THE DISTRIBUTION AND ABUNDANCE OF AQUATIC MACROINVERTEBRATES AS RELATED TO INSTREAM FLOWS IN THE JEFFERSON RIVER, MONTANA

by

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CONTENTS

INTRODUCTION

Recent concern over in-stream flow requirements for the maintainance of minimum, low, and high levels of aquatic habitat potential in Montana's streams has resulted in a need to gather information on the physical, chemical, and biological characteristics of these streams. Water in Montana's streams is used for agricultural, municipal, industrial, and recreational purposes. Dewatering of streams, particularly in the low flow months of August and September, can severely affect the quality of water available for irrigation and municipal consumption and significantly reduce the aquatic habitat potential for recreational purposes.

This study was initiated by the Montana Dept. of Fish and Game to determine the characteristics of the macroinvertebrate communities of the Jefferson River and to relate some of these characteristics to the discharge of the river. The Jefferson River is heavily used as a source of irrigation water and ranks fourth among the ten major rivers in the upper Missouri drainage in southwest Montana in fishing pressure (MDFG 1979).

Effects of stream dewatering have been known to cause significant qualitative and quantitative changes in macroinvertebrate communities. These effects include; elevated water temperatures, reduced current velocity, increased deposition of sediments, concentration of nutrients and dissolved salts, and decreased ability to dilute substances that increase biological oxygen demand (Gore 1976, Newell 1976). Results of this study can be used as basis for future comparisons to determine changes in the macroinvertebrate communities under lower or higher flow regimes than those observed during this study.

DESCRIPTION OF STUDY AREA

The Jefferson River is formed by the confluence of the Big Hole and Beaverhead Rivers near Twin Bridges, Montana and flows in a north-easterly direction to join with the Madison and Gallatin Rivers at Three Forks, Montana to form the Missouri River. The river is 77 mi long with an average width of 197 ft, an average gradient of 7.3 ft per mi, and a sinuosity of 1.60 (MDFG 1979). Flows for a 25 year period of record at the USGS gauge station near Silver Star on the upper river ranged from 50 to 20,300 cfs with a mean of 1,714 cfs and flows at the USGS gauge near Sappington on the lower river ranged from 134 to 21,000 cfs with a mean of 2,121 cfs. The high water period occurs from April through July during spring runoff and the low water period occurs during August and September reflective of dewatering through the summer irrigation season (MDFG 1979). Flows recorded at a USGS gauge near Three Forks during the period of this study ranged from 1,040 to 2,650 cfs (USGS unpub. data). Temperatures recorded in the lower river in 1963 and from 1971 through 1974 exhibited daily maxima that ranged from 74 to 79 F during the summer months. The substrate of the river is composed primarily of small to medium cobble interspersed with gravel.

Macroinvertebrate sample stations were selected by MDFG personnel at Silver Star (Station 4) and Waterloo (Station 3) in the upper river and at Cardwell (Station 2) and Three Forks (Station 1), Montana in the lower river (Figure 1). Sample stations were located at the bridges that span the river at Stations 4,3, and 2 and about one mile above the bridge at Three Forks.

METHODS

Macroinvertebrates were collected by MDFG personnel from riffle areas by means of a modified Hess sampler (Waters and Knapp 1961) which sampled an area of .093 m^2. Samples were collected from depths that ranged from approximatly 30 to 45 cm from substrates composed of small cobble interspersed with large amounts of gravel and finer sediments. Three Hess samples were collected at each station on July 19, August 15, September 13, October 10, and November 13 and 16, 1978. Samples were placed in containers, preserved in 10% formalin, and returned to the laboratory where macroinvertebrates were separated from the samples by MDFG personnel and stored in 70% ethanol. During the separation process, the three .093 m^2 samples taken at each station on each date were combined to yield a single sample of .28 m^2.

Macroinvertebrates were identified to the lowest practical taxon, usually genus or species, by using keys written by Bauman et al. (1977), Brinkhurst and Jameison (1971), Brown (1972), Edmunds et al. (1976), Hamilton and Saether (1970), Hilsenhoff (1975), Hiltunen (1970),

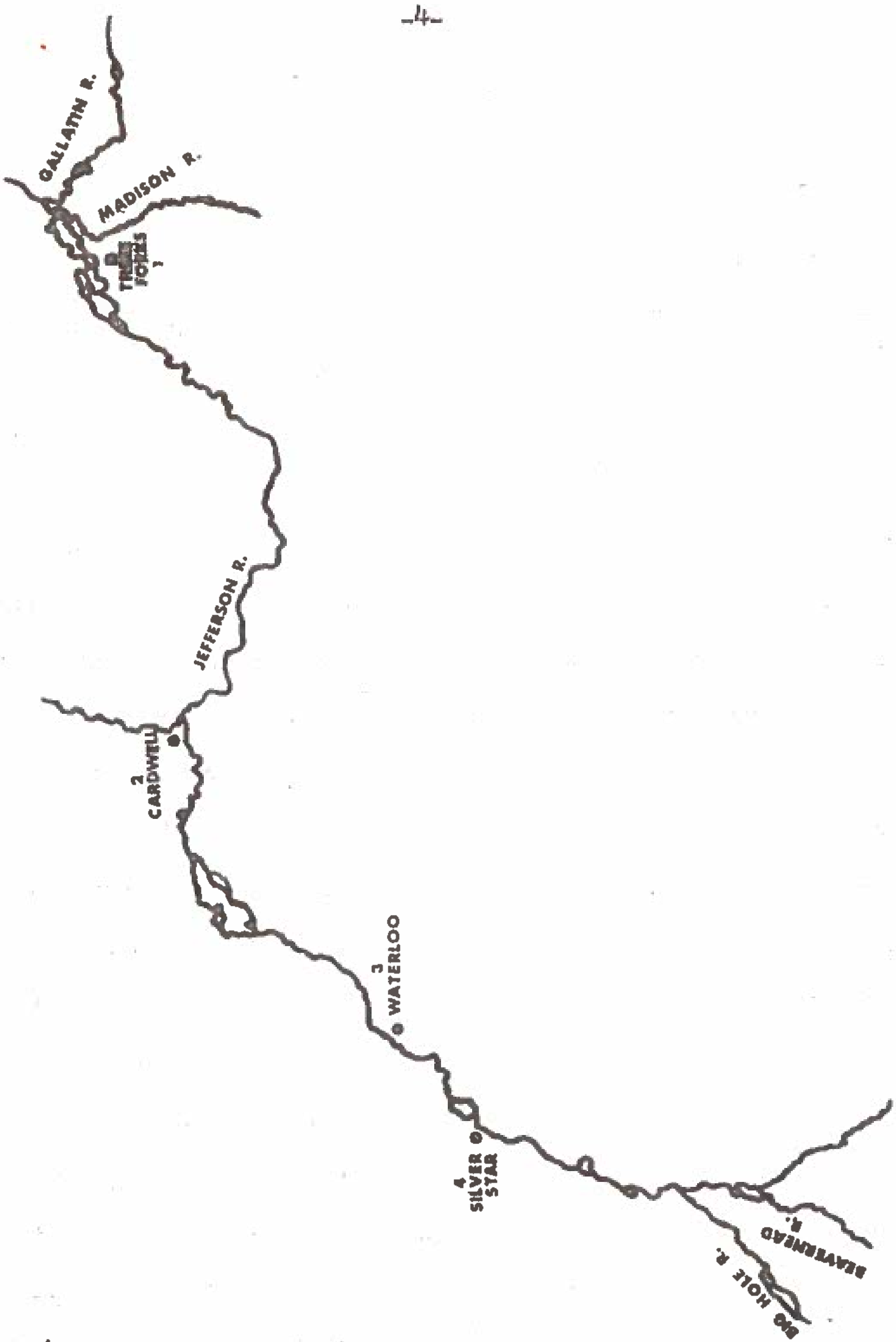

Figure 1. Map of the Jefferson River showing sample stations.

Jensen (1966), Johannsen (1934, 1935), Usinger (1971), and Wiggins (1977). Members of the families Chironomidae, Tubificidae, and Haplotaxidae were mounted on permanent microscope slides for identification and tubificid and haplotaxid oligochaetes were cleared in Amman's lactophenol prior to mounting.

Macroinvertebrate distributions were analyzed, in part, through the calculation of a coefficient of similarity (S) developed by Czekanowski (Clifford and Stephenson 1975). The index is described by:

$$S = \frac{2C}{A+B} = 1.0 \text{ maximum similarity}$$

where A = the number of taxa occurring at station A

B = the number of taxa occurring at station B

C = the number of taxa common to both stations A and B

The coefficient is a nearest neighbor comparison of one station with all other stations.

Water quality in the Jefferson River was assessed by utilizing a trial biotic index (B.I.) patterned after one developed by Hilsenhoff (1977). The index is described by:

$$B.I. = \frac{\text{Summation } n_i \; a_i}{N}$$

where n_i = the number in each taxon

a_i = the quality value assigned to that taxon (0 to 5)

N = the total number of macroinvertebrates in the sample

High index values indicate poor water quality while lower values indicate good water quality. Quality values that were assigned to the taxa collected in the Jefferson River are presented in Appendix Table 11. Very intolerant organisms are assigned a quality value of 0 while extremely tolerant forms are assigned a value of 5 and forms of intermediate tolerance are assigned an appropriate value between 0 and 5 which increases with the tolerance of the organism to disturbance of the environment. Chironomid pupae and nematodes were excluded from the biotic index calculation.

RESULTS

Distribution

A checklist of all taxa collected and their distributions is presented in Table 1. Seventy-five taxa were identified of which 43 (57%) were collected at Station 1, 40 (53%) were collected at Station 2, 56 (75%) were collected at Station 3, and 52 (69%) were collected at Station 4. Twenty-eight taxa were found to be common to all four stations while four were collected only at Station 1, two at Station 2, 8 at Station 3, and 7 at Station 4. Four taxa were collected only in the lower river (Stations 1 and 2) and 10 taxa were found only at the upper two stations (Stations 3 and 4). The fauna was characterized by rheophilous forms (*e.g.*, *Ameletus*, *Rhithrogena*, *Epeorus*, *Claassenia sabulosa*, *Hesperoperla pacifica*, *Glossosoma*, *Lepidostoma*, and *Diamesa*), burrowers (*e.g.*, *Ephemera simulans*, *Chironomus*, *Dicrotendipes*, and *Rhyacodrilus coccineus*), and forms tolerant of slow flows, sedimentation, or high temperatures (*e.g.*, *Baetis*, *Tricorythodes minutus*, *Paralepto-*

Table 1. Checklist and distributions of macroinvertebrate taxa collected in the Jefferson River at Three Forks (St. 1), Cardwell (St. 2), Waterloo (St. 3), and Silver Star (St. 4), Montana from July through November, 1978.

Taxa	STATION 1	2	3	4
EPHEMEROPTERA				
Siphlonuridae				
Ameletus sp.	-	-	X	X
Baetidae				
Baetis spp.	X	X	X	X
Pseudocloeon sp.	X	X	X	X
Heptageniidae				
Epeorus sp.	-	-	X	-
Heptagenia spp.	X	X	X	X
Rhithrogena sp.	X	X	X	X
Leptophlebiidae				
Choroterpes albiannulata McD.	X	X	X	X
Paraleptophlebia bicornuta (McD.)	-	-	X	X
P. debilis (Walker)	-	-	X	-
P. heteronea (McD.)	-	-	X	X
Traverella albertana (McD.)	X	-	-	-
Ephemerellidae				
Ephemerella inermis Eaton	X	X	X	X
E. margarita Needham	-	X	X	X
E. tibialis McD.	-	-	-	X
Tricorythidae				
Tricorythodes edmundsi Allen	X	-	X	X
T. minutus Traver	X	X	X	X
Ephemeridae				
Ephemera simulans Walker	-	-	-	X
ODONATA				
Gomphidae				
Ophiogomphus spp.	-	-	X	X
PLECOPTERA				
Pteronarcydae				
Pteronarcella badia (Hagen)	X	X	-	X
Pteronarcys californica Newport	-	X	-	-
Perlodidae				
Isogenoides sp.	X	X	X	X
Isoperla spp.	X	X	X	X
Skwala sp.	-	X	X	X

Table 1. (Continued)

	STATION			
	1	2	3	4
Perlidae				
Claassenia sabulosa (Banks)	X	X	X	-
Hesperoperla pacifica (Banks)	-	-	X	X
Chloroperlidae				
Chloroperlinae *	X	X	-	-
HEMIPTERA				
Corixidae				
Sigara sp.	-	-	-	X
TRICHOPTERA				
Psychomyiidae				
Psychomyia sp.	-	-	-	X
Hydropsychidae				
Cheumatopsyche spp.	X	X	X	X
Hydropsyche spp.	X	X	X	X
Glossosomatidae				
Glossosoma sp.	X	X	X	X
Hydroptilidae				
Hydroptila sp.	X	X	X	X
Brachycentridae				
Brachycentrus sp.	X	X	X	X
Limnephilidae				
Onocosmoecus sp.	-	-	X	-
Lepidostomatidae				
Lepidostoma sp.	-	-	-	X
Leptoceridae				
Ceraclea sp.	-	-	X	-
Nectopsyche sp.	-	-	X	-
Oecetis sp.	X	-	X	X
LEPIDOPTERA				
Pyralidae				
Paragyractis sp.	X	-	X	X
COLEOPTERA				
Dytiscidae				
Deronectes sp.	X	-	X	-
Elmidae				
Cleptelmis sp.	-	-	-	X
Dubiraphia sp.	X	-	-	-
Heterlimnius sp.	X	X	-	-

Table 1. (Continued)

	STATION			
	1	2	3	4
Microcylloepus pusillus (LeConte)	X	-	-	-
Optioservus quadrimaculatus Horn	X	X	X	X
Zaetzevia parvula (Horn)	-	X	-	-
DIPTERA				
Tipulidae				
Gonomyia group **	X	X	-	-
Hexatoma spp.	X	X	X	X
Tipula spp.	X	X	X	X
Simuliidae				
Simulium spp.	X	X	X	X
Chironomidae				
Thienemannimyia group ***	X	X	-	-
Diamesa spp.	X	X	X	X
Chironomus sp.	-	-	X	X
Dicrotendipes sp.	-	-	-	X
Microtendipes sp.	X	X	X	X
Phaenopsectra sp.	-	-	X	X
Polypedilum spp.	X	X	X	X
Rheotanytarsus spp.	X	X	X	X
Tanytarsus sp.	X	-	X	-
Cardiocladius sp.	-	X	X	X
Cricotopus spp.	X	X	X	X
Eukiefferiella spp.	X	X	X	X
Orthocladius spp.	X	X	X	X
Rheocricotopus sp.	X	-	-	-
Rhagionidae				
Atherix variegata Walker	X	X	X	X
Empididae	-	X	X	-
TURBELLARIA	-	-	X	X
NEMATODA	X	-	-	X
OLIGOCHAETA				
Lumbriculidae	-	-	X	-
Haplotaxidae				
Haplotaxis sp.	-	-	X	-
Tubificidae				
Rhyacodrilus coccineus (Vejdovsky)	X	X	X	X
Lumbricidae				
Eiseniella sp.	-	X	X	-

Table 1. (Continued)

	STATION			
	1	2	3	4
ISOPODA ****	-	-	X	X
GASTROPODA				
Ancylidae				
Ferrissia sp.	-	-	X	X
PELECYPODA				
Sphaeriidae				
Sphaerium sp.	-	-	X	-

* Nymphs of sub-family Chloroperlinae not seperable to genus.

** Group of 4 unseperable genera in larval stage; *Gonomyia*, *Molophilus*, *Helobia*, and *Trimicra*.

*** Group of 4 unseperable genera in larval stage; *Thienemannimyia*, *Conchapelopia*, *Arctopelopia*, and *Rheopelopia*.

**** Terrestrial or semi-aquatic forms, not *Asellus racovetzia* which is the common aquatic isopod in Montana.

phlebia bicornuta, Cheumatopsyche, Nectopsyche, Oecetis, Dubiraphia, Thienemannimyia group, Cricotopus, and Orthocladius).

Distribution of macroinvertebrate taxa among the sampling stations was tested through the calculation of Czekanowski coefficients of similarity (Table 2). The highest degrees of similarity (S = .796 and .795) were observed between Stations 3 and 4 and between Stations 1 and 2. No other combination of stations revealed an S value greater than .688 (Stations 2 and 3).

Table 2. Czekanowski coefficients of similarity (S) between stations on the Jefferson River.

Stations	1	2	3
2	.795	-	-
3	.667	.688	-
4	.674	.674	.796

Twenty-five taxa were collected only at Stations 3 and/or 4 and 10 taxa were found only at Stations 1 and/or 2. The fauna that was restricted to the lower river (Stations 1 and 2) was characterized by thermally tolerant forms (e.g., Dubiraphia, Microcylloepus pusillus, Theinemannimyia group, and Rheocricotopus) and relatively intolerant forms (e.g., Chloroperlinae, Pteronarcys californica, and Heterlimnius). The fauna that was found only in the upper river was characterized by burrowers (e.g., Ephemera simulans, Chironomus, Dicrotendipes, *Phaenopsectra*, and *Haplotaxis*), forms tolerant of a wide range of conditions (*e.g.*, *Nectopsyche*, Tubellaria, Isopoda, and *Sphaerium*), and relatively intolerant rheophilous forms (*e.g.*, *Ameletus*, *Epeorus*, *Ephemerella tibialis*, *Hesperoperla pacifica*, and *Cleptelmis*).

Numbers of taxa collected per sample at each station and the mean numbers per sample for each month and each station are given in Table 3. Numbers of taxa per sample were highest at Stations 3 and 4 ($\bar{X}$ = 27.4 and 25.8) and lowest at Stations 1 and 2 ($\bar{X}$ = 19.4 and 21.6). The highest numbers of taxa per sample were collected in August ($\bar{X}$ = 28.8) and November ($\bar{X}$ = 26.8) and the lowest in September ($\bar{X}$ = 20.0).

Abundance

Numbers of macroinvertebrates collected per sample at each station and the mean numbers per sample for each station and month are given in Table 4. Macroinvertebrate numbers were highest at Stations 3 and 4 ($\bar{X}$ = 822.0 and 644.2) and lowest at Stations 1 and 2 ($\bar{X}$ = 183.8 and 353.6). The highest numbers of macroinvertebrates were collected in August ($\bar{X}$ = 667.0) and November ($\bar{X}$ = 1179.8) and the lowest in October ($\bar{X}$ = 159.5).

Numbers of macroinvertebrates collected in the lower river (Stations 1 and 2) were compared with numbers collected in the upper river (Stations 3 and 4) by calculating mean numbers of macroinvertebrates per sample for the upper and lower river for each month and for the total series of samples (Table 5). These data were tested by means of a t test to

Table 3. Numbers of sub-ordinal taxa collected per sample (.28 m^2) and mean numbers of taxa collected per station and per month from the Jefferson River, Montana.

	STATION 1	2	3	4	$\bar{X}$/month
July	15	23	28	22	22.0
August	27	30	29	29	28.8
September	24	9	22	25	20.0
October	16	18	25	22	20.3
November	15	28	33	31	26.8
$\bar{X}$/station	19.4	21.6	27.4	25.8	

Table 4. Numbers of macroinvertebrates collected per sample (.28 m^2) and mean numbers of macroinvertebrates collected per station and per month from the Jefferson River, Montana.

	STATION 1	2	3	4	$\bar{X}$/month
July	101	151	327	249	207.0
August	452	583	879	754	667.0
September	228	175	411	351	291.3
October	54	129	270	185	159.5
November	84	730	2223	1682	1179.8
$\bar{X}$/Station	183.8	353.6	822.0	644.2	

determine the probability at which numerical differences between the upper and lower river were significant. The mean number of macroin-

Table 5. Mean numbers of macroinvertebrates per sample (.28 m^2) collected in the lower (Stations 1 and 2) and upper (Stations 3 and 4) Jefferson River.

	$\bar{X}$ Lower River	$\bar{X}$ Upper River	Prob. of Sig.*
July	126.0	288.0	P < .07
August	517.5	816.5	P < .05
September	201.5	381.0	P < .05
October	91.5	227.5	P < .14
November	407.0	1952.5	P < .07
Total	268.7	733.1	P < .06

* Probability at which differences between means are significant

vertebrates of the total series of samples for the upper river (733.1) was approximately 2.7 times that of the lower river (268.7). This difference was not significant at the commonly accepted interval of $P < .05$ but was significant at $P < .06$. Monthly mean numbers of macroinvertebrates ranged from approximately 1.5 to 4.8 times greater in the upper river than in the lower river samples. Samples collected in August and September yielded significantly different mean numbers at $P < .05$.

Numbers per sub-ordinal taxa are given in Appendix Tables 7,8, and 9. Two patterns of seasonal abundance were observed among the numerically dominant forms. Baetis, Choroterpes albiannulata, Tricorythodes minutus, Isogenoides, Claassenia sabulosa, Polypedilum, and Cricotopus were most abundant in August or September while Ephemerella inermis, Rhithrogena, Isoperla, Diamesa, Microtendipes, and Orthocladius were most abundant in November. Hydropsyche and Cheumatopsyche, the most abundant genera collected, reached maximum abundance in November but also reached relatively high numbers in August. Most of the other taxa collected were present in relatively low numbers with the exception of Heptagenia in July, Turbellaria in October and November at Station 3, and Rhyacodrilus coccineus at Stations 3 and 4 in September, October, and November.

Trial Biotic Index

Results of a trial biotic index patterned after Hilsenhoff (1977) are given in Table 6. Quality values assigned to the various taxa are

Table 6. Trial biotic index (B.I.) values per sample (.28 m^2) and mean B.I. per sample collected in the Jefferson River for each station and month.

	Station				
	1	2	3	4	$\bar{X}$ B.I./month
July	2.41	2.37	2.35	2.56	2.42
August	2.24	2.50	2.72	2.55	2.50
September	2.81	3.01	2.73	3.10	2.91
October	2.29	2.20	2.04	2.88	2.35
November	1.25	1.93	2.98	2.96	2.28
$\bar{X}$ B.I./station	2.20	2.40	2.56	2.81	

presented in Appendix Table 11. Mean B.I. values increased from Station 1 to Station 4 and ranged from 2.20 to 2.81. On a monthly basis, mean B.I. values increased from July (2.42) to a maximum in September (2.91), dropped in October, and were at a minimum in November (2.28).

DISCUSSION

River Zonation

Data indicated that the study area on the Jefferson River was divided into two distinct zones, an upper river section (Stations 3 and 4) and a lower river section (Stations 1 and 2). This was evidenced by the alliances of the two lower and upper stations that were detected with coefficients of similarity and by the markedly higher numbers of macroinvertebrates and taxa that were collected at Stations 3 and 4 than at Stations 1 and 2. A previous study has also divided the Jefferson River into upper and lower river zones (MDFG 1979). This study, however, set the boundary between the upper and lower reaches at the mouth of the Boulder River below Cardwell thus including Station 2 of the present study in the upper reach. Results of this study suggest that the division between upper and lower river zones on the Jefferson River probably occurs upstream of the Boulder River confluence.

The upper river zone was richer in macroinvertebrate numbers and taxa than the lower river despite the fact that mean monthly discharges in the critical months of August (652 cfs) and September (800 cfs) in the upper river fall far below the 1200 cfs that has been recommended to maintain a high level of aquatic habitat potential within the reach during this period (MDFG 1979). Mean discharges in August (745 cfs) and September (969 cfs) in the lower river differ less markedly from the minimum recommended discharge for high level habitat potential for that reach (1000 cfs) than do those of the upper zone. The upper section has also supported more abundant trout and whitefish populations than the lower section (Wells and Nelson 1978). The more diverse and abundant fauna of the upper river zone may be reflective of the relatively high flows that dominated the river in 1978. Flow data from a gauge station near Three Forks show that discharges in the period spanning August 15 through November 16,1978 ranged from 1040 to 2650 cfs (USGS unpublished data). Discharges of these magnitudes exceed the minimum recommended discharge required to support a high level of aquatic habitat potential in the lower Jefferson River during that period. It is plausible that during a year of high flows the upper river section supports richer macroinvertebrate populations than the lower section due to natural longitudinal changes in the river concomitant with loss of gradient, i.e., higher water temperatures, increased sedimentation, slower current velocities, and less diversity of niches (Hynes 1970). Thus the aquatic habitat potential of the lower river may be naturally lower than that of the upper section.

Distribution

The Jefferson River supported a relatively rich macroinvertebrate fauna in terms of the numbers of taxa collected. Seventy-five taxa were collected during the study. This can be compared with 59 taxa that were identified from the Madison River (Fraley 1978) and 66, exclusive of Chironomidae and Oligochaeta, that were collected in the East Gallatin River (Luedtke et al. 1974).

Many of the taxa collected in the Jefferson River were forms that are known to be tolerant of high temperatures, sedimentation, and slow flows. Such forms were often collected throughout the study area. Many of the intolerant forms that were collected were limited to the upper river section.

Most of the taxa collected in the Jefferson River have also been collected in the Madison and East Gallatin Rivers (Fraley 1978, Luedtke et al. 1974). A comparative list of taxa that were unique to the Jefferson and lower Madison Rivers is presented in Appendix Table 10. It should be noted that the caddisfly *Helicopsyche borealis*, which was not collected from the Jefferson River, probably does inhabit the river because larval cases of the species were found in some of the samples.

Of particular interest, was the collection of the mayfly *Tricorythodes edmundsi*. This species has, until recently, been known only from northern Mexico and Utah (Allen 1977). It has since been collected from the lower Yellowstone River and in the present study. It has been theorized that this species develops and emerges very rapidly under optimal conditions and may be more widely distributed than was previously believed (G.F. Edmunds Jr. personal communication).

Abundance

The Jefferson River supported relatively low numbers of aquatic macroinvertebrates when compared with other major tributaries of the Missouri River headwaters. Population estimates of 658.7, 1267.3, 2946.0, and 2308.8 macroinvertebrates per m^2 for Stations 1 through 4 on the Jefferson River can be compared with 3760 and 5012 per m^2 in the Madison River at Norris Bridge and Three Forks (Fraley 1978), 7669.1 per m^2 in the East Gallatin River near Belgrade (Luedtke et al. 1974), and 4916.3 (major insect orders only) per m^2 in the West Gallatin River at Moose Meadows (Roemhild 1971). The station at Three Forks on the Madison River supported 7.6 times the macroinvertebrate numbers than did the Three Forks station on the Jefferson River. Low macroinvertebrate numbers in the Jefferson River may be due to elevated water temperatures, sedimentation and reduced current velocities associated with dewatering.

The most abundant genera and species collected in the Jefferson River were classified into two groups based on their seasonal patterns of abundance. The long or winter cycle forms which over-winter in the larval form and complete their development and emerge in spring or early summer were characterized by an absence or presence in very low numbers in the critical flow period of August and September, began a numerical recovery in the October samples and reached maximum abundance in November. This group was typified by rheophilous forms such as Rhithrogena, Isoperla, and Diamesa. The short or summer cycle forms which rapidly complete their development in summer and emerge in August or September were characterized by an absence or presence in very low numbers in early summer or fall and reached maximum abundance in August or September. This group was typified by tolerant forms such as Choroterpes albiannulata, Tricorythodes minutus, Cricotopus, and Polypedilum. Although Claassenia sabulosa and Isogenoides both reached maximum abundance in August, they are actually long or winter cycle forms. Isogenoides emerges in early spring and has been collected in the adult form in May in the Jefferson, Gallatin and Missouri Rivers (Unpublished records, Montana State Univ.). Claassenia sabulosa emerges from June through September (Bauman et al. 1977) and has been collected in adult form in July and August from the Gallatin and Yellowstone Rivers (Unpublished records, Montana State Univ.). All of the Isogenoides and the majority of the C. sabulosa that were present in the August samples were early instar forms. A strong numerical reduction of both genera that occurred in September was followed by numerical recovery in larger later instars in October and November. Emergence, therefore can be eliminated as a cause of the numerical reduction of Isogenoides and C. sabulosa in September. It is suggested that the numerical reduction may have been related to elevated summer water temperatures, low current velocities, or sedimentation, or a combination of these factors, due to low summer discharges. These factors may have been responsible for the low summer numbers of some of the other rheophilous cold-water forms such as Rhithrogena and Isoperla which did not begin a numerical recovery until October and were most abundant in November. Gore (1976) found that current specialists such as Rhithrogena, Ephemerella, and Isogenoides drifted out of previously occupied areas when flows were decreased in the Tongue River.

Trial Biotic Index

A trial biotic index revealed that water quality steadily decreased going upstream from Station 1 to Station 4. On a monthly basis, water quality was highest in October and November and showed a steady decrease from July to September when water quality was lowest. Hilsenhoff (1977) determined that biotic index values of less than 1.75 indicated excellant water quality, a range of 1.75 to 2.25 indicated good water quality with some disturbance, a range of 2.25 to 3.00 indicated fair water quality with moderate disturbance, and a range of 3.00 to 3.75 indicated poor water quality. All of the mean B.I. values indicated that the Jefferson River has fair water quality and shows some moderate disturbance. Index values for September samples at Stations 2 and 4 were in the poor water quality range. High index values for November samples at Stations 3 and 4 were due to very large populations of Cheumatopsyche and Hydropsyche; however, these genera occurred with many intolerant forms that reached their maximum abundance in these samples. Fraley (1978) calculated mean biotic index values for samples collected at Norris Bridge and Three Forks on the lower Madison River and presented values of 2.64 and 2.68 for these stations.

CONCLUSIONS

1. Data indicated that the four macroinvertebrate sample stations represented two river zones, an upper river section (Silver Star and Waterloo) and a lower river section (Cardwell and Three Forks).
2. The upper river section supported a greater diversity and greater numbers of macroinvertebrates than the lower river section; however, biotic index values indicated slightly poorer water quality in the upper section.
3. The macroinvertebrate community was dominated by forms tolerant of sedimentation, high water temperatures, and low current velocities in August and September while rheophilous forms, typical of rubble or cobble substrates, low temperatures, and swift flows, were absent or present in low numbers in these months and most abundant in November. Biotic index values indicated that water quality was lowest in September and August and highest in November and October.
4. Macroinvertebrate numbers in the Jefferson River were low when compared with the other major tributaries that join to form the Missouri River.
5. Data collected in this study can be applied as a basis for comparison with future investigations under different flow regimes.

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APPENDIX

Table 7. Numbers per sub-ordinal taxa of macroinvertebrates collected in .28 m^2 bottom samples on July 19 and August 15, 1978.

	July				August			
Stations	1	2	3	4	1	2	3	4
EPHEMEROPTERA								
Ameletus sp.	--	--	--	--	--	--	--	--
Baetis spp.	33	54	62	26	21	89	67	50
Pseudocloeon sp.	10	10	28	7	1	9	--	--
Epeorus sp.	--	--	1	--	--	--	--	--
Heptagenia spp.	4	5	58	27	1	1	7	8
Rhithrogena sp.	3	9	1	--	14	7	--	3
Choroterpes albiannulata	1	--	--	--	1	7	102	10
Paraleptophlebia bicornuta	--	--	--	--	--	--	--	--
P. debilis	--	--	4	--	--	--	--	--
P. heteronea	--	--	1	--	--	--	--	--
Traverella albertana	--	--	--	--	2	--	--	--
Ephemerella inermis	13	29	47	40	--	--	--	2
E. margarita	--	--	4	4	--	1	9	12
E. tibialis	--	--	--	1	--	--	--	--
Tricorythodes edmundsi	--	--	--	--	--	--	11	8
T. minutus	15	7	8	10	180	115	325	264
Ephemera simulans	--	--	--	--	--	--	--	--
ODONATA								
Ophiogomphus spp.	--	--	1	--	--	--	4	1
PLECOPTERA								
Pteronarcella badia	--	--	--	--	1	2	--	--
Pteronarcys californica	--	--	--	--	--	--	--	--
Isogenoides sp.	4	1	3	--	19	39	8	55
Isoperla spp.	--	3	8	17	--	--	--	--
Skwala sp.	--	--	--	--	--	--	4	8
Claassenia sabulosa	--	5	1	--	36	41	--	--
Hesperoperla pacifica	--	--	--	1	--	--	--	--
Chloroperlinae	--	--	--	--	--	--	--	--
HEMIPTERA								
Sigara sp.	--	--	--	--	--	--	--	--
TRICHOPTERA								
Psychomyia sp.	--	--	--	--	--	--	--	--
Cheumatopsyche spp.	1	5	18	22	39	61	177	216
Hydropsyche spp.	3	2	15	48	60	93	41	29
Glossosoma sp.	--	1	--	4	9	5	6	15
Hydroptila sp.	--	1	--	2	--	1	--	--
Brachycentrus sp.	1	--	--	1	1	1	2	2
Onocosmoecus sp.	--	--	--	--	--	--	1	--
Lepidostoma sp.	--	--	--	--	--	--	--	--
Ceraclea sp.	--	--	--	--	--	--	--	--
Nectopsyche sp.	--	--	--	--	--	--	--	--
Oecetis sp.	1	--	2	--	--	--	--	1

Table 7. (Continued)

	July				August			
Stations	1	2	3	4	1	2	3	4
LEPIDOPTERA								
Paragyractis sp.	--	--	--	--	--	--	5	17
COLEOPTERA								
Deronectes sp.	--	--	--	--	--	--	--	--
Cleptelmis sp.	--	--	--	--	--	--	--	--
Dubiraphia sp.	--	--	--	--	--	--	--	--
Heterlimnius sp.	--	--	--	--	1	--	--	--
Microcylloepus pusillus	--	--	--	--	2	--	--	--
Optioservus quadrimaculatus	--	--	--	1	3	1	2	--
Zaetzevia parvula	--	--	--	--	--	2	--	--
DIPTERA								
Gonomyia group	--	--	--	--	--	--	--	--
Hexatoma spp.	--	--	--	--	4	4	--	2
Tipula spp.	--	--	--	--	--	--	--	--
Simulium spp.	1	1	--	1	--	7	--	--
Thienemannimyia group	--	--	--	--	3	1	--	--
Diamesa spp.	--	--	--	--	--	--	--	--
Chironomus sp.	--	--	--	--	--	--	--	--
Dicrotendipes sp.	--	--	--	--	--	--	--	--
Microtendipes sp.	--	--	1	--	--	--	4	6
Phaenopsectra sp.	--	--	--	--	--	--	1	1
Polypedilum spp.	6	3	32	9	26	19	21	16
Rheotanytarsus spp.	--	--	--	--	7	11	6	4
Tanytarsus sp.	--	--	--	--	--	--	--	--
Cardiocladius sp.	--	2	2	8	--	1	--	1
Cricotopus spp.	5	2	11	14	2	33	44	3
Eukiefferiella spp.	--	1	8	2	1	10	6	3
Orthocladius spp.	--	1	1	3	--	--	1	1
Rheocricotopus sp.	--	--	--	--	1	--	--	--
Chironomid pupae	--	1	2	--	1	2	4	7
Atherix variegata	--	--	--	--	5	6	1	1
Empididae	--	1	1	--	--	1	--	--
TURBELLARIA	--	--	3	--	--	--	15	--
NEMATODA	--	--	--	--	--	--	--	--
OLIGOCHAETA								
Lumbriculidae	--	--	--	--	--	--	--	--
Haplotaxis sp.	--	--	--	--	--	--	1	--
Rhyacodrilus coccineus	--	6	3	1	11	12	3	6
Eiseniella sp.	--	1	--	--	--	1	1	--
ISOPODA	--	--	--	--	--	--	--	--
GASTROPODA								
Ferrissia sp.	--	--	--	--	--	--	--	--
PELECYPODA								
Sphaerium sp.	--	--	1	--	--	--	--	--

Table 8. Numbers per sub-ordinal taxa of macroinvertebrates collected in .28 m^2 bottom samples on Sept. 13 and Oct. 10, 1978.

	September				October			
Stations	1	2	3	4	1	2	3	4
EPHEMEROPTERA								
Ameletus sp.	---	---	---	---	---	---	---	1
Baetis spp.	10	154	253	97	3	1	1	1
Pseudocloeon sp.	3	---	---	---	1	---	---	---
Epeorus sp.	---	---	---	---	---	---	---	---
Heptagenia spp.	---	1	1	8	---	1	2	---
Rhithrogena sp.	3	---	3	4	3	13	43	6
Choroterpes albiannulata	1	2	3	---	---	---	---	---
Paraleptophlebia bicornuta	---	---	1	2	---	---	---	---
P. debilis	---	---	7	---	---	---	---	---
P. heteronea	---	---	---	---	---	---	---	1
Traverella albertana	---	---	---	---	---	---	---	---
Ephemerella inermis	1	---	---	4	3	5	7	5
E. margarita	---	---	---	---	---	---	---	---
E. tibialis	---	---	---	---	---	---	---	---
Tricorythodes edmundsi	2	---	---	---	---	---	---	---
T. minutus	3	2	20	27	---	---	1	1
Ephemera simulans	---	---	---	---	---	---	---	---
ODONATA								
Ophiogomphus spp.	---	---	---	---	---	---	---	---
PLECOPTERA								
Pteronarcella badia	1	---	---	---	---	---	---	---
Pteronarcys californica	---	---	---	---	---	---	---	---
Isogenoides sp.	15	---	---	---	9	18	3	4
Isoperla spp.	---	---	---	---	---	---	4	7
Skwala sp.	---	---	---	---	---	---	2	2
Claassenia sabulosa	1	---	---	---	---	11	1	---
Hesperoperla pacifica	---	---	---	---	---	---	---	1
Chloroperlinae	1	---	---	---	---	---	---	---
HEMIPTERA								
Sigara sp.	---	---	---	5	---	---	---	1
TRICHOPTERA								
Psychomyia sp.	---	---	---	---	---	---	---	---
Cheumatopsyche spp.	28	---	10	126	2	7	33	45
Hydropsyche spp.	127	---	1	15	9	44	11	61
Glossosoma sp.	---	---	---	---	---	---	---	1
Hydroptila sp.	---	---	---	---	---	2	3	1
Brachycentrus sp.	---	---	---	1	---	---	---	---
Onocosmoecus sp.	---	---	---	---	---	---	---	---
Lepidostoma sp.	---	---	---	2	---	---	---	---
Ceraclea sp.	---	---	---	---	---	---	---	---
Nectopsyche sp.	---	---	---	---	---	---	---	---
Oecetis sp.	---	---	---	---	---	---	---	---

Table 8. (Continued)

	September				October			
Stations	1	2	3	4	1	2	3	4
LEPIDOPTERA								
Paragyractis sp.	1	--	2	5	1	--	--	4
COLEOPTERA								
Deronectes sp.	1	--	6	--	--	--	--	--
Cleptelmis sp.	--	--	--	--	--	--	--	--
Dubiraphia sp.	--	--	--	--	1	--	--	--
Heterlimnius sp.	--	--	--	--	1	--	--	--
Microcylloepus pusillus	1	--	--	--	1	--	--	--
Optioservus quadrimaculatus	1	--	--	1	--	--	2	--
Zaetzevia parvula	--	--	--	--	--	--	--	--
DIPTERA								
Gonomyia group	4	1	--	--	--	--	--	--
Hexatoma spp.	10	--	--	2	5	1	1	--
Tipula spp.	1	--	6	2	--	--	1	2
Simulium spp.	--	6	4	--	--	1	2	--
Thienemannimyia group	--	--	--	--	--	--	--	--
Diamesa spp.	--	1	--	--	--	--	1	--
Chironomus sp.	--	--	3	4	--	--	--	--
Dicrotendipes sp.	--	--	--	1	--	--	--	--
Microtendipes sp.	--	--	--	4	3	2	4	7
Phaenopsectra sp.	--	--	4	2	--	--	--	--
Polypedilum spp.	--	--	--	--	--	--	--	--
Rheotanytarsus spp.	--	--	--	6	--	1	1	--
Tanytarsus sp.	1	--	1	--	--	--	--	--
Cardiocladius sp.	--	--	--	--	--	--	--	--
Cricotopus spp.	8	7	1	4	--	1	3	7
Eukiefferiella spp.	--	--	--	--	--	--	--	--
Orthocladius spp.	--	--	--	3	9	12	11	15
Rheocricotopus sp.	--	--	--	--	--	--	--	--
Chironomid pupae	--	--	2	--	2	1	5	4
Atherix variegata	2	--	--	--	1	1	--	1
Empididae	--	--	--	--	--	--	--	--
TURBELLARIA	--	--	4	--	--	--	25	--
NEMATODA	--	--	--	--	--	--	--	--
OLIGOCHAETA								
Lumbriculidae	--	--	--	--	--	--	--	--
Haplotaxis sp.	--	--	1	--	--	--	--	--
Rhyacodrilus coccineus	2	1	74	26	--	7	99	11
Eiseniella sp.	--	--	--	--	--	--	--	--
ISOPODA	--	--	4	1	--	--	--	--
GASTROPODA								
Ferrissia sp.	--	--	--	1	--	--	--	--
PELECYPODA								
Sphaerium sp.	--	--	--	--	--	--	--	--

Table 9. Numbers per sub-ordinal taxa of macroinvertebrates collected in .28 m^2 bottom samples on Nov. 13 and 16,1978.

	November			
Stations	1	2	3	4
EPHEMEROPTERA				
Ameletus sp.	--	--	1	--
Baetis spp.	1	1	12	4
Pseudocloeon sp.	--	--	--	--
Epeorus sp.	--	--	--	--
Heptagenia spp.	--	1	--	--
Rhithrogena sp.	30	78	5	5
Choroterpes albiannulata	--	--	--	--
Paraleptophlebia bicornuta	--	--	--	--
P. debilis	--	--	--	--
P. heteronea	--	--	3	--
Traverella albertana	--	--	--	--
Ephemerella inermis	11	209	128	131
E. margarita	--	--	--	--
E. tibialis	--	--	--	--
Tricorythodes edmundsi	--	--	--	--
T. minutus	--	--	5	1
Ephemera simulans	--	--	--	2
ODONATA				
Ophiogomphus spp.	--	--	1	1
PLECOPTERA				
Pteronarcella badia	--	3	--	1
Pteronarcys californica	--	1	--	--
Isogenoides sp.	3	21	1	6
Isoperla spp.	9	80	72	76
Skwala sp.	--	1	--	2
Claassenia sabulosa	--	17	--	--
Hesperoperla pacifica	--	--	1	7
Chloroperlinae	--	8	--	--
HEMIPTERA				
Sigara sp.	--	--	--	--
TRICHOPTERA				
Psychomyia sp.	--	--	--	3
Cheumatopsyche spp.	4	43	721	619
Hydropsyche spp.	11	199	710	542
Glossosoma sp.	--	--	--	--
Hydroptila sp.	2	4	8	3
Brachycentrus sp.	--	2	2	3
Onocosmoecus sp.	--	--	--	--
Lepidostoma sp.	--	--	--	1
Ceraclea sp.	--	--	1	--
Nectopsyche sp.	--	--	3	--
Oecetis sp.	--	--	1	13

Table 9. (Continued)

	November			
Stations	1	2	3	4
LEPIDOPTERA				
Paragyractis sp.	--	--	2	5
COLEOPTERA				
Deronectes sp.	--	--	--	--
Cleptelmis sp.	--	--	--	1
Dubiraphia sp.	--	--	--	--
Heterlimnius sp.	1	1	--	--
Microcylloepus pusillus	--	--	--	--
Optioservus quadrimaculatus	--	2	1	--
Zaetzevia parvula	--	2	--	--
DIPTERA				
Gonomyia group	--	--	--	--
Hexatoma spp.	2	16	--	--
Tipula spp.	--	4	1	2
Simulium spp.	1	6	19	20
Thienemannimyia group	--	--	--	--
Diamesa spp.	5	14	283	9
Chironomus sp.	--	--	--	--
Dicrotendipes sp.	--	--	--	--
Microtendipes sp.	--	3	7	146
Phaenopsectra sp.	--	--	1	19
Polypedilum spp.	--	--	--	--
Rheotanytarsus spp.	2	--	5	--
Tanytarsus sp.	--	--	--	--
Cardiocladius sp.	--	2	4	--
Cricotopus spp.	--	--	--	--
Eukiefferiella spp.	--	--	4	--
Orthocladius spp.	1	6	64	--
Rheocricotopus sp.	--	--	--	--
Chironomid pupae	--	--	17	3
Atherix variegata	--	2	6	3
Empididae	--	1	--	--
TURBELLARIA	--	--	66	1
NEMATODA	1	--	--	1
OLIGOCHAETA				
Lumbriculidae	--	--	1	--
Haplotaxis sp.	--	--	--	--
Rhyacodrilus coccineus	--	3	67	50
Eiseniella sp.	--	--	--	--
ISOPODA	--	--	--	--
GASTROPODA				
Ferrissia sp.	--	--	1	2
PLECYPODA				
Sphaerium sp.	--	--	--	--

Table 10. Macroinvertebrate taxa collected in the Jefferson River but absent from collections made on the lower Madison River* contrasted with taxa collected in the lower Madison River which were absent from collections in the Jefferson River.

Present in Jefferson, Absent from Madison.	Present in Madison, Absent from Jefferson.
EPHEMEROPTERA	EPHEMEROPTERA
Paraleptophlebia bicornuta	Ephemerella grandis
P. debilis	Ephoron album
Traverella albertana	PLECOPTERA
Ephemerella margarita	Cultus sp.
E. tibialis	TRICHOPTERA
Tricorythodes edmundsi	Amiocentrus sp.
PLECOPTERA	Protoptila sp.
Isogenoides sp.	Leuchotrichia pictipes
TRICHOPTERA	Zumatrichia notosa
Onocosmoecus sp.	Helicopsyche borealis
COLEOPTERA	COLEOPTERA
Deronectes sp.	Lara sp.
Cleptelmis sp.	DIPTERA
Dubiraphia sp.	Antocha spp.
Heterlimnius sp.	Nilotanypus sp.
Zaetzevia parvula	Paracladopelma sp.
DIPTERA	Nanocladius (Microcricotopus)
Gonomyia group	AMPHIPODA
Rheocricotopus sp.	Hyalella azteca
Tanytarsus sp.	DECAPODA
Empididae	Orconectes sp.
OLIGOCHAETA	GASTROPODA
Lumbriculidae	Physa spp.
Haplotaxis sp.	PELECYPODA
Rhyacodrilus coccineus	Pisidium spp.
Eiseniella sp.	
TURBELLARIA	
NEMATODA	

* From Fraley (1978) collections made at Norris Bridge and Three Forks on the Madison River.

Table 11. Quality values (a_i) assigned to macroinvertebrate taxa from Hilsenhoff (1977), Fraley (1978)*, and author** and used in calculating trial biotic index (B.I.) for the Jefferson R..

EPHEMEROPTERA	Ameletus sp. 1**, Baetis spp. 3, Pseudocloeon sp. 2, Epeorus sp. 0, Heptagenia spp. 2, Rhithrogena sp. 0, C. albiannulata 3*, P. bicornuta 1**, P. debilis 1**, P. heteronea 1, T. albertana 3**, E. inermis 2*, E. margarita 2**, E. tibialis 2**, T. edmundsi 2, T. minutus 2, E. simulans 1.
ODONATA	Ophiogomphus spp. 0.
PLECOPTERA	P. badia 1*, P. californica 1, Isogenoides sp. 0, Isoperla spp. 0, Skwala sp. 1*, C. sabulosa 1*, H. pacifica 1*, Chloroperlinae 0*.
HEMIPTERA	Sigara sp. 3**
TRICHOPTERA	Psychomyia sp. 2, Cheumatopsyche spp. 4, Hydropsyche spp. 3, Glossosoma sp. 1, Hydroptila sp. 3, Brachycentrus 1, Onocosmoecus sp. 0, Lepidostoma sp. 2, Ceraclea 2, Nectopsyche sp. 2, Oecetis sp. 2.
LEPIDOPTERA	Paragyractis sp. 3*
COLEOPTERA	Deronectes sp. 3**, Cleptelmis sp. 1**, Dubiraphia sp. 3, Heterlimnius sp. 1**, M. pusillus 1, O. quadrimaculatus 2**, Z. parvula 1**.
DIPTERA	Gonomyia gr. 3**, Hexatoma spp. 3, Tipula spp. 2, Simulium spp. 3, Thienemannimyia gr. 4, Diamesa spp. 2, Chironomus sp. 5, Dicrotendipes sp. 3, Microtendipes sp. 2, Phaenopsectra sp. 1, Polypedilum spp. 3, Rheotanytarsus spp. 0, Tanytarsus sp. 0, Cardiocladius sp. 4, Cricotopus spp. 4, Eukiefferialla spp. 2, Orthocladius spp. 4, Rheocricotopus sp. 1, A. variegata 2, Empididae 4.
OLIGOCHAETA	Lumbriculidae 2**, Haplotaxis sp. 1**, R. coccineus 2**, Eiseniella sp. 2**.
MISCALLANEOUS	Turbellaria 2**, Isopoda 5, Ferrissia sp. 2**, Sphaerium sp. 4**.