The responses of insect communities in the East Gallatin River, Montana, to sewage effluents

by Thomas Harvey Glorvigen

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 responses of insect communities in the East Gallatin River, Montana, to two sewage effluents were studied. Numbers of Ephemer-optera, Plecoptera and Trichoptera were low and numbers of Diptera were high 0.72 km below Outfall I. The diversity index of this community was low. The community structure was believed to be primarily due to the abundant growths of "sewage fungus" present. Mayflies appeared to increase in numbers rapidly at Station 2 shortly after the use of Outfall I was discontinued. Nine months later the diversity index at this location was similar to those of the other stations.

There was no apparent effect of the sewage effluent from Outfall II on the insect community 6.32 km below it.

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Date June 6, 1972

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The responses of insect communities in the East Gallatin River, Montana, to two sewage effluents were studied. Numbers of Ephemeroptera, Plecoptera and Trichoptera were low and numbers of Diptera were high 0.72 km below Outfall I. The diversity index of this community was low. The community structure was believed to be primarily due to the abundant growths of "sewage fungus" present. Mayflies appeared to increase in numbers rapidly at Station 2 shortly after the use of Outfall I was discontinued. Nine months later the diversity index at this location was similar to those of the other stations. There was no apparent effect of the sewage effluent from Outfall II on the insect community 6.32 km below it.

INTRODUCTION

The addition of domestic sewage to a stream can alter its natural characteristics. Areas affected by sewage effluents often have small numbers of a few kinds of clean water insects, large numbers of a few kinds of tolerant forms, depressed dissolved oxygen levels and abundant growths of "sewage fungus" (Gaufin 1958; Hawkes 1963).

Avery (1970) studied the effects of the sewage effluent from the primary treatment plant for the City of Bozeman on the East Gallatin River. A comparison of areas above and below the outfall indicated there were smaller numbers of Trichoptera, Ephemeroptera, Plecoptera and Coleoptera, higher numbers of Diptera, an abundance of "sewage fungus", little reduction of dissolved oxygen levels and fewer species of fish in the area below the outfall.

This study was undertaken to assess the effects of changes in Bozeman's sewage disposal procedures upon the aquatic insects of the East Gallatin River. During collections made from April 7 through November 15, 1970, the city's sewage effluent entered the river from the primary treatment plant at a point 0.80 km below the river's origin. This sampling period and outfall location are referred to as Sampling Period I and Outfall I, respectively.

On December 2, 1970, Bozeman's sewage effluent began entering the river at a new location. During collections taken from December 5, 1970 through September 17, 1971, the sewage entered the river from Bozeman's secondary treatment plant at a point 6.85 km downstream from Outfall I. This collecting period and outfall location will be referred to as Sampling Period II and Outfall II, respectively. Sewage from this new facility received only limited and sporadic secondary treatment until August, 1971, when 80% began receiving secondary treatment on a sustained basis.

The objectives of this study were to determine the responses of insect communities in the East Gallatin River to: (1) the sewage effluent from Outfall I, (2) the elimination of the sewage effluent from Outfall I and (3) the introduction of a sewage effluent at Outfall II.

DESCRIPTION OF THE STUDY AREA

The East Gallatin River lies in Gallatin County in southwestern Montana. It is formed by the confluence of Bozeman and Rocky Creeks 0.8 km north of the City of Bozeman and flows north and west about 60 km before joining the West Gallatin River. The East Gallatin River drains an area of about 383 km^2 in which the major land uses are cattle ranching and wheat farming.

The river has an average elevation of about 1,390 m above mean sea level and a gradient of 4.4 m/km. In the study area, the river varies from 3 to 12 m in width and in depth from a few centimeters in the riffles to 2.0 m in the pools (Avery 1970). Records from 1939 to 1961 show low flows were commonly about 0.5 m^3/sec and occurred during the winter seasons (U.S.G.S. 1964). High flows were about 55 m^3/sec and took place during the spring seasons. The average flow from 1939 to 1961 was 2.40 m^3/sec. During this study, the average discharge of sewage into the river was about 0.14 m^3/sec.

METHODS

Collecting Stations

Five stations were sampled on the East Gallatin River (Fig. 1). These stations were located in the same riffles sampled by Avery (1970). Station 1 was situated 0.22 km above Outfall I. Station 2 was located 0.72 km below Outfall I. Station 3 was located 6.52 km below Outfall I and 0.33 km above Outfall II. Station 4 was located 13.17 and 6.32 km below Outfalls I and II, respectively. Station 5 was 20.94 and 14.09 km below Outfalls I and II, respectively. All stations had similar substrates (Avery 1970), with at least 70% of the substrate particles being between 19.1 and 50.8 mm in size.

Insect Sampling and Analysis

Insect samples were collected monthly during April 1970, from July 1970 through March 1971, and from July 1971 through September 1971. Collections were made with a Surber sampler having 25 meshes/2.54 cm. Three 0.09 m^2 samples were collected on a transect in each riffle on each sampling date. The samples were spaced about 2 meters apart on each transect and atypical areas were avoided. The initial transect was positioned at the lower end of a riffle and each succeeding one was located about 2 meters upstream from the preceding one. A minimum of four months elapsed before an area in a previous

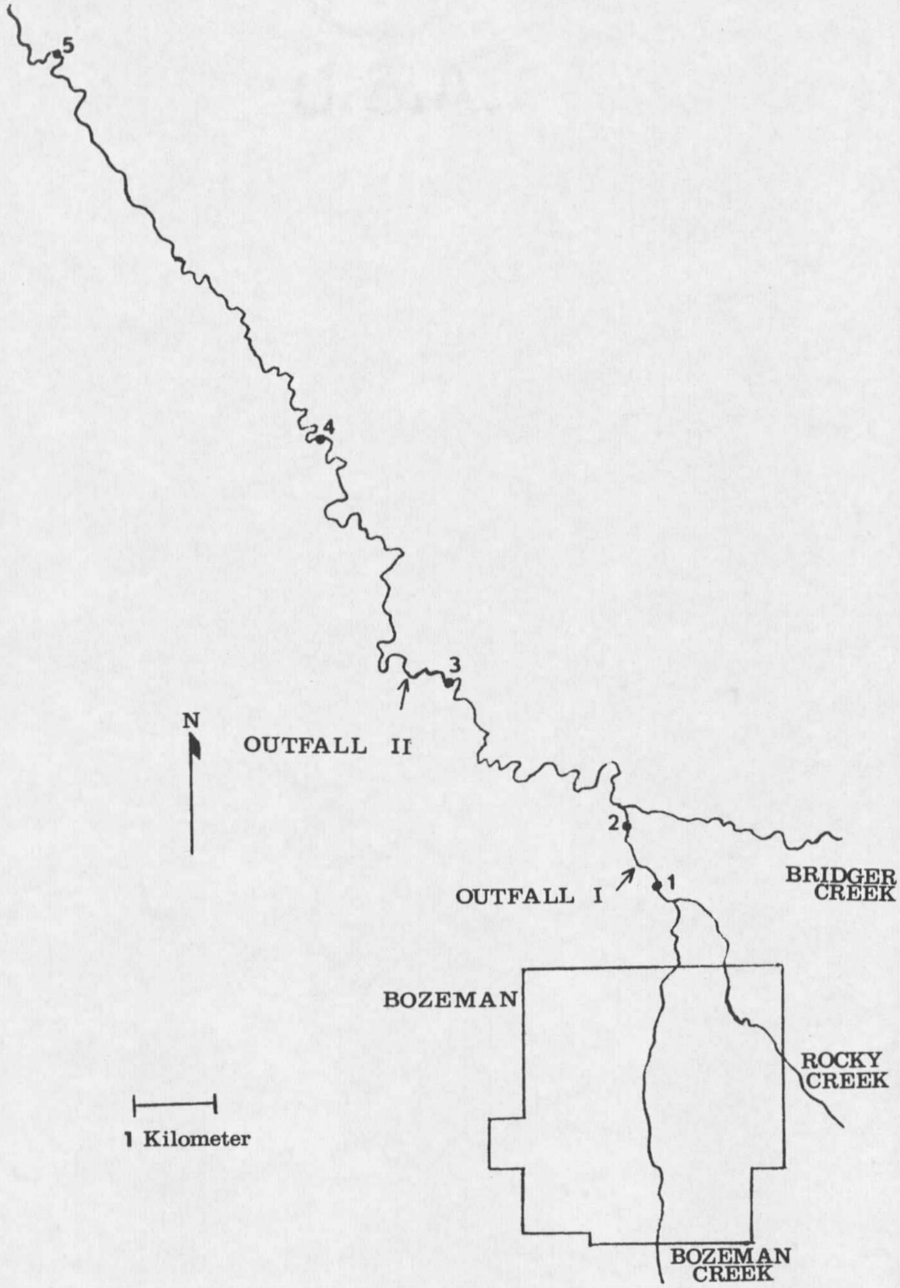

Figure 1. Map of study area showing the locations of sampling stations and sewage outfalls for the City of Bozeman.

transect was resampled. All samples were taken in water depths of 0.16 to 0.20 m.

Insect samples were preserved in the field with 10% formalin. Separation of insects from vegetation and bottom materials was performed in the laboratory with the aid of the sugar floatation technique (Anderson 1959). Insects from each sample were then identified to order, counted and stored in 40% isopropyl alcohol.

The Freidman test (Kraft & van Eeden 1968) was used to compare the median numbers of insects, by order, among the five stations during Sampling Periods I and II, separately. After differences among medians were indicated, a nonparametric multiple comparison procedure (Miller 1966) was applied to determine which pairs of stations were most responsible for the significant difference.

Insects collected in August and September of 1970 and 1971 were identified to genus. Diversity indexes were obtained from these collections using the equation of Margalef (1951), $d=m-1/\ln N$, where m is the number of species, N is the total number of individuals, and d is the index of diversity.

Chemical-Physical Analysis

Ten monthly samples were taken from April, 1970 through July, 1971. Six samples were taken during Sampling Period I and four during Sampling Period II.

Temperatures were measured at all stations on each sampling date with a Taylor pocket thermometer. Dissolved oxygen determinations were made in the field by titration. A 1000 ml water sample was collected from each station on each sampling date and taken to the Hydrobiology Laboratory at Montana State University where determinations of pH, specific conductance, alkalinity, ammonia, nitrite, nitrate, and inorganic phosphate were made within 12 hours of collection. Hydrogen ion concentrations were determined with a Beckman Expanded Scale pH meter (Model 76). Specific conductance was measured with a YSI Conductivity Bridge (Model 31) and an Industrial Instruments (Model CEL 4) dipping cell. Total alkalinity, ammonia, and orthophosphate determinations were made following the procedures described in the American Public Health Association (1965). Nitrite and nitrate determinations were made following Hach Chemical Company Methods (1967). A Klett spectrometer was used in determining nitrogen and orthophosphate levels.

RESULTS

Aquatic Insects

The numbers of insects collected at each station on each sampling date are presented in Table 1. The lowest number of insects taken on any collecting date was 625 collected on January 8, 1971 and the highest was 6349 taken on September 17, 1971. The total number of insects collected at Station 5 was nearly 3000 higher than at any other station.

The total numbers and ordinal compositions of insects taken at each station during Sampling Period I are shown in Table 2. Total numbers decreased from Stations 1 to 2 and progressively increased at stations downstream from Station 2. The proportions of Ephemeroptera and Diptera at Station 2 were notably the lowest and highest, respectively, of all the stations and the proportions of Plecoptera and Trichoptera were also somewhat lower. Most of the stoneflies, caddisflies, and mayflies collected at Station 2 during Sampling Period I were found with profuse growths of "sewage fungus", of which the filamentous bacterium *Sphaerotilus* is a component, covering much of their bodies. Avery (1970) also found this condition at Station 2. Many insects collected at Station 3 during the winter months of Sampling Period I also bore strands of "sewage fungus".

During Sampling Period II, total numbers of insects increased progressively from Stations 1 through 5 and the ordinal compositions