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THE BENTHIC MACROINVERTEBRATE COMMUNITY OF THE GREER'S FERRY RESERVOIR COLD TAILWATER, LITTLE RED RIVER, ARKANSAS

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ABSTRACT

This study provides an evaluation of the benthic faunal characteristics of the cold tailwater of Greer's Ferry Reservoir on Little Red River. This Ozark stream is characterized by cold and non-turbid water, and periodic drastic vacillation of water level, the results of a deep water discharge for hydroelectric generation. For these reasons the benthic macroinvertebrate community is qualitatively limited.

Pool and riffle habitats were sampled at six-week intervals at each of three stations established between 500 m-23 km below the dam. Most physicochemical characteristics measured were found not limiting, except water temperature and current velocity. Benthic organisms were limited to 59 taxa. Longitudinal zonation was characterized by an increase in diversity downstream with 15, 32, and 41 taxa collected at Stations 1, 2, and 3, respectively.

Overall dominant organisms numerically were oligochaetes, chironomids and isopods. Oligochaetes composed 62-79% of pool organisms collected. Isopods dominated riffles with 37-81% of organisms collected. Chironomids were usually the second most abundant in riffles and pools. The mean numerical ding crop was greatest at Station 1 with 1,241 organisms/m^{-2} and lowest at Station 2 with 437 organisms/m^{-2}.

INTRODUCTION

Stream habitats located below large impoundments which have been formed for hydroelectric purposes are usually characterized by daily fluctuations in contrast to seasonal flooding of other streams. When the outlet is a deep water discharge, the water is also characteristically cold and clear.

The purposes of this study were to survey the benthic macroinvertebrate characteristics in a stretch of the cold tailwater of Little Red River, and to elucidate the effects of cold water discharge on the parameters measured.

DESCRIPTION OF THE AREA

Headwater tributaries of Little Red River arise in the Ozark Plateau of north central Arkansas in Searcy, Stone, and Van Buren Counties. The river flows in a southeasterly direction with three major tributaries joining in Cleburne County. The river drains an area of 2,968 km^2 above the dam and empties into White River near Searcy, White County, Arkansas. The terrain of the upper portion of the river is rugged with the elevation varying abruptly, and having a steep gradient.

The area selected for study is located below Greer's Ferry Dam, a multipurpose structure completed by the U.S. Army Corp of Engineers in 1962 for the purposes of flood control, hydroelectric power, and recreation. The dam is located at river km 126, about 5 km northeast of Heber Springs, Cleburne County, Arkansas, at the crossing of State Highway 25. The impoundment formed by the dam has a shoreline of about 445 km and a surface area of 77,995 ha. Mean stream flow before impoundment of 31 cms has been altered to a variation between 0.62-248 cms.

Middle and upper reaches of the river flow within the Boston Mountain Plateau section of the Ozark Plateau Province with rocks of Mississippian and Pennsylvanian age. The Boston Mountain escarpment is capped by the resistant sandstone of the Atoka formation, which is the surface rock over most of the area (Croneis, 1930). The mountains form a rugged east-west belt across northern Arkansas and eastern Oklahoma, attaining elevations in excess of 670 m. The rocks of this region, in contrast to carbonate rocks of the Salem and Springfield Plateaus immediately to the north, are predominantly sandstone and shales (Thornbury, 1965).

Climax vegetation in the area is primarily oak-hickory. Most aquatic plants in the stream were *Fontinalis novaeangliae* Sull., *Elodea densa* (Planchon) Marie; Vict., *Porella pinnata* L., and *Potomageton* sp.

Three stations were established within T10N,R9W for the study. Station 1 is located in the north central portion of Sec. 7 at an elevation of 85 m and about 500 m downstream from the dam. Station 2 is located 14 km downstream from Station 1 at the junction of Sec. 16, 17, 20, and 21, where State Highway 110 crosses the River. Elevation at Station 2 is 78 m, a drop of 7 m from Station 1, or a drop of 0.5 m/km. Station 3 is located at Libby, an abandoned quarry, 9 km downstream from Station 2, in the NW ¼ of Sec. 34 at an elevation of 74 m. This represents a fall of 4 m from Station 2, or 0.44 m/km.

MATERIALS AND METHODS

Benthic macroinvertebrates and physicochemical data were collected at six-week intervals from 27 March 1971, through 8 January 1972. A total of eight collections were taken, with pool and riffle habitats sampled at each station.

Physicochemical procedures and determinations measured were: dissolved oxygen and temperature by the Hydrolab II B, carbon dioxide and alkalinity by standard limnological methods (Welch, 1948), hydrogen ion concentration by a Photovolt digital pH meter, and current velocity by timing a floating object over a known distance. Turbidity was not measured because of the clear nature of the stream.

Of 184 benthic samples collected, 144 were analyzed quantitatively and 40 qualitatively. On each sampling date three pool benthic samples were collected at each station along the edge of the pool with a 0.15 x 0.15 m Ekman dredge and the values were averaged. Samples were sieved with a benthic screen of 11.8 sq/linear cm. Three riffle samples were collected along a transect of the stream with a Surber sampler of 0.1 m^2 sample size and were averaged. Quantitative samples were preserved in 10% formalin. Qualitative or random samples were collected along the pool and riffle habitats by use of a small mesh dip net, and organisms were preserved in 70% ethanol. The random collections were standardized by length of time sampled.

RESULTS

Parameters studied are listed in Table 1. Water surface temperature of the stream demonstrated the cold nature of the water throughout the year with a range of 6.5-18.0 C, and a mean value of 10.9 C. Water temperature at 0.6 m was similar to surface temperatures. Temperatures moderated downstream from a mean of 8.6 C at Station 1 to a mean of 11.8 C at Station 3.

Surface dissolved oxygen values ranged from 4.8-11.4 ppm with a mean of 8.4 ppm. Dissolved oxygen concentrations increased from Station 1-3. Carbon dioxide concentrations were low with a range of 2.0-8.0 ppm and a mean of 5.0 ppm. There were no differences in carbon dioxide concentrations among stations.

Total alkalinity readings were uniform among stations and ranged from 56-88 ppm with a mean of 76 ppm. Phenolphthalein alkalinity was never present. Hydrogen ion concentrations were slightly alkaline with a pH range of 7.1 to 7.8. The mean for pH was 7.4. Similar readings were noted at each station sampled.

Current velocities in the riffles varied from station to station depending upon the width of the riffle, amount of runoff, and confluences of small tributaries downstream. All samplings were collected during periods of minimum or near minimum discharge from the dam. Current velocity varied from 0.5 m/sec at Station 2 to 1.2 m/sec at Station 3. Mean values were 0.69, 0.56, and 0.95 m/sec respectively at Stations 1, 2, and 3.

The benthic macroinvertebrate fauna of Little Red River was relatively restricted as to taxa collected. A total of 59 taxa were collected from all stations combined (Tables 2, 3). The most dominant organisms in pool and riffle areas were oligochaetes, chironomids, and isopods, in that order. Oligochaetes were the most abundant organism in the pools, while isopods were more abundant in the riffles. Station 1 provided 15 taxa, 11 of which were collected in quantitive samples (Table 2). A mean numerical standing crop of 1,241 organisms/ m^{-2} (0.1m^2) was collected from Station 1. Oligochaetes composed 62% of total organisms in the pool, or 1,618/m^{-2}. Chironomids of the pool had a mean of 773 organisms/m^{-2}. The riffle habitat of Station 1 provided 47 organisms/m^{-2}, of which isopods were 62% and chironomids 18%.

Station 2 had greater diversity than Station 1 with 32 taxa collected. Sixteen taxa were collected in quantitative results (Table 2). Mean numerical standing crop at Station 2 was 437 organisms/m^{-2}. In the pool, oligochaetes had a mean standing crop of 542/m^{-2} and constituted 79% of total organisms collected. Chironomids in the pool had a standing crop mean of 92/m^{-2}. The average number of riffle organisms at Station 2 was 23/m^{-2}, with isopods constituting 37% and chironomids 24% of the organisms collected.

Station 3 had greater diversity than Station 2 (Tables 2, 3). A total of 41 taxa were collected with 25 collected in quantitative samples and 16 in the qualitative samples Mean numerical standing crop for this station was 681 organisms/m^{-2}. Oligocheates were the prevalent pool organisms with a mean of 1.017/m^{-2}, and constituted 78% of the organisms collected. Pelecypods were the second most abundant taxon with a mean of 52/m^{-2}, or 5% of the organisms collected. Chironomids had a mean numerical standing crop of 38 organisms/ m^{-2}. Isopods were the dominant riffle organisms. The isopod standing crop was 82/m^{-2}, which composed 81% of the riffle organisms collected.

The percentage of oligochaetes increased at Stations 2 and 3, although there was a decrease in number/m^{-2}. This increase in percentage was due primarily to the drop in mean numbers of chrionomids downstream.

DISCUSSION

A limited number of investigations in the unique habitats of Ozark Plateau streams have been conducted (Robison and Harp, 1971; Case, 1970); however, more information is being published on natural, free flowing streams of northern Arkansas. There are a few publications dealing with cold tailwaters below large impoundments. Brown *et al.* (1967), Blanz *et al.* (1969), and Hoffman and Kilambi (1970) studied the cold tailwaters of some reservoirs in northwestern and extreme northern Arkansas; no study is known to have been conducted on Greer's Ferry tailwater.

Little Red River below Greer's Ferry Dam is characterized by cold, nonturbid, swift flowing water with daily flooding. The extent of flooding depends upon the amount of water released for generation of hydroelectric power. Maximum discharge of 248 cms has the potential of raising the tailrace level 3.7 m above minimum discharge levels.

The river water temperature is adequate to support a population of trout. Trout streams do not normally exceed 24 C maximum summer temperatures (Kendeigh, 1961). Rainbow trout, *Salmo gairdneri*, are stocked during the months of April-October by the Bureau of Sport Fisheries and Wildlife for a distance of 44 km downstream, or to 21 km below Station 3. Temperatures taken at depths of 0.6 m varied slightly from that of the surface. Reid (1961) indicated that stream temperatures in quiet pools will stratify, but stratification in this stream is not likely to occur appreciably except during long periods of minimum discharge.

Dissolved oxygen was not a limiting factor despite decreased oxygen values at lower depths of the reservoir. Deep impoundments with high concentrations of organic matter result in oxygen depletion due to respiration and lack of sunlight. In extreme cases oxygen concentration drops to zero in the lower strata (Ruttner, 1953). Upon discharge, physical aeration allows oxygen values to increase abruptly. Even though oxygen values normally vary inversely with temperature, the results of this study yielded somewhat higher oxygen readings at lower stations where temperature increased. This probably resulted from further oxygenation through continued turbulence in the stream, and water temperatures at lower stations still remained low enough to support relatively high concentrations of oxygen. Percent saturation ranged from 38-100% at Station 1 and 50-120% at Station 3.

Carbon dioxide concentrations may be directly related to physical aeration. Relatively low values are indicative of turbulence which allows rapid escape of carbon dioxide. No differences were noted in variations among stations.

Methyl orange alkalinity values were substantially lower than those reported by Case (1970) and Robison and Harp (1971) in studies of smaller Ozark streams; however, the location of the Little Red drainage basin in the Boston Mountain region excludes it from the predominance of carbonaceous deposits. Alkalinity values were somewhat less but comparable to those reported by Hoffman and Kilambi (1970) in studies of the Beaver Reservoir tailwater. Pre-impoundment alkalinity values are not available for Little Red, but Pfitzer (1962), in studies on reservoirs in the TVA System, found marked reduction in concentrations of the same streams after impoundment. Slight increases were noted in this study from Station 1-3 with a corresponding decrease in hydrogen ion concentration, which may be influenced by downstream tributaries.

Current velocities reported approximate minimum values since collections were made at near minimum discharges. Kindeigh (1961) suggested that a stream is considered swift flowing with velocities of 0.5 m/sec and greater. Little Red River, at minimum discharge, falls within his classification of swift flowing with a minimum value of 0.5 m/sec. The riffle velocities at Station 2 were somewhat less than at Stations 1 and 3 (Table 2). Riffle 2 was much wider, and the gradient was not as steep as those at Station 1 and 3. The substrate at Station 2 riffle consisted of small stones, gravel, and some very large sand particles. Substrates at Stations 1 and 3 were predominately larger stones and cobbles, again indicating greater current velocity.

Studies of natural free flowing streams show greater diversity characterized by numerous taxa unless influenced by some intrinsic or extrinsic factors. Comparative values among stations lead one to believe that the benthic macroinvertebrate community of Little Red River is qualitatively limited, since Janes Creek supported 100 taxa (Case, 1970). Spence and Hynes (1971), in a study above and below an impoundment on the Grand River revealed much greater diversity above the reservoir than below the cold water outlet. The cold nature of the tailwater and the drastic fluctuation in daily water level are two major factors tending to restrict the diversity of organisms in this stream. Neel (1963) indicated benthic fauna are adversely affected by flow variations that intermittently or periodically expose large areas of substrate. Natural streams, with a more stabilized substrate, allow more suitable habitats for increased diversity.

The numerical standing crop of pool macroinvertebrates was much greater than that of the riffles. This observation was in agreement with the results of Case (1970), but differed from those of Aggus and Warren (1965), and Robison and Harp (1971). Pools normally support fewer species than riffles because of fewer niches. Often in the relative absence of competitor or predator species, the forms present will establish relatively large populations. Oligochaetes and chironomids were the most abundant pool organisms and one may be puzzled by the existence of these in a stream of high discharge rates. They were found in detrital deposits along the edge of pools away from the strongest currents in the stream. Pool substrates near midstream were composed of cobbles and could not be sampled. Hoffman and Kilambi (1970) reported dominant organisms in the tailwater of Beaver Reservoir, a similar cold water situation, as chironomids and oligochaetes, in that order.

Longitudinal zonation was evident as 15, 32, and 41 taxa were collected at Stations 1, 2, and 3, respectively. Increased diversity of taxa downstream was reported by Sublette (1956), Robison and Harp (1971), and Case (1970). Increased species diversity was attributed to greater availability of niches and increasing diversity of microhabitats. Water temperature cannot be discounted as contributing to the increase, since this physical feature moderated downstream, and other physical and chemical features were found to be not limiting.

Seasonal variation among stream benthos of the northern temperature zone normally show numerical maxima during late fall and winter (Sublette, 1956; Hynes, 1963). Species of Ephemeroptera and Plecoptera long with *Crangonyx gracilis* showed this trend, but some other forms did not. Chironomids showed numerical maxima during July for Stations 1 and 2 and a peak in May at Station 3. Seasonal trends were probably altered by the pattern of discharge and subsequent scouring action of the stream. In addition, the predominant group, oligochaetes, as non-emergent, perennially aquatic forms, do not fluctuate numerically in definite seasonal patterns. In this study, changes in oligochaete numbers were random.

Oligochaetes were highest numerically at Station 1. Numerical values dropped at Station 2 but increased again at Station 3.

Of the four genera of chironomids found, *Stictochironomus* was the dominant pool form with *Glyptotendipes* being found but once (Table 3). Chironomid numbers were observed to decrease markedly downstream from Station 1. Water temperature may have been responsible for this phenomenon since it has been shown that chironomid numbers decrease with rising temperatures. Increased predation and competition may also have attributed to their numerical declines.

The isopod *Lirceus hoppinae* was the dominant riffle form, composing 90-95% of the total benthic fauna. Pennak (1953) reported that isopods seldom come into open water but remain secreted under rocks and vegetation. They are scavengers and feed upon any available food including aufwuchs.

Mollusks were not abundant but Pelecypods did increase significantly in Station 3 pool to become the second most abundant organism. Again, water temperature may have been limiting to suppress higher numerical values upstream since other measured parameters were not limiting.

The only amphipod found, *Crangonyx gracilis*, showed an increasing trend in numerical values during November and January. This species is an inhabitant of cooler water, and was reported in the study by Spence and Hynes (1971) as being found below a dam with cold water release.

Ephemeroptera and Plecoptera were not well represented, neither by total numbers nor diversity. Stream fluctuations and temperature probably limit their existence. All taxa identified in this study are typically found in small to moderately sized rivers with fairly rapid flow (Burks, 1953).

Random sampling added several taxa of Coleoptera and Hemiptera in the pools (Table 3). These were found secluded in vegetation, leaves, and detritus of somewhat protected areas away from swift currents.

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Table 1. Physicochemical characteristics expressed as mean values for eight determinations, Stations 1, 2 and 3 Pools, Little Red River, 27 March 1971 - 8 January 1972.

Station	Temp. C		Dissolved Oxygen ppm		CO_2 ppm	MO Alkalinity mg/l $CaCO_3$	pH	Current*** m/sec
	S*	B**	S	B				
1	9.0	8.6	7.6	7.0	4.9	73.5	7.4	0.7
2	11.9	11.5	8.6	8.1	5.1	72.5	7.4	0.6
3	13.1	11.6	9.2	9.2	5.0	78.5	7.5	0.9

*Surface.
**Depth.
***Riffle.

Table 2. Benthic macroinvertebrates expressed as no/m-^{2}, Stations 1, 2 and 3, Little Red River, 27 March 1971 - 8 January 1972.

TAXA	1		2		3	
	P*	R	P	R	P	R
HYDROZOA						
Hydra	0	1**	0	0	0	0
TURBELLARIA						
Dugesia tigrina (Girard)	1	0	1	1	1	3
OLIGOCHAETA	1618	1	678	2	1017	1
HIRUDINEA						
Dina parva Moore***	0	0	6	1	4	1
GASTROPODA	3	1	11	3	22	4
PELECYPODA	10	0	43	1	76	1
ISOPODA						
Asellidae	1	59	2	8	2	82
AMPHIPODA						
Crangonyx gracilis Smith	2	1	23	2	27	2
PLECOPTERA						
Taeniopteryx nivalis (Fitch)	0	0	0	1	0	1
Isoperla confusa Frison	0	0	0	0	0	1
EPHEMEROPTERA						
Pseudocleon myrsum (Burks)	0	1	0	1	0	1
Pseudocleon sp.	0	0	0	0	0	1
Stenonema tripunctatum (Banks)	0	0	0	1	0	1
Epeorus namatus Burks	0	1	0	1	0	0
Ephemerella invaria (Walker)	0	0	0	0	0	1
E. simplex McDunnough	0	0	0	0	0	1
HEMIPTERA						
Trichocorixa calva (Say)	0	0	0	0	1	0
ODONATA						
Ischnura	0	0	0	0	0	1
TRICHOPTERA						
Pycnopsyche	0	0	0	0	1	0
Ptilostomis	0	0	0	0	1	0
Limnephilis	0	0	1	0	0	0
LEPEDOPTERA						
Nymphula	0	0	0	0	1	0
COLEOPTERA						
Haliplus fasciatus Aube	0	0	0	1	1	1
Dineutus assimilis Kirby	0	0	1	0	0	0

*P — Pool.
R — Riffle.
**1 or less than 1.
***The Erpodbellidae are in need of a revision especially in the southern states. The species of *Dina* represented here has a conspicuous male bursa which was located on the ring, and the female gonopore was always located 2½ annuli posterior to the male gonopore, in the furrow.

TAXA	1		2		3	
	P	R	P	R	P	R
Berosus sp.	0	0	1	0	0	1
Enochrus sp.	0	0	0	0	0	1
DIPTERA						
Chironomidae	773	14	92	6	38	2
Limnophora aequifrons Stein	0	1	0	0	0	0
Tabanus	0	0	0	0	1	0
Simulium	0	0	0	0	1	0
Total/ m^{-2}	2406	75	856	23	1187	99

Table 3. Benthic macroinvertebrates collected in qualitative samples only, Stations 1, 2 and 3, Little Red River, 27 March 1971 - 8 January 1972.

TAXA	1		2		3	
	P	R	P	R	P	R
ISOPODA						
Lirceus hoppinae (Faxon)	X	X	X	X	X	X
Asellus brevicaudus Forbes	X	X	-	X	-	X
DECAPODA						
Orconectes	-	-	-	X	-	-
EPHEMEROPTERA						
Ephemerella temporalis McDunnough	-	-	X	-	-	-
HEMIPTERA						
Trichocorixa kanza Sailer	-	-	-	-	X	-
Gerris marginatus Say	X	-	-	-	-	-
G. canaliculatus Say	-	-	-	-	X	-
Sigara alternata (Say)	-	-	X	X	X	X
Hesperocorixa lucida Abbott	-	-	-	-	X	-
Mesovelia mulsanti White	-	-	-	X	-	-
Rhagovelia knighti Drake and Harris	-	-	-	-	-	X
Notonecta	-	-	X	-	X	-
MEGALOPTERA						
Sialis	-	-	X	-	-	-
LEPIDOPTERA						
Elophila	-	-	-	-	X	-
COLEOPTERA						
Hydrocanthus iricolor atripennis Say	-	-	-	-	X	-
Hydroporus	-	-	-	-	X	-
Helophorus	-	-	-	-	X	-

TAXA	1		2		3	
	P	R	P	R	P	R
Gyrinus affinis Aube	-	-	-	-	X	-
Tropisternis lateralis nimbatus (Say)	-	-	X	-	X	-
Tropisternis mexicanus striolatus LeConte	-	-	-	-	X	-
Haliplus triopsis Say	-	-	X	-	-	-
Coptotomus	-	-	X	-	-	-
Galerucella	-	-	-	-	-	X
DIPTERA						
Tipula	-	-	-	X	-	-
Limonia	-	-	-	X	-	-
Stictochironomus	X	-	X	-	X	-
Glyptotendipes	-	X	-	X	-	X
Cricotopus	-	X	-	X	-	-
Diamesa	-	-	-	-	-	X
GASTROPODA						
Physa elliptica Lea	X	-	X	X	X	-
Gyraulus parvus Say	-	-	X	X	-	-
PELECYPODA						
Musculium securis Prime	-	-	X	-	-	-
Pisidium compressum Prime	-	-	-	-	X	-
P. variabile Prime	X	-	X	-	X	-

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