THE AQUATIC MACROFAUNA AND WATER QUALITY OF COTTONWOOD CREEK, OKLAHOMA

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In a study of the aquatic macrofauna of Cottonwood Creek, Oklahoma, in November 1978, we used seines, an electroshocker, and an Ekman dredge to collect 26 fish species and 50 macroinvertebrate taxa. The predominant fishes were gizzard shad (*Dorosoma cepedianum*), plains minnow (*Hybognathus placitus*), emerald shiner (*Notropis atherinoides*), red shiner (*N. lutrensis*), sand shiner (*N. stramineus*), mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), orangespotted sunfish (*L. humilis*), and longear sunfish (*L. megalotis*). Two relatively distinct fish communities were apparent; one associated with the lower reaches of Cottonwood Creek and Cimarron River and the other with the small stream habitat of upper Cottonwood Creek and tributaries. Dragonfly naiads, giant water bugs, whirligig beetles, and water scavenger beetles were the predominant insects; Oligochaetes and chironomids characterized the benthos. The fauna was typical of that in lotic habitats of central Oklahoma and was principally composed of forms that are tolerant of organically enriched water.

INTRODUCTION

This study was conducted to provide ecological data that would serve as the basis for an environmental assessment of two potential sites for water supply dams on Cottonwood Creek, Oklahoma. The study, which was part of a broader ecological and land-use survey, consisted of a literature review and short-term field sampling. Before the present study, there were no published accounts describing the aquatic macrofauna of Cottonwood Creek. This study should help to fill a gap in the data base for central Oklahoma.

STUDY AREA

The Cottonwood Creek watershed is in central Oklahoma — primarily in Logan County, but including parts of Canadian, Kingfisher, and Oklahoma counties. It drains about 1000 km^2 of predominantly cropland and pastureland; a relatively small percentage of forest land is confined mainly to riparian areas. The main tributaries are Deer, Soldier, Walnut, Bluff, Chisholm, Cow, Blood Rush, and Wolf creeks. Cottonwood Creek drains to the northeast, emptying into the Cimarron River, which is part of the Arkansas River drainage basin.

The study area lies in the broad, rolling area of the Central Lowland Province, locally known as the Central Reddish Prairies, in the southern part of the tall-grass prairie (1). Elevations of the Reddish Prairies range from 300 to 425 m above mean sea level. The eastern part of the study area is on the fringe of the Cross Timbers area.

MATERIALS AND METHODS

Nine sites were sampled for aquatic organisms and habitat characterization. Two sites were on the Cimarron River — one downstream (station 1) and one upstream (station 2) from its confluence with Cottonwood Creek. Five sites (stations 3, 4, 5, 8, and 9) were on Cottonwood Creek. Station 6 was on Chisholm Creek and station 7 on Deer Creek. Sampling was done on 2-5 November 1978.

At each sampling site field determinations of water temperature, dissolved oxygen, and conductivity were made with a Hydrolab Corp. Model 8000 Water Quality System. Turbidity, in nephelometric turbidity units (NTU), was measured in the laboratory from field samples with a Hach Model 2100A turbidometer. Stream width, depth, and current velocity were determined by direct measurement, and discharge rates were determined as described by Hynes (2).

We collected at each station with two 6-mm-mesh seines (7.6 × 1.8 m and 3.0 × 1.2 m), by electroshocking (230 V AC), and by two replicate grabs of an Ekman dredge (15 × 15 cm). The electroshocker was not used at the Cimarron River stations because of high conductivity of the water. Present address: Ohio Cooperative Fishery Research Unit, The Ohio State University, 1735 Neil Avenue, Columbus, Ohio 43210.

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Organisms were preserved in the field in 10% buffered formalin. In the laboratory fish were sorted to species, counted, and their total length measured to the nearest millimeter. Where considerably more than 100 fish of a species were collected at a station, a random subsample of at least 100 was measured. Macroinvertebrates were sorted to the lowest practical taxon (usually genus or family) and counted. The numbers of macroinvertebrates collected by seining provided only gross estimates of their relative abundance because seining is suited primarily for collecting fish.

We used cluster analysis to examine associations among stations and fishes collected. (Macroinvertebrates data were too sparse to be analyzed in this fashion.) We adopted the Bray-Curtis dissimilarity measure for the analysis, using a flexible sorting strategy with the cluster intensity coefficient set at -0.25, following the recommendation of Clifford and Stephenson (3). To reduce the bias of a few disproportionately high values, we performed a cube root transformation on the data for analysis of station associations. For analysis of species associations, we applied a normal standardization (dividing by the standard deviation) in addition to the cube root transformation. The results of the cluster analysis were displayed as dendrograms, one for stations and one for species, combined with a two-way contingency table to show the relation among station and species clusters. Because no satisfactory statistical methods are now available, major clusters or groups were separated on the basis of the degree of dissimilarity shown in the dendrograms and the two-way table. Cluster analysis was performed by using the program CLASS developed by Dr. Robert Smith of the University of Southern California and installed at the Texas A&M University Data Processing Center.

RESULTS AND DISCUSSION

Water Quality

Water quality data were available from a U.S. Geological Survey gauging station located on Cottonwood Creek near Seward, Oklahoma. Data for temperature, discharge rate, conductivity, dissolved oxygen, percent oxygen saturation, and chemical oxygen demand were examined for 1973 through early 1978. Water temperatures showed cyclic seasonal trends, with summer highs near 25 C and winter lows approaching 0 C. Seasonal discharge rates were less predictable than temperatures. The period from fall 1975 through spring 1977 was characterized by relatively low flow. Conductivity values, like discharge rates, were variable, averaging about 1000 micromhos/cm^2, and were inversely related to flow. Dissolved oxygen concentration and percent oxygen saturation were generally lowest during summer. Dissolved oxygen generally ranged between 2.0 and 13.0 mg/*l*. Chemical oxygen demand was relatively constant during the period.

Our sampling effort was preceded by a protracted period of low rainfall; thus stream levels and flow rates were relatively low. In Cottonwood Creek, flow rates ranged from 0 to 0.13 m^3/s. No flow could be detected by our methods at Stations 3 and 8, and the greatest rates (0.13 m^3/s) were measured at Station 6 (Chisholm Creek) and (0.043 m^3/s) at Station 7 (Deer Creek). Sewage treatment plants on these two tributaries accounted for most of their flow. In the Cimarron River, flow rates were 0.086 m^3/s upstream from the confluence with Cottonwood Creek (station 2) and 0.15 m^3/s downstream (station 1).

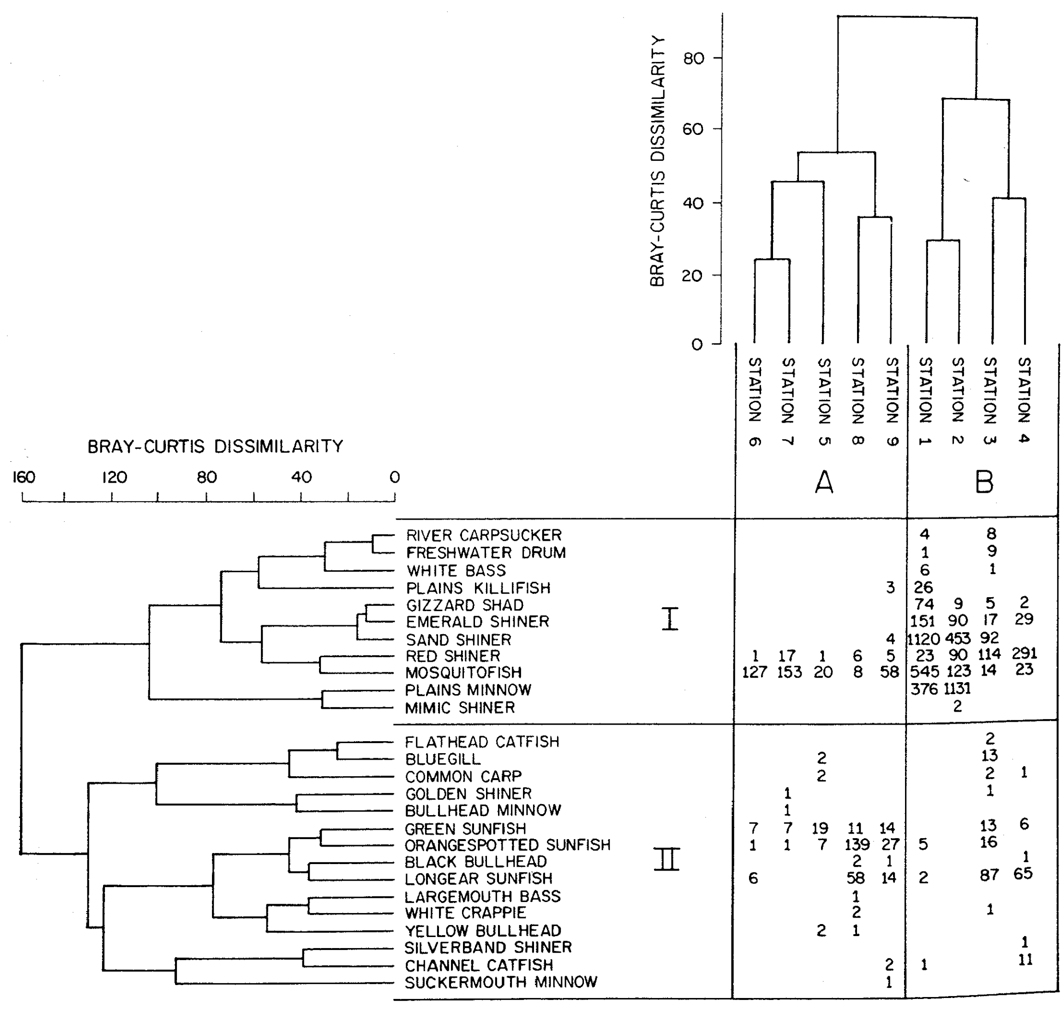
Because of the low flow rates and high air temperatures (near 20 C), water temperatures in the study area were high for the season. Temperatures ranged from 12.9 to 17.2 C in the Cottonwood drainage area and from 17.3 to 21.9 C in the Cimarron River. The low temperature reading (12.9 C) at Station 8 was probably due to low incident solar radiation; the tree canopy was fairly heavy, and the water was still and deep. Conductivity which was also relatively high — probably the result of the low flow rates — ranged from 1400 to 2000 micromhos/cm^2 in Cottonwood Creek and from 9000 to 12,700 in Cimarron River. Turbidity values ranged from 3 NTU at the upper Cottonwood Creek station (9) to 40 NTU in Cimarron River (Station 2) above the Cottonwood Creek confluence. These values are relatively low, but certainly not indicative of clear water.

Dissolved oxygen concentrations ranged from 1.57 to 7.73 mg/*l* and percent oxygen saturation from 16 to 89%. The lowest values were at stations 8, 7, and 3. These low values were probably the result of low flow and high nutrient loading from sewage treatment plants. High oxygen values were recorded from Cottonwood Creek above the influence of the sewage treatment plants (Station 9), and from the Cimarron River stations (1 and 2).

Fish

The reported ranges of 39 fishes include the Cottonwood Creek watershed and the Cimarron River near its confluence with Cottonwood Creek (4, 5). An additional 18 species are reported to occur elsewhere in the Cimarron River drainage and thus may also occur in the study area. Our sampling resulted in the collection of 5,789 fish of 26 species. Nine species — the gizzard shad (*Dorosoma cepedianum*), plains minnow (*Hybognathus placitus*), emerald shiner (*Notropis atherinoides*), red shiner (*N. lutrensis*), sand shiner (*N. stramineus*), mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), orangespotted sunfish (*L. humilus*), and longear sunfish (*L. megalotis*) — made up over 98% of the total catch. These nine species are common to small streams and back waters of this region (5).

Cluster analysis illustrates the relation between stations and species composition. Two major clusters of stations are apparent (Fig. 1). Cluster A is composed of stations



	Station 6 (A)	Station 7 (A)	Station 5 (A)	Station 8 (A)	Station 9 (A)	Station 1 (B)	Station 2 (B)	Station 3 (B)	Station 4 (B)
RIVER CARPSUCKER						4		8	
FRESHWATER DRUM						1		9	
WHITE BASS						6		1	
PLAINS KILLIFISH					3	26			
GIZZARD SHAD						74	9	5	2
EMERALD SHINER						151	90	17	29
SAND SHINER					4	1120	453	92	
RED SHINER	1	17	1	6	5	23	90	114	291
MOSQUITOFISH	127	153	20	8	58	545	123	14	23
PLAINS MINNOW						376	1131		
MIMIC SHINER							2		
FLATHEAD CATFISH								2	
BLUEGILL			2					13	
COMMON CARP			2					2	1
GOLDEN SHINER		1						1	
BULLHEAD MINNOW		1							
GREEN SUNFISH	7	7	19	11	14			13	6
ORANGESPOTTED SUNFISH	1	1	7	139	27	5		16	
BLACK BULLHEAD				2	1				1
LONGEAR SUNFISH	6			58	14	2		87	65
LARGEMOUTH BASS				1					
WHITE CRAPPIE				2				1	
YELLOW BULLHEAD			2	1					
SILVERBAND SHINER									1
CHANNEL CATFISH					2	1			11
SUCKERMOUTH MINNOW					1				

FIGURE 1. Cluster analysis dendrograms and two-way contingency table for fish collected from the Cottonwood Creek Watershed and adjacent waters of the Cimarron River, Logan County, Oklahoma. Values presented in the two-way contingency table are the number of fish collected at each station.

TABLE 1. *Number of benthic macroinvertebrates collected by Ekman dredge and relative abundance of macroinvertebrates collected by seine from the Cottonwood Creek Watershed and adjacent waters of the Cimarron River, Logan County, Oklahoma.*

	STATION								
TAXA	1	2	3	4	5	6	7	8	9
Oligochaeta									
Branchiura sowerbyi				2	2		182	5	
Dero digitata						6			
Limnodrilus sp.			4		13	268	258	9	9
Nais communis						1			
Hirundinea						a	2[a]		
Helobdella sp.						3	3		
Gastropoda						a			
Physa sp.						2			
Pelecypoda									
Sphaeriidae						1			
Unionidae				1					
Amphipoda									
Hyalella azteca						7			
Decapoda									
Orconectes nais			a	a	a	a	1[a]	a	a
Ephemeroptera									
Cloeon sp.						1			
Hexagenia limbata							1	8[a]	a
Odonata									
Nasiaeshna sp.						a			
Coenagrionidae						a			
Erpetogomphus sp.									a
Gomphus sp.	a	a							a
Progomphus sp.	b	b							b
Perithemis sp.						4[a]	1		
Plathemis sp.						a	a		
Argia sp.		1							
Hemiptera									
Belostoma sp.						a			a
Corixidae				a		b	b		
Gelastocoris sp.									a
Gerris sp.									a
Trichocorixa sp.							1		
Coleoptera									
Hydroporus sp.							1		
Berosus sp.	3								
Dubiraphia sp.									1
Dineutus sp.		b		b					
Hydrophilidae				a		b	a	a	a
Trichoptera									
Cheumatopsyche sp.					1				
Diptera									
Tipulidae									1
Chaoborus punctipennis								16	
Ceratopogonidae		1				1	3		
Alabesmyia sp.								1	
Chironomus sp.	1					11	151		
Cryptochironomus sp.			3	1					
Dicrotendipes sp.	1					17			
Kiefferulus sp.							2		
Parametriocnemus sp.									1
Pentaneurini				1					
Polypedilum sp.		1		1					
Procladius sp.						1	22	1	
Psectrocladius sp.	1								
Tanypus sp.						2			
Tanytarsini						1			
Trissocladius sp.									4
Xenochironomus sp.								1	
Tabanidae	a								

[a]Fewer than 10 collected by seine
[b]10 or more collected by seine

5, 6, 7, 8, and 9; those located on upper Cottonwood Creek and tributaries. Within this cluster, Stations 6 and 7 are most similar; these are most closely allied with Station 5, while Stations 8 and 9 are most similar to one another. Within Cluster B the Cimarron River stations (1 and 2) are most closely allied, and the two lower Cottonwood Creek stations (3 and 4) group together. Because of the small number of collections (9), species associations, based on cluster analysis, were difficult to discern. There are two major clusters. Species Cluster I is characterized mainly as those species with the strongest association with Station Cluster B, and species Cluster II with Station Cluster A. Although this characterization of the species clusters represents a considerable generalization, two distinct communities seem apparent; one is associated with the Cimarron River and lower Cottonwood Creek, and the other with the small stream habitat of the upper reaches of Cottonwood Creek and tributaries.

The four sample sites representing Station Cluster B (lower Creek and River) accounted for 87% of the fish collected. The principal species at these stations included gizzard shad, plains minnow, emerald shiner, red shiner, sand shiner, and mosquitofish. Gizzard shad were collected only from these four stations. Most were collected at Station 1, where they ranged in total length from 102 to 211 mm. Those collected at the other stations were well within this size range. The emerald shiner was also only collected at these stations. They ranged between 37 and 78 mm total length. Plains minnows, collected exclusively from the Cimarron River, were 26 to 96 mm long; those from station 2 (upstream) were somewhat smaller than those from station 1. Sand shiners (19-79 mm) were collected at Stations 1, 2, 3, and 9. Red shiners (21-66 mm) and mosquitofish (11-53 mm) were collected at all stations, but most came from stations in Cluster B. Miller and Robison (5) characterize all five of these species as widely distributed forms common to central Oklahoma sandy-bottom streams and rivers.

Green, orangespotted, and longear sunfishes were principally collected at the sites comprising Station Cluster A. However, they were found throughout the drainage (except at Station 2). The general lack of good sunfish habitat (backwater, cutbanks, deep holes, etc.) was probably the reason for the paucity of sunfish at Station 2. Young-of-the-year and yearling or older fish of all three species were generally present at most stations. These three sunfishes are widely distributed and are typically inhabitants of small streams or quiet pools and ponds (5).

Macroinvertebrates

Eighteen recognizable taxa of macroinvertebrates were collected along with the fish (Table 1). Leeches (*Hirundinea*) and snails (*Gastropoda*) were collected exclusively at Stations 6 and 7, Chisholm and Deer Creeks. The genera collected are often associated with organically enriched or polluted waters (6). Crayfish (*Orconectes nais*) were collected from all stations within the Cottonwood Creek drainage and were generally indicative of muddy substrates. The rest of the macroinvertebrates represented aquatic insects and insect larvae. The common forms were typical of those found in other Oklahoma streams (7, 8). The dragonflies (*Odonata*) of the family Gomphidae were generally associated with the sandy substrates of the Cimarron River (Stations 1 and 2) and portions of upper Cottonwood Creek (Station 9). None of the more abundant insects collected are considered especially characteristic of heavily polluted waters.

There were 38 different recognizable taxa of benthic macroinvertebrates collected from the study area with an Ekman dredge (Table 1). The number of organisms and taxa present at each of the stations was relatively small, except at Stations 6 and 7, Chisholm and Deer Creeks. The abundance of macrobenthos at Stations 6 and 7 was the result of the presence of large numbers of tubificid Oligochaetes (*Limnodrilus* sp. and *Branchiura sowerbyi*) and a chironomid, *Chironomus* sp. These forms are generally characteristic of organically enriched or polluted waters (6, 9). Leeches (*Hirundinea*) present only at Stations 6 and 7 also may be indicators of organic pollution (6).

Conclusions

The aquatic biota of the Cottonwood Creek watershed can be characterized as typical of that in other Oklahoma streams. The dominant inhabitants are relatively tolerant of organically enriched water — particularly red shiner, mosquitofish, sunfishes, and the abundant macroinvertebrates.

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REFERENCES

1. H. M. GALLOWAY, *Soil Survey of Logan County, Oklahoma.* U.S.D.A. Soil Conservation Service and Oklahoma Agric. Exp. Stn. Series 1948, No. 7, 1960.

2. H. B. N. HYNES, *The Ecology of Running Waters.* Univ. Toronto Press, 1970.

3. H. T. CLIFFORD, and W. STEPHENSON, *An introduction to numerical classification.* Academic Press, Inc., New York, 1975.

4. J. D. FELLEY, and E. G. COTHRAN, Southwest Nat. 25: 564 (1981).

5. R. F. MILLER, and H. W. ROBISON, *The fishes of Oklahoma.* Oklahoma State University Press, Mus. Nat. His., Ser. 1, Stillwater, 1973.

6. K. M. MACKENTHUN, *The practice of water pollution Biology,* U.S.D.I., Fed. Wat. Poll. Cont. Admn., Div. Tech. Supp., Washington, D.C., 1969.

7. W. K. REISEN, Proc. Okla. Acad. Sci. 55: 25-31 (1975).

8. J. WILHM, J. COOPER, and S. BURKS. Proc. Okla. Acad. Sci. 59: 85-88 (1979).

9. W. M. BECK, JR., *Environmental requirements and pollution tolerance of common freshwater Chironomidae.* U.S.E.P.A., Envir. Mon. Supp. Lab. Off. Res. Devel., Cincinnati, OH, Rpt. No. EPA-600/4-77-024, 1977.