BENTHIC INVERTEBRATES IN SELECTED STREAMS OF THE PICEANCE CREEK BASIN, NORTHWESTERN COLORADO, WATER YEARS 1977-81

By Kenneth J. Covay, Helen E. Stranathan, and Robert L. Tobin

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion for terms used in this report are listed below:

Multiply	*By*	*To obtain*
inch (in.)	25.40	millimeter
foot (ft)	0.3048	meter
square foot (ft^2)	0.09294	square meter
cubic foot per second (ft^3/s)	0.2832	cubic meter per second
foot per second (ft/s)	0.3048	meter per second
barrel (bbl)	0.16	cubic meters
acre	4,047	square meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
micromho per centimeter at 25° Celsius (μmhos)	1.000	microsiemens per centimeter at 25° Celsius
degree Fahrenheit (°F)	°C=5/9 (°F-32)	degree Celsius

The following term also is used in this report: milligrams per liter (mg/L).

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ABSTRACT

Data from the periodic collections of benthic organisms at six streamflow stations in the Piceance Creek basin are presented and summarized for water years 1977-81. A total of 162 genera from 8 insect orders and 8 non-insect orders were documented. Numbers of organisms per sample ranged from zero to 3,700. Counts generally were greater during low streamflow. Diptera (two-winged flies) were the most numerous organisms and the percent composition of Diptera increased downstream. Organisms associated with both unpolluted and polluted streams were collected.

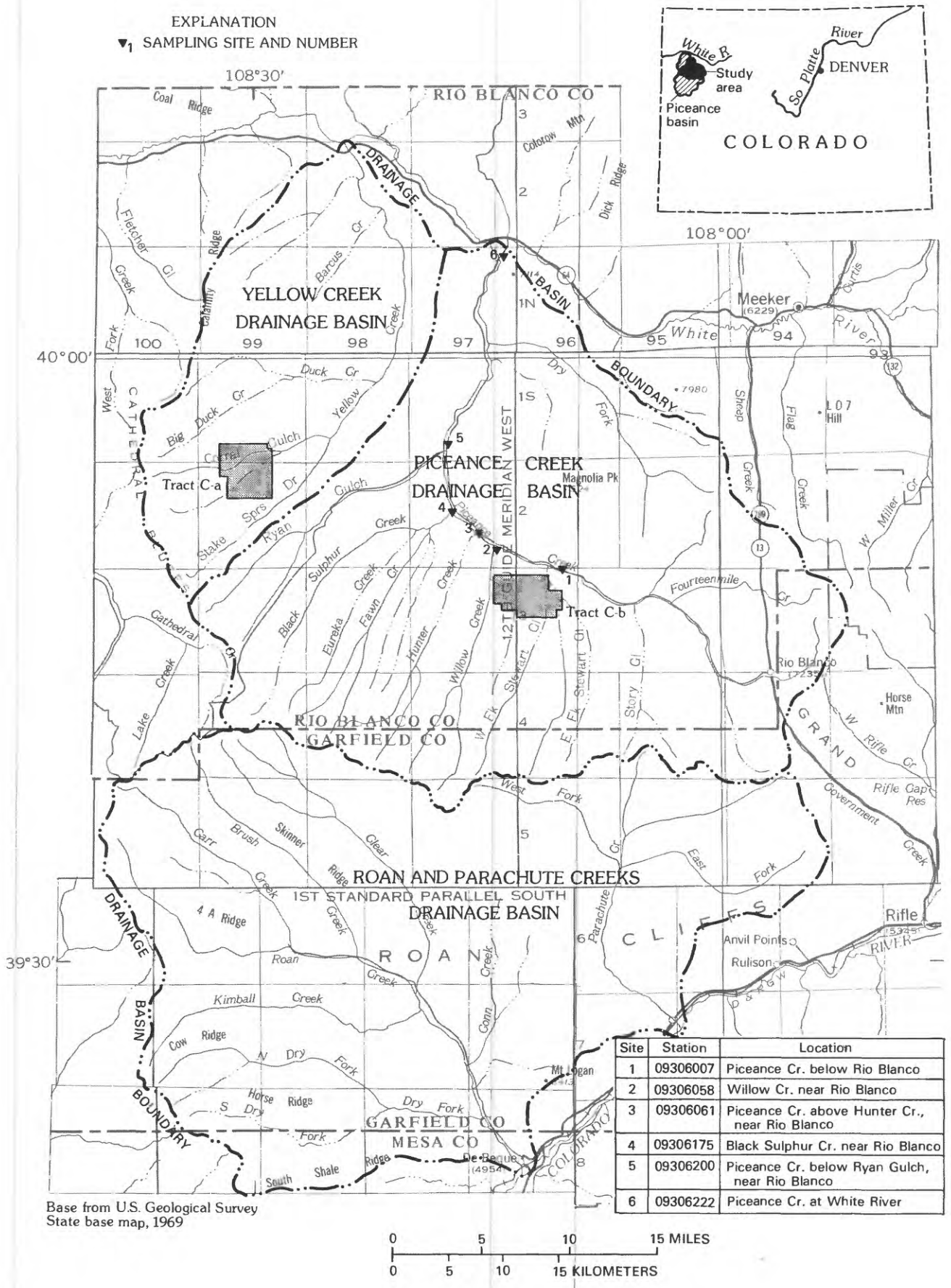
The assignment of taxa into trophic groups placed most taxa into the burrowers-sprawlers-clingers habit groups and primary and secondary consumer (food-web) groups. General community structure, however, remained balanced and stable. Mean diversity indices ranged from 2.21 to 2.82, and similarity indices indicate more than 50-percent consistency of composition. Mean diversity indices were greatest in the middle part of the Piceance Creek basin.

The types and numbers of benthic invertebrates present indicated that no deleterious water-quality conditions existed during the study period. Differences in benthos communities within and between sites are attributed to differences in water discharge, water temperature, substrate, and chemical quality of water.

INTRODUCTION

Increased demands for energy fuels and energy independence in the United States have accelerated commercial development of natural resources. In northwestern Colorado, major resources are oil shale, coal, and natural gas. Oil-shale development is expected to be greatest in the Piceance basin (fig. 1), which contains an estimated 1 trillion bbl of recoverable oil shale (Weeks and others, 1974; Taylor, 1982). Early in 1974, two Federal leases in Piceance basin, each with an area of 5,120 acres (fig. 1), were awarded to a consortium of oil companies for prototype development of oil shale. The two leased areas are referred to as Tract Colorado-a (C-a) and Tract Colorado-b (C-b). These oil-shale developments are expected to affect the environmental quality of water, land, and air.

Several types of water-quality data, including biological data, have been collected in the basin (Gray and others, 1983; Minshall and Minshall, 1977; Ward and Short, 1978). Data collected before major oil-shale development occurs will document existing water-quality conditions. These



Site	Station	Location
1	09306007	Piceance Cr. below Rio Blanco
2	09306058	Willow Cr. near Rio Blanco
3	09306061	Piceance Cr. above Hunter Cr., near Rio Blanco
4	09306175	Black Sulphur Cr. near Rio Blanco
5	09306200	Piceance Cr. below Ryan Gulch, near Rio Blanco
6	09306222	Piceance Cr. at White River

Figure 1.--Major drainage basins of the Piceance basin and benthic-invertebrate sampling sites in the Piceance Creek basin.

data, in conjunction with other water-quality data, can then be used to determine the magnitude of any water-quality changes resulting from oil-shale development. Because benthic invertebrates are sensitive to changes in water quality, the organisms were chosen as the principal type of biological data for collection during this study.

Purpose and Scope

This study was initiated to describe and document the communities of benthic invertebrates that existed at six selected sites in the Piceance Creek basin prior to major oil-shale development. Piceance Creek basin occupies the northeast corner of the Piceance basin and is one of four major drainage basins in the Piceance basin (fig. 1).

Six sampling sites, hereinafter referred to as sites, were established at six perennial gaging stations (fig. 1): four on the mainstream of Piceance Creek (sites 1, 3, 5, and 6), and one site each at the mouths of two tributaries, Willow Creek (site 2) and Black Sulphur Creek (site 4). Samples of benthic invertebrates were collected periodically at the same location at each of the six sites during the 1977-81 water years. Samples were collected monthly during the 1977-79 water years and quarterly during the 1980-81 water years.

Data analyses include: (1) Taxonomic identification to the genus level and to the species level whenever possible; (2) functional feeding-group analysis; (3) number of organisms and percentage composition of each sample; (4) food-web balance; (5) diversity and similarity indices; and (6) statistics.

Methods

All benthic-invertebrate samples were collected, preserved, and analyzed in accordance with accepted procedures of the U.S. Geological Survey (Greeson and others, 1977). A benthic-invertebrate sample was a composite of three 1-ft Surber grabs (mesh size=0.21 millimeters). Grabs were from cross sections at riffle areas at the same location each visit. This was done to maintain quality control within and between samples. No samples were collected from pooled or lentic areas in the stream because these substrates were considered unstable due to silting and diversity is greater in riffle areas. Organisms were separated from sand and gravel by a density-flotation method and were preserved in isopropyl alcohol. All samples were sent to Susswasser Freshwater Invertebrate and Algae Analysis in Paso Robles, Calif.,[1] for identification and enumeration. All data were derived from whole samples and not from subsets. Sample organisms from taxonomic groups were permanently preserved and are stored for future reference at the U.S. Geological Survey office in Meeker, Colo.

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[1]Use of the firm name in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Criteria used for the assignment of insects into trophic groups are based on Merritt and Cummins (1978). Trophic classifications of the non-insects are based on criteria of Pennak (1978) and Ward and Whipple (1959). Diversity indices were determined from procedures described by Wilhm and Dorris (1968) and similarity indices were computed according to Odum (1971).

Description of Study Area

The Piceance Creek basin drains the northeast part of Piceance basin and is in Rio Blanco and Garfield Counties, northwestern Colorado (fig.1). Piceance Creek basin has a drainage area of 630 mi^2. Piceance basin is part of the Colorado Plateau Physiographic Province (Thornbury, 1965) and contains a thick sequence of sedimentary rocks deposited during the Eocene Epoch. These sedimentary rocks consist of sandstones, shales, and marlstones, which comprise the Wasatch, Green River, and Uinta Formations. The Green River Formation contains the richest known deposits of organic oil shale and marlstone in the world (Donnell, 1961; Yen and Chilingarian, 1976).

The topography is classified as ridge and valley and is very dissected (Frickel and others, 1975; Thornbury, 1965). The ridges and valleys trend northeasterly. Drainage patterns range from trellis to parallel and seem to be structurally controlled.

Vegetation is related to elevation, slope orientation, and soil depth (Frickel and others, 1975). North-facing slopes retain more moisture, have better developed soils, and support a more dense plant community. Little or no shade from riparian vegetation exists along streams at the lower elevations.

The climate of the Piceance basin is semiarid. Precipitation occurs during the summer as local, short-duration, intense thunderstorms. Winter precipitation is mostly snow. Annual precipitation increases with elevation and ranges from 15 in. below 8,000 ft, to 25 in. above 8,000 ft (Weeks and others, 1974; Frickel and others, 1975). Air temperature also varies with elevation, but may be locally modified by topography. Temperature ranges from -48°F to 97°F (Frickel and others, 1975).

Historically, primary land use in the Piceance Creek basin has been agriculture, ranching, and hunting. Increased demand for energy has subjected the Piceance Creek basin to intense oil, gas, and oil-shale exploration. Preliminary development at tract C-b, which lies within the Piceance Creek basin, has resulted in the removal of some natural vegetation. Land use could be affected further by surface mining, retorting, construction, water impoundment, and population increases.

Piceance Creek is the principal stream in Piceance Creek basin. Piceance Creek originates in the Grand Hogback northeast of Rio Blanco, Colo. The creek flows northwesterly in its upstream reaches and northerly in its downstream reaches. Piceance Creek joins the White River 17 mi west of Meeker, Colo.

Medium and base flows in streams originate from springs and ground water. These flows provide about 80 percent of the total surface-water discharge in Piceance Creek basin (Weeks and others, 1974). High flows result from snowmelt in spring and thunderstorms in summer. Irrigation is common in Piceance Creek basin, and irrigation diversions may result in zero flows at some gaging stations during summer.

Flow at the mouth of Piceance Creek (site 6) ranged from less than 1.0 to 628 ft^3/s during the study. Mean discharge at site 5, Piceance Creek below Ryan Gulch, was less than average for water years 1977, 1978, and 1981. A record runoff was recorded for water year 1980. Mean discharge at site 5 is shown below:

Water year	Mean discharge (cubic feet per second)
1977	12.7
1978	16.0
1979	28.7
1980	35.4
1981	17.3
1965-81	20.1

GENERAL DISCUSSION AND SIGNIFICANCE OF BENTHIC INVERTEBRATES IN STREAMS

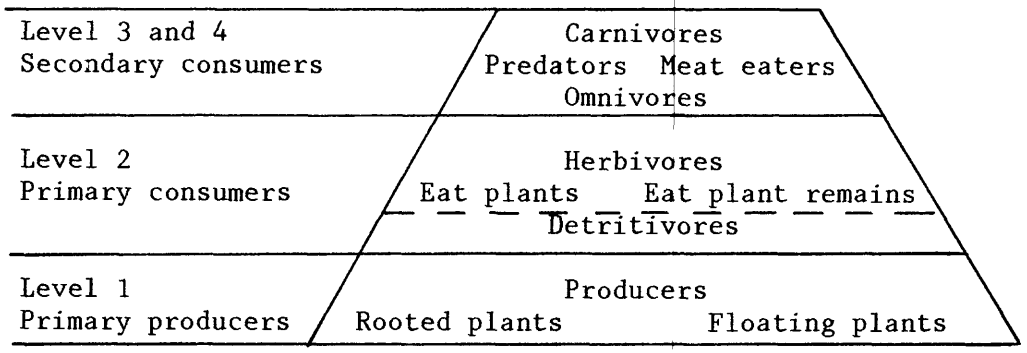
Biological communities in a stream are affected by the physical and chemical properties of the stream. Because of their relative immobility, long life in aquatic stages, and environmental sensitivity, benthic invertebrates are useful for water-quality analyses. Immature forms of Trichoptera (caddisflies), Plecoptera (stoneflies), and Ephemeroptera (mayflies) usually are found in clean natural water (unpolluted) because they require substantial concentrations of dissolved oxygen. Plesiopora (worms), Rhynchobdellida (leeches), and some immature Diptera (two-winged flies) can survive in water containing very little dissolved oxygen. Large numbers of these organisms often are found in oxygen-deficient streams that receive sewage discharges. Other factors that affect benthic-invertebrate communities are: types of substrate, sediment concentration, water temperature, turbidity, stream velocity, and ice (Hynes, 1960 and 1970; Odum, 1971; Reid and Wood, 1976; Gray and others, 1983). Two important chemical factors that may affect benthic invertebrate distribution and abundance are dissolved gasses and dissolved solids. Droughts and floods also modify distribution. Hynes (1970), however, suggests that many organisms in rivers and streams are controlled more by the type of substrate on which they live than by the general physical state of the water.

Water-quality degradation is not always limited to domestic or industrial activities. Cycles of nature will produce periods of degraded water quality in natural waters. Autumn leaves and debris can overload a stream system with decaying organic matter. Snowmelt runoff and thunderstorms can cause

rapid silting, substrate change, and decreased food supplies; major shifts in the types and numbers of organisms can occur after these events. When physical conditions are optimum and food supplies adequate, population numbers will increase until a limiting factor is reached.

Odum (1971) observes that communities have definite unity, characteristic trophic structure, and patterns of energy flow. Compositional unity is the probability that certain species will occur together. Functionally similar (trophic) communities are diverse organisms living together and obtaining food in the same manner. Energy flow is defined here as the quantity of energy derived from food sources that passes through living components of an ecosystem. Patterns of energy flow are studies of the two types of food chains, grazing and detritus.

In a balanced community, the base of a food web should contain the greatest number of organisms. Benthic invertebrates are an important link in the aquatic food web, occupying the primary and secondary consumer levels. They are the primary food source for fish. A typical food structure in a community is outlined below:



Classification of benthic invertebrates into environmental and functional groups is useful when interpreting stream ecology. Some organisms thrive only along stream reaches that have swift flowing waters or lotic conditions; other organisms are better suited to pooled or lentic waters. Merritt and Cummins (1978) divided aquatic insects into groups based on food-gathering behavior, habits of attachment, and concealment and movement. These functional-level characteristics, as well as energy transfer, and taxonomic identification are important elements in defining the benthic community of streams.

Diversity index (DI) is a ratio of the number of species or other taxa to another important value, usually the total number of organisms in a sample of the community. It measures the evenness of distribution of individuals within the community (Greeson, 1982). The use of a DI as an indicator of water-quality conditions is based on the assumption that unpolluted waters generally have a greater number of species, thus greater DI, than polluted waters. The DI in unpolluted waters is large because a benthic community can develop having many species of relatively equal abundance. Low values of DI

are indicative of polluted or environmentally stressed waters because these waters will favor only the tolerant organisms.

Wilhm and Dorris (1968) developed a measure of diversity which quantified community structure based on diversity per individual (d) as:

$$\bar{d} = \sum_{i=1}^{s} \frac{n_i}{n} \log_2 \frac{n_i}{n} \qquad (1)$$

where

s = the total number of taxa in each sample of the community;

i = the ith taxon in each sample, which ranges from 1 to s;

n_i = the number of individuals in each taxon; and

n = the total number of individuals in a sample.

Logarithms to the base 2 may be obtained by multiplying logarithms to the base 10 by 3.3219.

Diversity indices range from zero (all organisms belong to the same species) to any positive number. The upper limit, however, is about 9 and most frequently is less than 5. Wilhm (1970) reports that DI values for benthic macroinvertebrate communities in unpolluted water usually are between 3 and 4, and DI values in polluted water are less than 1.

A DI can be used to evaluate the balance of the community. Diversity tends to be greater in older communities and less in newly established ones. In benthic populations or other "parts" of communities, diversity is influenced by functional relations between trophic levels. For example, the number of predators will greatly affect the diversity of the prey populations. A community that has a moderate number of predators could experience a reduction in the density of a dominate organism. This would allow a less competitive species a better opportunity to occupy the space and utilize food supplies (Odum, 1971).

A similarity index (SI) is used to compare whole samples to each other using a particular taxon. Many SI's exist and a common SI (Odum, 1971) is given by the equation:

$$SI = \frac{2C}{A+B} \qquad (2)$$

where

C = the number of taxa common to both A and B;
A = the number of taxa in sample A; and
B = the number of taxa in sample B.

Similarity indices range from zero (two samples have no taxa in common) to 1 (two samples have identical taxa). The resultant number multiplied by 100 gives percent similarity.

BENTHIC-INVERTEBRATE DATA

A tabulation of 162 species from 200 samples, identified and enumerated to the species level whenever possible, and percent composition of each species per sample are in the "Supplemental Data" section (tables 5 to 10). The number of taxa in each sample and a diversity index computed at the genus level also are shown in these tables. Trophic classifications of all genera collected and identified during this study are shown in table 1.

Ranges of continuous-monitor data for selected water-quality and sediment characteristics (Tobin and others, 1984) and a summary of physical measurements and observations at the six biological sites are shown in tables 2 and 3. These data show the range of conditions in which benthic invertebrates existed in the Piceance Creek basin during the 1977-81 water years. General water-quality types and dissolved-solid ranges at collection sites during the same period are shown below:

Site number and name	Water-quality type	Range of dissolved solids (milligrams per liter)
1 Piceance Creek below Rio Blanco	Sodium magnesium bicarbonate	440 to 890
2 Willow Creek	Magnesium sodium bicarbonate	700 to 990
3 Piceance Creek above Hunter Creek	Sodium magnesium bicarbonate	470 to 1,100
4 Black Sulphur Creek	Magnesium sodium sulfate bicarbonate	500 to 1,380
5 Piceance Creek below Ryan Gulch	Sodium magnesium bicarbonate	420 to 1,720
6 Piceance Creek at White River	Sodium bicarbonate	720 to 3,660

Table 1.--Trophic classifications of benthic invertebrates collected at six sites in Piceance Creek basin, water years 1977-81

[Asterisk ⊛ indicates data are direct from Merritt and Cummins (1978). Circled asterisk ⊛ indicates data based on generalizations from Merritt and Cummins (1978), Pennak (1978), and Usinger (1956)]

INSECTS	Habitat		Habits							Food Gathering								Food Web			
	Lotic	Lentic	Sprawlers	Burrowers	Clingers	Climbers	Swimmers	Divers	Skaters	Piercers	Shredders	Scrapers	Collectors	Scavengers	Engulfers	Filter Feeders	Parasites	Detritivores	Herbivores	Carnivores	Omnivores
Coleoptera (water beetles)																					
Dytiscidae																					
Agabus sp.	*	*					*	*		*										*	
Colymbetes sp.	*						*			*										*	
Deronectes sp.	*	*				*	*			*										*	
Oreodytes sp.	*	*				*	*			*										*	
Rhantus sp.	*	*					*	*		*										*	
Dryopidae																					
Helichus sp.	*				*						⊛								*		
Elmidae																					
Dubiraphia sp.	*	*			*	*						⊛	⊛					⊛	⊛		
Microcylloepus sp.	*			*	*	*					*	*	*					*	*		
Optioservus sp.	*				*							*	*					*	*		
Haliplidae																					
Brychius sp.	*	*			*					*		*							*		
Haliplus sp.		*				*				*	*								*		
Hydrophilidae																					
Cymbiodyta sp.	*	*		*											*			*			*
Helophorus sp.	*	*				*					*								*		
Hydrobius sp.		*	*		*	*					⊛								⊛		
Collembola (springtails)																					
Isotomidae																					
Isotomurus sp.	*							*					*	*				*			*
Diptera (two-winged flies)																					
Ceratopogonidae																					
Atrichopogon sp.	*	*	*		*							⊛	⊛					*			
Culicoides sp.	*	*		*									*		*			*			*
Palpomyia sp.	*	*		*									*		*				*		*
Stilobezzia sp.		*		*											*						*

Table 1.--Trophic classifications of benthic invertebrates collected at six sites in Piceance Creek basin, water years 1977-81--Continued

INSECTS	Habitat		Habits							Food Gathering								Food Web			
	Lotic	Lentic	Sprawlers	Burrowers	Clingers	Climbers	Swimmers	Divers	Skaters	Piercers	Shredders	Scrapers	Collectors	Scavengers	Engulfers	Filter Feeders	Parasites	Detritivores	Herbivores	Carnivores	Omnivores
Diptera--continued.																					
Chironomidae																					
Arctopelopia sp. or Conchapelopia sp.	*	*	*							*					*						*
Brillia sp.	*		*	*							*		*					*			
Calopsectra sp.	*	*		*	*								*					*			
Cardiocladius sp.	*			*	*										*						*
Chironomus sp.	*			*							*		*					*	*		
Cladotanytarsus sp.	*	*		⊛	⊛								*					*			
Constempellina sp.	*			⊛	⊛								⊛					⊛			
Corynoneura sp.	*	*	*										*					*			
Corynoneura tarsi	⊛	⊛	⊛										⊛					⊛			
Cricotopus sp. 1, 2, 3, 4, 5, 18	*	*		*	*						*		*					*	*		
Cryptochironomus sp. 1, 2	*	*	*	*									*		*				*	*	
Cryptotendipes sp.	*	*	*										⊛		⊛				⊛	⊛	
Diamesa sp. 1, 2, 3, 4, 20	*		*										*					*			
Endochironomus sp.		*			*						*		*					*	*		
Eukiefferiella sp. 1, 2, 3, 4, 21	*	*	*									*	*		*				*	*	
Glyptotendipes sp.	*	*		*	*						*		*					*	*		
Metriocnemus sp.	*	*	*	*									*		*				*	*	
Micropsectra sp.	*	*	*			*							*					*			
Microtendipes sp.	*	*			*								*					*			
Odontomesa sp.	*		*										*					*			
Orthocladius sp. 1, 2, 3, 4, 17	*	*	*	*									*					*			
Paralauterborniella sp.		*			*								*					*			
Parametriocnemus sp.	*		*										*					*			
Pentaneura sp.	*	*	*							*			*		*			*			*
Phaenopsectra sp.		*			*							*	*					*	*		
Polypedilium sp.1, 2		*			*	*					*		*		*			*	*		*
Procladius sp.	*	*	*										*		*			*			*
Prodiamesa bathyphilia	⊛		⊛	⊛									⊛					⊛			
Prodiamesa olivaceae	⊛		⊛	⊛									⊛					⊛			
Psectrocladius sp.	*	*	*	*							*		*					*	*		
Psectrotanypus sp.	*		*												*						*
Rheotanytarsus sp.	*				*								*					*			

Table 1.--Trophic classifications of benthic invertebrates collected at six sites in Piceance Creek basin, water years 1977-81--Continued

INSECTS	Habitat		Habits							Food Gathering								Food Web			
	Lotic	Lentic	Sprawlers	Burrowers	Clingers	Climbers	Swimmers	Divers	Skaters	Piercers	Shredders	Scrapers	Collectors	Scavengers	Engulfers	Filter Feeders	Parasites	Detritivores	Herbivores	Carnivores	Omnivores
Diptera																					
Chironomidae--continued.																					
Smittia sp.		*		*									*					*			
Stempellina sp.	*	*	*		*	*							*					*			
Sympotthastia sp.	*		*										*					*			
Syndiamesa orientalis	⊛		⊛										⊛					⊛			
Tanytarsus sp.	*	*			*	*							*					*			
Thienemanniella sp.	*	*	*										*					*			
Trichocladius sp.	⊛	⊛		⊛	⊛						⊛		⊛					⊛	⊛		
Dixidae																					
Dixa sp.	*					*	*						*					*			
Dolichopodidae																					
sp. 1	⊛	⊛	⊛	⊛											⊛					⊛	
Empididae																					
sp. 1	⊛	⊛	⊛	⊛									⊛		⊛			⊛		⊛	
sp. 2	⊛	⊛	⊛	⊛									⊛		⊛			⊛		⊛	
Hemerodromia sp.	*		*	*									*		*			⊛		*	
Ephydridae																					
Brachydeutera sp.		*	*	*									*					*			
Ephydra sp.	*	*	*	*								*	*					*	*		
Muscidae																					
Limnophora sp.	*			*											*					*	
Limnophora aequifrons	⊛			⊛											⊛					⊛	
Psychodidae																					
Telmatoscopus sp. or (Pericoma sp.)	*	*		*									*					*			
Simuliidae																					
Cnephnia sp.	*				*								*					*			
Eusimulim sp.	⊛	⊛			⊛								⊛					⊛			
Simulium sp.	*	*			*								*					*			
S. vittatum	⊛	⊛			⊛								⊛					⊛			
Stratiomyidae																					
Euparyphus sp.	*		*									*	*					*	*		
Tabanidae																					
Tabanus sp.	*	*	*	*						*										*	
Tipulidae																					
Dicranota sp.	*	*	*	*											*					*	
Erioptera sp.	*	*		*									*					*			
Hexatoma sp.	*	*	*	*	*										*					*	
Limnophila sp.1, 2	*	*		*											*					*	

Table 1.--Trophic classifications of benthic invertebrates collected at six sites in Piceance Creek basin, water years 1977-81--Continued

INSECTS	Habitat		Habits						Food Gathering							Food Web			
	Lotic	Lentic	Sprawlers	Burrowers	Clingers	Climbers	Swimmers	Divers	Skaters	Piercers	Shredders	Scrapers	Collectors	Scavengers	Engulfers	Filter Feeders	Parasites	Detritivores	Herbivores	Carnivores	Omnivores
Diptera																					
Tipulidae--continued.																					
Limonia sp.	*	*	*	*							*								*		
Pedicia sp.	*	*		*											*						*
Tipula sp.1, 2	*	*		*							*		*					*	*		
Ephemeroptera (Mayflies)																					
Baetidae																					
Baetis sp.	*	*			*	*	*					*	*					*	*		
Callibatis sp.		*				*	*						⊛					*			
Ephemerellidae																					
Ephemerella sp. 1, 2, 3, 4	*	*	*		*		*					*	*					*	*		
E. inermis	⊛	⊛	⊛		⊛		⊛					⊛	⊛					⊛	⊛		
E. infrequens	⊛	⊛	⊛		⊛		⊛					⊛	⊛					⊛	⊛		
E. mollita	⊛	⊛	⊛		⊛		⊛					⊛	⊛					⊛	⊛		
Heptageniidae																					
Cinygma sp.	*				*							*	*					*	*		
Cinygmula sp.	*				*							*	*					*	*		
Heptagenia sp.	*				*							*	*		*			*	*	*	
Rhithrogena sp.	*				*							*	*					*	*		
Leptophlebiidae																					
Paraleptophlebia sp.	*		*		*		*				*		*					*			
Siphlonuridae																					
Ameletus sp.	*				*		*						*					*			
Siphlonurus sp.	*	*			*		*					*	*		*			*	*	*	
Tricorythidae																					
Trycorythodes fallax	⊛	⊛	⊛		⊛									⊛				⊛			
T. minutus	⊛	⊛	⊛		⊛									⊛				⊛			
Hemiptera (True Bugs)																					
Corixidae																					
Sigara sp.	*					*	*			*			*					*		*	
Veliidae																					
Microvelia sp.	*	*						*		*										*	
Velia sp.	⊛	⊛						⊛		⊛										⊛	

Table 1.--Trophic classifications of benthic invertebrates collected at six sites in Piceance Creek basin, water years 1977-81--Continued

INSECTS	Habitat		Habits							Food Gathering								Food Web			
	Lotic	Lentic	Sprawlers	Burrowers	Clingers	Climbers	Swimmers	Divers	Skaters	Piercers	Shredders	Scrapers	Collectors	Scavengers	Engulfers	Filter Feeders	Parasites	Detritivores	Herbivores	Carnivores	Omnivores
Odonata (Dragonfiles & Damselflies)																					
Agrionidae																					
Hyponeura sp.	*	*	*		*	*									*					*	
Ishnura sp.	*	*				*									*					*	
Coenagrionidae																					
Argia sp.	*	*	*		*	*									*					*	
Gomphidae																					
Ophiogomphus severus	⊛			⊛											⊛					⊛	
Plecoptera (Stoneflies)																					
Capniidae																					
Capnia sp.	⊛		⊛		⊛						⊛							⊛			
Paracapnia angulata	⊛		⊛		⊛						⊛							⊛			
Perlodidae																					
Isoperla sp.	*		*		*								*		*			*		*	
I. fulva	⊛		⊛		⊛								⊛		⊛			⊛		⊛	
I. patricia	⊛		⊛		⊛								⊛		⊛			⊛		⊛	
I. petersoni	⊛		⊛		⊛								⊛		⊛			⊛		⊛	
Taeniopterygidae																					
Taenionema sp.	⊛		⊛		⊛							⊛							⊛		
Trichoptera (Caddisflies)																					
Brachycentridae																					
Brachycentrus americanus	⊛				⊛								⊛					⊛			
Glossosomatidae																					
Agapetus sp.	*				*							*	*					*	*		
Hydropsychidae																					
Hydropsyche sp. 1, 2	*	*			*								*					*			
H. slossonae	⊛	⊛			⊛								⊛					⊛			
Hydroptilidae																					
Hydroptila sp.	*				*					*		*							*		
Ochrotrichia sp.	*				*					*		*						*	*		
Stactobiella sp.	*				*					⊛			⊛					⊛	⊛		
Lepidostomatidae																					
Lepidostoma sp.	*		*		*	*					*							*			
Limnephilidae																					
Hesperophylax sp.	*		*								*							*	*		
Lenarchus sp.		*	*			*							*					*			
Limnephilus sp.	*	*	*		*	*					*		*					*	*		

Table 1.--Trophic classifications of benthic invertebrates collected at six sites in Piceance Creek basin, water years 1977-81--Continued

NON-INSECTS	Habitat		Habits							Food Gathering								Food Web			
	Lotic	Lentic	Sprawlers	Burrowers	Clingers	Climbers	Swimmers	Divers	Skaters	Piercers	Shredders	Scrapers	Collectors	Scavengers	Engulfers	Filter Feeders	Parasites	Detritivores	Herbivores	Carnivores	Omnivores
Acarina (Mites)																					
Atractideidae																					
Atractides sp.	⊛				⊛												⊛			⊛	
Lebertiidae																					
Lebertia sp.	⊛				⊛												⊛			⊛	
Sperchonidae																					
Sperchon sp.	⊛				⊛												⊛			⊛	
Amphipoda (Sideswimmers, Scuds)																					
Gammaridae																					
Gammarus lacustris	⊛	⊛					⊛						⊛					⊛			⊛
Talitridae																					
Hyalella azteca	⊛	⊛					⊛						⊛					⊛			⊛
Gastropoda (Snails, Limpets)																					
Lymnaeidae																					
Lymnaea abrussa	⊛	⊛				⊛								⊛							⊛
Physidae																					
Physa sp.	⊛	⊛				⊛								⊛							⊛
Gordiia (Horsehair worms)																					
Gordiidae																					
Gordius sp.	⊛	⊛			⊛												⊛		⊛		
Opisthopora (Earthworms)																					
Lumbricidae																					
Eiseniella sp.	*	*	⊛														⊛				
E.tetraedra	*	*	⊛														⊛				
Pelecypoda (Clams, Mussels)																					
Sphaeriidae																					
Pisidium sp.	*	*	⊛									⊛			⊛	⊛				⊛	
P. insigne	*	*	⊛									⊛			⊛	⊛				⊛	

Table 1.--Trophic classifications of benthic invertebrates collected at six sites in Piceance Creek basin, water years 1977-81--Continued

NON-INSECTS	Habitat		Habits							Food Gathering								Food Web			
	Lotic	Lentic	Sprawlers	Burrowers	Clingers	Climbers	Swimmers	Divers	Skaters	Piercers	Shredders	Scrapers	Collectors	Scavengers	Engulfers	Filter Feeders	Parasites	Detritivores	Herbivores	Carnivores	Omnivores
Plesiopora (Aquatic Worms)																					
Tubificidae																					
Limnodrilus sp.	*	*		⊛												⊛		⊛			
Tubifex sp.	*	*		⊛												⊛		⊛			
Rhynchobdellida (Leeches)																					
Glossiphoniidae																					
Helobdella stagnalis	⊛	⊛			⊛									⊛			⊛			⊛	

Table 2.--Summary of continuous-monitor data for in Piceance Creek basin, water years 1977-81

[°C, degrees Celsius; micromhos, micromhos per

Site number and name	Water-quality characteristics	1977 Minimum	1977 Maximum	1977 Maximum daily range	1978 Minimum	1978 Maximum	1978 Maximum daily range
1.Piceance Creek below Rio Blanco	Temperature(°C)	0.0	29.5	18.0	0.0	23.0	13.5
	Specific conductance(micromhos)	ND	ND	ND	565	1,470	ND
	pH(units)	7.7	8.5	ND	7.7	8.6	ND
	Dissolved oxygen (mg/L)	5.4	12.9	3.7	ND	ND	ND
	Suspended-sediment concentration(mg/L	8.0	10,700	ND	7.0	9,250	ND
2.Willow Creek near Rio Blanco	Temperature(°C)	'0.0	'26.0	19.5	0.0	28.5	21.0
	Specific conductance(micromhos)	'1,000	'1,560	ND	ND	1,680	ND
	pH(units)	'7.6	'8.7	ND	7.7	8.6	ND
	Dissolved oxygen (mg/L)	'5.3	'11.6	'3.7	3.6	11.8	ND
	Suspended-sediment concentration(mg/L)	6.0	3,820	ND	0	998	ND
3.Piceance Creek above Hunter Creek	Temperature(°C)	ND	'26.5	'17.5	0.0	26.0	17.0
	Specific conductance(micromhos)	'793	'1,680	ND	550	1,580	ND
	pH(units)	'7.6	'8.7	ND	7.8	8.9	ND
	Dissolved oxygen (mg/L)	'4.9	'14.7	ND	3.1	13.6	7.9
	Suspended-sediment concentration(mg/L)	10.0	87,000	ND	0	4,110	ND

selected water-quality characteristics at six sites
(modified from Tobin and others, 1984)

centimeter at 25°C; mg/L, milligrams per liter; ND, not determined]

1979			1980			1981			5-year range	5-year maximum daily range
Mimimum	Maximum	Maximum daily range	Minimum	Maximum	Maximum daily range	Minimum	Maximum	Maximum daily range		
0.0	22.0	13.05	'0.0	'23.0	'15.5	0.0	26.5	16.5	0.0-29.5	18.0
606	1,380	ND	'706	'1,310	ND	878	1,390	ND	565-1,470	ND
'7.5	'8.6	ND	7.7	8.5	ND	7.8	8.7	ND	7.5-8.7	
'5.1	'12.3	'4.1	'6.0	'12.3	'3.9	5.4	11.7	4.7	'5.1-12.9	'4.7
8.0	3,920	ND	9.0	4,070	ND	8.0	623	ND	7-10,700	ND
'0.0	'24.0	'19.0	0.0	22.5	16.5	0.0	29.5	22.0	0.0-29.5	22.0
'1,050	'1,480	ND	'596	'1.,550	ND	'580	'1,590	ND	'580-1,680	ND
'7.7	'8.7	ND	'7.4	'8.8	ND	7.9	8.6	ND	'7.4-8.8	ND
'6.2	'12.9	'5.7	'5.5	'12.7	'3.3	'5.9	'12.0	'3.4	'3.6-12.9	'5.7
3.0	7,030	ND	20	753	ND	1.0	644	ND	0-7,030	ND
'0.0	'23.5	'13.5	0.0	22.0	13.5	0.0	26.0	17.0	'0.0-26.5	'17.5
'700	'1,630	ND	664	1,830	ND	1,120	1,620	ND	550-1,830	ND
'7.4	'8.7	ND	7.7	8.6	ND	7.8	8.6	ND	'7.4-8.9	ND
'6.0	'11.7	'5.3	5.0	12.5	6.1	5.1	14.4	7.0	'3.1-14.7	'7.9
19.0	4,750	ND	7.0	5,760	ND	10.0	1,560	ND	0-87,000	ND

Table 2.--Summary of continuous-monitor data for in Piceance Creek basin, water years 1977-81

[°C, degrees Celsius; micromhos, micromhos per

Site number and name	Water-quality characteristics	1977 Minimum	1977 Maximum	1977 Maximum daily range	1978 Minimum	1978 Maximum	1978 Maximum daily range
4.Black Sulphur Creek near Rio Blanco	Temperature(°C)	0.0	23.5	18.0	0.5	23.0	18.5
	Specific conductance(micromhos)	1,070	2,050	ND	870	2,020	ND
	Suspended-sediment concentration(mg/L)	14.0	6,400	ND	8.0	19,800	ND
5.Piceance Creek below Ryan Gulch	Temperature(°C)	ND	ND	ND	ND	ND	ND
	Specific conductance(micromhos)	ND	ND	ND	ND	ND	ND
	Suspended-sediment concentration(mg/L)	10.0	21,700	ND	9.0	8,100	ND
6.Piceance Creek at White River	Temperature(°C)	ND	ND	ND	-0.5	32.0	18.5
	Specific conductance(micromhos)	ND	ND	ND	628	6,870	ND
	Suspended-sediment concentration(mg/L)	14.0	2,600	ND	4.0	25,000	ND

[1] Based on incomplete record of less than 80 percent for the year.

selected water-quality characteristics at six sites
(modified from Tobin and others, 1984)--Continued

centimeter at 25°C; mg/L, milligrams per liter; ND, not determined]

1979			1980			1981			5-year range	5-year maximum daily range
Mimimum	Maximum	Maximum daily range	Minimum	Maximum	Maximum daily range	Minimum	Maximum	Maximum daily range		
0.5	22.5	19.5	0.0	23.0	15.0	0.0	23.0	15.0	0.0-23.5	19.5
950	1,960	ND	551	1,990	ND	200	1,910	ND	200-2,050	ND
13.0	2,000	ND	17.0	5,510	ND	11.0	2,620	ND	8-19,800	ND
ND	ND	ND	0.0	23.5	13.5	0.0	26.5	17.0	0.0-26.5	17.0
ND	ND	ND	593	1,980	ND	520	2,920	ND	520-2,920	ND
11.0	4,500	ND	8.0	4,060	ND	8.0	6,190	ND	8-21,700	ND
0.5	29.5	20.0	0.0	28.0	15.0	0.0	31.5	20.0	-0.5-32.0	20.0
790	3,620	ND	543	5,050	ND	1,320	10,000	ND	543-10,000	ND
10.0	4,500	ND	13.0	4,080	ND	12.0	3,190	ND	4-25,000	ND

Table 3.--Summary of physical measurements and observations at six sites in Piceance Creek basin, water years 1977-81

[NTU, nephelometric turbidity units; ft/s, foot per second; --, insufficient data]

Site number and name	Measurement or observation	[1]1977 Minimum	[1]1977 Maximum	[1]1978 Minimum	[1]1978 Maximum	[1]1979 Minimum	[1]1979 Maximum	[2]1980 Minimum	[2]1980 Maximum	[2]1981 Minimum	[2]1981 Maximum
1. Piceance Creek below Rio Blanco	Turbidity(NTU)	2.0	110	1.0	400	2.0	240	2.0	11	3.0	12
	Velocity(ft/s)	.84	2.18	.50	2.82	.91	2.45	--	--	--	--
	Ice	None	Shore	None	Shore	None	None	None	None	None	None
	Substrate	Silt, sand	Cobbles	Silt, sand	Cobbles	Silt, sand	Cobbles	Silt, sand	Cobbles	Silt, sand	Cobbles
2. Willow Creek near Rio Blanco	Turbidity(NTU)	2.0	100	1.0	72	2.0	22	8.0	22	2.0	22
	Velocity(ft/s)	.65	2.45	.95	2.23	.19	2.18	--	--	--	--
	[3]Ice	None	Shore	None	Shore, floating	None	None	None	None	None	None
	Substrate	Sand	Gravel	Sand	Gravel	Silt	Gravel	Sand	Gravel	Sand	Gravel
3. Piceance Creek above Hunter Creek	Turbidity(NTU)	1.0	165	2.0	380	2.0	280	2.0	35	5.0	43
	Velocity(ft/s)	.64	2.18	.64	2.23	.89	1.75	--	--	--	--
	[3]Ice	None	Shore	None	None	None	None	None	None	None	None
	Substrate	Silt, sand	Cobbles	Silt, sand	Cobbles	Fine sand	Cobbles	Sand	Cobbles	Sand	Cobbles
4. Black Sulphur Creek near Rio Blanco	Turbidity(NTU)	2.0	33	1.0	425	2.0	55	2.0	26	2.0	20
	Velocity(ft/s)	.82	2.14	.82	1.83	.93	1.45	--	--	--	--
	Ice	None	None	None	None	None	None	None	None	None	None
	Substrate	Algae in silt	Cobbles	Algae in silt	Cobbles	Algae in silt	Cobbles	Sand	Gravel	Sand	Gravel
5. Piceance Creek below Ryan Gulch	Turbidity(NTU)	4.0	120	2.0	150	2.0	280	2.0	41	6.0	58
	Velocity(ft/s)	.43	2.43	.91	2.01	1.32	1.75	--	--	--	--
	[3]Ice	None	Shore	None	None	None	None	None	None	None	None
	Substrate	Fine sand	Cobbles	Sand	Cobbles	Sand	Cobbles	Sand	Cobbles	Sand	Cobbles
6. Piceance Creek at White River	Turbidity(NTU)	2.0	160	4.0	375	6.0	340	1.0	73	4.0	110
	Velocity(ft/s)	.68	2.82	.93	2.18	1.08	1.92	--	--	--	--
	[3]Ice	None	Shore	None	None	None	None	None	None	None	None
	Substrate	Sand	Small cobbles	Sand	Small cobbles	Sand	Small cobbles	Sand	Small cobbles	Sand	Cobbles

[1] Data collected monthly
[2] Data collected quarterly
[3] Total ice cover has been observed

Characterization of Insects

Representatives of eight insect orders were collected in Piceance Creek basin. Variations in taxa were greatest for Diptera (two-winged flies) and least for Collembola (springtails). Collembola were collected only once during the 1981 water year at site 6. Although butterflies and moths were observed in the Piceance Creek basin, no species of aquatic Lepidoptera (butterflies and moths) were documented. The absence of Lepidoptera from the data base may be related to habit and habitat preference. Most aquatic Lepidoptera larva are leafrollers, netbuilders, or borers in large stems of water plants and, therefore, inhabit pooled areas in streams. All samples in this study were collected at riffle areas.

Coleoptera (water beetles) were represented by 5 families and 14 genera. The five families are: Halipidae (crawling beetles)--algae eaters; Dytiscidae (diving beetles)--predacious; Hydrophillidae (water scavengers)--larva are carnivores and adults are herbivores; Drydropidae (long-toed water beetles), including the genera Helichus sp., one of the few beetles where both larva and adult are truly aquatic; and Elimidae (riffle beetles)--most members prefer rapid flowing, clear, rocky streams. Only a few numbers of Coleoptera were collected at all sites. Optioservus sp., a widely distributed riffle beetle, was the most common organism found during maximum counts of Coleoptera at sites 1, 3, and 5.

Twelve families and 88 genera of Diptera (two-winged flies) were collected. These can be grouped into:

1. Four genera of Ceratopogonidae (biting midges). One species, Culicoides sp., is a blood sucker and is reported by Usinger (1956) to inhabit polluted puddles and ditches.

2. Chironomidae (non-biting midges). This group is an important food source for freshwater trout, bass, and whitefish (Usinger, 1956). They prefer soft, mucky substrates. Among the 26 species documented are:

   a. Procladius sp.--a predator of Ephemerella sp. and Ceratopogonidae;
   b. Psectrotanypus sp.--a predator of Chironomidae, Trichoptera, and Ephemeroptera;
   c. Cardiocladius sp.--a predator of Simuliidae (Black fly larva);
   d. Eukiefferiella sp.--a predator of Chironomid eggs and larva;
   e. Cryptochironomus sp.--a predator of Chironomid larva and Tubifex (aquatic earthworms);
   f. Diamesa sp.--prefer swift mountain streams;
   g. Cricotopus sp.--numerous and widely distributed, herbivore; and
   h. Chironomus sp.--numerous and widely distributed, herbivore.

3. Two genera of Ephydridae (shoreflies) that are found in alkaline, salt, and thermal waters. Two known species of this family are peculiar to saline and petroleum aquatic habitats (Usinger, 1956).

4. Simuliidae (black flies) and Tipulidae (craneflies) were collected seasonally in large numbers. Hexatoma sp. and Limnophila sp. (craneflies) are predators of Tubifex sp. and Diptera.

5. Musidae (house flies)--the Limnophora sp. are predators of black flies and craneflies.

Except at site 5, maximum counts of Diptera were characterized by one of the following genera: Cricotopus sp., Eukiefferiella sp., or Similium sp. Occasionally large numbers of Odontomesa sp., Metriocnemus sp., or Orthocladius sp. also were collected. Maximum counts at site 5 consistently had mixtures of two or more of the above genera.

Ephemeroptera (mayflies) are an important link in energy transfer from plant tissue to animal tissue. They are basic herbivores, defenseless, and numerous, hence prey for all. Six families and 15 species were collected. Baetis sp. was most numerous during maximum counts of Ephemeroptera at sites 1, 2, and 4. Mixtures of Trycorythodes sp. and Baetis sp. characterized the maximum counts of Ephemeroptera at sites 3, 5, and 6.

Two families and three species of Hemiptera (true-bugs) were collected at sites 1, 2, and 6. Three families of Odonata (one dragonfly, two damselflies) were collected at sites 1, 4, 5, and 6. Three families and seven species of Plecoptera (Stoneflies) were documented. Isoperla sp. is a predator of Chironomids, Ephemoptera and other Plecoptera. Isoperla sp. were collected consistently at all sites except site 6, Piceance Creek at White River.

Trichoptera (caddisflies) were collected at all sites in small numbers. Six families and 11 species were documented. This condition is unusual for Trichoptera as they usually are one of the more numerous invertebrates in Colorado streams (Canton and Ward, 1981; Minshall and Minshall, 1977). Hydrophysche sp. was the only Trichoptera consistently documented at all sites.

Habitat assignments for 11 species not previously documented by Merritt and Cummins (1978) in lotic conditions are listed in table 1. They are: Haliipus sp., Hydrobius sp., Stilobezzia sp., Endochironomus sp., Paralauterborniella sp., Phaenospectra sp., Polypedlium sp., Smittia sp., Brachycentrus sp., Callibaetis sp., and Lenarchus sp.

Characterization of Non-insects

Benthic invertebrates that are not insects were collected at all sites. These organisms comprise a small percentage of the total aquatic fauna.

Three species of Acarina (water mites) were collected. Sperchon sp., Lebertia sp., and Atractides sp. are associated with cold running water (Ward and Whipple, 1959). These species are insect parasites and carnivores and they require large concentrations of dissolved oxygen.

Most Amphipoda (sideswimmers and scuds) also are confined to substrates and waters that have large concentrations of dissolved oxygen. This group

often occurs in very large numbers. The two species collected, Gammarus lacustrus and Hyalella azteca, are found commonly in alkaline, brackish, and hard waters. Hardness, reported as concentrations of calcium carbonate, frequently exceed 180 mg/L in Piceance Creek basin. Hem (1970) classifies waters that exceed this concentration level as very hard.

Gastropoda (snails) live on the substrate and primarily are herbivores. They require water that has large concentrations of calcium carbonate for shell production. Lymnaea abrussa and Physa sp. require temperatures above freezing for maximum metabolism. Lymnaea sp. will burrow into mud to survive drought conditions (Pennak, 1978). Decreases in the number of snail species has occurred in areas of increasing pollution (Pennak, 1978). Because only two species were documented in Piceance Creek basin, they would not be a good choice for pollution monitoring. The Pelecypoda (clams and mussels), Pisidium sp. was collected only at site 4. This genus is widely distributed throughout North America.

Gordiia (horsehair worms) are a parasite of insects during their larval stage and are commonly found in warm sluggish streams from May to September (Ward and Whipple, 1959). Gordius sp. was collected at site 1.

Large populations of worms are good indicators of organic enrichment (Pennak, 1978; and Odum, 1971). They are filter feeders that ingest fine organic matter. Large populations have been found in stream environments that have areas of heavy silting, large concentrations of organic material, and minimal concentrations of dissolved oxygen. One genus each from Opisthopora (earthworms) and Plesiopora (aquatic worms) was identified. Eiseniella sp. was collected at sites 3 and 4. This earthworm normally is found only in cold mountain streams. The aquatic worm Tubifex sp. can survive minimal concentrations of dissolved oxygen for 48 days at 0° to 2°C and has been used extensively as an indicator organism for organic pollution. Small numbers of Tubifex sp. were collected regularly at site 6 and occasionally at all other sites.

Rhynchobdellida (leeches) can tolerate small concentrations of dissolved oxygen; large numbers of leeches usually are indicative of organic enrichment. Helobdella stagnalis was the only leech collected; it is known to be a snail parasite. Helobdella stagnalis normally adheres to solid substrates and is uncommon in mud or clay.

The variability in the range of non-insect species among the sites was greatest (11 species) at site 4 and least (2 species) at site 2. Non-insect species ranged from five to nine species at the other four sites.

Analysis and Results

The organism counts for the major orders at each site are shown in figures 2 to 7. Line plots are not continued into the 1980 and 1981 water years because only four samples per year were collected. A maximum benthic-invertebrate count of 3,700 organisms was collected during September 1980, at site 4. Collections of less than 100 organisms per sample were common at all

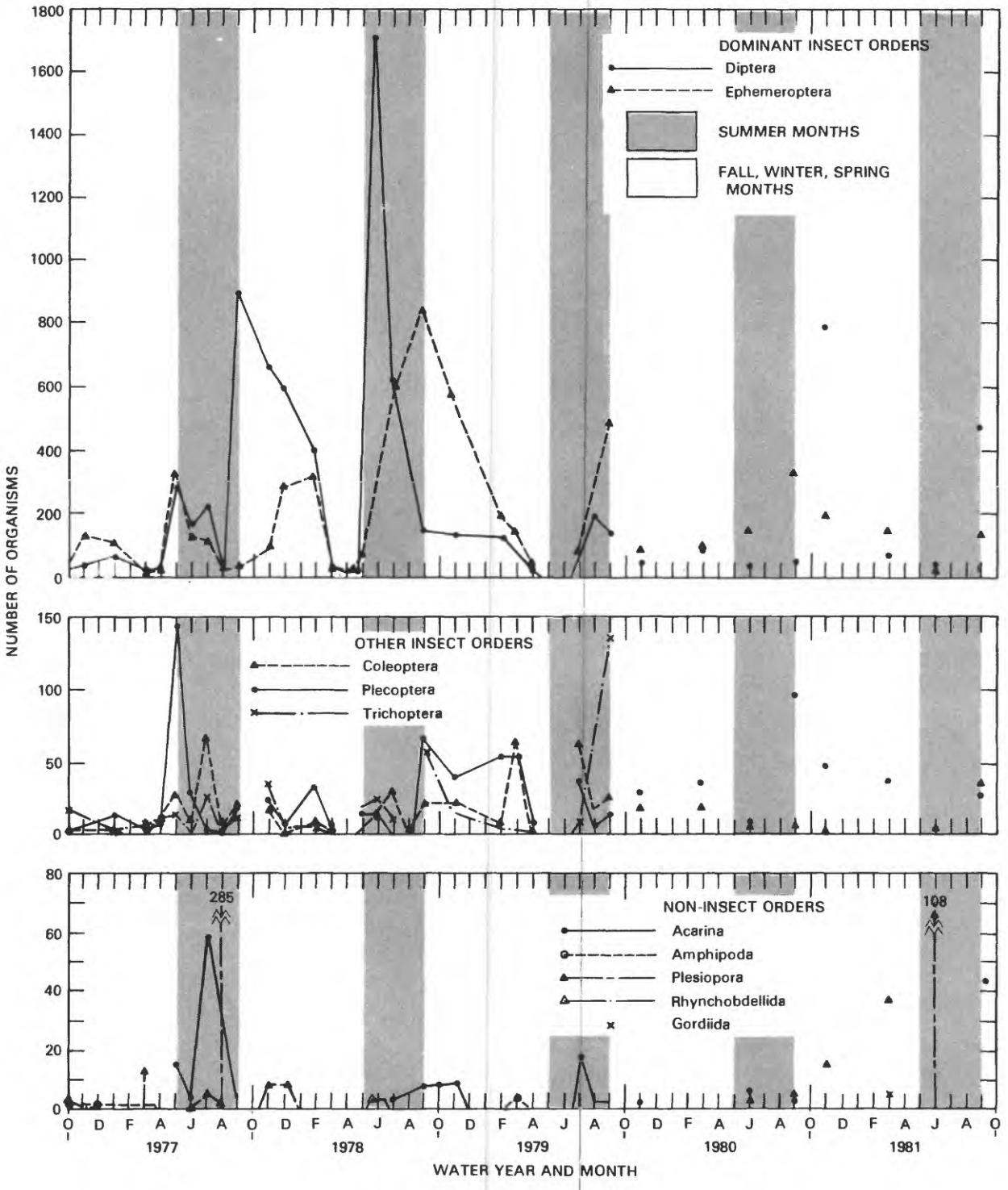


Figure 2.--Numbers and distributions of benthic invertebrates by order at site 1, Piceance Creek below Rio Blanco.

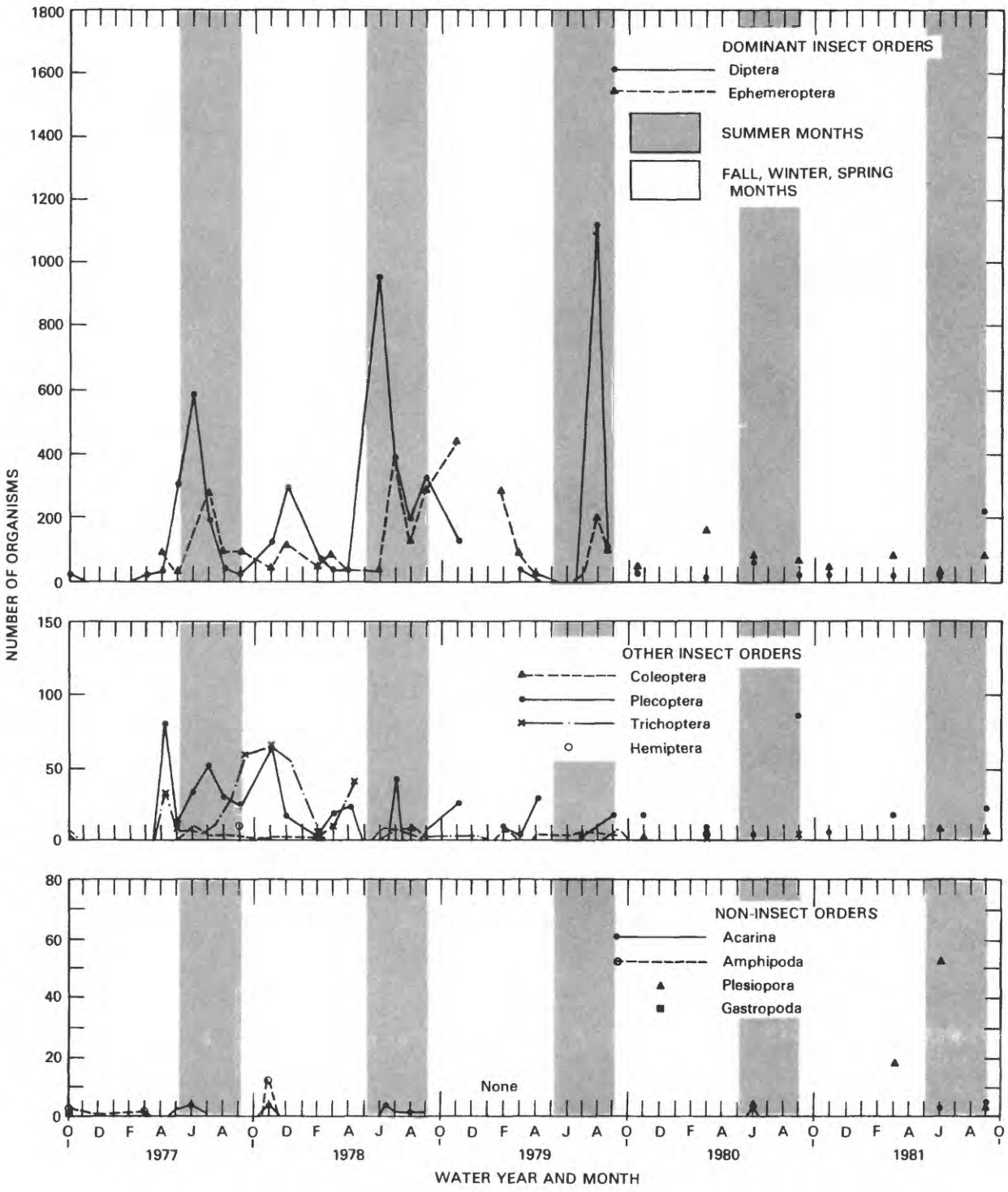


Figure 3.--Numbers and distributions of benthic invertebrates by order at site 2, Willow Creek near Rio Blanco.

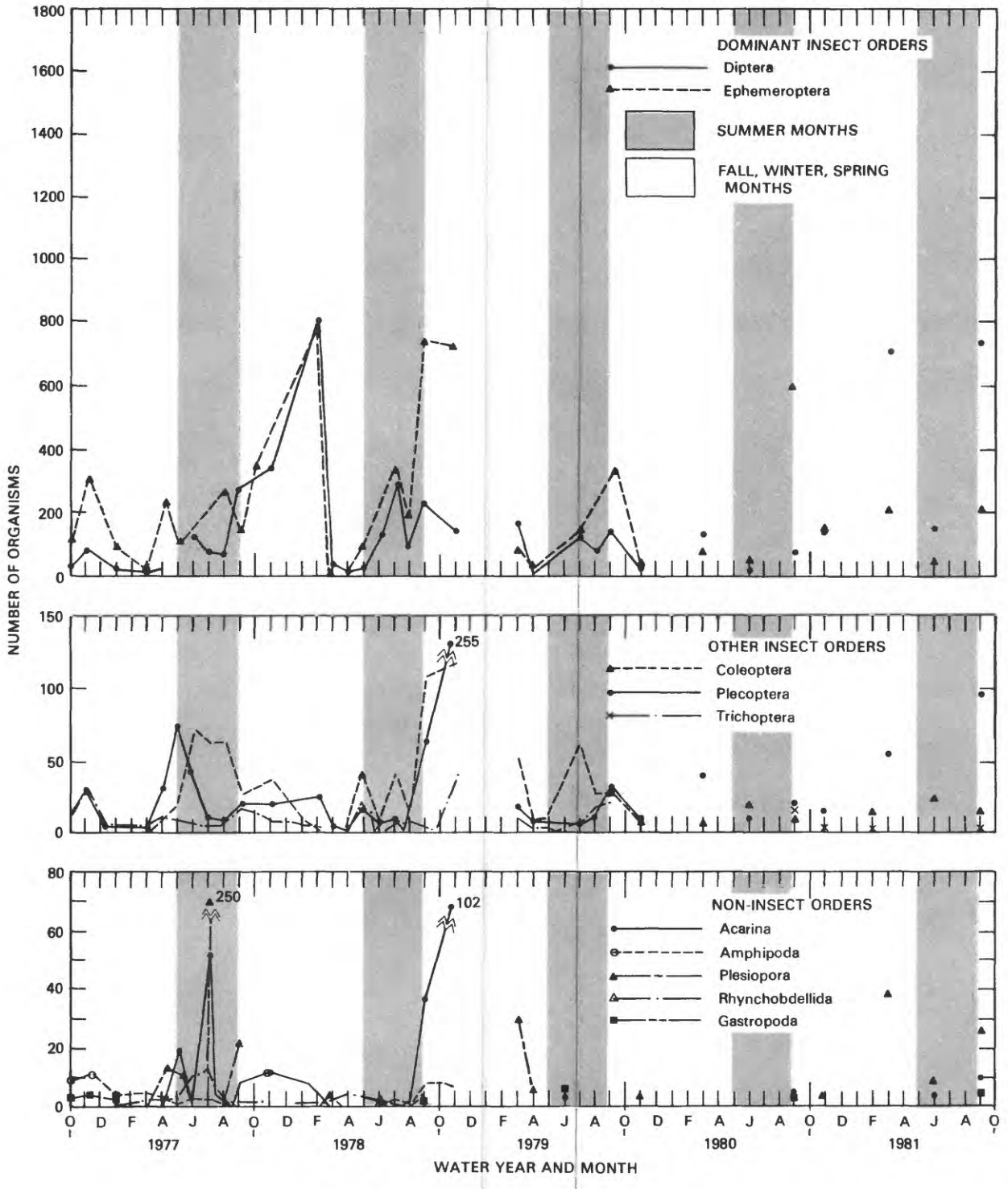


Figure 4.--Numbers and distributions of benthic invertebrates by order at site 3, Piceance Creek above Hunter Creek.

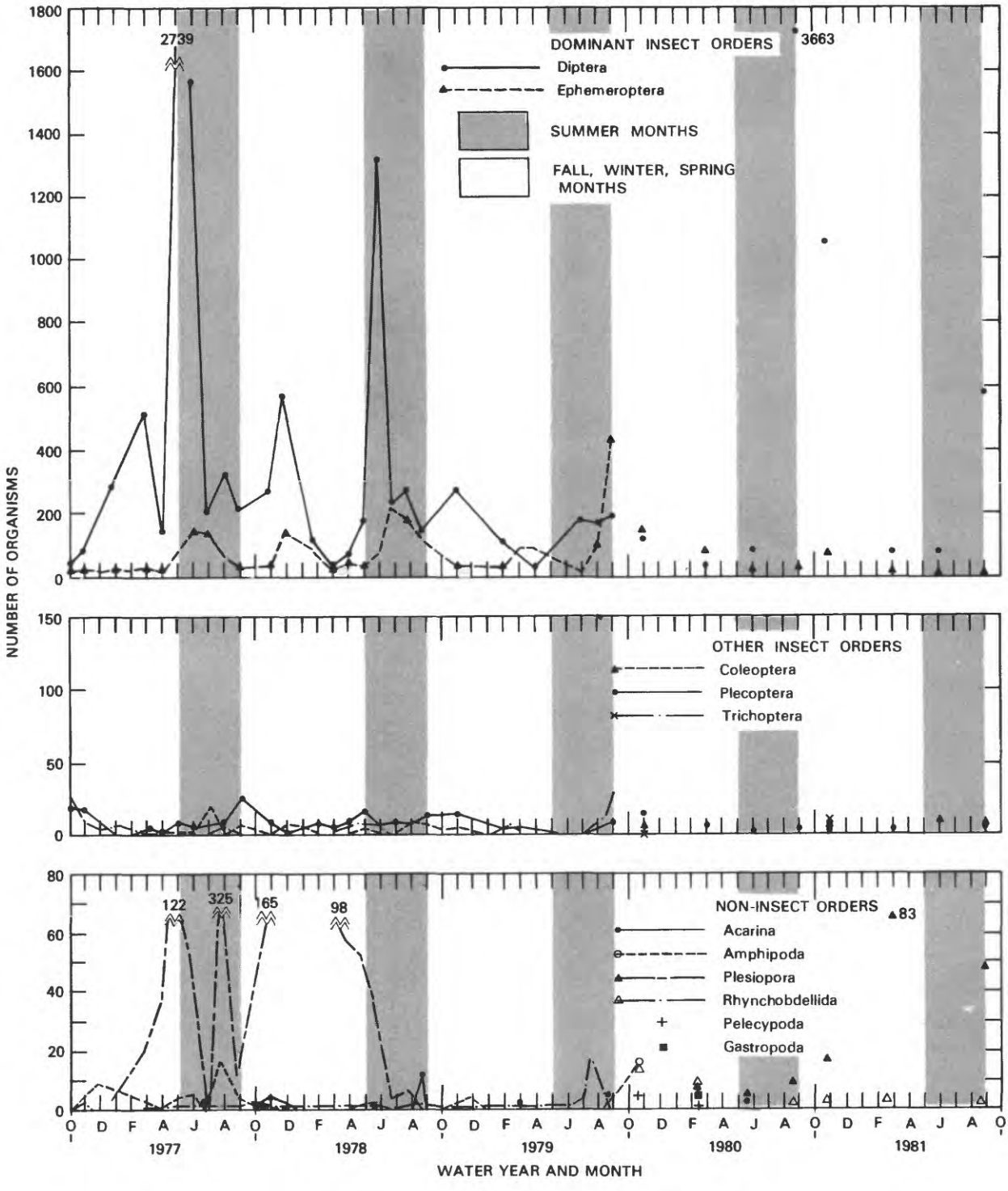


Figure 5.--Numbers and distributions of benthic invertebrates by order at site 4, Black Sulphur Creek near Rio Blanco.

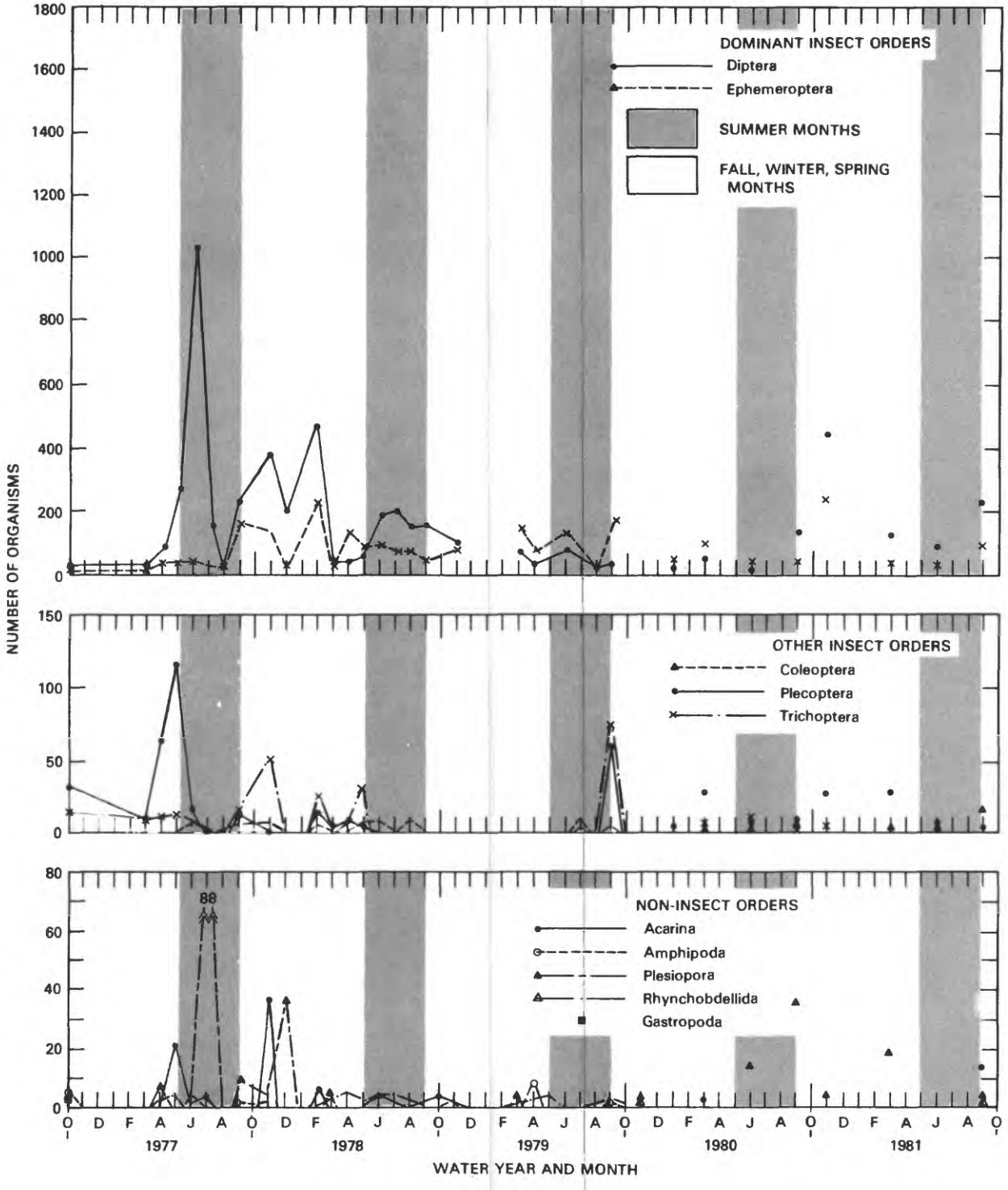


Figure 6.--Numbers and distributions of benthic invertebrates by order at site 5, Piceance Creek below Ryan Gulch.

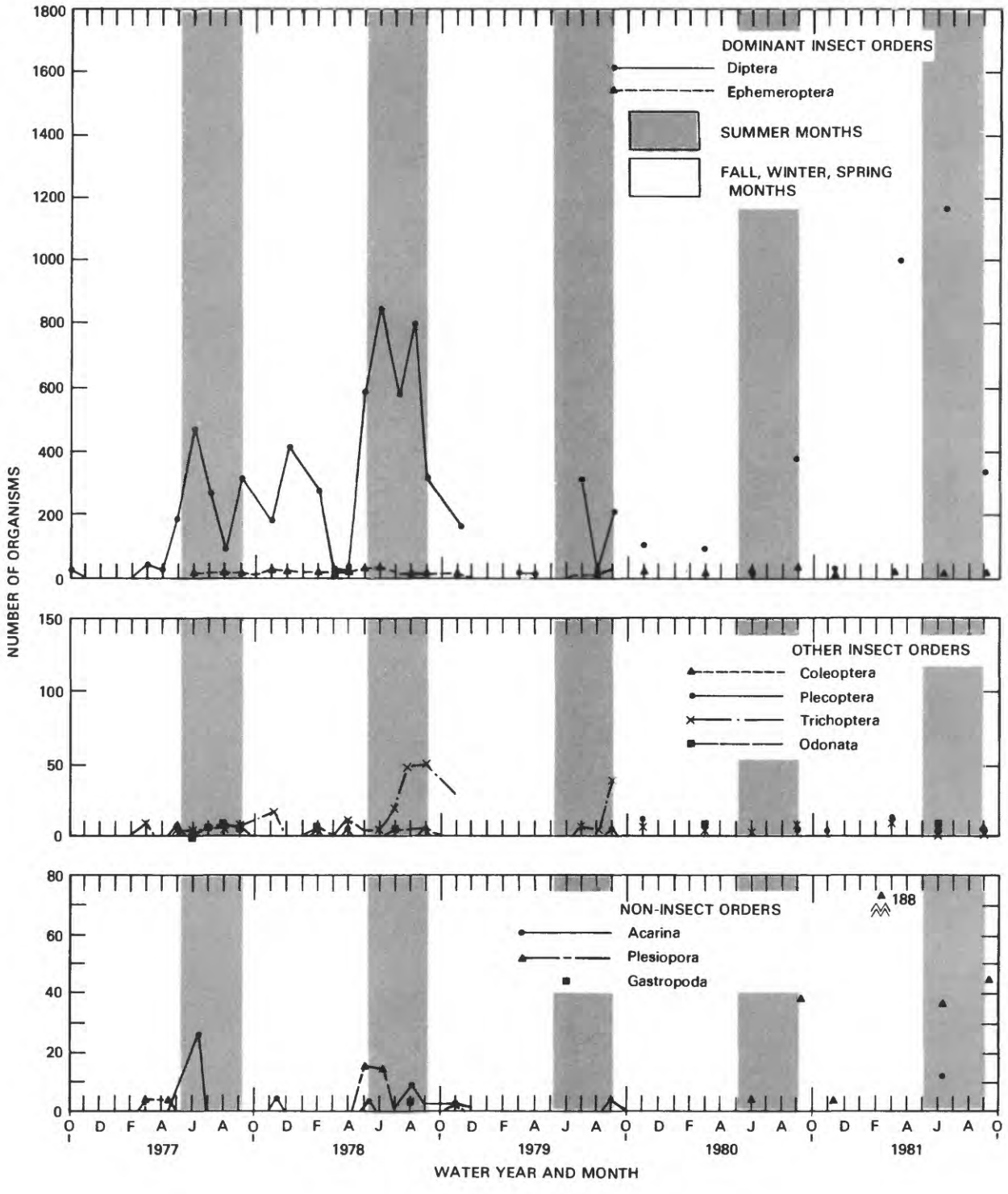


Figure 7.--Numbers and distributions of benthic invertebrates by order at site 6, Piceance Creek at White River.

sites during early spring runoff. Total counts tended to be greater during the low flow years of 1977, 1978, and 1981 and less during the high runoff years of 1979 and 1980.

Means and ranges for the number of species and total organism counts are summarized in figure 8. Site 4 generally had the most consistent range of species and greatest number of organisms. The composite data for the 5 years show that site 6 had the smallest number of species and sites 2, 5, and 6 had the fewest numbers of organisms.

The percent composition of major orders calculated from the 5-year data base at each site is shown in figure 9. Organisms from both Diptera and Ephemeroptera tended to characterize the upstream reaches of Piceance Creek at sites 1 and 3. The apparent shift in composition from Diptera to Ephemeroptera at site 3 when compared to site 1 may be related to local mosquito (Diptera) controls that used petroleum surface-filming agents at site 3. Diptera were the most numerous of the benthic organisms at the other four sites, and the percent composition of Diptera increased downstream.

The large percent composition of Diptera (fig. 9) and the reduction in numbers of organisms at site 6 when compared to the upstream sites (fig. 8) may be related to one or more of the following:

1. The change in water quality from a sodium magnesium bicarbonate type in the upstream reaches of Piceance Creek to a more mineralized sodium bicarbonate type at site 6.

2. Possible organic enrichment of Piceance Creek downstream from agricultural areas and other sources.

3. A general downstream increase in stream temperature.

Taxa identified from the data base for the 5 water years are summarized into habit groupings in figure 10. Total genera for each habit grouping within a given order are shown for a composite of the six sites and for each site. A similar presentation for the distribution of taxa into food-web assignments is given in figure 11.

Habit grouping placed most of the genera collected in the burrowers-sprawlers-clingers groups. All groups except skaters were present at one time or another at all sites. Although no definite geographical patterns are evident, the small bed-material size (silt to cobble) and moderate stream velocities (0.2 to less than 3 ft/s) shown in table 3 may have been favorable to the development of organisms in the burrowers-sprawlers-clingers groups.

Food-web grouping showed most genera belonged to the primary and secondary consumer levels. The food-web structure apparently was balanced and stable at all locations. Data analyses for individual sites and for site-to-site comparisons show that even though there were many variations in genera, distribution balance was similar at all locations. These data indicate that a good ecological balance of benthic organisms existed in Piceance Creek basin during the study.

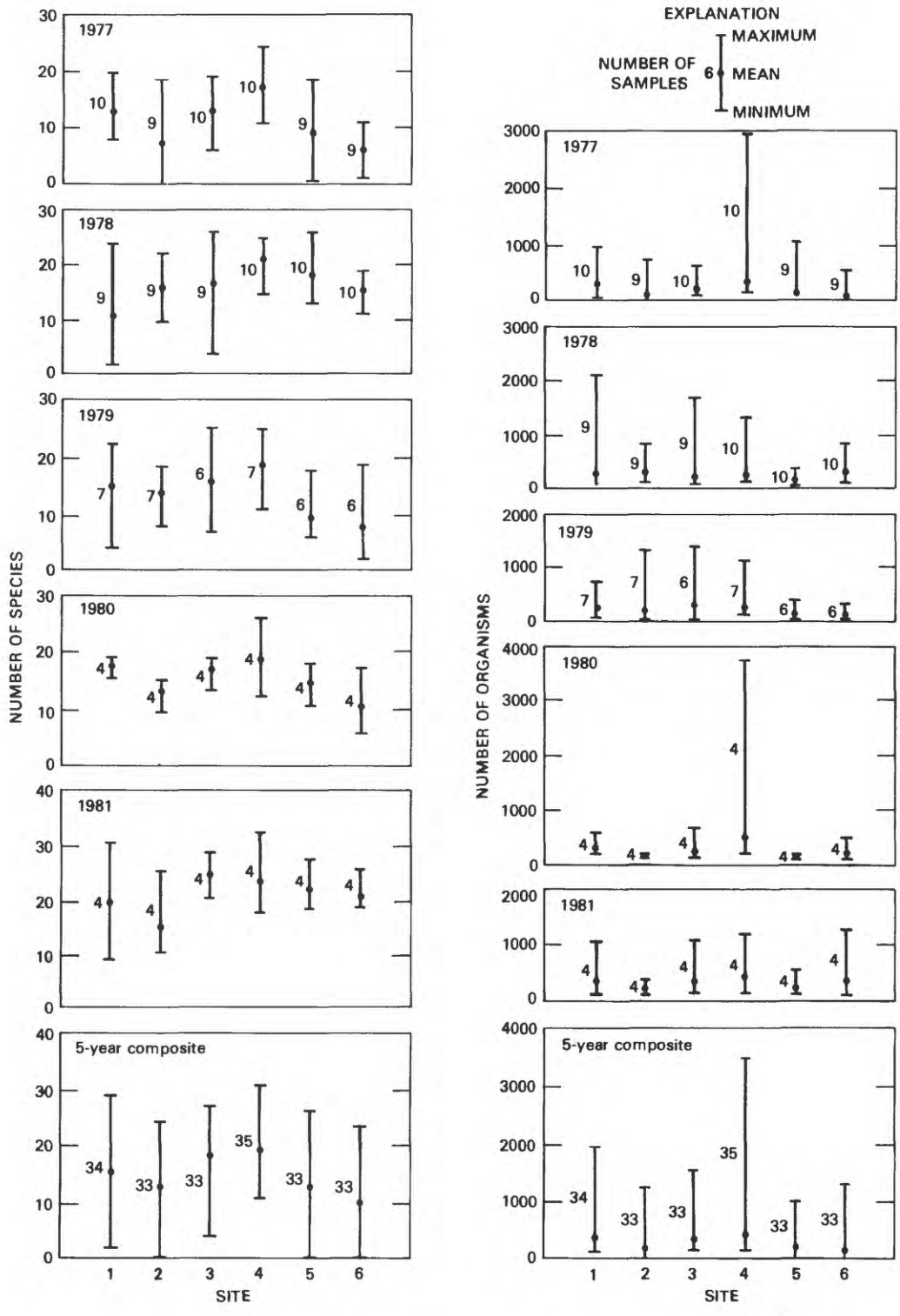


Figure 8.--Means and ranges for numbers of species and numbers of organisms by water year at the six sites.

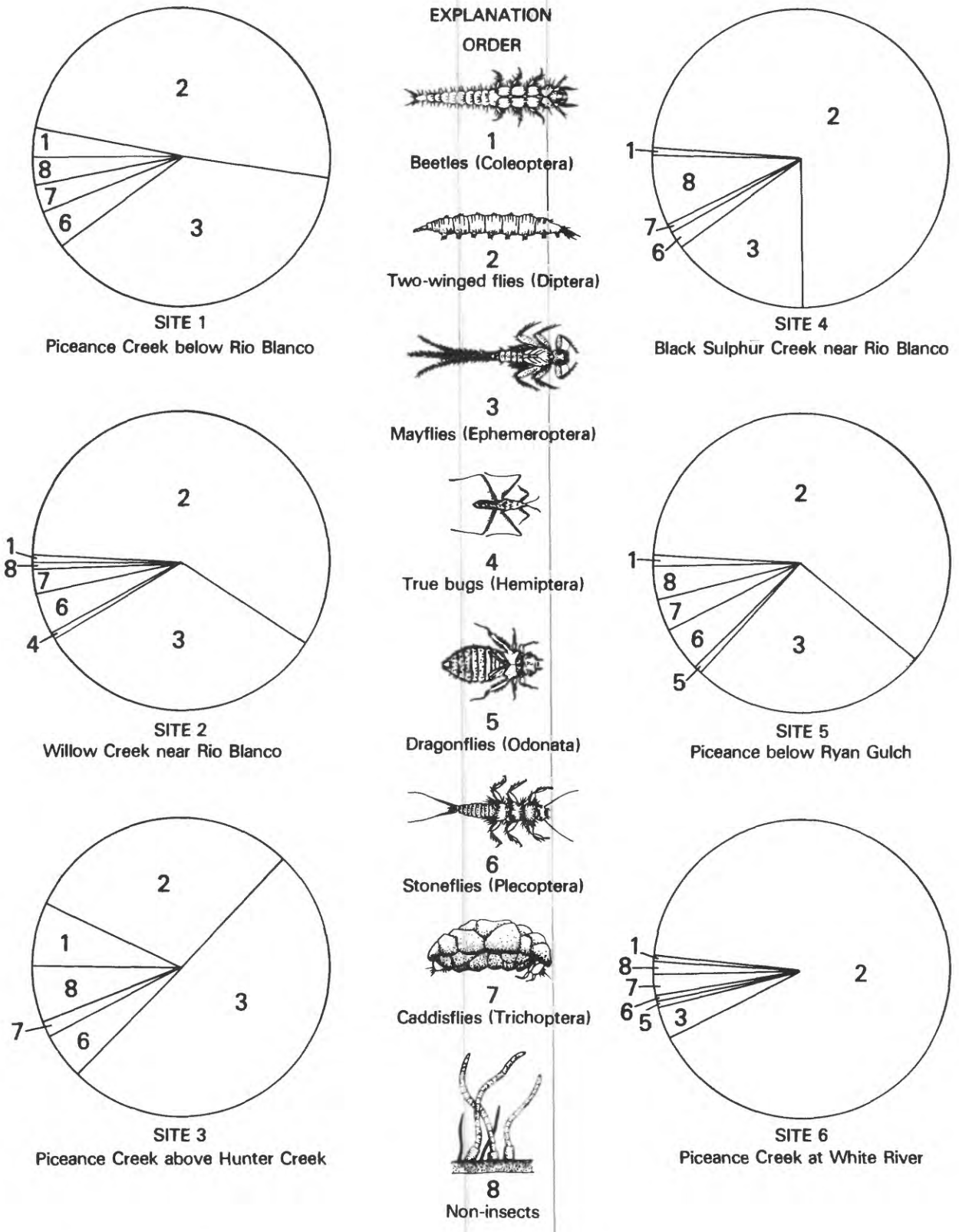


Figure 9.--Percent composition of benthic invertebrates at the order level at the six sites, composite of water years 1977-81.

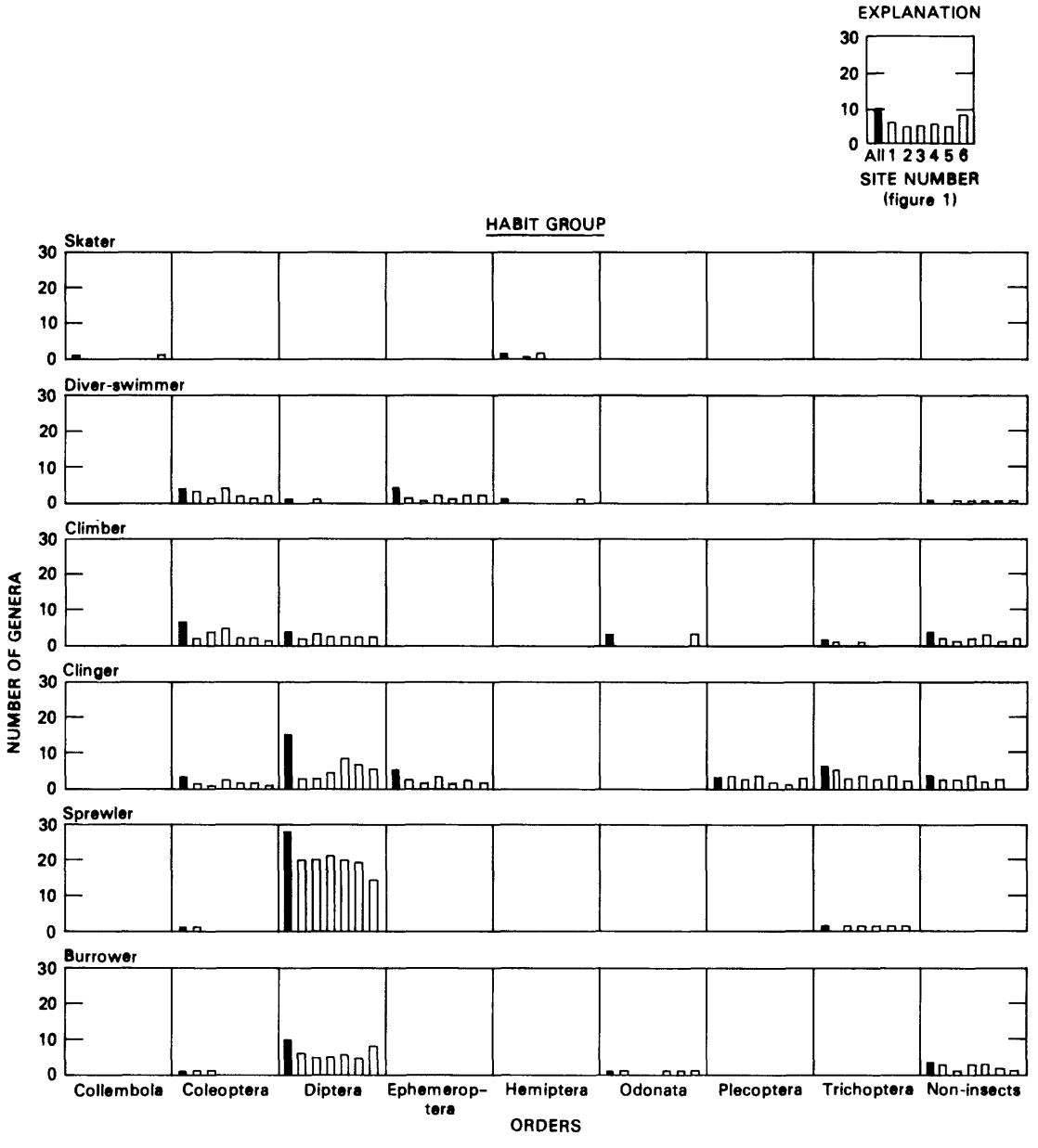


Figure 10.--Distribution of benthic-invertebrate genera assigned to habit groupings (from table 1) at the six sites. Data are for a composite of water years 1977-81 and show total genera collected compared to total genera collected in Piceance Creek basin at each site.

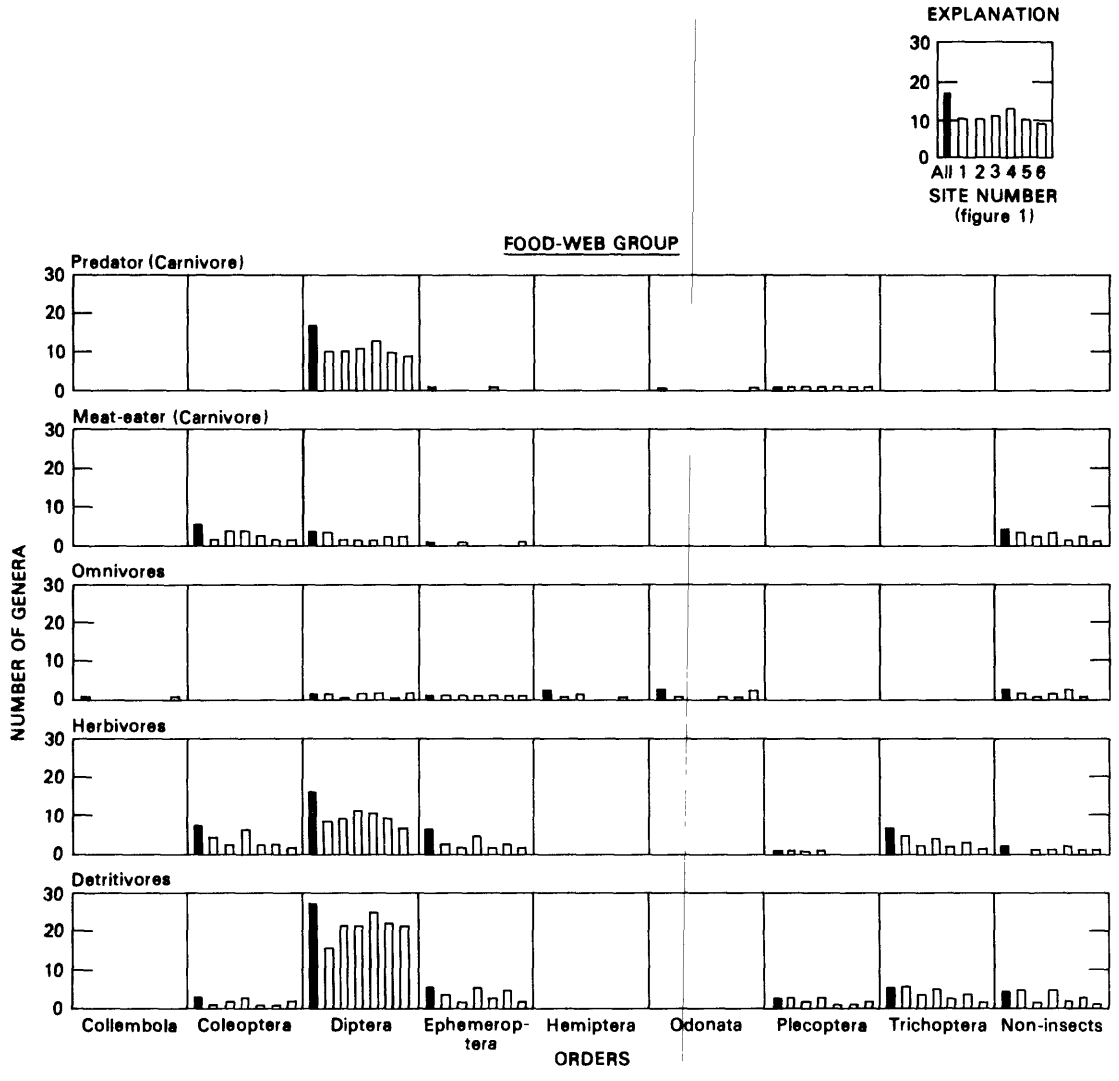
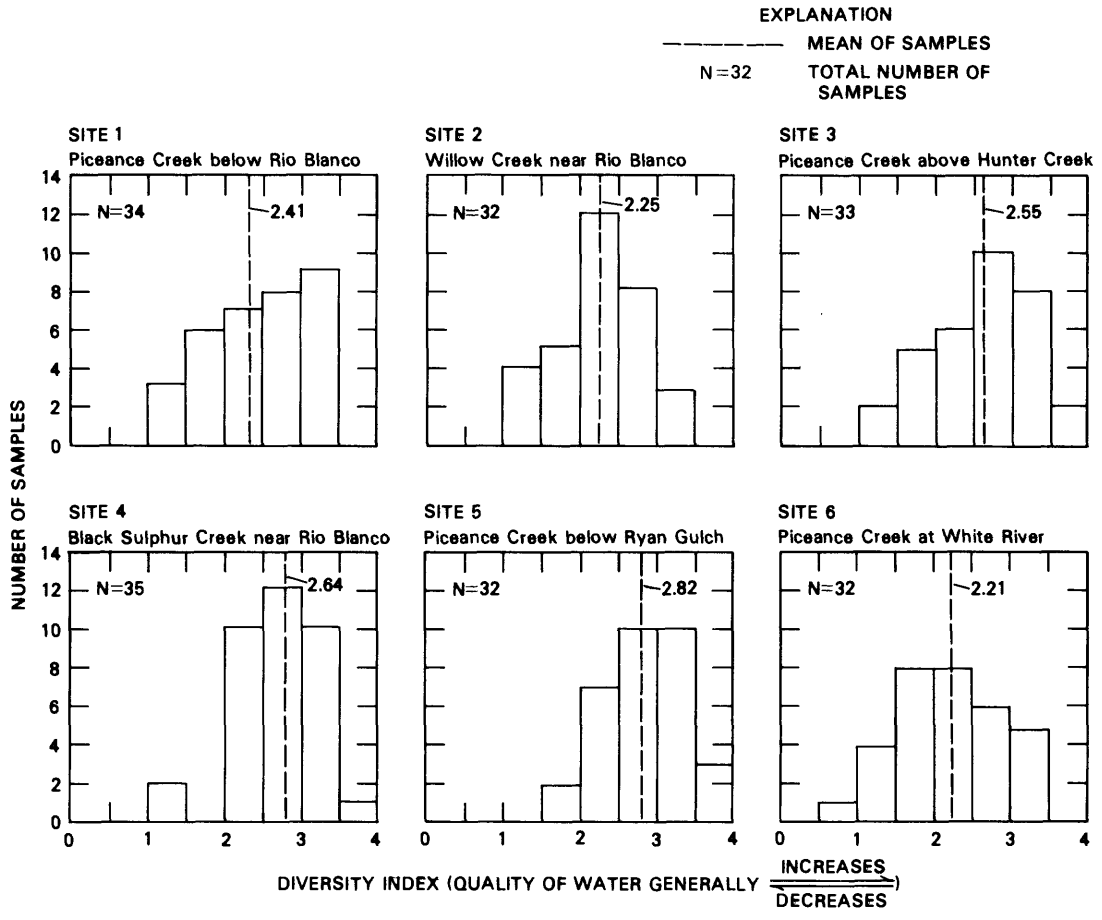


Figure 11.--Distribution of benthic-invertebrate genera assigned to food-web groupings (from table 1) at the six sites. Data are for a composite of water years 1977-81 and show total genera collected compared to total genera collected in Piceance Creek basin at each site.

Frequency distributions, means, and differences between means (at the 0.05 level of significance) of DI for each site are shown in figure 12. Samples that had both small organism counts and a DI of less than 0.5 were not considered in the data summaries. Except for site 1, Piceance Creek below Rio Blanco, the data approximate normal distribution curves.



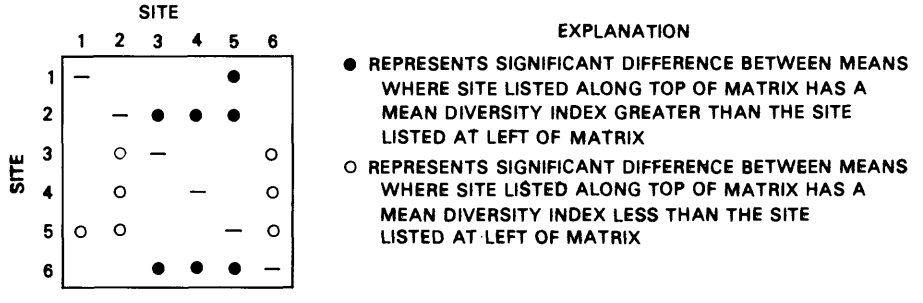


Figure 12.--Frequency distribution, means, and significant differences of means (at the 0.05 level of significance) of benthic-invertebrate diversity indices at the six sites, water years 1977-81.

Statistically, DI are significantly greater in the middle reaches of Piceance Creek at sites 3, 4, and 5 than at sites 1, 2, and 6 (fig. 12). These greater indices may have resulted in part from more consistent streamflow at sites 3, 4, and 5 than streamflows at sites 1 and 2. Springs are numerous in the basin, and perennial spring discharges and irrigation practices tend to augment and maintain or modify base flows to streams in the central parts of Piceance Creek basin. The small mean DI of 2.25 at site 2 may reflect the effects from hydrologic stresses during periods of discharge less than 0.1 ft^3/s. Also, bed-material size also was finer at this site than at sites 1, 3, 4, and 5.

The mean DI of 2.21 at site 6 near the mouth of Piceance Creek was the smallest of the six sites. Factors that may have influenced this difference are: (1) Increased concentrations of sodium bicarbonate from site 5 to site 6; (2) corresponding increases in concentrations of dissolved solids; (3) downstream increases in water temperature; and (4) smaller substrate particle size at site 6 than upstream sites.

Similarity indices (SI) comparing water years within each site are shown in table 4. Similarity indices comparing all organisms collected at individual sites with all organisms composited from the remaining sites for given water years are shown in figure 13. Yearly mean DI for each site also are plotted for comparison.

Data analyses show slight decreases in SI with time at each site (table 4) and for Piceance Creek basin in general (fig. 13). During the same period, DI tended to increase for the basin. Organisms collected at sites 1, 3, 4, and 5 tended to be the most representative of the basin; those collected at sites 2 and 6 were the least representative. The general shifts in the basin to a greater diversity and lesser similarity may represent a slow recovery from the hydrologic stresses produced during the low flow water years of 1977 and 1978. Statistical analyses for means of DI at each site for water years 1977-79 were compared with similar data for water years 1980 and 1981. Although the data showed no major differences at the 0.05 level of significance, the reduction in the number of samples collected after water year 1979 may have contributed to the apparent shifts.

SUMMARY AND CONCLUSIONS

Data from 200 samples of benthic organisms collected periodically during the water years 1977-81 at six sites in Piceance Creek basin are presented and summarized. The six sites include four on the mainstem of Piceance Creek and one site each at the mouths of two tributaries to Piceance Creek. All samples consisted of a composite of three 1-ft Surber grabs from riffle areas of the streams.

A total of 162 genera were identified from 8 insect orders and 8 non-insect orders. Trichoptera (caddisflies) were present but in numbers less than expected for Colorado streams. Organisms associated with unpolluted and polluted waters were collected, and 11 species not previously documented by Merritt and Cummins (1978) in lotic conditions are listed.

Table 4.--Matrices comparing similarity indices by water years for six sites in Piceance Creek basin

Site number and name		Water years 1978	1979	1980	1981
1. Piceance Creek below Rio Blanco	1977	0.65	0.56	0.55	0.52
	1978	--	0.69	0.57	0.56
	1979	--	--	0.55	0.52
	1980	--	--	--	0.55
2. Willow Creek near Rio Blanco	1977	0.66	0.57	0.53	0.41
	1978	--	0.74	0.68	0.58
	1979	--	--	0.61	0.37
	1980	--	--	--	0.44
3. Piceance Creek above Hunter Creek	1977	0.59	0.54	0.52	0.55
	1978	--	0.79	0.63	0.59
	1979	--	--	0.60	0.27
	1980	--	--	--	0.63
4. Black Sulphur Creek near Rio Blanco	1977	0.71	0.69	0.69	0.24
	1978	--	0.66	0.70	0.49
	1979	--	--	0.74	0.59
	1980	--	--	--	0.56
5. Piceance Creek below Ryan Gulch	1977	0.67	0.68	0.66	0.55
	1978	--	0.55	0.59	0.58
	1979	--	--	0.60	0.61
	1980	--	--	--	0.60
6. Piceance Creek at White River	1977	0.63	0.56	0.63	0.50
	1978	--	0.60	0.66	0.59
	1979	--	--	0.59	0.51
	1980	--	--	--	0.64

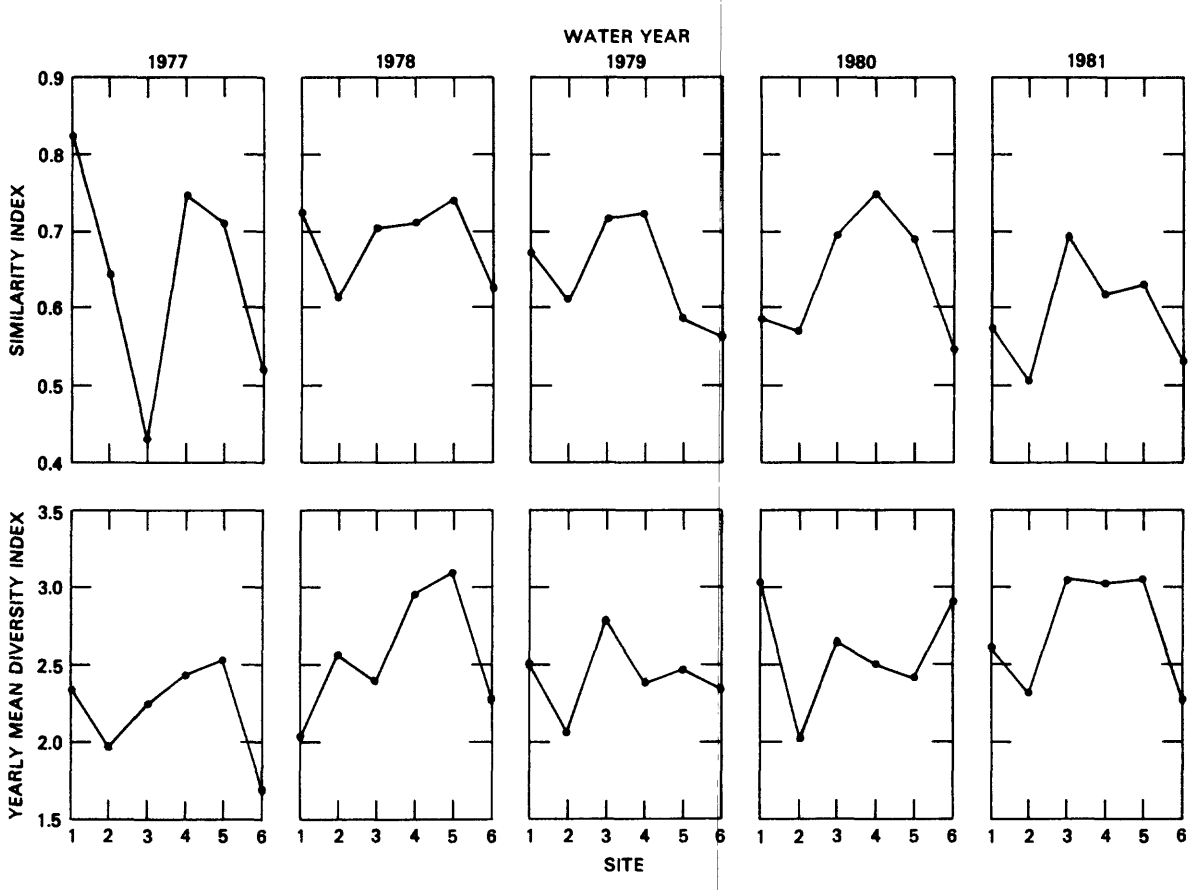


Figure 13.--Similarity indices and yearly mean diversity indices of benthic invertebrates at the six sites. Similarity indices were developed comparing yearly composites of organisms at individual sites with yearly composites of organisms at the remaining five sites.

Numbers of organisms per sample ranged from zero at site 2, Willow Creek near Rio Blanco and site 5, Piceance Creek below Ryan Gulch, to 3,700 organisms at site 4, Black Sulphur Creek near Rio Blanco. Counts of less than 100 organisms were common during spring runoff. Counts generally were greater during low-flow years than high-flow years.

A 5-year composite of data showed that Diptera were generally the most common organisms in samples from sites 2, 4, 5, and from site 6, Piceance Creek at White River. The percent composition of Diptera in samples increased downstream. Ephemeroptera were the most numerous benthic organisms at site 3, Piceance Creek above Hunter, and both Diptera and Ephemeroptera were common in the upstream reaches of Piceance Creek at site 1 Piceance Creek below Rio Blanco. Practices to control mosquito populations may have contributed to the lesser counts of Diptera at site 3.

The distribution of taxa into habit and food-web groups showed that most genera were grouped into burrowers-sprawlers-clingers and that the majority of taxa were primary and secondary consumers. Although species composition varied from year to year, general community structure remained balanced and stable.

The diversity indices (DI) of samples at the genus level ranged from 0.92 at site 6 to 3.62 at sites 3 and 5. An analysis of means of DI showed that the 5-year mean was greatest (2.82) at site 5 and least (2.21) at site 6. Diversity was significantly greater at sites 3, 4, and 5 than sites 2 and 6.

Comparisons of similarity indices (SI) indicate that similarity of taxa at each site generally decreased from 1977 to 1981. A similar decrease in similarity occurred when individual sites were compared with a composite of data from remaining sites in the basin. During the same period, diversity indices tended to increase slightly. Except for water year 1977, when similarity indices ranged from 0.82 to 0.43, the SI of benthic assemblages from sites 3, 4, and 5 ranged from 0.74 to 0.58 and were most representative of the basin. Similarity indices for samples collected at sites 2 and 6 ranged from 0.61 to 0.52, and benthic assemblages of these sites were consistently the least similar within the basin.

An assessment of water quality in Piceance Creek basin based on biological data indicates that no deleterious water-quality conditions existed during water years 1977-81. Although Diptera were the most numerous organisms in the basin, trophic balance and generally good diversity existed at all sites. No organism groups associated with polluted or stressed environments dominated the benthic invertebrates at any site.

The differences in composition of taxa between sites, the greater diversity indices at sites 3, 4, and 5 than at sites 2 and 6, and the general shifts in biological indices may have resulted from one or more of the following:

1. Hydrological stresses--Ranges in yearly discharge varied considerably during the study: water year 1979 was a low-flow year, whereas water year 1980 was a record high-flow year. In addition, local springs more effectively augmented and maintained streamflow at sites 3, 4, and 5 than elsewhere in the basin.

2. Differences in water temperature--Daily water temperature varied less at sites 3, 4, and 5 than at sites 1, 2, and 6. Water temperature increased downstream. Maximum water temperature exceeded 30°C at site 6.

3. Substrate particle size--Substrate particle size was finer at sites 2 and 6 than at the other four sites.

4. Chemical differences in water quality--Water-quality type was different at site 6 than at sites 1 through 5. Significant increases in concentrations of sodium, bicarbonate, and dissolved solids occurred in Piceance Creek between sites 5 and 6.

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SUPPLEMENTAL DATA

Table 5.--Taxa, numbers, and percent composition of benthic invertebrates at site 1,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977													1978	
					Early	Late									
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
COLEOPTERA															
Dytiscidae															
Agabus sp.							2/1	1/<1							
Colymbetes sp.															
Elmidae															
Optioservus sp.	2/3	1/1	1/1		9/11	21/3	7/2	62/12	4/1	19/2	16/2	1/<1	8/1		
Haliplidae															
Brychius sp.													1/<1		
Haliplus sp.															
Hydrophilidae															
Helophorus sp.															
Hydrobius sp.															
DIPTERA															
Ceratopogonidae															
Atrichopogon sp.														1/4	
Palpomyia sp.					1/1	24/3	37/12			5/1					
Chironomidae															
Arctopelopia sp. or															
Conchapelopia sp.		1/1			1/1			4/1	4/1	35/4		18/2	12/2		
Brillia sp.															
Cardiocladius sp.			1/1		1/1										
Corynoneura sp.										7/1					
Cricotopus sp. 1		1/1	4/3	1/4	5/6	241/30	47/15	163/32	4/1	833/84	459/56	327/36	168/22	2/8	
C. sp. 2											3/<1	29/3	25/16		
C. sp. 4															
C. sp. 5															
C. sp. 18															
Cryptochironomus sp. 1										2/<1	9/1	1/<1			
C. sp. 2															
Diamesa sp. 1			4/3	2/8							1/<1	16/2	19/2		
D. sp. 2												5/1	11/1		
D. sp. 3												2/<1			
D. sp. 4															
D. sp. 20															

Piceance Creek below Rio Blanco, Colo.

number = percent composition of sample]

1978									1979				1980					1981		
										Early	Late									
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
		3 <1							1 <1									2 2	
2 3	12 1	24 2		16 1	18 2	5 1	52 16		52 24	16 3	23 3	17 9	16 7	5 2	5 1	1 <1			20 3
				4 <1	2 <1	2 1	8 2			2 <1	1 <1								11 2
									1 <1 5 2										
	7 <1	1 <1				1 <1			1 <1								1 <1		8 1
		21 2		15 1	17 2	32 8	11 3			1 <1 1 <1									8 1
												1 <1		3 1	1 <1				
107 5 3 <1	6 <1		16 1	12 2 3 <1	14 4 1 3	23 7 8 2		27 12	20 4 20 4	7 1 14 2	12 6	8 4 4 2 2 1		3 1	25 2 52 5 16 2	1 <1		99 15	
14 1				2 <1	1 <1	2 1 1 <1	1 10					1 <1			5 <1	1 <1	1 1	1 <1	
				2 <1	11 3							1 <1			3 <1				

Table 5.--Taxa, numbers, and percent composition of benthic invertebrates at site 1,

[Upper number = number of taxa, lower

Order Family Genus species	1977							1978							
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Eukiefferiella sp. 1		2/1	7/5			11/1	31/10	34/7	1/<1	4/<1	154/19	145/16	45/6	4/16	
E. sp. 2							20/6								
E. sp. 3													7/1	1/4	2/50
E. sp. 4															
E. sp. 21															
Metriocnemus sp.															
Micropsectra sp.		2/1	2/1					2/<1		1/<1			3/<1	1/4	
Odontomesa sp.					3/4	1/<1	9/3	4/1			12/1	46/5	4/1	2/8	
Orthocladius sp. 1															
O. sp. 4															
Pentaneura sp.											19/2				
Phaenopsectra sp.								3/1					1/<1		
Psectrotanypus sp.						2/<1					1/<1			1/4	
Sympotthastia sp.															
Syndiamesa orientalis															
Tanytarsus sp.															
Thienemanniella sp.															
Empididae															
Hemerodromia sp.								1/<1							
Muscidae															
Limnophora sp.	2/3		3/2					3/1							
Limnophora aequifrons															
Simuliidae															
Simulium sp.	9/12	25/14	3/2				11/3	12/2	1/<1	9/1	4/<1	9/1	1/<1	1/4	
Stratiomyidae															
Euparyphus sp.										1/<1					
Tabanidae															
Tabanus sp.												1/<1			
Tipulidae															
Dicranota sp.		1/1				5/1							4/1		
Erioptera sp.															
Hexatoma sp.	3/4				2/2			1/<1	7/2	4/<1		1/<1			
Limnophila sp. 1											5/1				
L. sp. 2															
Limonia sp.										10/1					

number = percent composition of sample]

1978									1979								1980				1981		
											Early	Late											
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
2 3	25 1	16 1		12 1	2 <1	4 1	3 1		1 <1	17 3	16 2	5 3	39 18		4 1	27 3	5 2	6 5	2 <1
															7 1	30 3			
	4 <1	5 <1		5 <1	1 <1	8 2	2 1			2 <1	9 1				4 1	1 <1	2 1		3 <1
	83 4	23 2							7 3	62 11	14 2								
																	2 1		
		18 1					7 2				2 <1				6 1	18 2	5 2	1 1	70 10
		4 <1		4 <1	16 2														
													1 <1			3 <1	1 <1		
	5 <1	2 <1				29 8			11 5		2 <1			2 1		575 54	23 8	2 2	241 35
																17 2			
		3 <1																	
					1 <1		1 <1						1 <1			2 <1			
							1 <1									2 <1	1 <1		
						12 3													
		2 <1		4 <1															
		2 <1		2 <1	4 1		6 2				4 1					1 <1			1 <1
	1478 71	525 42		70 6	75 9				5 2	61 11	67 9			5 2	18 3				18 3
							2 1					1 <1	1 <1						
	1 <1	5 <1				7 2	17 5			1 <1		4 2	3 1		2 <1	12 1	6 2		7 1
																	1 <1		
		4 <1		8 1	1 <1					13 2		10 5	5 2	5 2	1 <1	4 <1	2 1	1 1	
							4 1									2 <1	5 2		
												1 <1	2 1		1 <1				
				10 1							3 <1								

Table 5.--Taxa, numbers, and percent composition of benthic invertebrates at site 1,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977 Oct	Nov	Jan	Early Mar	Late Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	1978 Feb	Mar	Apr
INSECTS															
Pedicia sp.															
Tipula sp. 1			3/2	5/21	3/4	6/1		3/1		1/<1			2/<1		
T. sp. 2															
EPHEMEROPTERA															
Baetidae															
Baetis sp.	35/46	129/70	101/68	8/33	11/13	22/3	108/34	115/23	37/10	10/1	63/8	277/30	304/40	10/40	
Ephemerellidae															
Ephemerella sp. 1	2/3	1/1	4/3		16/19	299/37	12/4			4/<1	13/2	4/<1	3/<1		
E. sp. 2															
E. sp. 3															
E. sp. 4															
Ephemerella inermis															
Ephemerella infrequens															
Ephemerella mollita															
Heptageniidae															
Heptagenia sp.															
Leptophlebiidae															
Paraleptophlebia sp.									1/<1						
Tricorythidae															
Trycorythodes fallax						2/<1	6/2	1/<1	8/2	7/1	6/1	8/1	8/1		
Trycorythodes minutus															
HEMIPTERA															
Veliidae															
Microvelia sp.										3/<1					
ODONATA															
Gomphidae															
Ophiogomphus severus				1/4										1/4	
PLECOPTERA															
Capniidae															
Capnia sp.															
Paracapnia angulata															
Perlodidae															
Isoperla sp.															
Isoperla patricia	3/4	7/4	11/7	2/8	9/11	145/18	23/7	2/<1		18/2	21/3	7/1	31/4	1/4	
Isoperla petersoni															

number = percent composition of sample]

1978						1979						1980					1981		
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
1 1	3 <1	1 <1			1 <1		3 1		2 1			4 2	3 1	1 <1 1 <1		2 <1			6 1
33 43	315 15	568 45		826 73	564 71	156 40	101 30	3 30	49 22	287 51	448 60	63 32	69 32	6 3	301 55	176 17	88 31	2 2	88 13
8 10	3 <1			2 <1		15 4	16 5	4 40	8 4			12 6	10 5		12 2	17 2	49 17		5 1
														39 19 39 19 21 10			8 3 2 1		
														42 20					
		4 <1																	
				1 <1															
		3 <1		23 2	11 1	22 6	11 3	11 3		1 <1		2 1				5 <1			17 3
					1 <1							3 2	3 1			4 <1	1 <1		
13 17	12 1			59 5	36 5	50 13	48 14	2 20	32 14	2 <1	5 1	23 12	28 13	1 <1 5 2 2 1	21 4 53 10	5 <1 35 3	14 7 17 6		24 4

Table 5.--Taxa, numbers, and percent composition of benthic invertebrates at site 1,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Taeniopterygidae															
Taenionema sp.															
TRICHOPTERA															
Brachycentridae															
Brachycentrus americanus															
Glossosomatidae															
Agapetus sp.						1 <1									
Hydropsychidae															
Hydropsyche sp. 1	13 17	10 5	2 1	4 17	9 11	10 1		11 2	4 1	11 1	31 4	3 <1	4 1		
H. sp. 2															
Hydropsyche slossonae															
Hydroptilidae															
Hydroptila sp.															
Ochrotrichia sp.								13 3							
Lepidostomatidae															
Lepidostoma sp.															
Limnephilidae															
Hesperophylax sp.	2 3	1 1										1 <1			
Lenarchus sp.															
NON-INSECTS															
ACARINA															
Atractideidae															
Atractides sp.															
Sperchonidae															
Sperchon sp.						15 2	3 1	57 11		4 <1					
AMPHIPODA															
Gammaridae															
Gammarus lacustris	2 3	1 1	1 1	1 4			3 1								
Talitridae															
Hyalella azteca															
GORDIIA															
Gordiidae															
Gordius sp.															

number = percent composition of sample]

1978									1979					1980				1981		
										Early	Late									
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
				1<1						1<1	6 1				16 3				
					2<1														
16 21	22 1	8 1		47 4	11 1	6 2	5 2		3 1	48 9	124 17	3 2	12 6	23 11	54 10				1<1
															26 5	3<1			
				8 1							1<1								5 1
										1<1									
2 3					1<1							37 19	7 3	1<1		1<1			
										2<1									
																			35 5
		3<1		6 1	8 1				16 7	1<1	1<1	1<1		5 2	2<1				10 1
		2<1					1<1												
																	3 1		

Table 5.--Taxa, numbers, and percent composition of benthic invertebrates at site 1,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977							1978							
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
OPISTHOPORA															
Lumbricidae															
Eiseniella tetraedra			1/1			1/<1									
PLESIOPORA															
Tubificidae															
Limnodrilus sp.					14/17				285/79		7/1	7/1			2/50
Tubifex sp.															
RHYNCHOBDELLIDA															
Glossiphoniidae															
Helobdella stagnalis	3/4	1/1	1/1					1/<1	10/2	3/1					
Total number of organisms	76	183	149	24	84	806	320	502	359	988	822	708	761	25	4
Total number of species	11	14	16	8	13	16	15	20	12	20	17	20	20	11	2
Diversity Index (DI)	2.56	1.63	2.03	2.60	3.25	2.38	3.06	2.88	1.25	1.20	2.26	2.48	2.63	2.84	1.00

Piceance Creek below Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978						1979						1980					1981		
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
														3 2	4 1	14 1	39 14	51 41 57 46	
77	2094	1253		1139	791	386	333	10	221	559	747	198	216	206	543	1059	277	125	680
8	16	24		21	23	18	23	4	16	20	18	16	20	18	20	30	23	9	22
2.26	1.56	1.91		1.80	1.81	3.08	3.37	1.85	3.10	2.50	2.07	3.09	3.20	3.23	2.50	2.59	3.19	1.71	3.14

Table 6.--Taxa, numbers, and percent composition of benthic invertebrates at site 2,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977 Oct	Nov	Jan	Early Mar	Late Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	1978 Feb	Mar	Apr
INSECTS															
COLEOPTERA															
Dytiscidae															
Agabus sp.							8 1	1 <1							
Colymbetes sp.															
Deronectes sp.															
Oreodytes sp.															
Unknown sp.															
Elmidae															
Optioservus sp.							1 <1	1 <1	3 2	2 1	1 <1	1 <1	2 2		
Haliplidae															
Haliplus sp.															
Hydrophilidae															
Cymbiodyta sp.										1 1					
Helophorus sp.															
DIPTERA															
Ceratopogonidae															
Palpomyia sp.							9 1	2 <1			1 <1				
Chironomidae															
Arctopelopia sp. or															
Conchapelopia sp.						2 1	5 1			5 3	5 2	6 1	3 3		2 2
Brillia sp.															
Corynoneura sp.															
Cricotopus sp. 1	2 20					273 82	72 10	64 12		3 2	35 13	42 9	25 25	7 6	6 5
C. sp. 2											1 <1	18 4	2 2		20 18
C. sp. 4												27 6			
C. sp. 5															
C. sp. 18															
Cryptochironomus sp. 1							6 1	3 <1							
Diamesa sp. 1	2 20			1 25	1 1		8 1				9 3				
D. sp. 2												10 2	3 3	2 2	3 3
D. sp. 3												1 <1			
D. sp. 4															
Eukiefferiella sp. 1					4 1		454 63	41 8	30 17	1 1	26 10	79 17	5 5	9 8	7 6
E. sp. 2															
E. sp. 3							14 2							1 1	2 2
E. sp. 4														2 2	

Willow Creek near Rio Blanco, Colo.

number = percent composition of sample]

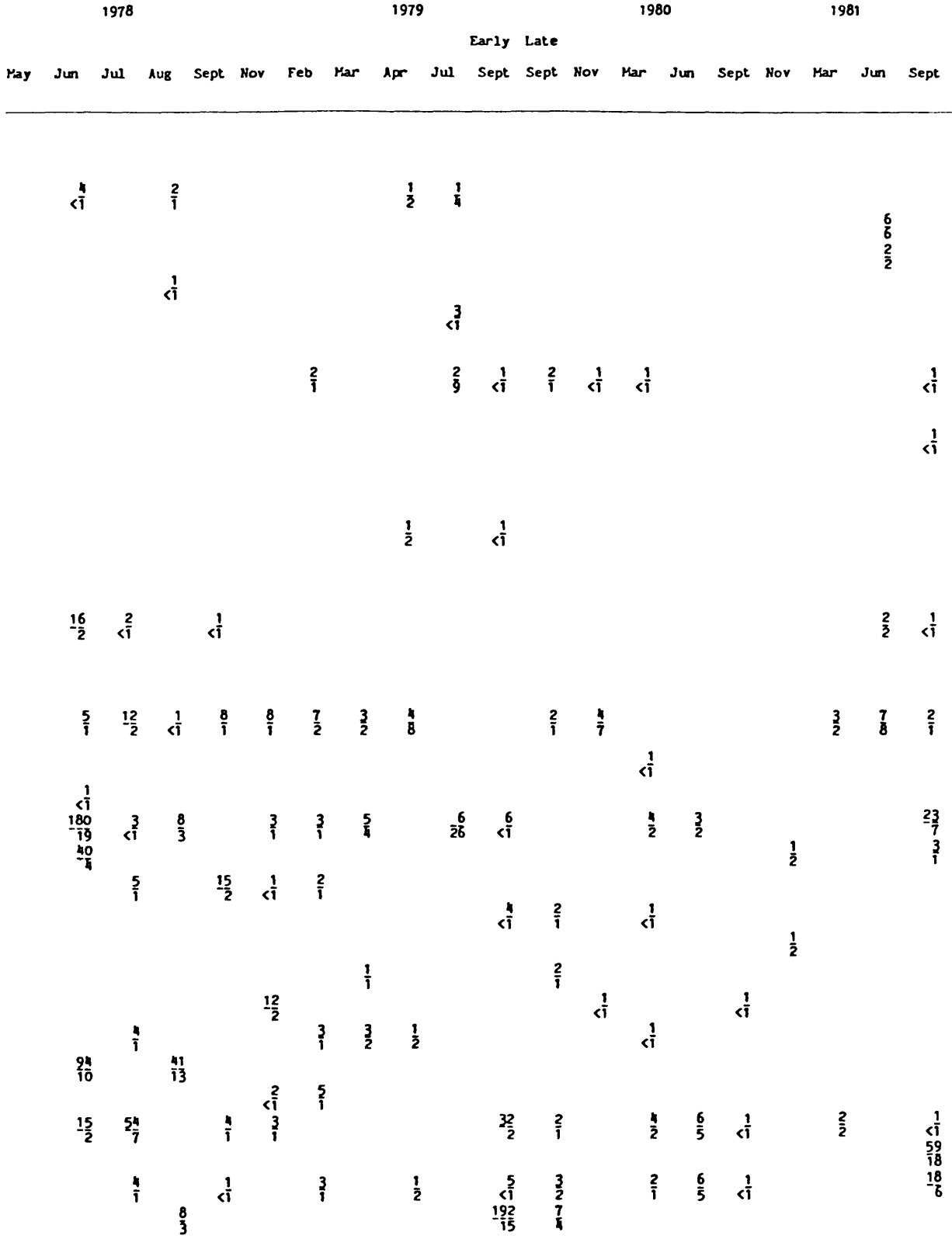

Table 6.--Taxa, numbers, and percent composition of benthic invertebrates at site 2,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Metriocnemus sp.															
Micropsectra sp.									4/1						
Microtendipes sp.															
Odontomesa sp.								3/<1	12/2			4/1	105/23	8/8	
Orthocladius sp. 1															
O. sp. 4															
Parametriocnemus sp.															
Phaenopsectra sp.								7/1	10/2						
Polypedilum sp. 1									5/1						
Psectrocladius sp.															
Psectrotanypus sp.													1/<1	1/1	
Stempellina sp.															
Sympotthastia sp.										6/3					
Tanytarsus sp.															
Thienemanniella sp.															
Dixidae															
Dixa sp.												1/<1			
Empididae															
sp. 1															
Hemerodromia sp.										4/2					
Ephydridae															
Brachydeutera sp.															
Muscidae															
Limnophora sp.									16/3						
Limnophora aequifrons															
Simuliidae															
Simulium sp.		1/10						4/1	19/4	2/1		13/5	5/1	1/1	
Stratiomyidae															
Euparyphus sp.											4/2	1/<1	1/<1		
Tipulidae															
Dicranota sp.						3/2						1/<1			
Hexatoma sp.					2/50	4/2	9/3		7/1				1/1		
Limnophila sp. 1						2/1	11/3					2/1			7/6
L. sp. 2												3/1		1/<1	2/2
Limonia sp.															
Pedicia sp.															
Tipula sp. 1						5/3	2/1	8/1	1/<1		1/1	7/3	2/<1	1/1	1/1
T. sp. 2															

number = percent composition of sample]

1978								1979						1980				1981		
										Early	Late									
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
	20 2	25 3	10 3							11 1	25 13	4 7		25 19	4 3	6 10	2 2		43 13
	5 1		4 1	2 <1								2 <1		5 4					
	10 1								2 9										
	3 1	2 <1					5 1	1 1				1 <1							
		3 <1	2 1				8 2		3 6	3 13	1 <1	4 2				8 13			10 3
																1 2			
																			5 2
	3 1	1 <1					6 2	2 1			1 <1			7 5					
					6 1														
							3 1	1 1											
					27 4														
							5 1				1 <1								
				1 <1										1 1					
		4 1					2 1							1 <1					
														2 1					
	8 1		1 <1	1 <1	2 <1			1 1	1 2		7 1	3 2	6 10		2 1	3 2				3 1
	539 56	221 29	111 36	266 43	74 13	13 4	25 19			3 13	841 64	22 12	7 11	2 1			1 2			53 16
	2 <1	2 <1																		1 <1
	1 <1		1				1 1													1 <1
		6 1	2 1						2 4								1 1			
	1 <1																			
												5 3								
							1 1													
	2 <1	2 <1		2 <1	4 1				9 17			1 1				1 2	1 1	2 2		1 <1
																		1 <1		2 1

Table 6.--Taxa, numbers, and percent composition of benthic invertebrates at site 2,

[Upper number = number of taxa, lower

Order Family Genus species INSECTS	1977 Oct	Nov	Jan	Early Mar	Late Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	1978 Feb	Mar	Apr
EPHEMEROPTERA															
Baetidae															
Baetis sp.					85/43	10/3	81/11	285/55	95/53	95/52	40/15	104/23	41/40	60/52	19/17
Ephemerellidae															
Ephemerella sp. 1						7/2									
Ephemerella inermis															
Ephemerella infrequens															1/1
Ephemerella mollita															
Tricorythidae															
Trycorythodes fallax															
Trycorythodes minutus															
HEMIPTERA															
Veliidae															
Microvelia sp.										2/1					
Velia sp.															
ODONATA															
Gomphidae															
Ophiogomphus severus															
PLECOPTERA															
Capniidae															
Capnia sp.															
Perlodidae															
Isoperla sp.															
Isoperla patricia	1/10				70/36	9/3	27/4	43/8	22/12	20/11	55/20	11/2	4/4	16/14	19/17
Taeniopterygidae															
Taenionema sp.															
TRICHOPTERA															
Brachycentridae															
Brachycentrus americanus							1/<1			1/1				1/1	
Hydropsychidae															
Hydropsyche sp. 1	1/10				25/13	3/1	2/<1	2/<1	16/9	49/27	35/13	36/8	2/2	5/4	32/29
H. sp. 2															
Hydroptilidae															
Ochrotrichia sp.								2/<1							
Limnephilidae															
Hesperophylax sp.							1/<1				18/7	7/2		3/3	

number = percent composition of sample]

1978						1979						1980				1981			
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Early Sept	Late Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
	14 <1	369 48	104 34	276 45	448 76	282 77	83 61	7 13	5 22	202 15	91 49	19 26	154 86	65 49	51 35	36 59	78 64		68 21
						5 1	3 2					4 7	4 2				4 3		
																2 3		20 21	
													3 2						
				1 <1	1 <1	5 1	1 1					1 <1	1 <1						
																		1 <1	4 1
			7 2																
												1 <1							
												2 3							
		39 5		2 <1	20 3	8 2	3 2	22 42	1 4	7 1	11 6	12 20	2 1	1 <1	46 32 33 23	2 3	9 7 6 5		18 6
															2 1				
		3 <1	2 1	1 <1	1 <1	1 <1	1 1	1 2			4 2			1 <1	4 3				
													2 1						
	1 <1	1 <1																	

Table 6.--Taxa, numbers, and percent composition of benthic invertebrates at site 2,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977 Oct	Nov	Jan	Early Mar	Late Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	1978 Feb	Mar	Apr
NON-INSECTS															
ACARINA															
Atractideidae															
Atractides sp.															
Sperchonidae															
Sperchon sp.						1/<1	4/1	2/<1			4/1				
AMPHIPODA															
Gammaridae															
Gammarus lacustris	2/20			1/25	1/1						10/4				
GASTROPODA															
Lymnaeidae															
Lymnaea abrussa	1/10														
PLESIOPORA															
Tubificidae															
Tubifex sp.						2/1									
RHYNCHOBDELLIDA															
Glossiphoniidae															
Helobdella stagnalis															
Total number of organisms	10			4	196	333	715	520	178	184	272	457	102	116	111
Total number of species	7			3	9	12	19	19	8	12	21	18	15	13	10
Diversity Index (DI)	2.72			1.50	1.92	1.24	2.05	2.42	2.06	2.01	3.49	3.07	2.75	2.47	2.72

number = percent composition of sample]

1978							1979						1980				1981		
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
																			2/1
		3/<1	1/<1	1/<1										1/<1				2/2	2/1
														3/2			16/13	50/54	2/1
																			2/1
	964	768	305	612	587	368	135	53	23	1312	186	61	179	132	146	61	122	93	326
	21	22	16	17	15	19	16	12	8	15	16	12	13	16	10	11	10	10	25
	2.20	2.26	2.39	1.72	1.36	1.70	2.06	2.69	2.76	1.63	2.64	2.93	1.05	2.59	2.17	2.08	1.89	2.11	3.36

Table 7.--Taxa, numbers, and percent composition of benthic invertebrates at site 3,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
COLEOPTERA															
Dytiscidae															
Agabus sp.							2/1								
Colymbetes sp.															
Deronectes sp.															
Rhantus sp.															
Dryopidae															
Helichus sp.															
Elmidae															
Dubiraphia sp.															
Microcylloepus sp.															
Optioservus sp.					7/2	18/6	64/17	57/9	57/14	21/4	34/5		8/<1		
Haliplidae															
Brychius sp.															
Haliplus sp.															
Hydrophilidae															
Helophorus sp.															
DIPTERA															
Ceratopogonidae															
Palpomyia sp.						19/6	3/1			2/<1	1/<1				
Stilobezzia sp.							1/<1								
Chironomidae															
Arctopelopia sp. or															
Conchapelopia sp.	1/1	4/1			1/<1	1/<1		10/2	1/<1	11/2			13/1		
Cardiocladius sp.															
Chironomus sp.														1/3	
Corynoneura sp.										4/1					
Cricotopus sp. 1	3/2	24/5	2/2		6/2	72/23	11/3	23/4	3/1	209/42	107/14		196/12	1/3	
C. sp. 2											4/1		85/5	1/3	
C. sp. 3															
C. sp. 4															
C. sp. 5															
C. sp. 18															

Piceance Creek above Hunter Creek near Rio Blanco, Colo.

number = percent composition of sample]

1978								1979				1980					1981		
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
		10 2	1 <1						1 <1									3 1	
														1 1				2 1	
																		1 <1	
											1 <1								
36 21	9 3	25 4	12 4	88 8	84 6		42 14		53 18	25 14	1 <1 21 4	4 5	2 1	13 18	4 1		10 1	13 6	7 1
1 1				9 1	17 1		2 1												3 <1
																		1 <1	
	10 3						1 <1						5 2				2 <1	14 7	
		16 2	8 3	38 3	43 3					1 1			3 1			2 1 2 1	3 <1		1 <1 4 <1
5 3 2 1	29 9 3 1	11 2	49 17	68 6	59 4		94 31		26 9 1 <1	8 5	34 6 12 2	10 12 5 6	67 30 16 7			30 11 12 4 26 9	4 <1 126 13 196 20 4 <1	3 1	390 37 3 <1

Table 7.--Taxa, numbers, and percent composition of benthic invertebrates at site 3.

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Cryptochironomus sp. 1															
C. sp. 2															
Diamesa sp. 1		4 1			4 1		2 1				6 1				
D. sp. 2													43 3	3 8	1 13
D. sp. 3															
D. sp. 20															
Eukiefferiella sp. 1		22 5			13 4	17 5	94 25	21 3	26 6	14 3	110 15		212 13	2 6	
E. sp. 2										20 4					
E. sp. 3													10 1	2 6	
E. sp. 4															
Glyptotendipes sp.															
Metriocnemus sp.														2 6	
Micropsectra sp.		3 1	3 3										2 <1	1 3	
Odontomesa sp.		1 <1			1 <1								11 1	5 14	
Orthocladius sp. 1															
O. sp. 3															
O. sp. 17															
Pentaneura sp.											37 5				
Phaenopsectra sp.							1 <1	1 <1						4 11	
Polypedilium sp. 1															
Prodiamesa olivaceae														1 3	
Sympotthastia sp.			1 1												
Syndiamesa orientalis															
Thienemanniella sp.															
Empididae															
sp. 1															
Hemerodromia sp.															
Ephydridae															
Ephydra sp.															
Muscidae															
Limnophora sp.		1 <1	1 1												
Limnophora aequifrons													1 <1		

number = percent composition of sample]

1978							1979						1980				1981		
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
	1 <1	3 <1		2 <1			3 1												
												1 1							1 <1
												2 2	1 <1			1 <1			
			1 <1				7 2	1 6					3 1						
	4 1		2 1																
																1 <1			
2 1	2 1	128 20	4 1	3 <1	6 <1		25 8		1 <1	30 17 1	23 4	1 1	6 3		2 <1 19 3	9 3 11 4	39 4		3 <1 11 1
		1 <1		3 <1			4 1	1 6			8 1	8 9	5 2				4 <1		3 <1
	3 1	13 2		4 <1			6 2			8 5	9 2								
													1 <1						
	5 1	11 2								4 2	5 1	2 2	13 6		2 <1	14 5	14 1		115 11
					1 <1		1 <1					1 1		1 1		3 1		1 <1	
		1 <1			3 <1								3 1			8 3	37 4		5 <1
2 1					2 <1				5 2		18 3	5 6		4 5	30 4 3 <1	9 3	224 23	117 57	36 3
																	4 <1		
	1 <1	24 4		1 <1			1 <1									1 <1			2 <1
							3 1	1 6									16 2		
											2 <1			1 1					10 1
										1 1							1 <1	1 <1	
			2 1	1 <1															
																		1 <1	
		3 <1		16 1	6 <1		5 2				1 <1								7 1

Table 7.--Taxa, numbers, and percent composition of benthic invertebrates at site 3.

[Upper number = number of taxa, lower

Order / Family / Genus species	1977 Oct	Nov	Jan	Early Mar	Late Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	1978 Feb	Mar	Apr
INSECTS															
Simuliidae															
Simulium sp.	8 / 6	23 / 5	2 / 2					5 / 1	23 / 6	12 / 2	81 / 11		249 / 15		
Simulium vittatum															
Stratiomyidae															
Euparyphus sp.						1 / <1			1 / <1						
Tabanidae															
Tabanus sp.					1 / <1										
Tipulidae															
Dicranota sp.		1 / <1			2 / 1	4 / 1	1 / <1	2 / <1			1 / <1		2 / <1		
Hexatoma sp.									1 / <1						
Limnophila sp. 1															
L. sp. 2															
Limonia sp.															
Tipula sp. 1	8 / 6	4 / 1		1 / 5	4 / 1	3 / 1	1 / <1	3 / <1	2 / <1				5 / <1		
T. sp. 2															
EPHEMEROPTERA															
Baetidae															
Baetis sp.	86 / 61	293 / 65	73 / 78	13 / 62	251 / 71	47 / 15	132 / 35	182 / 29	259 / 64	130 / 26	326 / 44		815 / 48	6 / 17	5 / 63
Ephemerellidae															
Ephemerella sp. 1	1 / 1	12 / 3			6 / 2	20 / 6	5 / 1				3 / <1		4 / <1		
E. sp. 2															
E. sp. 4															
Ephemerella inermis															
Ephemerella infrequens															
Ephemerella mollita															
Heptageniidae															
Cinygma sp.								1 / <1							
Cinygmula sp.															
Leptophlebiidae															
Paraleptophlebia sp.								1 / <1							
Siphlonuridae															
Siphlonurus sp.		1 / <1													

Piceance Creek above Hunter Creek near Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978							1979						1980				1981		
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
1 1	49 14	61 9	12 4	73 6	21 2		1 <1		78 26	13 7	19 4	6 7			5 1	2 1		4 2	125 12
			3 1	1 <1	2 <1					1 1									
1 1		3 <1 1 <1	3 1	1 <1	4 <1		1 <1			3 2	8 1 3 1		5 2 1 <1	4 5	1 <1 3 <1	1 <1 1 <1	5 1 5 1 15 2	2 1	
5 3	1 <1	7 1	1 <1	1 <1 3 <1			2 1		1 <1		1 <1	2 2	3 1	1 1		1 <1	4 <1	3 1	1 <1 11 1
88 51	215 63	321 49	164 57	584 50	485 36		48 16	8 47	61 20	59 34	321 60	31 36	50 22	6 8	567 83	128 45	101 10	1 <1	33 3
1 1					4 <1					1 1	1 <1			15 20 11 15 2 3 6 8	14 2	7 2	23 2 33 3 10 1	6 3 7 3	1 <1

Table 7.--Taxa, numbers, and percent composition of benthic invertebrates at site 3,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Tricorythidae															
Trycorythodes fallax	5/4	6/1				3/1	5/1	6/1	17/4	10/2	2/<1		7/<1		
Trycorythodes minutus															
PLECOPTERA															
Capniidae															
Capnia sp.				1/5											
Paracapnia angulata															
Perlodidae															
Isoperla sp.															
Isoperla patricia	10/7	24/5	2/2		29/8	69/22	37/10	7/1	5/1	17/3	13/2		20/1	2/3	1/13
Isoperla petersoni															
Taeniopterygidae															
Taenionema sp.															
TRICHOPTERA															
Brachycentridae															
Brachycentrus americanus															
Hydropsychidae															
Hydropsyche sp. 1	2/1	7/2	4/4	1/5	5/1	4/1	4/1	1/<1	4/1	14/3	5/1		3/<1		
Hydropsyche slossonae															
Hydroptilidae															
Hydroptila sp.															
Ochrotrichia sp.								2/<1		2/<1					
Limnephilidae															
Hesperophylax sp.	4/3	8/2	1/1	1/5	4/1	3/1			1/<1		2/<1		2/<1		1/13
Limnephilus sp.															
NON-INSECTS															
ACARINA															
Atractideidae															
Atractides sp.															
Lebertiidae															
Lebertia sp.															
Sperchonidae															
Sperchon sp.						18/6	2/1	50/8		7/1	12/2		5/<1		

number = percent composition of sample]

1978							1979						1980					1981		
											Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
		2 <1	11 4	153 13	239 18		9 3		67 22	5 3	4 1	1 1	1 <1		2 <1		18 2	16 8	163 15
												3 4	1 <1			4 1			
11 6	5 1	7 1		55 5	225 17		17 6	3 18	1 <1	9 5	28 5	2 2	35 16	8 11 1 1	5 1 10 1	7 2	17 2 32 3		82 8
											1 <1				2 <1				
					1 <1						2 <1								
8 5	1 <1	2 <1	5 2	3 <1	9 1		3 1			7 4	14 3		2 1		13 2	1 <1			1 <1
		1 <1		1 <1	6 <1						2 <1								
8 5					19 1		4 1	2 12		1 1							1 <1		
					48 4														4 <1
					5 <1														
1 1			4 1	40 3	49 4				2 1						2 <1			1 <1	5 <1

Table 7.--Taxa, numbers, and percent composition of benthic invertebrates at site 3.

[Upper number = number of taxa, lower

Order Family Genus species INSECTS	1977 Oct	Nov	Jan	Early Mar	Late Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	1978 Feb	Mar	Apr
AMPHIPODA															
Gammaridae															
Gammarus lacustris	8 6	10 2	1 1	4 19	3 1	1 <1	4 1		3 1	1 <1					
Talitridae															
Hyalella azteca															
GASTROPODA															
Physidae															
Physa sp.	2 1	2 <1	1 1												
OPISTHOPORA															
Lumbricidae															
Eiseniella tetraedra	3 2														
PLESIOPORA															
Tubificidae															
Limnodrilus sp.						10 3									
Tubifex sp.					13 4			250 39		23 5				4 5	
RHYNCHOBDELLIDA															
Glossiphonidae															
Helobdella stagnalis			2 2		3 1	6 2	11 3	12 2	3 1				1 <1	1 3	
Total number of organisms	141	450	93	21	353	316	380	634	406	498	744		1694	36	8
Total number of species	13	19	12	6	17	18	18	18	15	17	16		21	15	4
Diversity Index (DI)	2.24	2.17	1.46	1.72	1.85	3.26	2.65	2.53	1.92	2.68	2.55		2.42	3.62	1.55

Piceance Creek above Hunter Creek near Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978								1979					1980				1981			
											Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
		1 <1	2 1	8 1	2 <1														
					3 <1														
				1 <1											1 <1				2 <1
		2 <1					27 9	1 6				1 1				3 1	36 4	7 3	25 2
2 1	2 1		2 1	3 <1			1 <1												
174	340	656	286	1164	1346		307	17	298	176	539	85	223	74	687	284	984	204	1054
16	16	25	18	26	26		23	7	13	16	24	17	20	14	19	24	28	20	28
2.43	1.97	2.59	2.30	2.62	2.97		3.26	2.28	2.52	3.03	2.51	3.23	3.08	3.27	1.27	3.07	3.58	2.52	3.01

Table 8.--Taxa, numbers, and percent composition of benthic invertebrates at site 4,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
COLEOPTERA															
Dytiscidae															
Agabus sp.							1<1	6/2							
Colymbetes sp.															
Deronectes sp.							2<1	1<1							
Elmidae															
Optioservus sp.					1/1	2<1		8/2		5/2		5/1			
Haliplidae															
Brychius sp.															
Hydrophilidae															
Helophorus sp.															
DIPTERA															
Ceratopogonidae															
Palpomyia sp.						6<1	2<1				2/1	2<1		1/1	
Stilobezzia sp.							1<1								
Chironomidae															
Arctopelopia sp. or															
Conchapelopia sp.		12/12			5/3		4<1		5/1	64/24	22/6	17/2		5/3	
Calopsectra sp.											10/3				
Cardiocladius sp.															
Chironomus sp.									2<1			1<1			
Constempellina sp.															
Corynoneura sp.							5<1	2/1	3<1	3/1					
Cricotopus sp. 1	4/6	14/14	31/10	269/48	54/29	2498/85	1037/58	134/37	138/19	87/33	27/7	225/25	26/13	7/4	14/9
C. sp. 2					1/1	3<1					2/1	13/1	8/4	2/1	5/3
C. sp. 3															
C. sp. 4												9/1			
C. sp. 5															
C. sp. 18															
Cryptochironomus sp. 1										3/1		3<1	2/1		2/1
C. sp. 2															
Cryptotendipes sp.															
Diamesa sp. 1	4/6		8/2	38/7	18/10	4<1					11/3	19/2	1<1	6/4	2/1
D. sp. 2												17/2	29/14	9/5	4/3
D. sp. 5															

Black Sulphur Creek near Rio Blanco, Colo.

number = percent composition of sample]

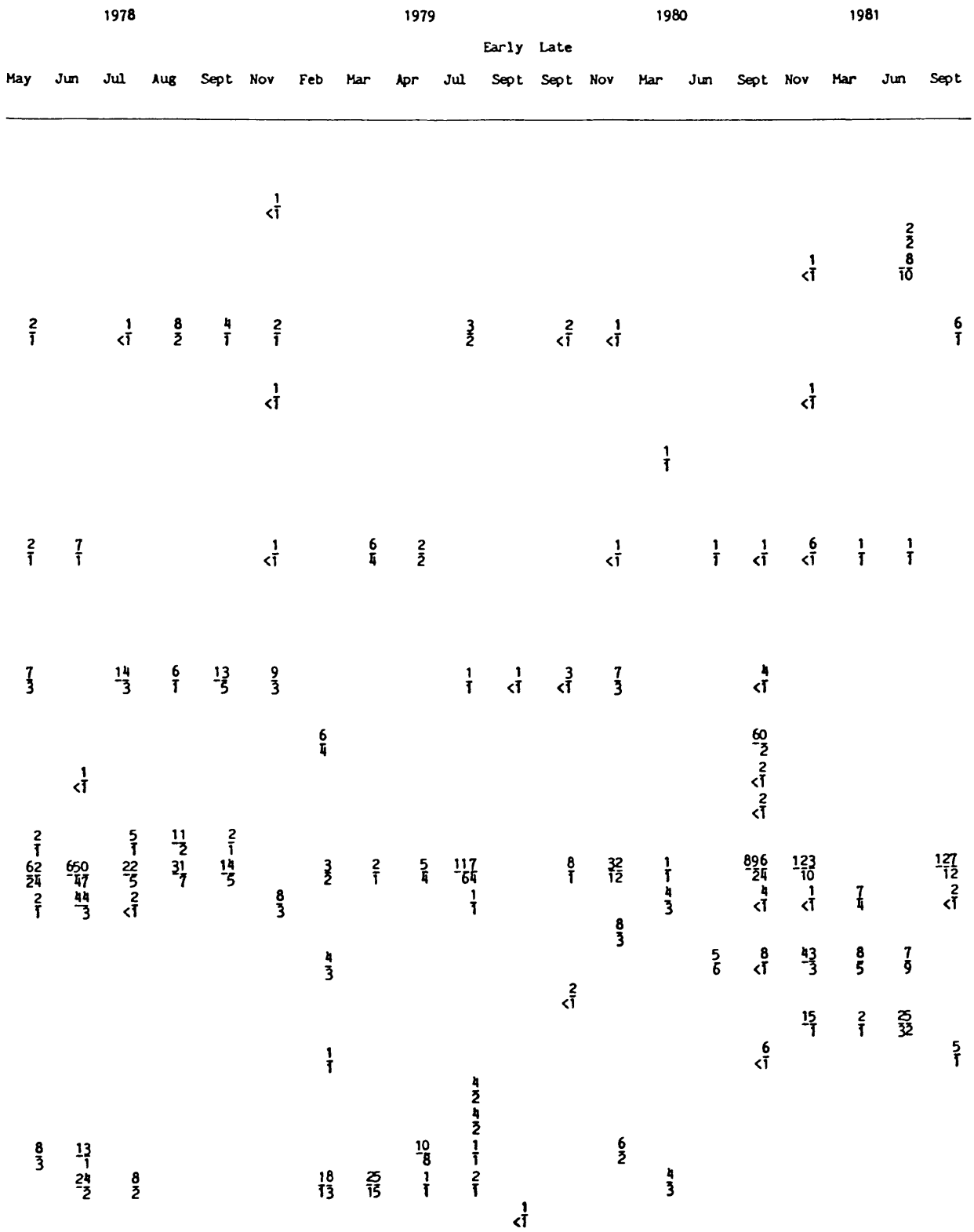

Table 8.--Taxa, numbers, and percent composition of benthic invertebrates at site 4,

[Upper number = number of taxa, lower

Order Family Genus species	1977													1978	
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Eukiefferiella sp. 1	4/6	5/5		10/2	11/6	20/1	185/10	5/1	45/6	2/1	14/4	150/17	23/11	2/1	9/6
E. sp. 2															
E. sp. 3															
E. sp. 4															
Metriocnemus sp.															2/1
Micropsectra sp.	1/1	32/32	203/62	74/13	28/15	14/<1	4/<1	3/1	18/2			8/1	6/3	1/1	
Microtendipes sp.															
Odontomesa sp.	1/1	2/2	30/9	106/19	12/6	6/<1	106/6	22/6	59/8	6/2	28/7	58/7	7/3		
Orthocladius sp. 1															
O. sp. 2															
O. sp. 4															
Phaenopsectra sp.					2/1	160/5	191/11	4/1	5/1					2/1	2/1
Polypedilum sp. 1			9/3	1/<1		14/<1			1/<1						15/10
P. sp. 2															
Procladius sp.															
Prodiamesa bathyphilia									1/<1						
Prodiamesa olivaceae									1/<1						
Psectrotanypus sp.	3/4		2/1	4/1	1/1	3/<1	4/<1	4/1	3/<1	16/6	2/1	10/1	2/1		
Rheotanytarsus sp.															
Syndiamesa orientalis															
Tanytarsus sp.															
Thienemanniella sp.															
Empididae															
sp. 1															
Hemerodromia sp.							4/<1								
Ephydridae															
Brachydeutera sp.							10/1								
Muscidae															
Limnophora aequifrons	2/3	1/1	3/1	1/<1		5/<1	4/<1	5/1	1/<1	1/<1	2/1	2/<1			
Psychodidae															
Telmatoscopus sp. or															
Pericoma sp.					1/1										
Simuliidae															
Eusimulim sp.															

number = percent composition of sample]

1978								1979						1980				1981		
										Early	Late									
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
10 4	304 22	32 7	12 3	27 10	1 <1	1 1	1 1	1 1	4 2	69 26	31 5	4 1		12 13	5 <1	23 2	2 1		
															4 <1				3 <1
4 2		3 1	1 <1				2 1		1 1		25 4			1 1	30 1				
	36 3	31 7	10 2							5 2	47 7								
	153 11	41 9	20 4						6 3	6 2	9 1	3 1		26 29	15 <1		2 1		10 2
4 2					62 20	19 14						2 1			2015 54	114 9			72 11
									3 2										2 <1
	2 <1	5 1	7 2								43 7	4 1			367 10	67 5	8 5	7 9	209 33
								4 3			2 <1		3 2	26 29	6 <1	425 34	10 6	20 25	105 16
														4 4					
																32 3			
																126 10			
37 14	24 2	17 4	3 1						13 7		1 <1				171 5				3 4
															6 <1				
				1 <1															
4 2																			
					44 14	2 1									1 <1			1 1	
			5 1																
										1 <1						12 1	1 1		
				3 1														1 1	
		9 2	8 2							1 <1									
							2 1				4 1		1 1				2 1	1 1	
4 2																			
	6 <1	2 <1	2 <1			1 1	1 1			1 <1	1 <1	7 3			3 <1	9 1		1 1	4 1
						1 1													
																42 3			

Table 8.--Taxa, numbers, and percent composition of benthic invertebrates at site 4,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Simulium sp.		2/2				1/<1	13/1	20/6	32/4	11/4	143/38	29/3	3/1		
Simulium vittatum															
Stratiomyidae															
Euparyphus sp.										1/<1					
Tipulidae															
Dicranota sp.															
Hexatoma sp.									2/<1						
Limnophila sp. 1					3/2					3/1					
L. sp. 2												6/1		1/1	1/1
Limonia sp.										5/2					
Tipula sp. 1	2/3		5/2	2/<1	3/2	5/<1		5/1	9/1		5/1	3/<1	3/1	2/1	1/1
T. sp. 2															
EPHEMEROPTERA															
Baetidae															
Baetis sp.	5/7	11/11	21/6	27/5	10/5	65/2	141/8	131/36	51/7	20/8	35/9	131/15	85/42	22/13	31/20
Callibatis sp.															
Ephemerellidae															
Ephemerella sp. 1				3/1		13/<1	3/<1					2/<1		4/2	2/1
Tricorythidae															
Tricorythodes fallax						1/<1			7/1	1/<1	1/<1	3/<1			
Tricorythodes minutus															
ODONATA															
Comphidae															
Ophiogomphus severus					1/1	1/<1		3/1	1/<1						
PLECOPTERA															
Capnidae															
Capnia sp.															
Perlodidae															
Isoperla patricia	18/26	15/15		4/1		8/<1	3/<1	5/1	9/1	22/8	6/2	2/<1	5/2	4/2	7/5
Isoperla petersoni															
TRICHOPTERA															
Brachycentridae															
Brachycentrus americanus									1/<1						

Black Sulphur Creek near Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978						1979						1980				1981		
										Early	Late							
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
4 2	10 1	39 9	143 32	86 31	131 42	36 27	8 5		13 7	72 27	6 1	24 9			44 1	20 2			12 2
																59 5			
						1 1						1 <1				1 <1			
		1 <1	1 <1		3 1	6 4	2 1									1 <1			
										3 1	1 <1		1 1	2 2			3 2		1 <1
2 1						1 1							16 12			5 <1	14 9		
8 3				1 <1			6 4	2 2			4 1	6 2							
											1 <1				13 <1				
2 1	5 <1	2 <1	1 <1	1 <1	1 <1		1 1	1 1	1 1			3 1	4 3			36 3		2 2	
																			14 2
25 10	65 5	202 45	165 37	90 33	27 9	26 19	94 58	91 76	4 2	80 30	396 63	119 44	78 60	9 10	27 <1	62 5	11 7		5 1
					1 <1														
													1 1		11 <1	4 <1	3 2	1 1	
			1 <1	11 4	10 3		1 1		4 2		1 <1	1 <1							
																1 <1			10 2
2 1	1 <1	1 <1												1 1		1 <1			
																	1 1		
13 5	5 <1	1 4	6 1	10 4	11 3	1 1	4 2	2 2		3 1	5 1	12 4	5 4		3 <1	2 <1	2 1		3 <1
														1 1					
											3 <1								

Table 8.--Taxa, numbers, and percent composition of benthic invertebrates at site 4,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Hydropsychidae															
Hydropsyche sp. 1	23 33	4 4			1 1			1 <1	3 <1	1 <1	2 1		2 1		1 1
Hydroptilidae															
Hydroptila sp.															
Limnephilidae															
Hesperophylax sp.				4 1							4 1				1 1
NON-INSECTS															
ACARINA															
Sperchonidae															
Sperchon sp.								2 1			1 <1	1 <1			
AMPHIPODA															
Gammaridae															
Gammarus lacustris		2 2	7 2	3 1		2 <1	4 <1		15 2	4 2	2 1	2 <1			
Talitridae															
Hyalella azteca															
GASTROPODA															
Lymnaeidae															
Lymnaea abrussa															
Physidae															
Physa sp.															
OPISTHOPORA															
Lumbricidae															
Eiseniella tetraedra	1 1														
PELECYPODA															
Sphaeriidae															
Pisidium sp.															
Pisidium insigne															
PLESIOPORA															
Tubificidae															
Tubifex sp.				3 1	19 3	33 18	122 4	50 3		325 44	10 4	58 15	165 19		98 58	51 34

number = percent composition of sample]

1978						1979								1980				1981		
											Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
	1<1			1<1			1/1			5/2	22/3	1<1						1/1	
																2<1			
2/1	1<1	2<1				1/1	2/1	1/1				1<1				2<1		1/1	
		1<1		11/4			1/1				3<1			1/1					
											4/1	9/3							
2/1		1<1			1<1	4/3					1<1	5/2							
																	1/1		
																	1/1		
																	1/1		
																1<1			
48/19	31/2	3/1	5/1				1/1						2/2	1/1	9<1	15/1	83/51		45/7

Table 8.--Taxa, numbers, and percent composition of benthic invertebrates at site 4,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
					Early	Late									
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
RHYNCHOBDELLIDA															
Glossiphoniidae															
Helobdella stagnalis	2 3				1 1	1 <1		2 1	3 <1	1 <1	2 1		2 1	4 2	2 1
Total number of organisms	70	100	326	561	186	2954	1774	363	740	266	379	883	204	170	152
Total number of species	13	11	12	14	18	22	21	19	25	20	21	25	15	16	18
Diversity Index (DI)	2.90	2.86	2.65	2.33	3.12	1.05	2.12	2.53	2.78	3.07	3.08	3.14	2.77	2.39	3.07

Black Sulphur Creek near Rio Blanco, Colo.--Continued

number = percent composition of sample]

	1978							1979					1980				1981		
											Early	Late							
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
	1 <1	4 1	1 <1	1 <1	1 <1	2 1	2 1		1 1	16 6	4 1	12 4	9 7		1 <1	1 <1	1 1		1 <1
256	1384	449	447	276	315	134	162	120	183	264	629	269	130	90	3714	1253	164	79	639
23	21	25	21	16	18	19	19	11	18	14	26	23	14	13	27	32	21	15	20
3.50	2.47	3.00	2.71	2.71	2.63	3.19	2.36	1.48	2.23	2.42	2.28	3.10	2.21	2.74	2.04	3.45	2.84	2.89	2.87

Table 9.--Taxa, numbers, and percent composition of benthic invertebrates at site 5,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
COLEOPTERA															
Dytiscidae															
Agabus sp.							1/<1								
Deronectes sp.							6/1								
Dryopidae															
Helichus sp.							1/<1								
Elmidae															
Optioservus sp.						4/1			2/14	4/1	7/1		4/1		3/2
Haliplidae															
Haliplus sp.															
Hydrophilidae															
Helophorus sp.															
DIPTERA															
Ceratopogonidae															
Culicoides sp.															
Palpomyia sp.							2/<1			1/<1			2/<1		
Chironomidae															
Arctopelopia sp. or Conchapelopia sp.				4/2		5/1	5/<1	5/2	1/7	11/3	38/7	3/2	44/6	1/3	14/10
Cardiocladius sp.															
Chironomus sp.								15/6					2/<1		
Corynoneura sp.								1/<1		5/1					
Corynoneura tarsi															
Cricotopus sp. 1	4/8			2/5	18/10	227/53	244/22	42/18		108/27	117/20	22/11	118/16	1/3	
C. sp. 2													78/11		
C. sp. 4												5/3			
C. sp. 18															
Cryptochironomus sp. 1							9/1			2/1	17/3	2/1	6/1	1/3	
C. sp. 2															
Diamesa sp. 1						7/4					5/1	26/13	2/<1	1/3	
D. sp. 2												1/1	11/2		1/1
D. sp. 3															
D. sp. 4															
Endochironomus sp.															

Piceance Creek below Ryan Gulch near Rio Blanco, Colo.

number = percent composition of sample]

1978							1979					1980				1981			
										Early Sept	Late Sept								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul			Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
9 6	8 3		8 4	2 1					6 3		3 1			1 2	1 1		1 1	1 1	10 3
																			5 2
													1 1		1 1			1 1	
																		1 1	
2 1	3 1	1 <1		2 1			1 <1	2 2	1 1					1 2				2 1	1 <1
3 2		2 1	8 4	3 2	13 7		2 1	16 17	4 2			2 3				1 <1			1 <1
																			6 2
																		2 1	
																			1 <1
																		2 1	
16 11	40 15	43 18	42 20	61 31	7 4		2 1		24 13		2 1	9 12	1 1		15 8	14 2	10 6	60 40	74 24
2 1													4 2			2 <1	42 24		
																7 1	13 7		
																1 <1	2 1		
1 1			2 1	19 10	1 1		27 13	4 4	8 4				1 1	6 11					2 1
					7 4			1 1							3 2		1 1		
	3 1						6 3	1 1					13 8						
					2 1														2 1
																		1 1	

Table 9.--Taxa, numbers, and percent composition of benthic invertebrates at site 5,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978	
				Early	Late									
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Eukiefferiella sp. 1				2 5	28 16	12 3	179 16	15 6		8 2	50 9	3 2	76 10	1 3	1 1
E. sp. 2							34 28			39 10			20 3	3 9	1 1
E. sp. 3															
E. sp. 4															
Metriocnemus sp.															
Micropsectra sp.								3 1				1 1	2 <1		
Microtendipes sp.															
Odontomesa sp.					1 1		283 26	27 11			17 3	55 28	45 6	3 9	
Orthocladius sp. 1															
O. sp. 3															
O. sp. 4															
Parametriocnemus sp.															
Phaenopsectra sp.					1 1	4 1							1 <1	3 9	
Polypedilum sp. 1								8 3			105 18				1 1
Procladius sp.															
Prodiamesa bathyphilia									1 7						
Prodiamesa olivaceae													1 <1		
Psectrotanypus sp.												3 2			
Rheotanytarsus sp.															
Syndiamesa orientalis															
Tanytarsus sp.															
Thienemanniella sp.															
Trichocladius sp.											1 <1				
Empididae															
sp. 1															
sp. 2															
Muscidae															
Limnophora sp.					1 1	1 <1									
Limnophora aequifrons															
Simuliidae															
Cnephnia sp.															
Simulium sp.				1 3				19 8		45 11		33 17	29 1		
Simulium vittatum															

Piceance Creek below Ryan Gulch near Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978							1979						1980			1981			
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
1 1	10 4	14 6	11 5	5 3	9 5		1 <1		5 3	2 13	7 2		8 5		1 1 4 2	52 8 5 1	9 5		2 1
													3 2						
										1 7	4 1								
	13 5		13 6	3 2								6 8			8 4	7 1	6 3		65 21
		6 2			8 5		4 2					1 1			12 6	14 2		4 3	2 1
									3 2										1 <1
	10 4	22 9	2 1	10 5	1 1				1 1		3 1				6 3	45 7			8 3
12 8	5 2	18 7	1 <1	20 10				3 3			3 1		12 7		72 37 6 3	34 5	13 7		3 1
																3 <1			
					2 1														8 3
1 1			2 1													4 <1			
	84 31	5 2	25 12	9 5					17 9						1 1			1 1	
				2 1															
			3 1																
					12 7		1 <1												
	3 1		7 3																
								1 1								1 <1	1 1		
			2 1	2 1															
			3 1	2 1															5 2
								1 1				1 1					3 2		
								1 1											
				1 1								2 3						1 1	2 1
																109 16			
1 1	1 <1		17 8	10 5	33 19		11 5	1 1		4 27	5 2	4 5	1 1			144 21			21 7

Table 9.--Taxa, numbers, and percent composition of benthic invertebrates at site 5,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Stratiomyidae															
Euparyphus sp.															
Tabanidae															
Tabanus sp.													1 <1		
Tipulidae															
Dicranota sp.				1 3	1 1	3 1							1 <1	1 3	2 1
Hexatoma sp.				1 3											
Limnophila sp. 1					1 1	1 <1									
L. sp. 2														2 6	
Tipula sp. 1	6 11			6 15			1 <1			1 <1	2 <1		14 2	1 3	1 1
EPHEMEROPTERA															
Baetidae															
Baetis sp.	3 6			12 30	26 15	16 4	21 2	18 8	9 64	126 32	37 6	10 5	199 27	7 21	60 41
Callibatis sp.															
Ephemerellidae															
Ephemerella sp. 1	1 2			1 3	11 6	12 3					1 <1				
E. sp. 3															
E. sp. 4															
Heptageniidae															
Heptagenia sp.															1 1
Leptophlebiidae															
Paraleptophlebia sp.															
Tricorythidae															
Trycorythodes fallax					2 1	5 1	16 1	2 1	7 1	14 4	93 16		35 5	2 6	46 32
Trycorythodes minutus															
ODONATA															
Gomphidae															
Ophiogomphus severus					1 1					3 1	1 <1				
PLECOPTERA															
Perlodidae															
Isoperla sp.															
Isoperla fulva															
Isoperla patricia	24 45			7 18	59 34	109 25	10 1			10 3	2 <1		12 2	1 3	8 5

Piceance Creek below Ryan Gulch near Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978							1979						1980				1981			
											Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
		79 33																	
					1 1		1 <1	1 1								3 <1			
												1 <1			1 1				
	4 1				1 1			1 1	2 1				2 3	2 1	3 2	1 <1	5 3		
18 13	20 7	40 16	37 18	6 3	17 10		144 70	4 4	8 4	3 20	100 30	16 21	88 51	6 11	15 8	183 27	25 14	1 1	
			3 1																
												1 1	1 1				3 2	2 1	
														2 4 5 9					
			1 <1																1 <1
50 35	60 22	11 5	13 6	35 18	57 32		2 1	48 50	106 56	4 27	77 23	24 32	8 5	13 23	8 4	27 4	2 1	3 2	73 23
2 1	1 <1	1 <1			1 1			1 1	1 1			2 3	1 1	1 2					
																	11 6 9 5		
2 1									2 1		56 17	3 4	22 13	2 4	3 2	26 4	3 2	1 1	3 1

Table 9.--Taxa, numbers, and percent composition of benthic invertebrates at site 5,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
TRICHOPTERA															
Brachycentridae															
Brachycentrus americanus															
Hydropsychidae															
Hydropsyche sp. 1	8/15			6/15	7/4	10/2	2/<1			5/1	47/8		19/3		2/1
H. sp. 2															
Hydroptilidae															
Hydroptila sp.															
Ochrotrichia sp.							4/<1			5/1					
Limnephilidae															
Hesperophylax sp.	2/4			1/3	1/1								2/<1		
NON-INSECTS															
ACARINA															
Atractideidae															
Atractides sp.															
Sperchonidae															
Sperchon sp.						18/4	2/<1	3/1		1/<1	34/6		5/1		
AMPHIPODA															
Gammaridae															
Gammarus lacustris	3/6						4/<1			1/<1	1/<1				
Talitridae															
Hyalella azteca															
GASTROPODA															
Physidae															
Physa sp.	2/4														
PLESIOPORA															
Tubificidae															
Limnodrilus sp.															
Tubifex sp.					6/3			80/34		8/2	3/1	30/15		5/15	

Piceance Creek below Ryan Gulch near Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978						1979						1980					1981		
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
1 1											1 <1								
22 15			1 <1					1 1			68 20		4 2	6 11	1 1	2 <1			
			1 <1																
													2 1						
																			3 1
1 1	4 1			2 1	3 2								1 1						10 3
		1 <1									1 <1								
					1 1			6 6											
	1 <1						4 2					2 3		13 23	33 17	4 <1	19 11	67 45	2 1 2 1

Table 9.--Taxa, numbers, and percent composition of benthic invertebrates at site 5,

[Upper number = number of taxa, lower

Order Family *Genus species*	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
RHYNCHOBDELLIDA															
Glossiphonlidae															
Helobdella stagnalis					1 1	2 <1							3 <1		5 3
Total number of organisms	53			40	176	429	1104	238	14	397	578	194	132	33	146
Total number of species	9			11	18	15	18	13	5	19	19	13	26	15	14
Diversity Index (DI)	2.50			2.88	3.02	2.17	2.45	2.93	1.63	2.90	3.29	2.89	3.43	3.54	2.35

Piceance Creek below Ryan Gulch near Rio Blanco, Colo.--Continued

number = percent composition of sample]

1978							1979						1980				1981		
										Early Sept	Late Sept								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul			Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
	5 2		4 2	1 1			1 <1	3 3		1 7	2 1	1 1							1 <1
144	275	243	206	195	176		207	96	188	15	333	76	173	56	194	689	178	150	314
17	18	13	22	19	18		14	18	14	6	15	15	18	11	19	23	19	16	27
2.98	3.08	2.83	3.62	3.24	3.14		1.72	2.68	2.32	2.39	2.54	3.08	2.63	2.98	3.10	3.19	3.58	2.02	3.27

Table 10.--Taxa, numbers, and percent composition of benthic invertebrates at site 6,

[Upper number = number of taxa, lower

Order / Family / Genus species	1977 Oct	Nov	Jan	Early Mar	Late Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	1978 Feb	Mar	Apr
INSECTS															
COLEOPTERA															
Dytiscidae															
Agabus sp.							2<1	2<1				1<1			
Colymbetes sp.															
Elmidae															
Microcylloepus sp.															
Optioservus sp.						1<1							1<1		
COLLEMBOLA															
Isotomidae															
Isotomurus sp.															
DIPTERA															
Ceratopogonidae															
Palpomyia sp.						10/5			23/21	32/10	7/3	2<1	20/8	5/12	4/9
Stilobezzia sp.							1<1								
Chironomidae															
Arctopelopia sp. or															
Conchapelopia sp.					2/1	5/3	4/1	20/7		7/2	15/6	2<1	2/1	3/7	3/6
Cardiocladius sp.															
Chironomus sp.													1<1		1/2
Cladotanytarsus sp.															
Corynoneura sp.									3/3	10/3					
Cricotopus sp. 1	3/50				4/14	74/39	23/5	193/68	26/24	76/23	59/25	16/4	3/1	4/10	2/4
C. sp. 2													7/3		
C. sp. 4															
C. sp. 5															
C. sp. 18															
Cryptochironomus sp. 1								4/1	1/1	2/1	4/2		3/1	2/5	2/4
C. sp. 2															
Diamesa sp. 1							4/1				3/1				
D. sp. 4															
Eukiefferiella sp. 1	3/50				17/59	58/30	101/20	1<1	2/2	2/1	89/37	14/3	54/22	8/20	4/9
E. sp. 2														3/7	
E. sp. 3															1/2
E. sp. 4															

Piceance Creek at White River, Colo.

number = percent composition of sample]

1978							1979					1980				1981			
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
		1 <1	1 <1															1 <1	
2 <1					1 <1				1 <1					1 10					2 1
																1 2	2 <1		
5 1	16 2	2 <1	12 1	3 1	5 2			2 67	1 <1					3 30	7 1		9 1	8 1	77 20
5 1	2 <1	16 3	34 4	4 1								2 2	2 2					6 <1	
															16 3		3 <1		
																1 2			
									1 <1							1 2		2 <1	1 <1
1 <1	1 <1																		
214 33	588 64	204 34	60 7	184 51	37 16				30 10		14 5	32 25	13 12		91 19	3 6	54 4	1081 81	217 58
30 5	1 <1								1 <1				4 4				15 1		
															11 2		8 1		
										5 38	17 6								
																1 2			
1 <1		2 <1			1 <1		1 5			1 8			2 2	1 10	1 <1		2 <1	8 1	13 3
1 <1																			
			1 <1		51 22							3 2							
					4 2														
32 5	164 18		1 <1	1 <1	23 10		1 5		2 1		10 4	14 11	36 32		43 9	12 25	717 57	24 2	1 <1
															133 28			2 <1	
									4 1		2 1		1 1		3 1		17 1	1 <1	
			4 <1	4 1						3 23	55 20								

Table 10.--Taxa, numbers, and percent composition of benthic invertebrates at site 6,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
Metriocnemus sp.															
Micropsectra sp.				2 4							4 2	148 35	39 16	1 2	
Microtendipes sp.															
Odontomesa sp.							4 1	2 1			1 <1	194 46	16 6	4 10	
Orthocladius sp. 1															
O. sp. 2															
O. sp. 3															
O. sp. 17															
Paralauterborniella sp.															
Phaenopsectra sp.						2 1							1 <1		
Polypedilum sp. 1														1	7 15
Psectrotanypus sp.				1 2		5 3						2 <1			
Smittia sp.															
Syndiamesa orientalis															
Tanytarsus sp.															
Thienemanniella sp.															
Dolichopodidae															
sp. 1															
Empididae															
Hemerodromia sp.										1 <1	1 <1				
Muscidae															
Limnophora sp.								1 <1							
Limnophora aequifrons															
Psychodidae															
Telmatoscopus sp. or													1 <1		
Pericoma sp.															
Simuliidae															
Simulium sp.				39 81	1 3	18 9	340 67	54 19	43 40	185 57		23 5	88 35	7 17	9 19
Simulium vittatum															
Tabanidae															
Tabanus sp.															
Tipulidae															
Eriopterа sp.															
Limnophia sp. 2												1 <1			

number = percent composition of sample]

1978						1979						1980				1981			
										Early	Late								
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
	2 <1								20 6		1 <1		20 18		12 3		98 8	76 6	
					1 <1							1 1				1 2	1 <1	5 <1	1 <1
									60 19										
				1 <1					1 <1			1 1				2 4	9 1		
16 2					1 <1				109 35		25 9	24 19			56 12	1 2	48 4		11 3
																	15 1		
																2 4			
																	8 1		
		6 1			1 <1														
2 <1																			
	2 <1	3 <1	1 <1						7 2										
					1 <1													1 <1	
												11 9							
																	1 <1		
							6 32		5 2										
									1 <1		1 <1								
																1 2			
																		1 <1	
		1 <1										1 1					1 <1	4 <1	
																2 4			
286 44	88 10	343 57	719 80	112 31	57 25		4 21	1 33	60 19	1 8	86 30	8 6	24 21		19 4			65 5	2 1
																10 21	7 1		
			1 <1																2 1
																4 3			

Table 10.--Taxa, numbers, and percent composition of benthic invertebrates at site 6,

[Upper number = number of taxa, lower

Order Family Genus species	1977												1978		
				Early	Late										
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
EPHEMEROPTERA															
Baetidae															
Baetis sp.					1 3				2 2	1 <1	2 1		9 4	2 5	4 9
Callibatis sp.		1 100						5 2				15 4			
Heptageniidae															
Rhithrogena sp.															
Siphlonuridae															
Ameletus sp.															
Tricorythidae															
Tricorythodes fallax							2 <1	1 <1	1 1	2 1	34 14	5 1	1 <1	2 5	4 9
Tricorythodes minutus															
ODONATA															
Agrionidae															
Hyponeura sp.															
Ishnura sp.													1 <1		
Coenagrionidae															
Argia sp.									5 5						
Gomphidae															
Ophiogomphus severus							1 <1	1 <1		2 1			1 <1		
PLECOPTERA															
Capniidae															
Capnia sp.															
Paracapnia angulata															
Perlodidae															
Isoperla sp.															
Isoperla patricia						3 2							1 <1		1 2
TRICHOPTERA															
Brachycentridae															
Brachycentrus americanus															
Hydropsychidae															
Hydropsyche sp. 1				6 13		2 1	2 <1		3 3	4 1	16 7		1 <1		5 11
H. sp. 2															
Hydroptilidae															
Stactobiella sp.															

Piceance Creek at White River, Colo.--Continued

number = percent composition of sample]

1978							1979						1980						1981		
										Early	Late										
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
5 1	18 2	2 <1	3 <1				6 32		1 <1	2 15	25 9		7 6		30 6	3 6	28 2		
																1 2			
																			1 <1
28 4	15 2	6 1	13 1	2 1	15 7		1 5		2 1		9 3	13 10	1 1	2 20	13 3	2 4	1 <1	3 <1	4 1
				2 1															
		1 <1	4 <1								1 <1		1 1				1 <1		2 1
												8 6				1 2			
				2 1							1 <1	2 2			1 <1	1 2	3 <1 7 1		
											1 <1								
2 <1	3 <1	16 3	41 5	46 13	26 11				1 <1	1 8	32 11	3 2	2 2	1 10	6 1		10 1	1 <1	1 <1
									1 <1										

Table 10.--Taxa, numbers, and percent composition of benthic invertebrates at site 6,

[Upper number = number of taxa, lower

Order Family *Genus species*	1977											1978		
				Early	Late									
INSECTS	Oct	Nov	Jan	Mar	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec	Feb	Mar	Apr
NON-INSECTS														
ACARINA														
Sperchonidae														
Sperchon sp.						9 5	23 5				4 2			
AMPHIPODA														
Talitridae														
Hyalella azteca														
GASTROPODA														
Physidae														
Physa sp.														
PLESIOPORA														
Tubificidae														
Tubifex sp.					4 14	4 2								
RHYNCHOBDELLIDA														
Glossiphoniidae														
Helobdella stagnalis														
Total number of organisms	6	1		48	29	191	507	284	109	324	239	423	250	41	47
Total number of species	2	1		4	6	12	12	11	10	12	13	12	19	11	13
Diversity Index (DI)	1.00	0		0.93	1.84	2.47	1.55	1.51	2.32	1.87	2.59	2.01	2.78	3.24	3.42

number = percent composition of sample]

1978						1979						1980				1981		
										Early	Late							
May	Jun	Jul	Aug	Sept	Nov	Feb	Mar	Apr	Jul	Sept	Sept	Nov	Mar	Jun	Sept	Nov	Mar	Jun	Sept
2 <1		1 <1	7 1	2 1	2 1						2 1							10 1	
					1 <1														
			2 <1																
13 2	12 1													2 20	36 8	2 4	188 15	34 3	41 11
																			1 <1
645	913	604	903	363	227		19	3	308	13	282	127	113	10	478	48	1253	1333	377
17	14	14	15	12	16		6	2	19	6	16	15	12	6	16	19	25	19	16
2.22	1.69	1.58	1.29	1.81	2.89		2.19	0.92	2.67	2.29	2.99	3.22	2.71	2.45	3.18	3.49	2.31	1.25	1.96

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