Preliminary Report on the Environmental Impact of an Experimental Application of the Insect Growth Regulator Bay Sir 8514. Wawa, Ontario. 1979

by

R.L. Millikin and K.L. Mortensen

Forest Pest Management Institute

Canadian Forestry Service

Sault Ste. Marie, Ontario

File Report Number 3

March, 1980

Acknowledgements

The authors would like to thank Dr. A. Retnakaran and L. Smith for the cooperative manner in which they set-up the program, A. Obarymskyj, B. Tomkins, and B. Zylstra for organizing and carrying out the spray formulation and deposit assessment, J.W. Beveridge for providing meteorological data, and special thanks to W. Cameron, M. Dacey and S. Fast for gathering the field data.

Introduction

In an ongoing search for effective and environmentally safe insecticides to use in spruce budworm, *Choristoneura fumiferana* Clemens, control programs, the Forest Pest Management Institute has been investigating the possibilities of using insect growth regulators. These compounds interfere with the synthesis of chitin, inhibiting the moulting process, and are therefore fairly specific to immature arthropods. The effects on larvae are similar to those observed with a juvenile hormone (A. Retnakaran, personal communication). As juvenile hormones, topically fed to honeybees, have been shown to cause mortality and to induce the differentiation of larvae into queens (Copijn, G.M. et al., 1979), it was considered necessary to field test colonies of honeybees against these potential hazards.

Application of the insect growth regulator must be made at bud flush in order to reach the budworm larvae (now in peak 4^{th} instar). At this time, forest songbirds have established themselves in territory and the possible effects on their breeding behavior can be observed.

Site Description

Terrestrial impact studies were conducted 5.7 km north of Wawa along the Trans Canada Highway 17, in an open mature stand of white birch, *Betula papyrifera* Marsh., and white spruce, *Picea glauca* (Moench) Voss., equally predominant. The bird plot was situated on the east side of the highway, and a clearing (approx. 320 m^2) in the southwest corner of the plot was ideal for the placement of honeybee colonies. The clearing was bordered by shrubs and young trees, predominantly willow, *Salix* L., white birch, balsam poplar, *Populus balsamifera* L. and white spruce, which provided ample shelter from winds but no overhead cover.

A control bird plot was set up approximately 45.2 km north of the spray block along Highway 17 on the east side of the highway in an area of forest similar to that of the treatment block. Comparing the plots themselves however, the control stand was more closed and therefore had less understory. The terrain was more uneven with scattered low wet areas and a predominance of Black spruce, *Picea mariana* (Mill.) B.S.P., rather than white spruce.

The control honeybee colonies were located approximately 26 km north of the spray block in an old abandonned gravel pit which lay adjacent to a small lake. The hives were partially sheltered from winds by an abundance of shrubs in the immediate vicinity of the colonies, but were open to full sunlight throughout most of the day.

Methods

Spray Application

The 100-acre test block was sprayed with a single application of Bay Sir 8514 at 04:57 EST on 19 June, 1979. Application was by a Cessna Agtruck equipped with a Micronair system, calibrated to deliver 4.7 ℓ/ha. Bay Sir 8514 (25% wetable powder)[1] was mixed with water, and a small amount of Rhodamine B dye[2] (0.1% of the formulation) was added to fascilitate deposit measurement. The total emission rate of 4.7 ℓ/ha contained 0.280 kg active ingredient/ha.

Deposit Assessment

Each deposit sampling unit included a 10 cm^2 Kromecote® card and a stainless steel plate from which the distribution and volume of deposits were assessed. Six samplers were situated along a transect through the bird plot, running perpendicular to the spray plane's flight path. Four samplers were placed on the bee hives themselves, and another two were set at the control plot in order to document possible drift.

Spray droplets deposited on the Kromecote® cards were later sized and counted using an NCR microcard reader. A drop density value was calculated for each card from the total droplet density (drops/cm^2) for each size class. Stainless steel plates were washed with toleune and the quantity of dye rinsed off was measured with a Baush and Lomb Spectronic 100. A sample of the formulation was kept

---

[1]Chemagro Ltd., Mississauga, Ont.

[2]Dupont of Canada Ltd., Toronto, Ont.

for a standard, in order to calculate the equivalent volume of deposit (ℓ/ha).

Terrestrial Invertebrates

Terrestrial invertebrate knockdown was collected each evening (about 17:00 EST) from ten days before the application to six days after, when postspray numbers in the treatment buckets appeared normal. Plastic wash basins, measuring 39 cm x 33 cm x 15 cm, were used for sampling. Eight buckets were placed throughout both treatment and control areas; three under willow, and five under white spruce.

Honeybees

Four colonies of the Italian strain of honeybees, *Apis mellifera* L., were used to study the effect of Bay Sir 8514 on pollinating insects. The colonies were of overwintered stock from the apiary of the Forest Pest Management Institute, Sault Ste. Marie, Ontario. Those selected for the field trials, were hived in standard Langstroth single brood chambers. The colonies were moved to the study area on 10 June, and monitoring equipment put in place on 11 June. Two colonies were located in the approximate center of the treatment block, and two colonies at the control site.

Monitoring equipment consisted of a dead bee box to retain dead bees at the front of the hive, a photo-electric device to measure hive entrance activity, an O.A.C. pollen trap, and a scale to gauge relative hive weights (weights were taken by placing a bathroom scale under an edge of the hive). Brood measurements

were taken with the aid of a 4 cm^2 wire grid, encompassing approximately 64 cells. Specific areas of eggs and/or young larvae were defined using the wire grid which was lettered and numbered for easy reference.

Monitoring began on 12 June and was terminated at the study area on 26 June. Colonies were then returned to the FPMI apiary for further observations. Pollen traps were replaced and daily measurements were taken from 18 July to 8 August.

Birds

Forest songbird populations were monitored on 4 hectare plots flagged within the treatment and control areas. Censuses began shortly after dawn each morning from 7 days before treatment to 7 days after, employing a breeding bird census technique similar to that described by Kendeigh (1957). While walking set lines (40 m apart) through the plot, the censor would record, on a plot map, the species, sex, and type of activity of each bird encountered. Male birds vocally defending a territory were assumed to have a mate and therefore recorded as two birds, all others (sighted, calling, females etc.) were recorded as one. The number of birds observed during each census indicate activity trends and relative abundance on that plot.

Daily maps were later combined over the prespray and then postspray time periods, in order to delineate territorial boundaries for each species.

Results

Deposit

Deposit results for the Bay Sir operation are presented in Table 1. Meteorological conditions for spray deposit were ideal (average wind speed 0.5 m/sec, average stability ratio 70.7, average relative humidity 94%, average temperature 6.6°C). Difficulty in obtaining consistent results with repeated colorimetric readings of the spray deposit, suggest that the small recorded deposit on control was due to an error in calibration. This problem is a result of the very low concentration of dye in the spray formulation. There were no spots on the control cards, and the possibility of drift over 45.2 km is highly unlikely. The largest deposit was recorded on cards placed in the open (road and bee hives). Conversely, deposit on the bird plot was slight, due to a filtering of the spray through the overhead canopy.

Terrestrial Insects

There was no observed increase in knockdown from willow as a result of the Bay Sir treatment (Figure 1). The slight increase from spruce, one day after the application (Figure 2), was of Diptera: Chironomidae, and other unidentified Diptera (Appendix I, Table 1). A similar increase was not observed on control (Appendix I, Table 2). Peaks in numbers of invertebrates collected from both treatment and control buckets on 11, 15 and 17 June, correspond quite closely to days of heavy rainfall prior to sampling. Rainfall seemed to have the greatest effect on Diptera: Sciaridae (Appendix I Tables 1-4).

Table 1

Summary of deposit results for the Bay Sir 8514 field trials* in Wawa, Ontario

		Spot Counting	Colorimetry	
	No. of deposit Samplers	Mean drop density drops/cm^2	Mean volume deposited ℓ/ha	Mean % of emitted volume
Bird plot	5	3.52 ± 3.47	0.12 ± 0.10	2.6%
Road	1	29.2	0.56	11.9%
Bee hives	4	29.3 ± 2.09	0.72 ± 0.10	15.3%
Control	2	0	0.02 ± 0.01	0.4%

*emitted dosage rate of 4.7 ℓ/ha, applied on 19 June, 1979.

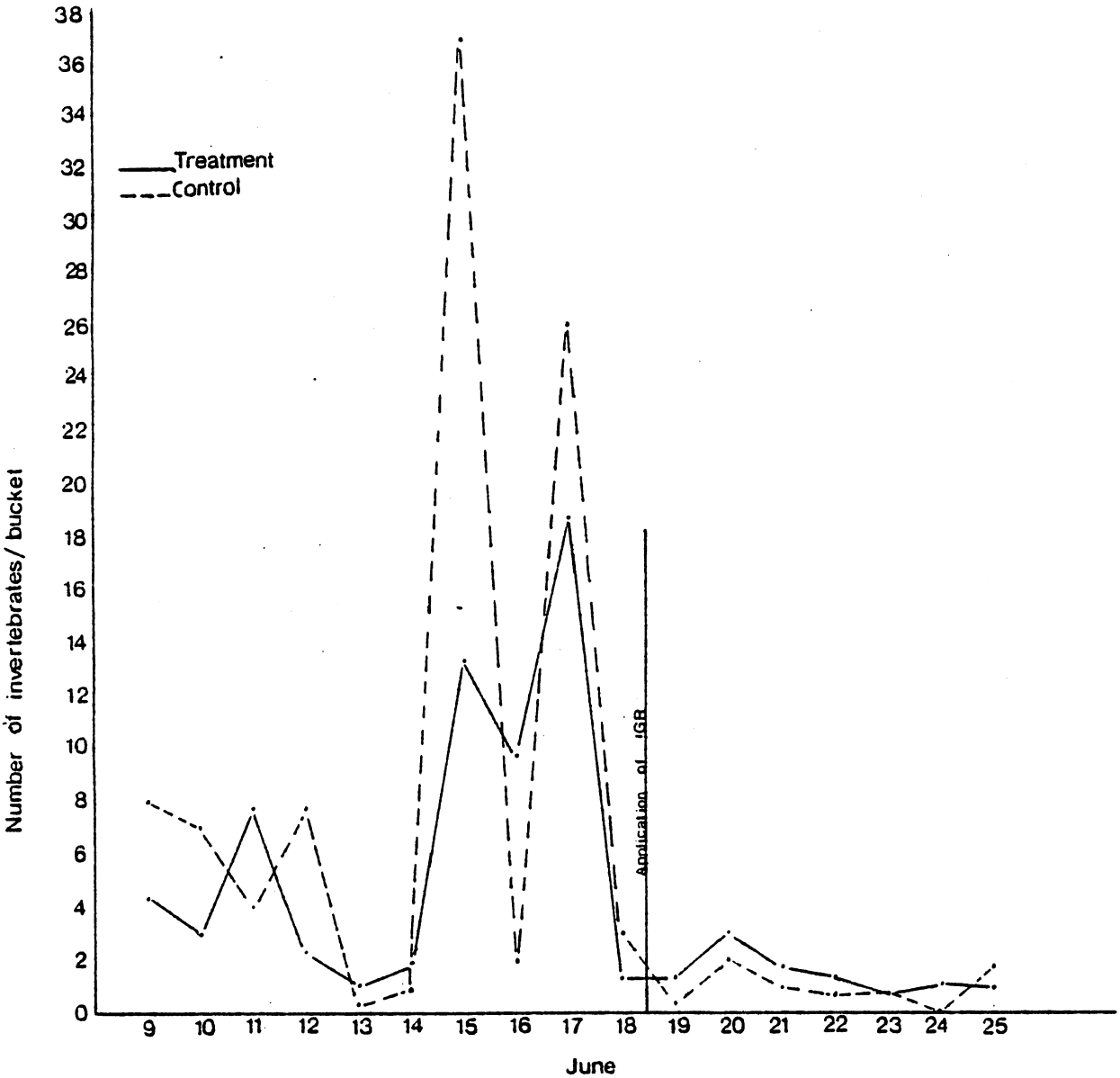

Figure 1. Comparison of terrestrial invertebrate knockdown from willow, in treatment and control areas

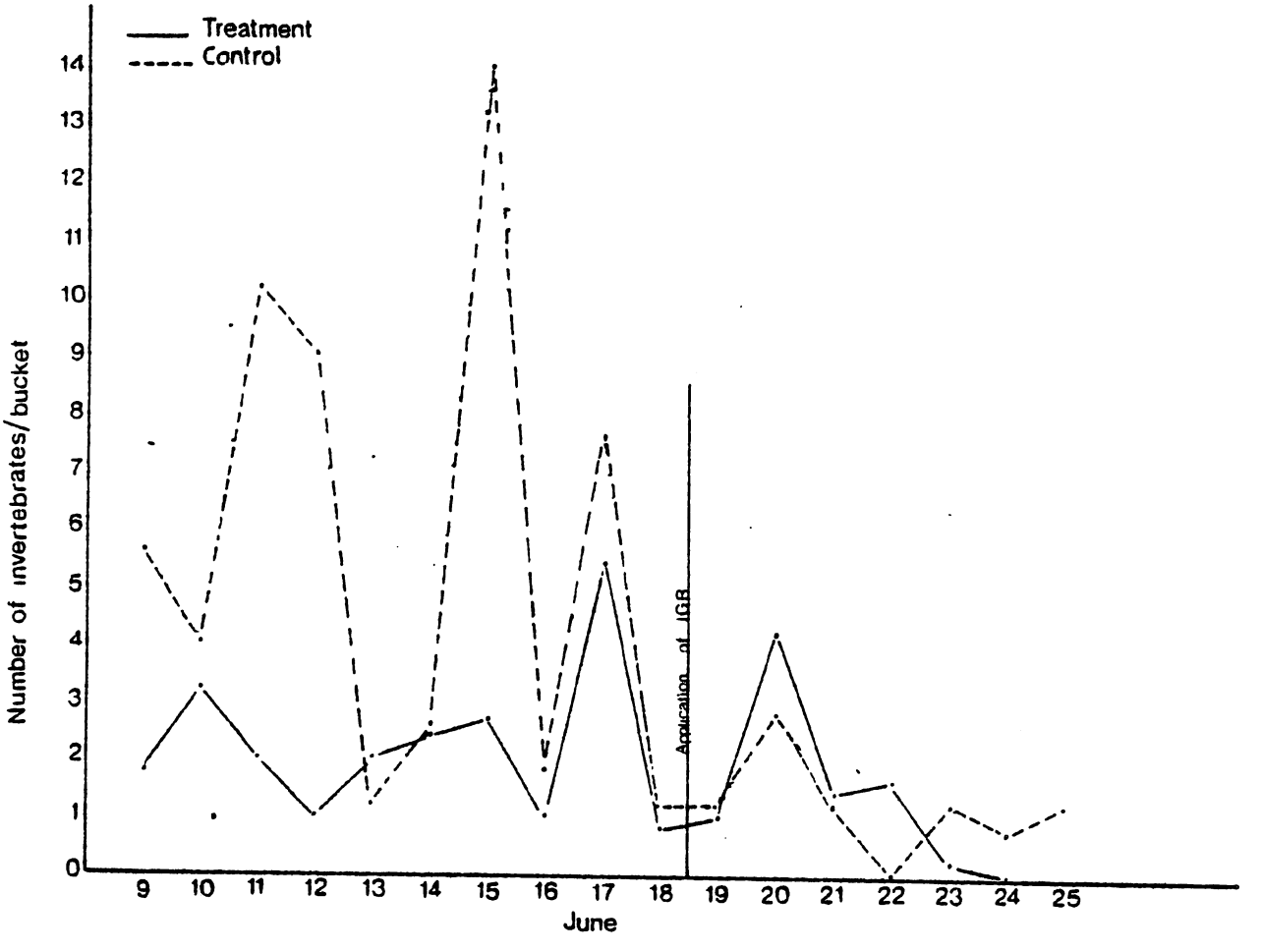

Figure 2. Comparison of terrestrial invertebrate knockdown from spruce, in treatment and control areas

Bees

Changes in the amount of pollen collected (Figure 3), were reflections of weather patterns, and did not appear related to the application. Mild temperatures continued throughout spray day under sunny skies, and pollen collecting was normal. It rained that evening, through until about noon the next day. Consequently, the amount of pollen collected on 20 June was reduced and on the two following days, both marked with considerable rainfall, no pollen was collected at all from either treatment or control hives.

Activity counts of treated and control hives were not significantly different with the exception of abnormally high readings two days before and after the application (Figure 4). These jumps in the counts are most likely due to problems with the counters where moisture within the mechanism effects their performance, magnifying the actual counts. The decline in activity of treatment hives following the application (days +2 and +3), was probably due to adverse weather conditions which would be consistent with the observed decrease in pollen collection on these days. Dead bee counts remained very low (Table 2), which would be expected as adult insects should not be affected by the IGR.

Capped brood measurements (Figure 5) indicate a normal gain over the study period with a greater rate of increase for the treatment hives. However, counts of designated areas of capped brood, showed some abnormality in the normal developmental cycle in one treatment colony (Table 3). The normal progression from egg to capped brood requires eight days, and on 5 July three out of four

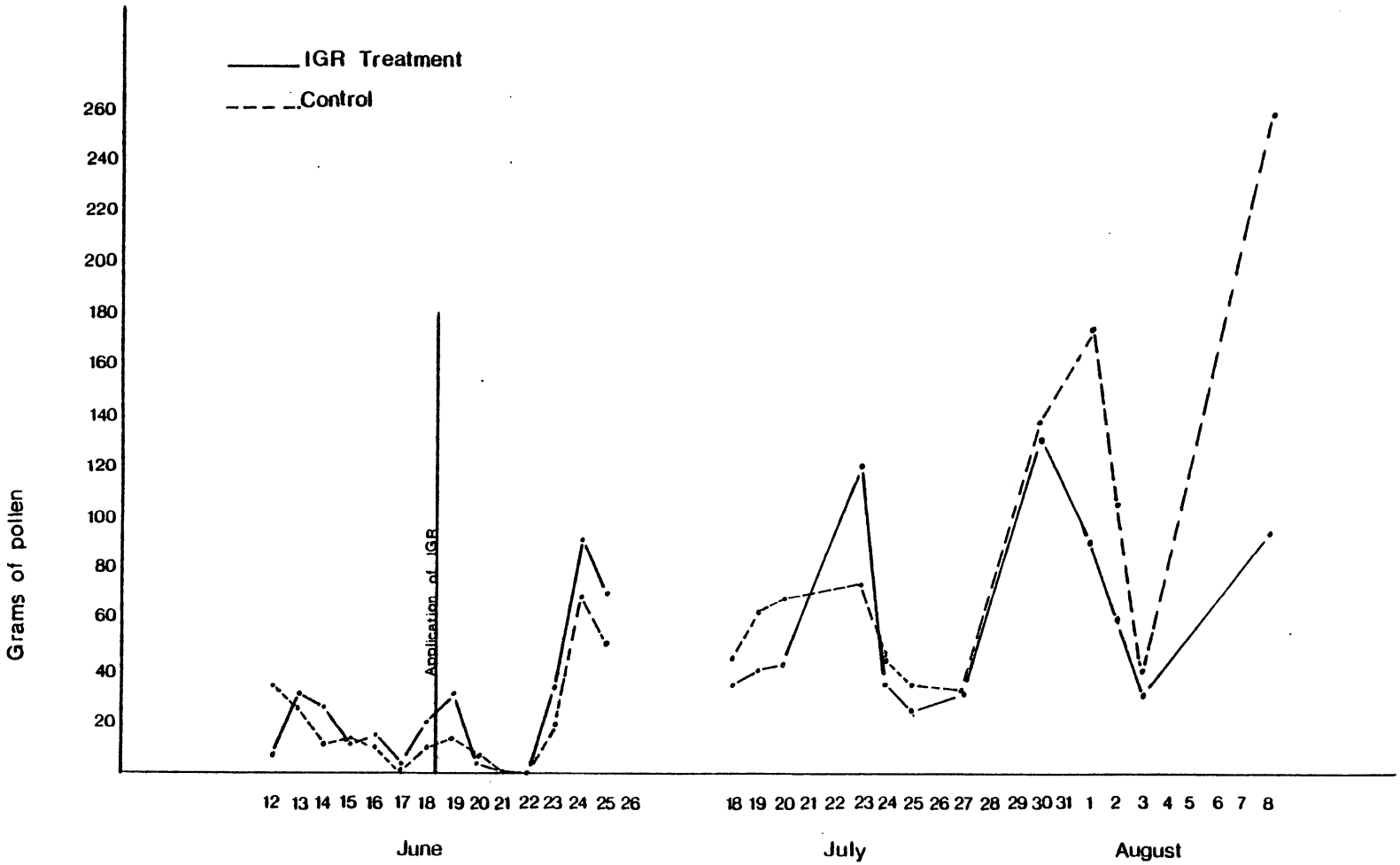

Figure 3. Average weight of pollen collected from IGR treated and untreated honey bee colonies

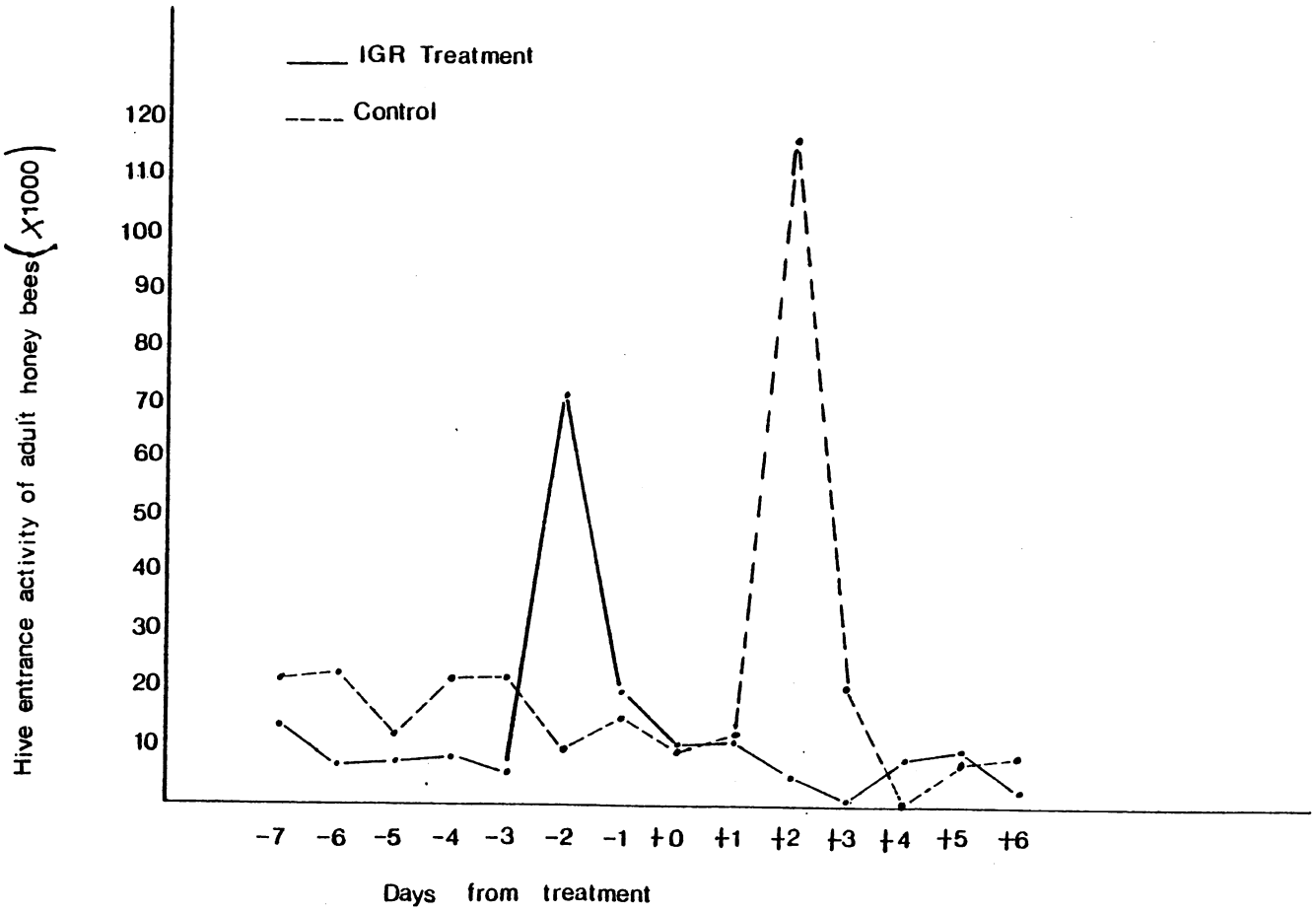

Figure 4. Average activity recorded at the hive entrance of IGR treated and untreated honey bee colonies

Table 2

Average Number of Dead Bees Collected From Dead Bee Trap at Hive Entrance

DATE	I.G.R. TREATMENT	CONTROL
JUNE		
12	1.5	3.0
13	2.5	2.0
14	0	1.5
15	0.5	0
16	0.5	0.5
17	0.5	4.0
18	6.0	0
19*	1.0	1.0
20	3.0	13.0
21	6.5	5.5
22	5.5	5.0
23	1.5	3.5
24	3.5	6.0
25	2.0	2.5

*Application at 0457 EST.

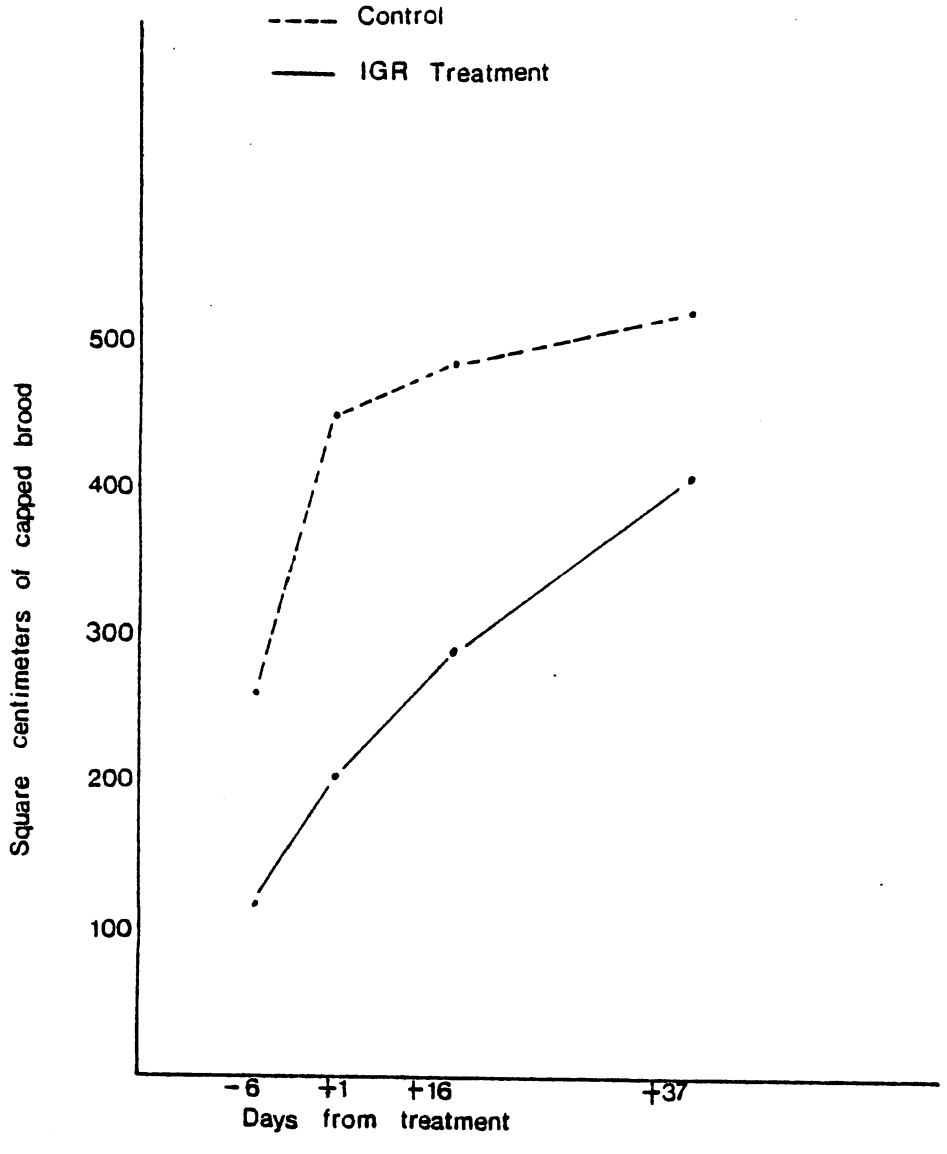

Figure 5. Average area of capped brood sampled from IGR treated and control honey bee colonies

Table 3

Estimated Number of Eggs, Young Larvae, Capped Brood or Empty Cells

Date	Stage	Treatment Hive 1	Treatment Hive 2	Control Hive 1	Control Hive 2
June	Eggs	128	128	106	96
20	Young Larvae				32
	Capped Brood				
	Empty				
July	Eggs				
5	Young Larvae		128		
	Capped Brood	128		96	116
	Empty			10	12

colonies had developed capped brood. Hive 58 however, had larvae in the cells that fifteen days previously had contained eggs. As these larvae were healthy, it is obvious that the queen had relaid eggs in those cells. Laboratory examination of the pollen from this hive, revealed numbers of very small, hard, segmented larvae. About 76 of the larvae were found in pollen samples between 20 and 25 June. These larvae did not resemble honeybee larvae in that they were not sickle shaped. However, it is not known at this time as to what position small larvae would take upon drying out amongst pollen.

During the period of field monitoring from 12 June to 25 June, the treatment colonies lost an average of 0.9 kg, while the control colonies lost an average of 0.25 kg. This difference is not significant.

Birds

Both treatment and control areas were similar in species complex (Appendix II Table 1 and 2), with the wood warblers (Parulidae) making up approximately 70% of the population. The Fringillidae population was abnormally low on both treatment and control plots. The treatment plot was more productive, supporting an average breeding population of 73 birds over the study period, almost double that of control (Tables 4 and 5).

Fluctuations observed in the daily activity of treatment and control populations (Fig. 6) correspond quite closely to weather patterns. Days of low activity were consistently overcast and windy with rain storms imminent. There was no observed reduction in activity consequent of the application.

Table 4
Forest bird population census
Insect Growth Regulator treatment plot
Wawa, Ontario
12 - 26 June, 1979
(IGR applied on 19 June at the emitted dosage rate of 0.280 kg AI/ha)

Family	Pre-spray						Post-spray								
	June 12 -7	June 13 -6	June 14 -5	June 16 -3	June 18 -1	Daily ave.	June 19 +0	June 20 +1	June 21 +2	June 22 +3	June 23 +4	June 24 +5	June 25 +6	June 26 +7	Daily ave.
Picidae	0	1	1	0	2	0.8	0	0	0	0	0	0	0	0	0.0
Tyrannidae	2	6	4	6	4	4.4	0	4	0	2	0	2	4	2	1.8
Sittidae	0	0	0	0	0	0.0	2	0	0	0	2	0	0	0	0.5
Troglodytidae	0	0	0	0	0	0.0	2	0	0	0	0	0	2	0	0.5
Turdidae	3	13	4	5	6	6.2	10	6	5	6	5	5	5	0	5.3
Vireonidae	8	2	4	8	8	6.0	10	10	4	10	6	8	8	8	8.0
Parulidae	46	40	47	60	46	47.8	60	36	64	36	67	52	58	46	52.4
Thraupidae	2	0	0	0	0	0.4	0	0	0	0	0	2	0	0	0.3
Fringillidae	4	8	2	6	4	4.8	4	6	6	4	0	8	4	2	4.3
Unidentified Birds	0	4	0	4	0	1.6	0	2	0	2	2	0	0	0	0.8
Total Birds	65	74	62	89	70	72.0	88	64	79	60	82	77	81	58	73.9

Table 5
Forest bird population census
Insect Growth Regulator Control Plot
Wawa, Ontario
12 June - 26 June, 1979

Family	Pre-spray							Post-spray								
	June 12	June 13	June 14	June 16	June 17	June 18	Daily	June 19	June 20	June 21	June 22	June 23	June 24	June 25	June 26	Daily
	-7	-6	-5	-3	-2	-1	ave.	+0	+1	+2	+3	+4	+5	+6	+7	ave.
Tetraonidae	1	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0.0
Picidae	1	0	0	0	0	0	0.2	0	0	0	0	0	1	0	0	0.2
Tyrannidae	4	6	0	2	2	4	3.0	2	4	4	2	0	8	2	4	3.3
Paridae	0	0	1	0	0	0	0.2	0	0	0	0	0	0	0	0	0.0
Sittidae	2	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.0
Mimidae	0	0	0	0	0	0	0.0	0	0	0	0	0	2	0	0	0.3
Turdidae	2	5	2	4	0	6	3.2	5	2	0	2	0	1	4	0	1.9
Sylviidae	4	0	0	0	4	2	1.7	0	2	0	2	0	2	0	0	0.8
Vireonidae	8	2	4	8	2	8	5.4	6	8	6	2	2	12	6	6	6.0
Parulidae	36	30	12	30	24	42	29.0	32	26	32	20	22	38	34	38	30.7
Fringillidae	0	0	2	2	2	5	1.8	2	2	0	8	0	2	0	0	1.8
Total Birds	58	43	21	46	34	67	44.8	47	44	42	36	24	66	46	48	44.1

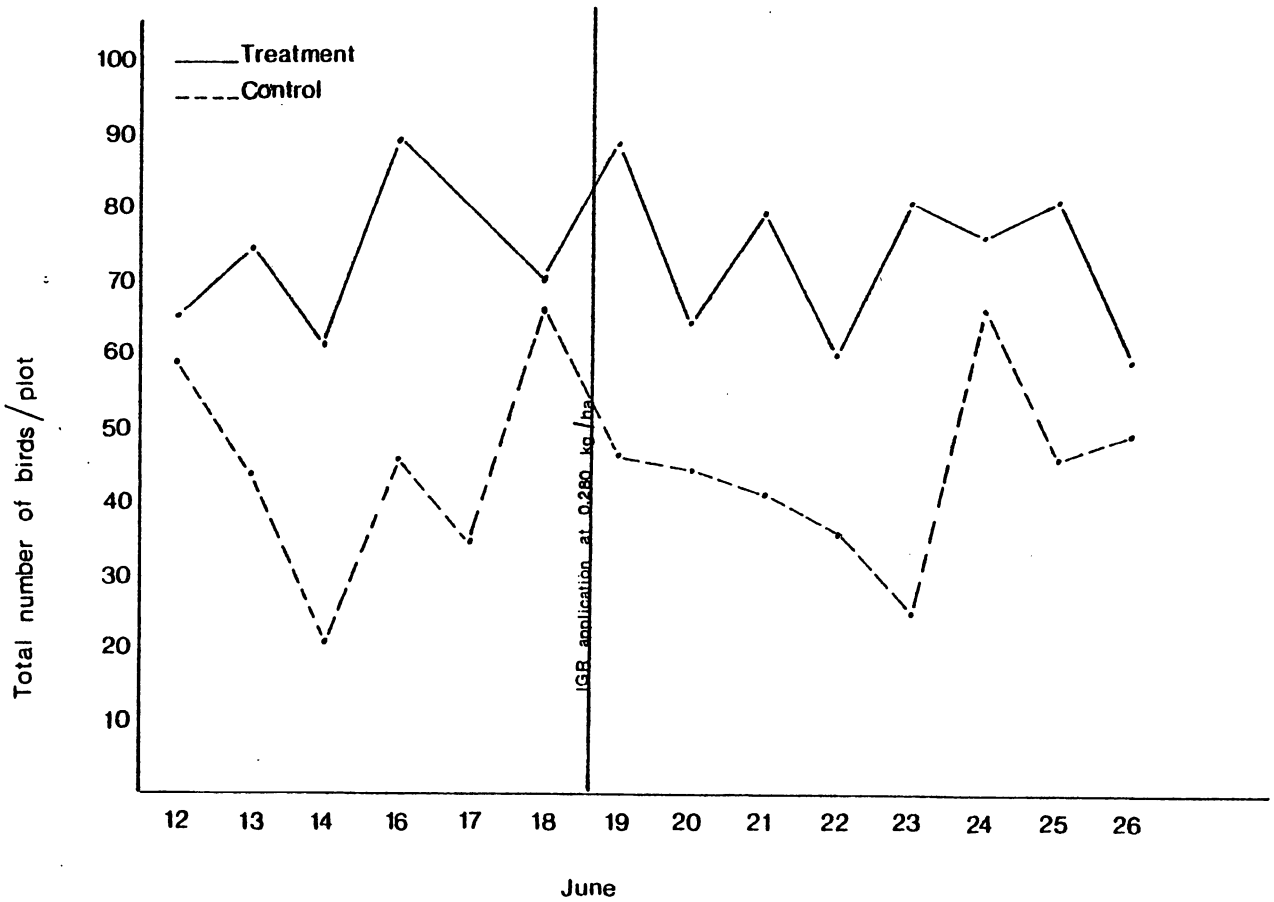

Figure 6. Forest songbird activity on treated and untreated plots before and after the IGR application

Breeding territories were well established before commencement of the study, and remained occupied during the postspray period. Shifting of territories across the plot boundaries is to be expected as these are artificial boundaries in a continuous environment. Territories are naturally flexible with some shifting in response to the availability of food, gravel and water, or to aggression by more dominant males of the same species. It is probable that the reduction in recorded numbers of the Least flycatcher, *Empidonax minimus* (Baird and Baird), on the treated plot (Appendix II Table 1) is due to territorial shifting across the plot boundary (Figure 7). Furthermore, other insectivorous species such as the Bay-breasted warble, *Dendroica castanea* (Wilson), the Blackburnian warbler, *Dendroica fusca* (Müller), the Yellow-rumped warbler, *Dendroica coronata* (Linnaeus), the Ovenbird, *Seiurus aurocapillus* (Linnaeus) and the Swainson's thrush, *Catharus ustulatus* (Nuttall), continued to defend territories (Figure 8 to 12) throughout the postspray period. The White-throated sparrow, *Zonotrichia albicollis* (Gmelin), also insectivorous during the breeding season, was similarily uneffected (Figure 13). Thus, potentially pesticide sensitive species, and those occupying various niches throughout the forest canopy, appeared undisturbed by the operation.

The treatment area was carefully searched after spray application for possible signs of pesticide stress to the bird population (tremors, bill wiping, irratic flight, unnatural behavior). No sick or dead birds were found.

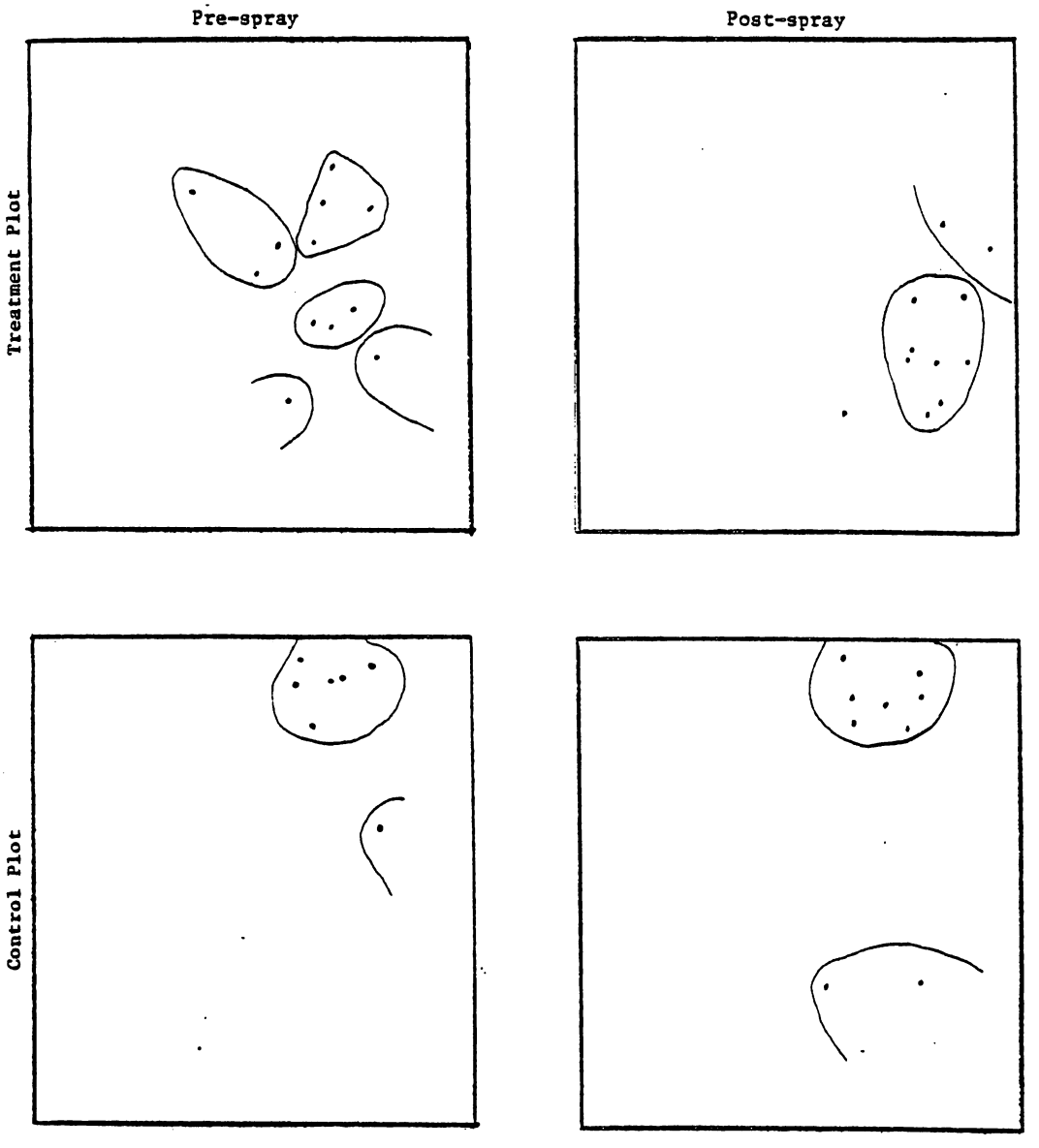

Figure 7. Territories of the Least flycatcher, *Empidonax minimus* (Baird and Baird), on treatment and control plots, before and after treatment

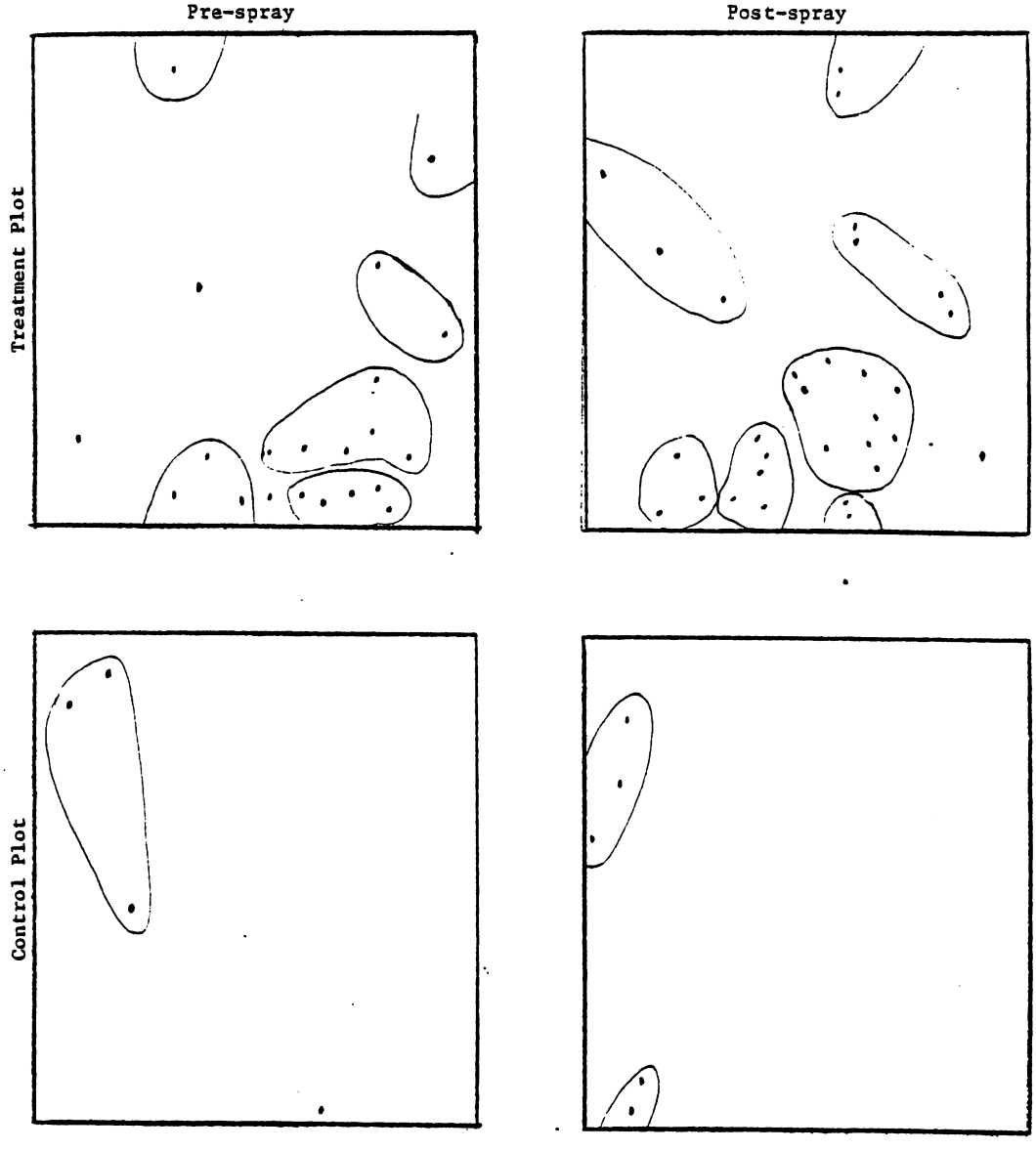

Figure 8. Territories of the Bay-breasted warbler, *Dendroica castanea* (Wilson), on treatment and control plots, before and after treatment

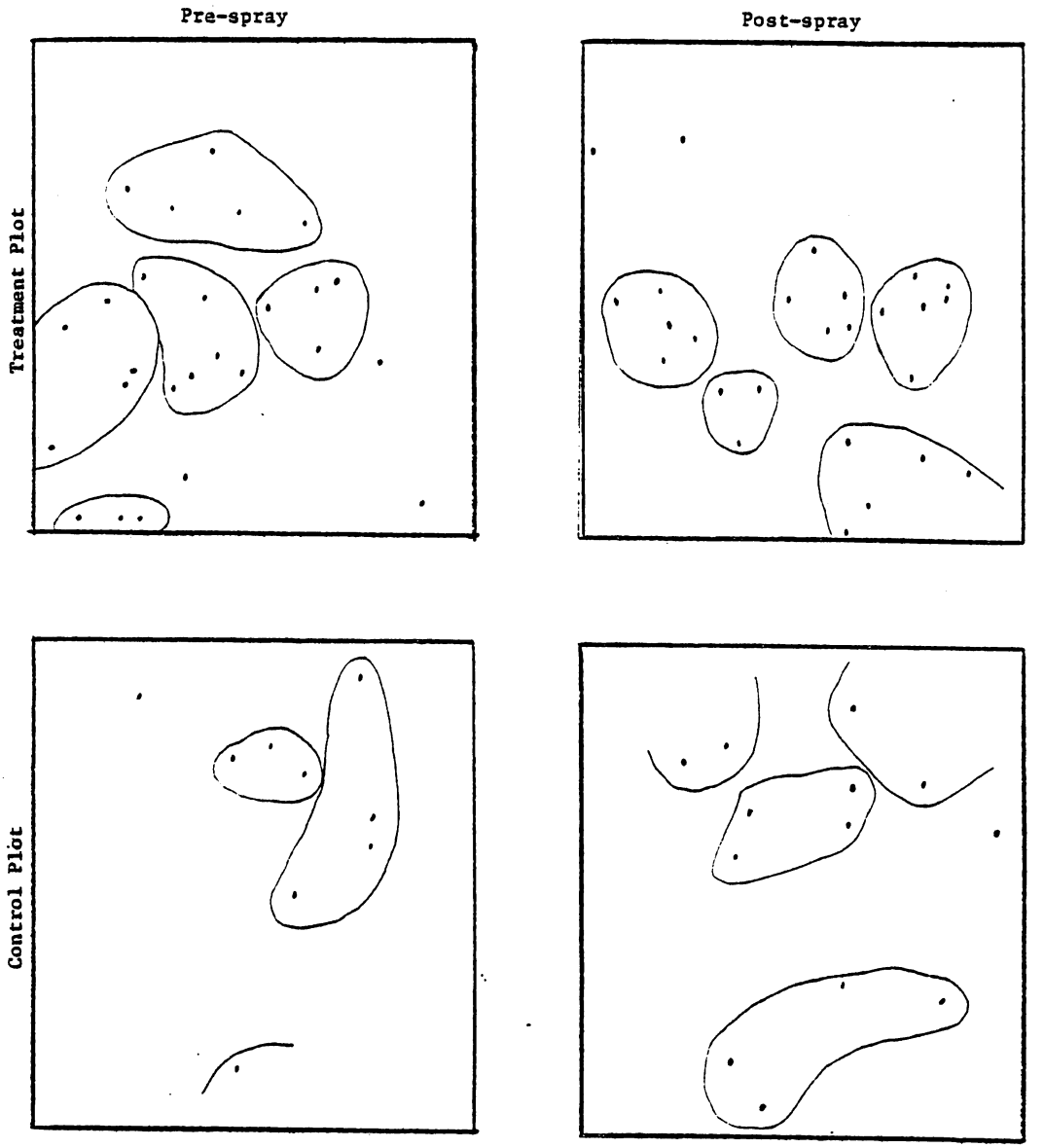

Figure 9. Territories of the Blackburnian warbler, *Dendroica fusca* (Müller), on treatment and control plots, before and after treatment

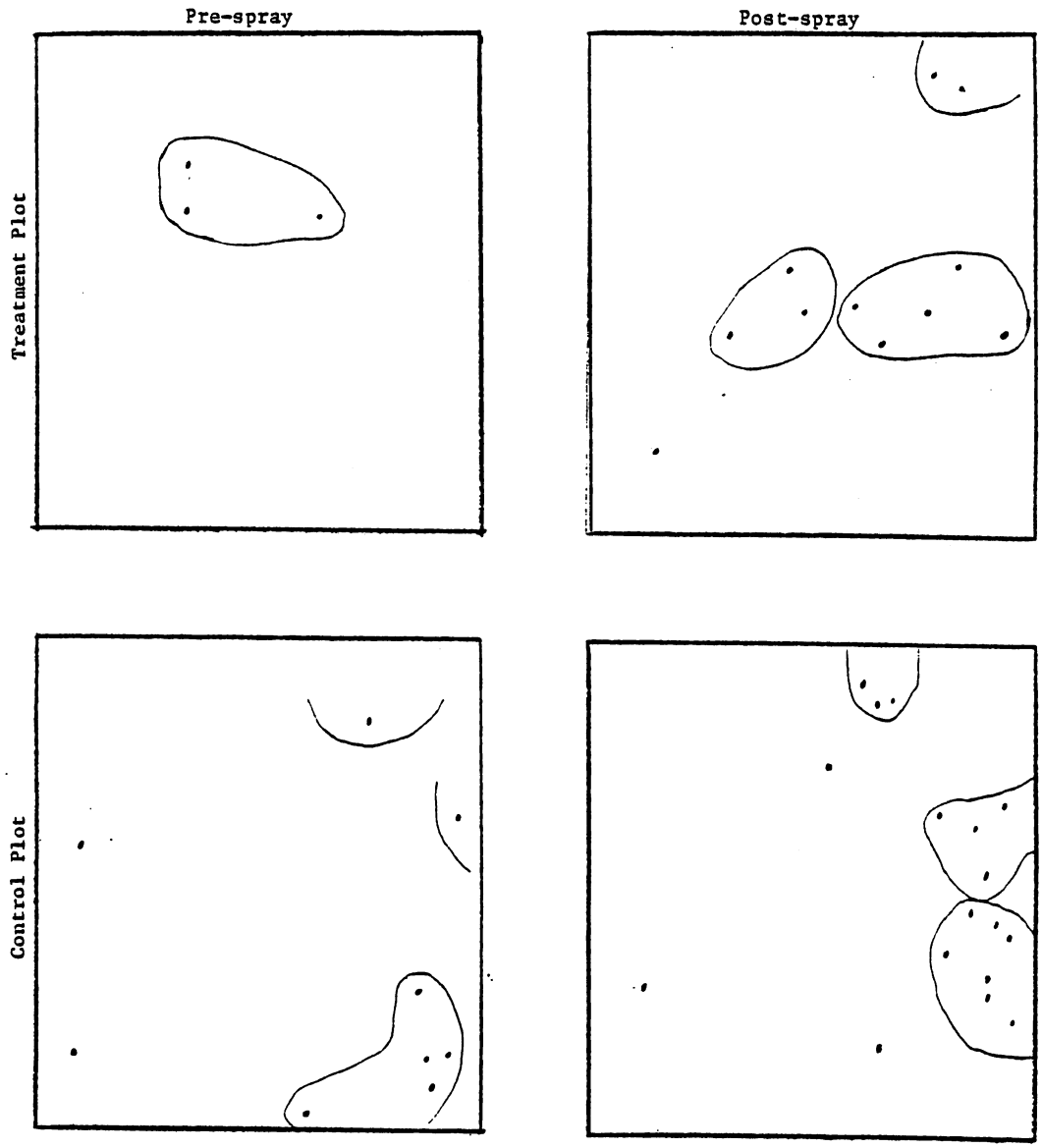

Figure 10. Territories of the Yellow-rumped warbler, *Dendroica coronata* (Linnaeus), on treatment and control plots, before and after treatment

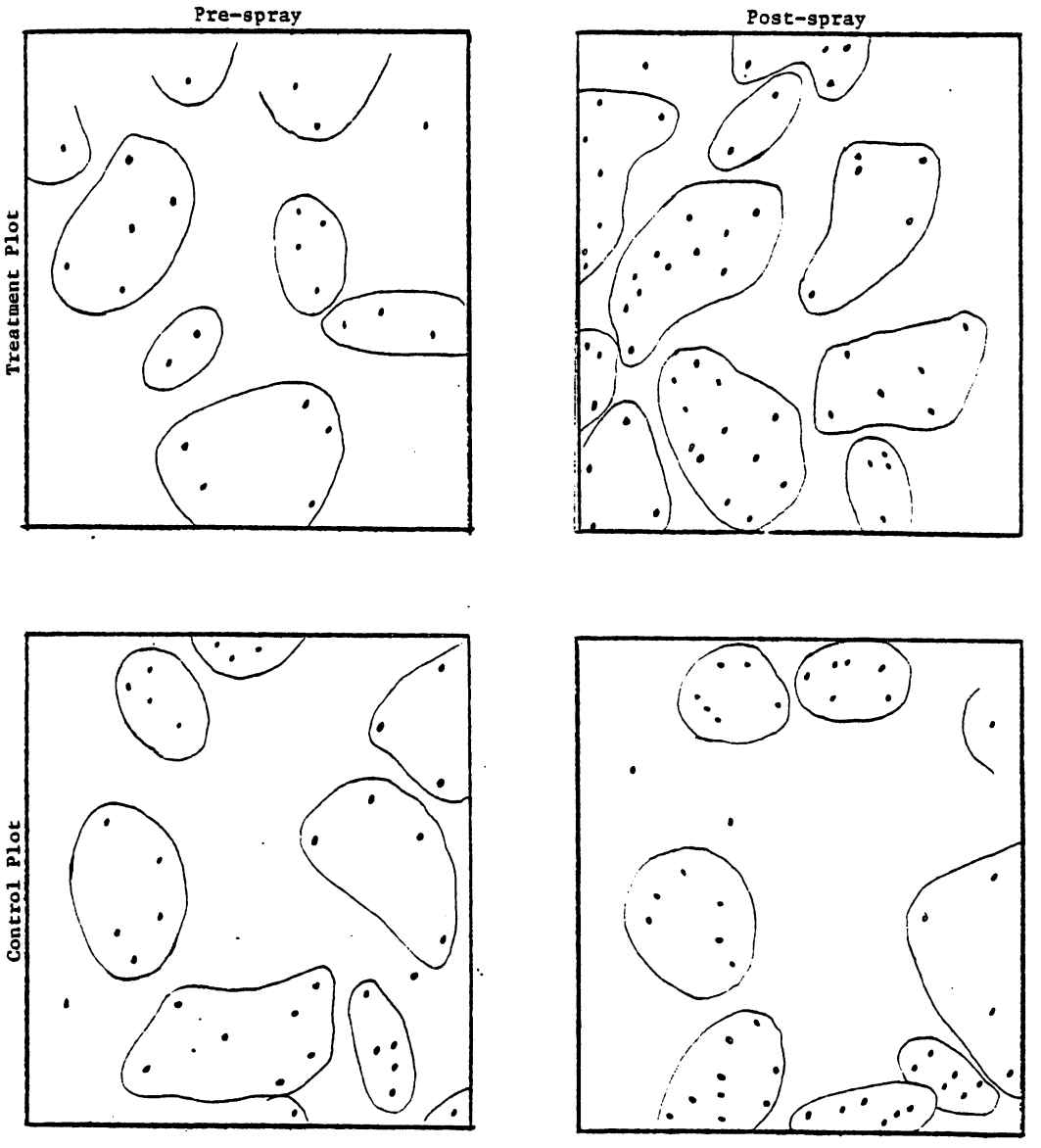

Figure 11. Territories of the Ovenbird, *Seiurus aurocapillus* (Linnaeus), on treatment and control plots, before and after treatment

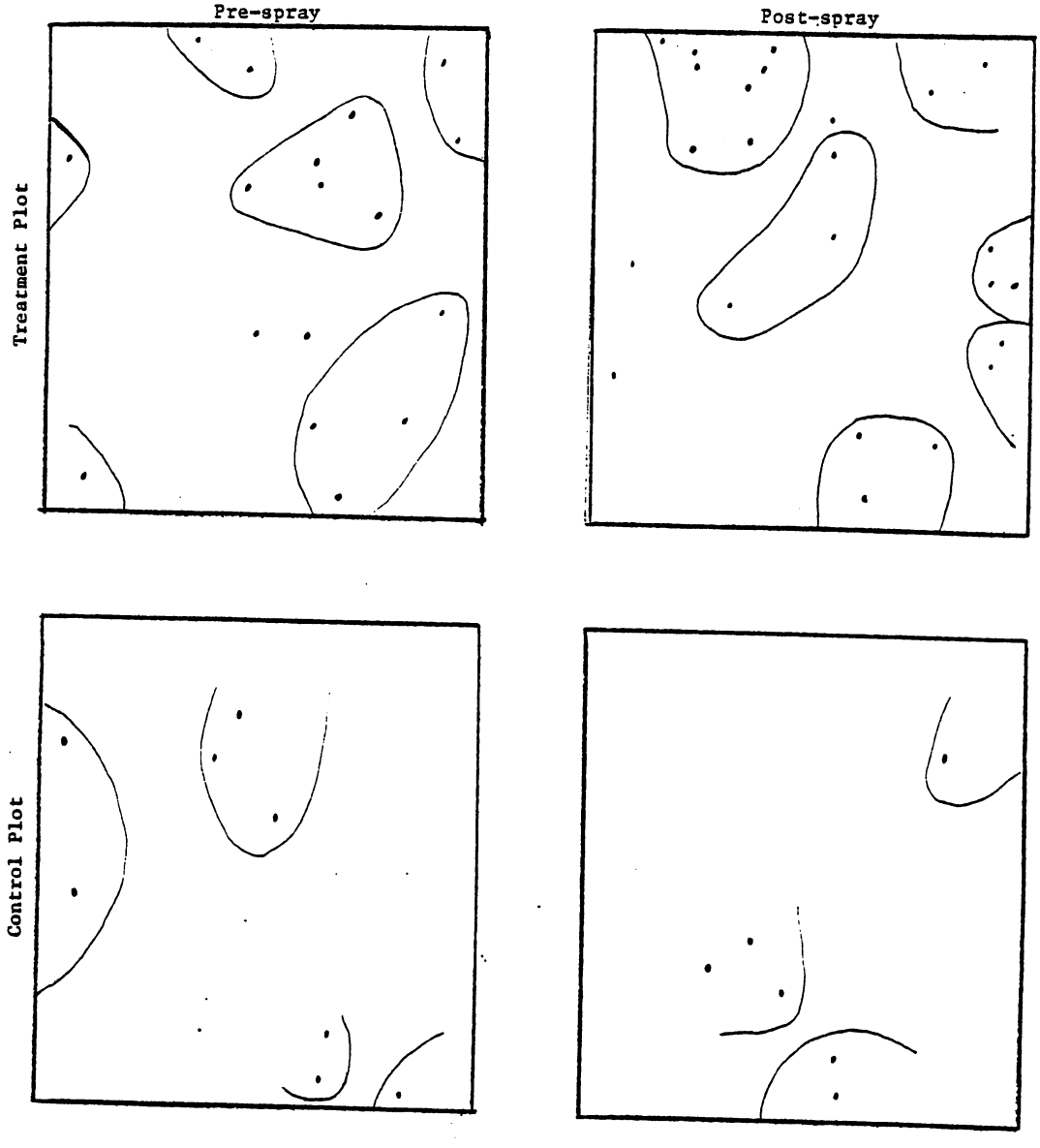

Figure 12. Territories of the Swainson's thrush, *Catharus ustulatus* (Nuttall), on treatment and control plots, before and after treatment

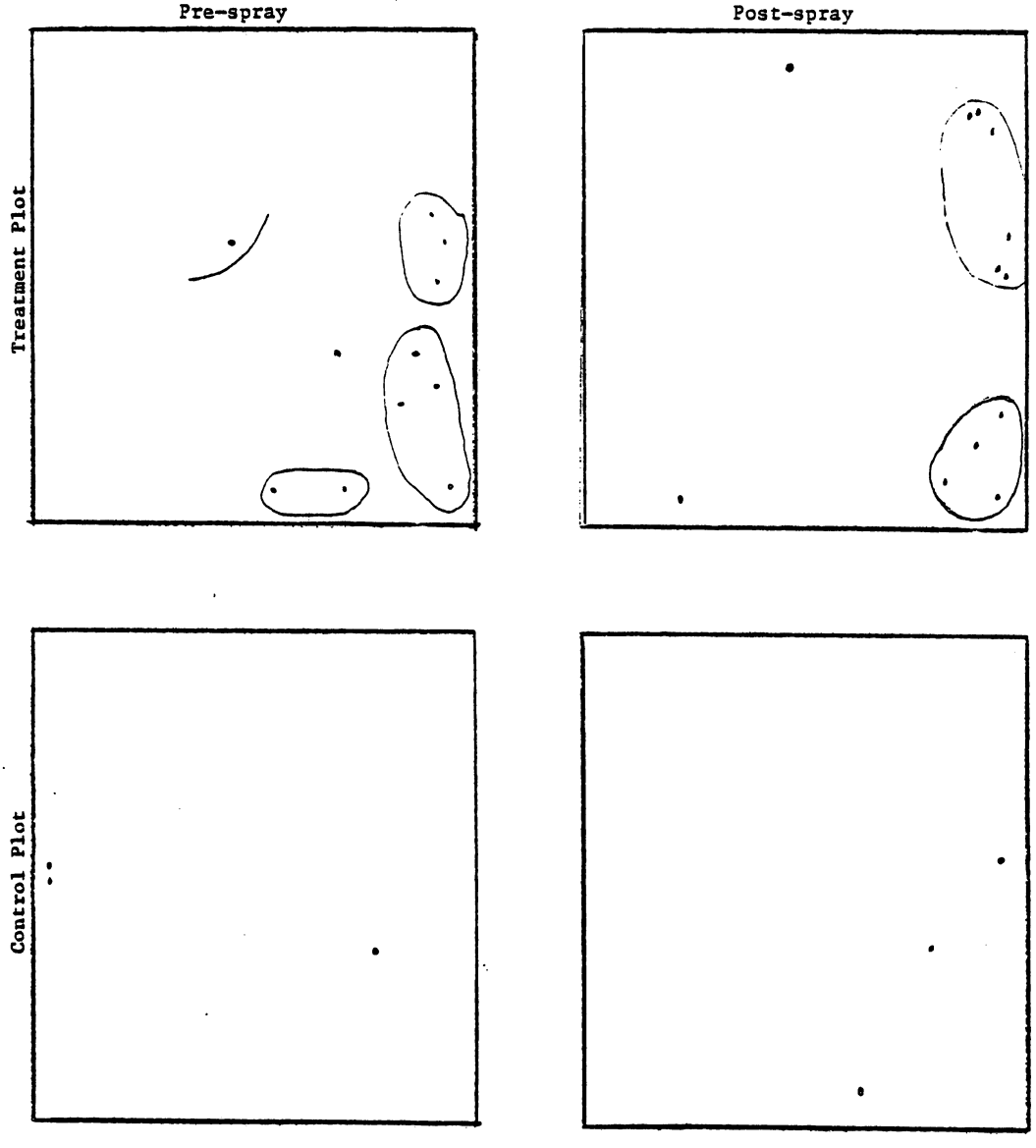

Figure 13. Territories of the White-throated sparrow, *Zonotrichia albicollis* (Gmelin), on treatment and control plots, before and after treatment

Conclusions

A single application of the insect growth regulator, Bay Sir 8514, applied at the dosage rate of 0.280 kg AI/ha over 100 acres, did not appear to have any overall effect on honeybees. There was no observed knockdown of terrestrial invertebrates consequent of the application; any increase in knockdown was merely a manifestation of adverse weather conditions having it's greatest effect on Diptera: Sciaridae. There was no visible change in the breeding behavior or activity of the resident avifauna population.

Literature Cited

Copijn, G.M., Beetsma, J. and Wirtz, P. 1979. Queen differentiation and mortality after application of different juvenile hormone analogues to worker larvae of the honeybee (*Apis mellifera* L.). Proceeding of the koninklizke Nederlandse Akademie Van Wetenschappen, Series C., Vol. 82 (1): 29-42.

Kendeigh, S.C. 1947. Bird population studies in the coniferous forest biome during a spruce budworm outbreak. Biological Bulletin No. 1, Ont. Dept. of Lands and Forests, Div. of Research.

APPENDICES

APPENDIX I

Terrestrial Invertebrates

Table I-1
Terrestrial invertebrate knockdown from spruce
IGR treatment plot
Wawa, Ontario
9 June - 25 June 1979

Date	June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23	June 24	June 25
Days before or after application	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5	+6
Arachnida																	
Acari								0.20									
Araneida	0.20	0.20				0.20			0.60	0.20				0.20		0.20	
Collembola					0.20	0.20			0.20								
Homoptera									0.20								
Coleoptera																	
Carabidae	0.40												0.20			0.20	
Staphylinidae	0.20					0.40		0.40	0.20								
Elateridae									0.20			0.20					
Other		0.20					0.30		0.20								
Lepidoptera larvae						0.20	0.30	0.20	0.40	0.40	0.20	0.20	0.40			0.40	
Diptera																	
Chironomidae			0.40			0.20			0.40			2.20					
Simuliidae	0.20	0.40	0.60				0.30						0.20	0.20			
Sciaridae	0.80	1.80	1.00	0.40	0.60	0.40	1.80	0.20	1.80		0.40	0.20	0.20	0.20			
Muscoidae					0.20				0.40					0.20	0.20		
Other		0.40		0.40	0.40	0.20			0.20	0.20		1.20	0.20	0.60			
Hymenoptera		0.20		0.20	0.60	0.60			0.60		0.40	0.20	0.20	0.20			
Total number of invertebrates/bucket	1.80	3.20	2.00	1.00	2.00	2.40	2.70	1.00	5.40	0.80	1.00	4.20	1.40	1.60	0.20	0.80	0.00

Table I-2
Terrestrial invertebrate knockdown from spruce
IGR untreated control plot
Wawa, Ontario
9 June - 25 June 1979

Date	June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23	June 24	June 25
Days before or after application	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5	+6
Gastropoda													0.20				
Arachnida																	
Acari	0.40			0.20													
Araneida		0.50	0.17	0.20	0.60	0.40	0.20	0.60	0.40	0.20	0.80	0.40					
Collembola	1.00			2.80	0.20	0.60	0.60		0.20	0.40	0.20	0.20					
Homoptera																	
Cicadellidae							0.20										
Coleoptera																	
Carabidae			0.17												0.40		
Staphylinidae	0.20			0.20	0.20		0.40	0.60									
Elateridae							0.20		0.20	0.20		0.20					
Other	0.40						0.20										
Lepidoptera larvae			0.17	0.20				0.20	0.40				0.40		0.20	0.75	0.20
Diptera																	
Chironomidae	0.40	0.50	0.17	0.40					0.80			0.40					
Simuliidae	0.20	0.75	0.50	0.40			0.40	0.40	0.20						0.20		0.20
Sciaridae	2.60	1.25	7.30	3.60	0.20	1.40	10.00		2.80	0.20	0.20	0.40			0.20		0.20
Muscoidae		0.25	0.17										0.20		0.20		0.20
Other	0.20	0.50	0.83	0.60					1.00			0.40	0.40				
Hymenoptera																	
Formicidae	0.20	0.25		0.40		0.20	0.80		0.20	0.20							0.20
Other			0.67				1.00		1.40			0.80					0.20
Total number of invertebrates/bucket	5.60	4.00	10.15	9.00	1.20	2.60	14.00	1.80	7.60	1.20	1.20	2.80	1.20	0.00	1.20	0.75	1.20

Table I-3
Terrestrial invertebrate knockdown from willow
IGR treatment plot
Wawa, Ontario
9 June - 25 June 1979

Date	June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23	June 24	June 25
Days before or after application	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5	+6
Arachnida																	
Araneida			0.33							0.33	0.33	0.33					0.33
Collembola			0.33				0.33				0.33						
Orthoptera																	
Acrididae				0.33				0.33									
Coleoptera																	
Carabidae								0.33		0.33						0.33	
Staphylinidae	0.33					0.33		0.33									
Other					0.33	0.67	0.33										
Trichoptera												0.33					
Lepidoptera larvae													0.33				0.33
Diptera																	
Chironomidae			1.00					0.67	0.67								
Simuliidae	0.33						1.00		0.67	0.33		0.67	0.33				
Sciaridae	3.33	1.00	4.00	0.67	0.67	0.33	7.00	7.33	4.67	0.33		1.00	0.67				
Muscoidae							1.33		1.33						0.33		
Other		1.67	1.33						9.00		0.67		0.33	0.67			
Hymenoptera																	
Formicidae	0.33	0.33				0.33	0.33		0.67							0.67	0.33
Other			0.67	1.33		0.33	3.00	0.67	1.67			0.67		0.67	0.33		
Total number of invertebrates/bucket	4.32	3.00	7.66	2.33	1.00	1.99	13.32	9.66	18.68	1.32	1.33	3.00	1.66	1.34	0.67	1.00	0.99

Table I-4
Terrestrial invertebrate knockdown from willow
IGR untreated control plot
Wawa, Ontario
9 June - 25 June 1979

Date		June 9	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20	June 21	June 22	June 23	June 24	June 25
Days before or after application		-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	+0	+1	+2	+3	+4	+5	+6
Arachnida																		
Acari								0.33										
Araneida		0.67			0.33		0.33	0.33		0.67								
Other										0.33								
Collembola		2.67	3.67	0.67	3.00			3.33	0.33	5.33	1.67	0.33				0.33		
Orthoptera																		
Acrididae							0.33											
Hemiptera								0.33										
Homoptera																		
Cicadellidae			0.33															
Coleoptera																		
Carabidae		0.33							0.33									
Staphylinidae		0.33						1.67										
Other										0,33								0.33
Lepidoptera	larvae						0.33								0.33			
Diptera																		
Chironomidae		0.67			0.67			1.33	0.33	2.67			0.33					
Simuliidae								2.33	0.33	2.33	0.33							
Sciaridae		1.67	2.00	2.00	1.67			17.33	0.33	7.33	0.67		0.33	0.33				0.33
Muscoidae																		
Other		1.00	0.67	0.67	1.00			2.67		2.67			0.33	0.33	0.33	0.33		
Hymenoptera																		
Formicidae		0.67			1.00	0.33		1.67	0.33	1.00			0.33					0.67
Other	adults		0.33	0.67				5.33		3.00	0.33		0.67	0.33				
Other	larvae									0.33								0.33
Total number of invertebrates/bucket		8.01	7.00	4.01	7.67	0.33	0.99	36.65	1.98	25.99	3.00	0.33	1.99	0.99	0.66	0.66	0.00	1.66

APPENDIX II

Bird Populations

Table II-1
Forest bird population census
Insect Growth Regulator treatment plot
Wawa, Ontario
12 June - 26 June, 1979
(IGR applied on 19 June at the emitted dosage rate of 0.280 kg AI/ha)

Family	Species	Pre-spray						Post-spray								
		June 12 -7	June 13 -6	June 14 -5	June 16 -3	June 18 -1	Daily ave.	June 19 +0	June 20 +1	June 21 +2	June 22 +3	June 23 +4	June 24 +5	June 25 +6	June 26 +7	Daily ave.
Picidae	Yellow-bellied Sapsucker	0	1	0	0	2	0.6	0	0	0	0	0	0	0	0	0.0
	Downy Woodpecker	0	0	1	0	0	0.2	0	0	0	0	0	0	0	0	0.0
Tyrannidae	Yellow-bellied Flycatcher	0	0	0	0	0	0.0	0	2	0	0	0	0	0	0	0.3
	Least Flycatcher	2	6	4	6	4	4.4	0	2	0	2	0	2	4	2	1.5
Sittidae	Red-breasted Nuthatch	0	0	0	0	0	0.0	2	0	0	0	2	0	0	0	0.5
Troglodytidae	Winter Wren	0	0	0	0	0	0.0	2	0	0	0	0	0	2	0	0.5
Turdidae	American Robin	0	0	0	0	0	0.0	0	0	0	0	2	0	0	0	0.3
	Hermit Thrush	0	3	0	0	0	0.6	0	0	0	0	0	0	0	0	0.0
	Swainson's Thrush	3	10	4	5	6	5.6	10	6	5	6	3	5	5	0	5.0
Vireonidae	Philadelphia Vireo	8	2	4	8	8	6.0	10	10	4	10	6	8	8	8	8.0
Parulidae	Black-and-white Warbler	0	0	0	0	0	0.0	0	0	2	0	2	0	0	0	0.5
	Tennessee Warbler	2	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0.0
	Nashville Warbler	4	0	0	2	2	1.6	4	2	2	2	4	4	4	2	3.0
	Magnolia Warbler	2	2	0	2	2	1.6	2	0	2	0	2	0	4	2	1.5
	Cape May Warbler	0	0	0	0	0	0.0	0	2	2	0	0	0	0	0	0.5
	Yellow-rumped Warbler	0	0	2	2	2	1.2	0	0	6	4	2	4	4	2	2.8
	Black-throated Green Warbler	2	2	6	6	4	4.0	8	6	10	6	8	4	4	0	5.8
	Blackburnian Warbler	8	8	15	12	6	9.8	8	2	8	0	8	4	12	12	6.8
	Chestnut-sided Warbler	2	0	2	6	8	3.6	4	6	6	4	4	2	4	6	4.5
	Bay-breasted Warbler	4	6	12	14	6	8.4	14	0	0	4	10	8	10	4	6.3
	Ovenbird	10	12	4	8	10	8.8	12	10	14	12	21	18	10	10	13.4
	Canada Warbler	4	4	6	6	2	4.4	6	4	4	0	4	2	2	2	3.0
	American Redstart	8	6	0	2	4	4.0	2	4	8	4	2	6	4	6	4.5

Table II-1 (cont'd)

Family	Species	Pre-spray						Post-spray								
		June 12 -7	June 13 -6	June 14 -5	June 16 -3	June 18 -1	Daily ave.	June 19 +0	June 20 +1	June 21 +2	June 22 +3	June 23 +4	June 24 +5	June 25 +6	June 26 +7	Daily ave.
Thraupidae	Scarlet Tanager	2	0	0	0	0	0.4	0	0	0	0	0	2	0	0	0.3
Fringillidae	Evening Grosbeak	0	0	0	0	0	0.0	0	0	0	0	0	4	0	0	0.5
	Dark-eyed Junco	0	0	0	2	0	0.4	2	2	0	0	0	2	0	0	0.8
	White-throated Sparrow	4	8	2	4	4	4.4	2	4	6	4	0	2	4	2	3.0
Unidentified Birds		0	4	0	4	0	1.6	0	2	0	2	2	0	0	0	0.8
Total Birds		65	74	62	89	70	72.0	88	64	79	60	82	77	81	58	74.1
Total Species		15	14	12	16	15	14.4	15	15	14	12	16	16	15	12	14.4

Table II-2
Forest bird population census
Insect Growth Regulator Control Plot
Wawa, Ontario
12 June - 26 June, 1979

Family	Species	Pre-spray							Post-spray								
		June 12 -7	June 13 -6	June 14 -5	June 16 -3	June 17 -2	June 18 -1	Daily ave.	June 19 +0	June 20 +1	June 21 +2	June 22 +3	June 23 +4	June 24 +5	June 25 +6	June 26 +7	Daily ave.
Tetraonidae	Ruffed Grouse	1	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0.0
Picidae	Yellow-bellied Sapsucker	1	0	0	0	0	0	0.2	0	0	0	0	0	1	0	0	0.2
Tyrannidae	Yellow-bellied Flycatcher	2	2	0	0	0	2	1.0	0	2	2	2	0	4	0	2	1.5
	Least Flycatcher	2	4	0	2	2	2	2.0	2	2	2	0	0	4	2	2	1.8
Paridae	Boreal Chickadee	0	0	1	0	0	0	0.2	0	0	0	0	0	0	0	0	0.0
Sittidae	Red-breasted Nuthatch	2	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.0
Mimidae	Brown Thrasher	0	0	0	0	0	0	0.0	0	0	0	0	0	2	0	0	0.3
Turdidae	American Robin	0	0	0	0	0	0	0.0	0	1	0	0	0	0	0	0	0.2
	Wood Thrush	0	0	0	0	0	0	0.0	2	0	0	0	0	0	0	0	0.3
	Hermit Thrush	2	2	0	0	0	2	1.0	2	0	0	2	0	1	0	0	0.6
	Swainson's Thrush	0	3	2	4	0	4	2.2	1	1	0	0	0	0	4	0	0.8
Sylviidae	Golden-crowned Kinglet	4	0	0	0	4	2	1.7	0	2	0	2	0	2	0	0	0.8
Vireonidae	Solitary Vireo	2	0	0	0	0	2	0.7	0	0	2	0	0	2	0	0	0.5
	Red-eyed Vireo	6	2	4	8	2	6	4.7	6	8	4	2	2	10	6	6	5.5
Parulidae	Black-and-white Warbler	0	2	0	0	0	0	0.3	2	0	0	0	0	0	0	0	0.3
	Tennessee Warbler	0	0	0	0	0	0	0.0	2	2	2	0	0	2	2	2	1.5
	Orange-crowned Warbler	0	2	0	2	0	0	0.7	0	0	0	0	0	0	0	0	0.0
	Nashville Warbler	2	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.0
	Magnolia Warbler	0	2	0	8	4	4	3.0	4	4	4	2	4	8	2	4	4.0
	Cape May Warbler	0	0	0	0	2	8	1.7	2	2	2	0	0	0	0	0	0.8
	Black-throated Blue Warbler	0	0	4	0	0	0	0.7	0	0	0	0	0	0	0	0	0.0
	Yellow-rumped Warbler	2	2	0	2	6	4	2.7	2	2	4	4	0	6	8	6	4.0

Table II-2 (cont'd)

Family	Species	Pre-spray June 12 -7	June 13 -6	June 14 -5	June 16 -3	June 17 -2	June 18 -1	Daily ave.	Post-spray June 19 +0	June 20 +1	June 21 +2	June 22 +3	June 23 +4	June 24 +5	June 25 +6	June 26 +7	Daily ave.
Parulidae (cont'd.)	Black-throated Green Warbler	0	0	0	2	0	0	0.3	0	2	0	0	0	0	0	0	0.3
	Blackburnian Warbler	6	2	0	4	4	4	3.3	2	2	2	2	4	2	4	6	3.0
	Chestnut-sided Warbler	2	2	0	2	2	2	1.7	2	2	4	6	2	4	2	4	3.3
	Bay-breasted Warbler	0	2	0	2	0	4	1.3	0	0	0	0	0	4	2	4	1.3
	Blackpoll Warbler	0	0	0	0	0	0	0.0	2	0	0	0	0	0	0	0	0.3
	Ovenbird	18	14	8	6	6	12	10.7	14	8	10	6	8	10	12	10	9.8
	Mourning Warbler	0	0	0	0	0	2	0.3	0	0	0	0	2	2	0	0	0.5
	Canada Warbler	6	2	0	2	0	2	2.0	0	2	2	0	2	0	2	2	1.3
	American Redstart	0	0	0	0	0	0	0.0	0	0	2	0	0	0	0	0	0.3
Fringillidae	Rose-breasted Grosbeak	0	0	0	0	2	4	1.0	0	0	0	0	0	0	0	0	0.0
	Evening Grosbeak	0	0	0	0	0	0	0.0	0	0	0	4	0	0	0	0	0.5
	Purple Finch	0	0	0	0	0	0	0.0	0	2	0	2	0	0	0	0	0.5
	Dark-eyed Junco	0	0	0	0	0	0	0.0	2	0	0	0	0	0	0	0	0.3
	White-throated Sparrow	0	0	2	2	0	1	0.8	0	0	0	2	0	2	0.	0	0.5
Total Birds		58	43	21	46	34	67	44.8	47	44	42	36	24	66	46	48	44.1
Total Species		15	14	6	13	10	18	12.7	15	16	13	12	7	17	11	11	12.8