ATHABASCA RIVER MONITORING PROGRAM - 1979

G. Byrtus
Pesticide Chemicals Br.
Pollution Control Div.
Alberta Environment
1981

Ackowledgements

I would like to express thanks and appreciation to all of the people that assisted in this program, especially R. Jackson, N. Wandler, G. Sawchuk, A. Kuzyk, D. Pledger, L. K. Peterson, L. Calder, B. Murray, N. Assmus, G. Bodie and A. Furnell.

Abstract

The Pesticide Chemicals Branch of Alberta Environment conducted a monitoring program in 1979 related to two methoxychlor treatments of the Athabasca River for black fly (*Simulium arcticum*) control. Three populations of black fly larvae were observed in 1979 and the first two populations were reduced by 91.2% (June 7 treatment) and 98.1% (July 11 treatment) respectively. Population reductions of nontarget invertebrate organisms was observed but recovery was fairly complete within 4 weeks of treatments. Silt samples collected over the summer indicated that methoxychlor did not accumulate in the river bottom silt. Water samples that were collected for the July 11 treatment at Fort McMurray (250 km downstream of treatment point) indicated that maximum concentrations of methoxychlor present in the river water was 3.5 ppb. Adult activity sampling indicated that there was a fairly close relationship between adult emergence expected through larval development data and adult activity measured along the river.

Table of Contents

List of Figures

List of Tables

List of Appendices

Introduction

In 1979 Alberta Environment, through the Pesticide Chemicals Branch, Pollution Control Division, conducted an environmental impact monitoring program along the Athabasca River in north-central Alberta. Being monitored was an experimental black fly (*Simulium arcticum* Malloch) control program conducted by Alberta Agriculture and the County of Athabasca No.12 along the Athabasca River.

The control program came about as a result of a renewed black fly outbreak in the Wandering River - Grassland area of northern Alberta (Figure 3) in 1978. Several head of cattle died as a direct result of black fly attacks, and farmers reported numerous herds were affected, resulting in reduced weight gain, interrupted breeding and general discomfort for the cattle. Local farmers had grown accustomed to low levels of black flies during the Athabasca Black Fly Research Program of 1974 to 1976 when the Athabasca River was treated experimentally with an insecticide, methoxychlor, to control the black fly larva in its natural habitat. With the conclusion of the research program in 1977 and a resurgence in black fly populations in 1978, local farmers began requesting a return to treatment of the river as a control measure.

The Pesticide Chemicals Branch focused on monitoring the ecological parameters related to the control program. The major objectives involved in the monitoring program, were:

1. To monitor black fly larval populations to correlate with and assist the local agencies in determining optimum treatment dates, as well as informing various government agencies as to the development of black fly larval populations over the summer.

2. To monitor macroinvertebrate populations at selected sites to determine any deleterious effects of methoxychlor treatments on resident populations.

3. To monitor methoxychlor residue accumulations in the silt bedload of the river over the period of the summer.

4. To monitor adult black fly activity over the surface of the river to show relative abundance and activity in comparison to other years.

5. To monitor adult black fly activity along the shoreline of the river and to correlate that with adult activity in comparison to other years.

6. To monitor the passage of the chemical past Fort McMurray's water treatment plant intake and to obtain water samples to determine amount of methoxychlor left in the river water as it passed by Fort McMurray.

River Characteristics

The Athabasca River is one of the larger rivers in Canada, originating in the Columbia Icefields of the Rocky Mountains, and drains a watershed of approximately 94,000 km^2 (Kellerhals *et al.* 1972). Much of this watershed is forest covered over organic soils with only limited agricultural settlement in the watershed area. Many large tributaries drain into the Athabasca, such as the McLeod, Pembina, Lesser Slave and Clearwater rivers, as well as numerous small tributaries. Some of these tributaries drain areas of above average precipitation (ie. Swan Hills) and as a result the Athabasca River is subjected to periodic fluctuations in river discharge. The discharge rate for the Athabasca River at the Town of Athabasca in 1979 is shown in Figure 1.

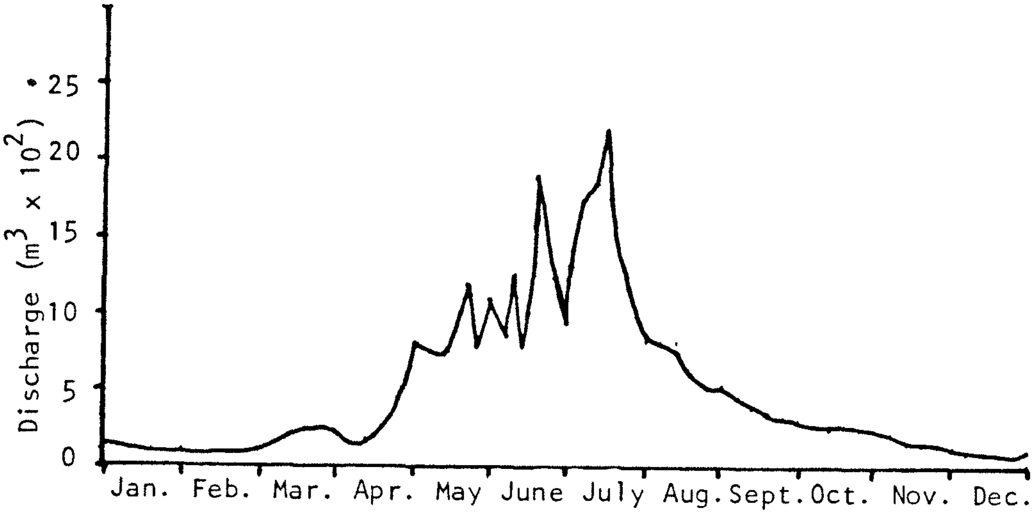
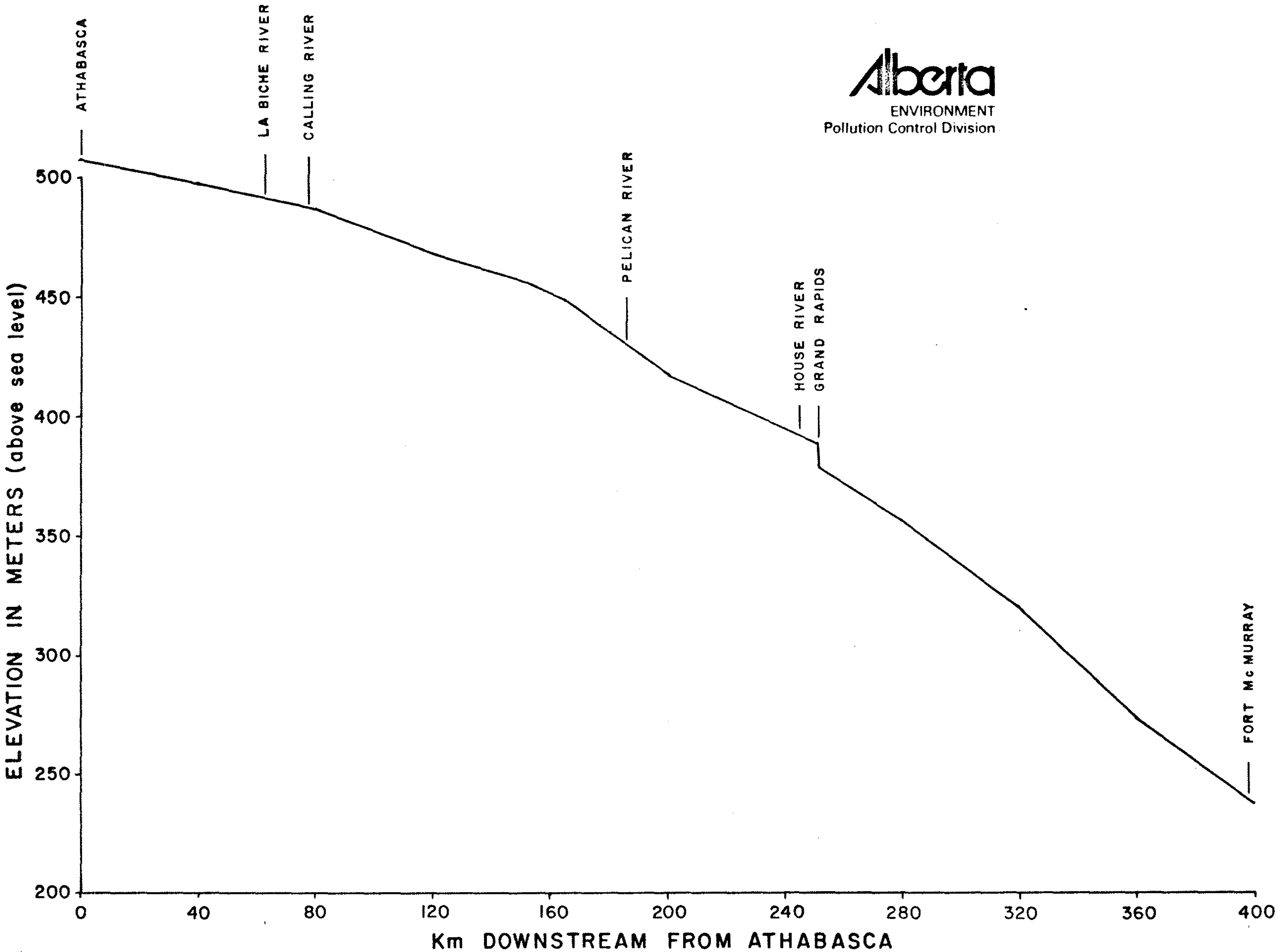


Figure 1 Discharge of Athabasca River at Athabasca, 1979 (Water Survey of Canada, Station 07BE001)

River bed material in the Athabasca River varies over the study reach. For approximately 55 km downstream of the Town of Athabasca the river bottom is mainly fine-grained silt with only occasional gravel outcroppings and bars. Below the confluence of the La Biche river at 60 km, more gravel and rock predominate. As well, the river velocity noticeably increases. Upstream of Fort McMurray gravel and large rock (along with limestone and oil sands formations) are very prominent, but below the confluence of the Clearwater at Fort McMurray, the river velocity slows and silt bottoms predominate as the river meanders around numerous islands on its way to the delta at Lake Athabasca. A river gradient profile of the study reach is presented in Figure 2.



ATHABASCA RIVER PROFILE

(Adapted from Kellerhals et al, 1972)

FIGURE 2

Treatment

Due to large numbers of black fly larvae in June and in July, two treatments were necessary. Alberta Environment, based on the recommendations of Depner et al. (1980a) consider a sample size of 500 larvae per sampling cone sufficient to warrant methoxychlor treatment of the Athabasca River to reduce populations of *S. arcticum* larvae. The methoxychlor used in 1979 was an emulsifiable concentrate formulation with 2.4 pounds active ingredient per gallon.

The treatment in June consisted of two separate injections. The first injection took place at 203 km downstream of the Town of Athabasca on June 5 using 454.6 litres of methoxychlor injected over a 7.5 minute period. River discharge at the treatment point was 827 cubic meters per second (m^3/s) and the effective dosage rate at the treatment point was 293 parts per billion (ppb). For the second injection at 59.5 km on June 7, 538.7 litres of methoxychlor were required. River discharge at the site was 978 m^3/s and the effective dosage rate was calculated to be 299 ppb.

The July treatment took place at 145 km on July 11 using 761.5 litres of methoxychlor. River flow was 1356 m^3/s and the effective dosage rate of this injection was 299 ppb.

The procedure and equipment used for the river treatments was developed by Depner in 1975 for the research program conducted on the Athabasca River (Depner et al. 1980a). Personnel from the Survey Branch, Technical Services Division of Alberta Environment conducted the measurements and calculations of discharge rates at each of the three injection points in 1979.

Study Area and Sampling Sites

The study area extended for a 230 km stretch of the Athabasca River (Figure 3). The upstream limit was a site 20 km upstream of the Town of Athabasca, while the downstream limit was 200 km downstream of the Town of Athabasca. As well, a 10 km reach of the Athabasca River upstream of Fort McMurray was also monitored for black fly larvae for the July treatment.

Sampling sites were located along the river about every 40 km. Table 1 lists the site designations and site locations used for the monitoring program in 1979. The sites were selected to correspond to sites used by Depner during the Black Fly Research Program of 1974-1977 (Depner *et al*, 1980a) and by Alberta Environment in 1978 (Pledger and Byrtus 1980).

TABLE 1

Distance From Athabasca (km)	Site Designation	
-20	Upstream	U1
40	Downstream	D1
80		D2
120		D3
160		D4
180		D5
200		D6
395		Fort McMurray

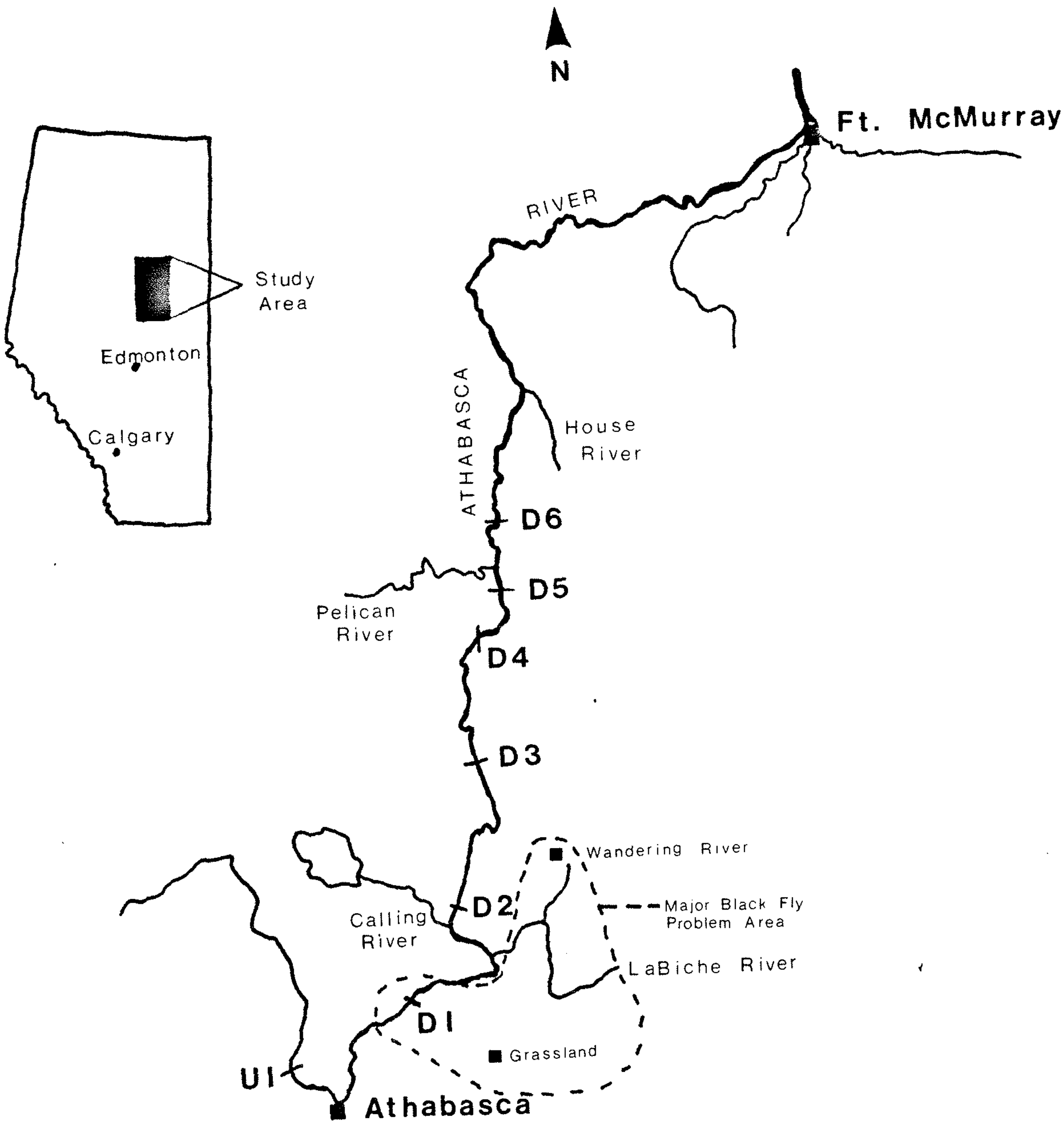


FIGURE 3 - Study Area And Sampling Sites

Alberta
ENVIRONMENT
Pollution Control Division

Materials and Methods

Black fly larval populations were sampled at each of the seven sites throughout the summer. The materials and procedure used are described by Pledger and Byrtus (1980) and by Depner *et al*. (1980a).

Non-target invertebrates were also sampled at the site locations. The method employed was the rock tumble method developed by Depner (Depner *et al*. 1980b). The samples were taken at a suitable riffle area near the site location at a depth of 0.5 meter.

The samples were sorted and the invertebrates were identified to the generic level with the aid of a dissecting microscope (Wild M5) and the following taxonomic keys: Ward and Whipple (1959), Usinger (1973), Pennak (1953), Merrit and Cummings (1978) and Wiggins (1977). Kaesler and Herricks (1979) have suggested that the discrimination of genera rather than of species is adequate for determining community structure as well as saving time and manpower.

Silt samples for methoxychlor residue analysis were obtained by using the modified Bogardi samplers which Charnetski employed during the Athabasca black fly research program. (Charnetski and Depner 1980). Three samplers were placed in the river at each site, in close proximity to the cone sets. The samplers were put in place on the downstream trip and were picked up on the return trip the next day. The silt samples that were obtained from the three samplers at each site were combined, mixed and subsampled to provide three replicates, providing sufficient silt was collected.

Adult black flies above the river surface of the river were sampled using high-speed adult sweeps (Pledger and Byrtus 1980). Adults were sampled at 8 km intervals, for a 1.6 km stretch, from Athabasca to 200 km downstream and return. The adults captured were preserved in alcohol and returned to the laboratory for sorting and counting.

Adult black fly activity near the river and in the farming area were monitored using barrel traps, similar to those used by Pledger (1978). The traps consisted of empty 22.5 litre metal pails painted with blue paint (Krylon® Spray Paint, Regal Blue Enamel #1901), the color found to be the most attractive to adult Simuliidae (Davies 1961). A 6 mil clear plastic wrapping (30 cm x 90 cm) was placed around the pail and taped into place. Tree Tanglefoot® was sprayed onto the plastic and the plastic was left in place for a period of one week. After a week, light plastic was placed over the 6 mil plastic, holding the captured insects in place and covering the Tree Tanglefoot®, making handling of the samples much easier. A new sheet of 6 mil plastic was subsequently attached to the pail for the next sampling period. The pails were suspended approximately 1.5 meters off of the ground. The barrel traps were located at each of the seven sites along the river (Figure 3), and two traps were located on the G. Lantz farm (SE 1/4, Sec 29, Twp 68, Rge 19, W4) in the Spruce Valley area near Grassland.

Monitoring of the passage of methoxychlor past the Fort McMurray water treatment plant intake was undertaken for the July 11 treatment only. Black fly larval cone sets were placed in the river 10 km upstream of Fort McMurray one week in advance of the July 11 treatment. Calculations as to the approximate time of passage were made, using data obtained during the research program as a reference (Charnetski, Depner and Beltaos 1980).

Prior to the expected arrival of the methoxychlor, monitoring of the cones was initiated. Disturbances of black fly larval populations due to the methoxychlor was noted and the water treatment plant was notified so that the water intake could be shut down prior to the arrival of the chemical. Water samples were also obtained before, during and after the chemical had passed Fort McMurray.

Results

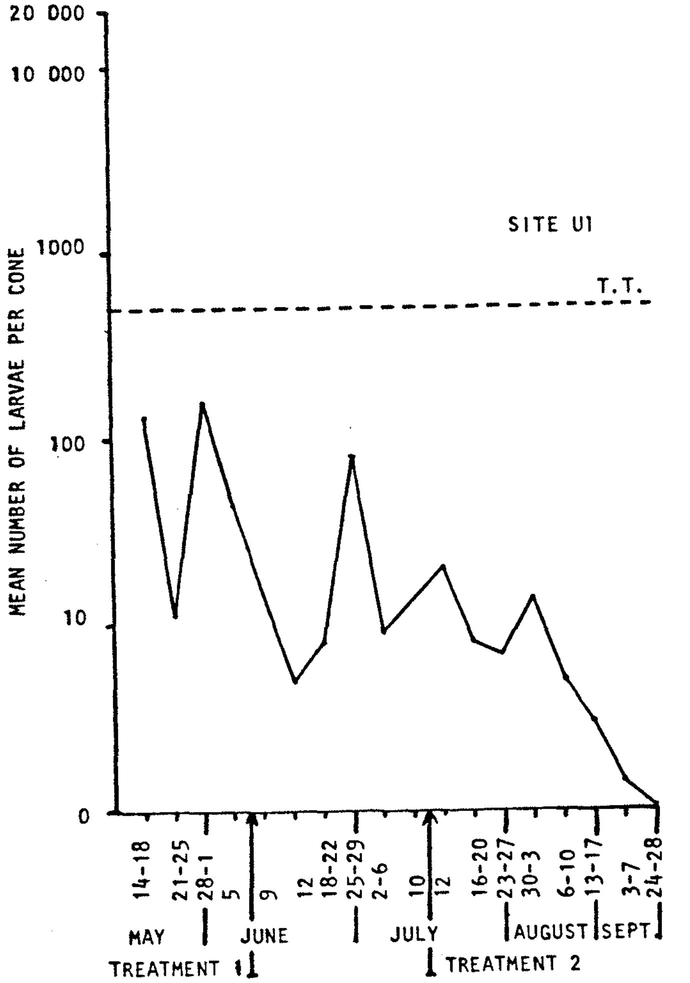
Larval Sampling

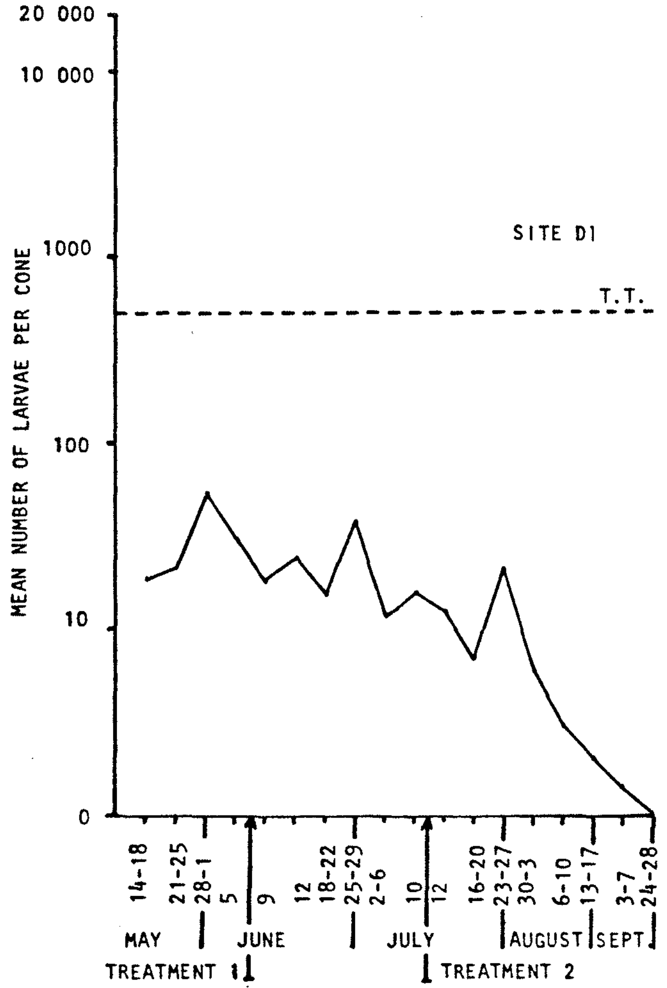
The first black fly larval samples were obtained on the 15 and 16 of May. Sampling continued on a weekly basis until the 16 of August. Samples were also obtained during the first and last weeks of September.

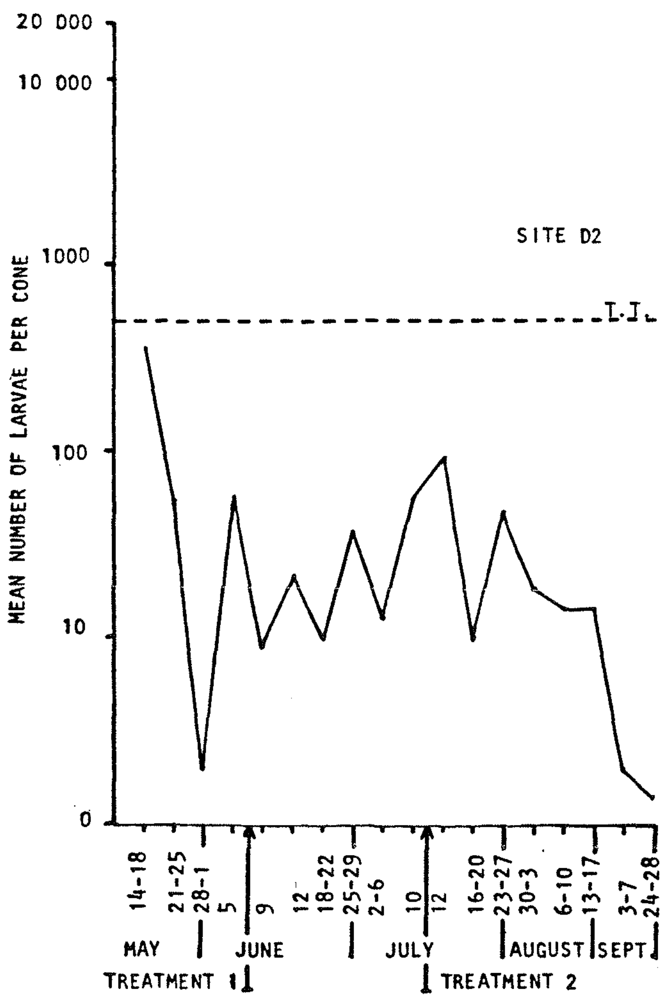
Larval numbers during 1979 exceeded any previous numbers obtained on the Athabasca River (Depner et al. 1980a, Pledger and Byrtus 1980). The week just prior to the first treatment (May 28 - June 1) had sites which averaged over 17,000 larvae per cone (Appendix 1), which is considerably above the treatment threshold of 500 larvae/cone.

By examining Figure 4 (obtained from Appendix 1), one initially observes that the sites U1, D1, and D2, compared to sites D3-D6, did not obtain large numbers of black fly larvae over the summer. This is consistent with data obtained during the research program (Depner et al. 1980a) where it was demonstrated that higher larval populations were generally observed downstream of 120 km.

It is apparent from Figure 5 that there were three *S. arcticum* larval population peaks during 1979. The first peak occurred in the last week of May, the second peak occurred during the last week of June and first week of July, and the third population peak occurred during the last week of July and first week of August. It should be mentioned that the first two peaks


SITE U1
T.T.
MEAN NUMBER OF LARVAE PER CONE
20 000
10 000
1000
100
10
0
14-18
21-25
28-1
5
9
12
18-22
25-29
2-6
10
12
16-20
23-27
30-3
6-10
13-17
3-7
24-28
MAY
JUNE
JULY
AUGUST
SEPT
TREATMENT 1
TREATMENT 2


SITE D1
T.T.
MEAN NUMBER OF LARVAE PER CONE
20 000
10 000
1000
100
10
0
14-18
21-25
28-1
5
9
12
18-22
25-29
2-6
10
12
16-20
23-27
30-3
6-10
13-17
3-7
24-28
MAY
JUNE
JULY
AUGUST
SEPT
TREATMENT 1
TREATMENT 2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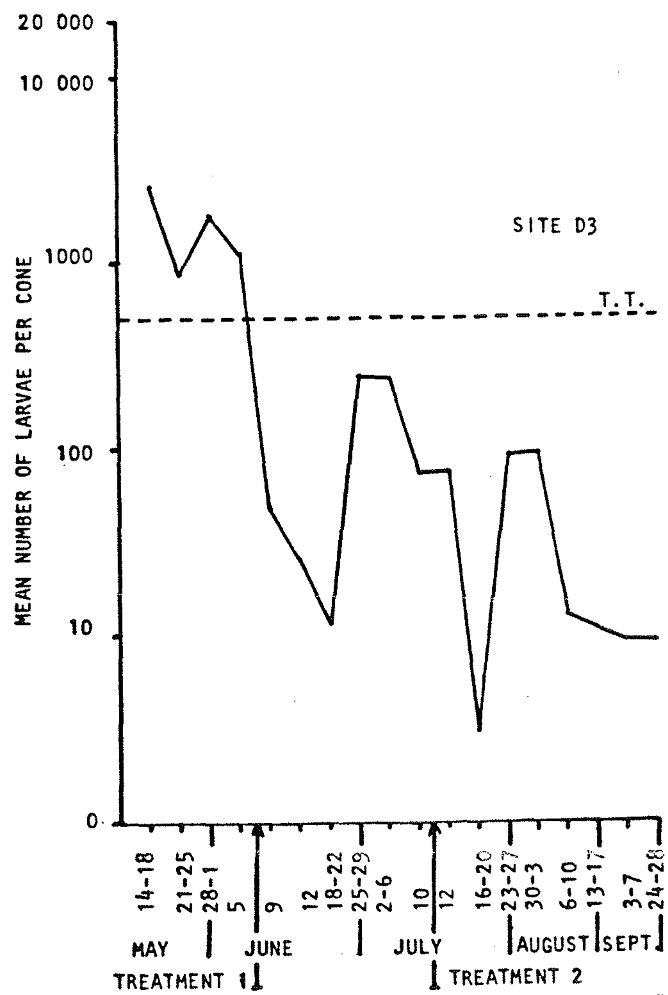
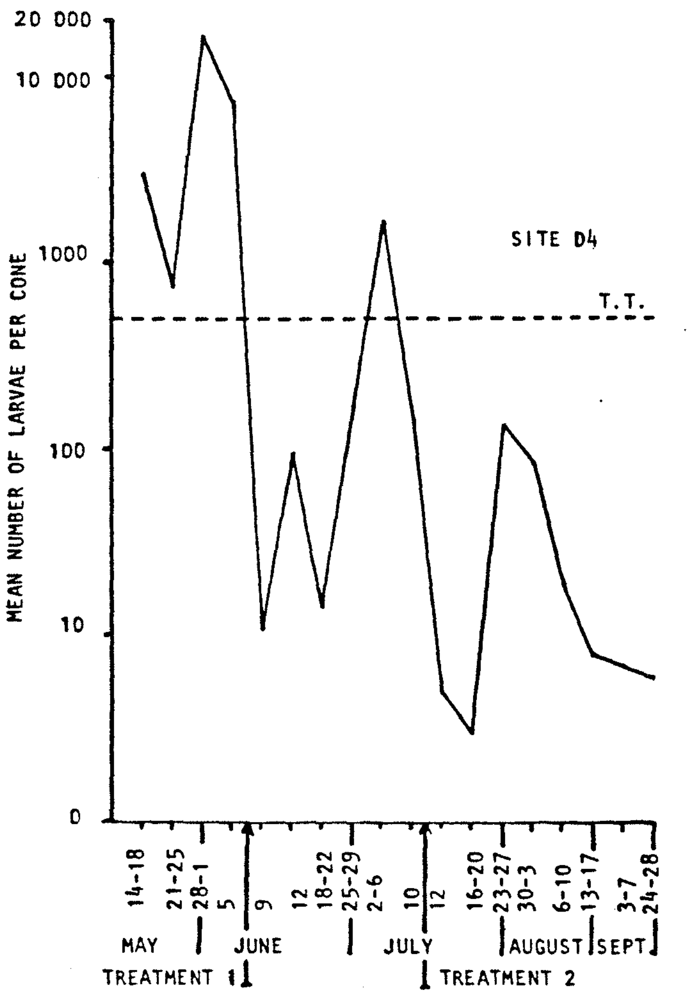
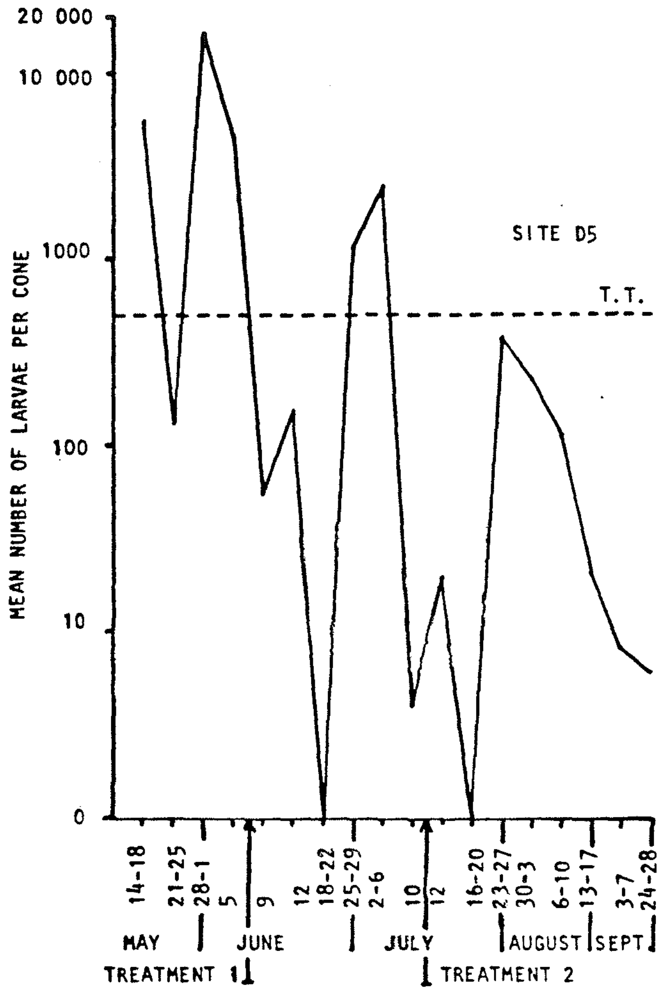
T.T.
MEAN NUMBER OF LARVAE PER CONE
20 000
10 000
1000
100
10
0
14-18
21-25
28-1
5
9
12
18-22
25-29
2-6
10
12
16-20
23-27
30-3
6-10
13-17
3-7
24-28
MAY
JUNE
JULY
AUGUST
SEPT
TREATMENT 1
TREATMENT 2


SITE D3
T.T.
MEAN NUMBER OF LARVAE PER CONE
20 000
10 000
1000
100
10
0
14-18
21-25
28-1
5
9
12
18-22
25-29
2-6
10
12
16-20
23-27
30-3
6-10
13-17
3-7
24-28
MAY
JUNE
JULY
AUGUST
SEPT
TREATMENT 1
TREATMENT 2





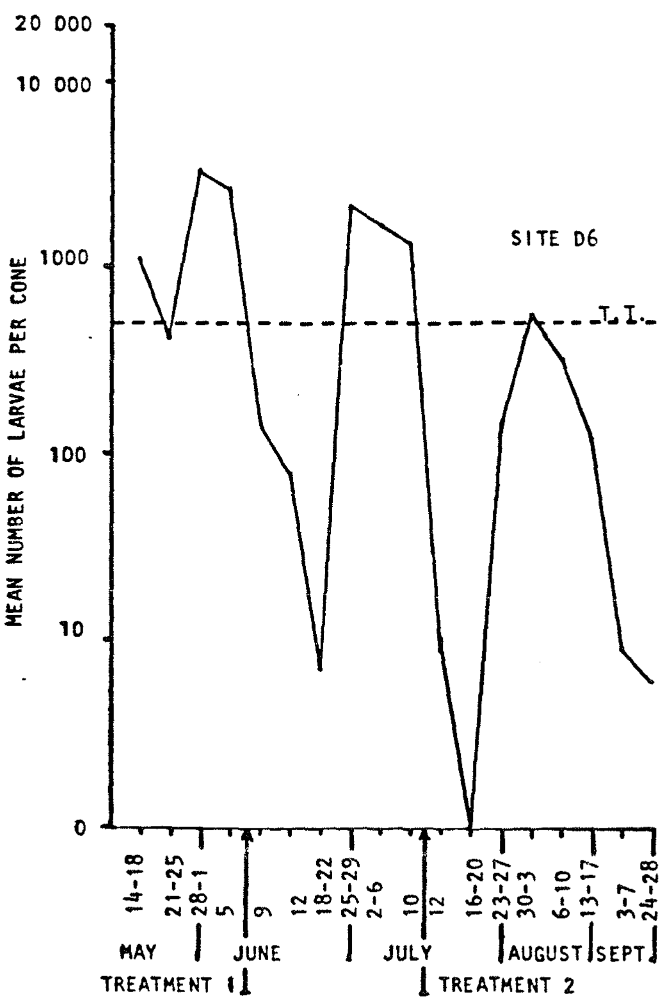
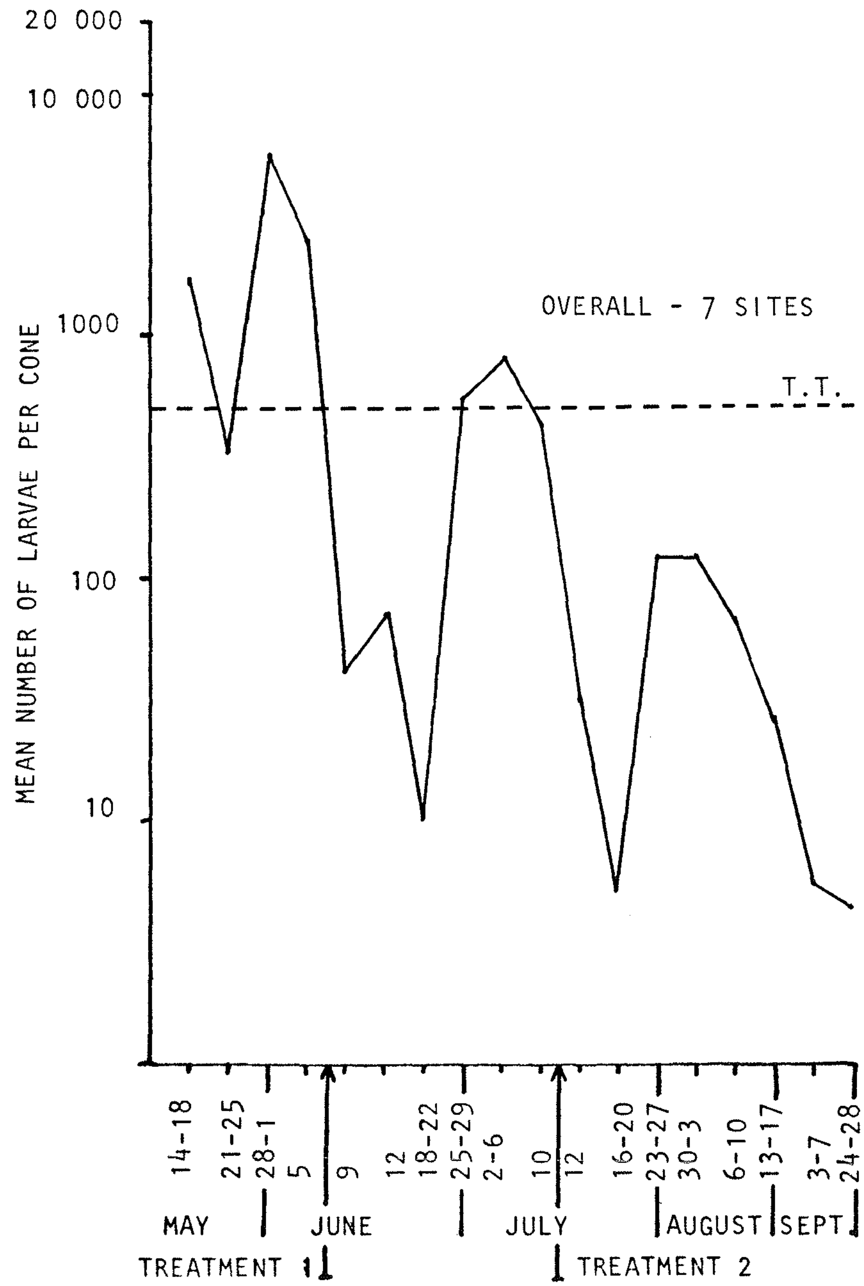


Figure 4 - Mean Number of Black Fly Larvae Per Cone Collected at 7 Sites Along The Athabasca River During The Summer of 1979.
T.T. - Treatment Threshold 500 Larvae/Cone

FIGURE 5 - Mean Number of Black Fly Larvae Collected at a Total of Seven Sites Along The Athabasca River During the Summer of 1979. T.T. - Treatment Threshold (500 larvae/cone)



are somewhat artificial in that methoxychlor treatments had a detrimental effect on larval populations.

Larval development (in terms of growth) is presented in Appendix 2. This data shows that the first hatch of S. arcticum larvae occurred just prior to the May 14-18 sampling period. After 3 weeks (June 9), development of black fly larvae not affected by the treatment had progressed to the pupal stage. On June 12, five days following the first treatment, a large number of larvae were present as late instars (21.3% as 7th instar) and a second hatch was evident (23.7% as 1st instar). This second hatch progressed in development over the next four weeks so that by July 10, 30.2% of the larvae were present as 7th instar, at which time the second treatment was undertaken. However the repetitive nature of larval hatches became evident for on July 12, 59.3% of the larvae are present as 1st and 2nd instars. This population proceeded in development until the August 13 - 17 sampling period when 38.7% of the larvae were present as mature larvae. The larval development noted after this sampling period should be considered spurious due to the low numbers of larvae obtained.

Following each treatment, significant reductions in the black fly larval populations were observed at the sites downstream of the injection points. The percent reduction in larvae at the treated sites was calculated using the modified Abbotts formula (Neal, 1974). Table 2 gives the percentage reduction for the June 7 injection and the July 11 treatment.

Table 2

Percent Reduction of Black Fly Larvae

	June 7[a]	July 11[b]
D2 (80km)	73.7%	--
D3 (120km)	92.9%	--
D4 (160km)	99.7%	97.3%
D5 (180km)	98.1%	--[c]
D6 (200km)	91.4%	99.5%
Fort McMurray (395km)	--	97.6%
Overall Mean	91.2%	98.1%

a- Control site D1 (40km), injection at 59.5 km
b- Control-mean of sites D1, D2, and D3, injection at 145 km
c- Pretreatment sets damaged, insufficient data

Table 2 indicates that the methoxychlor treatments were effective in reducing black fly larval populations for 140 km for the June injection and 250 km for the July 11 treatment. The moderate reduction at D2 for the June 7 injection is due to low pretreatment numbers of larvae.

Non-Target Invertebrate Sampling

Sampling for non-target invertebrates commenced on the 18 of May and continued on a weekly basis until the 26 of September.

June 7 Treatment - 59.5 km.

The data obtained was summarized and separated according to whether the sites were control sites or treated sites. Figures 6 to 22 show the percent proportions of various taxa over the summer. Figures 10 and 11 show immediate pre-treatment and immediate post-treatment comparisons of percent proportions between Control Sites (U1,D1) and Treated sites (D2, D3, D4, D5, D6). The Plecoptera were observed to have decreased by 10% in proportion after the treatment. The Ephemeroptera taxa increased by about 15% in proportion immediately after treatment (Figure 11). The Diptera decreased by 5% in proportion but this is attributable to reduction of S. arcticum numbers.

Haufe (1980) described nine insect genera that appeared to be sensitive to methoxychlor and which occurred in respectable numbers from samples taken from the Athabasca River. These genera are Ephemerella, Baetis, Heptagenia, and Rhithrogena (Ephemeroptera); Isoperla, Isogenus, and Hastaperla (Plecoptera); Cheumatopsyche and Hydropsyche (Trichoptera). Figures 23 to 31 depict the fluctuations in populations (mean numbers) over the summer of each of these genera and compare the control sites with the treated sites. The Ephemeropterans do not appear to have been

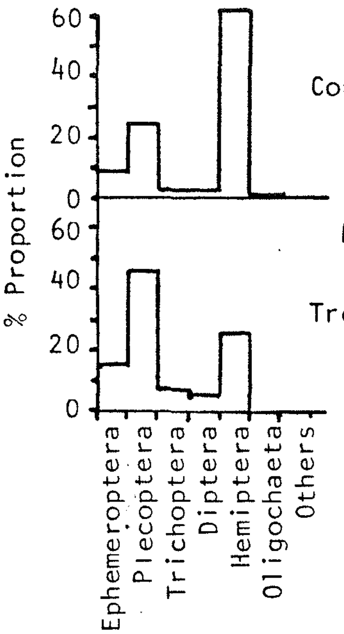


Figure 6
May 7-11

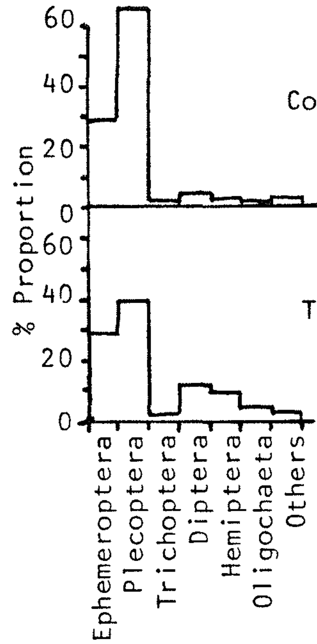


Figure 7
May 14-18

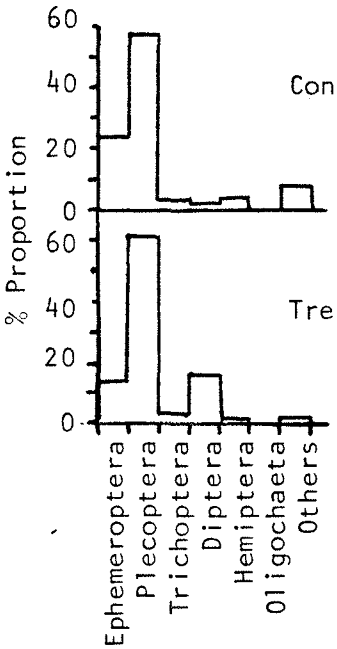


Figure 8
May 21-25

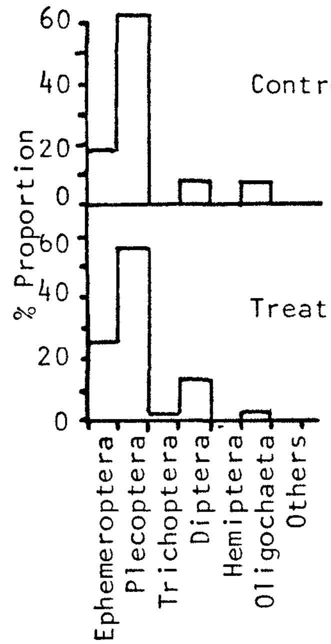


Figure 9
May 28-June 1

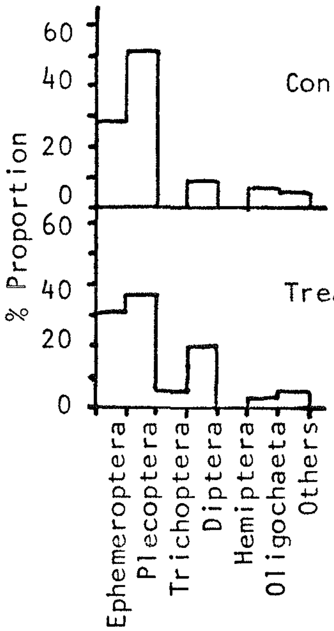


Figure 10
June 4-8

Figure 11
June 11-15

Figure 12
June 25-29

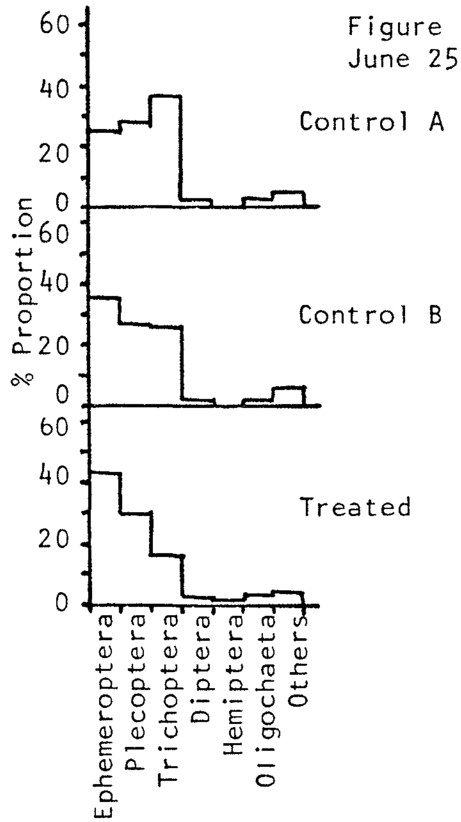


Figure 13
July 10-11

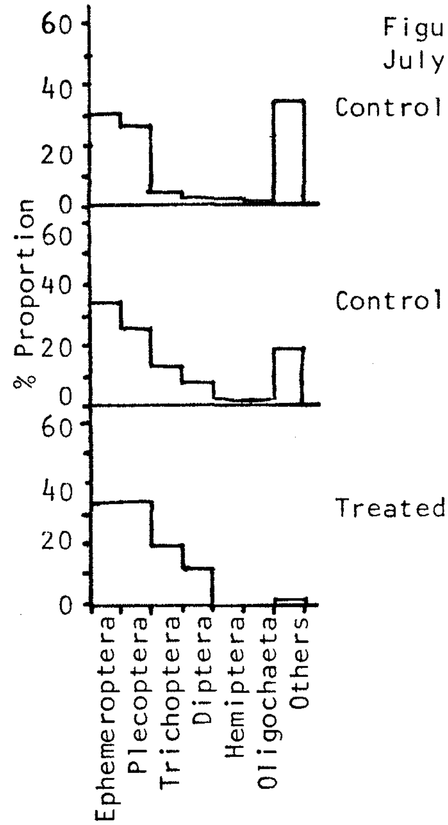


Figure 14
July 12

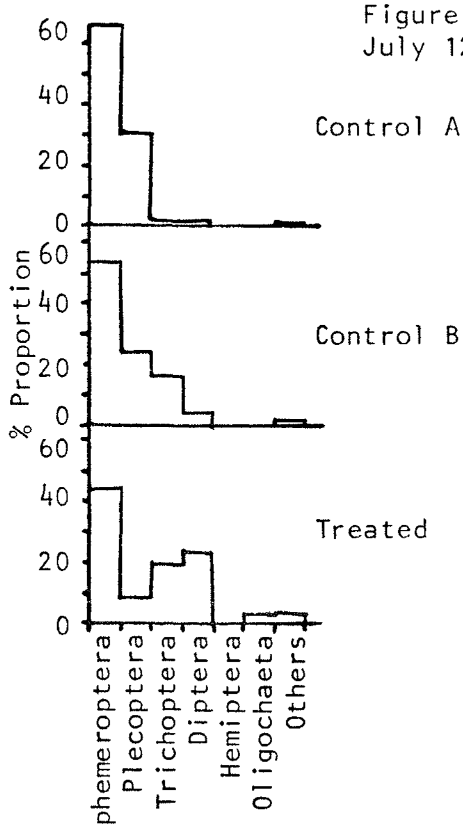
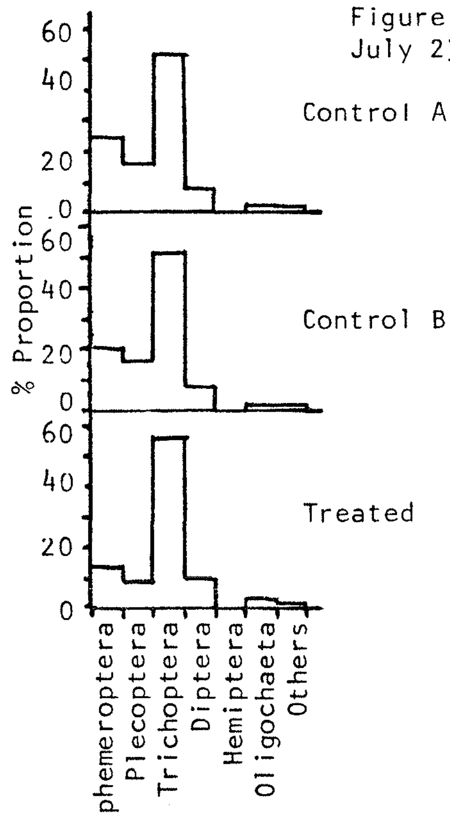


Figure 15
July 23-27



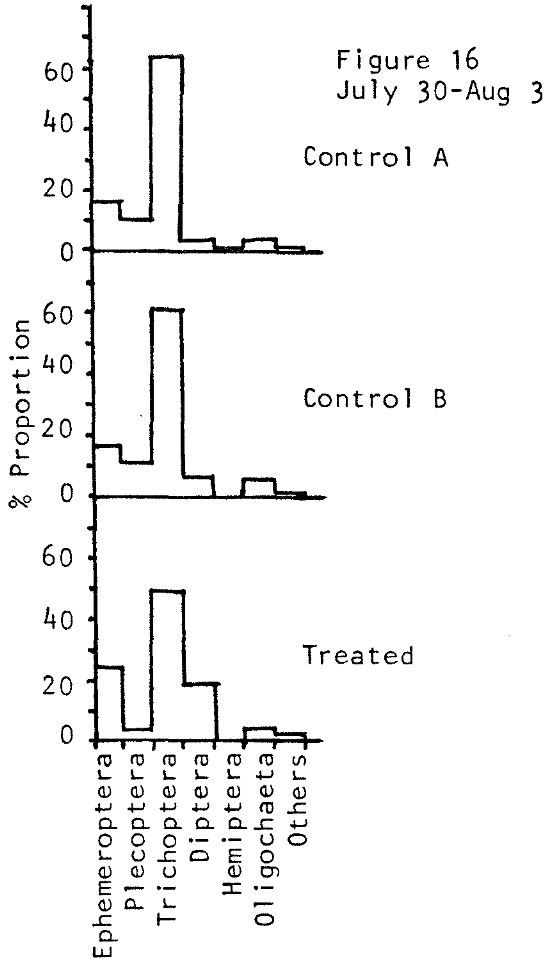


Figure 16
July 30-Aug 3

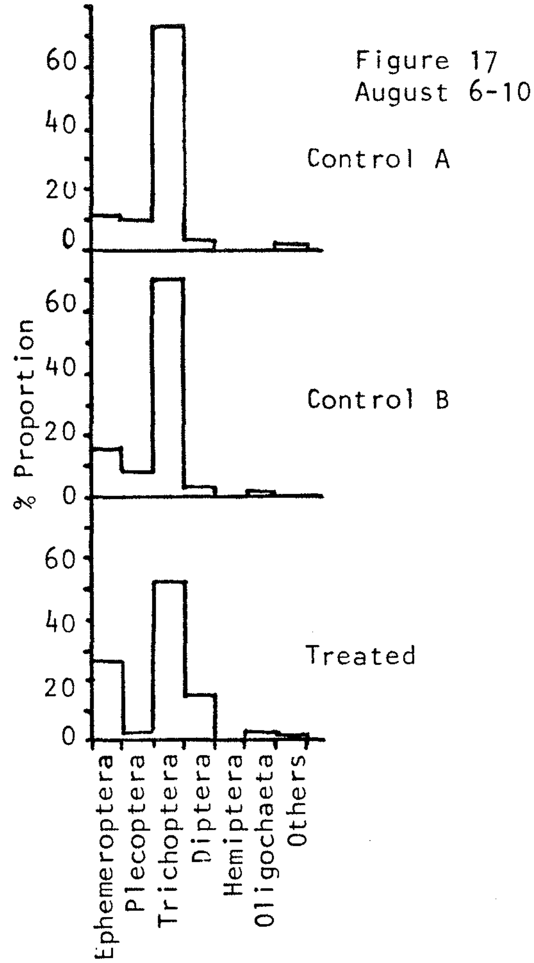


Figure 17
August 6-10

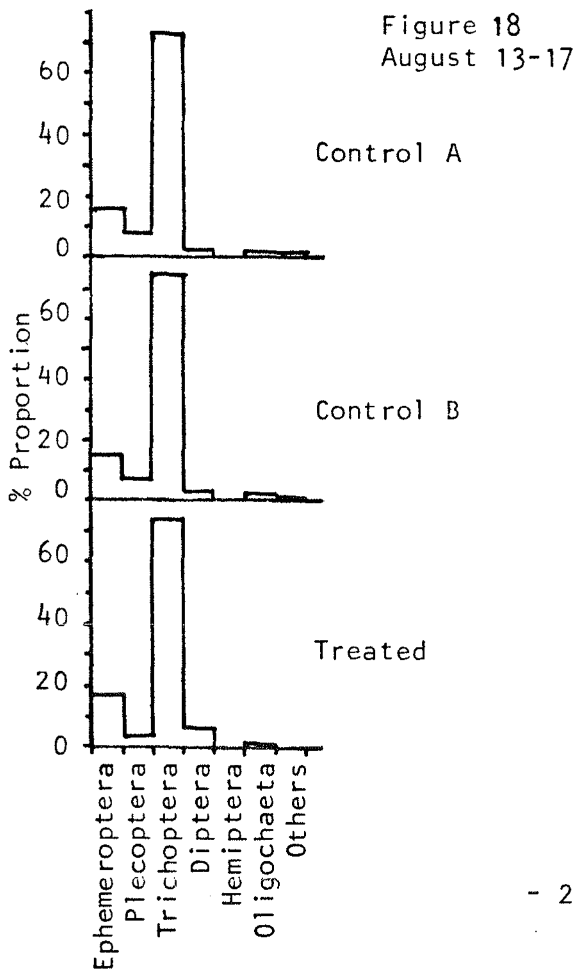


Figure 18
August 13-17

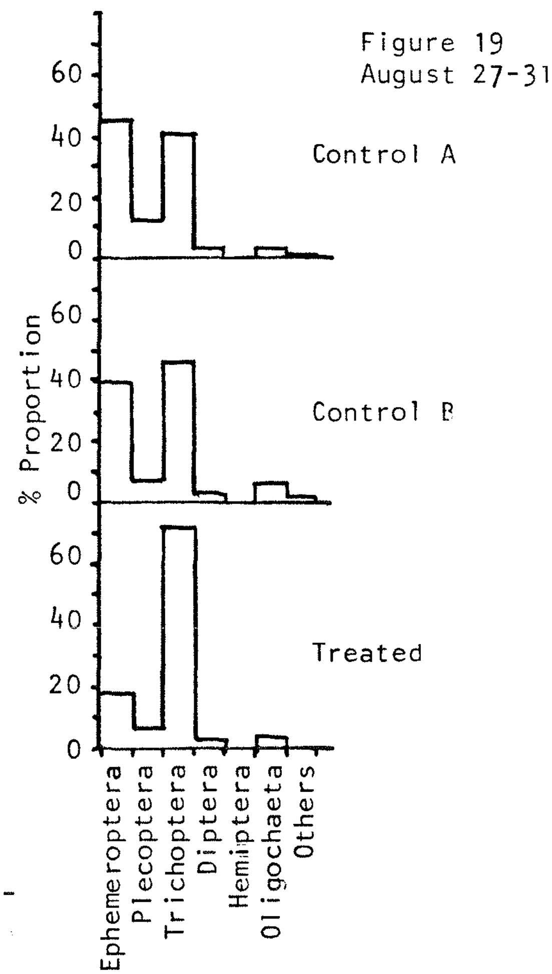


Figure 19
August 27-31

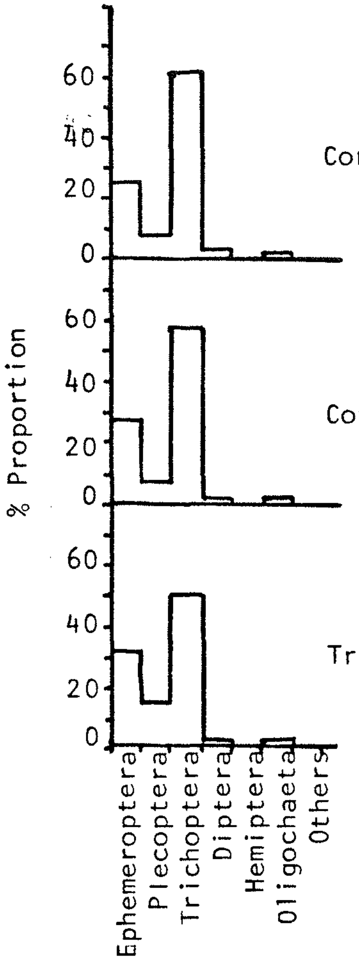


Figure 20
Sept. 3-7

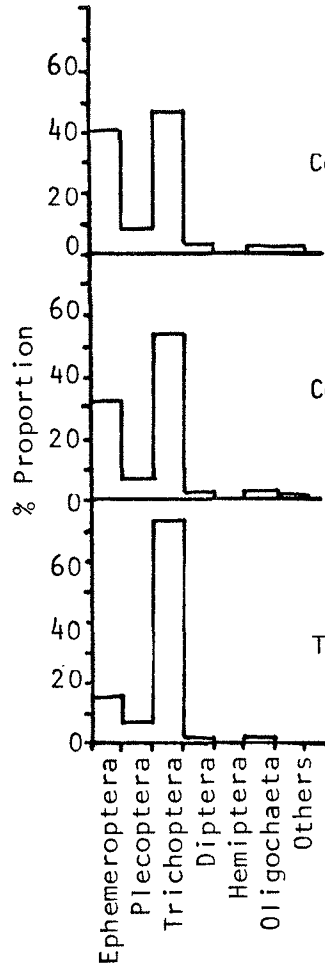


Figure 21
Sept. 17-21

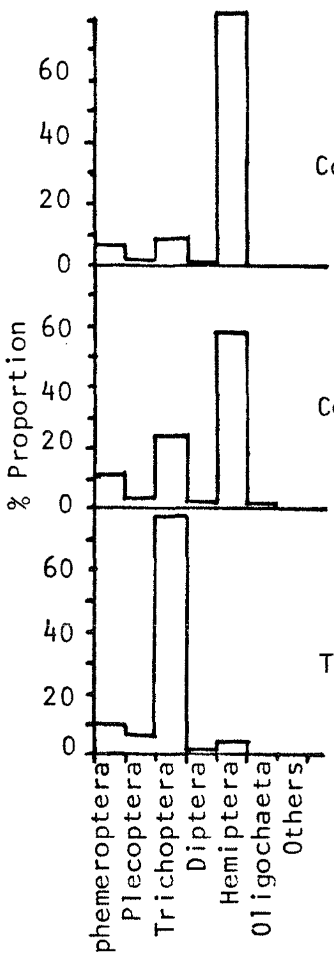


Figure 22
Sept. 24-28

Figures 6 - 22. Percent Proportions of Predominant Taxa in the Athabasca River over the summer of 1979.

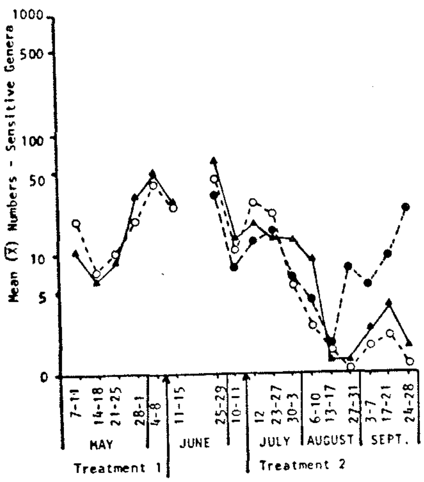


FIGURE 23 - Population Fluctuations of *Ephemerella*

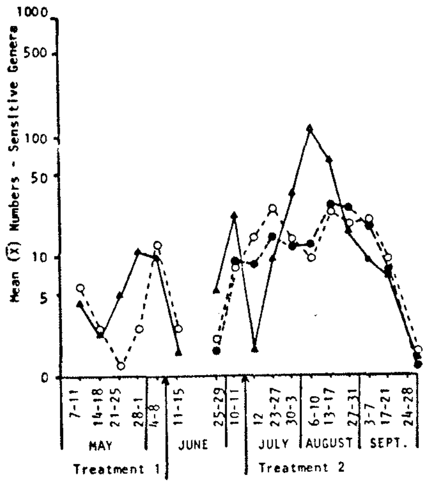


FIGURE 24 - Population Fluctuations of *Baetis*

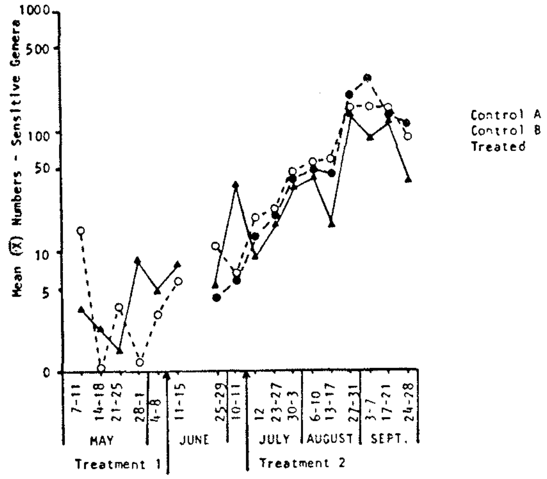


FIGURE 25 - Population Fluctuations of *Heptagenia*

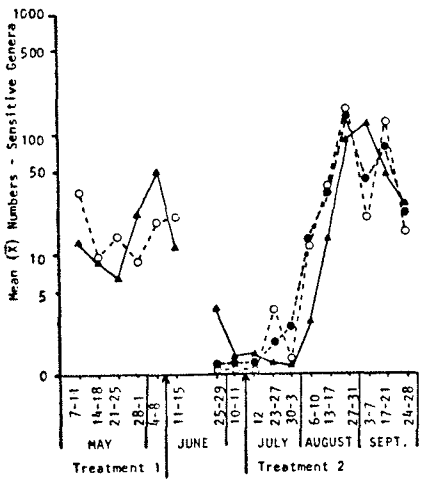


FIGURE 26 - Population Fluctuations of *Rhithrogena*

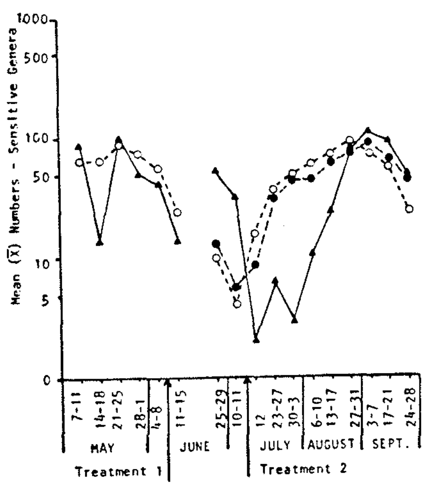


FIGURE 27 - Population Fluctuations of *Isogenus*

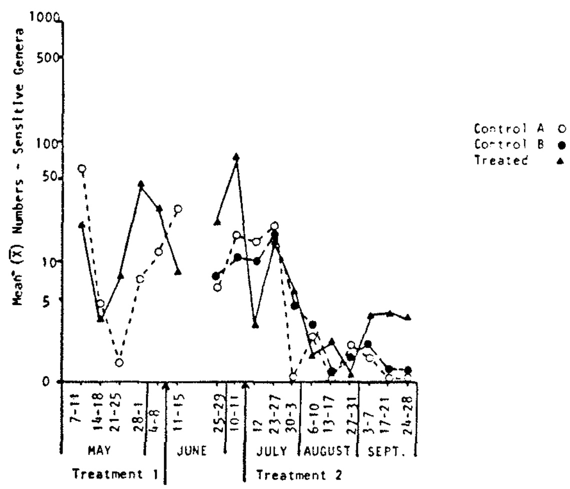


FIGURE 28 - Population Fluctuations of *Isoperla*

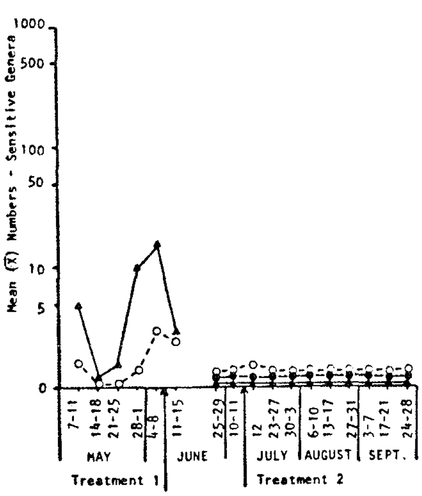


FIGURE 29 - Population Fluctuations of *Hastaperla*

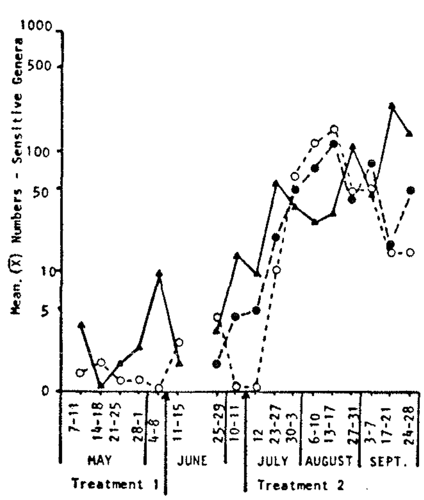


FIGURE 30 - Population Fluctuations of *Hydropsyche*

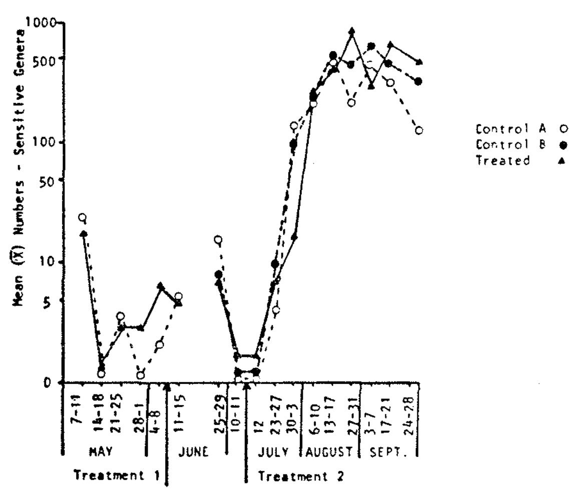


FIGURE 31 - Population Fluctuations of *Cheumatopsyche*

significantly affected by the methoxychlor. However, the Plecopterans and Trichopterans, specifically Isoperla (Figure 28), Hastaperla (Figure 29), Hydropsyche (Figure 30), and to a lesser extent Cheumatopsyche (Figure 31), appear to have been adversely affected to some degree, when comparing populations at treated sites with populations at control sites.

The diversity index (Shannon-Weiner $D = \Sigma$ pi $\log_2$pi, Smith 1974) does not show any significant impact on the benthic organisms due to methoxychlor when comparing the treated sites to the control sites (Figure 32).

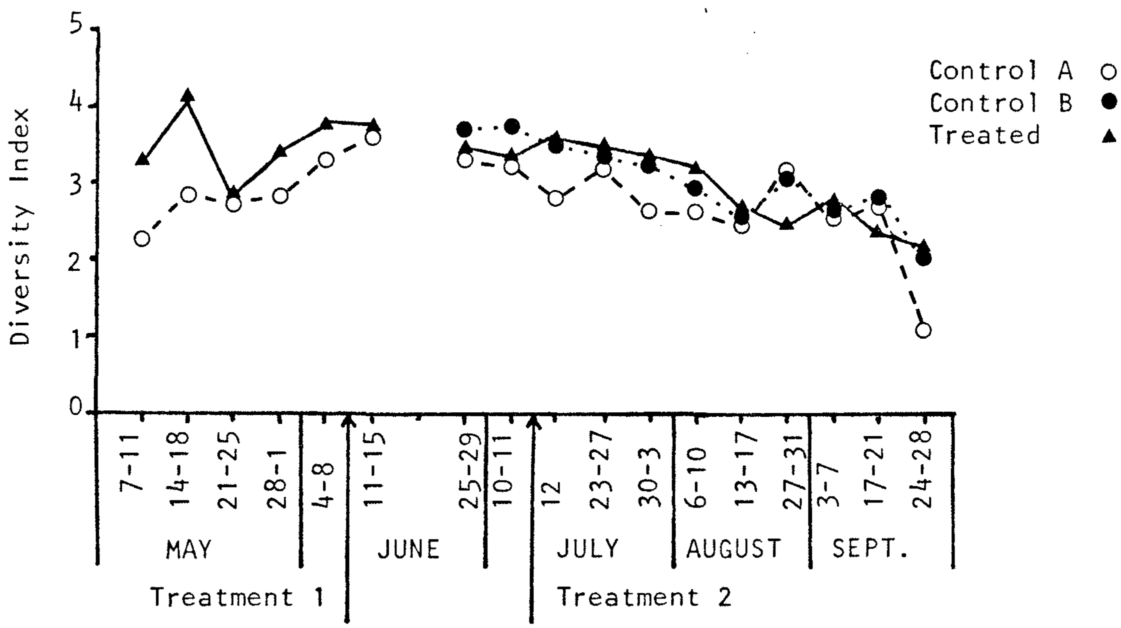


Figure 32 - Diversity Index of Invertebrate Populations from Treated and Non-treated Sites, 1979.

July 11 Treatment - 145 km.

The data for the second treatment was broken up into three groups. Control A included the same two sites that were control sites for the first treatment. Control B consisted of Control A plus D2 and D3, two sites that were exposed to methoxychlor in June. The treated sites (D4, D5, D6) were those exposed to chemical on July 11.

Figures 6 to 22 show the effect of the July treatment on the percent proportions of the various insect taxa. The Plecoptera show a marked decrease of about 15% between pre-treatment and post-treatment samples. The Ephemeroptera and Trichoptera appear to remain at about the same proportions as before, while the Diptera increased, likely due to the reduction of total numbers of organisms.

Figures 23 to 31 show population fluctuations of the sensitive genera over the summer. Figure 24 shows that Baetis populations appear to have been adversely affected by the methoxychlor and as well the populations at the treated sites were erratic later in the summer when other populations had stabilized. The Heptagenia populations (Figure 25) also show a decrease however there is large variability between the pre-treatment samples making this decrease uncertain. Isogenus populations (Figure 27) were adversely affected to a certain extent by the treatment but it is significant that they did not return to control site populations until late August. Isoperla populations (Figure 28) dropped as a result of the methoxychlor treatment but were back at control site levels two weeks later. Ephemerella (Figure 23), Hydropsyche (Figure 30), and Cheumatopsyche (Figure 31) populations did not appear to be affected to any extent by the methoxychlor treatment. Rhithrogena (Figure 26) and Hastaperla (Figure 29) populations were not present in the samples at the time of treatment so no chemical impact was noted.

The diversity calculated for the treated sites does not differ to any extent from the diversity calculated for the control sites (Figure 32), which is similar to the results observed for the first treatment.

Methoxychlor Residues in Silt and Water

A total of 79 silt samples were taken from the Athabasca River and analyzed for methoxychlor residues during 1979. The Pollution Control Laboratory of Alberta Environment did the analysis using a gas chromatograph, (Hall detector) and also used electron capture on several samples.

The Hall detector procedure used by the Pollution Control Lab had a detection level of 0.1 μg/g (100 parts per billion, ppb) which is one-third of the treatment dosage (300 ppb).

Of the 79 samples analyzed for methoxychlor, only two samples registered over 100 ppb. These samples were taken at site D5 (180 km) on July 11 and 12, 35 km downstream of the treatment point. The sample obtained on July 11 was picked up at 1920 hours (pre-treatment) and registered 778 ppb methoxychlor. The sample obtained on July 12 was picked up at 1410 hours (post-treatment) and registered 185 ppb methoxychlor.

Water samples which were obtained at Fort McMurray on July 13 and 14 were also analyzed by the Pollution Control Laboratory using a technique which had a detection limit for the water samples of 0.3 ppb. Post-treatment samples taken just after the leading edge of the methoxychlor passed through early on July 13 registered 2.3 ppb and 3.5 ppb while 24 hours later samples that were obtained did not register any detectable methoxychlor (Table 3).

Date	Time	Location	Concentration (ppb)
July 12	2255	Athabasca River	<0.3
July 12	2300	Athabasca River	<0.3
July 13	0500	Athabasca River	<0.3
July 13	0955	Athabasca River	2.3
July 13	0955	Ft. McMurray - water intake	1.4
July 13	1000	Athabasca River	3.5
July 13	1440	Suncor - storage pond	<0.3
July 13	1600	Syncrude - storage pond	<0.3
July 14	0750	Ft. McMurray - water intake	<0.3
July 14	0755	Athabasca River	<0.3
July 14	0800	Athabasca River	<0.3
July 14	1045	Ft. McMurray - storage pond	trace
July 14	1050	Ft. McMurray - treated water	<0.3

Table 3. Methoxychlor residues in water samples collected at Fort McMurray

Samples obtained near the Town of Fort McMurray's fresh water intake on the Athabasca River registered 1.4 ppb during the passage of chemical on July 13 while the next day (July 14) no detectable methoxychlor was found. Also on July 14, samples were taken from Fort McMurray's fresh water storage pond and a trace of methoxychlor was found but no chemical was detected in the treated drinking water.

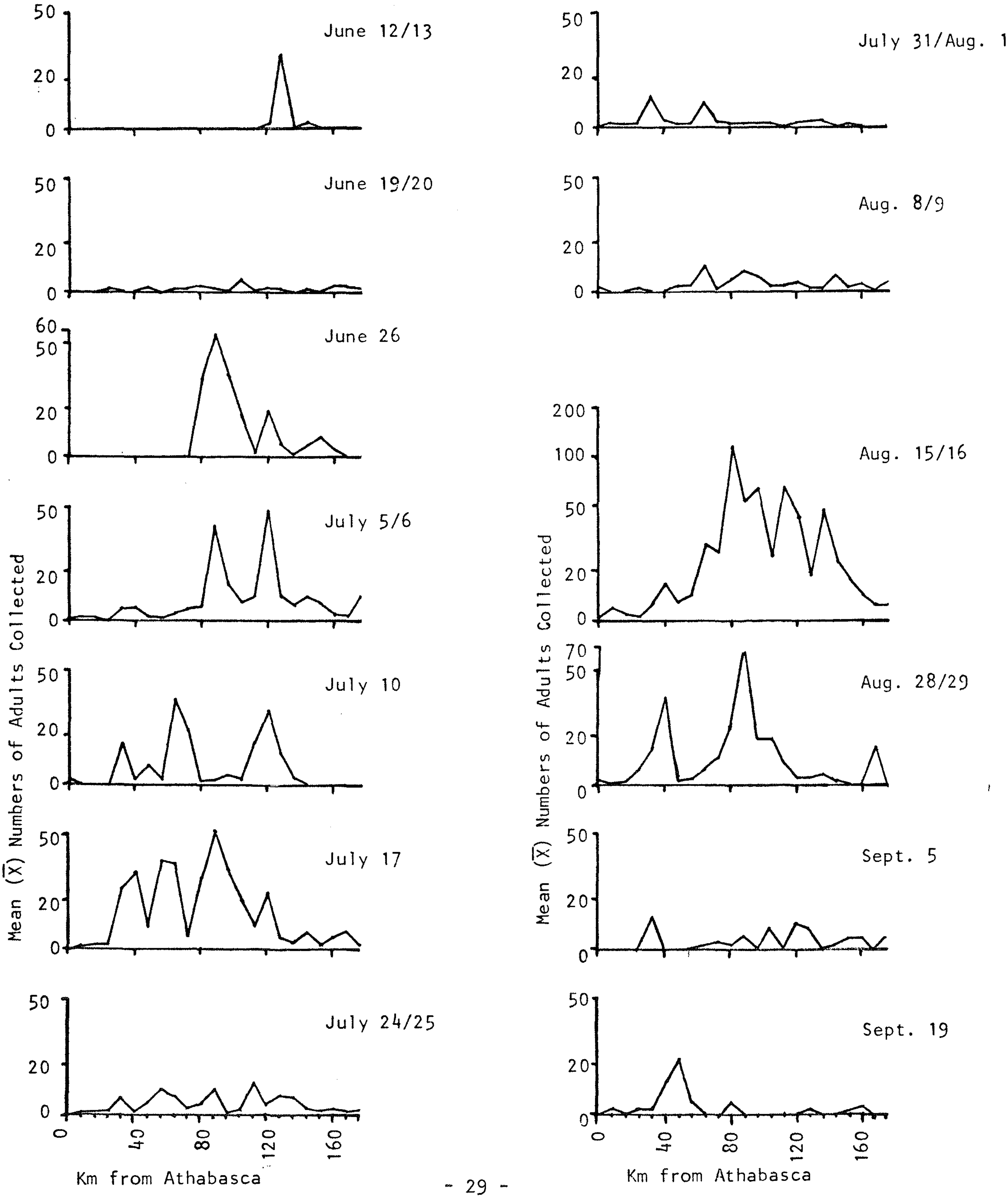
Samples were also taken from the GCOS (now Suncor) and Syncrude oil sand plants fresh water storage ponds on the afternoon of July 13 and no chemical was detected.

High Speed Adult Sweeps

Sweeping of the river surface for adult black flies (approximately 99% *S. arcticum*) commenced on the 12 of June when larval and pupal development indicated that some flies may have emerged. Sweeping continued until the 19 of September.

Adult activity was correlated with larval development to determine a chronological assessment of adult activity. Adults were first captured on June 12 and 13 (Figure 33), and this is related to advanced larval and pupal development from the week previous (Appendix 2). The next week (June 19 and 20) saw few adults collected. This is likely due to poor weather conditions for sampling at the time and to the effect of the June 5 and 7 treatments. On June 26, a shift upstream in adult activity was observed. On July 10, continued emergence and a shift upriver of the previous weeks adults was observed. A further shift upriver is noticed on July 17. Low numbers of adults and an even distribution noticed over the next three sampling periods is attributed to poor weather conditions, little emergence as evidenced by larval development, and low larval populations due to the treatment on July 11. On August 15 and 16 a large emergence was observed, larger than the two previous emergences possibly due to no methoxychlor reducing the larval populations. Samples collected on August 28 and 29 indicated a continued emergence as well as a slight shift in populations upriver. On September 5, activity was still observed at the lower sites but was diminished due to low larval populations of the previous sampling period. On

Figure 33 - Adult Activity (HSAS) on River Surface at Different Weeks During The Summer.



the last trip that samples were collected (September 19), very little activity was noted at the lower sites, however some activity was observed adjacent to the farming area at 40-56 km downstream.

Overall adult activity over the summer is presented in Figure 34. From this it is evident that two peaks in adult activity occurred, on July 10 and August 15 and 16. This correlates with larval development in that mature larvae and pupae were present in the river at this time (Appendix 2). Adult activity over the river surface tapered off to low levels during September.

Other information that was available from the sweeps included an indication of diurnal activity over the surface of the river (Figure 35). From the graph, two peaks in activity emerge, the first at approximately 0900 to 1100 hours and the second at 2000 to 2200 hours.

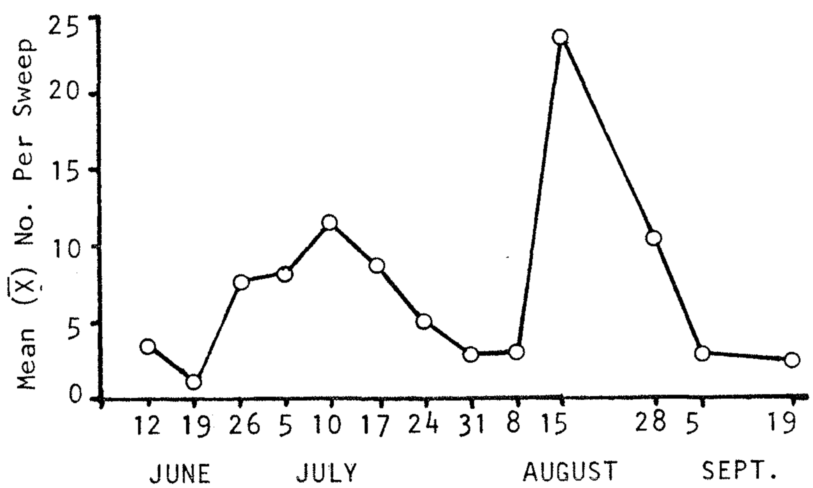


Figure 34 - Adult Activity on River Surface (HSAS) over Summer, 1979

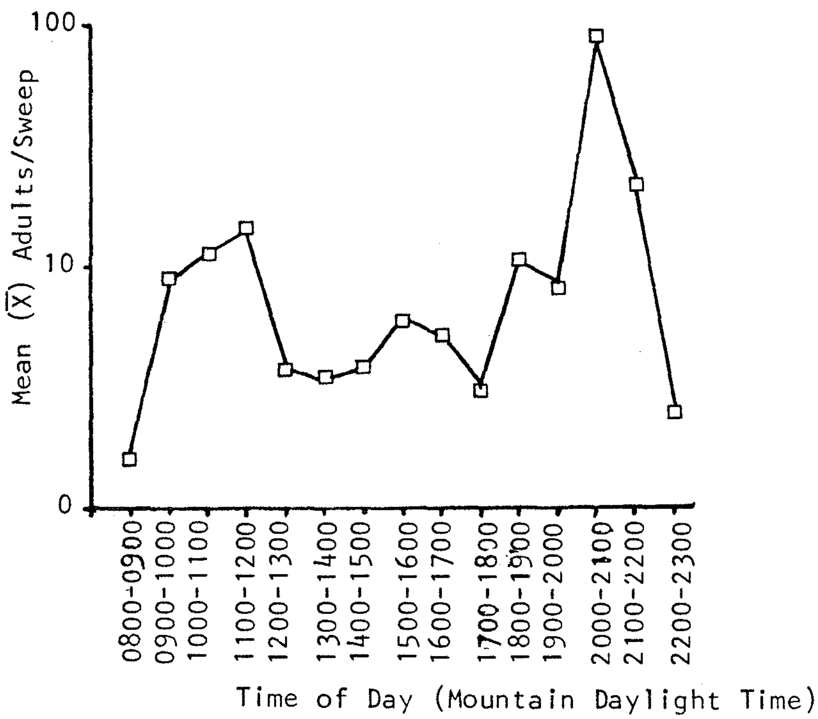


Figure 35. Relationship between Adult Activity And Time of Day

Barrel Traps

In 1979 high speed adult sweeps were complemented by the use of barrel traps at each site along the river and in the farming area. These were utilized to overcome many of the short term variable factors that often influence adult sweeping by expanding the sampling period from two minutes (the time it took to sweep 1.6 km) to one week. Also by placing identical traps in the farming area as were along the river, general comparisons as to adult activity could be made.

Figure 36 gives a graphic representation of adult Simuliids captured on barrel traps along the river and in the farming area. From the graphs it can be seen that populations increased in similar patterns on the river and on the farm during June and early July, peaking near the middle of July. A second peak occurred in early September on both the river and on the farm, with the peak on the farm being more pronounced. Numbers of adults obtained on the traps on the farm were considerably higher than numbers obtained on traps along the river and it was thought to be because of the proximity of preferred host material (cattle) on the farm.

Figure 37 illustrates the number of black flies collected at traps situated along the river. No flies were collected during the sampling period of June 5 (week ending June 5). Some flies were collected during the June 12 sampling period, indicating that some emergence had occurred during that sampling period. On June 19, many flies were collected, indicating that emergence was well

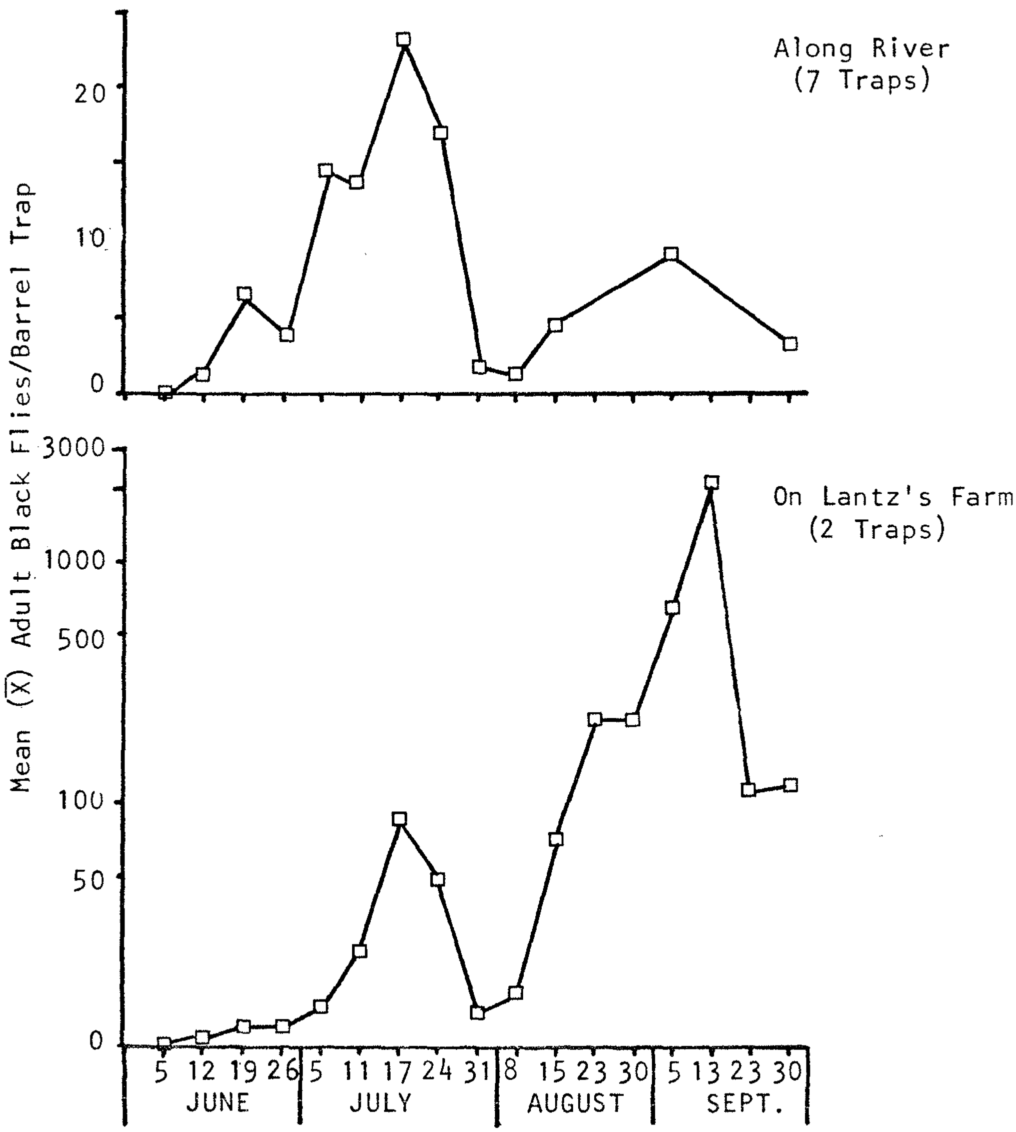


Figure 36. Mean Number of Adult Simuliidae/Barrel Trap Along River and on Lantz's Farm

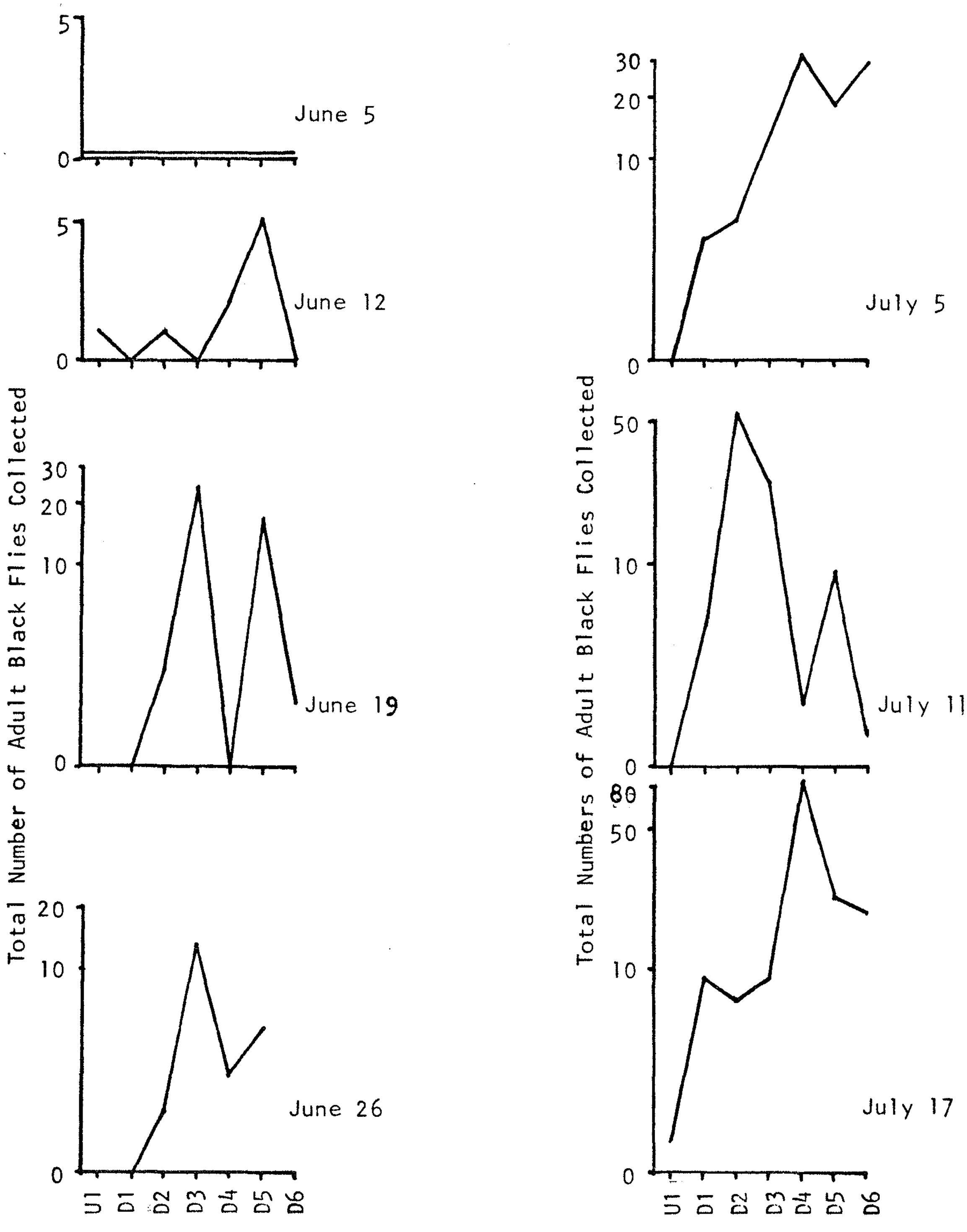


FIGURE 37 - Adult Black Flies Collected on Barrel Traps at Seven Sites Along the Athabasca River Over the Summer - 1979

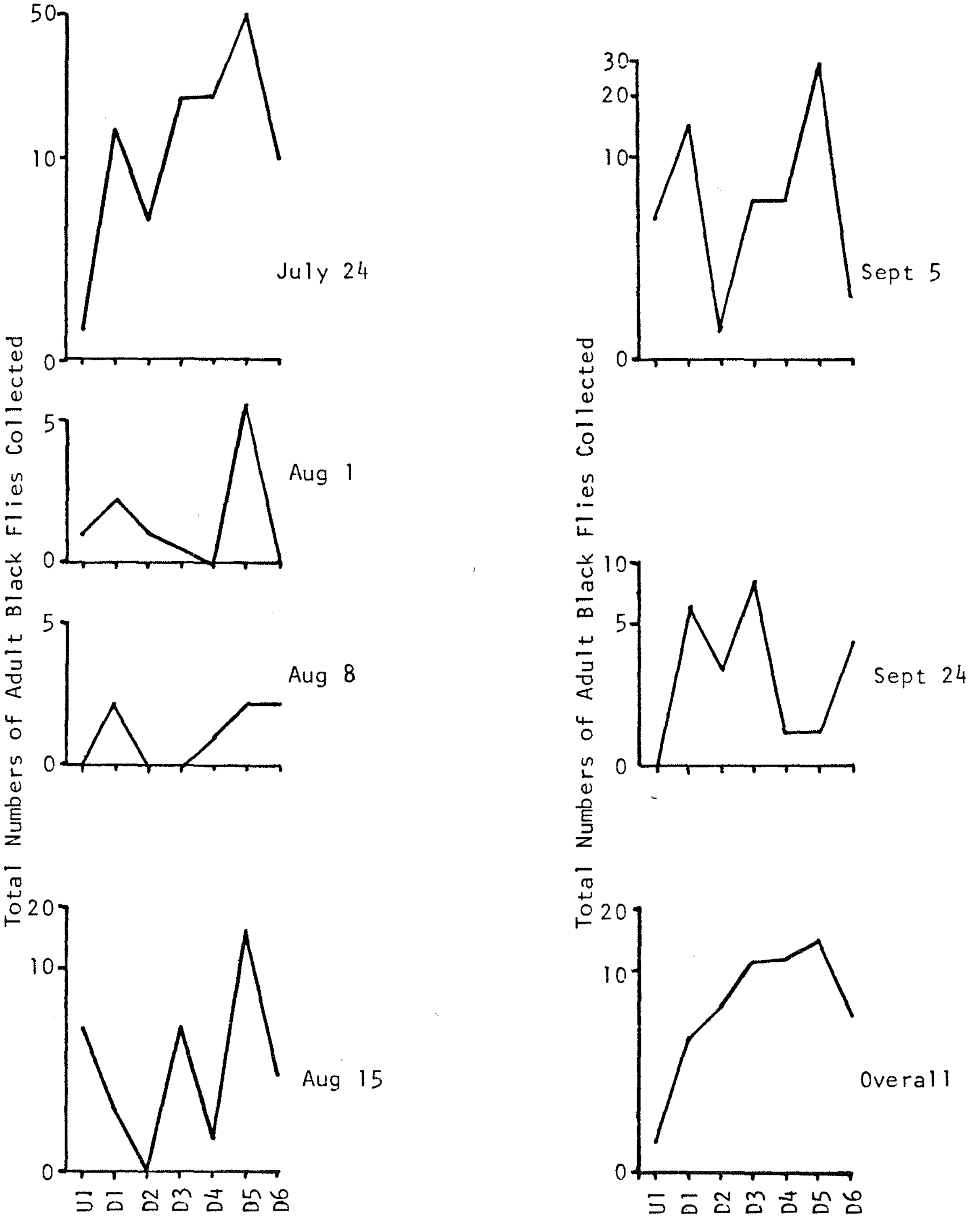


FIGURE 37 (cont'd) - Adult Black Flies Collected on Barrel Traps at Seven Sites Along the Athabasca River Over the Summer - 1979 established. The pattern continued over the next sampling period (June 26), but the following sampling period (July 5) showed a large increase in numbers collected at most of the sites. The next sampling period (July 11) showed a slightly reduced number, but it also indicated a shift upriver in adult populations. The following sampling period (July 17) shows adult populations greater at the lower sites and by correlating information from Appendix 2, it is apparent that another emergence occurred. A gradual decrease in adult populations is observed over the next three sampling periods. The sampling period of August 15 shows larger numbers and upon checking Appendix 2, another emergence was expected at this time. The sampling period of September 5 shows considerable populations, especially at the further downstream sites. This is attributed to the small but continual emergence of black flies. The sampling period of September 21 shows adult populations to be concentrated mainly at the upper sites, adjacent to the farming area.

DISCUSSION

Larval Sampling

The most obvious result of the larval sampling program was that there were three distinct populations of black fly larvae in the Athabasca River during the summer of 1979. This is evidenced by the data presented in Figure 4 and Appendix 2. Depner *et al.* (1980a) indicated that during the research program, no more than two larval hatches were observed in a season. Pledger and Byrtus (1980) observed only two main populations of larvae in the river over the 1978 season. Why there were three distinct larval populations in 1979 and no more than two in the previous five years of sampling is open to discussion. The abnormally large numbers of larvae collected during May provides an indication that 1979 may well have become a serious outbreak year had there been no treatments. Severe outbreaks of black flies had previously been reported in the study area in 1955 or 1956, 1963 and 1964 and in 1971 and 1972 (Fredeen 1977). The data suggests that 1979 may have been the next peak in the black fly population cycle and the three larval populations are merely indicative of a potential major and sustained outbreak.

Two of the three larval populations in 1979 were considerably over the treatment threshold of 500 larvae per cone but the third population was not sufficient to warrant a treatment. Of the two populations that warranted treatment, it was observed that maximum populations did not occur immediately prior to treatment, but one week before treatment. These slight population declines just prior to treatment may correspond to larval and pupal development and it is possible that some emergence may have occurred just prior to treatment. This is not indicated by results obtained from the cones, however the cones are, after all, artificial and not natural substrates and the cones are replaced weekly, thereby sampling only one week's accumulation of drifting larvae. Another possibility is that natural mortality due to competition, predation and other ecological factors (such as drift) may have been responsible for the reduction in high larval populations one week before treatment.

The information that was presented in the results pointed to higher larval populations at the sites below 80 km downstream of the Town of Athabasca (D3, D4, D5, D6) and this was also noted by Depner et al. (1980a). This is related to the natural preference of black fly larvae to objects (such as rocks, submerged logs, vegetation, etc.) which are located in regions of streams with fast water. Figure 2 indicates that below 80 km the river gradient increases, thereby increasing the velocity of the river. Also, below 160 km the river gradient increases again and a further increase in larval population density is observed (Figure 4).

From the reduction in black fly larval populations due to the methoxychlor (Table 2), it is apparent that a greater adverse effect on the larvae occurred for the July 11 treatment (98.1% mean reduction) than for the June 7 treatment (91.2% mean reduction). As well, reduction appeared to be greater over a larger distance for the July treatment (250 km) than for the June 7 treatment (140 km). These results are directly related to river discharge rates and the mode of action of methoxychlor. Methoxychlor, in the emulsifiable concentrate formulation used, is thought to adsorb to silt particles (Fredeen et al. 1975), which black flies filter, along with plankton and bacteria (Fredeen 1960) from water flowing past the larvae. Therefore, any effect on the silt washload (silt carried in suspension in the river water) of the river induced by increased discharge will influence the effect of methoxychlor on black fly larvae. An increase in river discharge will increase the water velocity and subsequently increase the silt washload due to bottom scour and reduced desposition. The increased silt washload will provide more sites for methoxychlor to adsorb to, resulting in a more efficient utilization of the chemical injected. As well, an increased amount of chemical would be used at greater discharge rates to maintain the 300 ppb dosage rate.

The efficiency of methoxychlor in reducing black fly larval populations in the Athabasca River is therefore enhanced by a greater discharge rate. As well, the distance that methoxychlor will be effective in reducing black fly larval populations will also be increased by a greater discharge rate. Depner et al. (1980a) indicated that when discharge rates exceed 560 m^3/s, methoxychlor treatment of the Athabasca River can be expected to be effective in reducing black fly larval populations for at least

160 km. In 1979, discharge rates for the 203 km injection on June 5 was 827 m^3/s, 978 m^3/s for the June 7 injection at 59.5 km and 1356 m^3/s for the July 11 treatment at 145 km.

Non-Target Invertebrate Sampling

The adverse impact of methoxychlor on non-target organism's (NTO's) in 1979 at the Order level appeared to be restricted mainly to the Plecoptera taxa (Figure 10 and Figure 13). At the generic level, a more detailed look at the impact of methoxychlor on "sensitive" NTO's showed little effect on the organisms examined from the June treatment, except for Rhithrogena, Isoperla, Hastaperla and Hydropsyche (Figures 25, 27, 28 & 29). These genera showed some reduction in numbers which can be attributed to the methoxychlor. For the July 11 treatment, Baetis, Heptagenia, Isogenus and Isoperla genera (Figures 23, 24, 26 & 27) showed some reduction in numbers which can be attributed to the methoxychlor.

Although the general immediate impact of the 1979 methoxychlor treatments on the non-target biota appeared to range from slight to moderate, the next consideraton is time of recovery. Flannagan et al. (1979) noted little recolonization of invertebrates within 4 weeks after methoxychlor treatment of the Athabasca River. In 1979 all of the "sensitive" genera had recovered to control site populations by three weeks after the June 7 treatment. Hastaperla populations (Figure 28) at both control and treated sites were negligible by the end of June. Flannagan (1977) indicated that Hastaperla was strongly affected by the 1975 methoxychlor treatment of the Athabasca River as no specimens were collected in the Fort McMurray area after mid-June. Our data suggests that Hastaperla nymphs are not present in control or treated reaches of the river after mid-June and this is likely due to adult emergence. Of the four genera that showed a reduction in numbers after the July 11 treatment, three had returned to control site populations levels by two weeks after treatment. The fourth genera, Isogenus (Figure 26), showed a marked extended effect and did not return to control site population levels until seven weeks after the treatment. One of the other three genera, Baetis (Figure 23), showed an initial decrease but then it underwent a marked increase over control site populations levels after the July treatment and did not return to control site population levels until also seven weeks after treatment. This suggests that the Baetis populations were able to increase unchecked due to lack of predators (Isogenus in this case) and did not return to stable population levels until the Isogenus populations were able to recover from the methoxychlor treatment.

In general, the impact of the methoxychlor treatments in 1979 appeared to be more detrimental to the Plecoptera than to the other genera, although the other taxa were slightly affected. Wallace and Hynes (1975) indicated that Plecoptera were predominant in drift samples after an aerial methoxychlor treatment of a stream in Quebec. Other insect taxa were present in the drift but in low numbers relative to the Plecoptera. They indicated, along with other authors (Flannagan et al. 1979), that methoxychlor causes "catastrophic" effects on NTO populations, however they based their conclusions on results obtained from drift samples, where the acute impact of the chemical is more pronounced than in standing crop samples. Using a standing crop sampling method, we did not detect "catastrophic" effects but it appeared that the impact of methoxychlor was limited to specific genera.

In analyzing the data, two control groups (Control A and Control B) were set up to determine any long term differences in numbers related to the June 7 treatment. No discernible differences between the controls were noted, indicating that the effect of the first treatment on the sites included in Control B was not significant, or that recovery was fairly complete three weeks after the June treatment.

Diversity indices, which are often used as indicators of stream pollution (Wilhm 1972, Whitton 1975), do not show any impact upon the non-target organisms due to the methoxychlor treatments (Figure 31). Depner et al. (1980b) indicated that methoxychlor treatments increased the diversity of invertebrates in the Athabasca River system after three years of river treatment. An increase in diversity was not noted in 1979, and it is suspected that increased experience in the field and lab enabled Depner et al. to detect an increase in diversity over the four years of the research program. One interesting aspect of Figure 31 is the curvilinear characteristic of the diversity index. It appears that diversity is relatively low in the spring and fall and peaks during June. This suggests that the river invertebrate community is more stable at this time of year, and that a methoxychlor treatment at this time of the year may not have a long term adverse impact. On the other hand, it can be suggested that a methoxychlor treatment be conducted when the diversity is low, thereby avoiding many of the taxa and affecting mainly the dominant taxa present. Unfortunately, black fly larval populations are only high enough to warrant treatment at the time when diversity is high.

Low diversity values are generally associated with polluted habitats (Wilhm 1972) or with substrates that are structurally unsuited as habitats for many invertebrates (Barton and Wallace 1980) and are caused by few organisms which dominate the community. Low values of diversity that occur in the spring and fall (Figure 32) appear to be caused by excessively large populations of Corixids (Hemiptera). The values of 1.05 that was obtained at Control A sites during the week of Sept. 24-28 is due to high numbers of Corixids which accounted for over 83% (by number) of the samples. The value of 2.29 obtained at the Control A sites during the week of May 7-11 is also due to high numbers of Corixids, which accounted for over 61% of the organisms collected.

Specificity of methoxychlor to black fly larvae vs. other invertebrate organisms has been discussed and debated to a considerable extent. Fredeen (1974) and Wallace et al. (1976) have stated that methoxychlor attaches to silt particles in water, which may make it more specific to filter feeders such as black flies. Wallace et al. (1973) pointed out a behavioural difference between black flies and many other invertebrate organisms which relates to specificity. Black flies extend their filter fans out into the current to capture more food. This would theoretically expose them to a greater amount of methoxychlor carried in the silt washload than insects which protect themselves from the water current by sheltering under rocks or burrowing, although these insects would be more susceptible to methoxychlor laden silt particles that settle out of the flow. Sebastien and Lockhart (1980) looked at a particulate formulation of methoxychlor and found it to be less directly toxic to laboratory fish and showed it to have promise in regards to increasing the specificity of methoxychlor to black flies. Haufe et al. (1980), using results from drift samples, indicated that increased drift of NTO's due to methoxychlor is only a temporary stimulatory effect and that casualty rates observed generally did not exceed the norm except for a few specific "sensitive" genera.

On the other hand, Wallace and Hynes (1975) reported "copious drift of aquatic insects...indicating that the impact of methoxychlor as a black fly larvicide is not confined to simuliid larvae". Flannagan et al (1979) showed that all non-target invertebrates were adversely affected by methoxychlor at the same time. Flannagan et al (1980) concluded that methoxychlor may be more specific to some non-targets than to Simulium. Gardner and Bailey (1975) stated that "methoxychlor is not specific for black fly larvae and consequently other species...are killed following black fly larviciding operations."

There are many different results and opinions in regards to the effect of methoxychlor on NTO's. Resolving the problem will not be an easy matter, as researchers work with different habitats, different water chemistry, different physical and hydrological characteristics and different sampling methods. Depner _et al_ (1980a) observed that when a low river discharge and a light silt load was present, control of black fly larvae was reduced and the effect of the treatment on NTO's was intensified. Therefore it appears that even the same system, under slightly different physical conditions, can result in a different impact on the aquatic biota.

One area of concern that has received little attention is the effect of invertebrate mortality due to methoxychlor treatments on the energy flow in the ecosystem. Although populations of NTO's generally return fairly soon to pre-treatment levels, the effect of the short-term disturbance on the standing crop and its subsequent repercussions on the overall flow of energy has not been examined in the Athabasca River system. Corbet (1958) looked at the effects of _Simulium_ control on insectivorous fishes and found that many fish quickly adapted to a reduction in their prime food source and switched to alternate food sources or moved to a more favorable habitat. Lockhart (1980), after the 1974 treatment of the Athabasca River, found low blood serum protein levels in one sample of white suckers seven weeks after treatment which is consistent with data obtained in starvation trials in the laboratory.

The effect of more than one methoxychlor treatment per year on NTO's has not been examined before on the Athabasca River. Black fly larval populations were significantly higher in 1979 and necessitated a second treatment. The impact on NTO's appears to have been slight, perhaps due to the high discharge rates that occurred in 1979. However the impact on fish was not examined in 1979. Gardner and Bailey (1975) discussed the posssible effects of multiple stream treatments on fish:

> "Laboratory exposure to methoxychlor (10-40 ppb) for a 3 day period does result in a number of pathological changes in fish... The changes are reversible, usually requiring at least a 2 week period after peak tissue residue concentrations are reached before repair occurs. Thus the frequency of larviciding operations could become very important. If a second stream treatment is carried out before the tissue damage has been repaired, further tissue damage compounds that which already exists. Therefore, at least in theory, even relatively minor pathological changes could, in time, become severe enough to seriously affect the survival of fish repeatedly exposed to the pesticide. The possibility thus exists for a slow decline in fish populations which would be more difficult to detect than a sudden massive fish kill."

Lockhart (1980), in his work on the Athabasca River research program, also observed a two week period was required for the clearance of most methoxychlor residues from fish.

Thus it appears that more than one treatment of the Athabasca River in a single season (which was not examined during the research program) has the potential of directly affecting the pathological state and subsequent survival of fish populatons. High discharge rates during the 1979 treatments likely acted as a flushing mechanism, limiting the exposure of fish and non-target invertebrates to methoxychlor but low river discharge rates may increase the exposure time of non-target organisms. The second river treatment in 1979 was effective in reducing larval black fly populations, but we must ask the question of whether it will have a detrimental impact over the long term on the river's biota. From results obtained during the research program, single treatments per season do not appear to have a long term impact on non-target invertebrate populations (Depner et al 1980b) or on fish (Lockhart 1980) but multiple treatments were not included in the scope of the research program.

The reproductive capabilities of a river the size of the Athabasca are enormous (as proven by numerous black fly outbreaks). To fully understand the communities and relationships in this river system may never be accomplished. An indication of acceptable damage to the system (if any damage at all is acceptable) may be all that will be developed. There are too many questions left unanswered to ignore this problem, at least while chemical control of black fly larvae in the Athabasca River is still being conducted.

Residues in Silt

Due to the fact that the analysis procedure used by the Pollution Control Laboratory had a detection limit (100 ppb) of one-third the treatment concentration (300 ppb), the results that were obtained are not indicative of methoxychlor levels in the silt bedload of the river. Rather they are only able to indicate if large accumulations of methoxychlor occurred in the silt bedload.

The pre-treatment sample that was obtained on July 11 at site D5 and contained 778 ppb of methoxychlor is open to questioning. Charnetski (personal communication, 1979) suggested that a pocket of methoxychlor may have been left from the 1974-76 research program treatments or the June 1979 treatment and may have been disturbed due to the rising water levels that occurred on July 11. The author feels that contamination of the sampling apparatus may have occurred at the treatment site and subsequently contaminated the silt sample at site D5.

Although the results obtained from the silt samples are not able to show residue levels of methoxychlor in the river silt, they do show that no accumulation of methoxychlor in the silt bedload occurred in 1979. This concurs with what Charnetski, Depner and Beltaos (1980) have indicated in their research work, that when river flows are high, very little deposition of silt occurs and loss of methoxychlor to the bedload is reduced.

Residues in Water

From the data presented on methoxychlor residues in water, it appears that the methoxychlor had either broken down or dissipated from 300 ppb concentration at the treatment site (145 km) to a 3.5 ppb concentration at Fort McMurray (395 km downstream of the Town of Athabasca). As the methoxychlor was in the river for approximately 36 hours by the time it reached Fort McMurray, it is quite likely that some degradation of the chemical occurred. Also, the length of the chemical treated slug of water was estimated to be about 24 hours long at Fort McMurray, as compared to 7.5 minutes at the treatment site, increasing the dilution of the methoxychlor.

The water treatment plant was unable to shut down its fresh water intake as the chemical was passing and the results indicate that a trace of methoxychlor was picked up by the water intake and deposited in the storage pond. The sample that was obtained from the treated drinking water supply did not have any detectable levels of methoxychlor.

Although data is limited, it appears that methoxychlor is broken down by photodegradation and microbial degradation (Gardner and Bailey 1975). They also indicated that methoxychlor is readily metabolized in mammals by the liver. Health and Welfare Canada (1978), in establishing Canadian drinking water standards, designated up to 100 ppb as allowable levels of methoxychlor in drinking water.

From the results obtained and the established guidelines set out, it is apparent that there was no significant danger to the drinking water supply at Fort McMurray for the July 1979 treatment. Charnetski, Depner and Beltaos (1980) detected maximum concentrations of methoxychlor after river treatments in Athabasca River water at Fort McMurray of 0.4 ppb in 1974, 0.13 ppb in 1975 and 0.2 ppb in 1976. It is evident that over the four treatment years that water samples were obtained at Fort McMurray, levels of methoxychlor in the river water did not exceed Health and Welfare Canada's guidelines for residue levels. Nevertheless, water sampling should be continued for future treatments as the established guidelines may be lowered with the development of new analytical techniques or new information regarding the toxicity of methoxychlor or its breakdown products is discovered.

<u>High Speed Adult Sweeps</u>

In taking the adult activity data and conjugating it with larval growth and development, the process of following the chronological sequence of larval growth, pupation and emergence as adult black flies was attained. By correlating the larval and adult information, the independent observations were reinforced and clarified.

One of the situations encountered in 1979 was that the results indicated three larval population peaks (Figure 5) and only two adult population peaks (Figure 34). We know that the first two larval peaks were affected by methoxychlor treatments while the third was not. We also know that the August adult peak was the most pronounced, and that the larval population preceeding it was not affected by methoxychlor. This suggests that the June and July adult population peaks were affected considerably by the methoxychlor treatments. Very few adults were observed in early June, indicating that the treatment in June was effective in reducing black fly populations while the peak in adult numbers in July indicates that the July treatment had less of an effect on reducing black fly populations. This may be because larval development was less synchronous than in May and either some larvae emerged prior to treatment, or some emergence occurred upstream of the treatment point (145 km), or reinfestation of the treated area from upstream caused post-treatment emergence from the treated area.

One of the observations made in the results was that some upstream shifts in adult numbers occurred at various times over the summer. This upstream shift in adult populations was also observed in 1978 (Pledger and Byrtus 1980). Also, Depner et al (1980a) were able to determine upstream migration of adult black flies along the Athabasca River. Other authors (Baldwin, Allan and Slater 1966, Waters 1972) have described upstream movement of other insects as well as black flies, possibly as a recolonization process to alleviate downstream drift of larval stages of insects and subsequent decolonization of upper reaches of streams and rivers. Another possibility is that upstream movement may occur due to the proximity of available host material in the upper reaches of the study area (0-80 km). This hypothesis also considers that the prime larval habitat occurs in the lower reaches of the study area (80-200 km). Another possibility for the higher adult numbers on the river in the vicinity of the farming area is the return of females to deposit their eggs in the river. The data indicates that the adults emerge primarily from the downstream reaches of the study area and fly upriver. This is due to the natural upstream migration of winged adult insects that are aquatic in their immature form and because of the proximity of large numbers of host animals in the farming area adjacent to the 0-80 km reach of the river.

Wolfe and Peterson (1960) in their work along the St. Lawrence River in Quebec observed diurnal peaks in adult activity at 1 to 2 hours after dawn and 1/2 to 1 hour before sunset. Their observations relate in a general way to our observations of 1979 (Figure 35). The peak in adult activity in the morning is about 5-6 hours after sunrise, however high humidity (90-95%) and cool temperatures (6-8°C) would restrict activity until closer to mid-day when temperatures would have warmed up and the humidity would have dropped. The peak in adult activity in the evening is quite considerable and can be related to a number of climatic factors i.e decreased wind velocity, optimum temperature and humidity levels, and optimum light intensity. Wolfe and Peterson (1960) observed that reflected light intensities between 1 and 25 foot-candles were associated with high levels of activity and light intensities above 25 foot-candles with low levels of activity. They concluded that only extremes of relative humidity (below 25% or above 95%), temperature (below 7°C or above 32°C) and wind velocities above 3 km per hour had any influence on the diurnal activity of black flies. Changing light intensity was suggested as the major factor in controlling diurnal rythym. They cite a number of authors (Dalmat 1955, Dyson-Hudson 1956, Lumsden 1952, and Haddow 1956) who also indicated that light intensity is a major factor in the diurnal behaviour of biting flies.

Barrel Traps

In comparing adult activity during 1979 as measured by barrel traps (Figure 36) with adult activity measured by sweeping (Figure 34), it is evident that two peaks were obtained with both methods. However on closer examination, the peaks do not align in the same time frame. In July, the peak in adult activity measured by sweeps occurs on July 10, while the peak measured by the barrel traps occurs during the sampling period ending July 17. This suggests that activity was high during the week of July 10-17. Barrel traps along the river in the two weeks previous showed fairly high activity while the traps on the farm did not. This indicates that the flies were emerging in this period and did not reach the farm in numbers until the July 17 sampling period.

The second peak of adult activity measured by the barrel traps occurred in early September (Figure 36) while the second peak in activity as measured by sweeps occurred in mid-August (Figure 34). This is a considerable discrepancy and is thought to be due to a shift in activity from the river to the farm. Unfortunately, no barrel trap samples were obtained along the river in late August, and it is quite likely that adult populations would have peaked then instead of early September.

The other possibility is that the adult activity measured by the sweeps was not indicative of adult populations and that the adult populations were actually higher in early September. Shemanchuk (personal communication, 1979) indicated that adult black flies were most numerous in the farming area in September, and this corresponds to our barrel trap results.

Relatively speaking though, the peaks along the river indicates that adult activity was more predominant in July than in September, and the data from the farm indicates that adult activity there was more predominant in September than in July.

The effect of the methoxychlor treatments on adult populations in the farming area is well described by the barrel trap data. It is apparent that the June treatments were effective in preventing large numbers of black flies from reaching the farming area, as very few flies were collected in June (Figure 36). The July treatment was not as effective, but this is likely due, as discussed in the adult sweeps section, to a wide range of larval development, and reinfestation or emergence from the area upstream of the treated reach. The August population, which was allowed to develop unchecked, produced the largest amount of flies collected, even though the larval populations at the time were the lowest (Appendix 1).

Figure 37, which describes the adult black flies collected on barrel traps along the river, shows that very few flies were ever collected at U1 (20 km upstream of the Town of Athabasca). This suggests that the extent of black fly activity is limited to the region downstream of the Town of Athabasca. In assessing the larval collection data (Appendix 1) and reports of problems related to adult black flies (Anonymous, 1972), this does appear to be the case.

Upon sorting and counting the black flies from the barrel traps, several limitations to the method and to our technique became apparent. The primary limitation is that identification of black flies could not be carried out due to dehydration and distortion caused by the plastic covering although handling of the samples in the field was simplified by using the plastic covering. Another limitation was the relatively few numbers collected along the river. Baiting of the traps with CO_2 would improve the capture rate, however problems in handling CO_2 along the river and in the boat precluded using it as a bait material. The difference between the numbers collected on the farm and along the river indicated the difference that bait (in the form of cattle) makes on collection numbers. Also recognized was that insufficient traps were set out along the river to obtain an accurate indication of adult activity over the length of the monitored reach.

CONCLUSIONS

1. Three distinct populations of black fly larvae were observed in the Athabasca River in 1979. Treatment of the Athabasca River with 300 ppb methoxychlor had an extremely adverse effect on larval black fly populations for at least 140 km for the June 7 treatment and for at least 250 km for the July 11 treatment.

2. Population reductions for some sensitive non-target invertebrates were observed, however these reductions were short term (except for *Isogenus*) and populations were overall back to control site levels within 4 weeks of each treatment.

3. Results from residue analysis of silt samples indicated that methoxychlor did not accumulate in the river bottom silt.

4. Results from residue analysis of water samples obtained at Fort McMurray indicated that levels of methoxychlor in river water were well below those levels permitted by Health and Welfare Canada.

5. Adult activity (as measured by sweeps above the river surface) correlated to expected adult emergence determined from larval development. The effect of methoxychlor treatments on altering adult black fly populations was determined to be significant.

6. Adult activity (as measured by barrel trap samples along the river and in the farming area) correlated to expected adult emergence and to adult activity measured by sweeps. The barrel trap samples also indicated the impact of methoxychlor treatments on reducing adult black fly populations in the farming area.

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	MAY					JUNE				JULY				AUGUST			SEPTEMBER	
Site	14-18	21-25	28-1	5	9	12	18-22	25-29	2-6	10	12	16-20	23-27	30-3	6-10	13-17	3-7	24-28
U1 (-20 km)	148	11	177	43	-	5 (4)	8	82	9	-	20	8	7	14	5	3	1	0
D1 (40 km)	19	21	53	30	18	23	14	38	12 (4)	16	13	7	21	6	3	2	1	0
D2 (80 km)	370	54	2	57	9	22	10 (2)	38	13 (2)	58	93	10	48	18	15	15	2	1 (4)
D3 (120 km)	2694	880	1808	1156 (3)	49	26	12 (4)	256	253	73	76	3 (4)	91 (2)	94 (2)	13	11	9	9
D4 (160 km)	3073	745	17599	7277	11 (4)	95	15 (2)	178	1749	151	5	3 (4)	138	85	19	8	7	6
D5 (180 km)	5692	134	17612	4751	55	152	0 (0)	1163 (5)	2508 (1)	4 (2)	19	0 (5)	388	216	122	20	8	6 (5)
D6 (200 km)	1053	415	3425	2742 (5)	140	79	7	2285	1787	1501	9	0 (3)	150	578 (4)	307	129	9	6
Fort McMurray (395 km)										826	25							
Overall Mean	1884	330	5811	2535	41	70	10.6	565	821	415	32	53	124	126	69	27	5.5	4.5

Appendix 1. Mean number of larvae per cone - total of six cones per site
(Numbers in brackets indicate number
of cones if less than six were obtained)

Larval		MAY				JUNE					JULY				AUGUST			SEPTEMBER
Instar	14-18	21-25	28-1	5	9	12	18-22	25-29	2-6	10	12	16-20	23-27	30-3	6-10	13-17	3-7	24-28
1	18.8	22.5	4.0	4.3	10.5	23.7	18.1	7.6	5.4	6.9	27.0	42.0	5.2	1.6	1.5	2.7	9.0	6.3
2	80.5	31.1	24.2	21.2	4.4	11.3	30.5	33.5	11.4	18.5	32.3	31.5	26.1	13.2	7.1	9.7	19.3	47.4
3	0.7	31.9	17.8	22.8	5.5	4.6	6.9	23.5	11.1	7.9	10.7	10.5	22.4	16.5	7.6	7.0	18.0	15.4
4	0.0	14.5	20.1	18.5	9.5	11.0	12.3	15.3	21.7	7.3	8.4	4.4	26.7	19.0	9.7	9.4	7.7	12.0
5	0.0	0.0	32.1	22.5	15.9	14.7	12.3	11.2	26.4	12.7	5.9	2.2	14.3	21.2	18.5	17.2	11.6	10.9
6	0.0	0.0	1.8	7.5	15.2	13.4	13.4	6.0	12.3	16.3	4.9	5.5	2.3	12.4	16.6	13.7	9.9	7.4
7	0.0	0.0	0.0	3.2	33.3	21.3	6.5	2.6	11.5	30.2	9.1	3.3	2.8	15.5	36.4	38.7	20.6	0.0
Pupa	0.0	0.0	0.0	0.0	5.7	0.0	0.0	0.3	0.2	0.2	1.7	0.6	0.2	0.6	2.6	1.6	3.9	0.6
N Larvae	79131	13868	244049	96332	1659	2382	276	23168	25447	10796	1412	181	4699	4536	2900	1120	233	175
Cones	42	42	42	38	40	34	26	41	31	32	42	34	38	36	42	42	42	39

Appendix 2. Larval Development Distribution (%) $\bar{x}$ of seven sites

APPENDIX 3

List of Invertebrate Genera Collected From Athabasca River - 1979

CLASS	ORDER	FAMILY	GENUS
Arachnoides	Hydracarina	Hydrachnidae	*Hydrachna*
Crustacea	Amphipoda	Gammaridae	*Gammarus*
	Amphipoda	Talitridae	*Hyallela*
	Cladocera	Daphnidae	*Daphnia*
	Mysidaecea	Mysidae	*Mysis*
Gastropoda	-	-	-
Insecta	Coleoptera	Amphizoidae	*Amphizoa*
	Coleoptera	Chrysomelidae	*Donacia*
	Coleoptera	Chrysomelidae	*Galerucella*
	Coleoptera	Dytiscidae	*Hydrocanthus*
	Coleoptera	Dytiscidae	*Hydrovatus*
	Coleoptera	Elmidae	*Optioservus*
	Coleoptera	Gyrinidae	*Gyrinus*
	Coleoptera	Haliplidae	*Haliplus*
	Coleoptera	Hydrophilidae	*Cercyon*
	Coleoptera	Hydrophilidae	*Paracymus*
	Diptera	Ceratopogonidae	*Culicoides*
	Diptera	Chironomidae	-
	Diptera	Dolichopodidae	-
	Diptera	Empididae	*Hemedromia*
	Diptera	Rhagionidae	*Atherix*
	Diptera	Simuliidae	*Simulium*
	Diptera	Tipulidae	*Pedicia*
	Ephemeroptera	Baetidae	*Baetis*
	Ephemeroptera	Baetidae	*Centroptilum*
	Ephemeroptera	Baetidae	*Metropus*
	Ephemeroptera	Baetidae	*Neocleon*
	Ephemeroptera	Ametropodidae	*Ametropus*
	Ephemeroptera	Caenidae	*Caenis*
	Ephemeroptera	Ephemerellidae	*Ephemerella*
	Ephemeroptera	Heptageniidae	*Cinygma*
	Ephemeroptera	Heptageniidae	*Epeorus*
	Ephemeroptera	Heptageniidae	*Heptagenia*
	Ephemeroptera	Heptageniidae	*Rhithrogena*
	Ephemeroptera	Heptageniidae	*Stenonema*
	Ephemeroptera	Leptophlebidae	*Leptophlebia*
	Ephemeroptera	Metretopididae	*Metretopus*
	Ephemeroptera	Metretopididae	*Siphloplecton*
	Ephemeroptera	Siphlonuridae	*Ameletus*
	Ephemeroptera	Siphlonuridae	*Isonychia*
	Ephemeroptera	Tricorythidae	*Tricorythodes*

APPENDIX 3 (Continued)

CLASS	ORDER	FAMILY	GENUS
Insecta	Hemiptera	Corixidae	-
	Lepidoptera	Arctiidae	-
	Plecoptera	Chloroperlidae	*Hastaperla*
	Plecoptera	Chloroperlidae	*Alloperla*
	Plecoptera	Nemouridae	*Brachyptera*
	Plecoptera	Nemouridae	*Nemoura*
	Plecoptera	Perlidae	*Acroneuria*
	Plecoptera	Perlidae	*Classenia*
	Plecoptera	Perlidae	*Neoperla*
	Plecoptera	Perlodidae	*Arcynopteryx*
	Plecoptera	Perlodidae	*Isogenus*
	Plecoptera	Perlodidae	*Isoperla*
	Plecoptera	Pteronarcidae	*Pteronarcys*
	Plecoptera	Pteronarcidae	*Pteronarcella*
	Trichoptera	Brachycentridae	*Brachycentrus*
	Trichoptera	Hydropsychidae	*Arctopsyche*
	Trichoptera	Hydropsychidae	*Cheumatopsyche*
	Trichoptera	Hydropsychidae	*Hydropsyche*
	Trichoptera	Hydropsychidae	*Diplectrona*
	Trichoptera	Hydroptilidae	*Neotrichis*
	Trichoptera	Glossosomatidae	*Agapetus*
	Trichoptera	Glossosomatidae	*Glossoma*
	Trichoptera	Leptoceridae	*Mystacides*
	Trichoptera	Leptoceridae	*Trianodes*
	Trichoptera	Leptoceridae	*Oecetis*
	Trichoptera	Limniphilidae	*Limnephilus*
	Trichoptera	Limniphilidae	*Platycentropus*
	Trichoptera	Limniphilidae	*Pycnopsyche*
	Trichoptera	Psychomyiidae	*Polycentropus*
	Trichoptera	Rhyacophilidae	*Rhyacophila*
	Odonata	Gomphidae	*Ophiogomphus*
Oligochaeta	-	Naididae	*Stylaria*
Pelecypoda	-	-	-

Sampling Date	Total Flies	No. of Sweeps	Mean Flies/Sweep
June 12	86	24	3.58
June 19	51	49	1.04
June 26	180	23	7.82
July 5	415	51	8.14
July 10	366	32	11.44
July 17	453	52	8.71
July 24	245	49	5.00
July 31	122	45	2.71
Aug. 8	143	51	2.80
Aug. 15	1231	52	23.67
Aug. 28	508	49	10.37
Sept. 5	96	35	2.74
Sept. 19	50	21	2.38

Appendix 4 - Adult Activity over Summer, High Speed Adult Sweeps

		June				July				August					September				Overall		
		5	12	19	26	5	11	17	24	1	8	15	23	30	5	13	20	24	TΣ	$\overline{X}$	S.D.
	U1	0	1	0	0	0	0	1	1	1	0	5			5			0	14	1.08	1.80
	D1	0	0	0	0	4	5	9	14	2	2	2			15			6	59	4.54	5.19
	D2	0	1	3	2	5	54	7	5	1	0	0			1			3	82	6.31	14.50
	D3	0	0	24	13	-	26	9	19	-	-	5			6			8	110	11.00	9.30
	D4	0	2	0	3	31	2	83	20	0	1	1			6			1	150	11.54	23.41
	D5	0	5	16	5	18	9	33	50	6	2	16			29			1	190	14.62	14.89
	D6	0	0	2	-	29	1	19	10	0	2	3			2			4	72	6.00	9.09
	Lantz	0	1	12	5	5	23	76	37	12	28	81	256	277	643	2533	129	212	4330	254.71	608.6
	Lantz	0	1	0	8	23	30	99	61	12	9	63	188	157	639	1668	87	32	3077	181	412.4
	TΣ	0	9	45	23	87	97	161	119	10	7	32			64			23			
River	$\overline{X}$	0	1.29	6.43	3.83	14.5	13.86	23	17	1.67	1.17	4.57			9.14			3.29			
	SD	0	1.8	9.62	4.88	13.46	19.83	28.43	16.12	2.25	.98	5.38			9.86			2.93			
	TΣ	0	2	12	13	28	53	175	98	24	37	144	444	434	1282	4201	216	244			
Lantz's	$\overline{X}$	0	1	6	6.5	14	26.5	87.5	49	12	18.5	72	222	217	641	2100.5	108	122			
	SD	0	0	8.49	2.12	12.73	4.95	16.26	16.97	0	13.44	12.73	48.08	84.85	2.83	611.65	29.7	127.28			

Appendix 5 Adult Black Flies Collected on Barrel Traps Along River and Lantz's Farm