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ABSTRACT

The purposes of this study were to determine the qualitative and quantitative distribution of fishes in the Jane's Creek watershed. Jane's Creek is a clear, spring-fed Ozark stream in northeastern Arkansas. A knowledge of the ichthyofauna of this stream prior to a long-range impoundment is of significance to the natural history of Arkansas. Jane's Creek and its tributaries were found to be alkaline, with no measurable turbidity, and to have low levels of carbon dioxide. Dissolved oxygen values ranged from 6.1 to 16.0 ppm. Only slight differences in physicochemical conditions were noted among stations and between pool and riffle areas at each station. A total of 52 species of fishes were collected during this study. Most fishes were collected by seining. A rotenone sample on 10 July 1972 yielded a standing crop of 3,005 specimens and 392 kg/ha (2,681 specimens and 349 lb/A), minnows and darters excluded. Except for black-spot disease (*Apophallus sp.*) on some cyprinids, the fishes generally appeared robust. The large number of fish species collected during the sampling period reflected the diversity of habitats available. These observations indicated a healthy ichthyofaunal population inhabiting a stream system receiving little if any pollution.

INTRODUCTION

Jane's Creek is a clear, spring-fed Ozark stream in western Randolph County, Arkansas. It arises in the northwestern corner of the county, near the Missouri line, and flows into Spring River near Ravenden, Arkansas, approximately 40 km below its origin. A 30-m earth embankment dam has been proposed for Jane's Creek as a long-range Corps of Engineers project. This dam will be constructed 4.8 km south of Ravenden Springs for the purpose of flood control and recreational benefits (White River Basin Coordinating Committee, 1968). A knowledge of the ichthyofauna of this stream prior to long-range impoundment is of significance to the natural history of Arkansas.

Other than a single fish collection taken by an Arkansas State University ichthyology class in 1969, no investigation of the fish population of Jane's Creek had been made prior to this study. Case (1970) investigated the benthic macro-invertebrates and limited physicochemical characteristics at two locations on Jane's Creek.

The purposes of this study were to determine the qualitative and quantitative variation and distribution of fishes in the Jane's Creek watershed. Habitat structure and selected physicochemical parameters were observed to elucidate patterns of fish distribution.

DESCRIPTION OF AREA

Jane's Creek cuts through the Salem Plateau of the Ozark Mountain physiographic providence (Fenneman, 1938). Surface rocks are of Ordovician age, consisting of dolomite, limestone and sandstone (Croneis, 1930). The dominant rock units in the watershed area are Cotter dolomite and Powell limestone (U.S. Geological Survey, 1929).

The soils of the Jane's Creek watershed are predominantly of the Razort-Pembroke and Talbott-Dewey associations (Soil Conservation Service, 1968).

The substrate in the pools ranges from solid rock at several upper stations to fine gravel and sand at the lower stations. The bottom of the riffles is composed of coarse gravel and chert.

The calculated mean stream gradient for Jane's Creek is approximately 2.8 m/km. Elevations for the stations sampled range from 170.1 m at station J-7 to 80 m at station J-2, 32 km downstream (Fig. 1).

The stream flows through pasture and woodlands of predominantly hickory, sycamore and oak. The observed vascular aquatic vegetation consisted of waterwillow, *Justicia americana* (L.) Vahl; watercress, *Nasturtium officinale* R. Br.; and spatterdock, *Nuphar luteum* (L.) Sibth. & Sm. Spatterdock was observed in all slowly flowing pools. *Chara* sp covered the bottom of the pool at station J-6.

The average annual rainfall in Randolph County is 49.64 in. (126 cm). Air temperatures range from 121 F to -22 F (44.4 C to -37.8 C) (Hickmon, 1941).

METHODS AND MATERIALS

Ten stations were selected as sampling sites in an attempt to sample the watershed adequately (Fig. 1). Six stations, spaced at approximately 8-km intervals along Jane's Creek, were sampled seasonally from 2 October 1971 through 7 July 1972. Four additional stations on intermittent streams, one each on Jane's, Brushy, Athy and Ferguson Creeks, were sampled only during the spring and summer because of an absence of water. On 10 July 1972 a rotenone sample was taken on Jane's Creek, station J-R, between stations J-4 and J-5. Map locations follow.

Jane's Creek

J-1 Jct. Sec. 7-8, T18N, R2W; Elv. 81 m

J-2 SE 1/4 Sec. 20, T19N, R2W; Elv. 94 m

J-3 NE 1/4 Sec. 1, T19N, R3W; Elv. 110 m

J-4 Jct. Sec. 19, T20N, R2W, & Sec. 24, R20N, R3W; Elv. 119 m

J-R NE 1/4 Sec. 13, T20N, R3W; Elv. 128 m

J-5 NW 1/4 Sec. 1, T20N, R3W; Elv. 137 m

J-6 Center Sec. 33, T21N, R3W; Elv. 158 m

J-7 NE 1/4 Sec. 29, T21N, R3W; Elv. 171 m

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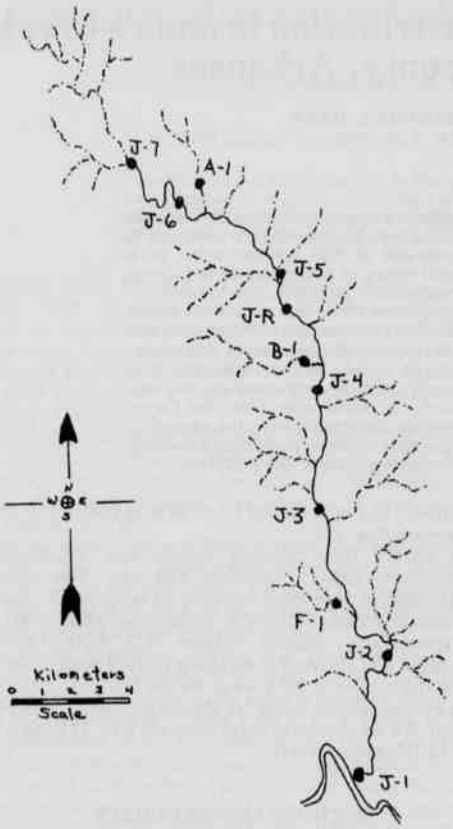

Figure 1. Jane's Creek watershed, Randolph County, Arkansas.

Ferguson Creek

F-1 SE 1/4 Sec. 20, T19N, R2W; Elv. 105 m

Brushy Creek

B-1 Jct. Sec. 13-24, T20N, R3W; Elv. 128 m

Athy Creek

A-1 Jct. Sec. 33-34, T19N, R3W; Elv. 155 m

On each sampling day the following determinations were made. Dissolved oxygen determinations and temperatures were obtained with the use of the Hydro-lab II B; standard limnological methods were used to determine free carbon dioxide and alkalinity values (Welch, 1948). The current velocity was determined by timing a float over a measured distance. Turbidity and light penetration were determined with the Jackson turbidimeter and Secchi disk, respectively.

Fishes were collected by the use of various seines, ranging from 3.0x1.2 m with 3.2-mm bar measured mesh to 15.3x1.8 m with 6.3-mm bar mesh. On 10 July 1972, rotenone was applied by the Arkansas Game and Fish Commission at the rate of 1.8 mg/liter (5 lb/acre-ft) to the pool at station J-R. Potassium permanganate was added to the water below the sample area in an attempt to neutralize the rotenone.

The fishes were fixed in 10% formalin for three days, washed with water for 24 hours and stored in 40% isopropanol. Classification was according to the keys of Eddy (1957), Pflieger (1968) and Moore (1969). Nonenclature is in accordance with that of Bailey et al. (1970).

RESULTS

Jane's Creek and its tributaries were found to be alkaline, with no measurable turbidity, and to have low levels of free carbon dioxide. Dissolved oxygen values ranged from 6.1 to 16.0 ppm. Only slight differences in physicochemical conditions were noted among stations and between pool and riffle areas at each station.

Methyl orange alkalinity ranged from a high of 324 ppm at station J-1 on 14 November 1971 to a low of 230 ppm at station J-3 on 6 May 1972. The mean value for all stations was 264.3 ppm. Phenolphthalein alkalinity was not detected.

Except for single determinations of 8.4 (station J-1, 14 November 1971) and 7.5 (stations J-4 and J-5, 31 October 1971), pH values were relatively constant in the range 7.8-8.2. Carbon dioxide values were consistently low with a range of 2.3-8.2 ppm.

Dissolved oxygen concentrations were usually near or above saturation. Percent saturation ranged from 70-100% in the pools during the fall and summer to 103-130% in the riffles during the spring and winter. Water temperature ranged from 24 C at station J-2 on 2 October 1971 to 1 C at station J-6 on 5 February 1972.

Current velocity ranged from 0.2 to 1.0 m/sec; the highest values were recorded during the spring. No discernible pattern in velocity variation was noted among stations.

A total of 52 species of fishes representing 12 families were collected from Jane's Creek and its tributaries during the study. A total of 10,125 specimens and 47 species were collected by seining. Of this total 7,417 specimens and 42 species were identified from the pools and 2,708 specimens and 33 species were identified from the riffles (Table I). Five additional species were collected during the rotenone sample on 10 July 1972.

Standing crop values of 3,005 specimens and 392 kg/ha (2,681 specimens and 349 lb/A), minnows and darters excluded, were established for the pool at station J-R from data collected by a rotenone sample on 10 July 1972. A predator-prey ratio of 1:11 was calculated.

There was a decrease in numbers of species from the lowermost station to the uppermost station. Species diversity was greatest at station J-1, where 36 species were collected. At the middle stations, J-2 through J-6, 20-27 species were collected. Only 14-18 species were collected from the upper stations, J-7 and those of tributary streams.

Species collected in relatively large numbers throughout the watershed included *Campostoma anomalum* (Agassiz), *Dionda nubila* (Forbes), *Pimephales notatus* (Rafinesque), *Notropis boops* Gilbert, *Notropis chrysocephalus* (Rafinesque), *Notropis galacturus* (Cope), *Notropis telescopus* (Cope), Notropis *zonatus* (Putnam), *Fundulus catenatus* (Storer), *Fundulus olivaceus* (Storer) and *Etheostoma caeruleum* Storer. Other species common at most stations but captured in relatively small numbers included *Hypentelium nigricans* (Lesueur), *Moxostoma duquesnei* (Lesueur), *Ictalurus natalis* (Lesueur), *Labidesthes sicculus* (Cope), *Micropterus dolomieui* Lacepede, *Lepomis macrochirus* Rafinesque, *Lepomis megalotis* (Rafinesque), *Etheostoma blennioides* Rafinesque,

Table I. Number and Species of Fishes Collected, Jane's Creek and Tributaries, Randolph County, Arkansas, 2 October 1971 - 7 July 1972

Taxa	Stations									
	J-1	J-2	J-3	J-4	J-5	J-6	J-7	F-1	B-1	A-1
*Ichthyomyzon gagei**										
Dorosoma cepedianum	4									
*Esox americanus**										
Esox niger						1				
Semotilus atromaculatus								1		
Nocomis biguttatus				8						
Hybopsis amblops	17			9	6	6	4			
Dionda nubila	12	264	331	236	357	361	160	1		3
Pimephales vigilax	403			5						
Pimephales notatus	152	9	5	10	57	181	32			
Campostoma anomalum	41	102	94	97	184	41	62	98	19	17
Notropis boops	18	231	8	50	226	139	63		1	
Notropis chrysocephalus	1	196	103	35	37	5			6	
Notropis galacturus	1	28	160	99	60	15			10	1
Notropis ozarcanus	5									
Notropis rubellus	6									
Notropis telescopus	32	272	282	254	482	109	2		8	13
Notropis umbratilis	1	64		4						
Notropis venustus	264									
Notropis whipplei	5									
Notropis zonatus	2	141	96	136	37	10		44	23	
Hypentelium nigricans		1	1	2	7	1		4		
Moxostoma duquesnei	29	6	8	6	4	8		2		
*Minytrema melanops**										
Erimyzon oblongus						1	1	1		1
*Ictalurus melas**										
Ictalurus natalis			1		1	1	11	4		
Ictalurus punctatus	1									
Noturus albater			8							
Noturus exilis		1								2
Noturus miurus	4									
*Aphredoderus sayanus**										
Fundulus catenatus	11	1	59	17	30	5	2	24	36	5
Fundulus olivaceus	37	5	18	49	83	109	58	105	22	13
Gambusia affinis	3									
Labidesthes sicculus	6	30	1	13	6	34	23			
Micropterus dolomieui	1	2		1	6		2	4	9	3
Micropterus punctulatus	5					8				
Lepomis cyanellus						3	1		1	
Lepomis macrochirus	41			2	5	11			4	
Lepomis megalotis	18	1		2	10	22	32		6	1
Ambloplites rupestris				1		7				
Percina caprodes	1									
Percina maculata	1									
Ammocrypta vivax	3									
Etheostoma blennioides	2	22	70	15		17	1			
Etheostoma caeruleum	110	214	154	112	165	70	240	61	12	48
Etheostoma euzonum	9	16	1	2						
Etheostoma flabellare		24	7	12	16	17	70	69	11	40
Etheostoma stigmaeum	64	1								
Etheostoma spectabile	1			8	2	8	27	18	7	4
Etheostoma zonale	14	87	7	13	9					
Totals	1325	1718	1351	1198	1790	1190	791	436	175	151

*Species collected only in the rotenone sample, 10 July 1972.

Etheostoma flabellare Rafinesque and *Etheostoma spectabile* (Agassiz).

Some species were limited in their distribution. *Erimyzon oblongus* (Girard) and *Semotilus atromaculatus* (Mitchill) were restricted to the headwater regions. Sixteen species including *Pimephales vigilax* (Girard), *Notropis umbratilis* (Girard), *Etheostoma euzonum* (Hubbs and Black), *Etheostoma stigmaeum* (Jordan) and *Etheostoma zonale* (Cope) were collected only in the lower stations. Eleven of the 16 were collected only at station J-1: *Dorosoma cepedianum* (Lesueur), *Notropis ozarcanus* Meek, *Notropis rubellus* (Agassiz), *Notropis venustus* (Girard), *Notropis whipplei* (Girard), *Ictalurus punctatus* (Rafinesque), *Noturus miurus* Jordan, *Gambusia affinis* (Baird and Girard), *Ammocrypta vivax* Hay, *Percina caprodes* (Rafinesque) and *Percina maculata* (Girard). Other species limited to one station were *Esox niger* Lesueur at J-6, *Nocomis biguttatus* (Kirtland) at J-4 and *Noturus albater* Taylor at J-3.

The relative number of specimens collected was greater during the fall and winter than during the spring and summer. No pattern of seasonal variation could be observed in relation to the number of species collected seasonally from a particular station. No migrational pattern could be determined in relation to seasonal data from station to station.

The majority of the species were captured in both pool and riffle areas, but most had definite habitat preferences. Sixteen species, *Esox niger, Dorosoma cepedianum, Erimyzon oblongus, Hybopsis amblops* (Rafinesque), *Notropis ozarcanus, Notropis rubellus, Notropis umbratilis, Notropis whipplei, Semotilus atromaculatus, Ictalurus punctatus, Gambusia affinis, Micropterus punctulatus* (Rafinesque), *Lepomis cyanellus* Rafinesque, *Ambloplites rupestis* (Rafinesque), *Percina caprodes* and *Percina maculata,* were collected only from pool areas. Four species, *Noturus exilis* Nelson, *Noturus miurus, Noturus albater* and *Etheostoma euzonum,* were collected only from the riffles.

Five additional species, *Ichthyomyzon gagei* Hubbs and Trautman, *Esox americanus* Lesueur, *Minytrema melanops* (Rafinesque), *Ictalurus melas* (Rafinesque) and *Aphredoderus sayanus* (Gilliams), were collected during the rotenone sample 10 July 1972. Only larvae of *Ichthyomyzon* were captured, and species determination was based on larval size.

DISCUSSION

The high alkalinity values recorded for Jane's Creek are related to the dominance of limestone rocks in the watershed. Cotter dolomite is the dominant substrate, although Powell limestone is present at station J-1 (U. S. Geological Survey, 1929). Thus alkalinity values differed little among stations. Case (1970) reported alkalinity values from Jane's Creek of 237-261 ppm, values slightly lower than those of this study. High alkalinity values have been reported from other Ozark streams (Clifford, 1966; Jackson and Harp, 1973; Robison and Harp, 1971). The pH values recorded for Jane's Creek in this study, 7.8-8.2, are similar to those reported by Case (1970) of 7.7-8.2. They are similar to values reported for Ozark streams of northern Arkansas (Jackson and Harp, 1973; Robison and Harp, 1971; Sublette, 1956). The relatively stable pH values observed in Jane's Creek indicate a well-buffered system, or an absence of allochthonous materials of strong influence, or both. Homeostasis is important in a healthy ecosystem.

Dissolved oxygen values were consistently near or above saturation. Case (1970) reported dissolved oxygen values of 4.7-9.0 ppm from 12 July to 18 October 1969, slightly lower than those reported herein, 6.1-16.0 ppm from 30 June to 31 October 1972. Clifford (1966) and Jackson and Harp (1973) reported similar dissolved oxygen patterns for other Ozark streams. Dissolved oxygen values varied inversely with temperature, a well-known phenomenon of dissolved gases in water (Odum, 1959; Reid, 1961; Welch, 1952). Dissolved carbon dioxide values, ranging from 2.3 to 8.0 ppm, were consistently low and variation was insignificant both seasonally and among stations. Case (1970) reported similar values for Jane's Creek. Low carbon dioxide values were typical in comparison with values of other Ozark streams and reportedly were due to buffering (Clifford, 1966; Sublette, 1956).

Except during the spring when current velocity for Jane's Creek was greatly increased by runoff, current speed varied slightly seasonally. Current speed fluctuated and reflected variations in stream gradient between stations. Jackson and Harp (1973) reported similar current velocities for Big Creek.

Turbidity was negligible or absent throughout the sampling period. Little erosion occurred because of the rocky nature of the soil and limited cultivation in the watershed.

A diverse ichthyofaunal population, 52 species, was collected from Jane's Creek and its tributaries during this survey. Jackson and Harp (1973) collected 33 species from a comparable Ozark stream, whereas Jenkins and Harp (1971) collected 21 species from a deltaic stream of similar size within 85 km of Jane's Creek. Beadles et al. (1972) reported 71 speices of fishes from the Strawberry River, a much larger Ozark stream of the White River drainage. Black (1940) reported only 129 species of fishes from the entire White River system. Therefore the Jane's Creek system contains approximately 40% of the species from the entire White River system.

The diversity of species collected from Jane's Creek and its tributaries is the result of four important factors: (1) the stability of the chemical environment as a result of buffering; (2) the variety of habitats created by variations in gradient, substrate and aquatic plants; (3) the proximity of station J-1 to Spring River; and (4) the clear unpolluted waters typical of the geographic area.

The Jane's Creek watershed is classified as a trellis drainage, consisting of a trunk stream with small, short, lateral tributaries. The stream increases in size gradually without increasing in stream order, as is typical of dendritic drainage patterns (Harrel, et al., 1967; Kuehne, 1962). Because of this gradual increase in water volume, many species were collected throughout the watershed and thus longitudinal succession was not distinctive. However, differences were observed in that a few species were restricted to the headwaters and others were restricted to the lower stations.

Larimore (1962) surveyed the fish population of a 1.6-km section of a warm-water Illinois stream similar in size to Jane's Creek. The sample area included both pools and riffles and had a mean depth of 15 cm. He reported standing crop values of 5,868 specimens and 108 kg/ha (5,235 specimens and 97 lb/A), excluding small fish. The weight values are lower, but the numerical values are higher, than those of Jane's Creek, which has a mean depth of 61 cm. Jane's Creek data support Larimore's (1962) conclusion that deep water supports a greater weight of fishes per unit area but smaller numbers.

A predator-prey ratio of 1:11 was calculated for Jane's Creek. This compares well with Larimore's (1962) value of 1:12.

Eleven species were found to be the most abundant and widespread species in the Jane's Creek watershed. They were captured at most of the stations and characteristically constituted approximately 75-95% of the total numerical catch

from a given station. The eight most common species were cyprinids characteristically found in clear, rocky Ozark streams with riffle areas of moderate to steep gradient interspersed with slow or moderate pools (Black, 1940; Meek, 1894; Pflieger, 1971). *Etheostoma caeruleum* was the prevalent darter and commonly accounted for more than 50% of the entire riffle population numerically. Trautman (1957) suggested that large populations of *E. caeruleum* are present in moderate-size streams of moderate or high gradient and increase markedly in areas without interspecific competition from *E. spectabile* and *E. blennioides*. Although these two competitive species were present in Jane's Creek, they constituted a minor part of the total riffle fauna numerically.

The tributaries and headwaters sampled were characterized by clear cool spring water and bedrock, boulder-strewn and coarse gravel bottoms with low flow velocities. They were dry during the fall and winter of 1971 except for a few intermittent pools. Consequently, field collections were taken during the spring and summer at these stations. *Semotilus atromaculatus* and *Erimyzon oblongus* were collected only from these habitats.

S. atromaculatus has been found typically in clear headwater regions of mountain and plains streams populated by few other species (Gerking, 1945; Hynes, 1971; Kuehne, 1962; Sheldon, 1968). *Erimyzon oblongus* migrates to the headwaters in the spring to spawn, but moves back down to large pools in the fall (Pflieger, 1971; Sheldon, 1968; Trautman, 1957).

The habitats of the lowest station, J-1 (50 m above the juncture with Spring River), were quite variable. The stream at this point remained clear with a moderate to low gradient, except during spring floods when the water level was 2-4 m above normal.

Station J-1 consisted of a series of small, deep pools with submerged logs and undercut banks, but no aquatic vascular plants. The riffle was not sampled in the spring or summer as it was eliminated by beaver construction. The substrate was variable, consisting of gravel, sand and firm clay. Of the 36 species collected there, 11 were taken from no other station. *Notropis ozarcanus, N. rubellus* and *N. whipplei* prefer medium-size clear streams with moderate gradients (Pflieger, 1971; Sheldon, 1968; Trautman, 1957). The darters *Ammocrypta vivax, Percina caprodes* and *P. maculata* and the madtom *Noturus miurus* prefer sluggish riffles or pools with silt-free gravel or sand bottoms (Hubbs and Lagler, 1958; Pfleiger, 1971; Trautman, 1957). *Dorosoma cepedianum* and *Ictalurus punctatus* are found typically in permanent pools of low gradient of larger streams and rivers (Pflieger, 1971; Trautman, 1967). Some of these species prefer larger streams and their presence at station J-1 was probably the result of emigration from Spring River.

Five other species were limited to the lowermost stations of Jane's Creek. *Pimephales vigilax* was collected only at stations J-1 and J-4, both characterized by a long, sluggish permanent pool typical of the preferred habitat (Pflieger, 1971; Trautman, 1957). *Notropis umbratilus* was collected on all occasions at station J-2 and during the spring at station J-4. This species prefers clear, quiet, protected backwater and overflow pools of warm temperatures, which were typical of station J-2 (Martin and Campbell, 1953; Pflieger, 1971). *Etheostoma euzonum* and *E. zonale* were most common in the riffle areas of the lower and middle stations on Jane's Creek. They prefer large gravel or rubble riffles of medium-size streams (Hubbs and Lagler, 1958; Trautman, 1957). *Etheostoma stigmaeum* tends to prefer the quieter pools of large and medium-size streams with gravel and sand bottoms (Pflieger, 1971). They were found at stations J-1 and J-2, which were most typical of the preferred habitat.

A few species were collected from only one station, possibly because of a particular habitat preference. One specimen of *Esox niger* was collected at station J-6, a quiet pool with an abundance of the alga *Chara*, which was not abundant at any other station. This condition typifies the preferred habitat of this fish (Pflieger, 1971). *Nocomis biguttatus* was collected on three occasions, but only at station J-4. The adults of this species prefer an area just above the riffles of clear rubble-bottomed streams with some attached vegetation (Pflieger, 1971; Trautman, 1957). Station J-4 fit this description, but so did several others.

Eight specimens of *Noturus albater* were collected 3 January 1972 at station J-3. This species is endemic to the upper White River drainage of Missouri and Arkansas and prefers swiftly flowing riffles (Taylor, 1970). The fact that it was collected only once probably is due to the collection methods used.

The pool and riffle areas of an Ozark stream are habitats containing different species compositions. However, many species were captured in both areas because of accidental or migrational movements of the population. Pools are inhabited characteristically by species preferring deep protected waters with a moderate to low gradient (Trautman, 1957). The predominant families found in the pools of Jane's Creek were Cyprinidae, Cyprinodontidae and Centrarchidae. Similar results have been reported by other investigators (Burton and Odum, 1945; Harrel et al., 1967; Sheldon, 1968). Most of the cyprinids were found in the pools. *Hybopis amblops, Notropis ozarcanus, N. rubellus* and *N. umbratilis* were captured only in these areas. The centrarchids of Jane's Creek were found predominantly in the pools and some species, such as *Micropterus punctulatus, Ambloplites rupestis* and *Lepomis cyanellus*, were limited to several pools of discontinuous distribution.

The predominant riffle forms in Jane's Creek were the darters, *Etheostoma*, and the madtoms, *Notorus*. Most of the darters and madtoms prefer areas of high gradient with gravel or rubble substrate (Hubbs and Lagler, 1958; Martin and Campbell, 1953; Pflieger, 1971; Trautman, 1957).

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