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THE AQUATIC INSECTS OF BLUEWATER CREEK,
MONTANA, ABOVE AND BELOW AN AREA OF INTENSIVE AGRICULTURE

by

GORDON FREDERICK ZILLGES JR.

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Approved:

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Head, Major Department

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Chairman, Examining Committee

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Graduate Dean

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VITA

The author, Gordon Frederick Zillges Jr., was born in Appleton, Wisconsin, February 16, 1947, to Mr. and Mrs. Gordon F. Zillges. He graduated from Kimberly High School in Kimberly, Wisconsin in June of 1964. In September of 1964, he entered the University of Montana and received a Bachelor of Science degree in Wildlife Biology in March of 1969. He began graduate studies at Montana State University in June of 1969 as a Graduate Research Assistant with the Montana Cooperative Fishery Unit.

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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~~ 23 taxa was collected at Station 1 and ~~26~~ 22 at Station 2. Larger numbers of Ephemeroptera, Plecoptera, Coleoptera and fewer Diptera were collected from Station 1 than from 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. Much of the differences 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 affected 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 compositional 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

study (Figure 1)

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 and aquatic insects were collected at each station on each sampling date. monthly from Sept. 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~~

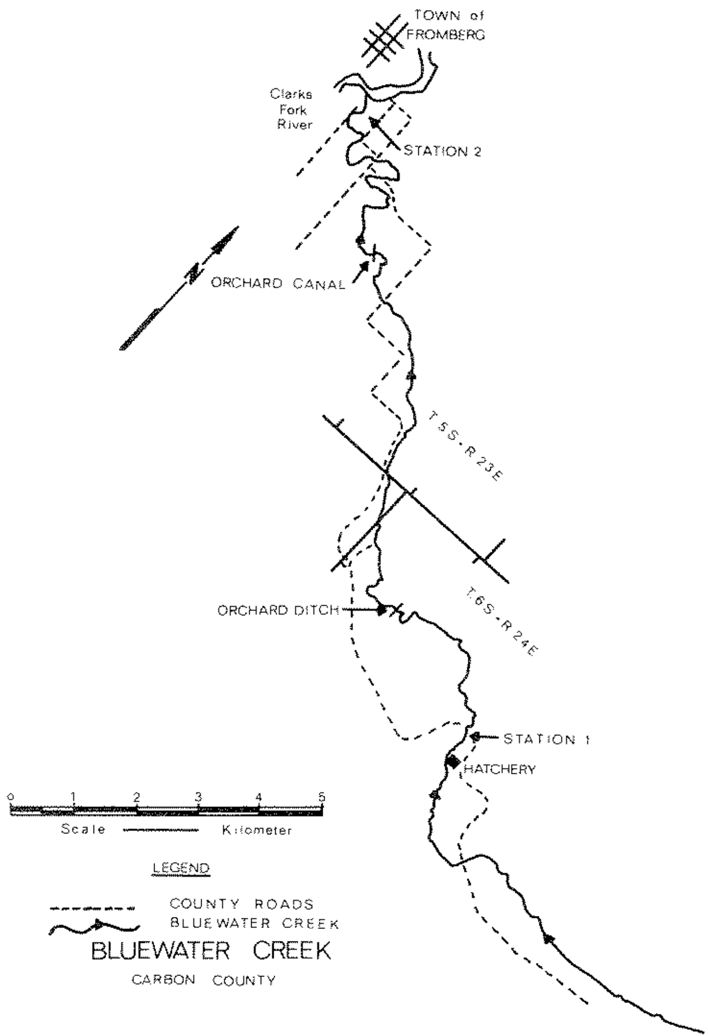

Figure 1. Map of Bluewater Creek showing location of irrigation canals and study stations.

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.

Benthos ~~Bottom and drift~~ samples were preserved in the field with 10% formalin. ~~formaldehyde.~~ Insects were separated from vegetation and bottom materials in the laboratory with the aid of ~~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 1280 m ~~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 14 ~~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).

— silt not measured

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 study 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 62.9 ~~56.3~~ m^3/min during June ~~May~~ to a low of 40.8 ~~44.2~~ m^3/min during September. At Station 2 discharge ranged from 375.7 ~~202.0~~ m^3/min in May to 8.7 ~~33.0~~ m^3/min during July. The greatest fluctuations ~~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 219.5 ~~25.3~~ metric tons/day during May to 1.7 ~~3.2~~ metric tons/day in February. At Station 2 they ranged from 3120.0 ~~1295.0~~ metric tons/day in May to 2.9 ~~5.8~~ metric tons/day in August ~~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~~ fewer 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~~ fewer 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 HCO_3	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
Mg & Ca, Na, K		
Total Hardness (as ppm $CaCo_3$)		
Maximum CO_3	1050	1010
Minimum SO_4	850	385
Mean Cl	907	741

Benthos

The total number of insects collected at Station 1 was 5482 and 5323 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.

4.2 m² of substrate

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	2254	16.0	39.3	16.6	45.9
	(T)	(0.3)	(T)	(T)	(T)	(T)
Dixa sp.	2	4	2.1		2.1	0.9
	(T)	(T)	(T)		(T)	(T)
Empididae	95	192	2.2	3.1	1.3	2.6
Hemerodromiinae	(T)	(T)	(T)	(T)	(T)	(T)
Fannia sp.			0.3			
			(T)			
Lispoides aequifrons	2	1			0.4	
	(T)	(T)			(T)	
Pericoma sp.	4	2			2.3	
	(T)	(T)			(T)	
Simulium arcticum	10	24	8.5	14.2	16.4	10.8
	(T)	(T)	(T)	(T)	(T)	(T)
Euparyphus sp.	3		1.0		4.1	
	(T)		(T)		(T)	
Sphaerophoria sp.					0.3	0.4
					(T)	(T)
Tetanocera sp.					0.4	
					(T)	
Dicranota sp.	16	2	3.1		2.8	
	(T)	(T)	(T)		(T)	
Hexatoma sp.	120	92	1.0		0.6	0.9
	(3.5)	(4.4)	(T)		(T)	(T)
Tipula sp.	27	1	0.3		0.3	1.6
	(8.3)	(T)	(T)		(T)	(T)

Table 5. Continued

Sample Type	Bottom		Day-Drift		Night-Drift	
Station	1	2	1	2	1	2
UNIDENTIFIED PUPAE	292 (T)	336 (T)	121.8 (T)	40.3 (T)	117.9 (T)	44.0 (0.1)
TOTALS	5482 (26.7)	5323 (13.9)	241.6 (T)	161.1 (T)	997.5 (3.9)	555.4 (1.2)

Ephemeroptera---A total of 1935 mayflies was collected at Station 1 and 1496 at Station 2. Mayflies made up 35 and 28% of all insects collected in the upstream and downstream riffles, respectively. The total volume of mayflies collected in the upper riffle (5.0 cc) was twice that of the lower (2.5 cc). Mayflies accounted for about 19% of the total insect volume collected at Station 1 and 18% at Station 2.

Five taxa of mayflies were collected. Three occurred in the upper riffle and 5 in the lower. *Ephemerella inermis*, *Tricorythodes minutus* and *Baetis parvus* accounted for 56, 3 and 40% respectively of the total number of mayflies collected at Station 1 and 1, 55 and 42% respectively at Station 2. These taxa made up 84, <1 and 16% respectively of total volume of mayflies collected at Station 1 and <1, 60 and 40% respectively at Station 2.

Trichoptera---A total of 740 caddisflies was collected at Station 1 and 826 at Station 2. Caddisflies represented 14% of the total number of insects collected in the upper riffle and 16% in the lower. The total volume of caddisflies collected was 6.7 cc at Station 1 and 4.1 cc at Station 2. Caddisflies constituted 25 and 29% of the total volume for all insects collected at Stations 1 and 2, respectively.

All 4 taxa of caddisflies collected occurred at Station 1 and 3 were found at Station 2. *Hydropsyche* and *Ochrotrichia* made up 70 and 23% respectively of all caddisflies collected in the upper riffle and

95 and 4% respectively in the lower. *Hydropsyche* made up 97 and 100% of total volume of caddisflies collected at Stations 1 and 2, respectively.

Coleoptera---About 19.5 times more beetles were collected at Station 1 (765) than at Station 2 (40). They represented 14% of all insects collected at Station 1 and 1% at Station 2. Each taxon of beetles had less than 0.1 cc volume in each sample.

Both taxa of beetles collected occurred in the upper riffle and 1 in the lower. Nearly 100% of the beetles collected at both stations were *Optioservus ovalis*.

Diptera---Almost 2.5 times fewer Diptera were collected in the upper riffle (1060) than in the lower (2572). They accounted for 19% of all insects collected at Station 1 and 48% at Station 2. However, the volume of Diptera collected at Station 1 (11.8 cc) was about 2.5 times that collected at Station 2 (4.7 cc). The volume of Diptera constituted 44 and 34% of the total volume of all insects collected in the upper and lower riffles, respectively.

All 12 taxa of Diptera collected occurred at Station 1 and 9 taxa occurred at Station 2. Chironomidae made up 73 and 88% of the total number of Diptera collected in the upper and lower riffles, respectively. *Tipula* and *Hexatoma* accounted for 70 and 30% respectively of the total volume of Diptera collected in the upper riffle and <1 and 94% respectively in the lower.

Odonata---No Odonata were collected at Station 1, but 15 *Ophiogomphus* with a volume of 2.2 cc were collected at Station 2. They accounted for less than 1% of the total number of insects collected at Station 2 and 16% of the total volume.

Unidentified pupae---Totals of 292 and 336 unidentified pupae were collected in the upper and lower riffles, respectively. They constituted 5% of all insects collected at Station 1 and 6% at Station 2. The volume of pupae was less than 0.1 cc in every sample.

Day-Drift

A total of 242 day-drifting insects was collected at Station 1 and 161 at Station 2 (Table 5). Numbers collected ranged from a high of 98 during April to a low of 1 during October at Station 1 and from 59 in July to 1 in November at Station 2. No taxon had a volume of 0.1 cc or greater in any sample.

Plecoptera---About 11 times more stoneflies were collected at the upper station (11) than at the lower (1). They made up 5% of all insects collected at Station 1 and 1% at Station 2.

Both taxa of stoneflies collected occurred at Station 1 and 1 taxon at Station 2. *Isoperla* constituted 93 and 100% of the number of stoneflies collected at Stations 1 and 2, respectively.

Ephemeroptera---A total of 45 mayflies was collected at Station 1 and 52 at Station 2. They accounted for 19% of total numbers of day-drift insects collected at Station 1 and 32% at Station 2.

Of the 4 taxa of mayflies collected, 3 occurred at Station 1 and 4 at Station 2. *Baetis parvus* and *Ephemerella inermis* constituted 56 and 43% respectively of all mayflies collected at Station 1 and 84 and 1% respectively at Station 2.

<u>Trichoptera</u>---Twelve and 10 caddisflies were collected at Stations 1 and 2, respectively. They made up 5% of the total number of insects collected at Station 1 and 6% at Station 2.

The four caddisfly taxa collected occurred at Station 1 and 3 were found at Station 2. *Hydropsyche* constituted 72% of all caddisflies collected at Station 1 and 93% at Station 2.

<u>Coleoptera</u>---Seventeen beetles were collected at Station 1 and 2 at Station 2. They accounted for 7 and 1% of all insects collected at Stations 1 and 2, respectively.

Of the 5 beetle taxa collected, all occurred at Station 1 and only 1 at Station 2. *Optioservus ovalis* constituted 81% of the beetles collected at Station 1 and 100% at Station 2.

<u>Diptera</u>---A total of 35 Diptera was collected at Station 1 and 57 at Station 2. They accounted for 14% of all insects collected at Station 1 and 35% at Station 2.

All of the 10 taxa of Diptera collected occurred at Station 1 while only 3 occurred at Station 2. Chironomidae and *Simulium arcticum* made up 46 and 24% respectively of Diptera numbers collected at Station 1 and 69 and 25% respectively at Station 2.

Unidentified pupae---Totals of 122 and 40 unidentified pupae were collected at Stations 1 and 2, respectively. They accounted for 50% of total insect numbers collected at Station 1 and 25% at Station 2.

Night-Drift

A total of 998 night-drifting insects was collected at Station 1 and 555 at Station 2 (Table 5). Numbers collected at Station 1 ranged from a high of 144 during March to a low of 4 in October. At Station 2 they ranged from 205 in July to 2 during May, November and December. The total volume of night-drifting insects collected was 3.9 cc at Station 1 and 1.2 cc at Station 2. The greatest volume was collected at Station 1 (0.7 cc) during March and at Station 2 (0.2 cc) during March, July and September. Volumes of less than 0.1 cc were recorded at both stations during several months.

Plecoptera---Almost 35 times more stoneflies were collected at Station 1 (157) than at Station 2 (5). They accounted for 16% of the number of drifting insects collected at Station 1 and 1% at Station 2. Stoneflies accounted for a total volume of 1.0 cc at Station 1 and less than 0.1 cc at Station 2. The volume of stoneflies at Station 1 constituted 26% of the total volume for all insects collected there.

All three taxa of stoneflies collected were present at Station 1 and 1 was at Station 2. *Isoperla* made up 97 and 100% of those collected at Stations 1 and 2, respectively. This genus also accounted for all volumes of stoneflies equal to or greater than 0.1 cc at both

~~Stations~~.

Ephemeroptera---A total of 596 mayflies was collected at Station 1 compared to 385 at Station 2. They constituted 60% of all insects collected at Station 1 and 69% at Station 2. Total volumes of mayflies collected at Stations 1 and 2 were 2.7 and 0.6 cc, respectively. Mayflies made up 69% of the total volume of all insects collected at Station 1 and 50% at Station 2.

Of 5 taxa of mayflies collected, 3 occurred at Station 1 and 5 at Station 2. *Baetis parvus* and *Ephemerella inermis* accounted for 68 and 31% respectively of mayfly numbers collected at Station 1 and 88 and less than 1% respectively at Station 2. They constituted 52 and 48% respectively of total volume of mayflies collected at Station 1 and 83 and less than 1% respectively at Station 2.

Trichoptera---Totals of 35 and 52 caddisflies were collected at Stations 1 and 2, respectively. Four percent of all insects collected at Station 1 were caddisflies compared to 9% at Station 2. Total volumes of caddisflies collected were 0.2 and 0.3 cc at Stations 1 and 2, respectively. These volumes accounted for 5% of total volume of all insects collected at Station 1 and 25% at Station 2.

All four taxa of caddisflies collected occurred at Station 1 and 3 were found at Station 2. *Hydropsyche* accounted for 79 and 94% of all caddisflies collected at Stations 1 and 2, respectively. *Hydropsyche* and *Rhyacophila acropedes* each accounted for 50% of the total volume of caddisflies collected at Station 1 while *Hydropsyche* made up 100% of that collected at Station 2.

Coleoptera---About 8.5 times more beetles were collected at Station 1 (44) than at Station 2 (5). They made up 4% of total numbers taken at Station 1 and 1% at Station 2. No taxon of beetles had a volume as great as 0.1 cc in any sample.

All of the 15 beetle taxa collected occurred at Station 1 while 4 occurred at Station 2. *Optioservus ovalis*, *Deronectes griseostriatus*, *Helichus striatus* and *Bidessus affinis* accounted for 37, 22, 20 and 8% respectively of the numbers of beetles collected at Station 1 and about 61, 14, 8 and 17% respectively at Station 2.

Diptera---A total of 48 Diptera was collected at Station 1 compared to 63 at Station 2. They constituted 5 and 11% of the total number of insects collected at Stations 1 and 2, respectively. All taxa of Diptera had volumes of less than 0.1 cc in each sample.

Fourteen taxa of Diptera were collected with 13 occurring at Station 1 and 8 at Station 2. Chironomidae and *Simulium arcticum* made up 35 and 34% respectively of the numbers of Diptera collected at Station 1 and 73 and 17% respectively at Station 2.

Odonata---No dragonfly larvae were collected at Station 1 and only 2 *Ophiogomphus* having a volume of 0.2 cc were collected at Station 2. They accounted for less than 1% of all insects and 17% of all volume collected at Station 2.

Unidentified pupae---Totals of 118 and 44 unidentified pupae were collected at Stations 1 and 2, respectively. They accounted for 12% of the total number of night-drifting insects collected at Station 1 and 8% at Station 2. The total volume of pupae was less than 0.1 cc at Station 1 and 0.1 cc at Station 2. They constituted 8% of the total volume of night-drifting insects collected at Station 2.

DISCUSSION

Station ~~1~~ 2 had a ~~smaller~~ larger range of temperatures, ~~less~~ more variable discharge rates and ~~lower~~ higher sediment loads than Station ~~2~~ 1. The more limited temperature range at Station 1 was due to proximity of the station to the artesian well and springs which supply Bluewater Creek and the absence of irrigational activities above the station. During most of the year the water was cooled by the air as it moved downstream. However, during July and August water temperatures were greater at Station 2 than at Station 1. This resulted from warming by the air, dewatering and addition of irrigation water from the Orchard Canal. Discharge rates fluctuated more at Station 2 primarily because of periodic dewatering and addition of irrigation water. Greater sediment loads at Station 2 primarily resulted from addition of silt laden irrigation water and increased soil erosion caused by intensive agriculture in the area.

The composition and dynamics of the insect community at Station ~~1~~ 2 differed greatly from that at Station ~~2~~ 1. ~~More taxa were found at Station 1 (42) than at Station 2 (26) (Table 5)~~. Much greater % numbers of Coleoptera, Plecoptera and ~~Ephemeroptera~~ and much fewer Diptera were collected at Station 1 than at Station 2. Riffle beetles, which comprised most of the Coleoptera collected, and Plecoptera are generally considered clean water forms. Large numbers of *Ephemerella inermis* were collected at Station 1 but not at Station 2. *Tricorythodes minutus* occurred in small numbers at

Four taxa having major differences between stations were Tipula, Ephemerella inermis, Tricorythodes minutus, Ochrotrichia, Optioservus ovalis, Chironomidae and Empididae.

diff 300 % of 7

Station 1 and large numbers at Station 2. Much smaller numbers of Diptera were collected at Station 1 than at Station 2.

Spring only?

Community and population dynamics differed at the two stations. Peak numbers ~~of benthic and drifting~~ insects ~~occurred~~ during different months ~~at Station 1 than at Station 2~~. This was in part due to compositional differences between th~~e two~~ stations. however even ~~Most~~ taxa common to both stations reached peak densities during different months, ~~at Station 1 than at Station 2~~.

Some natural differences in benthos is to be expected between two sampling areas however the differences seen here are too great.

The biotic differences found between stations were probably the result of physical differences caused by agricultural activities. ~~The higher temperatures at Station 2 may have been limiting to some taxa.~~ The higher sediment loads there may have been detrimental to certain taxa by inflicting mechanical damage and reducing their available habitat and food. The high discharges at Station 2 probably caused periodic scouring of some insects there.

LITERATURE CITED

Aagaard, F. C. 1969. Temperature of surface waters in Montana. U. S. Geol. Surv. and Mont. Fish and Game Comm. Helena, Mont. 613 pp.

Anderson, N. H., and D. M. Lehmkuhl. 1967. Catastrophic drift of insects in a woodland stream. Ecology, 49(2):198-206.

Anderson, R. O. 1959. A modified floatation technique for sorting bottom fauna samples. Limnol. and Oceanogr., 4(2):223-225.

Armitage, K. B. 1958. Ecology of the riffle insects of the Firehole River, Wyoming. Ecology, 39(4):571-580.

Bianchi, D. R. 1963. The effects of sedimentation on egg survival of rainbow trout and cutthroat trout. M.S. Thesis. Mont. State Univ. 28 pp., Bozeman, Mont.

Cordone, A. J., and D. W. Kelly. 1961. The influences of inorganic sediment on the aquatic life of streams. Calif. Fish and Game, 47(2):189-228.

Dodds, G. S., and F. L. Hisaw. 1925. Ecological studies of aquatic insects IV. Altitudinal range and zonation of mayflies, stoneflies, and caddisflies in the Colorado Rockies. Ecology, 6:380-390.

Peters, J. C. 1965. The effects of stream sedimentation on trout embryo survival. Pp. 275-279. In Biological Problems in Water Pollution, Third Seminar, 1962. U. S. Dept. Health, Education and Welfare. Public Health Serv. Pub. 999-SP-25. 424 pp.

____________. 1967. Effects on a trout stream of sediment from agricultural practices. J. Wildl. Mgmt., 31(4):805-812.

____________. 1971. Effects of sediment control on fish populations. Ph.D. Thesis. Colo. State Univ. 86 pp., Fort Collins, Colo.

Powell, G. C. 1958. Evaluation of the effects of a power dam water release pattern upon the downstream fishery. Colo. Coop. Fish. Unit Quart. Rep., 4:31-37.