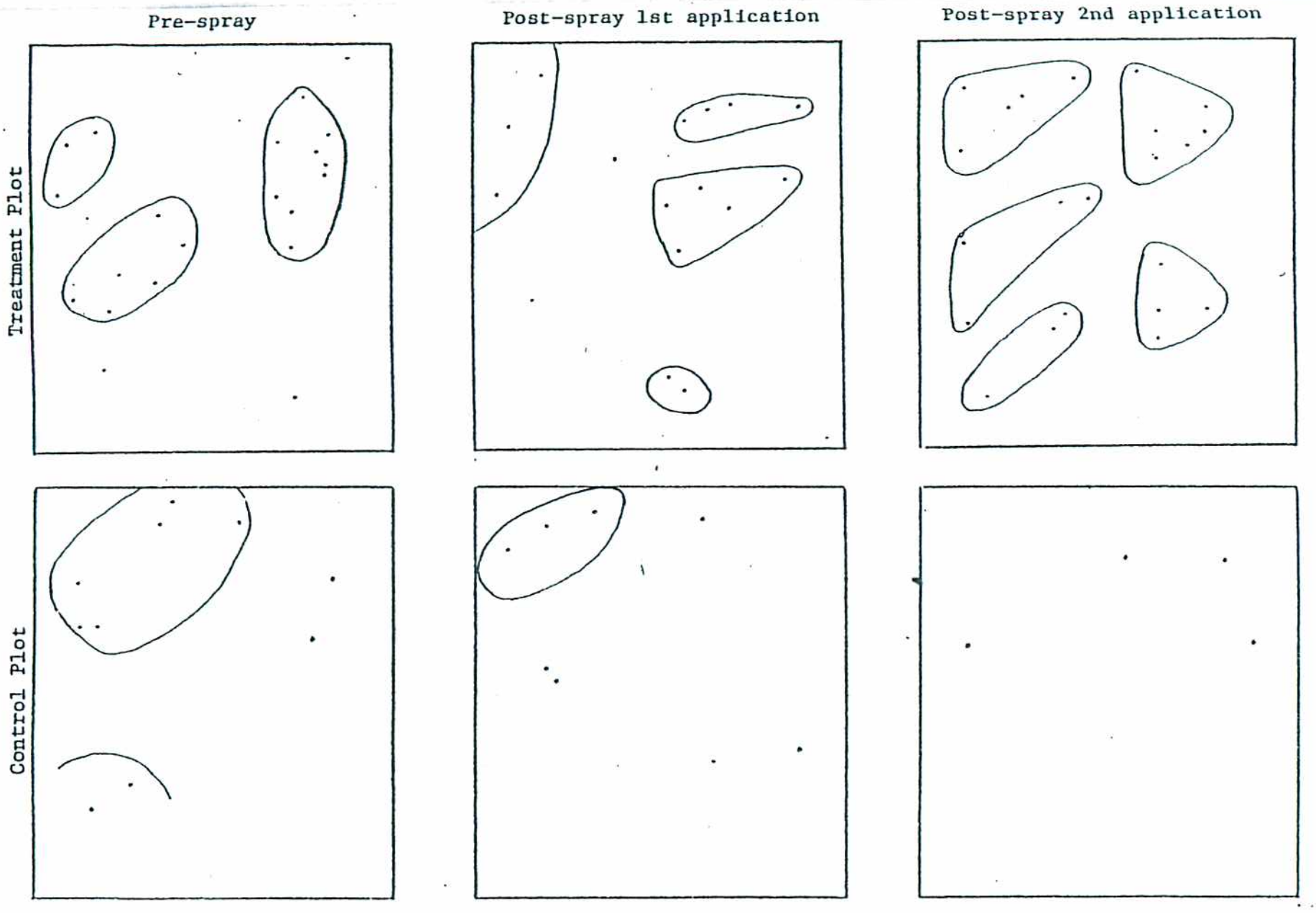


Figure 6. Breeding territories of the Swainson's Thrush, *Catharus ustulatus* (Nuttall)

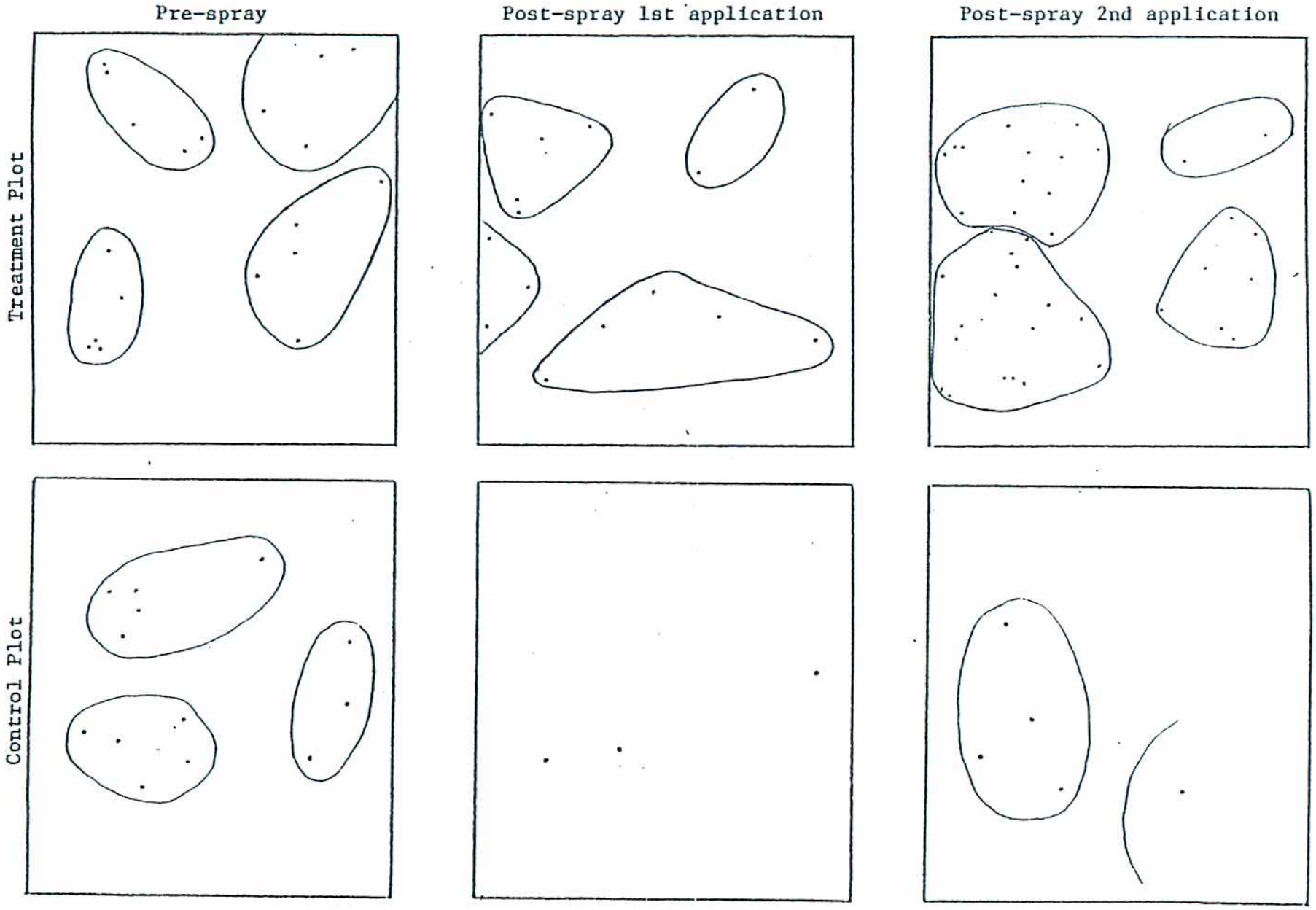
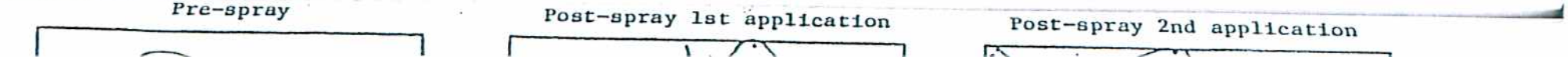


Figure 7. Breeding territories of the Veery, *Catharus fuscescens* (Stephen)



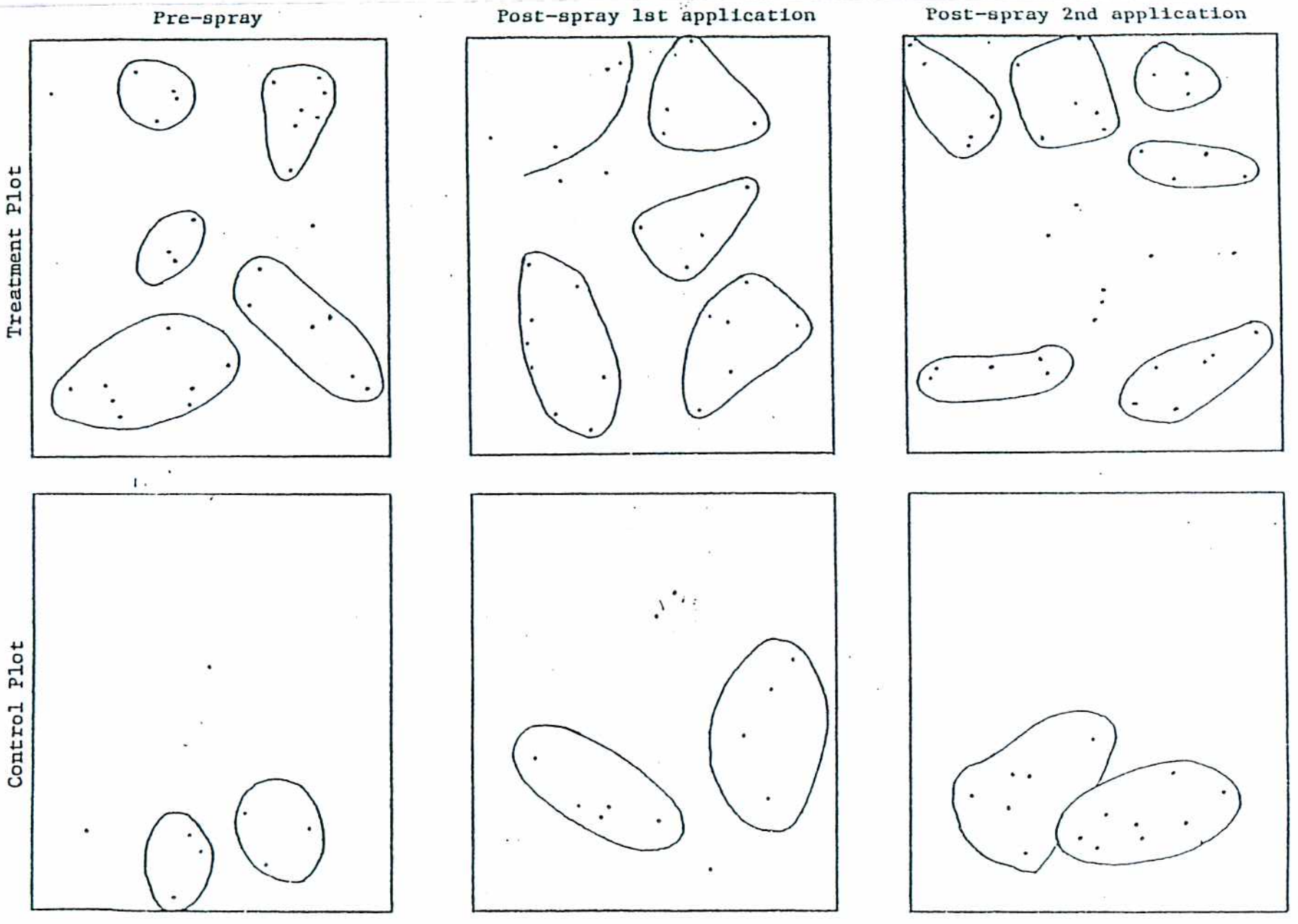


Figure 8. Breeding territories of the White-throated sparrow, *Zonotrichia albicollis* (Gmelin)

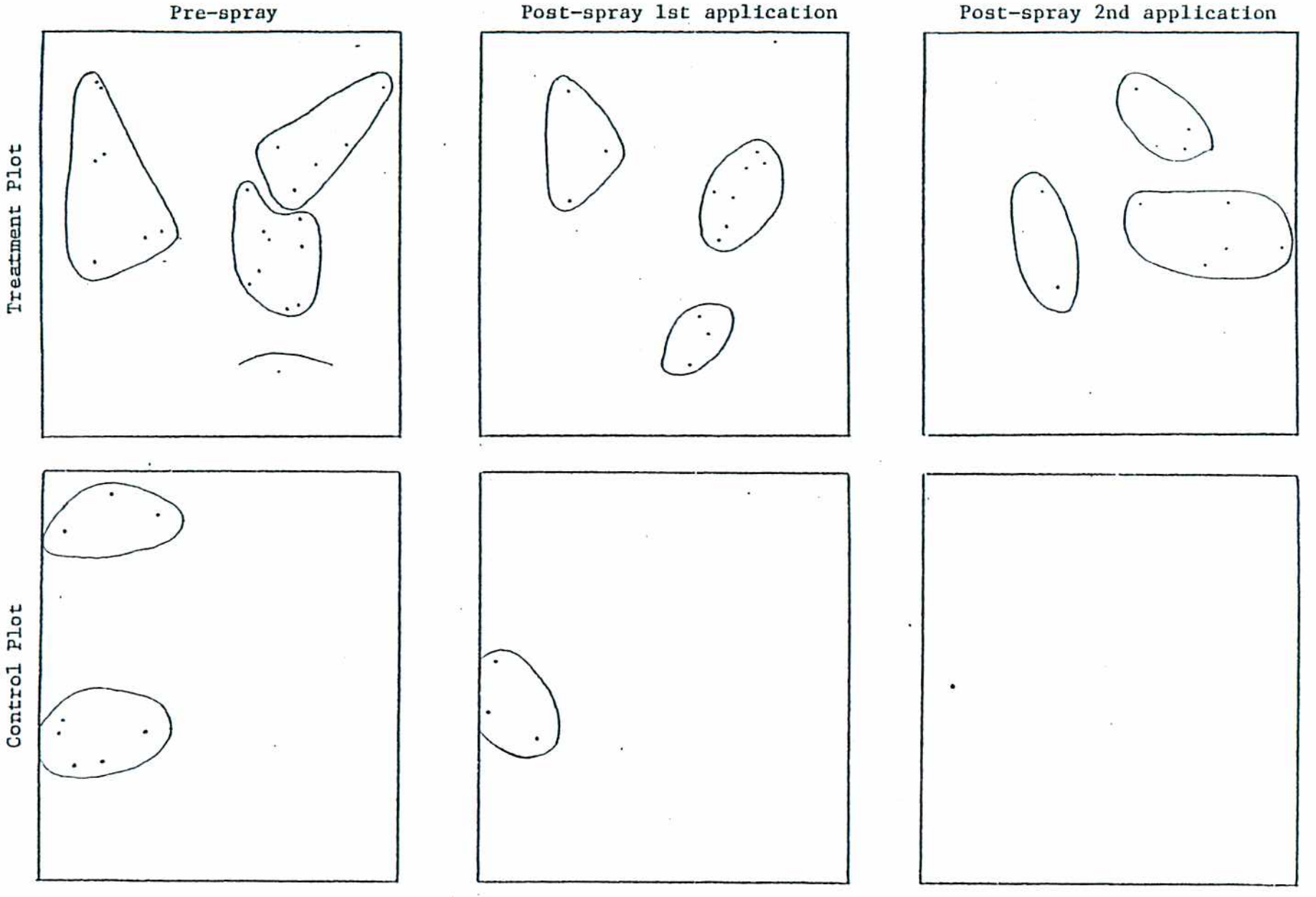


Figure 9. Breeding territories of the Ruby-crowned Kinglet, *Regulus calendula* (Linnaeus)

Figure 9. Breeding territories of the Ruby-crowned Kinglet, Regulus calendula (Linnaeus)

APPENDIX IV

Aquatic invertebrates collected in drift net sets and by Surber and rock sampling in treatment and control streams, Montcalm County, Quebec. 1979.

Table 1
Aquatic organisms caught in drift net sets*,
Ruisseau Castor Treatment Station,
Montcalm County, Quebec.
22 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-2 am	-2 pm	-1 am	-1 pm	Pre	Spray Day 0 hr	+½ hr	+1 hr	+2 hr	pm	+1 am	+1 pm	+2 am
Depth (m)		0.30	0.26	0.25	0.26	0.26	0.25	0.25	0.25	0.22	0.24	0.24	0.24	0.24	0.21	0.22	0.23	0.23	0.21	0.22	0.22	0.21
Current velocity (m/sec)		0.58	0.30	0.36	0.30	0.33	0.27	0.24	0.24	0.30	0.32	0.33	0.30	0.27	0.27	0.27	0.27	0.27	0.24	0.36	0.30	0.30
Volume of drift column (m^3)		73.60	32.99	38.07	32.99	36.29	28.55	25.38	25.38	27.92	32.48	33.50	30.46	27.41	23.98	25.13	26.27	26.27	21.32	33.50	27.92	26.95
Nematoda																						
Pelecypoda																						
Arachnida																						
Hydracarina					0.30	0.28	0.70				0.62											
Crustacea																						
Ostracoda																						
Collembola				0.26			0.70	0.39	0.39			0.60	0.33				0.76	0.38	0.47			0.37
Ephemeroptera																						
Heptageniidae																						
Baetidae		0.54	1.52	1.84		0.83	1.40	1.58		0.36	1.23	1.79	2.30	0.73	1.67	1.19		3.81	0.47	0.61	0.36	1.48
Odonata																						
Aeshnidae				0.26																		
Unidentified																0.40						
Plecoptera							0.35						0.66									
Hemiptera																						
Corixidae																						
Notonectidae								0.39								0.80	0.38	0.38		0.30		
Gerridae								0.39									1.52	0.76		0.30		
Megaloptera																						
Trichoptera	larvae	0.27	0.30					0.39	0.39				0.33			0.40			114.92	0.30	1.08	
	pupae													0.36								
Coleoptera																						
Amphizoidae	adults																0.38					
Haliplidae	adults																	0.38				0.37
Elmidae	larvae																					
	adults			0.52													0.38			0.30		
Curculionidae	adults										0.62											
Diptera																						
Tipulidae	larvae																0.38					
	pupae																					
Simuliidae	larvae	0.14		0.26				0.39			0.31	0.30						0.38				
Chironomidae	larvae	0.41		0.79		0.28	0.70	0.39					0.66	0.36					0.94		0.36	0.37
	pupae															0.40	0.38	0.38				
Heleidae	larvae																		0.47			
Empididae	larvae																					
Fish				0.26																		
Total aquatic invertebrates		1.36	1.82	4.20	0.30	1.38	3.85	3.94	0.79	0.36	2.77	2.69	4.27	1.46	1.67	3.18	4.19	6.47	117.26	2.15	1.79	2.60

* expressed as number of organisms/10 m^3 of water in drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 1 (cont'd)

water in drift column

** application at 7:05 am on 29 June 1979
and again at 4:25 am on 5 July 1979

Table 1 (cont'd)
Aquatic organisms caught in drift net sets*,
Ruisseau Castor Treatment Station,
Montcalm County, Quebec.
22 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		+2 pm	+3 pm	+4 am	+4 pm	+5 am	+5 pm	Pre	0 hr	+½ hr	+1 hr	+2 hr	+6½hr	pm	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
		Spray Day																				
Depth (m)		0.47	0.50	0.50	0.40	0.40	0.37	0.37	0.37	0.37	0.37	0.37	0.32	0.31	0.31	0.30	0.28	0.28	0.31	0.30	0.28	0.29
Current velocity (m/sec)		0.69	0.63	0.57	0.45	0.51	0.45	0.30	0.30	0.30	0.30	0.30	0.54	0.36	0.33	0.27	0.30	0.30	0.27	0.27	0.30	0.24
Volume of drift column (m^3)		137.18	44.42	40.19	25.38	28.76	23.48	31.30	31.30	31.30	31.30	31.30	48.73	31.47	43.27	34.26	35.53	38.07	35.41	34.26	35.53	29.44
Nematoda		0.07																				
Pelecypoda													0.20									
Arachnida																						
Hydracarina		0.07		0.25	0.39								0.20	0.32		0.29				0.58		0.68
Crustacea																						
Ostracoda																		0.52				
Collembola				0.25							1.92	0.32							0.28		0.28	
Ephemeroptera																						
Heptageniidae			0.22					0.32														0.34
Baetidae		1.82	1.13	0.25	1.97	2.09		7.35	1.92	0.64	0.64	1.28	2.87	0.64	0.46	1.46	1.97	0.26	0.85	5.55	2.53	1.36
Odonata																						
Aeshnidae					0.39																	
Unidentified																						
Plecoptera		0.22	0.45					0.32			0.32	0.32	0.62		0.46			0.26				
Hemiptera																						
Corixidae			0.22																			
Notonectidae																						
Gerridae																						
Megaloptera																0.29						
Trichoptera	larvae	0.15	0.45		0.79												0.28					
	pupae																		0.28			
Coleoptera																						
Amphizoidae	adults																	0.26				
Haliplidae	adults																					
Elmidae	larvae		0.45		0.39			0.32														
	adults						0.43															
Curculionidae	adults																			0.29		
Diptera																						
Tipulidae	larvae																					
	pupae	0.22																				
Simuliidae	larvae									0.32			0.82		0.46	0.29	0.56		0.56	0.58	0.28	
Chironomidae	larvae	1.09	0.68		0.79	1.04				0.32	0.64				0.46			0.52	0.56	0.88	0.56	0.34
	pupae	0.15	0.68		0.39					0.64			0.20	0.64								
Heleidae	larvae																					
Empididae	larvae	0.07																				
Fish		0.07						0.32														
Total aquatic invertebrates		3.94	4.28	0.75	5.12	3.13	0.43	8.63	1.92	1.92	3.51	1.92	4.92	1.59	1.85	2.34	2.82	1.84	2.54	7.88	3.66	2.72

* expressed as number of organisms/10 m^3 of water in drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 2
Aquatic organisms caught in drift net sets*,
Ruisseau Castor Downstream Station,
Montcalm County, Quebec.
24 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-5		-4	-3		-2		-1		Spray Day		+1		+2
		Diu.	Noc.	Diu.	24 hr	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	24 hr
Depth (m)		0.19	0.12	0.18	0.16	0.14	0.13	0.13	0.15	0.14	0.16	0.21	0.16	0.18	0.16
Current velocity (m/sec)		0.24	0.36	0.30	0.27	0.24	0.36	0.27	0.21	0.24	0.27	0.12	0.21	0.33	0.30
Volume of drift column (m^3)		45.1	49.4	53.0	92.7	40.8	43.2	36.0	31.0	28.5	46.4	36.6	25.4	75.6	62.4
Oligochaeta															
Gastropoda															
Arachnida															0.32
Hydracarina		0.22	0.20	0.19	0.22	0.49	0.23	0.28	0.32		0.43	0.27			0.16
Crustacea															
Amphipoda					0.11										
Collembola															
Ephemeroptera			0.20					0.55		0.70		0.55			0.32
Heptageniidae		0.22	4.85	1.13	0.97	4.16	0.23	2.50	0.65	6.67		0.44	1.57	4.89	3.21
Baetidae															
Odonata															
Aeshnidae															
Plecoptera			0.40		0.11					0.35					0.64
Hemiptera															
Notonectidae															
Gerridae															
Megaloptera															
Corydalidae															
Trichoptera	larvae	0.22	0.61	0.19	0.22	0.49		0.28			0.22	0.55		0.66	0.16
	pupae			0.19	0.22		0.46								0.64
Coleoptera															0.48
Haliplidae	adults			0.19											
Elmidae	larvae		0.40		0.11			1.66							
	adults		1.21		0.32	0.49						1.37		0.26	1.44
Psephenidae	larvae														0.16
Diptera															
Tipulidae	larvae				0.22				0.32						
	pupae														0.64
Blephariceridae	larvae	0.22													0.32
Simuliidae	larvae		1.01		0.22	0.73		0.28				1.37		0.39	0.32
	pupae							0.28							
Chironomidae	larvae		6.88	2.45	1.40	1.47	0.23	3.61	0.65	1.05	2.80	1.91	1.18	1.85	1.28
	pupae	0.22	1.01			0.24		0.28	0.65		0.22	0.27	0.39	0.26	0.16
Fish															0.16
Total aquatic invertebrates		1.11	16.79	4.34	4.10	8.08	1.16	9.43	2.58	8.78	3.66	10.65	3.14	8.33	10.43

Diu. - Diurnal drift (from about 7:00 am to 7:00 pm)
Noc. - Nocturnal drift (from about 7:00 pm to 7:00 am)

* expressed as number of organisms/10 m^3 of water in drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

and again at 4:25 am on 5 July 1979

Table 2 (cont'd)
Aquatic organisms caught in drift net sets*,
Ruisseau Castor Downstream Station,
Montcalm County, Quebec.
24 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		+3		+4		+5		Spray Day		+1		+2		+3		+4
		Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.	Noc.	Diu.
Depth (m)		0.48	0.47	0.40	0.36	0.30	0.27	0.23	0.20	0.48	0.17	0.17	0.30	0.16	0.17	0.16
Current velocity (m/sec)		0.96	0.69	0.54	0.51	0.45	0.39	0.36	0.36	0.42	0.36	0.36	0.30	0.42	0.30	0.36
Volume of drift column (m^3)		347.0	371.6	210.5	177.6	154.1	97.6	98.7	169.1	186.0	75.5	53.1	120.8	53.9	66.1	51.9
Oligochaeta				0.10	0.06											
Gastropoda																
Arachnida																
Hydracarina				0.52	0.11	0.13		0.41			0.13					
Crustacea							0.10									
Amphipoda					0.06											
Collembola																
Ephemeroptera				0.19			0.20	0.10								
Heptageniidae																
Baetidae		0.06	0.16	2.19	0.62	0.32	2.87		3.19	0.11	1.46	0.19	0.58		0.76	0.39
Odonata																
Aeshnidae				0.05												
Plecoptera					0.11											
Hemiptera										0.22		0.19				
Notonectidae																
Gerridae				0.05					0.06							
Megaloptera							0.10									
Corydalidae																
Trichoptera	larvae				0.11		0.41		1.83	0.16	0.27		0.33		0.15	
	pupae	0.06		0.10	0.06											
Coleoptera																
Haliplidae	adults	0.03				0.06										
Elmidae	larvae			0.14	0.06			0.10	0.06	0.05						
	adults			0.05				0.10			0.27		0.08			
Psephenidae	larvae						0.10						0.08			
Diptera																
Tipulidae	larvae			0.05			0.10									
	pupae			0.05	0.17		0.10							0.19		
Blephariceridae	larvae															
Simuliidae	larvae			0.33	0.11		1.23		0.95	0.05	0.80		0.74	0.74		1.16
	pupae															
Chironomidae	larvae			0.14		0.13	0.72		0.59	0.05	0.27	0.19		0.56	0.15	0.39
	pupae			0.10						0.05			0.08			
Fish							0.10									
Total aquatic invertebrates		0.14	0.16	4.05	1.46	0.65	6.04	0.71	6.68	0.70	3.18	0.57	1.90	1.48	1.06	1.93

Diu. - Diurnal drift (from about 7:00 am to 7:00 pm)
Noc. - Nocturnal drift (from about 7:00 pm to 7:00 am)

* expressed as number of organisms/10 m^3 of water in drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 3
Aquatic organisms caught in drift net sets*,
Untreated Control Stream,
Montcalm County, Quebec.
22 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-2 am	-2 pm	-1 am	-1 pm	Spray Day 4 am	5 am	6 am	7 am	8 am	9 am	pm
Depth (m)		0.23	0.27	0.23	0.23	0.24	0.23	0.21	0.21	0.21	0.17	0.22	0.22	0.17	0.17	0.17	0.17	0.17	0.17	0.24
Current velocity (m/sec)		0.42	0.24	0.15	0.39	0.44	0.48	0.24	0.24	0.30	0.24	0.24	0.27	0.33	0.33	0.33	0.33	0.33	0.33	0.36
Volume of drift column (m^3)		40.86	27.41	14.59	37.94	44.67	46.70	21.32	21.32	26.65	17.26	22.33	25.70	23.73	23.73	23.73	23.73	23.73	23.73	36.55
Oligochaeta				0.68																
Pelecypoda																				
Arachnida																				
Hydracarina		0.49							0.47	0.38										
Crustacea																				
Decapoda																				
Isopoda								0.47												
Collembola			0.36																	0.82
Ephemeroptera																				
Heptageniidae								0.47						0.42						
Baetidae		1.22	6.57	1.37	0.26	0.67		4.69	0.47	2.63	2.32	0.44	0.78	4.64	0.84	2.11	0.42	0.42	0.42	
Odonata																				
Aeshnidae			0.36											0.42						0.27
Plecoptera								0.47						0.42						
Hemiptera																				
Notonectidae													0.39					0.42		
Saldidae																				
Megaloptera																				
Trichoptera	larvae		2.19							0.38		0.44	1.17	0.84				0.84		
	pupae																			
Coleoptera																				
Elmidae	larvae				0.26															
	adults				0.26															
Psephenidae	larvae																			
Diptera																				
Tipulidae	larvae																			
Blephariceridae	larvae		0.73	0.68		0.22														
Simuliidae	larvae	0.24	0.36	0.68		0.22	0.21			0.38										
	pupae								0.47											
Chironomidae	larvae	0.73	0.73		1.05	1.12	0.21	0.47	0.47	0.38	0.58		1.17	0.84	0.42					
	pupae					0.22						0.90	0.39	0.42						
Fish															0.42					
Total aquatic invertebrates		2.69	11.31	3.43	1.84	2.46	0.43	6.57	1.88	4.13	2.90	1.79	3.89	8.01	1.26	2.11	0.42	1.69	0.42	1.09

* expressed as number of organisms/10 m^3 of water in drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 3 (cont'd)
Aquatic organisms caught in drift net sets*,
Untreated Control Stream,
Montcalm County, Quebec.
22 June to 9 July 1979

Days before or after application of 0.070 kg AI/ha azamethiphos**		+1 am	+1 pm	+2 am	+3 pm	+4 am	+4 pm	+5 am	+5 pm	Spray Day 4 am	5 am	6 am	pm	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Depth (m)		0.22	0.22	0.18	0.70	0.70	0.58	0.53	0.53	0.52	0.51	0.51	0.47	0.48	0.37	0.39	0.38	0.34	0.41	0.33	0.28
Current velocity (m/sec)		0.39	0.24	0.12	0.48	0.36	0.42	0.45	0.48	0.48	0.48	0.48	0.39	0.42	0.39	0.39	0.30	0.24	0.24	0.36	0.39
Volume of drift column (m^3)		35.47	22.33	9.14	47.38	35.53	34.35	33.63	35.87	35.19	34.52	34.52	51.69	85.28	61.04	64.34	48.22	34.52	41.62	50.25	46.19
Oligochaeta																					
Pelecypoda																					
Arachnida																					
Hydracarina				1.09																	
Crustacea																					
Decapoda																					
Isopoda					0.21																
Collembola		0.28	0.45																		
Ephemeroptera																	0.62				
Heptageniidae		0.28	0.45		1.48																
Baetidae			0.90	10.94	0.63					0.28	0.28		0.19		0.16	0.46		0.58			
Odonata															0.49	1.24	0.42	0.29	0.48	0.20	0.21
Aeshnidae																					
Plecoptera				1.09	0.42	0.56	0.29	0.84		1.71		0.58	0.58				0.21		0.48		
Hemiptera																					
Notonectidae			0.45																		
Saldidae						0.28														0.20	
Megaloptera													0.19								
Trichoptera	larvae			2.19	1.06	1.41	0.87		0.28	0.56	0.28			0.12	0.16	0.46	0.21	0.58	0.48	0.40	0.21
	pupae				0.21		0.29	0.89	0.28	0.56		0.29		0.12		0.16	0.21	0.29		0.40	0.21
Coleoptera																					
Elmidae	larvae																				
	adults																				
Psephenidae	larvae				0.21															0.20	
Diptera																					
Tipulidae	larvae						0.29														
Blephariceridae	larvae							0.30													
Simuliidae	larvae			1.09						0.28		0.29	0.19	0.23		0.46		0.87	0.24	0.40	0.64
	pupae																				
Chironomidae	larvae			2.19	1.26	1.68	0.29			0.56					0.33		0.83	1.16		0.60	
	pupae			1.09	0.63		0.29														
Fish									0.28												0.21
Total aquatic invertebrates		0.56	2.24	19.69	6.12	3.94	2.33	2.08	0.56	4.00	0.58	1.16	1.16	0.47	1.15	2.64	2.49	3.77	1.68	2.40	1.52

* expressed as number of organisms/10 m^3 of water in drift column

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 4
Bottom fauna populations*,
Ruisseau Castor Treatment Station,
Montcalm County, Quebec.
16 June to 31 August 1979

Date		16 June	24 June	3 July	9 July	15 July	30 July	31 August
Days before or after first (and second) application of 0.070 kg AI/ha azamethiphos**		-13 (-19)	-5 (-11)	+4 (-2)	10 (+4)	+16 (+10)	+31 (+25)	+63 (+57)
Nematoda		0.25 ± 0.50		0.25 ± 0.50		0.50 ± 1.00		
Oligochaeta		0.25 ± 0.50		0.75 ± 0.50		0.25 ± 0.50	0.25 ± 0.50	0.25 ± 0.50
Pelecypoda		1.00 ± 2.00	0.25 ± 0.50		0.25 ± 0.50	1.25 ± 2.50	0.75 ± 1.50	0.75 ± 0.96
Ephemeroptera								
Ephemeridae		0.25 ± 0.50			2.00 ± 2.45	0.50 ± 1.00		
Heptageniidae		3.25 ± 2.36	2.50 ± 3.00	4.00 ± 3.40	0.75 ± 0.96	3.50 ± 4.51	0.25 ± 0.50	3.00 ± 2.16
Baetidae		13.00 ± 6.22	5.75 ± 4.80	8.50 ± 7.05	0.25 ± 0.50	3.00 ± 2.58	2.00 ± 1.63	6.00 ± 6.22
Odonata								
Aeshnidae		0.25 ± 0.50			0.25 ± 0.50	0.25 ± 0.50		1.75 ± 1.71
Cordulegastridae								0.25 ± 0.50
Plecoptera		0.25 ± 0.50		0.75 ± 0.96		1.00 ± 2.00	0.25 ± 0.50	0.50 ± 0.58
Hemiptera								
Notonectidae		0.25 ± 0.50						
Megaloptera				0.50 ± 1.00		1.75 ± 3.50		1.25 ± 1.50
Trichoptera	larvae	2.25 ± 2.22	1.00 ± 0.82	0.25 ± 0.50	0.75 ± 1.50	0.75 ± 1.50	0.50 ± 0.58	8.00 ± 8.68
	pupae			0.25 ± 0.50	0.25 ± 0.50	0.25 ± 0.50		
Coleoptera								
Haliplidae	adults		0.25 ± 0.50					
Sphaeriidae	adults	0.25 ± 0.50						
Elmidae	larvae	0.25 ± 0.50						
	adults			0.25 ± 0.50		0.75 ± 1.50	0.50 ± 0.58	0.50 ± 0.58
Diptera								
Tipulidae	larvae	0.25 ± 0.50				0.25 ± 0.50	0.50 ± 1.00	4.50 ± 4.43
Simuliidae	larvae	0.25 ± 0.50				0.25 ± 0.50		0.25 ± 0.50
Chironomidae	larvae	0.50 ± 1.00		1.25 ± 1.30	0.75 ± 0.96	0.50 ± 0.58	14.75 ± 11.35	29.25 ± 54.51
	pupae	0.25 ± 0.50						0.25 ± 0.50
Heleidae	larvae			0.50 ± 0.58		0.25 ± 0.50		1.50 ± 3.00
Tabanidae	larvae	0.25 ± 0.50		0.25 ± 0.50				
Empididae	larvae	0.25 ± 0.50						
Total aquatic invertebrates		23.25 ± 7.00	9.75 ± 6.40	17.50 ± 8.85	5.25 ± 0.96	15.00 ± 9.70	19.75 ± 14.95	58.00 ± 66.25

* mean numbers and standard deviations of organisms collected in four 0.093 m^2 Surber samples

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 5
Bottom fauna populations*,
Ruisseau Castor Downstream Station,
Montcalm County, Quebec.
17 June to 30 July 1979

Date		17 June	23 June	3 July	9 July	15 July	30 July
Days before or after first (and second) application of 0.070 kg AI/ha azamethiphos**		-12 (-18)	-6 (-12)	+4 (-2)	+10 (+4)	+16 (+10)	+31 (+25)
Oligochaeta		0.25 ± 0.50	1.25 ± 0.50	2.50 ± 1.29	0.25 ± 0.50	3.00 ± 1.15	3.00 ± 2.94
Gastropoda				0.25 ± 0.50			
Pelecypoda						0.50 ± 1.00	0.50 ± 1.00
Arachnida							
Hydracarina			0.25 ± 0.50				
Collembola			0.25 ± 0.50				
Ephemeroptera							
Ephemeridae		0.25 ± 0.50	2.50 ± 5.00				
Heptageniidae		5.00 ± 8.68	9.25 ± 9.07	8.50 ± 7.59	3.50 ± 3.32	6.75 ± 5.62	2.00 ± 2.31
Baetidae		4.25 ± 1.26	21.50 ± 16.05	19.75 ± 7.50	3.00 ± 1.63	9.00 ± 6.38	0.25 ± 0.50
Anisoptera							
Gomphidae					0.25 ± 0.50		
Petaluridae							0.75 ± 1.50
Aeshnidae		0.25 ± 0.50	0.50 ± 1.00		0.50 ± 0.58		
Libellulidae		0.25 ± 0.50					
Plecoptera		0.75 ± 0.96	5.50 ± 7.05	2.75 ± 3.10	1.25 ± 1.26	4.75 ± 3.30	0.50 ± 0.58
Megaloptera							
Corydalidae		0.50 ± 0.58		0.25 ± 0.50			0.25 ± 0.50
Trichoptera	larvae	1.50 ± 3.00	2.00 ± 1.63	1.75 ± 1.26	0.25 ± 0.50	2.25 ± 3.86	
	pupae	0.50 ± 1.00		1.00 ± 1.41		0.75 ± 0.50	
Coleoptera							
Elmidae	larvae		6.25 ± 6.70			2.00 ± 1.63	2.25 ± 2.06
	adults	0.25 ± 0.50	1.25 ± 1.50	1.00 ± 0.82	0.50 ± 1.00	1.00 ± 1.41	
Psephenidae	larvae		0.50 ± 1.00	1.25 ± 2.50		1.00 ± 1.41	0.75 ± 1.50
Diptera							
Tipulidae	larvae		0.25 ± 0.50	0.50 ± 0.58			
Simuliidae	larvae						
	pupae	0.25 ± 0.50				0.25 ± 0.50	
Chironomidae	larvae	0.50 ± 1.00	6.50 ± 2.52	0.75 ± 0.96	1.00 ± 2.00	1.50 ± 1.29	4.75 ± 2.22
	pupae	0.25 ± 0.50	1.25 ± 0.96	1.25 ± 0.96	0.25 ± 0.50	0.50 ± 0.58	0.25 ± 0.50
Empididae	pupae	0.25 ± 0.50					
Total aquatic invertebrates		15.00 ± 18.67	59.00 ± 36.94	41.50 ± 9.33	10.75 ± 7.23	33.25 ± 15.52	15.25 ± 8.62

* mean numbers and standard deviations of organisms collected in four 0.093 m^2 Surber samples

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 6
Bottom fauna populations*,
Untreated Control Stream,
Montcalm County, Quebec.
16 June to 28 August 1979

Date		16 June	23 June	3 July	9 July	15 July	30 July	28 August
Days before or after first (and second) application of 0.070 kg AI/ha azamethiphos**		-13 (-19)	-6 (-12)	+4 (-2)	+10 (+4)	+16 (+10)	+31 (+25)	+60 (+54)
Ephemeroptera								
Heptageniidae		1.75 ± 0.50		0.25 ± 0.50	1.00 ± 0.82	6.00 ± 2.94	1.75 ± 2.06	1.25 ± 1.50
Baetidae		3.75 ± 3.30	4.75 ± 4.27	3.50 ± 3.00	0.25 ± 0.50	2.00 ± 2.16	1.50 ± 0.58	1.00 ± 0.82
Anisoptera								
Gomphidae		0.25 ± 0.50			0.25 ± 0.50	0.50 ± 0.58		0.25 ± 0.50
Plecoptera		0.25 ± 0.50	0.50 ± 0.58		0.25 ± 0.50	0.50 ± 0.58	0.50 ± 0.58	5.25 ± 3.77
Trichoptera	larvae	1.75 ± 1.26		2.50 ± 2.52	0.25 ± 0.50	2.25 ± 1.50	1.00 ± 1.16	1.75 ± 2.87
	pupae			0.50 ± 0.58			0.25 ± 0.50	
Coleoptera								
Elmidae	larvae		0.25 ± 0.50		0.50 ± 1.00			
Diptera								
Tipulidae	larvae			0.75 ± 0.96		1.25 ± 1.26	0.50 ± 0.58	1.25 ± 1.50
Blephariceridae	larvae				0.25 ± 0.50	0.25 ± 0.50		
Simuliidae	pupae	0.25 ± 0.50						
Chironomidae	larvae	3.00 ± 2.16	6.25 ± 4.65	3.00 ± 2.45	0.50 ± 0.58	4.50 ± 5.01	3.00 ± 2.16	5.00 ± 3.16
	pupae		0.50 ± 1.00					0.50 ± 0.58
Heleidae	larvae					0.25 ± 0.50		
Total aquatic invertebrates		11.00 ± 5.35	12.25 ± 6.99	10.50 ± 5.07	3.25 ± 2.63	17.50 ± 9.89	8.50 ± 5.45	16.25 ± 6.95

* mean numbers and standard deviations of organisms collected in four 0.093 m^2 Surber samples

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 7
Aquatic invertebrates collected from rocks*,
Ruisseau Castor Treatment Station,
Montcalm County, Quebec.
16 June to 31 August 1979

Date		16 June	24 June	3 July	9 July	15 July	30 July	31 August
Days before or after first (and second) application of 0.070 kg AI/ha azamethiphos**		-13 (-19)	-5 (-11)	+4 (-2)	+10 (+4)	+16 (+10)	+31 (+25)	+63 (+57)
Pelecypoda							0.25 ± 0.50	
Arachnida								
Hydracarina			0.25 ± 0.50				0.25 ± 0.50	
Collembola							0.25 ± 0.50	
Ephemeroptera								
Heptageniidae		3.75 ± 2.36	4.25 ± 2.50	1.25 ± 1.50	5.00 ± 2.16	3.50 ± 3.32	1.75 ± 2.06	3.25 ± 4.57
Baetidae		3.25 ± 2.99	8.25 ± 11.90	3.25 ± 0.96	4.25 ± 4.27	0.50 ± 0.58	0.50 ± 1.00	1.25 ± 1.26
Odonata								
Aeshnidae						0.25 ± 0.50		
Plecoptera		0.50 ± 0.58	0.25 ± 0.50	0.25 ± 0.50	0.50 ± 0.58			
Megaloptera					0.25 ± 0.50			
Trichoptera	larvae	4.00 ± 1.41	0.75 ± 0.50	0.75 ± 0.50	1.00 ± 0.82	1.75 ± 1.50	1.00 ± 0.82	
	pupae	0.50 ± 0.58	0.25 ± 0.50				0.25 ± 0.50	
Coleoptera								
Elmidae	larvae	0.50 ± 1.00				0.25 ± 0.50		
Diptera								
Tipulidae	larvae		0.25 ± 0.50					
Blephariceridae	larvae	0.25 ± 0.50						
Simuliidae	larvae	0.50 ± 0.58	1.75 ± 2.87				0.25 ± 0.50	
	pupae					1.00 ± 2.00		
Chironomidae	larvae	2.00 ± 2.16	3.50 ± 2.65	2.00 ± 2.71	3.25 ± 1.71	0.75 ± 0.96	1.50 ± 1.91	1.50 ± 0.58
Empididae	larvae		0.25 ± 0.50					
Total aquatic invertebrates		15.25 ± 7.04	19.75 ± 15.02	7.50 ± 3.70	14.25 ± 4.86	8.00 ± 5.77	6.00 ± 5.23	6.00 ± 5.10

* mean numbers and standard deviations of organisms collected from four rocks approximately 20 cm in diameter

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 8
Aquatic invertebrates collected from rocks*,
Ruisseau Castor Downstream Station,
Montcalm County, Quebec.
17 June to 30 July 1979

Date		17 June	23 June	3 July	9 July	15 July	30 July
Days before or after first (and second) application of 0.070 kg AI/ha azamethiphos**		-12 (-18)	-6 (-12)	+4 (-2)	+10 (+4)	+16 (+10)	+31 (+25)
Nematoda		0.25 ± 0.50					
Pelecypoda						0.25 ± 0.50	
Arachnida							
Hydracarina		0.25 ± 0.50	0.25 ± 0.50		0.25 ± 0.50		
Ephemeroptera							
Heptageniidae		9.25 ± 4.03	3.25 ± 3.30	1.50 ± 1.73	2.75 ± 0.96	3.25 ± 2.22	1.50 ± 1.00
Baetidae		4.75 ± 5.50	20.25 ± 10.59	1.50 ± 1.73	3.00 ± 2.16	4.00 ± 4.24	1.75 ± 2.87
Anisoptera							
Aeshnidae		0.25 ± 0.50					
Macromiidae			0.50 ± 1.00				
Plecoptera		1.00 ± 8.16	0.75 ± 0.96		0.50 ± 0.58	0.25 ± 0.50	0.25 ± 0.50
Trichoptera	larvae	8.75 ± 7.68	1.00 ± 1.41	3.75 ± 0.96	3.75 ± 2.36	1.00 ± 0.82	8.00 ± 8.29
	pupae	2.00 ± 2.71	1.75 ± 3.50	0.75 ± 0.50	1.00 ± 0.82	0.50 ± 1.00	1.25 ± 1.89
Coleoptera							
Elmidae	larvae		0.75 ± 0.96			0.50 ± 1.00	0.75 ± 0.96
	adults	0.25 ± 0.50	0.50 ± 0.58		0.75 ± 0.96		
Psephenidae	larvae			0.25 ± 0.50			
Diptera							
Tipulidae	larvae		0.25 ± 0.50				
Simuliidae	larvae			1.00 ± 1.41	0.25 ± 0.50		0.50 ± 1.00
Chironomidae	larvae	5.75 ± 4.19	6.50 ± 3.00	9.25 ± 9.22	16.00 ± 17.17	5.25 ± 2.22	8.50 ± 8.70
	pupae						0.25 ± 0.50
Total aquatic invertebrates		32.25 ± 18.64	35.75 ± 7.80	18.00 ± 6.38	28.25 ± 14.29	14.75 ± 7.37	23.00 ± 16.69

* mean numbers and standard deviations of organisms collected from four rocks approximately 20 cm in diameter

** application at 7:05 am on 29 June 1979 and again at 4:25 am on 5 July 1979

Table 9
Aquatic invertebrates collected from rocks*,
Untreated Control Stream,
Montcalm County, Quebec.
16 June to 28 August 1979

Date		16 June	23 June	3 July	9 July	15 July	30 July	28 August
Days before or after first (and second) application of 0.070 kg AI/ha azamethiphos**		-13 (-19)	-6 (-12)	+4 (-2)	+10 (+4)	+16 (+10)	+31 (+25)	+60 (+54)
Arachnida								
Hydracarina			1.50 ± 1.29		1.50 ± 3.00			
Ephemeroptera								
Heptageniidae		3.25 ± 2.50	0.25 ± 0.50	0.25 ± 0.50	0.25 ± 0.50	2.50 ± 2.89	4.25 ± 1.26	10.25 ± 7.63
Baetidae		5.50 ± 5.20	4.50 ± 2.65	3.00 ± 1.15	6.00 ± 2.16	2.00 ± 2.16		4.75 ± 3.59
Plecoptera		0.75 ± 0.96					0.50 ± 0.58	0.75 ± 9.57
Trichoptera	larvae	3.50 ± 2.38	0.50 ± 0.58	4.00 ± 2.45	5.50 ± 1.73	3.00 ± 2.58	4.00 ± 1.63	4.25 ± 0.96
	pupae	0.50 ± 0.58		1.75 ± 1.71	1.50 ± 0.58	0.50 ± 0.58	0.25 ± 0.50	0.25 ± 0.50
Coleoptera								
Elmidae	larvae				0.25 ± 0.50			
Psephenidae	larvae				2.25 ± 4.50		0.25 ± 0.50	
Diptera								
Simuliidae	larvae	0.25 ± 0.50						1.00 ± 2.00
	pupae	0.75 ± 1.50			3.00 ± 6.00			
Chironomidae	larvae	5.75 ± 8.02	10.00 ± 8.60	1.00 ± 0.82	27.25 ± 26.76	47.50 ± 37.29	9.50 ± 6.61	57.50 ± 45.86
	pupae				0.25 ± 0.50	0.25 ± 0.50		0.25 ± 0.50
Total aquatic invertebrates		20.25 ± 7.85	16.75 ± 11.84	10.00 ± 4.90	47.75 ± 31.26	55.75 ± 38.66	18.75 ± 6.95	79.00 ± 43.55

* mean numbers and standard deviations of organisms collected from four rocks approximately 20 cm in diameter

** application at 7:05 am on 29 June and again at 4:25 am on 5 July 1979

APPENDIX V

Fish diets in the treatment stream.
Montcalm County, Quebec. 1979.

Table 1
Brook trout sampled for stomach content analysis,
from Ruisseau Castor Treatment Station,
Montcalm County, Quebec.
21 June to 31 August 1979

Date	21 June	3 July	9 July	15 July	29 - 31 August
Number of Fish Sampled	10	11	12	13	10
Mean Total Length (mm)	92.30	57.00	50.92	54.62	105.00
Range	74 - 110	44 - 91	41 - 62	41 - 112	58 - 131
Mean Fork Length (mm)	90.50	55.36	49.25	53.54	104.40
Range	72 - 109	43 - 89	40 - 60	40 - 110	57 - 130
Mean Weight (g)	8.56	2.25	1.18	2.34	13.74
Range	4.4 - 12.6	0.7 - 7.8	0.7 - 1.8	1.2 - 14.2	2.3 - 23.6
Mean Volume of Stomach Contents (ml)	0.08	0.09	0.06	0.05	0.12
Range	0.0 - 0.2	<0.1 - 0.2	0.0 - 0.2	0.0 - <0.1	<0.1 - 0.3
$\frac{\text{Mean Volume of Stomach Contents (ml)}}{\text{Mean Weight (g)}}$	0.009	0.040	0.051	0.021	0.009

Table 2
Stomach contents of brook trout from
Ruisseau Castor Treatment Station*,
Montcalm County, Quebec.
21 June to 31 August 1979

Sample Date		Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms per Stomach				
		21 June	3 July	9 July	15 July	29 - 31 August	21 June	3 July	9 July	15 July	29 - 31 August	21 June	3 July	9 July	15 July	29 - 31 August
No Food Present		20	0	8	8	0										
Aquatic Insects																
Ephemeroptera																
Ephemeridae			18					15.5					1.0			
Heptageniidae						10					0.5					2.0
Baetidae		50	55	25	54	50	22.4	22.9	5.5	27.9	29.6	1.8	2.0	2.0	2.3	2.6
Odonata					8					1.7					1.0	
Hemiptera																
Gerridae						10					1.0					1.0
Megaloptera																
Sialidae						10					0.5					1.0
Corydalidae					23					5.0					1.0	
Trichoptera	larvae	30	55	58		50	22.5	26.4	19.2		8.1	1.3	2.7	1.6		2.8
	pupae			8	15				5.9	3.8				2.0	1.0	
Coleoptera	larvae		9					0.9					1.0			
	adults	10	9			20	1.3	4.6			5.0	1.0	2.0			1.5
Diptera																
Simuliidae	larvae				8	10				0.8	0.6				1.0	1.0
	pupae				23					7.1					1.7	
Chironomidae	larvae		27	25	77	90		5.0	3.4	26.3	24.1		3.7	3.0	5.7	3.0
	pupae		18	17	15	10		4.7	0.6	4.6	0.5		1.0	1.0	1.0	2.0
Unidentified			9		8	10		1.4		1.7	2.0		1.0		1.0	1.0
Other Aquatic Invertebrates																
Nematomorpha						10					0.5					1.0
Oligochaeta			9		8	10		2.3		5.0	0.5		3.0		1.0	1.0
Arachnida																
Hydracarina			9			30		1.1			1.5		1.0			1.3
Crustacea																
Decapoda						40					8.5					1.0
Terrestrial Arthropods																
Collembola			9					1.8					1.0			
Ephemeroptera					8					4.2					1.0	
Homoptera		40	9	17	15	40	25.5	1.1	1.1	5.8	3.5	4.0	1.0	1.0	2.0	2.3
Trichoptera					8					5.4					1.0	
Lepidoptera		20				10	17.5				0.5	1.5				1.0
Hymenoptera				8		10			2.7		0.5			1.0		2.0
Coleoptera		20	9			40	4.0	0.9			5.6	1.5	1.0			1.5
Diptera		20	18	67		20	6.9	10.2	61.6		7.0	2.5	2.0	5.1		3.0
Unidentified			9		8			1.4		0.8			4.0		1.0	

* application at 7:05 am on 29 June 1979
and again at 4:25 am on 5 July 1979