Plecoptera of the West Fork of the West Gallatin River and factors influencing their distribution
by David Charles Burns

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:
Factors affecting the distribution of Plecoptera in the West Fork of the West Gallatin River, Montana were investigated. From June, 1971 through July, 1972 benthos samples were taken using a Surber-type sampler at 10 stations. Another station was established in March, 1972 for an intensive study of insect-substrate relationships. Adult stoneflies were collected from February, 1972 through September, 1972. Differences in stream width, base flows, current velocity, substrate size composition, water temperature, bank canopy coverage, pH, total hardness, total alkalinity, Φ-phosphate, nitrate, ammonia, periphyton and allochthonous detritus were noted at the 10 stations which were sampled monthly.

The most significant differences between sampling stations were found to be associated with the geology of the area and distribution of terrestrial vegetation. Major factors influencing the distribution of stoneflies in the West Fork study area were apparently substrate, food, stream width and temperature.

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Head, Major Department

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ABSTRACT

Factors affecting the distribution of Plecoptera in the West Fork of the West Gallatin River, Montana were investigated. From June, 1971 through July, 1972 benthos samples were taken using a Surber-type sampler at 10 stations. Another station was established in March, 1972 for an intensive study of insect-substrate relationships. Adult stoneflies were collected from February, 1972 through September, 1972. Differences in stream width, base flows, current velocity, substrate size composition, water temperature, bank canopy coverage, pH, total hardness, total alkalinity, ϕ-phosphate, nitrate, ammonia, periphyton and allochthonous detritus were noted at the 10 stations which were sampled monthly.

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INTRODUCTION

The stoneflies (Plecoptera) of the West Fork of the West Gallatin River and some probable factors affecting their distribution were examined during a 15 month study beginning in July, 1971. The West Fork was chosen for this study because of the ingress of a recreational development into this semiprimitive area and baseline information about the fauna of this area was desired. The influence of the development on the West Fork in terms of changes in water quality due to sewage effluent, increased sediment load, or other factors could hopefully be monitored in the future via reactions of the stonefly species complex which should vary little from year to year under undisturbed conditions according to Hynes (1961).

Rather than doing a survey of the whole community of benthic fauna on the West Fork and using nebulous quantities, such as species diversity indices (Dickman, 1968; others), to indicate the relative stability of the communities present, a more intensive study of one taxocene, as suggested by Hurlbert (1971), was undertaken. This approach also avoids the necessity of trying to describe discrete communities at different sampling stations; this is generally impossible in such relatively unpolluted areas as noted by Armitage (1961). Since Wiggins (1964) has pointed out that the determination of the exact taxonomic composition of the fauna present is critical in such work, the choice of Plecoptera for the taxocene to be studied seems to be justified. This order is relatively well known in this geographic area because of the works of Castle (1939), Gaufin, *et al.* (1966), Gaufin, *et al.* (1972) and Ricker (1943) Their papers were valuable aids in the identification of the species present.

Plecoptera also appeared to be a logical choice for the focus of a study such as this because of the relative sensitivity of the order to the types of changes in water quality expected to occur in the study area (Gaufin, 1965).

Presence of the taxa to be studied in the study area is of great importance when choosing a group for study. The West Fork could be classified as a torrential stream. Stoneflies are well adapted to this habitat according to such authors as Nielsen (1950, 1969) and Madsen (1968a). Specific factors influencing the distribution of this order in the rithron, as defined by Hynes (1970a), have been studied by many researchers. Hynes (1941b) noted many general characteristics of the ecology of the British Plecoptera. Minshall (1969) found that a large number of species were capable of being present in a stream despite a generally monotonous appearance of the stream. He also reported that stoneflies were a dominant taxa in headwater streams and Mackereth (1957) noted higher numbers of Plecoptera in swifter areas of a stony stream.

Due to the small altitudinal range of the study area, few problems associated with natural zonation were expected but it has been pointed out by Minshall and Kuehne (1969) that Plecoptera are replaced as the dominant taxa as one proceeds downstream. Studies in the Rocky Mountains include that done by Dodds and Hisaw (1925) who showed a definite altitudinal zonation of Plecopteran species in Colorado. After a study of the Yellowstone River in Montana, Stadnyk (1971) concluded that downstream eutrophication was a major factor affecting the distribution of Plecoptera.

Mead (1971) makes a case for the use of simple models in ecological studies, and points out that even though two or more variables are known to be correlated, this should not prevent the analysis of their separate effects on a population. Therefore, in this study many interrelated variables were studied.

The importance of selecting similar sampling locations, as noted by Gaufin (1956), was kept in mind. Riffles, as defined by Keller (1971), were chosen for the primary areas of study. This was done because of the importance of turbulence, as noted by Eriksen (1964), in substrate-current-oxygen relationships. Ulfstrand (1967) has also pointed out the importance of the interplay of these three factors along with their effect on the distribution of food for benthic organisms. Thorup (1964) points out the biotopes and manifestations of other ecological variables are reflected by the substrate composition and Cummins (1964) has emphasized the importance of analyzing substrate size in studies of stream benthos. However, Scott (1964) notes that all species do not react in the same way to changes in substrate composition.

It has been shown by Needham (1969) that production apparently varies with stream width, while the roles that aquatic and terrestrial primary producers play in community dynamics may also vary with stream size according to Chapman (1964). Minshall (1967) and Nelson and Scott (1962) have noted that allochthonous detritus may contribute from 50 to 100 percent of the energy to primary consumers.

Shading by riparian vegetation has been shown by Thorup (1970) to probably influence the frequency of benthos. Shading may strongly influence stream temperature and Minshall (1968) has noted an increase in variation of stream temperature with the lack of streamside vegetation. The distributions of two stonefly species have been shown to be closely tied to temperature by Minshall and Minshall (1966).

Temperatures low enough to produce consolidated sheet ice have been shown to kill benthic invertebrates by Brown, *et al.* (1953) while snow cover has been shown to be an effective insulator of streams by Gard (1963). Both conditions could be expected in the study area due to its location. However, some degree of cold may be necessary for the development of many Plecoptera, since Davis and Warren (1965) have shown high growth efficiencies for a stonefly in winter.

Temperature may influence the emergence patterns in insects according to Corbet (1964). Emergence complicates the study of the effects of environmental change on Plecoptera since the factors affecting life as an adult are not fully understood.

Life cycles are of primary importance and some knowledge of the life history of the insect becomes necessary when trying to understand factors influencing its distribution. This has been pointed out by Ulfstrand (1968b) who found apparent changes in the life cycles of a stonefly with changes in some environmental conditions.

Macan (1961b) has reviewed the literature on most of the above factors which are important in limiting the range of freshwater animals. In addition, he has pointed out the importance of certain chemicals. The importance of the effects of water chemistry to this study will be discussed later.

DESCRIPTION OF THE STUDY AREA

The study area is located about 50 kilometers (31 miles) due southwest of Bozeman, Montana on the West Fork of the West Gallatin River, which is a small east flowing tributary of the West Gallatin River (Figure 1).

The West Fork drains a structural and topographic basin bounded on the south and west by the Lone Mountain intrusive complex and on the north by the Pre-Cambrian Spanish Peaks (Montagne, 1971). Cretaceous strata form the exposed stratigraphic units of the basin and are interbedded with igneous sills. These overlay the Kootenai Formation, forming non-resistant units susceptible to various types of mass-gravity movements (Kehew, 1971).

The geology of the drainages of the tributaries to the West Fork has been described by Walsh (1971). The South Fork is characterized by muddy sandstone ledges and ribbon-like clay lenses below gravel surfaces. Located near Ousel Falls is the apex of an outwash consisting of Andesitic pebbles and cobbles. In terms of area drained, length of channel and sediment load, the South Fork is the largest of the tributaries to the West Fork. This drainage is the source area for West Fork plain outwash gravels and was probably extensively glaciated during the Bull Lake glaciation about 130,000 years ago (Dr. J. Montagne, personal communication).

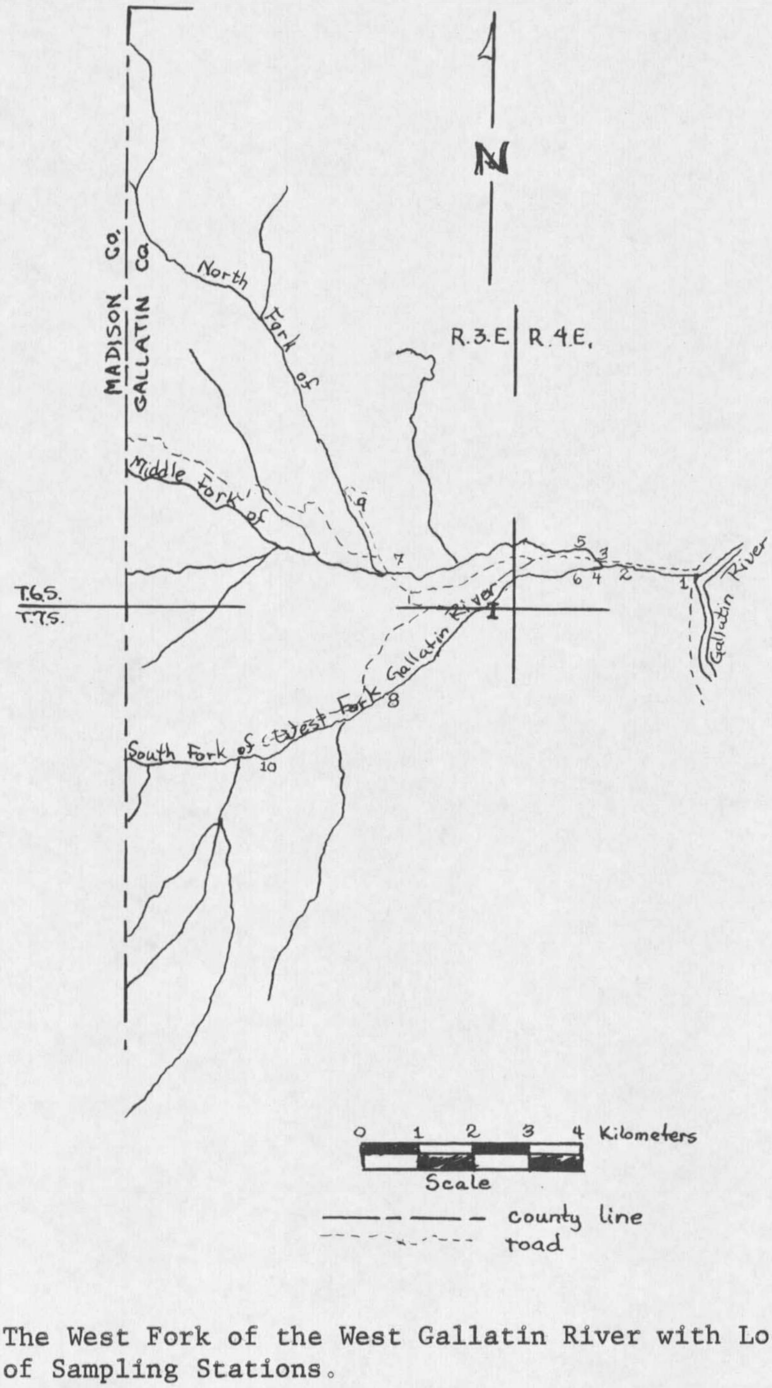

Figure 1. The West Fork of the West Gallatin River with Locations of Sampling Stations.

TABLE 1. THE LOCATION OF SAMPLING STATIONS.

Station	Elevation Meters	(Feet)	Legal Description	Location
1	1830	(6000)	T6S, R4E:32	West Fork, immediately above Hiway U. S. 191 bridge.
2	1848	(6060)	T6S, R4E:32	West Fork, approx. 183 meters (200 yds.) below the confluence with the South Fork.
3	1853	(6075)	T6S, R4E:31	West Fork, immediately above its confluence with the South Fork.
4	1853	(6075)	T6S, R4E:31	South Fork, immediately above its confluence with the West Fork.
5	1860	(6100)	T6S, R4E:31	West Fork, below Big Sky meadow village.
6	1860	(6100)	T6S, R4E:31	South Fork, above major area of private homes.
7	1922	(6300)	T6S, R3E:35	West Fork, above the Big Sky meadow village.
8	1922	(6300)	T7S, R3E:2	South Fork, in a steep sided canyon.
9	1982	(6500)	T6S, R3E:35	North Fork, immediately below the Lone Mountain Guest Ranch.
10	1982	(6500)	T7S, R3E:10	South Fork, approx. 183 meters (200 yds.) above Ousel Falls.

Bull Lake moraines of the North Fork lie in the West Fork Basin near the confluence of the North and Middle Forks. The North Fork drainage is the only area of Pre-Cambrian outcrops and is separate from the bulk of the West Fork outwash.

The Middle Fork is more similar in geological aspect to the South Fork than the North Fork. No sampling stations for this study were established on the Middle Fork due to problems of accessibility at elevations around 1982 meters (6500 feet).

Stations 1 through 10 were established to check relative macrobenthos abundance, gather related data and collect adult Plecoptera. Their locations are shown on Figure 1 and Table 1. Another station, indicated by "I" on Figure 1, was established as an intensive sampling site in order to study benthic macrofauna-substrate relations. This station was located on the South Fork in T7S, R3E:1 at approximately 1891 meters (6200 feet) in elevation.

Major terrestrial vegetation types associated with the area are shown on the vegetation map (Figure 2, Montana State University, 1972).

When this study was undertaken, county and logging roads may have contributed some sediment to the stream during periods of runoff and some sewage effluent may have been entering the lower stretch of the stream from the few homes and ranches in the West Fork Basin.