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Ichthyofaunal Diversification and Distribution in an Ozark Stream in Northcentral Arkansas

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ABSTRACT

The distribution and diversity of the ichthyofauna of Arkansas are poorly known. This study is part of a continuing effort to elucidate the natural history of Arkansas. Big Creek is a relatively small, clear, cool-water stream in the Ozark Plateau of northcentral Arkansas. Big Creek and its tributaries drain into Lake Norfork, an impoundment on North Fork River. A total of 6,779 fish of 30 species was collected. Dominant pool species included **Notropis boops, Fundulus catenatus, F. olivaceus, Labidesthes sicculus,** and **Campostoma anomalum**; dominant riffle species included **Etheostoma spectabile, E. caeruleum, Notropis boops, Fundulus catenatus,** and **Campostoma anomalum.** The numerical standing crop ranged from 1.3 to 2.6 fish/m_2 in the pools and riffles, respectively. The relative uniformity of substrate and soil types throughout the watershed, and the absence of rooted aquatic plants, limited the diversity of species found. The concomitant reduction in competition and predation probably explains the relatively large numerical standing crop.

INTRODUCTION

Modern drainage and land clearing equipment is allowing conversion of wetlands to farmlands at an exponential rate (Holder, 1970). The industrial development of Arkansas is also accelerating. The environmental impact of these and related efforts is seen in every part of Arkansas, and it may be expected to intensify in the future. It is of immediate concern, therefore, that the natural history of Arkansas be documented before these changes become so widespread that the original biotic interrelationships cannot be discerned.

Big Creek is a relatively small, clear, cool-water stream contained entirely in Fulton County, in northcentral Arkansas, in the midst of the Ozark Mountains. Fishing pressure along the stream is light and it is used sparsely as a water source for cattle and swine. Shipman Creek is its only named tributary. The waters of Big Creek and its tributaries empty into Lake Norfork, an impoundment on the North Fork River constructed by the U. S. Army Corps of Engineers in 1944. The North Fork River is a tributary of the White River. Although no studies have been done on Big Creek itself, studies on similar tributaries of the White River have been done by Meek (1894), Keith (1964), and Cashner (1967).

The waters of Big Creek arise as three unnamed tributaries within 4-5 km of Viola. The stream flows 35.4 km through Fulton County and empties into Lake Norfork east of Elizabeth, Arkansas. Shipman Creek arises northwest of Viola and flows 6 km to its confluence with Big Creek southwest of Viola.

The stream channel averages 3.7 m in width. The predominant pool substrate is rocks 5-15 cm in diameter; the riffle substrate is coarse gravel. The stream banks are lined alternately with mixed forests of oak and hickory and pasture lands. No species of rooted aquatic plants were noted in the stream.

Elevation in the main channel of the stream drops from 283 to 198 m; mean gradient is 8.1 m/km. The topography of the watershed is developed over limestone and dolomite ridges of the Salem Plateau in the Ozark Mountain physiographic province (Fenneman, 1938). The dominant geologic units are Jefferson City dolomite and Powell limestone (Croneis, 1930).

The major soils adjacent to Big Creek and its tributaries are of the Razort-Pembroke and Agnos associations. Soils of the Razort-Pembroke association are deep, well-drained, moderately permeable, neutral to acid, loamy soils on level to gently sloping flood plains of terraces and streams. Soils of the Agnos association are deep, well-drained, slowly permeable, acid loamy soils on gently sloping ridgetops and moderately steep hillsides (SCS, 1972).

METHODS AND MATERIALS

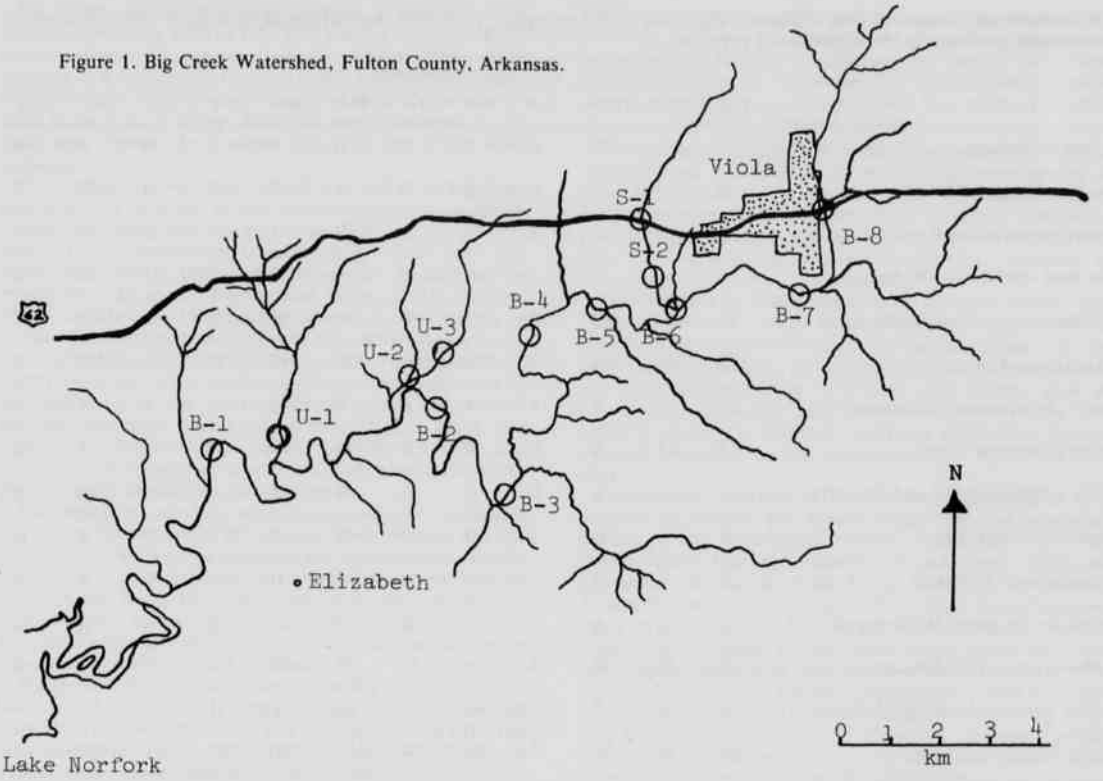
Thirteen stations were spaced appropriately for adequate coverage of the watershed. Eight were on Big Creek, two on Shipman Creek, and three on unnamed tributaries (Fig. 1). Each station was sampled three times. Sampling was standardized as to unit effort expended in seining at each station. The series were taken during 8-21 August 1970, 20-31 December 1970, and 4-9 April 1971.

On each sampling date, the following determinations were conducted at each station in both pool and riffle areas. Dissolved oxygen determination was by the sodium azide modification of the Winkler method (APHA, 1960). Analysis of alkalinity and carbon dioxide content was by standard limnologic procedures (Welch, 1948). A Beckman pH meter was used to determine the hydrogen ion concentration. Turbidity was determined with the aid of a Jackson turbidimeter and light penetration was determined by a Secchi disc. Water temperatures were determined by a centigrade thermometer and current speed was determined by timing a floating disk over a known distance.

Fish samples were procured by a 9.1x1.8-m seine with 0.5-cm bar measure mesh, a gill net 5.5x1.2 m with a 2.5-cm mesh, and a hoop net 0.8 m in diameter and 4.6 m long with a 3.8-cm mesh. The collected specimens were preserved temporarily in 10% formalin. After several days they were washed in water, identified, and preserved in 40% isopropyl alcohol. Nomenclature is in accordance with Bailey et al. (1970).

[1] Present address: Big Creek Resort, Route 1, Elizabeth, Arkansas.

Figure 1. Big Creek Watershed, Fulton County, Arkansas.



RESULTS

Big Creek and its tributaries were alkaline, range 40-232 ppm, mean value 132 ppm. No phenolphthalein alkalinity was present. Oxygen values varied seasonally from 6.0 to 13.8 ppm, but percentage saturation was always high (94-99%). Carbon dioxide was not detected at any station. The mean pH of the stream was 7.1, but ranged from 6.5 to 8.1. Current speed ranged from 10 to 61 cm/sec in the riffles. Turbidity was less than 25 ppm at all stations on all occasions.

Except for current, pool and riffle areas showed only slight differences in physicochemical conditions. No appreciable physicochemical differences were observed from station to station. Except for temperature readings (4-33.6 C) and oxygen values, seasonal variation was slight.

A total of 6,779 fish of 30 species was collected (Table I). The pools yielded 5,091 fish of 28 species; the riffles yielded 1,688 fish of 21 species. The mean density was 1.3 and 2.6 fish/m^2 in the pools and riffles, respectively. There were more fish per square meter in the riffles than in the pools at every station.

The pools at station B-7 yielded the largest number of fish with a total of 625 fish of 15 species. Other pools yielding large quantities of fish were at stations B-2, B-8, and S-1 with 609, 589, and 575 fish, respectively. Station U-2 yielded the lowest number of fish with only 108 being taken. On an areal basis station B-7 had the greatest density with 3.4 fish/m^2. Stations B-8, S-1, and S-2 yielded 2.1, 2.1, and 2.0 fish/m^2, respectively. The lowest density was 1.2 fish/m^2 at station B-1.

The highest yielding riffles on Big Creek and its tributaries were at station B-7, where 269 fish of seven species were collected. Other riffles yielding large numbers of fish were at B-3 (201) and B-1 (166). The greatest density was at station B-7, which yielded 5.6 fish/m^2. Other stations yielding a large number of fish per square meter were S-2 (3.9) and B-6 (3.6). The lowest number for a riffle was at station B-1, which yielded 1.1 fish/m^2.

Nine species limited strictly to the pools of Big Creek and its tributaries were *Notropis zonatus, N. telescopus, Lepomis humilis, Ictalurus natalis, I. punctatus, Micropterus salmoides, Moxostoma erythrurum, Erimyzon oblongus,* and *Esox lucius.* Species preferring the pool habitat are so designated in Table I. Of the six species found predominantly in riffle habitat, *Etheostoma blennioides* and *Cottus carolinae* were found only in the riffle.

Although most species were found throughout the watershed, 15 species were taken at three or fewer stations. Most of these were limited to a headwater environment (Table I).

DISCUSSION

Most Ozark streams flow through several soil types (Croneis, 1930). There are but two soil types in the Big Creek watershed and 10 of the 13 stations sampled lie within one of these, the Razort-Pembroke association. This factor and the sameness of the substrate at all stations probably account for the relative uniformity of the physicochemical data throughout the watershed. No correlations between physicochemical data and fish distribution could be demonstrated.

Table I. Number and Species of Fish Collected, Big Creek and Tributaries, Fulton County, Arkansas, 8 August 1970 - 9 April 1971 (*Predominantly pool forms, **Predominantly riffle forms).

Taxa	Stations												
	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	S-1	S-2	U-1	U-2	U-3
**Esox lucius* Linnaeus	0	1	0	0	0	0	0	0	0	0	0	0	0
**Erimyzon oblongus* (Mitchill)	0	0	0	0	0	0	3	0	1	0	0	0	2
**Hypentelium nigricans* (Lesueur)	0	2	5	1	0	1	0	1	4	2	0	0	0
**Moxostoma erythrurum* (Rafinesque)	0	6	2	3	0	2	8	0	0	1	0	0	3
**Campostoma anomalum* (Rafinesque)	13	34	19	20	12	6	30	35	24	43	62	84	215
**Notropis boops* Gilbert	107	366	292	169	236	104	510	249	195	12	223	0	4
**Notropis chrysocephalus* (Rafinesque)	16	9	5	14	4	0	5	0	1	1	4	0	3
**Notropis galacturus* (Cope)	8	41	0	0	0	0	0	0	0	0	9	0	1
**Notropis lutrensis* (Baird and Girard)	0	0	1	0	0	0	0	0	0	0	0	0	0
**Notropis telescopus* (Cope)	0	0	0	0	0	0	0	2	0	0	0	0	0
**Notropis zonatus* (Putnam)	0	0	3	0	0	0	0	0	0	0	4	0	0
***Phoxinus erythrogaster* (Rafinesque)	0	0	0	0	0	0	0	0	0	0	0	14	58
**Pimephales notatus* (Rafinesque)	0	0	26	36	56	12	28	23	0	7	0	0	0
**Semotilus atromaculatus* (Mitchill)	0	0	0	0	0	0	0	2	1	5	1	4	31
**Fundulus catenatus* (Storer)	61	25	21	7	26	14	111	191	307	31	81	10	157
**Fundulus olivaceus* (Storer)	21	44	29	57	107	26	71	96	92	47	24	2	6
**Labidesthes sicculus* (Cope)	194	116	34	82	17	33	46	0	0	75	54	0	0
**Ictalurus natalis* (Lesueur)	4	0	0	0	0	0	4	0	1	0	0	0	0
**Ictalurus punctatus* (Rafinesque)	1	0	0	0	0	0	0	0	0	0	0	0	0
**Lepomis cyanellus* Rafinesque	1	0	1	4	1	0	1	4	2	7	5	7	7
**Lepomis humilis* (Girard)	0	0	0	0	6	3	0	0	0	1	0	0	0
**Lepomis macrochirus* (Rafinesque)	1	3	0	2	4	1	3	1	5	4	5	0	3
**Lepomis megalotis* (Rafinesque)	9	13	33	10	0	17	12	12	20	11	0	0	1
**Micropterus dolomieui* Lacepede	2	10	4	2	4	8	3	1	1	2	4	1	0
**Micropterus salmoides* (Lacepede)	0	0	1	0	0	3	0	0	0	0	0	0	0
***Etheostoma blennioides* Rafinesque	0	0	0	0	3	0	0	0	0	0	0	0	0
***Etheostoma caeruleum* Storer	1	19	8	8	10	26	13	20	0	10	16	19	4
***Etheostoma spectabile* (Agassiz)	16	43	25	17	28	55	46	93	17	24	37	34	39
***Percina caprodes* (Rafinesque)	4	2	0	0	0	0	0	0	0	0	0	0	3
***Cottus carolinae* (Gill)	0	0	0	1	0	0	0	0	0	0	0	0	0
Totals	459	734	509	433	514	311	894	730	671	283	529	175	537

Big Creek and its tributaries contain a relatively large numerical standing crop of fish with limited diversity. Keith (1964) collected 72 species from the upper White River drainage of Arkansas and Cashner (1967) collected 108 species from the entire White River drainage, whereas 30 species were taken in the writers' survey. All of the species collected in this study were reported by Cashner (1967) for the White River drainage.

The continuity of substrate and soil type within the Big Creek watershed was reflected in the relative uniformity of species composition throughout the watershed. With the exception of station U-2, a headwaters tributary from which only nine species were taken, the number of species at each station ranged from 15 to 17. Burton and Odum (1945), Kuehne (1962), and Sheldon (1968) reported that there was normally an increase in the number of species as one moved downstream. This was not the case in the Big Creek watershed because of the reappearance of similar habitat, an observation supported by the uniformity of the physicochemcial data. Longitudinal zonation, therefore, should not be thought of in terms of a uniform, continuous change, because specific conditions and populations may reappear at intervals, as was indicated by the discontinuous distribution of some species.

The absence of rooted aquatic plants accentuates the pattern of uniform distribution of fish species. Their absence was due to the coarse nature of the substrate and rapid current. Similar results have been reported in other Ozark-type streams (Robison and Harp, 1971). The lack of muddy bottoms and organic debris has resulted in a lack of species normally associated with such conditions and an abundance of species associated with clean gravel bottoms.

The limited species composition of the Big Creek watershed has resulted in a relatively large standing crop. Robison and Harp (1971) reported 0.11-0.39 and 0.02 fish/m^2 in riffle and pool communities, respectively. The mean density of fish in the writers' study, approximately 10 times that of Robison and Harp (1971), was probably a result of reduced competition and predation because of limited species diversity.

The fish of Big Creek and its tributaries can be divided into two groups, pool and riffle forms, on the basis of habitat preference (Table I). Because of their mobility and migratory habits, this separation is not always absolute. Twenty-seven species comprising 75% of the total number of fish collected were procured from the pools, whereas 21 species comprising 25% were procured from the riffles. Factors contributing to a larger and more diverse group of fish in the pools include the absence of the limiting factor of current (Kendeigh, 1961); and the presence of more macroinvertebrates and the accumulation of drift organisms which provide a greater and more acessible supply of food (Robison and Harp, 1971); also the absolute number of fish collected in pools was larger because a relatively larger area was sampled.

The population of fish was greater on an areal basis in the riffles. Because of the optimal conditions of light and oxygen, riffles were more productive of aufwuchs and benthic fauna than pools, thus providing a better food supply for those fish best adapted to cope with the current (Robison and Harp, 1971).

Notropis boops, Fundulus catenatus, F. olivaceus, Labidesthes sicculus, and *Campostoma anomalum* were the prevalent forms, constituting 40, 14, 11, 10, and 8%, respectively, of the fish collected in the pools. They are all species indicative of small, clear-water streams of high alkalinity (Moore, 1968; Trautman, 1957). All of these species except *Campostoma anomalum* are topwater feeders (Trautman, 1957). This suggests potential interspecific competition, but the large numbers indicate that competition was minimal, probably because of abundance of food. *Campostoma anomalum* is normally a riffle species, but it was found primarily in the pools. Trautman (1957) stated that it becomes a pool species in streams of moderate to high gradient in which there is considerable current in the pools.

The dominant centrarchids found in the pools were *Lepomis megalotis* and *Micropterus dolomieui.* Both were species of wide distribution (Table I). *Lepomis megalotis* is mostly indigenous to small streams, preferring the larger, clear-water pools (Trautman, 1957). The lack of large pools at stations B-5, U-1, and U-2 coincided with an absence of *L. megalotis* at those stations.

The presence of large numbers of *Notropis boops* and *Fundulus catenatus,* normally considered pool species, in the riffle collections may have been due to their migration from one pool to another, feeding, or the lack of distinct riffles at some of the lower stations. Other dominant riffle forms, such as *Etheostoma spectabile* and *Etheostoma caeruleum,* are uniquely adapted to the swift waters by streamlined bodies, enlarged pectoral fins, and degenerate swim bladders (Reid, 1961).

Longitudinal zonation of the fish was characterized by a decrease in number per square meter from the headwater stations to the downstream stations. Thompson and Hunt (1930) found that the number of individuals decreased downstream but the size of the fish increased, so that biomass density remained about the same. No biomass recordings were made in this survey, but personal observation showed that within a given species the specimens taken downstream were considerably larger than those taken in the headwaters.

Erimyzon oblongus, Phoxinus erythrogaster, and *Semotilus atromaculatus* definitely preferred the headwaters of Big Creek and its tributaries (Table I). *Erimyzon oblongus* prefers streams whose bottoms are mostly sand and gravel. After spawning or in early summer the adults migrate downstream. *Phoxinus erythrogaster* remains in headwater areas the year round. *Semotilus atromaculatus* prefers the headwaters of small streams, but will migrate to larger pools in the summer (Trautman, 1957).

Several species of fish were distributed sparsely throughout Big Creek and its tributaries. One specimen of *Esox lucius* was collected at station B-2. Its presence there was seemingly out of place in terms of both habitat preference and range (Trautman, 1957; Moore, 1968). In 1970 the Arkansas Game and Fish Commission stocked about 6,000 *Esox lucius* in Lake Norfork, and its presence probably was due to its being trapped after having migrated from Lake Norfork to feed.

Three cyprinids, *Notropis lutrensis, N. telescopus,* and *N. zonatus,* were collected in small numbers and had a very limited distribution. *Notropis lutrensis* is an uncommonly collected species in the clearer Ozark streams. Competition from close relatives (e.g. *N. galacturus*) may be an important factor controlling its distribution (Pflieger, 1971). *Notropis zonatus* and *Notropis telescopus* are both fish common to Ozark uplands, preferring the clear-water pools of headwater streams (Moore, 1968).

Two species of ictalurids, *Ictalurus natalis* and *I. punctatus,* were limited in distribution in Big Creek and its tributaries (Table I). Nine specimens of *Ictalurus natalis* were taken from three stations (Table I). This species normally prefers low-gradient brooks which contain clear water and some aquatic vegetation (Trautman, 1957). The high gradient and lack of rooted aquatic plants probably limited its numbers in Big Creek and its tributaries. *Ictalurus punctatus* seldom is present in beds of aquatic vegetation and is highly migratory,

ascending small streams for the purpose of spawning (Trautman, 1957). The one specimen collected was taken at station B-1, the lowest station and the closest to Lake Norfork.

Three specimens of *Etheostoma blennioides* were taken from the riffles of station B-5. These riffles were composed of large rocks and were covered with an algal growth not common to most of the riffles. This environment resembles the preferred habitat of this species (Trautman, 1957).

One specimen of *Cottus carolinae* was taken from the riffles at station B-4. It is normally a species of widespread distribution in upland spring-fed streams (Moore, 1968).

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