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THE DISTRIBUTION AND ABUNDANCE OF AQUATIC INSECTS IN THE MIDDLE WEST GALLATIN DRAINAGE

by

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A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

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in

Zoology

Approved:

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VITA

Paul Allen Garrett was born July 25, 1943, in New Albany, Mississippi. He is the son of Mr. and Mrs. Roger A. Garrett. He attended public schools in Houston, Texas and Memphis, Tennessee, graduating from Messick High School, Memphis, in June, 1961. He received a Bachelor of Science degree from Memphis State University, Memphis, Tennessee, In January, 1966. In May, 1966, he enlisted in the U. S. Air Force and was commissioned 2nd Lieutenant in August, 1966. In June, 1967, he married the former Grace Ann Jung.

Released from active duty in February, 1970 at Phoenix, Arizona, he and Grace moved to Belgrade, Montana where he entered a graduate program at Montana State University in September, 1970.

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ABSTRACT

The distribution and abundance of aquatic insects in the West Fork of the West Gallatin River and a contiguous section of the West Gallatin were studied. Benthic samples were taken monthly with a modified Surber-type sampler from July 1970 to August 1971 at eleven stations. Selected physical and chemical parameters were measured.

Differences in fauna were found along the gradient of physical and biological conditions from the upper stations on the West Fork to the lower stations on the West Gallatin. Plecoptera and Ephemeroptera dominated the fauna in numbers and biomass at uppermost stations on the West Fork. Diptera increased in a downstream direction on the West Fork and the species composition of the insect community changed.

In the West Gallatin River, the faunal association was distinctly different from that of the West Fork. *Pteronarcys californica* (Plecoptera), *Hydropsyche* and *Arctopsyche* (Trichoptera) dominated the insect community in biomass.

A general increase in biomass and numbers in a downstream direction was observed.

It appears that food, ice cover, temperature, stream size, and substrate were the major factors influencing species distribution and insect biomass.

INTRODUCTION

Because of man's increasing ability through technology to modify his local environment to suit his immediate needs and objectives, human activities have had an increasingly profound effect on the biota of flowing waters over the last two centuries (Hynes, 1970). These activities may be direct and obvious such as modification of stream channels, or more subtle, such as slow addition of heavy metals to aquatic ecosystems. During the past twenty-five years or so, awareness of the consequences of such activities to aquatic ecosystems has grown and an increasing research effort has been channeled into ascertaining their true significance.

In view of the Big Sky recreational development in the West Fork drainage, the present study was initiated to determine the existing distribution and relative abundance of aquatic insects in the West Fork and a contiguous section of the West Gallatin River, and to identify some of the factors affecting their distribution. To these ends, monthly benthos collections were made at stations established on the West Fork and West Gallatin River from June 1970 to August 1971.

A great volume of literature has accumulated on the effects of various stream modifications on their biota. In a classic paper, Gaufin and Tarzwell (1956) showed that the effect of gross organic pollution on stream biota was catastrophic. King and Ball (1964) described the response of stream biota to the deleterious effects of siltation caused by adjacent construction of an interstate highway. Whitney and Bailey (1963) found a ninety percent reduction in standing crop of trout in a straightened section of a Montana stream. Zillges (1971) studied the responses of aquatic insects to agricultural runoff in Bluewater Creek, Montana. The recovery of the fauna of a dredged English mill stream was described by Crisp and Gledhill (1970). Macan (1963) described how the invertebrate fauna of a small stream showed a dramatic response to even relatively slight organic enrichment by domestic sewage.

It is to be expected that increased use of the West Fork and West Gallatin River drainages by man will produce some ecological effects which may be reflected in the composition of aquatic communities. Construction of dwellings and roads along with changes in land use patterns may contribute to siltation, while an increase in both transient and resident human populations will contribute more organic and inorganic nutrients to the watershed. The results of this study will provide a baseline of information by which the magnitude of the impact of these changes on the aquatic ecosystem can be measured. They will, at the same time, provide in some degree a measurement of the ability of the developer to successfully integrate a large recreational complex into the ecology of a natural area without serious ecological disruption and degradation of the natural and esthetic resources.

Bould

DESCRIPTION OF THE STUDY AREA

The West Gallatin River originates in the southern tip of the Gallatin Range in the northwest corner of Yellowstone National Park and flows northward into Montana, draining an area of about 213,600 hectares. The river flows through a narrow valley for about 65 kilometers and enters a canyon just below the mouth of the West Fork, through which it pursues a turbulent course for about 32 kilometers before coming out onto the Gallatin Valley at an elevetion of 1520 meters.

The study area (Fig. 1) consists of the lower West Fork and a contiguous section of the West Gallatin from Porcupine State Game Range to Moose Meadows campground. The West Fork drains 20,700 hectares (Van Voast, 1972) in an eastward direction, entering the West Gallatin just above the canyon at 1823 meters. The West Fork is formed by three tributaries: the South Fork, the Middle Fork, and the North Fork. The upper sections of these tributaries flow through narrow valleys covered with coniferous forest. The drainage widens downstream into a broad alluvial sagebrush covered plain (Montagne, 1971) upon which the summer village of Big Sky is being developed. A highway is being constructed up the valley and extensive modification of the stream bed has occurred since the end of the sampling period.

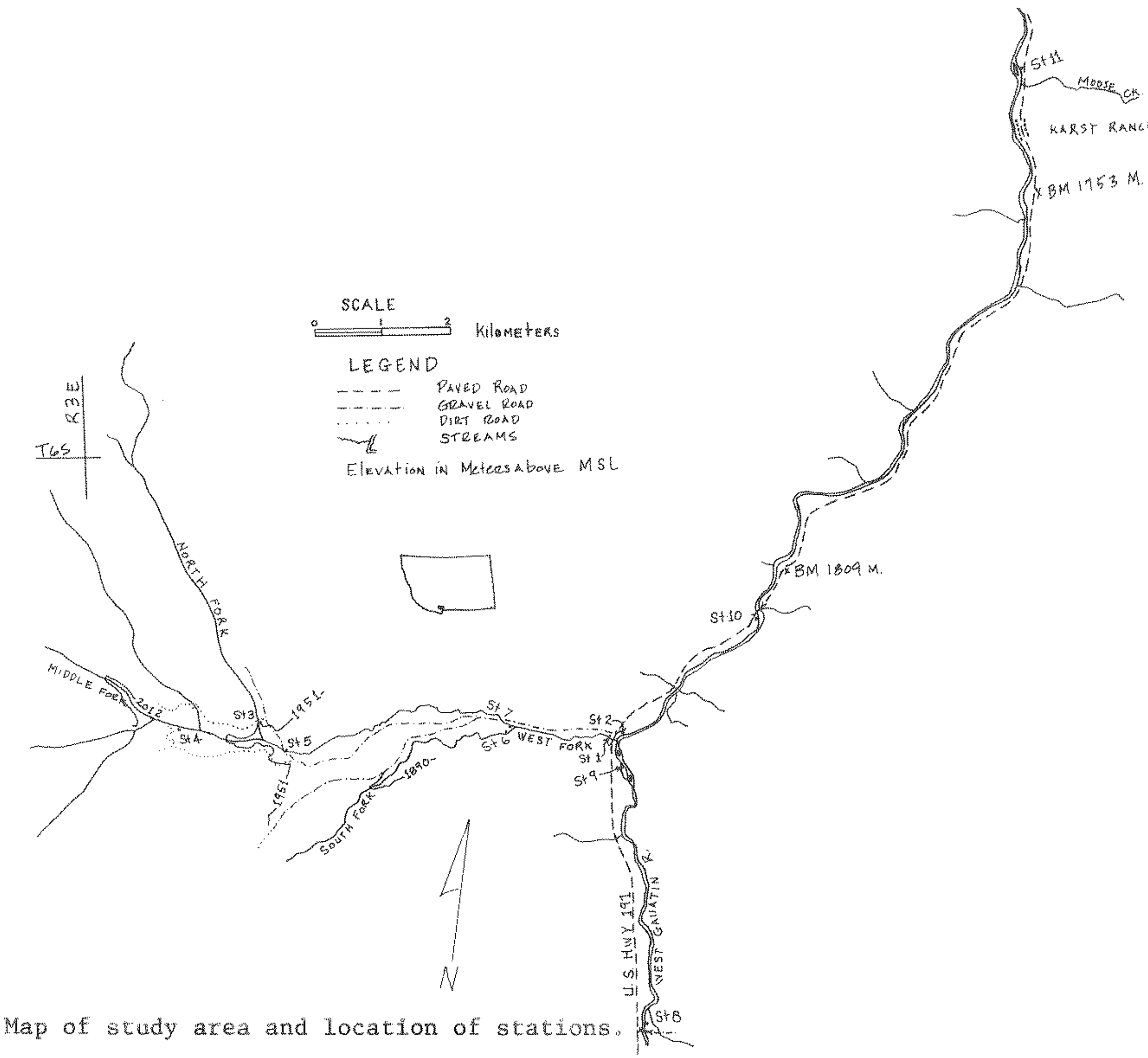

Figure 1. Map of study area and location of stations.

The geological history of the West Gallatin drainage is complex. The entire upper Gallatin drainage is a depressed tract within the Gallatin-Madison uplift, which is composed of the Gallatin Range to the east and the Madison Range to the west. Basic geological structure includes igneous and metamorphic rocks overlain with sandstones, silt-stones, marine carbonate rocks, shales, limestones, and alluvium (Hall, 1961, and Montagne, 1971).

Total elevation relief of the upper drainage is over 1500 meters, from about 3350 meters on several peaks in the Madison Range to 1738 meters at Moose Meadows. According to Hall (1961) there is evidence that during the Pleistocene glaciation this area was subjected to four distinct glacial episodes, and that glacial activity was greater here than in other similar areas nearby.

Analysis of Weather Bureau data for Montana from 1931 to 1952 by Hall (1961) revealed that the upper Gallatin drainage has one of the most severe climates in the state, with respect to mean annual snowfall 394 cm, mean annual temperature (35.5 F), mean maximum temperature (51.5 F), mean minimum temperature (18.5 F), and number of frost-free days (40-60). The general picture created is that of a climate distinctly cooler than in much of the surrounding area.

Vegetation type of the area falls within the temperate grassland-coniferous forest ecotone ecscribed by Odum (1961). Streamside vegetation included grassy meadows, willow, and sagebrush flats, and conifers.

Prior to the start of the Big Sky recreational complex, human land use in the upper Gallatin drainage was limited. There was little commercial development, save for several dude ranches and a few bars and motels. There was little agriculture and little irrigation. There are numerous summer homes along the West Gallatin and the West Fork. Logging activity has been slight, with the total acreage logged in the last ten years estimated at less than 1400 hectares (Finzer, USFS, personal communication). Approximately 600 hectares of this lies within the West Fork drainage and may have caused increased siltation of the stream bed, especially in the Middle and South Forks.

Tables 1 and 2 below indicate flow data for the West Gallatin and West Fork respectively.

Table 1. Flow data (m^3/s) for the West Gallatin River at Spanish Creek gauging station (from Surface Water Data for Montana, USGS, 1966-68.)

Year	Mean Annual Flow	Minimum Monthly Mean	Maximum Monthly Mean
1966	20.5	10.24, Feb.	59.32, June
1967	27.4	8.63, Jan.	110.92, June
1968	30.6	9.48, Jan.	125.86, June

Table 2. Flow data (m^3/s) for West Fork drainage from 8/2/70 to 5/25/71 (Van Voast, 1972).

	Minimum Measured Discharge	Maximum Measured Discharge
South Fork	0.19 3/25/71	1.50 8/2/70
Middle Fork	0.10 3/26/71	1.62 5/25/71
North Fork	0.03 1/3/71	0.23 8/10/70
West Fork Main Stem	0.25 1/3/71	3.15 8/2/70

Analysis of USGS surface water records for 1966-70 indicate maximum flows consistently occur in June, while minimum flows may occur throughout the winter, depending on local climate. The five year trend through 1970 was for increasing flows in the Gallatin drainage, with 1970-71 having the highest mean annual discharge recorded (Van Voast, 1972).

METHODS

Sampling Stations

Eleven sampling stations were established on the West Fork of the West Gallatin River and on a contiguous section of the West Gallatin River itself (Fig. 1). Station one was in a riffle on the West Fork main stem 50 meters above its confluence with the West Gallatin River. Station two was in a flat riffle on the west side of the West Gallatin River approximately 100 meters downstream from its confluence with the West Fork. Station three was on the North Fork just below a logging road bridge approximately 0.4 kilometers above the confluence of the North and Middle Forks. Station four was on the Middle Fork approximately 1.3 kilometers above the confluence of the Middle and North Forks, in a riffle which passed through a willow flat. Station five was on the Middle-North Fork 400 meters downstream from the confluence of the Middle and North Forks. Station six was on the South Fork in a riffle 150 meters upstream from the confluence of the South and Middle-North Forks. Station seven was on the Middle-North Fork 30 meters upstream from the confluence of the Middle-North and South Forks. Station eight was on the east side of the West Gallatin 100 meters downstream from the bridge at Porcupine Game Range. Station nine was in a shallow side channel on the west side of the West Gallatin River approximately two kilometers south of the confluence of the West Gallatin and the West Fork. Station ten was in a flat riffle on the southwest side of the

West Gallatin 75 meters upstream from the Jack Smith bridge on U. S. Highway 191. Station eleven was in a deep riffle in the east channel of the West Gallatin at U. S. Forest Service Moose Meadows campground.

Collection and Analysis of Samples

Benthos samples were collected monthly at the eleven sampling stations from July 1970 to August 1971 when weather and water conditions permitted. Table 3 shows a schedule of collected samples. Care was taken in collecting the samples to avoid sampling any particular area of substrate two months in succession. A modified Surber sampler with a 0.5 square meter frame and a cod one meter in depth with nine meshes per centimeter was used. Samples were preserved in the field in 40% formalin, taken into the laboratory and stored until analysis, which consisted of the following procedure.

Insects were separated from detritus and gravel by hand, using a hand lens and dissecting microscope when necessary, and preserved in either 70% ethyl or 40% isopropyl alcohol. They were later classified to the lowest possible taxa using appropriate sections from Usinger (1956), Pennack (1953), or Edmondson (1959). Other taxonomic references used were Wiggins (1965), Gaufin, *et al.* (1966), and Newell (1970). Specimens from a number of taxa were sent to experts for verification or correction of classification. A few Diptera forms which could not be positively identified were added to counts of Tipulidae, the family they most resembled.

Table 3. Schedule of samples collected at respective stations from July 1970 to July 1971.

	1970						1971		
Station	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.
1	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X		X	*
3	X	X	X	X	X			X	X
4	X	X	X	X	X			X	X
5	X	X	X	X	X			X	X
6	X	X	X	X	X	X	X	X	X
7	X	X	X	X	X	X	X	X	X
8	X	X	X	X	X	X		X	X
9	X	X	X	X	X			X	X
10	X	X	X	X	X	X	X	X	X
11	X	X	X	X	X	X	X	X	X

*Lost.

For July, November and March samples, total numbers of individuals per taxa were counted or approximated by use of subsamples. Those samples with extremely large numbers of insects to be counted were subsampled in a plexiglass tray sixteen inches square, on the bottom of which was scribed sixteen equal squares, numbered from one to sixteen. The separated insects were placed in the tray, suspended in alcohol, and stirred until evenly distributed. Numbers of squares were randomly selected and the insects in that square were withdrawn and counted by taxa. Subsequent squares were sampled until at least 500 individuals had been counted. Total numbers in the sample were then approximated by a simple proportion.

In other months, sample numbers were visually estimated and taxa placed in abundance categories with the following class limits:

Category	Number of Individuals
Rare	1 - 5
Common	6 - 20
Numerous	21 - 50
Abundant	51 - 500
Very Abundant	Over 500

These class limits were selected on the basis of convenience and relative accuracy obtainable.

Standing crops of insects were estimated by volumetric determinations at the ordinal level. Insects were drained on a sieve, blotted, and volumes determined to the nearest 0.5 milliliter by displacement in alcohol.

Diversity indices were computed for insects collected in July, November and March samples using Margalef's (1951) equation:

$$\text{Diversity} - \frac{S - 1}{\text{Ln } N}$$

where S is the number of taxa and Ln N is the natural logarithm of the total number of individuals.

Average station diversity was calculated for each station by means of the following formula:

$$\text{Average diversity} = \frac{\frac{\Sigma Si - 1}{3}}{\text{Ln } \frac{\Sigma Ni}{3}}$$

where Si is the number of taxa in the ith month (July, November or March), and Ni is the number of individuals in the ith month.

Aquatic plants and detritus caught in the cod were retained in some samples. Plant material was drained, blotted, and volumes thereof measured to the nearest milliliter in a graduated cylinder.

Measurements were made on pertinent physical parameters at most of the stations. Current measurements were made during low flow conditions using a Gurley Pygmy current meter. Twenty to thirty measurements were made in each sampling area as close to the substrate as possible. Depths were measured in the sampling areas to the nearest centimeter at twenty to thirty points under low flow conditions.

Substrate analysis was carried out using a modification of the photographic technique developed by Cummins (1964), based on the Wentworth scale of substrate size classes (Cummins, 1962). Substrate photographs were taken with the aid of an underwater viewing box using a 35 mm single lens reflex camera with an internal light meter and Ektachrome ASA 64 film. In the laboratory, developed slides were projected to actual size (based on a known reference placed in the photograph) on a grid having divisions three centimeters by five centimeters. At each intersection on the grid, substrate size was determined with calipers. One to three slides were analyzed at each station. Substrate composition was expressed as average percentage of total intersections in each size class.

RESULTS

Insects

Initial work with benthic insects collected involved determination of taxa present in the study section. Following is a taxonomic list of the insects found during the study.

EPHEMEROPTERA

Ephemerella grandis Eaton
inermis Eaton
doddsi Needham
edmundsi Allen
hystrix Traver
coloradensis Dodds
tibialis McDunnough
spinifera Needham
Rithrogena robusta Dodds
Cinygmula McDunnough
Epeorus
Iron longimanus Eaton
Ironopsis sp. Traver
Baetis sp. A
parvus Dodds
Centroptilum Eaton
Ameletus Eaton
Paraleptophlebia Lestage

PLECOPTERA

Pteronarcys californica Banks
Pteronarcella badia Hagen
Nemoura
Zapada cinctipes Banks
haysi Ricker
frigida Claassen
Prostoia besametsa Ricker
Brachyptera Newport
Leuctra Stephens
Isogenus modestus Banks
Diura knowltoni Frison

Arcynopteryx
Frisonia parallela Frison
Megarcys sp. Klapa'lek
Acroneuria pacifica Banks
theodora Ricker
Alloperla Banks
Paraperla Banks
Isoperla Banks
Peltoperla Needham

TRICHOPTERA

Rhyacophila acropodes Banks
angelita Banks
hyalinata Banks
Arctopsyche McLachlan
Hydropsyche Pictet
Parapsyche elsis Milne
Brachycentrus Curtis
Micrasema McLachlan
Amiocentrus Allen
Drusinus Betten
Neophylax McLachlan
Neothremma Banks
Glossosoma Curtis
Oligophlebodes Banks
Dicosmoecus McLachlan
Radema Hagen

DIPTERA

Chironomidae

Simuliidae

Tipulidae

Rhagionidae
Atherix variegata Walker

Blepharoceridae

Psychodidae

Dueterophlebiidae

Muscidae

Empididae

COLEOPTERA

Elmidae

Tables 4 through 14 show occurrence and abundance of insects at each station for the months indicated. Numbers of individuals are given for samples at all stations in March, July and November. The remainder of the section contains analysis and explanation of the data presented in these tables.

Table 15 contains data on standing crops of insects at the ordinal level as determined by volumetric displacement. As one might expect, insect volumes were usually greatest in early spring samples. Immature forms had reached maturity, yet the bulk of emergence had not begun. Stations eleven, ten, nine, and one, in that order, had the highest mean standing crops, as averaged over comparable months' samples, while mean standing crops at stations eight, six, seven, three, four, and five were considerably less.

Stations two, ten, and eleven on the West Gallatin, and station one on the West Fork had considerably greater total numbers of individuals in spring and winter samples than did station eight on the West Gallatin or other stations on the West Fork (Tables 4-14). Seasonal variations in numbers and biomass were generally less at stations three, four, and five on the West Fork, due in part to a generally lower standing crop,

Table 4. Numbers and abundance categories of aquatic insect taxa from monthly samples at station 1. For July, November, and March samples, numbers of individuals per taxa, percent total numbers per order, and total number of individuals are shown. In August, October, December, January, and April, numbers of individuals per taxa were estimated as being in one of five abundance categories. Total number of taxa is tabulated for each month. Class limits and symbols for abundance categories are: R=Rare 1-5; P=Present 6-20; N=Numerous 21-50; A=abundant 51-500; V=very abundant 500+.

	1970						1971			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	Aug.
EPHEMEROPTERA										
Ephemerella doddsi	4	A	A	A	99	A	A	208	A	A
grandis	2		R		13	P	P	35	N	
inermis	4				19	N	P	117	A	
hystrix			R	R	4	N	P	12	N	
coloradensis	6									R
tibialis	1	N	R							N
edmundsi			R							
Baetis sp. A	63		P					10	P	A
Baetis parvus			P	R			R		P	
Ameletus		P				R				
Rhithrogena	4	A	N	A	413	A	A	29	A	A
Cinygmula	4		P		5	P	R	9	P	N
Epeorus										
Iron		P								P
Ironopsis				P		P	P			R
Percentage of total numbers	66				41			5		
PLECOPTERA										
Pteronarcella							R	1	R	
Nemoura cinctipes					12	P	P	10	A	
Nemoura spp.[1]			R			A	P	2400	V	P
Brachyptera					1	N	A	5	R	
Leuctra			R				R			
Acroneuria			R				R		R	
Arcynopteryx		R	R		6	R	P	3	R	P
Isogenus	2									
Diura		R		R	10	R	R		R	
Isoperla									P	
Alloperla	6		P	P	124	A	A	36	A	P
Paraperla		R		R						R
Percentage of total numbers	6				11			27		
TRICHOPTERA										
Arctopsyche	2	P	P	N	65	A	N	65	N	N
Rhyacophila		R	R	R	6	N	P	102	N	
Glossosoma		P	R	R		R		5	R	
Brachycentrus	7	P	N	P	19	P	P	9	P	P
Oligophlebodes							R		R	
Percentage of total numbers	7				7			2		
DIPTERA										
Chironomidae	20	A	P	P	504	V	V	6000	V	A
Blepharoceridae		R	P	R			P			P
Rhagionidae	5	P	P	P	16	P	P	38	N	
Simuliidae		N	N	N			P	5	P	N
Psychodidae					7	P	R	5	R	
Tipulidae	4	P	P	P	6	P		7	P	P
Percentage of total numbers	22				40			66		
COLEOPTERA										
Elmidae				R	7	R	R			
Percentage of total numbers	0				<1			0		
Total number of taxa	15	17	23	18	19	23	27	22	27	18
Total number of individuals	134				1336			9111		

[1]Probably includes three species: *besametsa*, *haysi*, and *frigida*.

Table 5. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 2. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970						1971		
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mar.	Apr.	Aug.
EPHEMEROPTERA									
Ephemerella doddsi	3	P	N	N	63	A	33	P	P
grandis		R	R	P	199	N	37	A	
hystrix				R		R	6		
inermis	8		R	P	300	A	139	A	
coloradensis	4								
edmundsi							18	N	P
tibialis	7	N	P	R					P
Baetis sp. A	40	A	P	P	19	P	169	N	A
Ameletus		P		R					
Rhithrogena	5				83	A	279	P	
Cinygmula	38	N			23	P	7	N	P
Epeorus									
Iron									R
Paraleptophlebia			P						
Percentage of total numbers	53				29		23		
PLECOPTERA									
Pteronarcys		R		R	4	P	53	A	
Pteronarcella		R	P		43	P	137	A	R
Nemoura cinctipes					20	R	15	R	
Nemoura spp.[1]						A		P	
Brachyptera							1		
Acroneuria	2	R		R		P	10	R	R
Arcynopteryx		P	R			R	2	R	
Isogenus	1								R
Diura			P	R		R	5	R	
Isoperla					9	P	216	P	
Alloperla	3	P	R	P	41	N	50	N	R
Percentage of total numbers	3				5		17		
TRICHOPTERA									
Hydropsyche				P	66	P	15	N	
Arctopsyche	3	P	A	N	80	P	88	P	P
Parapsyche					1				
Rhyacophila	4				7	N	6	P	R
Glossosoma	1	P			20	R	2	P	
Brachycentrus	8	N	N	R	15	R	130	R	R
Amiocentrus		R						R	
Micrasema		R			3			R	
Neophylax	1								
Radema			R			R			
Unidentified pupae		R	P						
Percentage of total numbers	9				7		8		
DIPTERA									
Chironomidae	32	A	P	A	1350	V	1400	A	A
Blepharoceridae							8		
Rhagionidae	16	P	P	P		P	67	A	P
Simuliidae	9	P		R			4		
Psychodidae					5	R	3	R	
Tipulidae	11	P	P	P	31	P	33	A	P
Empididae	1						1		
Muscidae	1						1		
Percentage of total numbers	35				59		52		
COLEOPTERA									
Elmidae		R			13	P		R	R
Percentage of total numbers	0				>1		0		
Total number of taxa	21	21	16	18	22	27	30	28	17
Total number of insects	198				2395		2935		

[1]Probably includes three species: *besametsa*, *haysi*, and *frigida*.

Table 6. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 3. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970					1971		
	July	Aug.	Sept.	Oct.	Nov.	Mar.	July	Aug.
EPHEMEROPTERA								
Ephemerella doddsi					9	2	N	
coloradensis	22	A	P				N	N
inermis							R	
grandis				R				
spinifera							R	
Rhithrogena	3	N	A	A	135	46	P	N
Cinygmula	117	A		P			N	A
Epeorus								
Iron	2	A	N				R	A
Ironopsis	1	R	A	N	41	13		
Baetis parvus	25	A	A	P		3	N	A
Ameletus		R		R			R	R
Percentage of total numbers	61				21	6		
PLECOPTERA								
Nemoura cinctipes	10	A	N	A	65	24	R	A
Brachyptera				A	511	952		
Leuctra	2	R		R	3			
Acroneuria	2	R					R	
Arcynopteryx		P	R	P	6	21		R
Diura				R				
Isogenus							R	R
Alloperla			P	A	11	12		R
Paraperla	4		R	P	6			R
Peltoperla	2	R	R					
Percent of total numbers	6				69	92		
TRICHOPTERA								
Arctopsyche			R					
Parapsyche	12	P	N	N	8	13	R	P
Rhyacophila	6	P	P	P	8	11	P	P
Glossosoma	4	A	R	P	20	1	A	P
Neophylax					2			
Neothremma		P		R	3			
Oligophlebodes	26							
Radema			R		7			
Dicosmoecus							R	
Percentage of total numbers	17				6	1		
DIPTERA								
Chironomidae	27	P	R	P	22	5	N	R
Simuliidae	3			R			R	R
Tipulidae	12				10	1	P	
Percentage of total numbers	15				4	1		
COLEOPTERA								
Elmidae		R			2			R
Percentage of total numbers	0				>1		0	
Total number of taxa	18	18	16	19	18	13	19	17
Total number of insects	280				1149	1104		

Table 7. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 4. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970					1971	
	July	Aug.	Sept.	Oct.	Nov.	Mar.	Apr.
EPHEMEROPTERA							
Ephemerella spinifera					5	30	P
doddsi	6	A	A	A	269	617	A
coloradensis	18	P					
hystrix					24	25	R
tibialis	4	A		R			
Baetis parvus	35	A	A	R	61	138	P
Ameletus				R		14	R
Paraleptophlebia							P
Rhithrogena	13	A	A	A	261	70	A
Cinygmula	44	A	P			51	A
Epeorus							
Iron	2	N	P				
Ironopsis		P	R	N	31	4	
Percentage of total numbers	57				52	72	
PLECOPTERA							
Nemoura cinctipes	3	N	N		109	66	N
Brachyptera				A	179	86	P
Leuctra		R					R
Acroneuria		R	P	R	2	4	P
Arcynopteryx			R	P	6	5	
Isogenus	7						
Alloperla	1	N	N	R	17	28	P
Paraperla		R	R		3	1	
Percentage of total numbers	5				25	14	
TRICHOPTERA							
Arctopsyche					1	3	R
Parapsyche	3	P	P	P	18	24	R
Rhyacophila	5	P	R	P	24	36	P
Brachycentrus		R					
Glossosoma	40	N	P	R	88/40*	1	
Neophylax							
Oligophlebodes					1	38	R
Dicosmoecus	1*	R	R		2	1	R
Radema		P	R		15		
Percentage of total numbers	23				15	8	
DIPTERA							
Chironomidae	5	N	P	R	70	53	P
Blepharoceridae							
Simuliidae	1	P	R		1	1	R
Psychodidae					1	6	P
Tipulidae	19	P	P	P	5	8	R
Percentage of total numbers	12				6	5	
COLEOPTERA							
Elmidae	6	P	P	R	21	9	P
Percentage of total numbers	3				2	1	
Total number of taxa	18	23	20	16	24	25	23
Total number of insects	213				1254	1319	

*On TRICHOPTERA indicates pupae.

Table 8. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 5. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970					1971		
	July	Aug.	Sept.	Oct.	Nov.	Mar.	Apr.	Aug.
EPHEMEROPTERA								
Ephemerella doddsi			A	A	171	37	N	
spinifera						3	R	
hystrix				R	79	1		
coloradensis	8	P						
inermis	1			P		13	P	
tibialis		P	P	R		3	R	
Baetis sp. A			N					
Baetis parvus	72	N	A	P	63	37	N	
Ameletus					5	1		
Rhithrogena	3		N	A	223	20	P	
Cinygmula	34	P	N	N	5	38	N	
Epeorus								
Iron	3	P	R					
Ironopsis			P	R	19		R	
Paraleptophlebia				R	2	4		
Percentage of total numbers	70				52	63		
PLECOPTERA								
Nemoura cinctipes		R	P	P	39	9	P	
Brachyptera					48	7	P	
Leuctra					2	3	R	
Arcynopteryx			P	P	6		R	
Diura					3	1	R	
Isogenus	8	R						
Alloperla	2	R		P	62	5	P	
Percentage of total numbers	6				15	10		
TRICHOPTERA								
Arctopsyche				R	6	3	P	
Parapsyche	2	R	R	R	7			
Rhyacophila	1		R		15	12		
Glossosoma	7	P	N		3/25*	15*		
Brachycentrus	2			P	5	1		
Neophylax					3			
Neothremma	1							
Oligophlebodes			R			1	P	
Dicosmoecus				R	3			
Radema				P	24			
Drusinus				R			R	
Percentage of total numbers	8				8	15		
DIPTERA								
Chironomidae	26	P	R	N	261	13	P	
Simuliidae			R		4			A†
Psychodidae					5			
Tipulidae	3				1	6	R	
Percentage of total numbers	17				25	8		
COLEOPTERA								
Elmidae		R	R	P	7	10	P	
Percentage of total numbers	0				>1	4		
Total number of taxa	15	12	17	20	27	23	20	
Total number of insects	173				1096	246		

*On TRICHOPTERA indicates pupae.
†August, 1971 - *Simuliidae* observed in abundance at station 5.

Table 9. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 6. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970						1971			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	Aug.
EPHEMEROPTERA										
Ephemerella doddsi		R	A	A	170	A	A	137	A	R
grandis	1			R		P		11	P	
inermis	8			R	19	P	R	61	A	
hystrix					3	R	P	16		
coloradensis	4	R								
tibialis	4	P		R						P
Baetis sp. A	42								P	N
Baetis parvus	10	P	N					8	P	P
Ameletus									R	
Rhithrogena	14		A		130	P	A	23	A	N
Cinygmula	14	P		P	6		N	22	A	P
Epeorus										
Iron	10	P								N
Ironopsis			P	P						R
Percentage of total numbers	60				48			11		
PLECOPTERA										
Nemoura cinctipes				P	12		R	27	P	
Nemoura spp.[1]							P	580	A	
Brachyptera					12		P	15	N	
Acroneuria	1			R						
Arcynopteryx		P	R	P			R	2		P
Diura			R		7	R		7	P	
Isogenus	12									
Alloperla	3	R	P	N	5	P	P	20	A	R
Paraperla			R		1					R
Percentage of total numbers	9				5			25		
TRICHOPTERA										
Arctopsyche	4	P	P	N	65	R	P	50		P
Parapsyche			R							
Rhyacophila	3	P		P	13	R	R	39	P	P
Glossosoma	4		R		1				R	P
Brachycentrus	8	P	P	P	5	R	R	7	P	P
Oligophlebodes	1					R				
Dicosmoecus			R							
Radema			R	R						
Percentage of total numbers	11				12			4		
DIPTERA										
Chironomidae	21	R		N	207	P	A	1500	A	N
Blepharoceridae								1		
Rhagionidae	6	R	P	P	16	P	P		R	R
Simuliidae	1		P				P			A
Psychodidae						R			R	
Tipulidae	7	R	P	P	15	P	P	27	P	P
Percentage of total numbers	20				35			60		
Total number of taxa	21	16	16	17	17	15	17	19	20	19
Total number of insects	178				677			2553		

[1]Probably includes three species: *besametsa*, *haysi*, and *frigida*.

Table 10. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 7. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970						1971			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	Aug.
EPHEMEROPTERA										
Ephemerella doddsi	11	A	A	A	151	A	A	182	A	N
grandis	2			P	6	R	R	6	R	
inermis	4				25	A	P	9	A	R
hystrix			R	N		A	A	94	P	
coloradensis										R
tibialis	1	P		R			R			N
Baetis sp. A	61	A	P			N		2	R	P
Baetis parvus		A	P	P	4	N	R			A
Ameletus					1					
Rhithrogena	22		P	A	71	A	A	73	N	P
Cinygmula	16	P				N	N	19	P	N
Epeorus										
Iron										N
Ironopsis					3	P		1		
Percentage of total numbers	56				26			30		
PLECOPTERA										
Nemoura cinctipes	1	R			11			15		
Nemoura spp.[1]						N	A	400	P	
Brachyptera					4	N	P	17		
Leuctra			R	R	3		R	2	R	
Acroneuria						P				
Arcynopteryx			R	R		P	R			R
Diura							R			
Isogenus	5				1					
Alloperla	2	R	R	P	20	A	A	53	A	P
Paraperla					1	R				
Percentage of total numbers	4				4			38		
TRICHOPTERA										
Arctopsyche	2		P	R	13	P	P	3	P	P
Rhyacophila	14	P	N	N	43	N	N	58/25*	P	
Glossosoma	1*	P	A	P	13/15*	R	R	12	R	N
Brachycentrus	3		N		5	N	P	2*	P	R
Neophylax					1					
Oligophlebodes				R	88	A	A	231	N	
Dicosmoecus			R		3	R				
Drusinus								2		
Radema						R				
Percentage of total numbers	10				18			26		
DIPTERA										
Chironomidae	52	A	N	A	475	A	A	51	A	A
Blepharoceridae			R		4		P			R
Dueterophlebiidae										R
Ragionidae					4			2		
Simuliidae			P	P	1		R			P
Psychodidae					16	P	P	3		
Tipulidae	11	P	P	P	4	P		12	P	P
Percentage of total numbers	30				49			5		
COLEOPTERA										
Elmidae	1	R	R	A	37		P	14	P	P
Percentage of total numbers	>1				4			>1		
Total number of taxa	17	12	18	18	27	25	24	24	18	20
Total number of insects	209				1023			1288		

[1]Probably includes three species: *besametsa*, *hayei*, and *frigida*.

*On TRICHOPTERA indicates pupae.

Table 11. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 8. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970						1971		
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mar.	Apr.	Aug.
EPHEMEROPTERA									
Ephemerella doddsi	2		N		14	N	21	P	
grandis			R	P	15	P		R	
inermis					15	P	7	P	
hystrix						R		R	
coloradensis	7								
tibialis		R							R
Baetis sp. A	51	R	A		21	P	54	A	A
Baetis sp. B		R		P		P			A
Ameletus						P			
Rhithrogena	2	R	A	A	244	A	287	A	R
Cinygmula	13						8	P	P
Paraleptophlebia				R					
Percentage of total numbers	30				53		67		
PLECOPTERA									
Pteronarcys	46	N	N	N	38	P	1		R
Pteronarcella			P	N	21	R	2	P	
Nemoura cinctipes							11	P	
Leuctra							2		
Acroneuria	17	P	P	P	8	R	6	P	P
Arcynopteryx			P	R	3		1	R	
Diura		R		R	2	R			
Isogenus	3								
Isoperla							2		
Alloperla	14		P	P		N	27	P	
Percentage of total numbers	32				12		9		
TRICHOPTERA									
Hydropsyche				P	5	R			
Arctopsyche		P		P	8	P	4		
Rhyacophila			N		1	R	7	R	
Glossosoma						R	5		
Brachycentrus	49	N	A	P	5		2	R	
Micrasema			P	R					
Amiocentrus	2								
Radema					3			R	
Percentage of total numbers	20				4		3		
DIPTERA									
Chironomidae	2	R		P	60	P	70	P	P
Blepharoceridae	22		A		6	N	17	R	P
Rhagionidae		N	P	A	60	P	4	P	P
Simuliidae			P	R			2		
Tipulidae	21	P	A	N	33	P	23	P	P
Percentage of total numbers	18				28		21		
COLEOPTERA									
Elmidae			R		16		1		R
Percentage of total numbers	0				3		>1		
Total number of taxa	14	12	17	18	20	21	23	19	12
Total number of insects	251				578		564		

Table 12. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 9. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970					1971		
	July	Aug.	Sept.	Oct.	Nov.	Mar.	Apr.	Aug.
EPHEMEROPTERA								
Ephemerella doddsi				R	8	28	P	
grandis				N	114	141	A	
inermis	6			P	234		A	
hystrix				P	12			
coloradensis	37							
tibialis	80	R						P
Baetis sp. A	121	R	N	A	146	1	P	A
Ameletus	1	R	R	R	4	4		
Rhithrogena	2	R	N	A	326	105		
Cinygmula	40					95	A	N
Percentage of total numbers	5				13	6		
PLECOPTERA								
Pteronarcys	67	P	A	A	10	13	P	
Pteronarcella		R	P	A	99	30	N	N
Nemoura cinctipes				P		26	1	
Nemoura spp.[1]							P	
Brachyptera						1		
Acroneuria	65	P	P	A		11	N	R
Capnia						1	R	
Arcynopteryx			R		4	12		R
Isoperla			P	A	53	103	P	
Diura					1	5	R	
Alloperla	1		R	A	15	270	R	P
Percentage of total numbers	2				2	8		
TRICHOPTERA								
Hydropsyche			A	A	124			
Artopsyche	2	R	P	A	322	10	P	R
Rhyacophila					2			R
Glossosoma	1				5			
Brachycentrus	28	P	A	P	13	2	P	
Micrasema			R	P	105			
Amiocentrus	6	R		R	7			
Radema	2				1	2		
Percentage of total numbers	1				9	1		
DIPTERA								
Chironomidae	[2]	P	P	P	[2]	[2]	V	V
Rhagionidae	26	N	A	N	46	2	N	N
Simuliidae		R		R				
Psychodidae							R	
Tipulidae	20	P	P	P	1	8	A	N
Percentage of total numbers	92				76	85		
COLEOPTERA								
Elmidae	1			R		2	P	
Percentage of total numbers	>1				0	>1		
Total number of taxa	19	14	16	23	24	23	21	12
Total number of insects	5506				6648	5862		

[1]/ Probably includes three species: *besametsa*, *haysi*, and *frigida*.

[2]/ *Chironomidae* included many mud dwelling forms, too numerous to count. Numbers for these months were estimated at about 5000, based on density of *Chironomidae* in sample from station 1, March 1971.

Table 13. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 10. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total number of individuals are shown. Class limits for abundance categories as in Table 4.

	1970						1971			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	Aug.
EPHEMEROPTERA										
Ephemerella doddsi	4		A	A	89	A	A	54	A	
grandis		R		R	12	P	P	17	N	
inermis		A		R	19	A		141	A	
hystrix						R	R	14	R	
coloradensis	5								A	
tibialis	14	N	R							P
edmundsi				R				10	A	
Baetis sp. A	87	A	N	N	11	N	A	321	A	A
Ameletus					2	R				
Rhithrogena	52	A	P	A	258	A	N	239	N	
Cinygmula	33						R	11	P	P
Epeorus										
Iron	19	P							P	R
Ironopsis		R							R	
Percentage of total numbers	75				14			36		
PLECOPTERA										
Pteronarcys	23	P	N	A	29	A	A	11	A	P
Pteronarcella				N	16	P	P	32	N	
Nemoura cinctipes					10	R	P	10	R	
Nemoura spp.[1]						P	A	164		
Brachyptera					1		R	1		
Acroneuria	17	N	P	N	11	N	N	33	A	R
Arcynopteryx			R	R						
Isoperla					52	N	N	171	A	
Alloperla		R	R	P	25	N	N	125	P	R
Percentage of total numbers	14				5			24		
TRICHOPTERA										
Hydropsyche	6	A	A	A	523	A	A	125	A	
Arctopsyche	1	A	A	A	814	A	A	55	A	P
Rhyacophila					31	P	P	36	R	
Glossosoma					8	P	P	5	P	
Brachycentrus	3	P	P	P	35		N	17	N	P
Micrasema					3					
Amiocentrus	1	R	R							
Radema						R				
Percentage of total numbers	4				52			11		
DIPTERA										
Chironomidae	6	A	P	A	640	A	A	620	A	A
Blepharoceridae		R	P	R	31	P	P	1	P	P
Dueterophlebiidae	2									
Rhagionidae	4	N	N	A	44	N	P	17	N	P
Simuliidae	7	A	P	P	10	A	A	5	P	N
Tipulidae	2	N	N	A	34	N	N	21	P	P
Percentage of total numbers	7				28			30		
COLEOPTERA										
Elmidae		P					R	1		
Percentage of total numbers	0				0			>1		
Total number of taxa	18	20	17	19	24	24	25	27	27	14
Total number of insects	291				2708			2257		

[1]Probably includes three species: *besametsa*, *haysi*, and *frigida*.

Table 14. Numbers and abundance categories by taxa of aquatic insects from monthly samples at station 11. Total number of taxa per month is tabulated. For July, November and March percent of total numbers in each order and total numbers of individuals are shown. Class limits for abundance categories as in Table 4.

	1970						1971			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	Aug.
EPHEMEROPTERA										
Ephemerella doddsi			R	P	5	P	A	8		
grandis			R	P	145	A	A	168	A	
inermis	1				45	A	A	2400	V	
hystrix					6	R	A	60	P	R
coloradensis	1									
edmundsi						P	A	2088	A	
tibialis		P	R							N
Baetis sp. A	6	R	N	N	25	R	A	260	V	A
Ameletus			R	R	2		N			
Rhithrogena				P	64	R	A	16	R	R
Cinygmula	5					R	N	12	P	
Epeorus										
Iron										R
Ironopsis						R				R
Percentage of total numbers	28				10			49		
PLECOPTERA										
Pteronarcys	1	P	P	A	165	A	A	227	A	A
Pteronarcella				A	56	A	P	46	N	
Nemoura cinctipes					19	R	R	4		
Nemoura spp.[1]						N	A	600	A	
Acroneuria	2	P	P	N	38	A	N	22	N	P
Arcynopteryx				R		P	R		R	
Isogenus								3		
Isoperla			R		83	A	N	188	N	
Alloperla	1	R	R	A	39		N	10	P	
Percentage of total numbers	9				14			11		
TRICHOPTERA										
Hydropsyche	1	A	N	A	445	A	A	1400	V	
Arctopsyche		P	N	A	645	A	N	1130	V	
Rhyacophila			R	R	14	N	N	208	P	
Glossosoma	4							10	R	
Brachycentrus		R	N	P	29*/16	N	R	38		N
Micrasema				R		A	N	192	N	P
Amiocentrus		R	P			R	R		A	R
Percentage of total numbers	11				41			29		
DIPTERA										
Chironomidae	10	A	A	N	800	A	V	1000	V	A
Blepharoceridae	3*		P		1	R	R	1		
Rhagionidae	9	P	N	A	133	A	A	174	A	A
Simuliidae		R	P	R	6	N	N	20		
Tipulidae	3	N	P	R	6	P	R	23	N	
Percentage of total numbers	53				33			12		
COLEOPTERA										
Elmidae		R			6			4	P	R
Percentage of total numbers	0				>1			>1		
Total number of taxa	13	14	19	19	23	27	28	28	24	14
Total number of insects	47				2788			10,312		

[1]Probably includes three species: *besametsa*, *haysi*, and *frigida*.

*On TRICHOPTERA and DIPTERA indicates pupae.

Table 15. Volumes of aquatic insects measured to the nearest 0.5 ml. Volumes less than .3 ml are recorded as T (trace). Means represent mean volumes calculated from the values of months not marked with asterisks.

Station	Month	Ephemer-optera	Plecop-tera	Trichop-tera	Diptera	Total
1	Jan.*1971	4.	3.	1.5	5.	13.5
	Apr. 1971	10.	8.	2.5	8.	28.5
	July 1970	0.5	T	T	0.5	1.5
	Aug. 1970	1.5	T	3.	1.	6.
	Sept. 1970	1.5	T	1.5	1.5	4.5
	Oct. 1970	1.T	T	1.5	1.	3.5
	Dec.*1970	4.5	1.5	1.5	5.5	13.
						Mean 8.8
2	Mar. 1971	7.5	11.	8.5	8.	35.
	July 1970	0.5	T	T	0.5	1.
	Aug. 1970	0.5	T	T	1.	1.5
	Sept. 1970	0.5	0.5	1.	0.5	2.5
	Oct. 1970	0.5	0.5	0.5	1.	2.5
	Dec.*1970	3.5	2.5	1.5	4.	11.5
						Mean 8.5
3	Mar. 1971	2.5	6.	1.5	T	10.
	July 1970	1.	0.5	0.5	1.	3.
	Aug. 1970	1.5	0.5	0.5	T	2.5
	Sept. 1970	3.5	0.5	2.5	T	6.5
	Oct. 1970	3.5	1.5	2.	T	7.0
						Mean 5.8
4	Apr. 1971	2.5	1.5	1.	T	5.0
	July 1970	1.	T	1.	1.	3.
	Aug. 1970	4.	0.5	2.	0.5	7.
	Sept. 1970	1.5	1.	0.5	1.	4.
	Oct. 1970	0.5	1.	2.	0.5	4.
						Mean 4.6
5	Apr. 1971	1.	1.	0.5	T	2.5
	July 1970	1.	T	T	0.5	1.5
	Aug. 1970	1.	0.5	0.5	T	2.
	Sept. 1970	1.5	T	1.	T	2.5
	Oct. 1970	1.	0.5	0.5	0.5	2.5
						Mean 2.2
6	Jan.*1971	2.	0.5	0.5	1.	4.
	Apr. 1971	4.5	2.	0.5	1.	8.
	July 1970	1.	T	0.5	0.5	2.
	Aug. 1970	1.	T	0.5	T	1.5
	Sept. 1970	2.	0.5	1.5	2.	6.

Table 15. (Continued).

Station	Month	Ephemer-optera	Plecop-tera	Trichop-tera	Diptera	Total
	Oct. 1970	2.	0.5	1.5	1.5	5.5
	Dec.*1970	0.5	T	T	0.5	1.
						Mean 4.5
7	Jan.*1971	6.	3.	3.	5.	17.
	Apr. 1971	2.5	1.5	1.	1.	6.
	July 1970	1.	T	T	0.5	1.5
	Aug. 1970	2.	T	1.5	0.5	4.
	Sept. 1970	0.5	0.5	1.	0.5	2.5
	Oct. 1970	0.5	0.5	0.5	1.	2.5
	Dec.*1970	3.5	2.5	1.5	4.	11.5
						Mean 3.3
8	Apr. 1971	1.5	0.5	T	1.	3.
	July 1970	1.	3.	0.5	0.5	5.
	Aug. 1970	0.5	0.5	T	1.	2.
	Sept. 1970	0.5	7.	0.5	1.	9.
	Dec. 1970	2.	4.	0.5	1.5	8.
						Mean 5.4
9	Apr. 1971	7.	3.	0.5	4.	14.5
	July 1970	1.5	6.	1.	2.	10.5
	Aug. 1970	1.	T	T	2.	3.
	Sept. 1970	T	10.5	4.	3.	17.5
	Oct. 1970	1.5	6.	3.	3.5	14.
						Mean 11.9
10	Jan.*1971	2.	9.5	28.5	4.	44.
	Apr. 1971	4.	34.	29.	3.5	70.5
	July 1970	T	3.5	1.	1.	5.5
	Aug. 1970	0.5	3.5	0.5	1.	5.5
	Sept. 1970	1.	6.	4.5	1.5	13.
	Oct. 1970	1.	18.	5.5	1.5	26.
	Dec.*1970	2.5	17.	21.	3.5	44.
						Mean 24.6
11	Jan.*1971	6.5	7.5	13.5	5.5	33.
	Mar.*1971	24.	23.	79.	6.	133.
	Apr. 1971	9.	22.	35.	5.	71.
	July 1970	1.	1.	0.5	0.5	3.
	Aug. 1970	T	7.	3.5	1.	11.5
	Sept. 1970	0.5	5.	3.	3.	11.5
	Oct. 1970	0.5	42.	8.5	1.5	52.5
	Dec.*1970	4.	18.	32.	3.	57.
						Mean 29.8

as well as a higher percentage of fall-maturing species, particularly Ephemeroptera.

Fauna of the upper stations (three, four, and five) on the West Fork were dominated in numbers and biomass by Ephemeroptera and Plecoptera. Together they comprised 79% of the total number of insects collected in July, November and March samples, and 67% of the measured volume. *Rhithrogena robusta*, *Cinygmula* sp., *Ephemerella doddsi*, *Baetis parvus*, *Iron longimanus*, *Ironopsis* sp., *Brachyptera* sp., *Acroneuria theodora*, *Nemoura cinctipes*, and *Arcynopteryx* subgenus *Megarcys* were prominent taxa.

Less common Ephemeroptera included *Ephemerella coloradensis*, *E. tibialis*, *E. spinifera*, and *Ameletus* sp. Less common Plecoptera included *Diura knowltoni*, *Isogenus modestus*, *Leuctra* sp., *Alloperla* sp. and *Peltoperla* sp. which was restricted to station three. Trichoptera were represented primarily by *Rhyacophila* spp., Limnephilidae, especially *Glossosoma*, and *Parapsyche elsis*. Diptera were present in small numbers at these stations in contrast to the lower stations.

Samples from stations six, seven and one on the West Fork showed an increase in Diptera and certain Plecoptera, especially Chironomidae, *Alloperla* spp., and *Nemoura* spp. The most numberous of the *Nemoura* nymphs collected was probably *besametsa* (David Burns, unpublished data). The large increase in numbers of Diptera was reflected in a decrease in the percent of total numbers composed by Plecoptera and Ephemeroptera.

For July, November and March samples from these stations, Ephemeroptera and Plecoptera together contributed 39% of the total number of insects collected and 52% of the measured biomass. At stations six, seven and one, Diptera (mostly Chironomidae) contributed 58, 25, and 64%, respectively, of the total number of insects collected in July, November and March.

Prominent mayfly taxa at stations six, seven and one included *Ephemerella doddsi*, *Ephemerella inermis*, *Ephemerella hystrix*, *Cinygmula* sp., *Baetis* spp., and *Rhithrogena robusta*. *Alloperla* and *Nemoura* spp. were the most numerous Plecoptera. *Acroneuria* spp., *Arcynopteryx* subg., *Megarcys* sp., *Diura knowltoni* and *Isogenus modestus* were among less numerous Plecopteran taxa. Most prominent Trichoptera were *Glossosoma* and *Oligophlebodes* (Limnephilidae). Other numerous Trichoptera included *Rhyacophila* spp., *Arctopsyche* sp., and *Brachycentrus* sp. Of Dipteran taxa, Chironomidae were most numerous, particularly at station one, where they seemed to be associated with the heavy spring bloom of *Hydrurus*.

Large Plecoptera (Pteronarcidae) and large Trichoptera (*Hydropsyche* and *Arctopsyche*) were primarily responsible for the high standing crops (biomass) in spring samples from stations ten and eleven, where they reached their greatest abundance. At station ten in April 1971, Plecoptera and Trichoptera contributed 48 and 41%, respectively, of a total volume of 70.5 ml, while in the April 1971 sample from station eleven, the percentages were 31 and 49 of a total volume of 71 ml. Prominent Plecoptera at the West Gallatin stations included *Pteronarcys californica, Pteronarcella badia, Acroneuria pacifica, Arcynopteryx parallela, Isoperla* spp., *Alloperla* spp., and *Nemoura* spp. *Diura knowltoni, Isogenus modestus,* and *Brachyptera* sp. were uncommon at the West Gallatin stations.

In addition to Hydropsychidae, Trichoptera were well represented by *Brachycentrus, Micrasema, Amiocentrus* (Brachycentridae) and *Rhyacophila* spp. Limnephilidae, prominent in the West Fork, formed a very small component of the West Gallatin fauna.

Ephemerella was the most numerous mayfly genus in the West Gallatin, with an extensive species complex. The most prominent species were *inermis, edmundsi, doddsi, hystrix,* and *grandis*. *Rhithrogena robusta* and *Baetis* sp. A (including individuals of the genus *Centroptilum*, were also prominent throughout the sampling period.

Diptera were prominent at stations on the West Gallatin, the most numerous by far being the Chironomidae. Tipulidae were common, and *Atherix variegata* was a very significant component of the faunal complex. Other less prominent Diptera included Muscidae, Dueterophlebiidae, and Empididae. While Simuliidae were not found in great numbers in many samples, they were observed in the frequency category of "Abundant" in August, December, 1970 and January 1971 samples from station ten. They were also observed at a high density in February 1971 at station ten and in August 1971 just below station five.

Coleoptera (Elmidae) were found in small numbers throughout the study area except at station six (South Fork). They contributed little to the standing crops of insects (Table 15), so volumes were not measured.

Insect diversity was calculated for each sample taken in March, July and November. Station three had the lowest monthly diversity index, 1.86 units in March 1971, while station five had the highest, 3.99 units, also in March 1971. Other stations with relatively low monthly diversity indices included station one, 2.30 in March 1971; station eight, 2.35 in July 1970; and station nine, 2.09 in July 1970.

A one-way analysis of variance showed no significant seasonal differences in insect diversity indices between samples taken in March, July or November (significance level = .05).

Average station diversity was calculated for each station using the previously stated formula. Table 16 shows average station diversity ranked in order of descending magnitude and average number of taxa per station. At stations one and nine, those with the lowest average diversity index, the fauna, although having a good species complement, characteristically included one or two taxa which were extremely abundant (Chironomidae and *Nemoura*).

In comparing the rankings of stations based on average station diversity index versus the average number of taxa (Table 16), it is

Table 16. Average station diversity and average numbers of taxa per station in independent rank order. Average number of taxa were computed from March, July and November samples (Tables 4 through 14).

Station	Average Diversity	Station	Average No. Taxa
5	3.36	10	23
7	3.20	2	23
4	3.08	7	22.7
10	3.00	4	22.3
2	2.92	9	22
8	2.92	5	21.7
6	2.56	11	21.3
3	2.52	6	19
11	2.43	8	19
9	2.43	1	18.7
1	2.16	3	16.7

apparent that the diversity index calculated by this equation is relatively sensitive to numbers of individuals. Wihlm (1967) discusses this sensitivity at some length, and compares this parameter to others which were designed to perform a similar function. Some of the stations having the highest numbers of taxa per sample had a relatively low diversity index, due to a greater number of individuals per taxa. In examining this data, this trend seems to follow a downstream direction, being apparent at stations one, nine, ten and eleven.

Physical-Chemical Parameters

Table 17 presents measurements of current speed, depth, and width of the stream at each station under low flow conditions. Figure 2 presents substrate composition as percentage of the total bottom

Table 17. Values for physical parameters measured under low flow conditions. Depths on station seven were not taken due to the channel alterations.

Station	Current Average	(m/sec) Range	Depth Average	(cm) Range	Width (m) Average
1	.42	.15-.61	26	15-38	10.5
2	.41	.24-.52	41	30-54	40
3	.15	.12-.24	10	4-20	4.5
4	.32	.19-.64	21	12-28	2.5
5	.25	.18-.39	29	16-50	5.5
6	.39	.11-.73	33	14-52	5.5
7	.45	.21-.61	--	------	5.0
8	.52	.12-1.06	35	19-49	40
9	.15	.09-.21	15	7-23	5.9
10	.45	.15-.73	17	6-36	30
11	.58	.15-1.15	*	0-45	30

*The large size of the substrate at station eleven increases variations in depth in any given area, making an average relatively meaningless.

surface covered by each size class of particles.

Stations three and nine formed a group distinct from the other stations in terms of these physical parameters. At both, pebbles were the dominant substrate, current velocity was lower and more uniform than at other stations and depths were less than at all other stations. These stations differ from each other in their proximity to the West Gallatin, temperature regime, aufwuchs, and bankside vegetation; station nine being in a willow-sage flat and station three having mixed conifers along the banks immediately above and below, and grassy meadows farther from the creek bank.

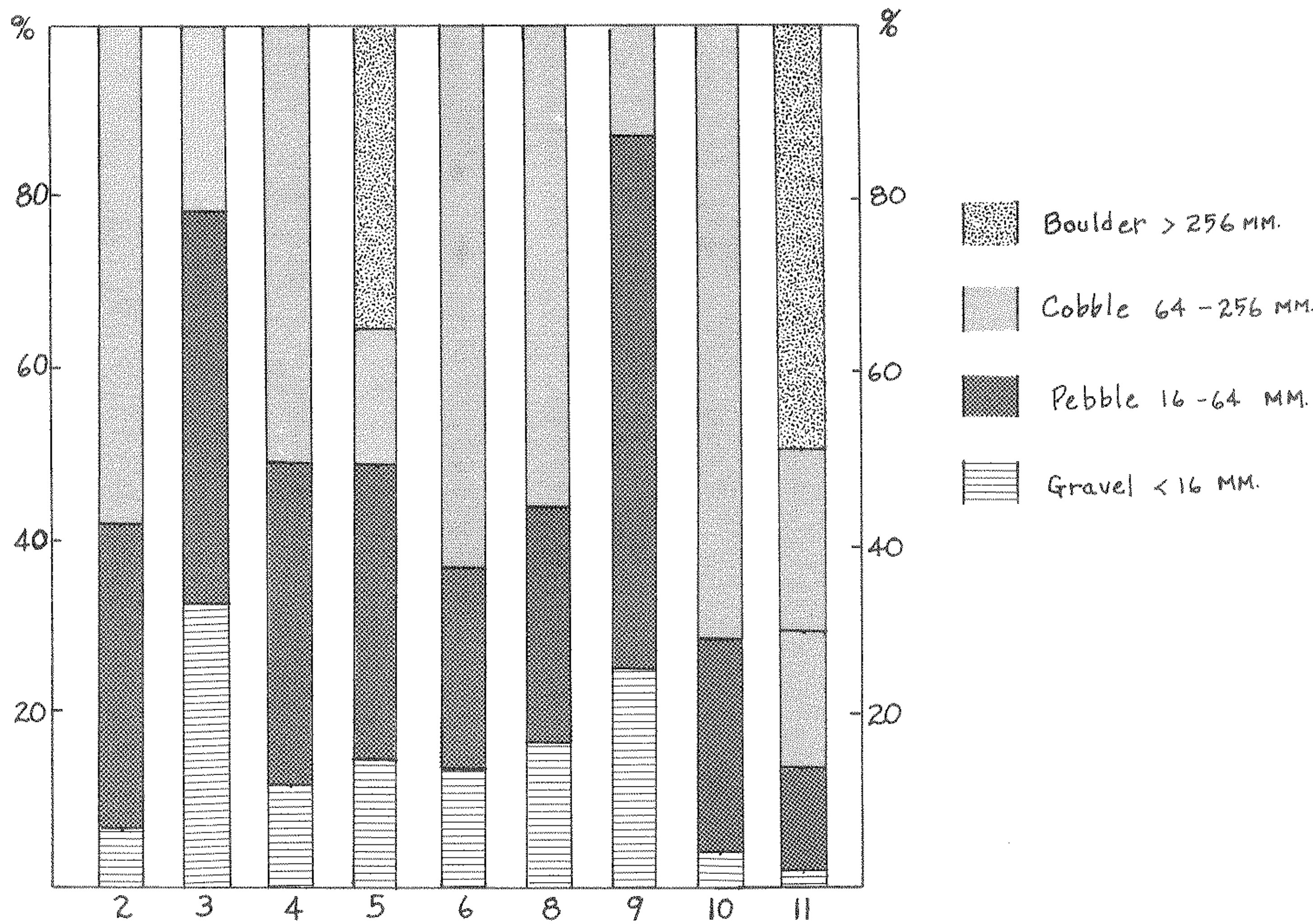

Figure 2. Substrate composition according to size at sampling stations.

At stations one, two, four, six, seven, eight and ten, cobble is the dominant substrate class, while at stations five and eleven small boulders form the dominant substrate. At station five, occurrence of boulders is restricted to a small area immediately below the bridge, and is probably due to constriction of the stream channel by the bridge footings, with resultant downstream scouring. At station eleven, occurrence of small boulders is widespread and a reflection of increased volume and speed flow.

There was considerable overlap of current speed amont all stations other than three and nine, with stations eight and eleven having the highest average speed. This is reflected in the increased size of substrate particles. The cobble at station eight was very large, almost the size of small boulders.

Table 18 presents data on total alkalinity and temperature. The highest temperature observed was 13.2° C at station eight on July 6, 1971. It has been shown that maximum temperatures in small, stony streams of temperate regions occur in mid-afternoon and that diurnal variations rarely exceed 5-6° C (Macan, 1958; Edington, (1966). Maximum temperatures in the West Gallatin probably do not exceed 15 to 16° C in the study section. Edington (1966) also found that summer temperatures of small streams could vary considerably over relatively short distances, depending on the degree of screening from direct isolation. It seems likely that maximum summer temperatures in the upper West Fork

Table 18. Data on total alkalinity (as ppm $CaCO_3$) and water temperature. Time is on a twenty-four hour clock. (Montana State University, 1972)

	6 July 71			16 Aug. 71		13 Sept. 71			18 Oct. 71		21 Feb. 72			21 Mar. 72	
Station	TA	Time	Temp.	Time	Temp.	TA	Time	Temp.	Time	Temp.	TA	Time	Temp.	Time	Temp.
1	62	1133	6.6	1115	12.0	114	1104	8.1	1015	2.0	135	----	0.5	1015	2.0
3	40	1025	4.4	0900	9.8	87	0908	4.8	0912	0.9	111	----	-1.0	0850	0.0
4	47	1015	5.5	0850	4.2	78	0858	5.0	0903	0.8	---	----	-1.0	----	---
6	70	1120	6.6	1050	12.0	118	1056	5.9	1005	2.0	138	----	-1.0	0820	0.5
7	48	1127	6.6	1035	10.9	104	1048	6.1	0955	2.2	134	----	-1.0	0825	0.0
8	95	1157	6.6	1130	13.2	120	1228	10.4	1110	2.7	119	----	0.0	1010	2.0
10	86	1250	8.4	0957	12.1	124	1220	11.0	1020	4.0	125	----	0.0	0800	5.0
11	81	1305	7.4	1014	12.0	118	1155	9.7	0930	4.0	120	1120	0.0	0755	3.0

are slightly cooler than in the West Gallatin, due to screening of insolation by vegetation and topography.

The temperature regime at stations two, ten and eleven on the West Gallatin may be affected by the input of a large warm spring (temperature 12-13° C, Dr. G. Roemhild, personal communication) just below the confluence of the West Fork and the West Gallatin. Temperature measurements in Table 18 for July and August did not indicate elevation of summer temperatures; however, those for September, October, February and March indicated a moderating effect in fall, winter and early spring.

Bottom ice, which may be a factor influencing winter survival of aquatic insects (Hynes, 1970), was not observed at stations two, ten or eleven during winter sampling, while bottom ice of a frazil nature was observed at all stations on the West Fork for which winter samples were taken. Station eight on the West Gallatin and upper stations on the West Fork were subject to ice cover from mid-December to early March. Station one on the West Fork was ice-covered for a shorter period, while stations two, ten and eleven were not subject to ice cover at all.

Waters of the West Gallatin drainage are predominately calcium bicarbonate in nature. In the study section, alkalinity ranged from 0.8 me/L in the North Fork to 3.0 me/L at station eight on the West Gallatin (Table 18). Alkalinities in the North and Middle Forks were consistently lower than those in the South Fork and West Gallatin, reflecting the igneous nature of the North-Middle Fork drainage. Alkalinities at all stations were highest during winter, when base flow conditions were obtained. Values of pH were between 7.5 and 8.8 throughout the study section, the highest value occurring at station eleven. Ammonia, nitrate, ϕ-phosphate, chloride and sulfate concentrations in the West Gallatin drainage were very low and the water was of high quality by health and esthetic standards (Montana State University, 1972).

Plant Material

Volumes of algae and detritus retained in the cod of the sampler are shown in Table 19. Volumes at the upper stations of the West Fork were composed of mostly allocthonous detritus, while lower stations contained more filamentous algae. Based on the volumes determined and observations on the other samples for which volumes were not measured, it appears that the amount of plant material in the aquatic ecosystem increased in a downstream direction, an exception being station eight on the West Gallatin. Also, volumes were greatest in the early spring and least in the summer after runoff had occurred. In his analysis of factors affecting stonefly distribution in the Yellowstone River, Stadnyk (1971) encountered similar seasonal changes in the aufwuchs community. This he attributed to scouring action of ice and silt on the aufwuchs.

Table 19. Volumes of plant material (in milliliters) caught in the cod by station and months. Composition is given in descending order of visual prominence. Diatoms were ubiquitous throughout the study area.

Station	Month	Volume	Plant Composition
1	Jan.	625	filamentous algae, detritus
	Mar.	1000+	filamentous algae, detritus
	Aug.	100	filamentous algae, detritus
2	Aug.	45	filamentous algae, detritus
	Dec.	195	filamentous algae, detritus
3	Aug.	25	detritus
4	Apr.	85	detritus, filamentous algae
5	Apr.	200	detritus
6	Apr.	135	filamentous algae, detritus
	Aug.	35	filamentous algae
7	Apr.	55	filamentous algae
	Aug.	40	detritus
	Dec.	105	filamentous algae
8	Apr.	85	*Nostoc*, detritus
	Aug.	25	*Nostoc*
	Dec.	60	*Nostoc*
10	Apr.	240	filamentous algae, detritus
	Dec.	180	filamentous algae, detritus
11	Jan.	205	filamentous algae, detritus
	Mar.	500	macrophytes, filamentous algae, detritus
	Apr.	260	macrophytes, filamentous algae, detritus
	Aug.	120	filamentous algae, macrophytes, detritus
	Dec.	300	macrophytes, filamentous algae, detritus

The algal community in the West Fork was visually dominated in the late winter and early spring by *Hydrurus*, in the summer by *Spirogyra*. These two also occurred in the West Gallatin, but were not quite so noticeable. Diatoms occurred at all stations, but were especially noticeable at station nine, where they formed heavy encrustations on the substrate. Aufwuchs at station eight was visually dominated by *Nostoc*. Development of the aufwuchs community was greatest at station eleven, the only station at which macrophytes were noticed. This was probably attributable to the increased stability of the larger substrate and freedom from ice cover at this station.

DISCUSSION

Distribution of Aquatic Insects

Hynes (1970) and Macan (1961) discussed a complex of factors which affect the composition, numbers and distribution of a stream's insect fauna. Included were current speed, substrate, temperature, dissolved substances, suspended substances, flow regime, light, food, geography and various biotic factors, such as predation and interspecific competition. A tremendous volume of literature now exists on the interaction of these and other factors in determining the distribution and abundance of aquatic insects.

Current speed may well affect stream insects more through its relationship to substrate and food availability than directly. Ambühl's (1959) discovery of a boundary layer of slow-moving water at the substrate-water interface may explain many of the unsuccessful attempts to correlate species' micro-distribution with current. Chutter (1969) used three different sampling regimes in studying current-organism relationships. By partial regression analysis, he found significant current organism relationships (90% level) for *Cheumatopsyche* sp. (Trichoptera) and *Simulium* sp. (Diptera) in samples collected at the same site on the same day. Data from different stations collected on the same day failed to show any significant regression, nor did that taken from the same station over a three-month period of time. These results would seem to indicate that the interaction of current with other factors peculiar to each location is more significant than the constant physical effect of current on organisms. Knight and Gaufin (1964) did find that current plays a significant role in respiratory physiology, certain Plecoptera being more tolerant of low dissolved oxygen concentrations when current velocity was high.

Scott (1958) observed that *Hydropsyche fulvipes* was most numerous where the current was over forty centimeters per second, while *Glossosoma* was most numerous in moderate current (twenty centimeters per second) on small cobble. Distributions found in this study agree with his results. *Glossosoma* sp. was more numerous at stations on the West Fork which had somewhat smaller substrate particles, while *Hydropsyche* and *Arctopsyche* were most abundant at station eleven, which has the highest average current speed and the largest sized substrate.

Edington (1965) also found distribution of net-spinning Trichoptera related to higher current velocities, and Zahar (1951) found the distribution of Simuliidae related to current pattern, larvae being most numerous in areas of non-turbulent flow. Station ten had a non-turbulent current pattern, which may be a partial explanation for the aggregation of Simuliidae there in winter samples.

Substrate is one of the most basic features of an aquatic biotope. Thorup (1966) suggested that substrate be used to delimit aquatic biotopes as an easily recognized elemental feature of the environment. Knight and Gaufin (1967) used substrate and stream size as basic features in their division of the Gunnison River in Colorado into several stream types. They found that certain species of stoneflies were peculiar to each type.

Limiting consideration to stony substrates, Hynes (1970) stated that the larger the stones, the more diverse will be the invertebrate fauna, presumably due to increased stability of the substrate, as well as a wider size range of crevices and interstitial spaces, inviting presence of a wider size range of organisms. Of the two stations with pebbles predominating, station three had the lowest average number of taxa (16.7), while station nine had close to the highest (22.0). However, station nine had much more available food, both as detritus and autochthonous material. Station eleven, with a higher percentage of insects in the larger size classes, also had the largest substrate. Substrate size composition is closely related to current, thus a relationship between current and the size distribution of organisms is logical. However, a great number of small organisms were also present at station eleven.

An effect of substrate size on standing crops may be indicated at station eleven. The high stability of the substrate allowed maximum development of aufwuchs and provided a maximum number of niches for organisms to occupy (Hynes, 1970).

The effect of temperature on the distribution of aquatic insects has been extensively investigated and discussed, and is undoubtedly of primary importance, both directly and indirectly. Minshall (1969) concluded that temperature was effective in determining the distribution of Plecoptera in a headwater stream. Knight and Gaufin (1966) considered temperature significant in determining Plecoptera distribution in a section of the Gunnison River, a trout stream in Colorado. Kamler (1965) concluded that temperature was significant in the distribution of Ephemeroptera and Plecoptera in Polish streams. Data of Vincent (1967) indicated that species composition of the insect fauna of the Gibbon River in Yellowstone Park was affected by the heating of the river by thermal waters. It appeared that *Ephemerella grandis* and *Hydropsyche* sp. were limited by lower temperatures at his upper station. The distribution for these two species in the present study follows the same pattern, for both were most numerous below the influence of the warm spring. *E. grandis* reached its maximum density at station eleven, followed by station nine. Station nine is admittedly above the warm spring area, but it is subject to considerable warming in late spring and early summer, being shallow and completely exposed to the sun. It also provides an abundance of prey organisms for the carnivorous numphs. This may be proposed as evidence that food is the most significant factor in determining distribution of this species within existing physical limits. Numbers of *Hydropsyche* were greatly reduced above the area of the warm spring.

The presence of ice, both bottom and surface, is related to temperature. Effects of ice on stream insects are not well documented. Gaufin (1959) reported a drastic reduction in benthic insects following severe bottom icing conditions in the Provo River, Utah, while Brown, *et al.* (1953) found bottom ice of a frazil nature to have little ill effect on bottom insects, although surface ice, when it trapped them, killed them. Reimers (1957) attributed a reduction in benthic insects to extensive ice and snow cover. Gard (1963) has shown that ice and snow cover can serve to insulate a stream from supercooling. Vincent (1967) also concluded that numbers of insects were reduced by the action of surface ice, especially *Hydropsyche*. The distribution observed in my study area agrees with his findings.

Surface ice appears to be very significant in relation to numbers and biomass of benthic insects in the West Gallatin drainage. Station eight on the West Gallatin and stations above one on the West Fork were subject to extensive ice and snow cover from December to March or April. Stations two, ten, and eleven were not subject to ice cover at all, and station one had little surface ice, although bottom ice was observed. Ice cover at station eight became very thick, sixty centimeters or more, while ice at upper stations on the West Fork was not as thick, but had more snow cover. Insects could have been subject to crushing or freezing by surface ice, as well as scouring by drifting surface ice in the spring (Stadnyk, 1971). Station eight had the lowest average standing crop of all stations on the West Gallatin, while station one had the highest average standing crop of all stations on the West Fork. Ice and snow cover could also affect stream insects by reducing autochthonous and allochthonous food supplies; assuming, of course, that food ever becomes critical or limiting to stream insects.

Food is a major factor in the distribution of aquatic insects (Ulfstrand, 1968; Minshall, 1967; Scott, 1958). Egglishaw (1964) demonstrated that microdistribution of some aquatic insects could be significantly correlated to the distribution of organic detritus on the bottom. Using a series of experiments using shallow metal pans filled with rocks, leaves, and rubber strips, he determined with reasonable certainty that the observed distribution was relative to food supply, not cover.

Species' food habits often influence both micro- and macrodistribution. Scott (1958) attributed the microdistribution of *Glossosoma* to its diatom grazing habit, by virtue of the fact that larger stones tended to have more filamentous algae and moss. Knight and Gaufin (1966) concluded that *Arcynopteryx parallela* was excluded from higher elevations because it consumed more plant material, while *A. signata*, being more carnivorous, was found at higher elevations; however, data collected by Richardson (Richardson and Gaufin, 1971) did not bear out that conclusion.

Richardson (Richardson and Gaufin, 1971) found evidence of prey selection by *Arcynopteryx parallela* against Simuliidae, while *A. signata* took them frequently. It is reasonable to expect distribution and numbers of carnivorous species to follow distribution and abundance of prey species.

Several authors have indicated that allochthonous material and detritus is the major food source of many, if not most, aquatic insects (Minshall, 1967; Richardson and Gaufin, 1971; Demory and Chapman, 1963). In the present study it is notable that the highest standing crops of insects (Table 15) occurred at those stations with the greatest volumes of plant material, both allochthonous and autochthonous (Table 19). The relationship between filamentous algae, *Nemoura* spp., and Chironomidae at station one is obvious, and station eleven had high plant volumes associated with high insect standing crops.

It is doubtful that water chemistry affected distribution of aquatic insects in the study area. Differences in primary productivity are more likely to be due to the influence of other factors, i.e., light, temperature, and substrate.

Life Histories of Aquatic Insects

Species' life histories are significant in interpreting fluctuations in numbers and changes in kinds of organisms. Changes or differences in environmental conditions can be reflected by changes in dominant organisms, leading to varying patterns in seasonal fluctuations (Hynes, 1961; Ulfstrand, 1968). Hynes (1970) discussed life history phenomena and categorized types of life cycles among aquatic insects. Variations in univoltine development include both slow and fast seasonal development. Many aquatic insects follow these patterns with various degrees of modification. Slow seasonal organisms are those in which the eggs hatch shortly after deposition and growth is gradual over a relatively long period until emergence. This type is typified by *Ephemerella doddsi* and *Nemoura cinctipes* (Radford and Hartland-Rowe, 1971). Fast seasonal organisms have an extended quiescent period in the egg stage, perhaps overwintering as such, then a shorter period of rapid growth from hatching to emergence. This type is exemplified by *Nemoura besametsa* and *Ephemerella coloradensis* (Hartford-Rowe and Radford, 1971). Interpretation of size frequency data is complicated by species' variation in length of hatching and emergence periods. For example, many species of *Rhithrogena* have a very long emergence period, thus nymphs of all size classes may be found throughout the year. Others, apparently among which is *Ephemerella tibialis*, have a much shorter emergence period and nymphs are more uniform in size for each year class.

Table 20 gives life history data for some taxa occurring in the study area for which life histories have been determined by analysis of size distributions of nymphs or by other investigators.

Table 20. Life cycle patterns of some univoltine insects found within the study area, based on size distributions and occurrence of nymphs and larvae, and life history studies by Hynes (1961), Scott (1958), Ulfstrand (1968), Gaufin (1959), and Radford and Hartland-Rowe (1971).

Taxa	Observations of Small Individuals	Development Slow	Development Fast	Emergence Period
Ephemerella inermis	September	X		June-July
doddsi	August	X		June-Aug.
grandis	August	X		June-Aug.
edmundsi	December		X	May-June
hystrix	October		X	May-June
coloradensis	April		X	Aug.-Sept.
Iron longimanus	not obs.		X	Aug.-Sept.
Rhithrogena robusta	all year	X		May-Sept.
Cinygmula sp.	October	X		Aug.-Sept.
Ameletus sp.	not obs.	X		Apr.-May
Pteronarcella badia	September	X		June-July
Nemoura cinctipes	October	X		Apr.-May
Nemoura sp.	December		X	Mar.-Apr.
Brachyptera sp.	October	X		Apr.-May
Hydropsyche sp.	July	X		June-July

Small *Ephemerella inermis* were taken in September and subsequent fall samples at several stations. They became abundant in some November and December samples, indicating that a high percentage of eggs hatch in the fall. The nymphs appeared to have grown little over the winter months. It is possible that development of some eggs was delayed until January or February, as numbers reached a maximum at station eleven in

March. This could be due to late winter recruitment from eggs, drift, or the presence of another species, i.e., *Ephemerella infrequens*, which is practically impossible to distinguish from *E. inermis* in the nymphal stage (Dr. G. Roemhild, personal communication). A few large nymphs of this type were taken in July, thus the peak of emergence must have been in June and early July.

The life cycle of *Ephemerella doddsi* in the study area seemed to coincide with the life cycle determinations made by Radford and Hartland-Rowe (1971). Small nymphs were present in August samples, numbers increasing through the fall as hatching progressed. The nymphs appeared to grow throughout the winter at a reduced rate. Growth in spring was rapid to maximum size in June and July. A few very large specimens were taken as late as August, indicating a long emergence period.

Small nymphs of *Ephemerella edmundsi* showed up in December samples, and numbers increased through March. Large specimens were not seen in July, thus emergence had occurred by that time. It appears that most *E. edmundsi* overwinter in the egg stage, at least until late January.

Ephemerella hystrix followed a similar pattern, except that small nymphs were seen as early as October. Numbers increased in November and December samples, and at some stations reached a spring maximum. Largest nymphs were taken in April, as no May or June samples were collected due to high water.

Ephemerella coloradensis is a fall emerging form. The nymphs hatch in early spring and mature through the summer. Emergence occurs in September or late August.

Rhithrogena robusta is known to have a long emergence period (W. L. Peters, personal communication). Nymphs of various sizes were present together throughout the year. Other *Rhithrogena* species could be present, although none were identified.

Small nymphs of *Iron longimanus* were not observed, but mature nymphs were collected in August and September, indicating fall emergence.

Small nymphs of *Cinygmula* sp. were taken in October. They increased in average size and number through spring and summer to maturity in August and September.

Small *Ameletus* nymphs were not observed. However, fairly large *Ameletus* were collected in fall samples, and mature nymphs were seen emerging in April, 1971 at station eleven.

Small nymphs of *Pteronarcella badia* were taken in September. It appears that most eggs hatched by November and numbers of nymphs decreased from that time into spring, but this trend is not consistent at every station. Adults were observed in June and July, but specimens were not collected.

Nemoura cinctipes is a slow growing species. Nymphs hatched in early fall and matured in March and April, emerging in April and May.

There is a complex of *Nemoura* species which includes at least *haysi, besametsa* and *frigida* (David Burns, unpublished data) that are not distinguishable as nymphs. These began appearing in December and continued to increase in numbers until March. Adults were present March through July (Burns, unpublished data). Hynes (1970) and Radford and Hartland-Rowe (1971) discussed at length the possibility of inter-specific competition between such closely allied species and mechanisms for avoidance of competition for available space and food.

Small *Brachyptera* nymphs appeared in fall samples and numbers increased in spring, particularly at station three, indicating that hatching may continue through most of the winter. Mature nymphs were taken in April and were not seen in July samples.

Apparently eggs of *Hydropsyche* sp. hatch in early summer, since small larvae were taken in July. The hatching period appeared to be long, numbers of larvae increasing from summer to fall. *Hydropsyche* reached maximum numbers in November at station ten and in March at station eleven. The pattern of numbers at station ten is typical of a univoltine organism which has a long growth period, i.e., a gradual increase in numbers through recruitment until a maximum is reached, then a decline due to mortality until emergence. Possibilities for an explanation for the spring maximum at station eleven include sampling error, habitat selection, and drift. Since Waters (1961) and Bishop and Hynes (1969) found Trichoptera to be relatively uncommon in drift, it is most likely that sampling variation or habitat selection is responsible.

Life histories of other prominent organisms have been determined by other investigators or can be extrapolated to a certain extent from the data. Holdsworth (1941) determined *Pteronarcys proteus* to have a four year life cycle; one year in the egg stage, three in the nymphal stage. *Pteronarcys californica* taken in this study appeared to follow the same pattern. No explanation is readily available for the low numbers of one and two year nymphs of *P. californica* from July and August samples on the West Gallatin. The possibility of habitat selection seems the most likely.

Arctopsyche sp. and *Parapsyche elsis* have at least two year life spans as larvae, large individuals being observed in autumn samples. *Glossosoma* sp. also appears to have a two year life span, overwintering in the pupal stage after its growing period.

CONCLUSION

In continuing a study of aquatic insects in this area, effort would be best conscentrated on autumn and spring samples, as sampling efficiency in relation to numbers of taxa per sample was greatest in this period. In addition, the nymphs are large enough to be more readily identifiable. Considering the volume of material obtained from a 0.5 meter square sample and the tediousness of separating insects from debris, a more profitable method might be that of sampling individual rocks, especially in the larger size classes, or "kick" samples mentioned by Macan (1961), which have been shown to provide adequate representation of the species composition of insect communities. Gaufin and Tarzwell (1956) found this to be a reliable indicator of the trophic or pollutional state of aquatic insect communities. The quantitative value of Surber samples is at best questionable (Needham and Usinger, 1956).

Insect communities within the study area seemed typical of those expected in rocky, mountain streams. Taxonomic composition varied along the gradient of physical conditions measured and distinctions could be made. Communities at upper stations on the West Fork (three, four, and five) were dominated in numbers and biomass by Plecoptera and Ephemeroptera. Limnephilidae were the most common Trichoptera. Downstream of station, Diptera increased and species composition of the insect fauna changed. In the West Gallatin, new additions were made to the species complex and the fauna was dominated by yet different taxa. Higher standing crops were present in the stations downstream of the West Fork. The data points to a moderation of physical conditions, coupled with changes in the nature of the stream, as causative agents for observed distributions of insects.

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