The aquatic insects of Bluewater Creek, Montana, above and below an area of intensive agriculture
by Gordon Frederick Zillges

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Fish and Wildlife Management
Montana State University

Abstract:
A study comparing the aquatic insects above (Station 1) and below (Station 2) an area of intensive agriculture was conducted on Bluewater Creek from September, 1969 through August, 1970., There were greater fluctuations of flow, temperature ranges and sediment loads at Station 2. A total of 42 taxa was collected at Station 1 and 26 at Station 2. Ephemeroptera was numerically dominant in bottom and day-drift samples from Station 1 while Diptera was dominant at Station 2. Much greater numbers of Plecoptera and Coleoptera were collected at Station 1 than at Station 2. Peak numbers of benthic and drifting insects occurred during different months at Station 1 than at Station 2. The difference between the two insect communities were probably the result of changes in characteristics of the stream caused by intensive agriculture.

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Date June 9, 1971

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ABSTRACT

A study comparing the aquatic insects above (Station 1) and below (Station 2) an area of intensive agriculture was conducted on Bluewater Creek from September, 1969 through August, 1970. There were greater fluctuations of flow, temperature ranges and sediment loads at Station 2. A total of 42 taxa was collected at Station 1 and 26 at Station 2. Ephemeroptera was numerically dominant in bottom and day-drift samples from Station 1 while Diptera was dominant at Station 2. Much greater numbers of Plecoptera and Coleoptera were collected at Station 1 than at Station 2. Peak numbers of benthic and drifting insects occurred during different months at Station 1 than at Station 2. The difference between the two insect communities were probably the result of changes in characteristics of the stream caused by intensive agriculture.

INTRODUCTION

Many streams in the western United States are influenced by irrigational activities and agricultural land-use practices. In 1962 the Montana Fish and Game Department began a series of studies to determine the affects of these activities and practices on Bluewater Creek (Peters 1965, 1967 and 1971; Bianchi 1963). These studies indicated irrigation and intensive agricultural land-use caused greater flow fluctuations, temperature modifications and increased sediment loads in the stream.

Changes in stream flows, temperature ranges and sediment loads may affect communities of aquatic insects. Anderson and Lehmkuhl (1967) found small increases in flow had a scouring effect and resulted in increased numbers of drifting insects. Powell (1958) reported large reductions in numbers of Ephemeroptera, Plecoptera and Trichoptera as a result of large diurnal fluctuations and reduced minimum flows below a power dam. Aquatic insects show temperature preferences (Dodds and Hisaw 1925; Armitage 1958), thus modification of temperatures in a stream may result in communal changes. Increased sediment loads may result in increased deposition of sediments. Cordone and Kelly (1961) reviewed the literature on sediment and concluded deposition of sediments could destroy populations of insects.

The present study was undertaken to compare benthic and drifting insects above and below an area of irrigational activity and intensive agriculture. Field collections were made from September, 1969 through August, 1970.

METHODS

Two riffles (Stations 1 and 2) were selected for the sampling of benthic insects (Figure 1). A fixed station for sampling drifting insects was established immediately above each riffle. Chemical and physical data were collected at each station on each sampling date. A Beckman pocket pH meter (Model 180) was used to obtain pH readings. Alkalinity, dissolved oxygen and total hardness were determined using a Hach chemical kit (Model DR-EL). Daily flow, temperature and sediment data were obtained from the United States Geological Survey.

Insect samples were collected monthly from September, 1969 through May, 1970 and twice monthly from June, 1970 through August, 1970. A minimum of 2 weeks separated consecutive sampling periods.

Benthos samples were collected with a Surber sampler having 25 meshes per 2.54 cm. Three 0.09 m^2 samples were collected along a transect in each riffle on each sampling date. The initial transect was established at the lower end of each riffle and succeeding transects were positioned about 0.9 m upstream from the preceding one. A minimum of 4 months elapsed before an area was resampled. All samples were taken in water with depths of 0.15 to 0.45 m.

Drift samples were collected in a net having a nylon bag (7.9 meshes/cm) 1 meter in length attached to a brass frame with an opening of 15.2 x 60.9 cm. Two drift samples were collected from each station

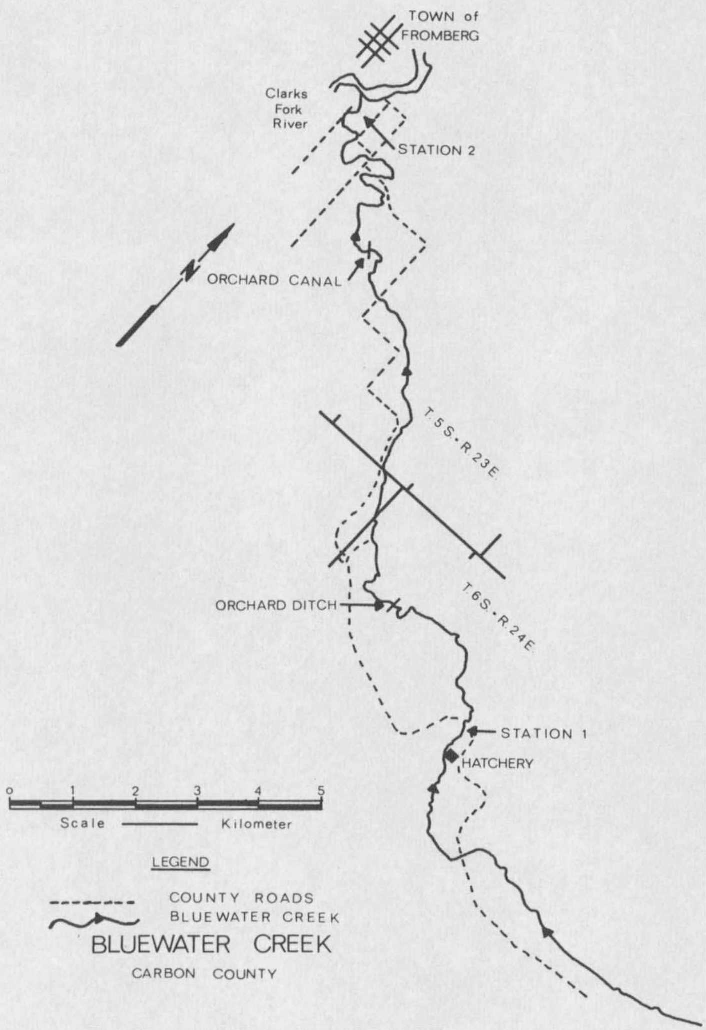

Figure 1. Map of Bluewater Creek showing location of irrigation canals and study stations.

on each sampling date. One drift sample from each station was taken during the day and another 2-3 hours after sunset. Drift samples were of 30 minutes duration and were taken midway between the bottom and surface of the stream. The velocity of the water was determined with a Gurley current meter immediately previous to taking each drift sample.

Bottom and drift samples were preserved in the field with 10% formaldehyde. Insects were separated from vegetation and bottom materials in the laboratory by the sugar flotation technique (Anderson 1959). Insects in each sample were sorted to taxon, counted, measured volumetrically to the nearest 0.1 cc and preserved in 40% isopropyl alcohol. Taxa measuring less than 0.1 cc per sample were recorded as having trace (T) volumes. Numbers and volumes of drifting insects were calculated for 50.8 m^3 of discharge.

DESCRIPTION OF STUDY AREA

Study Stream

Bluewater Creek flows northwesterly from its origin in the foothills of the Pryor Mountains 24.2 km to its confluence with the Clarks Fork of the Yellowstone River near Fromberg, Montana (Figure 1). Elevation of the stream ranges from approximately 4200 feet near its headwaters to about 1077 m near its mouth (Aagaard 1969). The stream has an average width of about 3 m in its upper 5 km and 5 m in its lower 19 km (Bianchi 1963). Bottom materials in order of decreasing abundance are gravel, rubble and silt in the upper portion of stream and silt, gravel and rubble in the lower portion (Bianchi 1963).

Bluewater Creek received about 49 m^3/min of water from artesian springs and a well within its upper 6 km (Peters 1971). Flow in the lower 18 km of stream was usually about 51 m^3/min. Flows and temperatures fluctuated less and sediment loads were lower in the upper 10 km of stream than in the lower 14 km (Peters 1971).

Grazing was the major land-use along the upper 10 km of Bluewater Creek. Only small amounts of water were diverted for irrigation from this portion of the stream. Along the lower 18 km of stream cultivation was intensive, and large amounts of water were diverted for irrigation. The largest amount of water was removed approximately 10 km below the source of the stream through the Orchard Ditch. This ditch had an initial capacity of 68 m^3/min, an overall length of 10 km and was in operation from about June 1 through September 30, 1970.

Small and varying amounts of water removed through the Orchard Ditch returned to Bluewater Creek through natural drainages. Twelve miles below its source, the stream received irrigation waste water from the Clarks Fork River by way of the Orchard Canal Irrigation Project. This project had 31 km of main ditch, a capacity of 255 m^3/min and was in operation from approximately April 15 through November 15, 1970.

Salix and *Betula occidentalis* were abundant on streambanks along the upper half of the stream. Common aquatic plants in the upper portion of the stream were *Berula erecta*, *Rorippa nasturtium-aquaticum*, *Zannichellia*, *Chara*, *Vaucheria*, and an unidentified moss and leafy liverwort. Little woody vegetation occurred on streambanks along the lower portion of the stream. *Cladophora* was the only common aquatic plant in the lower portion of the stream.

Sampling Stations

Station 1 was located approximately 6 km below the source of the stream in an area of little cultivation or irrigational activity. Station 2 was located about 24 km from the source of the stream below an area of intensive cultivation and irrigational activity. Both study riffles had similar substrates (Table 1).

Table 1. Composition of bottom materials in two 0.09 m^2 samples from each study riffle.

Class	Size (mm)	Percent of Total Volume	
		Station 1	Station 2
Cobble			
Large	>50.8	20.15	15.52
Medium	38.1-50.8	17.15	23.61
Small	19.1-38.1	38.80	34.39
Pebble	4.76-19.1	18.15	19.37
Gravel	2.00-4.76	3.50	3.21
Sand	<2.00	2.25	3.90

RESULTS

Chemical-Physical Data

Mean monthly maximum and minimum temperatures were higher at Station 1 than at Station 2 during all months of the year except July, August and September (Table 2). Temperatures ranged between 18 and 5.5 C at Station 1 and 25 and 0.0 C at Station 2.

Stream discharge was more stable at Station 1 than at Station 2 (Table 3). Discharge at Station 1 ranged from a high of 56.3 m^3/min during May to a low of 44.2 m^3/min during September. At Station 2 discharge ranged from 202.0 m^3/min in May to 33.0 m^3/min during July. The greatest variations in discharge at Station 2 occurred during the irrigation season, April through October.

Mean monthly sediment loads were always smaller at Station 1 than at Station 2 (Table 3). Sediment loads at Station 1 ranged from 25.3 metric tons/day during May to 3.2 metric tons/day in February. At Station 2 they ranged from 1295.0 metric tons/day in May to 5.8 metric tons/day in February. Greatest sediment loads were recorded during April, May and June when runoff and irrigation wastewater were maximum.

Alkalinity, dissolved oxygen and pH were similar at Stations 1 and 2, but total hardness averaged 165 ppm higher at Station 1 (Table 4).

Table 2. Mean monthly maximum and minimum temperatures (C) at sampling stations (from USGS data).

Stations	1		2	
Date	Max.	Min.	Max.	Min.
1969				
September	15.6	13.9	15.6*	13.9*
October	11.7	11.1	7.8	6.7
November	11.1	10.0	5.6	4.4
December	10.6	9.4	4.4	3.9
1970				
January	9.4	8.3	2.8	1.7
February	10.6	10.0	6.1	5.6
March	10.6	8.3	6.7*	6.1*
April	11.7	10.0	8.3	7.2
May	15.6	13.3	13.9*	12.2*
June	17.8	14.4	17.2	13.3
July	17.8	15.0	22.8	17.8
August	17.2	15.0	20.6	16.7

* Means based on incomplete records.

Table 3. Mean monthly discharges (m^3/min) and sediment loads (metric tons/day) at sampling stations (from USGS data).

Stations	Discharge 1	Discharge 2*	Sediment 1	Sediment 2*
Date				
1969				
September	44.2	100.3	3.7	51.9
October	50.5	122.9	3.8	42.8
November	53.4	58.7	3.2	11.4
December	51.3	51.0	4.0	7.4
1970				
January	51.0	50.2	3.7	6.8
February	50.8	49.3	3.2	5.8
March	52.9	60.0	3.7	59.4
April	54.1	71.1	4.3	121.0
May	56.3	202.0	25.4	1299.3
June	52.4	150.1	8.2	84.2
July	50.5	33.0	3.9	14.5
August	47.4	47.1	3.7	24.0

* Means based on incomplete records.

Table 4. Maximum, minimum and mean values of 4 chemical characteristics at sampling stations from September, 1969 through August, 1970.

Stations	1	2
Alkalinity (as ppm $CaCo_3$)		
Maximum	200	250
Minimum	107	105
Mean	176	179
Dissolved Oxygen (ppm)		
Maximum	9.5	10.5
Minimum	8.0	8.0
Mean	8.6	9.1
pH		
Maximum	8.4	8.6
Minimum	7.7	7.9
Total Hardness (as ppm $CaCo_3$)		
Maximum	1050	1010
Minimum	850	385
Mean	907	741

Benthos

The total number of insects collected at Station 1 was 5482 and at Station 2 was 5323 (Table 5). Numbers of insects collected at Station 1 ranged from a high of 762 in July to a low of 104 in October and at Station 2 from 884 in August to 34 in May. The total volume of insects collected at Station 1 (26.7 cc) was approximately twice that collected at Station 2 (13.9 cc). The volume of insects collected at Station 1 ranged from a high of 5.0 cc in December to a low of 0.2 cc in October and at Station 2 from 2.4 cc in February to less than 0.1 cc in July.

Plecoptera---About 18 times more stoneflies were collected at Station 1 (690) than at Station 2 (38). They made up 13% of total insect numbers collected at Station 1 and 1% at Station 2. The total volume of stoneflies collected at Station 1 (3.2 cc) was 8 times greater than at Station 2 (0.4 cc). Volume of stoneflies constituted 12% of the volume for all insects collected at Station 1 and 3% at Station 2.

Four taxa of stoneflies were collected with 3 occurring at each station. *Isoperla* accounted for 94% of all stoneflies collected at Station 1 and 92% at Station 2. It made up 97% of the total volume of stoneflies collected at Station 1 and 50% at Station 2.

Table 5. Numbers and volumes (cc) of insects collected from benthic (4.2 m^2) and drift (per 762 m^3) samples from September, 1969 through August, 1970. (Volumes in parentheses). T = Trace.

Sample Type	Bottom		Day-Drift		Night-Drift	
Station	1	2	1	2	1	2
PLECOPTERA	690 (3.2)	38 (0.4)	11.0 (T)	1.0 (T)	156.6 (1.0)	4.5 (T)
Kathroperla sp.	42 (T)	1 (T)			1.5 (T)	
Nemoura sp.			0.8 (T)		4.0 (T)	
Acroneuria sp.	2 (0.1)					
Isogenus sp.		2 (0.2)				
Isoperla spp.	646 (3.1)	35 (0.2)	10.2 (T)	1.0 (T)	151.1 (1.0)	4.5 (T)
EPHEMEROPTERA	1935 (5.0)	1496 (2.5)	45.1 (T)	51.5 (T)	595.9 (2.7)	384.8 (0.6)
Baetis parvus	788 (0.8)	633 (1.0)	25.3 (T)	43.4 (T)	405.6 (1.4)	337.9 (0.5)
Choroterpes albiannulata		2 (T)				1.3 (T)
Ephemerella inermis	1086 (4.2)	8 (T)	19.2 (T)	0.3 (T)	184.2 (1.3)	0.8 (T)
Tricorythodes minutus	61 (T)	825 (1.5)	0.6 (T)	7.5 (T)	6.1 (T)	16.6 (T)
Heptagenia elegantula		28 (T)		0.3 (T)		28.2 (0.1)

Table 5. Continued

Sample Type	Bottom		Day-Drift		Night-Drift	
Station	1	2	1	2	1	2
TRICHOPTERA	740 (6.7)	826 (4.1)	12.2 (T)	9.8 (T)	34.9 (0.2)	54.1 (0.3)
Brachycentrus sp.	5 (T)	3 (T)	0.8 (T)	0.3 (T)	1.0 (T)	2.9 (T)
Hydropsyche sp.	517 (6.5)	787 (4.1)	8.8 (T)	9.1 (T)	27.6 (0.1)	48.8 (0.3)
Ochrotrichia sp.	171 (T)	36 (T)	2.2 (T)	0.4 (T)	2.1 (T)	0.4 (T)
Rhyacophila acropedes	47 (0.2)		0.4 (T)		4.2 (0.1)	
COLEOPTERA	765 (T)	40 (T)	16.7 (T)	1.9 (T)	44.3 (T)	5.1 (T)
Helichus striatus			0.6 (T)		8.8 (T)	0.4 (T)
Agabus sp.					0.4 (T)	
Bidessus affinis			0.4 (T)		3.4 (T)	0.9 (T)
Deronectes griseostriatus			1.9 (T)		9.9 (T)	0.7 (T)
Hydroporus sp.	1 (T)					
Hygrotus sp.					0.3 (T)	
Laccophilus maculosus					1.4 (T)	
Elmidae					0.4 (T)	

Table 5. Continued

Sample Type	Bottom		Day-Drift		Night-Drift	
Station	1	2	1	2	1	2
COLEOPTERA, cont'd						
Optioservus ovalis	764 (T)	40 (T)	13.5 (T)	1.9 (T)	16.4 (T)	3.1 (T)
Dineutus sp.					0.3 (T)	
Gyrinus bifarius					0.3 (T)	
Haliplus borealis					1.0 (T)	
H. strigatus					0.8 (T)	
Peltodytes callosus					0.3 (T)	
Enochrus sp.					0.3 (T)	
Tropisternus sp.			0.3 (T)		0.3 (T)	
ODONATA		15 (2.2)				1.5 (0.2)
Ophiogomphus sp.		15 (2.2)				1.5 (0.2)
DIPTERA	1060 (11.8)	2572 (4.7)	34.8 (T)	56.6 (T)	47.9 (T)	63.4 (T)
Phaenicia sericata	1 (T)					0.3 (T)
Cecidomyiidae	1 (T)		0.3 (T)		0.3 (T)	

Table 5. Continued

Sample Type	Bottom		Day-Drift		Night-Drift	
Station	1	2	1	2	1	2
DIPTERA, cont'd						
Chironomidae	779 (T)	2254 (0.3)	16.0 (T)	39.3 (T)	16.6 (T)	45.9 (T)
Dixa sp.	2 (T)	4 (T)	2.1 (T)		2.1 (T)	0.9 (T)
Empididae Hemerodromiinae	95 (T)	192 (T)	2.2 (T)	3.1 (T)	1.3 (T)	2.6 (T)
Fannia sp.			0.3 (T)			
Lispoides aequifrons	2 (T)	1 (T)			0.4 (T)	
Pericoma sp.	4 (T)	2 (T)			2.3 (T)	
Simulium arcticum	10 (T)	24 (T)	8.5 (T)	14.2 (T)	16.4 (T)	10.8 (T)
Euparyphus sp.	3 (T)		1.0 (T)		4.1 (T)	
Sphaerophoria sp.					0.3 (T)	0.4 (T)
Tetanocera sp.					0.4 (T)	
Dicranota sp.	16 (T)	2 (T)	3.1 (T)		2.8 (T)	
Hexatoma sp.	120 (3.5)	92 (4.4)	1.0 (T)		0.6 (T)	0.9 (T)
Tipula sp.	27 (8.3)	1 (T)	0.3 (T)		0.3 (T)	1.6 (T)

Table 5. Continued

Sample Type	Bottom		Day-Drift		Night-Drift	
Station	1	2	1	2	1	2
UNIDENTIFIED PUPAE	292	336	121.8	40.3	117.9	44.0
TOTALS	5482 (26.7)	5323 (13.9)	241.6 (T)	161.1 (T)	997.5 (3.9)	555.4 (1.2)