Effects of controlled flow reductions on aquatic insects in a stream riffle
by William McClay

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


Abstract:
A study was conducted on Blacktail Creek in southwestern Montana from May, 1966, to September, 1967, to determine the effects of controlled flow reductions on the ecology of aquatic insects. Two riffles were selected for study: one served as a control, and the other, the test riffle, was subjected to flow reduction^ of 75 and 90% during the summers of 1966 and 1967, respectively. Four samples of aquatic insects were collected with a Surber sampler along a transect in each riffle on each sampling date.. Samples were collected bimonthly during the periods of dewatering and monthly during the period of natural flow. Physical and chemical data were collected on each sampling date. Average depth, average water velocity, and water volume were the physical parameters most affected by flow reductions. During the period of 75% dewatering, aquatic insect populations in the control riffle increased, while those in the test riffle remained stable. Insect densities in the test riffle, relative to those in the control riffle., were higher during the period of 75% dewatering' than during the full-flow period. A decline in the numbers of aquatic insects/m^2 in the test riffle was associated with the resumption of natural flow conditions. Total numbers of insects in the test riffle did not reach their initial high value until two months after the initial high was reached in the test riffle. Trichoptera were affected most by flow reductions.

# EFFECTS OF CONTROLLED FLOW REDUCTIONS ON AQUATIC INSECTS IN A STREAM RIFFLE

by

WILLIAM McCLAY

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

of

MASTER OF SCIENCE

in

Fish and Wildlife Management

Approved:

Head, Major Department

Chairman, Examining Committee

Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

August, 1968

## ACKNOWLEDGMENT

The author wishes to express his appreciation to those who assisted him during the course of the investigation: Dr. William R. Gould directed the study and aided in the preparation of this manuscript; Melvin E. Kraft assisted with the field work; my wife, Sigrid, helped both with the field work and with the sorting of bottom samples; and David P. Jacobson assisted with statistical analyses. Sincere appreciation for the verification of identification of aquatic insects is extended to Drs. O. S. Flint (Trichoptera), A. R. Gaufin (Plecoptera), W. L. Peters (Ephemeroptera), A. Stone (Tipulidae and Simulidae), W. W. Wirth (Rhagionidae, Chironomidae, and Ephydridae), and L. V. Knutson (Empididae). The investigation was financed by the Montana Cooperative Fishery Unit and the Montana Fish and Game Department under Federal Aid to Fish Restoration Project F-9-R.

TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# ABSTRACT

A study was conducted on Blacktail Creek in southwestern Montana from May, 1966, to September, 1967, to determine the effects of controlled flow reductions on the ecology of aquatic insects. Two riffles were selected for study: one served as a control, and the other, the test riffle, was subjected to flow reductions of 75 and 90% during the summers of 1966 and 1967, respectively. Four samples of aquatic insects were collected with a Surber sampler along a transect in each riffle on each sampling date. Samples were collected bimonthly during the periods of dewatering and monthly during the period of natural flow. Physical and chemical data were collected on each sampling date. Average depth, average water velocity, and water volume were the physical parameters most affected by flow reductions. During the period of 75% dewatering, aquatic insect populations in the control riffle increased, while those in the test riffle remained stable. Insect densities in the test riffle, relative to those in the control riffle, were higher during the period of 75% dewatering than during the full-flow period. A decline in the numbers of aquatic insects/$m^2$ in the test riffle was associated with the resumption of natural flow conditions. Total numbers of insects in the test riffle did not reach their initial high value until two months after the initial high was reached in the test riffle. Trichoptera were affected most by flow reductions.

# INTRODUCTION

The summer flows of many streams in the western United States are reduced by the diversion of water for irrigation. In 1965, the Montana Fish and Game Department sponsored studies on Blacktail Creek in southwestern Montana to determine the effects of reduced flows on fish populations. Water was diverted from a portion of the stream to simulate conditions that might occur from dewatering for irrigation. During the first summer of the study some aquatic insects were stranded by dewatering and sedimentation increased in some areas. My study was initiated to determine the effects of reduced flows on the habitat and dynamics of aquatic insect communities. Field work was conducted from May 6, 1966, through September 1, 1967.

Populations of aquatic insects are affected by stream flows. Surber (1936), Tarzwell (1937), and Logan (1963) showed an inverse relationship between numbers of insects and flow, and suggested a scouring effect. Irving and Culpin (1956) showed that diurnal water level fluctuations below a dam in Idaho reduced the production of aquatic bottom invertebrates. Powell (1948) compared aquatic insect populations below a power dam in Colorado with those above the impoundment. In the area below the dam, subjected to large diurnal and reduced minimum flows, weights of populations were less, individual organisms were smaller, and there were severe reductions in the numbers of mayflies, stoneflies, and caddisflies. Briggs (1948) reported the numbers and weights of bottom organisms to be much greater below a percolation dam in California than above and attributed this to the stabilization effect of the dam on water flows.

## METHODS

The test riffle was selected in the uppermost section (A, Fig. 1) of the 52 m portion of the stream used for the fish population studies conducted by Wipperman (1966, 1967) of the Montana Fish and Game Department and Kraft (1968). A dewatered state was maintained throughout a three month summer period by diverting a percentage of the calculated base flow of 0.90 $m^3$/sec. The base flow in Section A was reduced 75% to 0.22 $m^3$/sec from May 23 to August 23, 1966. Flow was decreased 90% to 0.09 $m^3$/sec from July 3 to September 3, 1967. Another riffle, the control, was selected upstream in an area free from dewatering influences (Fig. 1).

Three 0.3 $m^2$ samples of the stream bottom were collected along a transect in each riffle with a Surber sampler. Material was collected to a depth of about 7.5 cm in the test riffle, but only to 5 cm in the control riffle due to the presence of bedrock. The samples from each riffle were dried and put through a series of Tyler soil screens to separate them into seven size categories. The volume of each size category was determined by displacement of water and its percent of the total volume calculated.

Aquatic insect samples were taken with a Surber sampler. The lower end of each riffle was sampled first so upstream areas, to be sampled later, would not be disturbed. Four 0.3 $m^2$ samples, spaced 0.6 m apart along a transect, were collected in each riffle on each sampling date. Areas with large amounts of aquatic vegetation or large rubble were avoided. Succeeding samples were taken in a similar manner on transects established about 0.6 m upstream from the preceeding one. After seven months of

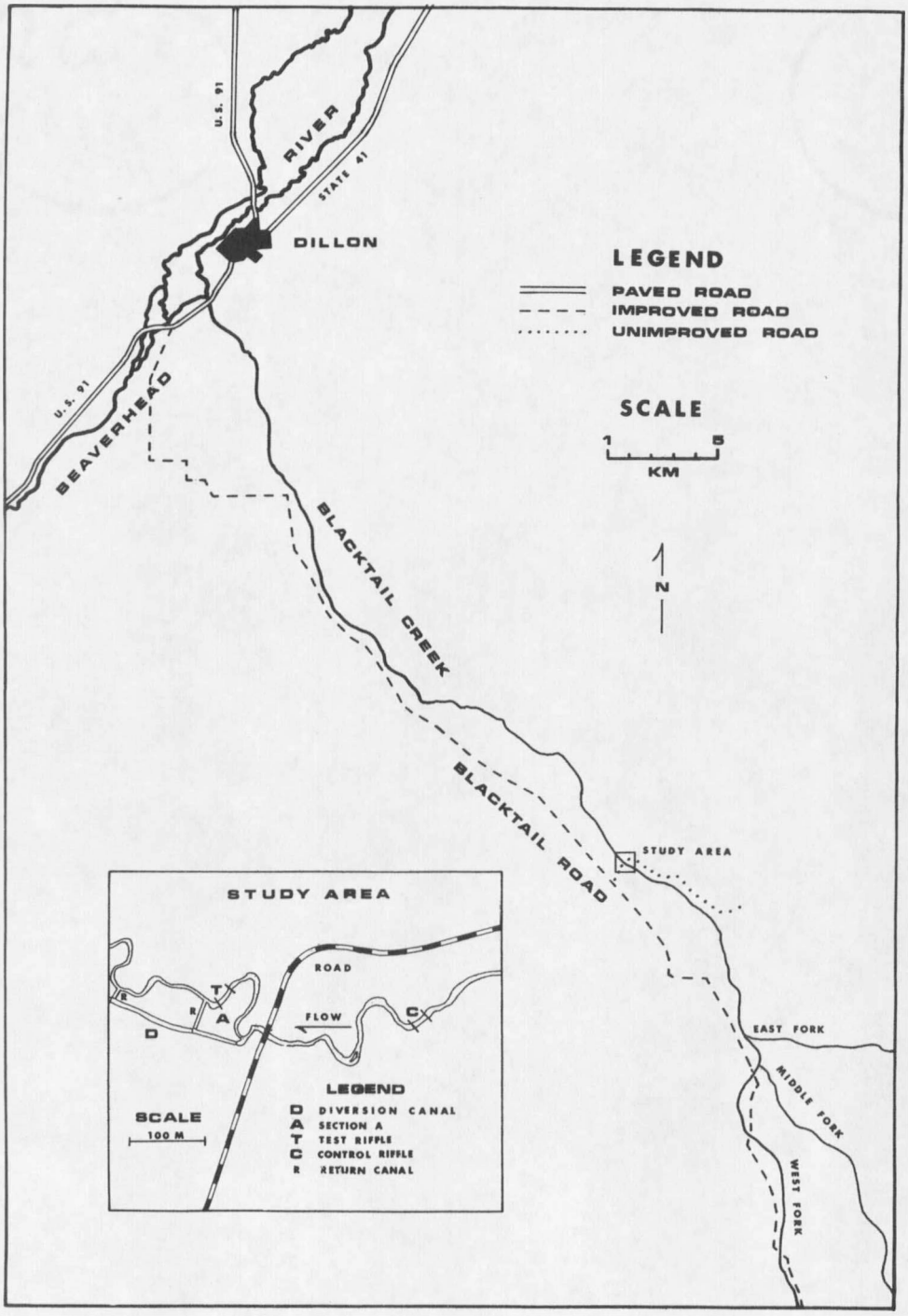


Figure 1. Map of Blacktail Creek and study area.

sampling, the upper ends of the riffles were reached and collections were taken at the downstream ends but were staggered so that sample sites in the second series fell between those of the first series (Fig. 2). Samples were collected every two weeks during the periods of dewatering and every four weeks during natural flows (August 26, 1966, to June 25, 1967) except in June, 1967, when high spring flows prevented sampling. Hereafter, the three above mentioned flow periods will be referred to as the period of 75% dewatering, 90% dewatering, and full-flow.

A total of 168 samples were collected (84 from each riffle) on 21 sampling dates. Samples were placed in plastic bags, preserved in 10% formalin, then later sorted to Order, counted, and preserved in 70% alcohol. Volumes of insects were determined to the nearest 0.1 cc by displacement in 70% alcohol. Trichoptera cases were not included in volumetric measurements. Numbers and volumes of insects from the test riffle were compared to those from the control riffle by flow period with an analysis of variance test. Significance is reported at the 1% level unless otherwise stated. Insects from three selected sampling dates (March 24, July 7, and September 1, 1967) were identified to species where practicable.

Physical and chemical data were collected on each sampling date. Flows were calculated from velocity and depth measurements taken with a Gurley current meter at 0.3 m intervals on a transect across the stream. Velocities were obtained at 0.4 the depth of the water. The velocity and

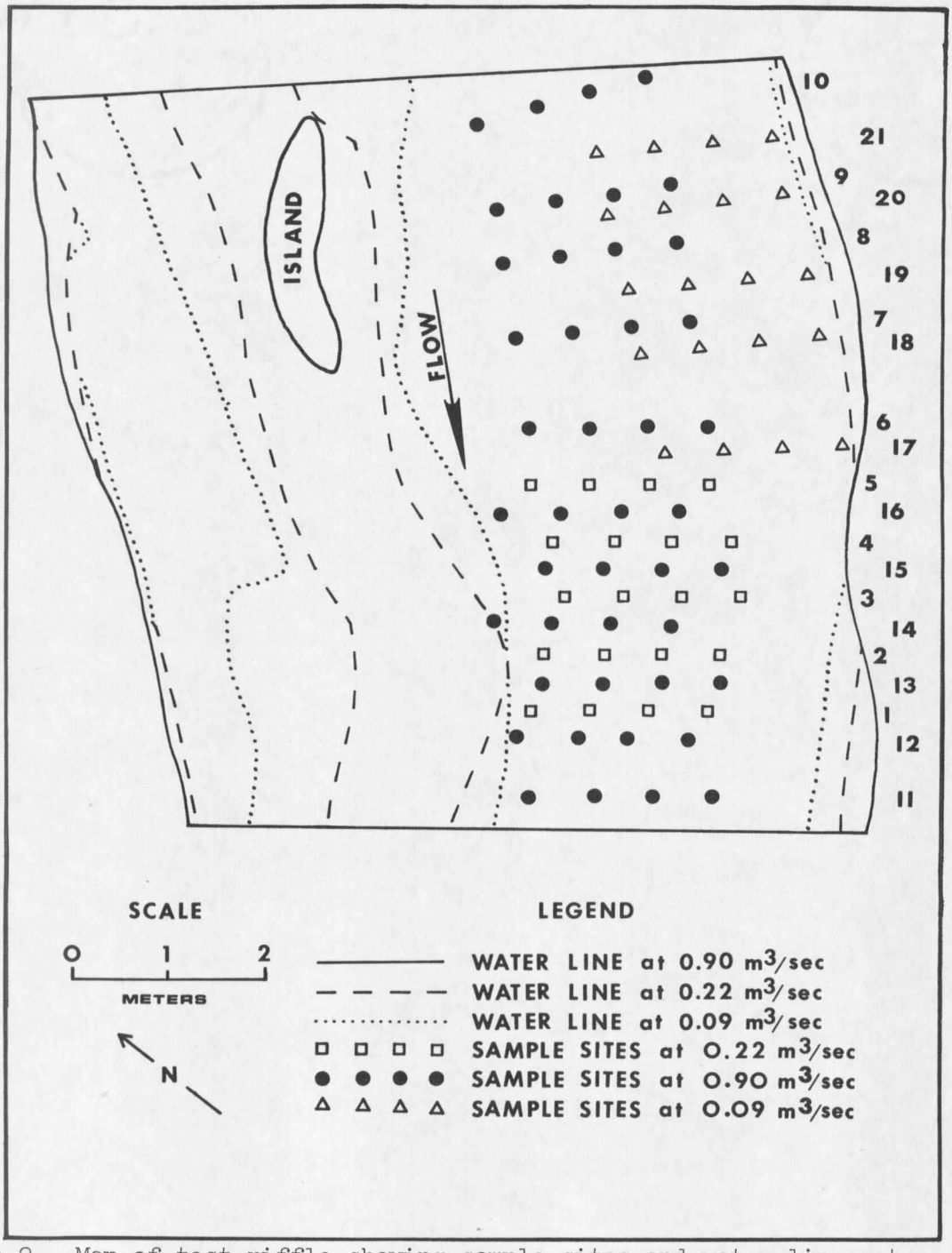


Figure 2. Map of test riffle showing sample sites and water lines at three flow conditions. Numbers indicate the location of transects and the sequence in which they were established.

depth at each sample site were recorded. Water temperatures were recorded on Taylor thermographs during the dewatered periods. Maximum-minimum thermometers were used throughout the full-flow period and were read on each sampling date. A model DR-EL Hach kit was used to determine dissolved oxygen, alkalinity, pH, and turbidity on each sample date.

Maps were constructed of both riffles when flow was near the calculated base of 0.90 $m^3$/sec and of the test riffle when the flow was reduced by 75 and 90%. A polar planimeter was used to determine the area of the watered zones under each flow condition.

## DESCRIPTION OF STUDY AREA

Blacktail Creek originates from three major tributaries in southeastern Beaverhead County, Montana (Fig. 1). The tributaries head at an elevation of about 2400 m in the snowfields of the Snowcrest Range, a series of mountains composed of folded and faulted sedimentary rock from the Precambrian to Upper Cretaceous Periods (Klepper, 1950). Blacktail Creek is formed where the East Fork joins the combined flows of the Middle and West Forks at an elevation of about 1900 m. Blacktail Creek flows northwesterly 45 km through coniferous forests which merge with sagebrush and grassland hills. It drains an area of about 808 $km^2$ and empties into the Beaverhead River, about 3 km southeast of Dillon, Montana.

This creek flows through a broad valley capped with coalescent alluvial fans which head at the mouths of the many gulches (Alden, 1953). It meanders through a well defined channel of Tertiary deposits of glacial outwash, sand, and gravel (Alden, 1953) that is lined with willow (Salix sp.) interspersed with groves of cottonwood (Populus sp.).

Blacktail Creek is characterized by high spring runoffs with low flows the remainder of the year (Fig. 3). The United States Geological Survey operated a gage station about 13 km below the study area from January, 1947, through September, 1966. The highest mean monthly flow (6.6 $m^3$/sec) for the 19 year period 1947 through 1965 was recorded in June, 1964. The lowest mean monthly flow (0.4 $m^3$/sec) was recorded in January and February of the same year.