The distribution and abundance of aquatic insects in the middle West Gallatin drainage
by Paul Allen Garrett

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

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 Ephemer-optera 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.

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Date 30 July 1973

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by

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

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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.

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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.

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

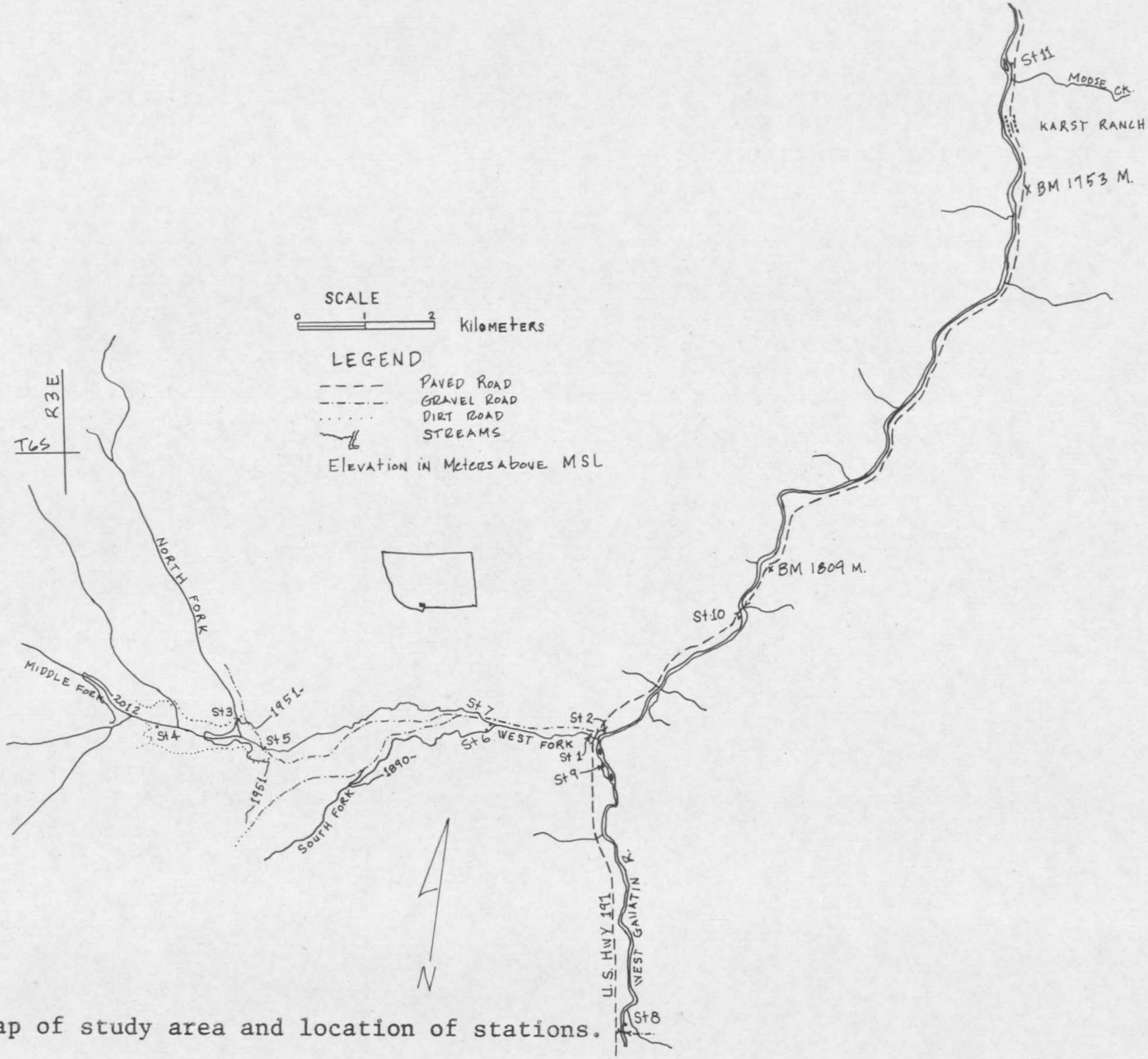

Figure 1. Map of study area and location of stations.

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.

Station	1970						1971		
	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,