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Population Dynamics and Species Diversity of Ichthyo-Parasitofauna of the Buffalo National River

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POPULATION DYNAMICS AND SPECIES DIVERSITY OF ICHTHYO-PARASITOFAUNA OF THE BUFFALO NATIONAL RIVER

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES
(Cont'd)

INTRODUCTION

The Buffalo River originates in the Ozark plateau in Newton County, Arkansas. This magnificent Ozarkian wilderness river is about 238 km long and flows north-eastward to its confluence with the White River. The Buffalo River drains 3,465 km^2 and has some 30 named tributaries. In its upper reaches, huge multicolored cliffs extend nearly 213 m above the river as it flows through mountainous countryside which reaches an elevation of 732 m. Within its watershed may be found 700 species of plant life, a habitat for 250 species of birds, and a variety of game animals. In its aquatic habitat may be found a variety of game fishes, especially the famous smallmouth bass, Micropterus dolomieui Lacepede. The Buffalo River is known throughout the United States for its outstanding recreational opportunities and unique beauty (State Committee on Stream Preservation 1969).

The Buffalo River was declared a National River (Public Law 92-237) by the Congress of the United States in 1972. As a National River, its use for recreational and other land use activities within its watershed may result in altered qualities of its aquatic and surrounding terrestrial habitats. Such changes may directly or indirectly affect the ichthyo-parasitofauna of the Buffalo River. Hence, an investigation of fishes and fish parasites of the Buffalo River was undertaken to provide baseline information for future comparative studies of this nature which may determine the impact of man's activities on this beautiful wilderness river.

The objectives of this investigation were:

1. To determine the population dynamics of the smallmouth bass and its helminth and copepod parasites.

2. To provide information on species composition and seasonal abundance for pool and riffle fishes.

3. To establish community species diversity indices and correlate the indices with selected water quality parameters.

MATERIALS AND METHODS

Monthly fish collections were made from the Buffalo River at Ponca, Hasty, and Rush representing upstream, midstream, and downstream stations, respectively (Fig. 1) from January 1974 through February 1975. The Ponca collecting station was located about 47 km from the headwaters of the Buffalo River, and collections were made both upstream and downstream from the low-water bridge on State Highway 74 in Newton County. The mid-stream station, Hasty was about 48 km from the Ponca station and collections were made near the low-water bridge on a gravel road about 4 km southwest of Hasty, in Newton County. The Rush station was approximately 68 km downstream from the Hasty station and was located in Marion County.

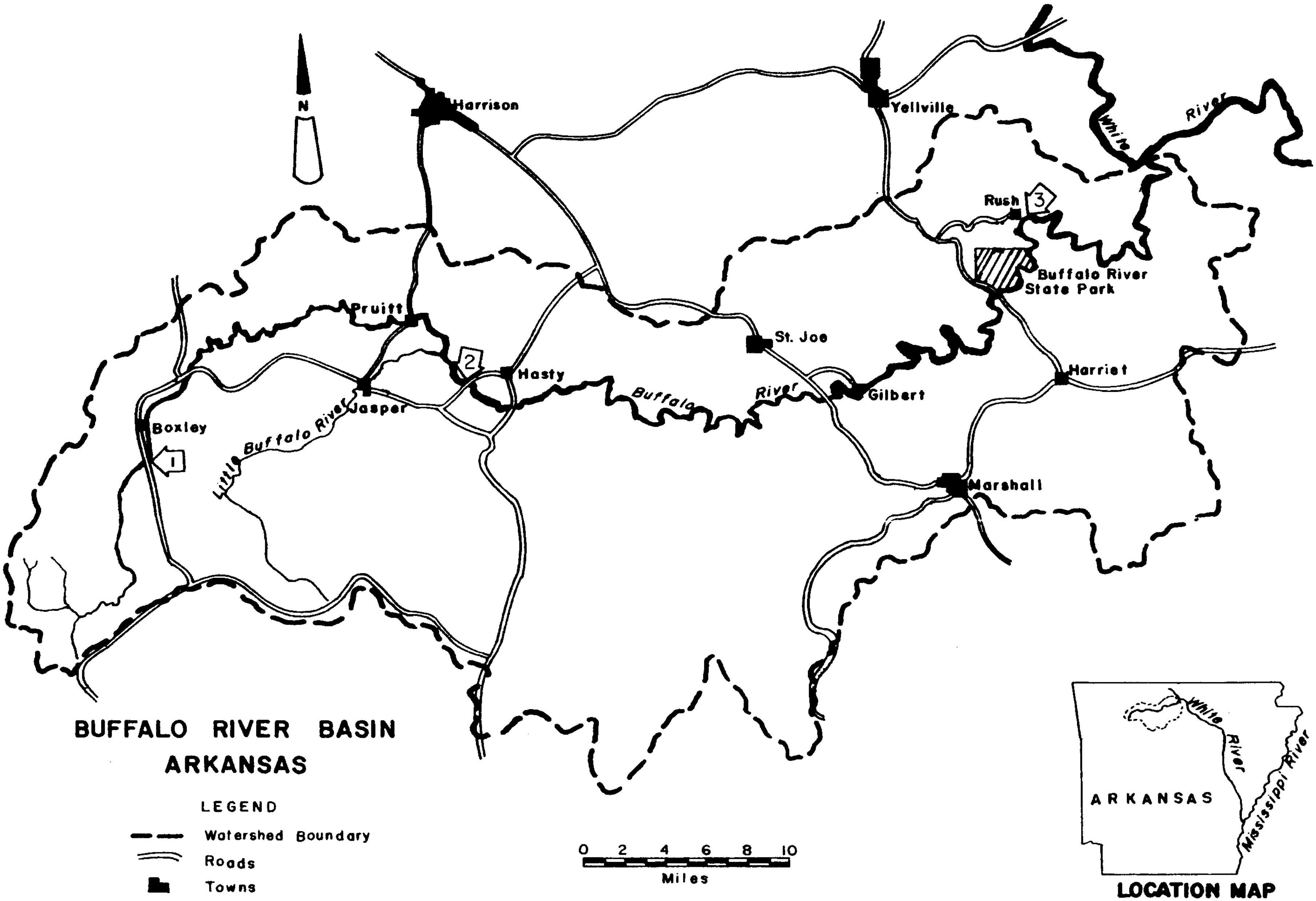
Fishes were collected from pools by electroshocker using a boatmounted 115-volt AC generator coupled to a Coeffelt Model II C variable voltage pulsator. The stunned fishes were picked up by long-handled dip nets. The Riffle collections were made by blocking off a portion of riffle by a 3 x 1.8 m (10 x 6 ft) seine with 3.2 mm (1/8 in) square mesh. The electrodes fastened to long wooden poles were placed upstream from the seine and were moved toward the seine while the substrate was agitated to dislodge the stunned fishes. The other method of riffle collecting was by placing a seine in the riffle and dragging it upstream while kicking the substrate immediately in front of the seine. The most efficient shocking voltage was 120-150 volts pulsed direct current. Each month, three seine hauls were made in each of the riffle stations and the pools were shocked for 30 minutes.

All the fishes in the collections were identified, counted and returned to the stream with the exception of smallmouth bass. Soon after collection total length in millimeters and total weight in grams were recorded for smallmouth bass. Scale samples were taken from the tip of the left appressed pectoral fin ventral to the lateral line. Scale impressions were made on acetate strips using a Carver Press at 1,050 kg/cm^2 pressure at 95 C. Distances from focus to each annulus and to the edge of the scale (scale radius) were measured along the anterior field at a magnification of 40x using a Eberbach Scale Projector. Fish were assigned ages based on the number of annuli on the scales.

Fishes collected from pools and riffles were analyzed for seasonal species composition. Data were futher analyzed for community species diversity by the method described by

FIGURE 1. Map of Buffalo River showing sampling sites.

1. Ponca
2. Hasty
3. Rush



BUFFALO RIVER BASIN
ARKANSAS

LEGEND

- Watershed Boundary
- Roads
- Towns
- Sampling Stations

Patten (1962). Statistical significances were expressed at the 0.01 level unless otherwise stated.

Smallmouth bass were grossly examined, skinned, and eviscerated in the field. Their branchial apparatus was immediately fixed in vials of 70% ethanol, and the rest of the viscera fixed *in toto* in vials of hot (50 C) alcohol-formol-acetic (AFA) fixative (Cable 1977). Before skinning, leeches were removed from their external sites and fixed in vials of hot AFA. After skinning, yellow grubs (digenetic trematode metacercariae) were removed from the flesh and fixed in vials of hot AFA. The number of black spot or neascus (digenetic trematode metacercariae) was recorded, but they were not recovered. The fixed viscera and parasites were returned to the laboratory for processing and parasite identification.

Monogenetic trematodes recovered from the branchial apparatus and kidneys were stained and mounted in a mixture of 1:3 Turtox CMC-S and Turtox CMC-10 fixative-stain-mountant (Becker and Heard 1965).

Digenetic trematodes (except strigeids), cestodes, and leeches were stained with Delafield's hematoxylin (Cable 1977), cleared in terpineol, and mounted in Permount. Strigeid trematodes were stained and mounted in the same manner as monogenetic trematodes.

Large nematodes were cleared in lactophenol and temporarily mounted in glycerin. Minute nematodes were stained and mounted using the same procedure as for monogenetic trematodes.

Copepodes were identified in 70% ethanol.

Parasite community structure was analyzed using diversity indices according to Patten (1962) and modified from Wilhm and Dorris (1968). Community diversity, the manner in which individual ichthyoparasites are distributed among species, may be expressed by a value (d) obtained from the equation:

$$d = -\sum_{i=1}^{s} n_i \log_2 \frac{n_i}{n}$$

where n is the total number of ichthyoparasites per host, n_i is the number of individual parasites of species i, and s is the number of parasite species per host. Community diversity values (d) must lie between a theoretical maximum diversity and a theoretical minimum diversity.

Maximum diversity results if each individual ichthyoparasite belongs to a different species (s = n), and minimum diversity results if every individual parasite is of the same species (s = 1). Maximum diversity values are derived from the equation:

$$d_{max} = \log_2 n! - s \log_2 (\tfrac{n}{s})!$$

Minimum diversity values are derived from the equation:

$$d_{min} = \log_2 n! - \log_2 \{n - (s-1)\}!$$

Individual diversity, the ratio of the number of individual ichthyoparasites of each species to the total number of individual parasites in the sample, is expressed by a value ($\bar{d}$)

obtained from the equation:

$$\bar{d} = - \sum_{i=1}^{s} \frac{n_i}{n} \log_2 \left(\frac{n_i}{n}\right)$$

Redundancy, an expression of the dominance of one or more ichthyoparasite species, is expressed by a value (R) obtained from the equation:

$$R = \frac{d_{max} - d}{d_{max} - d_{min}}$$

In obtaining the values used for ichthyoparasite community diversity (d), redundancy (R), and individual diversity ($\bar{d}$), each fish host and its parasites constituted a community. Overall values for these variables were calculated taking an average of the individual values obtained from each fish host.

All data were analyzed using IBM 370-155 computer, and the programs are on file with the authors.

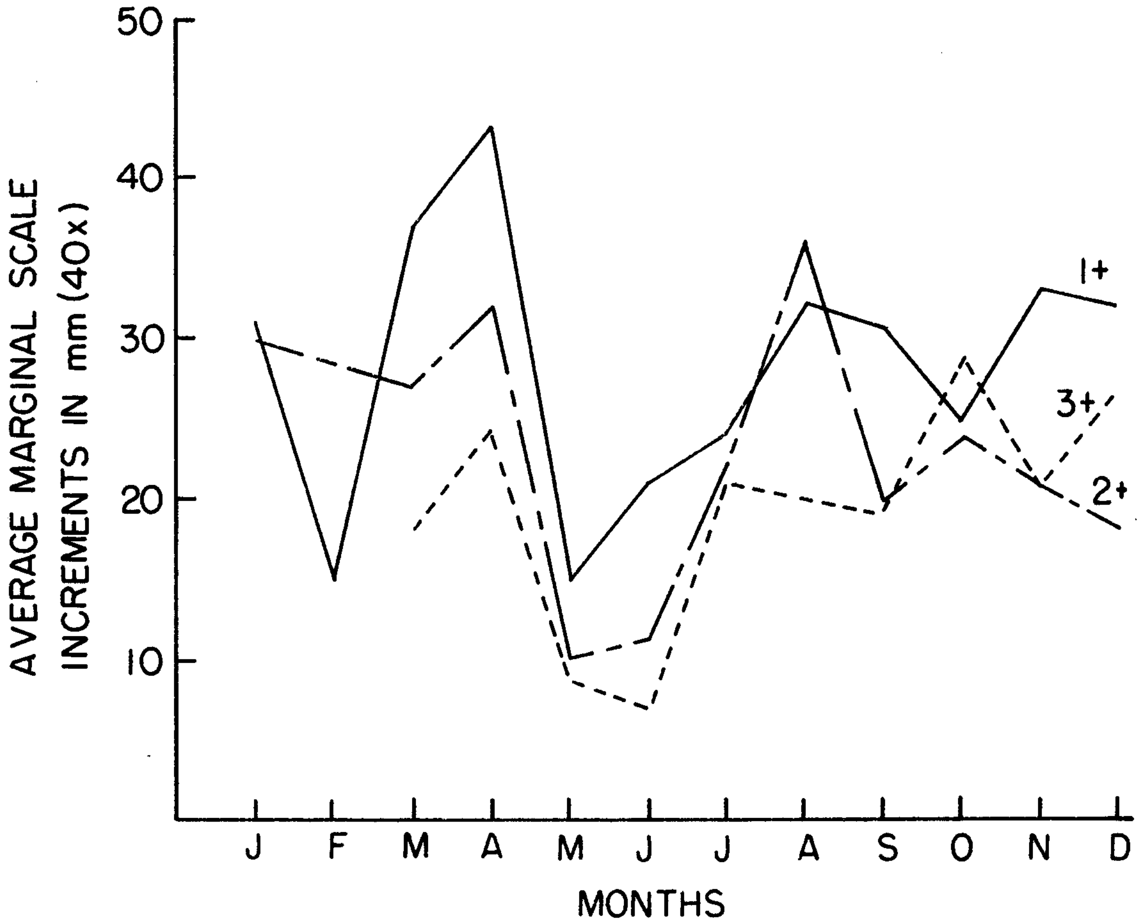
RESULTS AND DISCUSSION

Population Dynamics of Smallmouth Bass

Time of annulus formation

Monthly average scale increments from annulus to scale margin for age groups 1+, 2+, and 3+ are shown in Figure 2. A sharp decrease in marginal increment was evident during May and June for age groups 2+ and 3+ and during the month of May for age group 1+. Although sufficient data were not available, age groups 4+ and 5+ also showed a decrease in marginal increments during May and June. Smallmouth bass from the Buffalo

FIGURE 2. Monthly average marginal scale increments.



AVERAGE MARGINAL SCALE INCREMENTS IN mm (40x)
50
40
30
20
10
J F M A M J J A S O N D
MONTHS
1+
2+
3+

River formed an annulus during May - June and the one-year olds formed an annulus earlier than older age groups.

In Oklahoma, largemouth bass formed an annulus during April-June while the young bass formed annuli earlier than older bass (Jenkins and Hall 1953). Hoffman et al. (1974) reported similar findings for Lake Fort Smith, Arkansas, largemouth bass and spotted bass. Hogue and Kilambi (1975) stated that bluegill from Lake Fort Smith formed annuli from late February to early June and the older fish formed annuli later than the younger fish. It appears the time of annulus formation is about the same for the centrarchids of this region. Although it is generally believed that the time of annulus formation is generally correlated with low water temperature (Rounsefell and Everhart 1953), it appears from the above studies, that factors other than temperature must be operating in determining the time of annulus formation. Phlieger (1966) stated that nesting by smallmouth bass from a small Ozark stream was from the last week of April to the first week of July. Therefore, spawning activity may be one of the factors inducing annulus formation.

Total length - scale radius relationship

Data from 146 smallmouth bass (65 males; 72 females; 9 unsexed) were used in estimating total length-scale radius relationship by the formula:

$$L = a + b\,S$$

where:

L = Total length in mm

S = Scale radius in mm (40x)

a and b = Constants

Since the relationship was not significantly different between males and females ($F_{2,133} = 1.24$), data for males, females, and unsexed smallmouth bass were pooled and the total length-scale radius relationship was estimated as:

$$L = 40.33 + 1.86\ S$$

Length-weight relationship and condition factor

Length-weight relationship and condition factor were estimated from the formula:

$$\log W = \log a + b \log L$$

$$\text{Condition factor } (K) = W \times 10^5/L^3$$

where:

L = Total length in mm

W = Total weight in g

a and b = Constants

The estimated length-weight relationship for smallmouth bass (sexed and unsexed fish pooled) was:

$$\log W = 3.0 \log L - 4.97666$$

with an average condition factor of 1.1.

Annual growth and growth parameters

Lengths attained at each annulus were calculated from the total length-scale radius relationship and are presented in Table 1. The age-length data were analyzed by the Bertalanffy formula (Ricker 1975):

$$L_t = L_\infty \left(1 - e^{-K(t-t_0)}\right)$$

TABLE 1. Average calculated lengths and growth rates of smallmouth bass.

Age Group	Number of fish	Total Length (mm) at each Annulus 1	2	3	4	5	6
1	55	108.9					
2	27	112.8	185.8				
3	20	110.6	178.9	227.6			
4	10	92.3	151.8	202.1	241.8		
5	9	119.8	176.0	223.5	271.0	310.9	
6	5	100.7	175.5	229.6	273.4	317.5	346.9
Weighted Mean		109.1	177.1	221.2	259.4	313.3	346.9
Average Increment		109.1	32.0	44.1	38.2	53.9	33.6

where:

L_t = Length at age t

K = Growth constant

t_0 = Age when length is zero

The Bertalanffy growth formula for describing the growth of smallmouth bass was:

$$L_t = 583\ (1 - e^{-0.14\ (t\ +\ 0.48)})$$

It was estimated that Buffalo River smallmouth bass would attain 95% of the asymptotic length at the age of 21 years. Using the length-weight relationship, asymptotic weight was estimated as 2,091 g (4.6 lb).

Growth of Buffalo River smallmouth bass was compared with other studies (Table 2). Although first year growth of smallmouth bass from the Buffalo River was greater than from other areas, average annual increment, based on the first six years of life, was smaller than from other areas. In comparison to earlier findings (Peek 1965), smallmouth bass of this study had only 77% of the average annual increment reported by Peek.

In wild populations, growth is influenced by temperature and food availability (Brown 1960; Coble 1967; Keating 1970; Forney 1972) and infestation by parasites (Hunter and Hunter 1938). Findings of this study could not be compared with those of Peek (1965) as data on water quality and parasites were not reported in his study. In our study, water quality parameters and parasitofauna were monitored and analyses of bass stomachs are in progress. We recommend that a similar study be undertaken

TABLE 2. Comparison of growth of smallmouth bass from different waters.

Locality & Reference	Total Length (mm) at each Annulus											
	1	2	3	4	5	6	7	8	9	10	11	12
Buffalo River, AR (Present Study)	109.1	177.1	221.2	259.4	313.3	346.9						
Buffalo River, AR (Peek 1965)	80.2	161.5	231.5	301.2	370.8	449.2	525.1	585.5				
Iowa Streams (Cleary 1951)	91	175	224	282	348	432						
Stillwater River, OH (Brown 1960)	97	160	241	312	373	404	427	480				
Missouri Streams, MO (Lowry 1953)	81	175	251	300	358	391	406	414	419	417	419	445
North America averages (Coble 1975)	92.5	167.5	230	275	317.5	352.5	375	397.5	422.5			

in 5 years on the Buffalo River smallmouth bass to compare and evaluate changes in growth patterns.

Mortality and survival rates

Instantaneous mortality rate (i) was estimated from the relative abundance of age groups or catch curve (Ricker 1975). The Buffalo River smallmouth bass had an instantaneous mortality rate of 0.43. The survival rate (e^{-i}) was 0.64 with an annual mortality rate (a) of 36%. The annual mortality rate for the smallmouth bass of this study was lower than those reported for bass populations from Michigan, Wisconsin, Ohio, Ontario, and Missouri in which the annual mortality rates exceeded 50 percent (Coble 1975). Brown (1960) and Fajen (1972) attributed the high mortality rates for Ohio and Missouri populations to fishing mortality. Probably fishing intensity by anglers is less in the Buffalo River than in those waters listed by Coble (1975).

Species Composition and Relative Abundance of Fishes

Species of fishes and their occurrence in pool and riffle stations are given in Appendix 1. Monthly collections of fishes were grouped into seasons. The year was divided into four seasons: winter (December - February), spring (March - May), summer (June - August), and fall (September - November).

Seasonal abundance of fishes in pools

The species of fishes collected and their seasonal abundance at Ponca, Hasty, and Rush stations are given in Table 3. A total of 1,478 fish belonging to 41 species was collected from all the pools during the study period. Of this total, 15.8% from Ponca, 48.1% from Hasty, and 36.1% from Rush were obtained. The number of fishes collected among pools was significantly different (x^2_2 = 235.64). There was no significant difference between pool stations (x^2_2 = 2.98) regarding the number of species.

Ponca

The most abundant fish in this pool was L. megalotis comprising 22.2% of the fishes collected. H. amblops was the second abundant species (17.5%) followed by N. biguttatus (12.4%). N. pilsbryi, A. rupestris, I. natalis, and M. dolomieui contributed from 9.8 to 2.9% of the total fish collected.

L. megalotis was equally abundant in summer and fall (30.8%) followed by winter (23.0%) and spring (15.4%). Seasonal abundance of H. amblops was greatest in winter (51.2%) followed by spring (43.9%); its abundance was minimal (2.4%) during summer and fall seasons.

Seasonal abundance of various species was: winter - H. amblops, N. pilsbryi, and L. megalotis; spring - H. amblops, N. biguttatus, and L. megalotis; summer - L. megalotis, C. anomalum, I. natalis, N. biguttatus, and N. galacturus; fall - L. megalotis and N. biguttatus. There was no seasonal difference (x^2_3 = 0.21) in the number of species collected from Ponca pool.

TABLE 3. Seasonal abundance of fishes in Ponca (P), Hasty (H), and Rush (R) pools.

Species	Winter P	Winter H	Winter R	Spring P	Spring H	Spring R	Summer P	Summer H	Summer R	Fall P	Fall H	Fall R	TOTAL P	TOTAL H	TOTAL R
Etheostoma blennioides	-	1	-	-	2	-	-	9	2	1	-	-	1	12	2
Etheostoma caeruleum	-	4	-	-	-	-	-	-	-	-	-	-	-	4	-
Etheostoma zonale	-	-	-	-	3	-	-	-	-	-	-	-	-	3	-
Percina caprodes	-	-	-	-	-	-	-	1	-	2	-	-	2	1	-
Campostoma anomalum	-	4	-	-	-	-	7	-	-	1	1	-	8	5	-
Campostoma oligolepis	3	6	8	2	-	-	-	-	-	-	-	-	5	6	8
Dionda nubila	-	43	22	-	-	-	-	-	1	-	2	3	-	45	26
Hybopsis amblops	21	31	2	18	-	-	1	-	-	1	1	7	41	32	9
Nocomis biguttatus	5	1	-	10	-	1	5	1	-	9	-	-	29	2	1
Notropis boops	-	40	46	4	53	1	1	19	39	-	33	6	5	145	92
Notropis Chrysocephalus	-	21	6	1	-	-	-	-	-	-	-	-	1	21	6
Notropis galacturus	1	1	-	-	-	-	5	-	2	-	-	-	6	1	2
Notropis greenei	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Notropis ozarcanus	-	-	-	-	-	-	-	3	-	-	-	-	-	3	-
Notropis pilsbryi	14	16	31	4	2	-	4	1	8	1	-	2	23	19	41
Notropis rubellus	-	2	16	-	-	1	-	-	2	-	9	3	-	11	22
Notropis telescopus	4	67	6	1	1	-	-	1	-	3	-	-	8	69	6
Pimephales notatus	2	26	6	1	5	-	-	2	1	-	4	8	3	37	15

Species	Winter P	Winter H	Winter R	Spring P	Spring H	Spring R	Summer P	Summer H	Summer R	Fall P	Fall H	Fall R	TOTAL P	TOTAL H	TOTAL R
Cottus bairdi	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Cottus carolinae	-	2	5	-	-	-	-	-	-	-	-	-	-	2	5
Lepisosteus osseus	-	-	-	-	-	-	-	1	-	-	-	2	-	1	2
Labidesthès sicculus	-	5	2	-	-	-	-	-	-	-	-	-	-	5	2
Anguilla rostrata	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1
Total number of fish	71	322	259	65	137	48	53	138	115	45	114	111	234	711	533
Total Species	14	25	25	13	14	13	12	18	18	12	15	18	22	34	33

Hasty

N. boops and *L. megalotis* were the abundant species of Hasty pool, and comprised 20.4 and 18.4%, respectively, of the total number of fishes collected. Other species comprising 9.7 to 2.9% were *N. telescopus*, *L. cyanellus*, *D. nubila*, *P. notatus*, *H. amblops*, *A. rupestris*, *M. dolomieui* and *N. chrysocephalus*.

Seasonal abundance of *N. boops* was greatest in spring (36.6%) followed by winter (27.6%), fall (22.8%), and summer (13.0%). *L. megalotis* was abundant during summer and fall (34.6 and 31.6%, respectively) and decreased to about 18.0% in winter and spring.

Abundance of fishes during winter in decreasing order were, *N. telescopus*, *D. nubila*, *N. boops*, *H. amblops*, *P. notatus*, *L. megalotis*, and *N. chrysocephalus*. In spring, *N. boops*, *L. megalotis*, and *L. cyanellus* were abundant. During summer, *L. megalotis*, *L. cyanellus*, and *N. boops* were abundant while *L. megalotis* was the only dominant species in the fall collections.

There was no significant difference in the number of species among seasons ($x^2_3 = 4.11$) but seasonal abundance was significant ($x^2_3 = 158.10$). The significance in seasonal abundance was due to the high number of fishes collected in winter and there was no significance between spring, summer and fall seasons.

Rush

L. megalotis and *N. boops* were the abundant species in Rush pool and contributed 25.5% and 17.3%, respectively, to the total number of fishes collected during the study period. Other species comprising 8 to 5% of the total were *D. nubila*, *L. macrochirus*, and *N. pilsbryi*. *L. megalotis* was most abundant in fall (31.6%) and winter (30.2%), and comprised 22.8% and 15.4% in summer and fall, respectively. Greatest abundance of *N. boops* was in winter (50.0%) and summer (42.4%).

The abundant species in winter were, *N. boops*, *L. megalotis*, *N. pilsbryi*, *D. nubila*, and *L. macrochirus*. During spring and fall *L. megalotis* was the only abundant species while *N. boops* and *L. megalotis* were abundant in summer.

Species composition was not significantly different ($x_3^2 = 3.94$) between seasons. Number of individuals collected was significant between seasons ($x_3^2 = 179.42$) with most and least numbers collected being in winter and spring, respectively.

Comparisons of pool stations

Comparison of number of species by seasons and stations showed no association between seasons and stations ($x_6^2 = 1.75$). That is, distribution of species in pools was not influenced by seasons and vice versa. Pooled data for the three pool stations showed that fishes of the families Cyprinidae and Centrarchidae comprised 90% of all the fishes. In Ponca and Hasty pools, cyprinids were most abundant (55.1% and 55.7%, respectively), and centrarchids were second in abundance

(34.2% and 36.0%, respectively). Centrarchids and cyprinids comprised 49.3% and 43.0%, respectively, of the Rush pool collections. The cyprinids, *H. amblops*, *D. nibula*, and *N. boops*, and the sunfish, *L. megalotis* collected from the pools are generally pool inhabitants (Pflieger 1975).

Seasonal abundance of fishes in riffles

Species of fish and their relative abundances in the riffle collections are given in Table 4. A total of 8,996 fishes belonging to 37 species was collected from the riffles during the study period. Abundance of fishes among the three riffles was significant (x_2^2 = 886.89) and Hasty riffle yielded the most number followed by Rush and Ponca riffles. There was no significant difference in the number of species collected among the three riffle stations (x_2^2 = 0.83).

Ponca

The most abundant species in the collections from Ponca riffle were *E. juliae* (44.5%) and *E. caeruleum* (21.6%). Distribution of *E. juliae* among the seasons was significantly different (x_3^2 = 44.38) and its abundance increased from winter (18.7%) through summer (33.9%). Numbers of *E. caeruleum* collected were significantly different between seasons (x_3^2 = 49.34). This difference was due to low numbers collected in the fall (10.9%). During spring, summer, and winter, they comprised 36.2, 26.8, and 26.1%, respectively.

In winter, *E. juliae* (40.8%) and *E. caeruleum* (27.6%) were

TABLE 4. Seasonal abundance of fishes in Ponca (P), Hasty (H), and Rush (R) riffles.

Species	Winter			Spring			Summer			Fall			TOTAL		
	P	H	R	P	H	R	P	H	R	P	H	R	P	H	R
Hypentelium nigricans	-	-	-	-	-	-	1	-	2	4	-	-	5	-	2
Moxostoma duquesnei	2	6	-	-	-	-	-	2	1	-	3	-	2	11	1
Moxostoma erythrurum	1	3	1	-	-	4	2	4	3	-	-	-	3	7	8
Ambloplites rupestris	1	4	4	6	9	5	4	10	6	4	7	7	15	30	22
Lepomis cyanellus	2	2	15	3	23	5	-	25	3	-	6	1	5	56	24
Lepomis macrochirus	-	-	19	-	1	-	-	1	4	-	2	12	-	4	35
Lepomis megalotis	12	24	41	8	25	21	16	47	31	16	35	43	52	131	136
Micropterus dolomieui	1	6	5	4	7	3	-	7	1	2	5	3	7	25	12
Micropterus punctulatus	-	-	3	-	2	1	1	2	3	-	-	6	1	4	13
Micropterus salmoides	-	5	11	-	-	2	-	-	5	-	1	3	-	6	21
Ictalurus melas	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Ictalurus natalis	2	-	1	3	-	1	6	-	-	-	-	2	11	-	4
Noturus albater	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Noturus exilis	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Noturus flavater	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-
Pylodictis olivaris	-	-	-	-	1	1	-	2	1	-	-	1	-	3	3
Fundulus catenatus	-	-	4	-	-	-	-	-	-	-	-	-	-	-	4
Fundulus olivaceus	-	-	2	-	3	2	-	-	-	-	4	1	-	7	5

Species	Winter			Spring			Summer			Fall			TOTAL		
	P	H	R	P	H	R	P	H	R	P	H	R	P	H	R
Notropis ozarcanus	-	1	-	-	1	-	-	-	-	-	-	-	-	2	-
Notropis pilsbryi	13	146	16	18	219	12	90	191	54	10	71	17	131	627	99
Notropis rubellus	1	80	47	1	13	22	-	60	2	1	26	1	3	179	72
Notropis telescopus	7	126	-	2	32	-	-	1	-	8	33	-	17	192	-
Notropis whipplei	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3
Pimephalus notatus	-	1	-	-	1	-	-	1	-	-	-	-	-	3	-
Hypentelium nigricans	1	-	-	-	-	-	-	2	1	-	-	-	1	2	1
Moxostoma duquesnei	-	-	-	-	-	-	-	3	-	-	-	-	-	3	-
Ambloplites rupestris	-	-	-	-	-	-	-	-	-	-	7	-	-	7	-
Lepomis megalotis	1	-	-	-	-	-	-	35	-	-	-	-	1	36	-
Micropterus dolomieui	-	-	-	-	-	-	1	9	-	-	4	2	1	13	2
Ictalurus natalis	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Noturus albater	14	8	41	33	36	55	24	13	21	17	13	14	88	70	131
Noturus exilis	10	6	1	11	7	1	23	8	-	5	3	-	49	24	2
Noturus flavater	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1
Fundulus catenatus	-	-	-	-	2	-	-	-	1	-	-	-	-	2	1
Fundulus olivaceus	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Cottus carolinae	8	9	4	21	26	6	26	44	4	11	6	3	66	85	17
Ichthyomyzon castaneus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1

Species	Winter			Spring			Summer			Fall			TOTAL		
	P	H	R	P	H	R	P	H	R	P	H	R	P	H	R
Etheostoma blennioides	4	4	7	3	2	12	9	3	4	2	1	2	18	10	25
Etheostoma caeruleum	98	214	111	136	237	154	101	92	25	41	28	64	376	571	354
Etheostoma euzonum	3	25	31	2	47	5	1	4	6	-	11	10	6	87	52
Etheostoma juliae	145	301	378	159	366	608	209	243	430	263	225	601	776	1135	2017
Etheostoma stigmaeum	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Etheostoma zonale	16	1	81	10	7	74	8	5	39	2	7	55	36	20	249
Percina caprodes	-	-	-	-	2	2	-	-	-	-	-	-	-	2	2
Percina evides	-	-	1	-	-	16	-	-	-	-	-	-	-	-	17
Campostoma anomalum	-	-	-	3	-	4	72	-	4	21	19	3	96	19	11
Campostoma oligolepis	17	122	20	3	257	26	27	137	24	7	38	35	54	554	105
Dionda nubila	6	25	4	2	6	1	-	67	-	-	10	-	8	108	5
Hybopsis amblops	-	38	-	-	15	-	-	13	-	-	2	-	-	68	-
Hybopsis dissimilis	-	3	4	-	-	5	-	1	6	-	1	-	-	5	15
Nocomis biguttatus	-	1	-	-	-	-	4	-	-	-	3	-	4	4	-
Notropis boops	7	24	1	-	73	2	2	40	2	-	16	-	9	153	5
Notropis chrysocephalus	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-
Notropis galacturus	1	1	-	-	-	2	-	16	9	-	2	1	1	19	12
Notropis greenei	-	1	8	-	-	7	-	11	21	-	-	2	-	12	38

	Winter			Spring			Summer			Fall			TOTAL		
	P	H	R	P	H	R	P	H	R	P	H	R	P	H	R
Total number of fish	355	1139	758	404	1350	1014	598	999	655	388	526	810	1745	4014	3237
Total species	20	22	17	14	20	19	15	23	19	12	21	14	24	30	25

the abundant species with C. oligolepis, E. zonale, N. albater, N. pilsbryi, and N. exilis contributing 5.0 to 3.2% to the season's collections. During spring, N. albater, N. pilsbryi, N. exilis and E. zonale comprised 8.0 to 2.0% of the collections. Like in winter, E. juliae (39.6%) and E. caeruleum (33.7%)were the abundant species in the spring. In summer, E. juliae (34.9%), E. caeruleum (16.9%), N. pilsbryi (15.1%) and C. anomalum (12.0%) were the abundant species; C. oligolepis, C. carolinae, N. albater, and N. exilis contributed 5.0 to 3.0% to the season's abundance. In the fall collections, E. juliae was most abundant (67.8%) while E. caeruleum comprised 10.6%. C. anomalum, N. albater, C. carolinae, and N. pilsbryi contributed 6.0 to 3.0% to the total catch in the fall.

Number of species collected among the seasons was not significant ($x^2_3 = 2.27$). There was significant difference in the number of fishes collected among the seasons ($x^2_3 = 82.87$) with the greatest number being collected in summer and least during winter.

Hasty

Of the 4,014 fish collected from Hasty riffle, E. juliae (28.3%), N. pilsbryi (15.6%), E. caeruleum (14.2%), and C. oligolepis (13.8%) were abundant. Seasonal abundance of E. juliae was significant ($x^2_3 = 42.88$); its abundance during summer (21.4%) and fall (19.8%) was similar but spring (32.2%) and winter (26.5%) abundances were different among themselves and with summer and fall. The number of N. pilsbryi collected among the seasons was significant (x_3^2 = 79.92): fall collections (11.3%) were the lowest and winter; summer and spring abundances comprised 23.3, 30.5, and 34.9%, respectively. There was no difference between winter and summer, and summer and spring abundances. Seasonal abundance of E. caeruleum was significant (x_3^2 = 208.00) but the difference in the spring (41.4%) and winter (37.4%) abundances were not significant. During summer and spring they contributed 16.1% and 4.9%, respectively. Distribution of C. oligolepis among the seasons was significant (x_3^2 = 175.67); except for winter (22.0%) and summer (24.7%) all other comparisons were significant. The most and least abundances were in spring (46.4%) and fall (6.9%).

In the winter collections, E. juliae (26.4%), E. caeruleum (18.8%), N. pilsbryi (12.8%), N. telescopus (11.1%) and C. oligolepis (10.7%) were the abundant species. N. rubellus, H. amblops, D. nubila, E. euzonum, and N. boops comprised 7.0 to 2.1% of the winter collections.

During spring, E. juliae (27.1%), C. oligolepis (19.0%), E. caeruleum (17.6%) and N. pilsbryi (16.3%) were abundant. Other species comprising 5.4 to 2.0% of spring collections were N. boops, E. euzonum, N. albater, N. telescopus and C. carolinae.

E. juliae (24.3%), N. pilsbryi (19.1%), C. oligolepis (13.7%) and C. carolinae (9.2%) were the abundant species in the summer collections. D. nubila, N. rubellus, C. carolinae, N. boops, and L. megalotis contributed 6.7 to 3.5% of the season's collections.

The abundant species in the fall collections were E. juliae (42.8%) and N. pilsbryi (13.5%). The abundance of C. oligolepis, N. telescopus, E. caeruleum, N. rubellus, and C. anomalum ranged from 7.2 to 3.6%.

For the Hasty riffle, there was no seasonal difference in the number of species (x^2_3 = 0.22) but the difference in the number of fishes collected was highly significant (x^2_3 = 2469.16). Spring collections were greatest followed by winter, summer, and fall collections.

Rush

E. juliae and E. caeruleum comprised 62.3% and 10.9%, respectively, of the total 3,237 fishes collected. Abundance of E. juliae was significantly different (x^2_3 = 82.50) between seasons; there was no difference between winter and summer which had low abundance. The abundance of E. caeruleum between seasons was significantly different (x^2_3 = 106.54) and each season's abundance was significantly different from each of the other seasons. The abundance increased from summer through spring.

In the winter collections, E. juliae was dominant (49.9%) and E. caeruleum (14.6%) and E. zonale (10.7%) were the next abundant species. The abundance of N. rubellus, N. albater, E. euzonum, C. oligolepis, and N. pilsbryi ranged from 6.2 to 2.1%.

E. juliae was the most abundant (60.0%) and E. caeruleum was the second most abundant (15.2%) of the spring collections.

E. zonale, N. albater, C. oligolepis and N. rubellus contributed 7.3 to 2.2%.

In the summer, E. juliae was the most abundant (65.8%). The abundance of N. pilsbryi, E. zonale, E. caeruleum, C. oligolepis, N. greenei and N. albater ranged from 8.3 to 3.2%.

During the fall season, E. juliae was again the most abundant fish (74.2%). E. caeruleum, E. zonale, C. oligolepis and N. pilsbryi comprised 7.9 to 2.1% of the fall collections.

There was no difference in the number of species among the seasons (x_3^2 = 0.79). Seasonal abundance of fishes was significant (x_3^2 = 84.86%). There was no difference in the number of fish collected in winter and spring and the abundances of fishes in other seasons were significant with spring and summer yielding highest and lowest numbers.

Comparison of riffle stations

Number of species collected were not different either between the seasons or the riffle stations (x_6^2 = 1.87). In Ponca and Rush riffles, fishes of the family Percidae were dominant contributing 69.5 and 83.9% of the collections. In the Hasty riffle collections, members of the families Percidae (45.5%) and Cyprinidae (48.5%) were dominant. In all three stations, E. juliae was the most dominant. Among the percids, darters were the predominant members. Among the cyprinids, N. pilsbryi and C. anomalum were the dominant species in Ponca and Rush collections. In Hasty collections, N. pilsbryi, C.

oligolepis, N. telescopus and N. rubellus were the dominant cyprinids. Among the ictalurids, N. albater was the dominant species in all the stations.

Of the above fishes, N. telescopus was mainly a riffle inhabitant whereas N. pilsbryi, N. rubellus, N. albater, C. anomalum and C. oligolepis inhabited both riffles and pools. All the darters are riffle inhabitants (Pflieger 1975). Of the two stonerollers, the largescale stoneroller (C. oligolepis) was more abundant than the common stoneroller (C. anomalum). The largescale stoneroller is less tolerant of stream alteration than the common stoneroller. (Ill. Nat. Hist. Sur. Rept. 1976).

Comparisons of pool and riffle stations

There was no difference in the number of species either between the three collecting stations or between pool and riffle habitats ($x_2^2 = 1.27$). However, species collected in the pools and riffles were not the same. Pool collections were dominated by cyprinids (51.0%) and centrarchids (40.5%) while percids (64.0%) and cyprinids (29.3%) were the dominant groups of the riffle collections.

Among the cyprinid fishes, N. boops (32.1%) was the dominant species followed by N. pilsbryi (11.0%), N. telescopus (11.0%), H. amblops (10.9%) and D. nubila (9.4%) in the pool collections. Of these, the primary pool inhabitants, N. boops, H. amblops and D. nubila comprised 52.4% of the cyprinid collections whereas the pool-riffle inhabitants, N. pilsbryi and

N. telescopus contributed 22.0%. N. pilsbryi and C. oligolepis comprised 59.6% of the riffle cyprinid collections.

The data presented in this report indicate a distinct difference in the fishes collected from riffle and pool stations of the Buffalo River.

Helminth and Copepod Parasites of the Smallmouth Bass

Becker, Heard, and Holmes (1966) reported the helminth and copepod parasites of the smallmouth bass in their pre-impoundment investigation of the White River in northwestern Arkansas. This is the only report of these parasites from the smallmouth bass in rivers in Arkansas. Appendix 2 compares these parasites with those found in the present investigation along with the common name of the parasite and its site of removal from the host.

A total of 15 species was reported from White River smallmouth bass (Becker, Heard, and Holmes 1966), while 32 species were taken from Buffalo River smallmouth bass in the present investigation (Appendix 2). Those species of parasites of White River smallmouth bass also were present in or on Buffalo River smallmouth bass.

Appendix 2 indicates several parasites which were identified only to genus. The digenetic trematodes Neascus sp. and Rhipidocotyle sp. were so identified due to the taxonomic difficulties encountered with Neascus, and the fact that the papillae on the anterior hood of Rhipidocotyle are not demonstrable in young worms or are withdrawn when the worm is contracted. The number of these papillae aid in the speciation of *Rhipidocotyle*. The nematodes *Contracaecum* sp. and *Philometra* sp. were also identified only to genus. An unidentifiable nematode cyst was also encountered. Usually only the larvae of *Contracaecum* were found, making species identification impossible. Taxonomic difficulties also were encountered with *Philometra*. A similar situation also existed with clam glochidia.

In general, monogenetic trematodes, leeches, and copepods have direct life cycles, i.e., there is no intermediate host necessary to complete their developmental cycle. On the other hand, digenetic trematodes, cestodes, acanthocephalans, and nematodes have indirect life cycles with one to several intermediate hosts a necessity, as the case may be.

Schmitz (1973, 1974) surveyed the benthic macroinvertebrates of the Buffalo River. Information derived from his investigations verify the presence of these organisms necessary for the life cycles of certain helminth parasites of smallmouth bass of the Buffalo River. Unfortunately, data is lacking concerning microinvertebrates of the Buffalo River. However, the existence of certain icthyoparasites discovered in the present study is indicative of their presence, especially copepods and ostracods.

As more species of digenetic trematodes, cestodes, and nematodes were found in Buffalo River smallmouth bass than in White River smallmouth, it may be concluded that the species composition of these parasites imparts a more complex and diversified parasitocoenosis to the Buffalo River. This situation enables parasites to be used as models for indications of the effects of various biotic and abiotic factors on the interplay of many ecological factors necessary to maintain the Buffalo River as a biologically homeostatic ecosystem, commensurate with the absence of man's impact on this beautiful river.

It should be noted that none of the parasites encountered in this investigation are pathogenic to man.

Parasites at all collecting sites
during all seasons combined

Table 5 indicates the prevalence of the helminth and copepod parasites of 127 smallmouth bass from the Buffalo River at all collecting sites and seasons combined. All of these hosts were infected with at least one species of parasite.

Monogenetic trematodes

Table 5 reveals that of the six species of monogenetic trematodes found, Actinocleidus fusiformis and Urocleidus principalis each infected 31.5% of the fish for the highest infection rates. They also occurred in the highest average numbers of monogeneans per fish (1.3 and 15.3, respectively). The largest number of monogeneans recovered from a single host was 541 U. principalis (Table 5).

The discovery of Leptocleidus megalonchus (Table 5) marks the only report of this monogenean since it was first described

TABLE 5. Prevalence of helminth and copepod parasites of 127 smallmouth bass of the Buffalo River.

Parasite	% Fish Infected	Average Number of Parasites Per Fish	Standard Deviation	Maximum Number of Parasites Per Fish
Monogenetic Trematodes				
Acolpenteron ureteroecetes	1.6	<0.0	0.20	2
Acinoocleidus fusiformis	31.5	1.3	2.94	15
Clavunculus bursatus	15.7	0.4	1.31	9
Cleidodiscus banghami	23.6	0.8	2.48	15
Leptocleidus megalonchus	0.8	0.1	0.71	8
Urocleidus principalis	31.5	15.3	64.41	541
Digenetic Trematodes				
Clinostomum marginatum	33.1	1.4	5.54	59
Crepidostomum cornutum	38.6	6.2	28.07	298
Cryptogonimus chyli	44.9	73.6	335.63	3480
Leuceruthrus micropteri	44.9	1.0	1.58	8
Neascus sp.	78.7	9.2	13.58	83
Pisciamphistoma reynoldsi	10.2	0.2	0.88	6
Posthodiplostomum minimum	7.9	3.4	17.45	151
Rhipidocotyle papillosum	20.5	0.7	2.04	14
Rhipidocotyle septpapillata	7.9	0.2	0.90	8
Rhipidocotyle sp.	64.6	26.9	66.56	587
Cestodes				
Bothriocephalus cuspidatus	3.2	0.1	0.59	6
Proteocephalus ambloplitis adult	15.7	0.4	1.49	15
Proteocephalus ambloplitis larva	14.2	0.4	1.08	7
Acanthocephalan				
Neoechinorhynchus cylindratus	79.5	11.6	16.53	88
Nematodes				
Capillaria catenata	7.1	0.4	3.07	34
Contracaecum sp.	19.7	2.8	9.50	59
Philometra sp.	12.6	0.4	1.44	8
Rhabdochona cascadilla	2.4	<0.0	0.15	1
Spinitectus carolini	59.8	4.2	7.19	34
Nematode cyst	93.7	190.9	336.88	2055
Molluscs				
Glochidia	7.9	4.4	33.62	372
Leeches				
Myzobdella moorei	29.9	0.5	0.93	6
Piscicola punctata	1.6	<0.0	0.37	4
Copepods				
Achtheres micropteri	46.5	1.4	2.59	15
Ergasilus centrarchidarum	33.9	1.6	3.48	24
Lernaea cruciata	4.7	0.1	0.33	3

in 1936. It is currently being redescribed by Mayes and Becker. The lowest infection rate of all the monogenetic trematodes was represented by this species (Table 5).

Digenetic trematodes

Neascus sp. (black spot) infected more hosts than any of the other digenetic trematodes (78.7%), and was the third highest in infection rate of all the parasites encountered (Table 5).

Cryptogonimus chyli was found to occur in the highest average number of digeneans per fish (73.6) and also occurred in the greatest maximum number of all other parasites per fish - a total of 3,480 in one fish (Table 5). According to Hoffman (1967), C. chyli metacercariae have been reported from the flesh of several fish hosts which are also found in the Buffalo River, viz., A. rupestris, E. caeruleum, and M. dolomieui (Appendix 1).

The usual intermediate hosts of the digenetic trematodes include snails. However, the mussel Elliptio dilatatus Rafinesque serves as the first intermediate host for Rhipidocotyle papillosum, while their metacercariae are found in such fish hosts as A. rupestris, C. bairdi, and M. dolomieui (Hoffman 1967). These fishes are indigenous to the Buffalo River (Appendix 1). Another mussel, Lampsilis sp., is the first intermediate host for R. septpapillata, while its metacercariae are found in fish hosts to include Fundulus diaphanus (LeSueur), Lebistes sp., Lepomis gibbosus (Linnaeus), M. salmoides, and

Semotilus atromaculatus (Mitchell) (Hoffman 1967). Of these fishes, only M. salmoides was found in the Buffalo River, but other species of Fundulus and Lempomis occur there (Appendix 1). The species of Rhipidocotyle together accounted for a rather high percentage of smallmouth bass infected with digenetic trematodes in the Buffalo River (Table 5).

The metacercariae of Clinostomum marginatum and Posthodiplostomum minimum were encountered in 33.1% and 7.9%, respectively, of the fish. Their presence is pertinent because both parasites have herons as definitive or final hosts with the addition of loons for P. minimum (Hoffman 1967). The first intermediate hosts for C. marginatum are species of the snail Helisoma, while Physa sp. are snail intermediate hosts for P. minimum (Hoffman 1967). It is interesting to note that Hoffman (1967) indicated that it is safe to assume that C. marginatum is capable of infecting any species of freshwater fish.

The first intermediate host for Crepidostomum cornutum are species of the snails Sphaerium Scopoli and Musculium Link, and the second intermediate host for the metacercarial stage are crayfish (Hoffman 1967). C. cornutum adults are also found in 13 genera of fishes and in salamanders and frogs (Hoffman 1967). Of these fish genera, six were found during the present study. Table 5 indicates that 38.6% of the smallmouth bass were infected with C. cornutum with as many as 298 per fish.

It is evident from this rather rich fauna of ichthyoparasitic digenetic trematodes with their indirect life cycles involving certain piscivorous birds, fishes, frogs, salamanders, and aquatic micro- and macroinvertebrates, that there is a very complex food web existing in the Buffalo River. Further evidence for this thesis will be apparent when other indirect life cycles of ichthyoparasites are considered in the present study.

Cestodes

The bass tapeworm *Proteocephalus ambloplitis* was found in both its adult and plerocercoid stages which infected approximately the same percentage of fish (15.7% and 14.2%, respectively) (Table 5). The first intermediate hosts for the procercoid stage of this tapeworm are copepods, the second intermediate hosts for the plerocercoid are numerous species of fishes, and the definitive hosts are black basses (Hoffman 1967).

The percentage of fish infected with *Bothriocephalus cuspidatus* was only 3.2% (Table 5). This tapeworm also uses a copepod as its first intermediate host for the procercoid stage, with small fishes possibly acting as "carriers" (Hoffman 1967).

The presence of these two cestode parasites, evidenced by their life cycles, is further indication of the complexity of food web in the Buffalo River.

Acanthocephalans

Neoechinorhynchus cylindratus was the only acanthocephalan taken, but it infected 79.5% of the fish (Table 5). This helminth had the second highest percent infection of all the parasites found in the present study, an average of 11.6 parasites per fish, and as many as 88 per fish. Ostracod crustaceans serve as first intermediate hosts, and fishes such as the bluegill may serve as second intermediate hosts (Hoffman 1967). The bluegill is indigenous to the Buffalo River (Appendix 1). From the prevalence of this helminth, it appears that the Buffalo River supports a prolific ostracod population, and that the interrelationships among the intermediate and definitive hosts is very conducive to maintaining such a high prevalence of this spiny-headed worm.

Nematodes

One of the disappointing facets of the parasitology phase of this investigation was the inability to microscopically identify a type of nematode cyst which infected more fish (93.7%) than any other parasite (Table 5). These nematode cysts also were found in the greatest average number of parasites per fish (190.9) and the second highest maximum number of parasites per fish (2,055) (Table 5). Because of its prevalence, identity and knowledge of the life cycle of this nematode would undoubtedly lend impetus to the fact that there are dynamic interrelationships among the rich diversity and abundance of ichthyoparasites, their intermediate, and definitive hosts in the Buffalo River.

In the life cycles of Camallanus oxycephalus and Philometra sp., the larvae are ingested by copepods which are in turn eaten by the definitive hosts (Hoffman 1967). C. oxycephalus infected 44.9% of the fish, while Philometra sp. infected only 12.6%.

The larvae of Rhabdochona cascadilla are found in mayflies (Hoffman 1967). Although this nematode was encountered in only 2.4% of the fish (Table 5), its presence involves another intricate relationship between intermediate host and parasite. In this case an aerial and macrobenthic insect acts as an intermediate host for the ichthyoparasitic nematode.

Spinitectus carolini infected 59.8% of the fish representing the second highest percent of infection by a nematode (Table 5). Having this high prevalence, it is unfortunate that the life history of this nematode is unknown. This discovery would undoubtedly lend further knowledge of the intricacies of host-parasite relationships.

Contracaecum sp. infected 19.7% of the fish with as many as 59 taken from one host (Table 5). Although the species of Contracaecum discovered in the present study was not determined, C. spiculigerum (Rudolphi, 1809) and C. brachyurum (Ward and Magath, 1917) have both been reported from many species of fish hosts including Micropterus (Hoffman 1967). The definitive hosts of C. spiculigerum include such piscivorous birds as cormorants, mergansers, gulls, and pelicans (Hoffman 1967). As there is a distinct possibility that the species of

Contracaecum found in Buffalo River smallmouth bass may be one or both of these nematodes, it is conceivable that there is further interposition of piscivorous birds in the food web of this river.

Molluscs

Although relatively few molluscs are parasites, glochidia larvae of unionid clams are ectoparasites of fishes (Hoffman 1967). Although only 7.9% of the fish were infected with glochidia, as many as 372 were encountered on a single fish (Table 5). The presence of these glochidia and the fact that two digenetic trematodes discovered in this investigation utilize clams as intermediate hosts, indicate the importance of these mussels to certain parasitic life cycles in the Buffalo River.

Leeches

Of the two leeches taken, *Myzobdella moorei* infected the highest percentage of fish (29.9%), whereas *Piscicola punctata* infections were only incidental (1.6%) (Table 5). Although leech life cycle information is inadequate, they are assumed to have direct life cycles. Leeches serve as vectors for many blood parasites of fishes (Hoffman 1967), but these parasites were not monitored in this study.

Copepods

Achtheres micropteri and *Ergasilus centrarchidarum* infected 46.5% and 33.9%, respectively, of the fish, but their average number per fish was only 1.4 and 1.6, respectively (Table 5). However, as many as 24 E. centrarchidarum or 15 A. micropteri were taken from a single host (Table 5). Infections with the anchor worm Lernaea cruciata were incidental (Table 5).

In examining the above data concerning the prevalence of the helminth and copepod parasites of the smallmouth bass in the Buffalo River for the combined collecting sites and seasons, and considering the life cycles which are known for these parasites, one is impressed by their important contribution to the very complex ecosystem of this magnificent river.

Parasites at each collecting site during the combined seasons

Table 6 indicates the percent of infected fish, the average number of parasites per fish, the standard deviation of the mean, and the maximum number of parasites per fish at each of the three collecting sites during the combined seasons. The upstream, midstream and downstream collecting sites were Ponca, Hasty, and Rush, respectively. Table 7 gives the chi-square values for various infections.

It should be explained that the smallmouth bass collections at Ponca were very meager due to low water levels brought upon by an unpredictably dry year. However, certain statistical comparisons of parasite prevalence between this collecting site and the other two could be made (Table 7).

Of the monogenetic trematodes, only Cleidodiscus

TABLE 6. Prevalence of the helminth and copepod parasites of the smallmouth bass of the Buffalo River at each collecting site during the combined seasons.

	% Fish Infected			Average Number of Parasites Per Fish			Standard Deviation			Maximum Number of Parasites Per Fish		
(Fish Examined)	(12)	(76)	(39)	(12)	(76)	(39)	(12)	(76)	(39)	(12)	(76)	(39)
Parasite	Ponca	Hasty	Rush	Ponca	Hasty	Rush	Ponca	Hasty	Rush	Ponca	Hasty	Rush
Monogenetic Trematodes												
Acolpenteron ureteroecetes	0.0	1.3	2.6	0.0	<0.0	<0.0	0.00	0.23	0.16	0	2	1
Actinocleidus fusiformis	33.3	39.5	15.4	1.9	1.7	0.3	3.65	3.33	1.15	10	15	7
Clavunculus bursatus	16.7	19.7	7.7	0.5	0.6	0.1	1.45	1.54	0.52	5	9	3
Cleidodiscus banghami	41.7	26.3	12.8	2.7	0.8	0.1	4.79	2.47	0.34	14	15	1
Leptocleidus megalonchus	8.3	0.0	0.0	0.7	0.0	0.0	2.31	0.00	0.00	8	0	0
Urocleidus principalis	33.3	46.1	2.6	52.8	17.2	0.1	154.51	55.86	0.64	541	396	4
Digenetic Trematodes												
Clinostomum marginatum	41.7	30.3	35.9	1.1	1.0	2.2	2.27	2.32	9.42	8	15	59
Crepidostomum cornutum	50.0	46.1	20.5	7.1	9.0	0.4	17.23	35.41	1.05	61	298	5
Cryptogonimus chyli	8.3	26.3	92.3	0.1	4.7	230.5	0.29	23.60	579.62	1	149	3840
Leuceruthrus micropteri	8.3	47.4	51.3	0.1	1.1	1.0	0.29	1.50	1.56	1	7	8
Neascus sp.	66.7	80.3	79.5	19.3	9.8	4.9	27.18	12.68	5.34	83	82	24
Pisciamphistoma reynoldsi	1.67	11.8	5.1	0.5	0.3	0.1	1.45	0.95	0.35	5	6	2
Posthodiplostomum minimum	25.0	9.2	0.0	11.8	3.8	0.0	24.32	20.18	0.00	79	151	0
Rhipidocotyle papillosum	25.0	22.4	15.4	0.8	0.8	0.3	1.54	2.45	1.03	5	14	6
Rhipidocotyle septpapillata	8.3	9.2	5.1	0.1	0.3	0.1	0.29	1.14	0.22	1	8	1
Rhipidocotyle sp.	50.0	78.9	41.0	27.9	39.3	2.5	52.68	80.86	7.79	153	587	46
Cestodes												
Bothriocephalus cuspidatus	8.3	3.9	0.0	0.2	0.1	0.0	0.58	0.73	0.00	2	6	0
Proteocephalus ambloplitis adult	0.0	18.4	15.4	0.0	0.5	0.2	0.00	1.87	0.58	0	15	2
Protoocephalus ambloplitis larva	16.7	11.8	17.9	0.3	0.3	0.5	0.89	0.96	1.35	3	5	7
Acanthocephalan												
Neoechinorhynchus cylindratus	50.0	90.8	66.7	2.3	17.3	3.5	3.26	19.15	4.59	10	88	18
Nematodes												
Camallanus oxycephalus	0.0	61.8	25.6	0.0	2.6	0.6	0.00	4.39	1.23	0	22	5
Capillaria catenata	0.0	7.9	7.7	0.0	0.2	0.9	0.00	0.81	5.44	0	5	34
Contracaecum sp.	8.3	25.0	12.8	0.3	4.5	0.3	0.87	11.98	1.15	3	59	6
Philometra sp.	8.3	10.5	17.9	0.3	0.3	0.6	1.15	1.25	1.84	4	7	8
Rhabdochona cascadilla	0.0	3.9	0.0	0.0	<0.0	0.0	0.00	0.20	0.00	0	1	0
Spinitectus carolini	58.3	72.4	35.9	5.0	5.7	1.0	7.82	8.18	2.53	26	34	15
Nematode cyst	91.7	92.1	97.4	88.4	187.2	229.5	149.31	310.81	417.50	499	1937	2055
Molluscs												
Glochidia	8.3	7.9	7.7	0.1	6.6	1.5	0.29	43.04	8.21	1	372	51
Leeches												
Myzobdella moorei	8.3	27.6	41.0	0.1	0.4	0.7	0.29	0.91	1.06	1	6	4
Piscicola punctata	0.0	1.3	2.6	0.0	0.1	<0.0	0.00	0.46	0.16	0	4	1
Copepods												
Achtheres micropteri	25.0	52.6	41.0	0.3	1.5	1.7	0.65	2.45	3.13	2	13	15
Ergasilus centrarchidarum	41.7	47.4	5.1	0.8	2.4	0.1	1.34	4.25	0.22	4	24	1
Lernaea cruciata	0.0	7.9	0.0	0.0	0.1	0.0	0.00	0.42	0.00	0	3	0

TABLE 7. Chi-square values for the prevalence of the helminth and copepod parasites of the smallmouth bass of the Buffalo River comparing each collecting site during the combined seasons.

* = significant (0.05 level); X^2 critical value 3.84, 1 df.

Values not recorded indicate X^2 test inapplicable (sample site <5 hosts).

banghami infections provided enough data to compare its prevalence at all three collecting sites, and its decrease between Ponca and Rush was significant (Tables 6 and 7). There was also a significant decrease in Actinocleidus fusiformis between Hasty and Rush (Tables 6 and 7). Urocleidus principalis had the highest number of all monogeneans per fish at Ponca and Hasty; 541 and 396, respectively (Table 6). There appeared to be no definite pattern in the prevalence of monogenetic trematodes among the collecting sites during the combined seasons.

It was possible to statistically compare the percentage of infections with the digenetic trematodes Clinostomum marginatum, Crepidostomum cornutum, and Rhipidocotyle sp. among all three collecting sites (Table 6 and 7). C. marginatum decreased significantly between Ponca and Hasty, while C. cornutum decreased significantly in a progressive fashion downstream (Tables 6 and 7). The only significant difference in Rhipidocotyle sp. was an increase between Ponca and Hasty (Tables 6 and 7). Cryptogonimus chyli was obviously more prevalent at Rush than Ponca or Hasty (Table 6). Other significant differences occurred between Hasty and Rush: an increase of Leuceruthrus micropteri, and decreases of Neascus sp. and R. papillosum (Tables 6 and 7). Other than the progressive downstream decline of C. cornutum, there was no distinctive pattern of distribution of digenetic trematodes among the collecting sites during the combined seasons.

Other than the significant increase of the plerocercoid larvae of the cestode Proteocephalus ambloplitis between Hasty and Rush, there was no characteristic prevalence of cestodes among the collecting sites during the combined seasons.

No significant differences were found in the infection percentages by the ancanthocephalan Neoechinorhynchus cylindratus among the collecting sites during the combined seasons (Tables 6 and 7).

Spinitectus carolini was the only nematode for which chi-square analyses could be employed to determine any significant prevalence differences among the three collecting sites during the combined seasons. A significant increase of this nematode was found only between Ponca and Hasty (Tables 6 and 7). Although chi-square analysis was inapplicable for the unidentified nematode cyst, its consistently higher percentage of infection than any other parasite at each of the collecting sites demarked it as a most important parasite of the smallmouth bass.

No significant differences in the percent of fish infected among the three collecting sites during the combined seasons was noted for those parasites which could be subjected to chi-square analysis: the leech Myzobdella moorei, and the copepods Achtheres micropteri and Ergasilus centrarchidarum.

The above data indicate that except for the decline in percent infection of smallmouth bass with the digenetic trematode Crepidostomum cornutum in a progressive fashion downstream, there was no significant set pattern of infection among the collecting sites during the combined seasons.

Parasites during each season for the combined collecting sites

Table 8 indicates the percent of infected fish, the average number of parasites per fish, the standard deviation of the mean, and the maximum number of parasites per fish during each season for the combined collecting sites. Table 9 gives the chi-square values for the various infections.

Of the monogenetic trematodes, it was possible to perform the chi-square analysis for complete seasonal distribution only for Urocleidus principalis. Tables 8 and 9 indicate that this monogenean infected a significantly higher percentage of fish in the fall and and winter than in the summer. U. principalis had the highest average number of parasites per fish as well as the highest maximum number of parasites per fish of all the monogeans during each of the seasons (Table 8). Two other monogeans for which partial seasonal chi-square analyses were possible and which showed significant differences were Clavunculus bursatus which decreased between winter and spring, and Cleidodiscus banghami which was higher in the fall than the spring and increased between spring and summer (Tables 8 and 9). There thus appeared to be no consistent seasonal distribution among the monogenetic trematodes.

TABLE 8. Prevalence of the helminth and copepod parasites of the smallmouth bass of the Buffalo River during each season for the combined collecting sites.

	% Fish Infected				Average Number of Parasites Per Fish				Standard Deviation				Maximum Number of Parasites Per Fish			
(Fish Examined)	(32)	(20)	(48)	(27)	(32)	(20)	(48)	(27)	(32)	(20)	(48)	(27)	(32)	(20)	(48)	(27)
Parasite	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
Monogenetic Trematodes																
Acolpenteron ureteroecetes	3.1	0.0	2.1	0.0	<0.0	0.0	<0.0	0.0	0.18	0.00	0.29	0.00	1	0	2	0
Actinocleidus fusiformis	31.3	20.0	39.6	25.9	1.5	0.3	2.2	0.3	3.42	0.55	3.64	0.68	15	2	14	3
Clavunculus bursatus	18.8	35.0	10.4	7.4	0.4	1.5	0.2	0.1	1.13	2.58	0.67	0.27	5	9	4	1
Cleidodiscus banghami	40.6	10.0	12.5	33.3	1.4	0.8	0.3	1.0	3.16	3.35	0.76	2.75	14	15	3	14
Leptocleidus megalonchus	0.0	0.0	2.1	0.0	0.0	0.0	1.7	0.0	0.00	0.00	1.15	0.00	0	0	8	0
Urocleidus principalis	25.0	25.0	43.8	22.2	4.5	2.1	32.4	7.6	14.31	5.55	100.59	25.91	77	20	541	131
Digenetic Trematodes																
Clinostomum marginatum	25.0	15.0	41.7	40.7	1.3	3.1	0.9	0.9	3.15	13.17	1.54	1.75	15	59	7	8
Crepidostomum cornutum	31.3	35.0	45.8	37.0	1.7	1.7	13.6	1.6	3.89	3.36	44.73	3.23	15	12	298	13
Cryptogonimus chyli	43.8	55.0	25.0	74.1	40.2	269.4	29.7	46.3	98.78	790.56	135.54	95.58	462	3480	801	461
Leuceruthrus micropteri	34.4	30.0	54.2	55.6	0.4	0.6	1.1	1.4	0.67	1.23	1.57	2.06	2	5	7	8
Neascus sp.	90.6	45.0	79.2	88.9	6.5	3.1	14.3	7.8	7.94	4.24	19.19	7.25	40	12	83	28
Pisciamphistoma reynoldsi	6.3	30.0	8.3	3.7	0.1	0.6	0.3	0.1	0.25	1.05	1.19	0.38	1	4	6	2
Posthodiplostomum minimum	15.6	5.0	6.3	3.7	8.9	0.1	2.3	1.1	30.74	0.45	12.01	5.77	151	2	79	30
Rhipidocotyle papillosum	18.8	15.0	10.4	44.4	0.7	0.4	0.3	1.4	2.35	1.35	1.36	2.84	13	6	8	14
Rhipidocotyle septpapillata	18.8	0.0	0.0	14.8	0.6	0.0	0.0	0.3	1.63	0.00	0.00	0.71	8	0	0	3
Rhipidocotyle sp.	68.8	55.0	68.8	59.3	36.3	18.4	29.0	18.4	105.31	35.04	56.49	36.47	587	146	260	129
Cestodes																
Bothriocephalus cuspidatus	3.1	0.0	4.2	3.7	0.1	0.0	0.2	<0.0	0.35	0.00	0.91	0.19	2	0	6	1
Proteocephalus ambloplitis adult	15.6	20.0	18.8	7.4	0.4	0.2	0.6	0.1	0.91	0.41	2.26	0.42	3	1	15	2
Proteocephalus ambloplitis larva	9.4	5.0	6.3	40.7	0.3	0.2	0.2	1.0	0.84	0.67	0.72	1.72	4	3	4	7
Acanthocephalan																
Neoechinorhynchus cylindratus	68.8	75.0	87.5	81.5	4.8	7.2	19.0	9.9	5.70	8.00	21.93	13.94	22	31	88	51
Nematodes																
Camallanus oxycephalus	15.6	35.0	75.0	33.3	0.2	1.0	3.3	1.5	0.47	1.84	4.85	3.24	2	6	22	14
Capillaria catenata	0.0	5.0	8.3	14.8	0.0	0.1	0.2	1.5	0.00	0.45	0.82	6.54	0	2	5	34
Contracaecum sp.	6.3	5.0	35.4	18.5	0.2	0.1	6.6	1.3	1.07	0.22	14.22	5.21	6	1	59	27
Philometra sp.	21.9	5.0	12.5	7.4	0.6	0.4	0.4	0.3	1.46	1.79	1.37	1.35	7	8	7	7
Rhabdochona cascadilla	0.0	0.0	6.3	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.24	0.00	0	0	1	0
Spinitectus carolini	56.3	45.0	70.8	55.6	2.3	5.3	6.3	1.9	3.68	7.67	9.41	3.42	14	26	34	16
Nematode cyst	96.9	80.0	97.9	92.6	114.0	364.7	200.0	136.8	164.87	582.23	311.73	245.91	744	2055	1532	909
Molluscs																
Glochidia	0.0	15.0	14.6	0.0	0.0	2.3	10.8	0.0	0.00	7.36	54.22	0.00	0	31	372	0
Leeches																
Myzobdella moorei	21.9	30.0	33.3	33.3	0.4	0.4	0.5	0.4	1.01	0.75	1.09	0.64	4	3	6	2
Piscicola punctata	0.0	5.0	2.1	0.0	0.0	0.2	<0.0	0.0	0.00	0.89	0.14	0.00	0	4	1	0
Copepods																
Achtheres micropteri	37.5	40.0	50.0	55.6	0.9	0.6	1.3	3.0	1.46	0.94	1.76	4.48	5	4	8	15
Ergasilus centrarchidarum	34.4	45.0	35.4	22.2	0.8	1.4	2.4	1.1	1.34	2.50	4.73	3.04	5	10	24	15
Lernaea cruciata	0.0	5.0	8.3	3.7	0.0	0.1	0.1	<0.0	0.00	0.22	0.49	0.19	0	1	3	1

TABLE 9. Chi-square values for the prevalence of the helminth and copepod parasites of the smallmouth bass of the Buffalo River comparing each season for the combined collecting sites.

* = significant (0.05 level); X^2 critical value 3.84, 1 df.

Values not recorded indicate X^2 test inapplicable (sample size <5 hosts).

	Uninfected/Infected Fish				Combination Season Chi-Square Values					
(Fish Examined)	(32)	(20)	(48)	(27)						
Parasite	Fall	Winter	Spring	Summer	Fall - Winter	Fall - Spring	Fall - Summer	Winter - Spring	Winter - Summer	Spring - Summer
Monogenetic Trematodes										
Acolpenteron ureteroecetes	31/1	20/0	47/1	27/0						
Actinocleidus fusiformis	22/10	16/4	29/19	20/7		0.58	0.20			1.42
Clavunculus bursatus	26/6	13/7	43/5	25/2	1.73	1.12		5.87*†		
Cleidodiscus banghami	19/13	18/2	42/6	18/9		8.39*†	3.33			4.69*†
Leptocleidus megalonchus	32/0	20/0	47/1	27/0						
Urocleidus principalis	24/8	15/5	27/21	21/6	0.00	2.92	6.24*†	2.10	4.95*†	3.48
Digenetic Trematodes										
Clinostomum marginatum	24/8	17/3	28/20	16/11		2.34	1.66			6.11
Crepidostomum cornutum	22/18	13/7	26/22	17/10	7.87*†	1.70	2.19	6.77*†	2.07	5.47*†
Cryptogonimus chyli	18/14	9/11	36/12	7/20	6.24*†	3.08	5.52*†	5.68*†	1.86	1.70
Leuceruthrus micropteri	21/10	14/6	22/26	12/15	2.88	3.65	3.19	3.31	3.04	1.35
Neascus sp.	3/29	11/9	10/38	3/24				7.72*†		
Pisciamphistoma reynoldsi	30/2	14/6	44/4	26/1						
Posthodiplostomum minimum	27/5	19/1	45/3	26/1						
Rhipidocotyle papillosum	26/6	17/3	43/5	15/12		1.12	4.56*†			1.14
Rhipidocotyle septpapillata	26/6	20/0	48/0	23/4						
Rhipidocotyle sp.	10/22	9/11	15/33	11/16	1.00	0.00	5.75*†	1.17	8.53*†	6.87*†
Cestodes										
Bothriocephalus cuspidatus	31/1	20/0	46/2	26/1						
Proteocephalus ambloplitis adult	27/5	16/4	39/9	25/2		1.30				
Proteocephalus ambloplitis larva	29/3	19/1	45/3	16/11						
Acanthocephalan										
Neoechinorhynchus cylindratus	10/22	5/15	6/42	5/22	2.34	4.22*†	1.25	1.63	2.29	5.00*†
Nematodes										
Camallanus oxycephalus	27/5	13/7	12/36	18/9	2.60	2.71	2.54	9.72*†	1.42	1.25
Capillaria catenata	32/0	19/1	44/4	23/4						
Contracaecum sp.	30/2	19/1	31/17	22/5						2.38
Philometra sp.	25/7	19/1	42/6	25/2		1.24				
Rhabdochona cascadilla	32/0	20/0	45/3	27/0						
Spinitectus carolini	14/18	11/9	14/34	12/15	6.24*†	1.80	2.87	4.05*†	5.12*†	1.78
Nematode cyst	1/31	4/16	1/47	2/25						
Molluscs										
Glochidia	32/0	17/3	41/7	27/0						
Leeches										
Myzobdella moorei	25/7	14/6	32/16	18/9	4.33*†	1.23	9.73*†	7.17*†	5.88*†	0.00
Piscicola punctata	32/0	19/1	47/1	27/0						
Copepods										
Achtheres micropteri	20/12	12/8	24/24	12/15	3.87*†	1.21	1.92	5.67*†	1.11	2.14
Ergasilus centrarchidarum	21/11	11/9	31/17	21/6	5.87*†	9.16*†	1.05	5.49*†	2.74	1.42
Lernaea cruciata	32/0	19/1	44/4	26/1						

It was possible to analyze by the chi-square test, the complete seasonal distribution of only four of the digenetic trematodes: *Crepidostomum cornutum*, *Cryptogonimus chyli*, *Leuceruthrus micropteri*, and *Rhipidocotyle* sp. (Tables 8 and 9). Of these digeneans only *C. cornutum* showed a definite significant trend of infection percentages through consecutive seasons, increasing between fall and winter, increasing further in the spring, then decreasing in the summer (Tables 8 and 9). *C. chyli* increased between fall and winter, decreased between winter and spring, represented the highest number of parasites per fish, and except for fall, occurred as the greatest number of parasites per fish than any of the digenetic trematodes during each season (Tables 8 and 9). Seasonal fluctuations of *L. micropteri* were nonsignificant (Tables 8 and 9). Infections with *Rhipidocotyle* sp. were higher in the fall than in the summer, higher in the summer than in the winter, and decreased between spring and summer (Tables 8 and 9). Significant fluctuations of other digeneans for which incomplete seasonal analyses were possible were revealed for *Neascus* sp. which increased between winter and spring, and *Rhipodocotyle papillosum* which was higher in the summer than in the fall (Tables 8 and 9). Except for *C. cornutum*, there appeared to be no prevalent trend of seasonal distribution among the digenetic trematodes.

Chi-square analyses of the seasonal distributions of the cestodes was impossible in all instances except one for which no significant difference was found (Tables 8 and 9).

The acanthocephalan *Neoechinorhynchus cylindratus* was found to be significantly more prevalent in the spring than in the fall, and decreased significantly between spring and summer (Tables 8 and 9).

Only the nematodes *Camallanus oxycephalus* and *Spinitectus carolini* could be analyzed for all seasons using the chi-square test. *C. oxycephalus* increased significantly from winter to spring when it reached its highest percentage of infection (Tables 8 and 9). *S. carolini* decreased significantly from fall to winter, and was significantly higher in the spring and summer than in the winter (Tables 8 and 9). Further possible incomplete seasonal comparisons for the other nematodes revealed no significant differences (Tables 8 and 9). Of the seven nematodes encountered and of the two which could be completely analyzed for seasonal distribution, both *C. oxycephalus* and *S. carolini* increased significantly in percentage of infection from winter to spring when they infected the largest number of fish (Tables 8 and 9). Table 8 indicates that the unidentified nematode cyst consistently infected the highest percentage of fish, occurred in the highest average number of parasites per fish, and the highest maximum number of parasites per fish of all the nematodes during each season (Table 8). Except for the maximum number of parasites per fish in the winter, the unidentified nematode cyst was found in greater numbers in all three of the above categories than any other parasite during each season (Table 8). Except for the increase of *C. oxycephalus* and *S. carolini* as noted above, the nematodes appeared to have no particular pattern of seasonal distribution.

Further anaylses of the seasonal distributions of parasites revealed that glochidia occurred only in the winter and spring, having a greater average number and maximum number of parasites per fish in the spring (Table 8). Chi-square analysis of these data was not possible.

Of the two leeches, chi-square analysis for their seasonal distribution could be made only for *Myzobdella moorei*. It increased significantly from fall to winter and from winter to spring, having the highest percentage of infection during the spring and summer (Tables 8 and 9). Infections with *Piscola punctata* were incidental.

Two of the three copepods could be analyzed by the chi-square test throughout the seasons: *Achtheres micropteri* and *Ergasilus centrarchidarum*. *A. micropteri* increased significantly from fall to winter and from winter to spring, having the highest percentages of infection in the spring and summer (Tables 8 and 9). On the other hand, *E. centrarchidarum* also increased significantly between fall and winter, was significantly higher in the spring and fall, but was significanlty lower in the spring than in the winter (Tables 8 and 9). Thus it appeared that *A. micropteri* infections were more prevalent in the spring and summer; *E. centrarchi-*

darum in the winter and spring. Infections with the anchor worm *Lernaea cruciata* were very minor.

A summary of the seasonal distributions of percentages of fish infected by these parasites of the smallmouth bass of the Buffalo River indicates that certain ichthyoparasites displayed significant seasonal distribution patterns and others did not. Infections with the monogenetic trematode *U. principalis* were highest in the fall and winter, while glochidia and the copepod *E. centrarchidarum* were highest in the winter and spring. Infections with the digenetic trematode *C. cornutum*, the acanthocephalan *N. cylindratus*, and the nematodes *C. oxycephalus* and *S. carolini* were all highest in the spring. Infections with the leech *M. moorei* and the copepod *A. micropteri* were highest in the spring and summer. The unidentified nematode cyst infected a higher percentage of hosts during all seasons than any other parasite. It also occurred in the highest average number of parasites per fish, and except for the winter, displayed the highest maximum number of parasites per fish of all the parasites.

Parasites during each season for each collecting site

Tables 10, 11, and 12 indicate the percent fish infected, the average number of parasites per fish, the standard deviation of the mean, and the maximum number of parasites per fish during each season for the collecting sites at Ponca, Hasty and Rush,

TABLE 10. Prevalence of the helminth and copepod parasites of the smallmouth bass of the Buffalo River during each season for the Ponca collecting site.

	% Fish Infected				Average Number of Parasites Per Fish				Standard Deviation				Maximum Number of Parasites Per Fish			
(Fish Examined)	(4)	(2)	(5)	(1)	(4)	(2)	(5)	(1)	(4)	(2)	(5)	(1)	(4)	(2)	(5)	(1)
Parasite	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
Monogenetic Trematodes																
Acolpenteron ureteroecetes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	NA	0	0	0	0
Actinocleidus fusiformis	25.0	0.0	40.0	100.0	2.3	0.0	2.6	1.0	4.50	0.00	4.34		9	0	10	1
Clavunculus bursatus	25.0	50.0	0.0	0.0	1.3	0.5	0.0	0.0	2.50	0.71	0.00		5	1	0	0
Cleidodiscus banghami	75.0	0.0	20.0	100.0	4.0	0.0	0.4	14.0	4.97	0.00	0.89		11	0	2	14
Leptocleidus megalonchus	0.0	0.0	20.0	0.0	0.0	0.0	1.6	0.0	0.00	0.00	3.58		0	0	8	0
Urocleidus principalis	0.0	0.0	60.0	100.0	0.0	0.0	120.4	31.0	0.00	0.00	235.87		0	0	541	31
Digenetic Trematodes																
Clinostomum marginatum	50.0	0.0	40.0	100.0	2.3	0.0	0.6	1.0	3.86	0.00	0.89		8	0	2	1
Crepidostomum cornutum	50.0	0.0	60.0	100.0	1.8	0.0	14.2	7.0	2.36	0.00	26.37		5	0	61	7
Cryptogonimus chyli	0.0	0.0	20.0	0.0	0.0	0.0	0.2	0.0	0.00	0.00	0.45		0	0	1	0
Leuceruthrus micropteri	0.0	0.0	20.0	0.0	0.0	0.0	0.2	0.0	0.00	0.00	0.45		0	0	1	0
Neascus sp.	75.0	0.0	80.0	100.0	11.8	0.0	35.8	5.0	18.91	0.00	33.60		40	0	83	5
Pisciamphistoma reynoldsi	0.0	50.0	20.0	0.0	0.0	0.5	1.0	0.0	0.00	0.71	2.24		0	1	5	0
Posthodiplostomum minimum	25.0	0.0	20.0	100.0	8.0	0.0	15.8	30.0	16.00	0.00	35.33		32	0	79	30
Rhipidocotyle papillosum	50.0	0.0	0.0	100.0	1.0	0.0	0.0	5.0	1.15	0.00	0.00		2	0	0	5
Rhipidocotyle septpapillata	25.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.50	0.00	0.00		1	0	0	0
Rhipidocotyle sp.	50.0	0.0	60.0	100.0	10.8	0.0	33.8	123.0	15.09	0.00	66.89		32	0	153	123
Cestodes																
Bothriocephalus cuspidatus	25.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	1.00	0.00	0.00		2	0	0	0
Proteocephalus ambloplitis adult	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00		0	0	0	0
Proteocephalus ambloplitis larva	0.0	0.0	20.0	100.0	0.0	0.0	0.6	1.0	0.00	0.00	1.34		0	0	3	0
Acanthocephalan																
Neoechinorhynchus cylindratus	25.0	50.0	60.0	100.0	1.0	0.5	2.6	10.0	2.00	0.71	2.79		4	1	6	10
Nematodes																
Camallanus oxycephalus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00		0	0	0	0
Capillaria catenata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00		0	0	0	0
Contracaecum sp.	0.0	0.0	20.0	0.0	0.0	0.0	0.6	0.0	0.00	0.00	1.34		0	0	3	0
Philometra sp.	0.0	0.0	20.0	0.0	0.0	0.0	0.8	0.0	0.00	0.00	1.79		0	0	4	0
Rhabdochona cascadilla	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00		0	0	0	0
Spinitectus carolini	50.0	100.0	40.0	100.0	3.5	17.0	2.0	2.0	6.35	12.73	3.08		13	26	7	2
Nematode cyst	100.0	50.0	100.0	100.0	147.5	11.5	85.6	20.0	236.77	16.26	107.53		499	23	271	20
Molluscs																
Glochidia	0.0	0.0	20.0	0.0	0.0	0.0	0.2	0.0	0.00	0.00	0.45		0	0	1	0
Leeches																
Myzobdella moorei	25.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.50	0.00	0.00		1	0	0	0
Piscicola punctata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00		0	0	0	0
Copepods																
Achtheres micropteri	50.0	0.0	20.0	0.0	0.5	0.0	0.4	0.0	0.58	0.00	0.89		1	0	2	0
Ergasilus centrarchidarum	50.0	50.0	20.0	100.0	1.0	0.5	0.2	4.0	1.41	0.71	0.45		3	1	1	4
Lernaea cruciata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00		0	0	0	0

TABLE 11. Prevalence of the helminth and copepod parasites of the smallmouth bass of the Buffalo River during each season for the Hasty collecting site.

	% Fish Infected				Average Number of Parasites Per Fish				Standard Deviation				Maximum Number of Parasites Per Fish			
(Fish Examined)	(14)	(10)	(38)	(14)	(14)	(10)	(38)	(14)	(14)	(10)	(38)	(14)	(14)	(10)	(38)	(14)
Parasite	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
Monogenetic Trematodes																
Acolpenteron ureteroecetes	0.0	0.0	2.6	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.32	0.00	0	0	2	0
Actinocleidus fusiformis	50.0	10.0	44.7	35.7	2.3	0.2	2.4	0.5	4.23	0.63	3.75	0.85	15	2	14	3
Clavunculus bursatus	28.6	40.0	13.2	14.3	0.6	2.4	0.2	0.1	1.09	3.34	0.75	0.36	3	9	4	1
Cleidodiscus banghami	50.0	10.0	13.2	50.0	1.9	1.5	0.3	0.8	3.75	4.74	0.80	1.12	14	15	3	4
Leptocleidus megalonchus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0	0	0	0
Urocleidus principalis	50.0	50.0	47.4	35.7	10.1	4.2	25.1	12.4	20.70	7.44	74.80	34.97	77	20	396	131
Digenetic Trematodes																
Clinostomum marginatum	28.6	10.0	39.5	21.4	1.6	0.1	1.0	0.9	4.05	0.32	1.69	2.30	15	1	7	8
Crepidostomum cornutum	42.9	60.0	47.4	35.7	3.2	3.1	15.2	1.9	5.44	4.31	49.40	4.00	15	12	298	13
Cryptogonimus chyli	14.3	30.0	15.8	64.3	0.7	14.5	0.3	13.9	2.40	45.15	0.84	39.43	9	143	4	149
Leuceruthrus micropteri	35.7	20.0	55.3	64.3	0.7	0.6	1.2	1.6	1.33	1.58	1.65	1.87	5	5	7	6
Neascus sp.	100.0	50.0	79.0	85.7	8.4	3.9	12.5	8.1	6.28	4.93	16.13	8.81	23	12	82	28
Pisciamphistoma reynoldsi	7.1	40.0	7.9	7.1	0.1	0.8	0.3	0.1	0.27	1.32	1.08	0.53	1	4	6	2
Posthodiplostomum minimum	28.6	10.0	5.3	0.0	18.1	0.2	0.8	0.0	44.91	0.63	4.57	0.00	151	2	28	0
Rhipidocotyle papillosum	21.4	10.0	10.5	64.3	1.2	0.1	0.4	2.1	3.47	0.32	1.52	3.63	13	1	8	14
Rhipidocotyle septpapillata	28.6	0.0	0.0	21.4	1.1	0.0	0.0	0.4	2.35	0.00	0.00	0.94	8	0	0	3
Rhipidocotyle sp.	92.9	80.0	73.7	78.6	77.7	31.8	32.0	25.9	151.91	44.51	58.73	38.40	587	146	260	129
Cestodes																
Bothriocephalus cuspidatus	0.0	0.0	5.3	7.1	0.0	0.0	0.2	0.1	0.00	0.00	1.02	0.27	0	0	6	1
Proteocephalus ambloplitis adult	21.4	10.0	21.1	14.3	0.6	0.1	0.7	0.2	1.16	0.32	2.51	0.58	3	1	15	2
Proteocephalus ambloplitis larva	14.3	10.0	2.6	35.7	0.4	0.3	<0.0	1.0	1.16	0.95	0.16	1.57	4	3	1	5
Acanthocephalan																
Neoechinorhynchus cylindratus	100.0	90.0	89.5	85.7	8.4	11.2	22.8	15.4	5.81	9.09	23.14	17.20	22	31	88	51
Nematodes																
Camallanus oxycephalus	28.6	60.0	84.2	35.7	0.4	1.9	3.8	2.2	0.63	2.28	5.27	4.23	2	6	22	14
Capillaria catenata	0.0	0.0	10.5	14.3	0.0	0.0	0.3	0.4	0.00	0.00	0.92	1.09	0	0	5	3
Contracaecum sp.	7.1	0.0	42.1	14.3	0.1	0.0	8.3	2.1	0.27	0.00	15.59	7.19	1	0	59	27
Philometra sp.	14.3	0.0	10.5	14.3	0.4	0.0	0.3	0.6	1.16	0.00	1.18	1.87	4	0	7	7
Rhabdochona cascadilla	0.0	0.0	7.9	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.27	0.00	0	0	1	0
Spinitectus carolini	85.7	40.0	73.7	78.6	3.6	5.1	7.5	3.1	4.05	6.95	10.19	4.37	14	17	34	16
Nematode cyst	92.9	80.0	97.4	85.7	112.9	383.9	177.4	147.6	130.21	562.04	276.67	257.17	404	1937	1532	877
Molluscs																
Glochidia	0.0	20.0	10.5	0.0	0.0	4.4	12.1	0.0	0.00	10.20	60.53	0.00	0	31	372	0
Leeches																
Myzobdella moorei	7.1	30.0	42.1	7.1	0.1	0.3	0.7	0.1	0.27	0.48	1.19	0.27	1	1	6	1
Piscicola punctata	0.0	10.0	0.0	0.0	0.0	0.4	0.0	0.0	0.00	1.26	0.00	0.00	0	4	0	0
Copepods																
Achtheres micropteri	35.7	70.0	52.6	57.1	0.8	0.7	1.4	2.9	1.25	0.48	0.31	4.41	4	1	8	13
Ergasilus centrarchidarum	57.1	80.0	39.5	35.7	1.4	2.6	3.0	1.7	1.65	3.10	0.84	4.02	5	10	24	15
Lernaea cruciata	0.0	10.0	10.5	7.1	0.0	0.1	0.2	0.1	0.00	0.32	0.55	0.27	0	1	3	1

TABLE 12. Prevalence of the helminth and copepod parasites of the smallmouth bass of the Buffalo River during each season for the Rush collecting site.

	% Fish Infected				Average Number of Parasites Per Fish				Standard Deviation				Maximum Number of Parasites Per Fish			
(Fish Examined)	(14)	(8)	(5)	(12)	(14)	(8)	(5)	(12)	(14)	(8)	(5)	(12)	(14)	(8)	(5)	(12)
Parasite	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
Monogenetic Trematodes																
Acolpenteron ureteroecetes	7.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.27	0.00	0.00	0.00	1	0	0	0
Actinocleidus fusiformis	14.3	37.5	0.0	8.3	0.6	0.4	0.0	0.1	1.87	0.52	0.00	0.29	7	1	0	1
Clavunculus bursatus	7.1	25.0	0.0	0.0	0.1	0.5	0.0	0.0	0.27	1.07	0.00	0.00	1	3	0	0
Cleidodiscus banghami	21.4	12.5	0.0	8.3	0.2	0.1	0.0	0.1	0.43	0.35	0.00	0.29	1	1	0	1
Leptocleidus megalonchus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0	0	0	0
Urocleidus principalis	7.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.07	0.00	0.00	0.00	4	0	0	0
Digenetic Trematodes																
Clinostomum marginatum	14.3	25.0	60.0	58.3	0.6	7.6	0.6	0.9	1.74	20.77	0.55	1.00	6	59	1	3
Crepidostomum cornutum	14.3	12.5	20.0	33.3	0.2	0.4	0.4	0.8	0.58	1.06	0.89	1.48	2	3	2	5
Cryptogonimus chyli	85.7	100.0	100.0	91.7	91.1	655.4	282.4	88.1	135.25	1187.41	355.97	127.75	462	3480	801	461
Leuceruthrus micropteri	42.9	50.0	80.0	50.0	0.6	0.8	1.6	1.4	0.76	0.89	1.52	2.39	2	2	4	8
Neascus sp.	85.7	50.0	80.0	91.7	3.2	2.8	6.2	7.7	2.08	3.69	10.06	5.63	6	9	24	17
Pisciamphistoma reynoldsi	7.1	12.5	0.0	0.0	0.1	0.3	0.0	0.0	0.27	0.71	0.00	0.00	1	2	0	0
Posthodiplostomum minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0	0	0	0
Rhipidocotyle papillosum	7.1	25.0	20.0	16.7	0.1	0.9	0.2	0.3	0.27	2.10	0.45	0.62	1	6	1	2
Rhipidocotyle septpapillata	7.1	0.0	0.0	8.3	0.1	0.0	0.0	0.1	0.27	0.00	0.00	0.29	1	0	0	1
Rhipidocotyle sp.	50.0	37.5	40.0	33.3	2.2	6.1	0.8	0.9	4.84	16.13	1.10	1.56	17	46	2	4
Cestodes																
Bothriocephalus cuspidatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0	0	0	0
Proteocephalus ambloplitis adult	14.3	37.5	20.0	0.0	0.3	0.4	0.4	0.0	0.73	0.52	0.89	0.00	2	1	2	0
Proteocephalus ambloplitis larva	7.1	0.0	20.0	41.7	0.1	0.0	0.8	1.1	0.53	0.00	1.79	2.02	2	0	4	7
Acanthocephalan																
Neoechinorhynchus cylindratus	50.0	62.5	100.0	75.0	2.2	3.9	6.4	3.5	4.12	4.39	4.83	5.09	14	13	12	18
Nematodes																
Camallanus oxycephalus	7.1	12.5	80.0	33.3	0.1	0.1	2.4	0.8	0.27	0.35	1.52	1.48	1	1	4	5
Capillaria catenata	0.0	12.5	0.0	16.7	0.0	0.3	0.0	2.9	0.00	0.71	0.00	9.79	0	2	0	34
Contracaecum sp.	7.1	12.5	0.0	25.0	0.4	0.1	0.0	0.5	1.60	0.35	0.00	1.17	6	1	0	4
Philometra sp.	35.7	12.5	20.0	0.0	0.9	1.0	1.0	0.0	1.88	2.83	2.24	0.00	7	8	5	0
Rhabdochona cascadilla	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0	0	0	0
Spinitectus carolini	28.6	37.5	80.0	25.0	0.6	2.6	1.2	0.3	1.09	5.21	1.10	0.65	3	15	3	2
Nematode cyst	100.0	87.5	100.0	100.0	105.6	429.0	486.6	133.9	185.75	687.78	546.17	251.75	744	2055	1338	909
Molluscs																
Glochidia	0.0	12.5	40.0	0.0	0.0	0.3	11.6	0.0	0.00	0.71	22.23	0.00	0	2	51	0
Leeches																
Myzobdella moorei	35.7	37.5	0.0	66.7	0.8	0.6	0.0	0.8	1.42	1.06	0.00	0.72	4	3	0	2
Piscicola punctata	0.0	0.0	20.0	0.0	0.0	0.0	0.2	0.0	0.00	0.00	0.45	0.00	0	0	1	0
Copepods																
Achtheres micropteri	35.7	12.5	60.0	58.3	1.2	0.5	1.2	3.4	1.81	1.41	1.30	4.83	5	4	3	15
Ergasilus centrarchidarum	7.1	0.0	20.0	0.0	0.1	0.0	0.2	0.0	0.27	0.00	0.45	0.00	1	0	1	0
Lernaea cruciata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0	0	0	0

respectively.

Chi-square analyses of seasonal prevalence of ichthyoparasitic helminth and copepods at each of the collecting sites was impractical due to the small sample size of hosts, especially at Ponca. Nevertheless, certain data become apparent concerning the seasonal occurrence of these parasites at the three collecting sites (Tables 10, 11, and 12).

Only smallmouth bass taken at Rush during the fall were infected with the monogenean *Acolpenteron ureteroecetes*, while *Leptocleidus megalonchus* was found only at Ponca in the spring (Tables 10, 11, and 12). Although no single species of monogenetic trematode was found during each season at all collecting sites, four species were encountered during all seasons and these occurred only at Hasty: *Actinocleidus fusiformis*, *Clavunculus bursatus*, *Cleidodiscus banghami*, and *Urocleidus principalis* (Tables 10, 11, and 12).

None of the digenetic trematodes occurred at each of the collecting sites during each of the seasons (Table 10, 11, and 12). *Clinostomum marginatum*, and *Crepidostomum cornutum* were taken at each site during each season except for the winter at Ponca (Tables 10, 11, and 12). *Rhipidocotyle septpapillata* was absent from collections made during the winter and spring at all collecting sites (Tables 10, 11, and 12). At Hasty, except for *R. septpapillata*, all other digeneans were present during all seasons (Table 11). At Rush, *Posthodiplostomum minimum* was not found, *Pisciamphistoma reynoldsi* was not taken in the spring and summer, and *R. septpapillata* was not encountered in the winter and spring (Table 12). All other digeneans were collected at Rush during each season (Table 12). During all seasons at Rush, *Crytogonimus chyli* infected a very high percentage of hosts and had the highest maximum numbers of digeneans per fish - as many as 3,480 per host during the winter (Table 12).

The cestodes *Bothriocephalus cuspidatus* and adult *Proteocephalus ambolplitis* were absent from collections at Rush and Ponca, respectively (Tables 10 and 12). Otherwise, no consistent pattern of seasonal distribution of cestodes among the collecting sites was noted (Tables 10, 11, and 12).

The acanthocephalan *Neoechinorhynchus cylindratus* infected a rather high percentage of hosts at all sites during all seasons (Tables 10, 11, and 12).

The nematode *Rhabdochona cascadilla* was encountered incidentally only at Hasty in the spring (Table 11). *Capillaria catenata* infections did not occur at any of the collecting sites in the fall (Tables 10, 11, and 12). During each season at each collecting site, the unidentified nematode cyst consistently infected high percentages of hosts with the highest average number of parasites per fish of any of the parasites except the monogenean *Urocleidus principalis* in the spring at Ponca (Tables 10, 11, and 12). The unidentified nematode cyst also occurred in the highest maximum numbers per fish of all parasites for each season at each site with the following exceptions: *U. principalis* at Ponca in the spring, *Rhipidocotyle* sp. at Hasty in the fall, and *Cryptogonimus chyli* at Rush in the winter (Tables 10, 11, and 12). The only consistent pattern of nematode seasonal distribution at Hasty and Rush occurred with *Camallanus oxycephalus* which increased in percentage of infection from fall to winter, increased from winter to spring, and decreased from spring to summer although it is not known whether these differences are significant (Tables 11 and 12). This nematode was not found at Ponca. Other consistencies in nematode seasonal distribution at each of the collecting sites were not apparent.

Glochidia were found on fish collected at all three sites in the spring, and at Hasty and Rush in the winter; otherwise they were not encountered (Tables 10, 11, and 12).

There appeared to be no definite pattern of seasonal distribution of the leeches among the collecting sites (Tables 10, 11, and 12).

The copepod *Achtheres micropteri* was encountered at Hasty and Rush during each season, but there was no concurrent seasonal prevalence (Tables 11 and 12). Although *Ergasilus centrarchidarum* occurred during each season at Hasty, it was not found at Rush during the winter and summer (Tables 11 and 12). The anchor worm *Lernaea cruciata* was found only at Hasty, but not in the fall (Table 11).

A summary of the data concerning the occurrence of these ichthyoparasites at each site during each season (Tables 10, 11, and 12) reveals certain distribution patterns which are worth noting for future investigations. Four of six species of monogeneans occurred during all seasons only at Hasty; another species only in the spring at Ponca. None of the digenetic trematodes were encountered at each collecting site during each season, but *Rhipidocotyle septpapillata* was not found during the winter and spring at any collecting site. Other digeneans occurred at the various collecting sites during certain seasons, but there appeared to be no concomitant pattern of their seasonal distribution among these collecting sites. No scheme of seasonal distribution of adult cestodes at each site was noted except for the presence of *Bothriocephalus cuspidatus* at Rush, and *Proteocephalus ambloplitis* at Ponca. The only species of acanthocephalan encountered in this investigation occurred at each collecting site during each season. Glochidia were not found to infect fish at any of the collecting sites in the summer and fall. A definite pattern of seasonal distribution of the leeches among the collecting sites was not apparent. The copepod *Achtheres micropteri* occurred each season at Hasty and Rush; *Ergasilus centrarchidarum* each season only at Hasty. Infections with the anchorworm *Lernaea cruciata* were found only at Hasty, being absent in the fall.

Community Diversity of Ichthyofauna

Populations of different species determine the characteristics of communities. Persistent changes in an environment bring about changes in the populations and hence the community structure. Community structure can be useful as a biological index of environmental conditions. Diversity index is a method of describing community structure and permits summarization of large amounts of information about numbers and kinds of organisms. Theoretically, maximum diversity exists when there are a great many species and each species is represented by one individual; and minimum diversity exists when all individuals belong to a single species.

There has been no study on the community diversity of the Buffalo River fishes. Therefore, the presentation given here will serve as baseline information for future studies in evaluating fish faunal and environmental changes in the Buffalo River. Community diversity (d) is calculated using the formula of Patten (1962) derived from the information theory and later modified by Wilhm and Dorris (1968) as:

$$d = \sum_{i=1}^{S} n_i \log_2 n_i/n$$

where:

n_i = Number of individuals belonging to the i species

n = Total number of individuals in the sample

Pool stations

Monthly community diversity indices for Ponca, Hasty, and Rush pool collections are given in Table 13. Mean monthly diversity indices were not significantly different between the

TABLE 13. Community diversity indices for pool stations.

Month	Ponca	Hasty	Rush
December	39.6	187.1	127.7
January	123.9	75.4	343.6
February	27.5	360.7	132.0
March	135.7	94.3	56.9
April	17.3	125.0	23.4
May	26.5	87.2	25.3
June	65.9	122.1	63.3
July	69.8	126.3	94.5
August	-	126.2	104.1
September	-	104.5	98.0
October	47.0	146.6	66.8
November	54.8	34.4	149.1

stations, hence the indices were pooled into seasons. There were no significant differences either between the pools or between the seasons with no interaction. However, it should be noted that the greatest diversity was recorded in the winter (157.5) and lowest in the spring (65.7). Although statistically not significant, more species (32) were collected in winter and least (22) in spring with 26 and 27 species being collected in summer and fall, respectively. There was no significant difference (x_2^2 = 5.84) among spring, summer and fall seasons in the number of fishes collected but winter collections were significantly larger than in the other seasons. Occurrence of large number of species and individuals in pools during winter was probably due to movement of fishes into pools to avoid cold winter temperature and low dissolved oxygen in the shallow areas.

Monthly diversity indices were regressed on water temperature, dissolved oxygen and pH by stepdown multiple regression analysis to evaluate the effects of these water quality parameters on community diversity. The physicochemical parameters significantly ($F_{3,8}$=21.3) influenced the diversity of Rush pool fishes and accounted for 80% variability in diversity indices (Table 14). Of these parameters, only dissolved oxygen and temperature had significant effect on the diversity and dissolved oxygen was 1.8 times more important than water temperature (standard regression coefficient temperature = 0.77, D.O. = 1.36). Community diversity of Hasty

TABLE 14. Mean monthly community diversity indices and water quality parameters, R^2 and standard regression coefficient for pool and riffle stations.

Station	Habitat	Temperature C	Dissolved Oxygen	pH	St. Reg. Coefficient Temp	Oxygen	pH	R^2	D
Ponca	Pool	15.2	10.8	7.4	1.52	2.53	-1.25	0.71	68.1
	Riffle	15.8	10.6	7.5	1.13	0.45	0.29	0.63	328.6
Hasty	Pool	14.7	9.4	7.5	-0.95	-0.89	0.63	0.34	154.4
	Riffle	15.0	9.8	7.6	1.01	0.91	-0.02	0.40	963.2
Rush	Pool	16.1	9.9	7.6	0.91	1.52	-0.02	0.80	131.8
	Riffle	16.9	10.3	7.6	-0.41	-0.45	0.60	0.35	550.2

pool was not significantly affected ($F_{3,8}$=3.7) by the water quality parameters and accounted for only 34% variability of the indices (Table 14). The Ponca pool diversity indices were significantly influenced by the physicochemical parameters ($F_{3,8}$=8.63) at the 0.05 level and accounted for 71% of variability.

There were no significant differences between the pools either in the monthly or seasonal water quality parameters (Appendix 3). However, the water quality parameters influenced significantly the Rush and Ponca community diversity indices. This indicates that some other factors, probably the physicochemical parameters not monitored and/or availability of food organisms to the pool fishes may have affected species diversity.

Riffle stations

Monthly community diversity indices for Ponca, Hasty, and Rush stations are given in Table 15. There was significant difference in the mean monthly diversities between riffle stations ($F_{2,33}$=6.65), and the diversity index of Hasty was significantly higher than that of the Ponca station. There were no differences in the diversity indices among the seasons within the riffle stations. However, winter (393.2) and fall (396.4) had the low indices while spring (736.1) and summer (664.9) showed high diversity indices.

Multiple regression analysis indicated that water temperature, dissolved oxygen, and pH (Appendix 3) had no

TABLE 15. Community diversity indices for riffle stations.

Month	Ponca	Hasty	Rush
December	77.3	217.8	91.4
January	307.8	1202.7	385.9
February	188.1	456.4	611.7
March	302.0	1275.3	948.8
April	354.4	920.5	715.0
May	249.2	1543.9	315.6
June	255.6	451.6	290.3
July	670.8	1911.9	769.7
August	651.6	819.1	163.3
September	164.3	334.1	577.2
October	325.6	435.4	855.7
November	116.4	578.8	180.0

significant effect on community diversity. Details of standard regression coefficients and R^2 values are given in Table 14. Regression of community diversity on riffle water velocity showed that water velocity did not significantly effect community diversity of Hasty and Rush riffles and accounted for 3% of variability. However, for Ponca riffle, the water velocity was negatively correlated with community diversity (t_{10}=5.21) and accounted for 73% of variability. Analysis of water velocity showed significant difference between the riffle stations ($F_{2,33}$=7.98) and there was no difference between the Ponca and Rush riffle stations. Since water velocity did not affect Rush community diversity, although similar to Ponca in water velocity, it is reasonable to assume that some other factor(s) influenced the community diversities.

Comparison of pool and riffle community diversities

Average monthly community diversity of riffle habitat (547.6) was significantly greater ($F_{1,62}$ = 35.42) than in the pool habitat (102.4). Seasonal comparison indicated that the two habitats differed significantly except during winter. However, it should be noted that in the winter the riffle diversity index was 2.5 times greater than the pool habitat.

There were no significant differences between the pool and riffle stations either in total number of species collected or in the number of species within the families that were common in both the habitats. However, the total number of fishes collected from the riffle habitat was significantly greater than from the pool habitat. Further, fishes of the families Percidae, Cyprinidae, and Ictaluridae were collected in greater numbers from the riffle habitat, while fishes of the families Cyprinidae and Centrarchidae were more abundant in the pool collections. The difference in the diversity indices between the riffle and pool habitats was due to the number of fishes obtained from these two habitats.

Parasite Diversity

Certain general statements may be made concerning the interpretation and interrelationships between the values of community diversity (d), redundancy (R), and individual diversity ($\bar{d}$). A high community diversity (d) value indicates a large parasite community in each fish, while a low community diversity value is indicative of a small parasite community in each fish. High individual diversity ($\bar{d}$) values mark a complex organization within the community, while low values result from a simple organization within the community. Individual diversity ($\bar{d}$) is independent of sample size so that its value is not affected by changes in the number of individuals in the community. Low redundancy (R) values indicate a more even distribution of parasite species in the community, while high redundancy values are a sign of the predominance of certain species in the community. Thus, redundancy (R) and individual diversity ($\bar{d}$) are inversely related so that low redundancy values should correspond to high individual diversity values and vice versa.

Table 16 reveals the mean individual diversity ($\bar{d}$), mean redundancy (R), and mean community diversity (d) values for helminth and copepod parasite communities of the small-mouth bass of the Buffalo River for: all collecting sites and seasons combined, each collecting site during the combined seasons, and the combined collecting sites during each season. Table 17 indicates these mean $\bar{d}$, R, and d values during each season for each collecting site.

In order to picture the overall diversity indices for the ichthyoparasites of the smallmouth bass of the Buffalo River, Table 16 indicates these values for all the sites and seasons combined. This information is desirable in order to compare the values for the diversity indices commensurate with the collecting sites and seasons.

In examining the diversity indices at each collecting site during the combined seasons (Table 16), the highest mean individual diversity ($\bar{d}$) and mean community diversity (d) occurred at Hasty. Both of these values were higher than their respective values for the combined seasons and collecting sites indicating that the ichthyoparasite organization within the community and the parasite community in each fish was higher at Hasty than at Ponca or Rush during the combined seasons (Table 16). The highest mean redundancy (R) value was commensurate with the lowest mean individual diversity ($\bar{d}$)

TABLE 16. Mean individual diversity ($\bar{d}$), redundancy (R), and community diversity (d) values for helminth and copepod parasite communities of the smallmouth bass of the Buffalo River for collecting sites and seasons combined, at each collecting site during the combined seasons, and during each season for the combined collecting sites.

	All Sites All Seasons Combined	All Seasons Each Site			All Sites Each Season			
(Fish Examined)	(127)	(12)	(76)	(39)	(32)	(20)	(48)	(27)
Indices		Ponca	Hasty	Rush	Fall	Winter	Spring	Summer
Mean Individual Diversity ($\bar{d}$)	1.58	1.48	1.78	1.20	1.45	1.20	1.72	1.74
Mean Redundancy (R)	0.5071	0.3829	0.4722	0.6133	0.5327	0.5650	0.4905	0.4633
Mean Community Diveristy (d)	519.58	362.62	560.79	487.56	487.56	684.88	594.70	483.31

TABLE 17. Mean individual diversity ($\bar{d}$), redundancy (R), and community diversity (d) values for helminth and copepod parasite communities of the smallmouth bass of the Buffalo River during each season for each collecting site.

	Ponca				Hasty				Rush			
(Fish Examined)	(4)	(2)	(5)	(1)	(14)	(10)	(38)	(14)	(14)	(8)	(5)	(12)
Indices	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
Mean Individual Diversity ($\bar{d}$)	1.19	1.29	1.56	2.55	1.79	1.38	1.85	1.86	1.18	0.95	0.88	1.54
Mean Redundancy (R)	0.3901	0.1305	0.4875	0.3360	0.4935	0.5662	0.4546	0.4313	0.6127	0.6721	0.7661	0.5112
Mean Community Diversity (d)	224.54	33.94	547.36	648.58	505.14	419.86	599.99	610.71	194.54	1178.88	601.85	320.91

value at Rush during the combined seasons (Table 16), indicating a somewhat simple organization within the community with the predominance of certain species such as the digenean Cryptogonimus chyli and cysts of an unidentified nematode (Table 6). This situation confirmed the assertion that individual diversity ($\bar{d}$) and redundancy (R) are inversely related.

Further confirmation of this phenomenon is indicated by the lowest mean individual diversity ($\bar{d}$) and highest redundancy (R) values for each season at the combined collecting sites being found in the winter (Table 16). Again, Cryptogonimus chyli and the unidentified nematode cysts (Table 8) accounted for this inverse relationship between individual diversity ($\bar{d}$) and redundancy (R). The highest mean community diversity (d) value also occurred in the winter for the combined collecting sites (Table 16) indicating large parasite communities in each fish (Table 8).

Table 17 reveals that the highest mean community diversity (d) value occurred during the winter at Rush when each collecting site was compared for each season. At Ponca and Hasty, higher mean community diversity (d) values occurred during the spring and summer than in the fall and winter with the highest values in the summer (Table 17). These high values indicate large and complex parasite communities in each fish. Highest mean individual diversity ($\bar{d}$) values were indicated for the summer at each of the collecting sites, although the spring and summer values at Hasty were almost identical

(Table 17). The lowest mean redundancy (R) values were recorded for the winter at Ponca, and the summer at Hasty and Rush (Table 17). These values were commensurate with the concept of inverse porportionality between mean individual diversity ($\bar{d}$) and mean redundancy (R) values except at Ponca (Table 17). Thus at Hasty in the spring and summer, and at Rush in the summer there was a complex organization within the ichthyoparasite community with a relatively even distribution of species. On the other hand, the highest mean redundancy (R) values and the lowest mean individual diversity ($\bar{d}$) values were recorded for the winter at Hasty and the spring at Rush (Table 17). These high mean redundancy values were brought about primarily by the presence of large numbers of the unidentified nematode cysts at Hasty, and by the digenean <u>Cryptogonimus chyli</u> and the unidentified nematode cysts at Rush (Tables 11 and 12). The highest mean redundancy (R) value at Ponca was observed during the spring, although the lowest mean individual diversity ($\bar{d}$) at Ponca was recorded for the fall (Table 17). This high mean redundancy (R) value at Ponca in the spring was undoubtedly due to the existence of large numbers of the monogenean <u>Urocleidus principalis</u>, the digenean <u>Rhipidocotyle</u> sp., and the unidentified nematode cysts (Table 10).

In summarizing the mean ichthyoparasite diversity indices data, certain information becomes evident for comparison with similar data from future investigations of this nature concerning the Buffalo River. The most complex organization within the community and the largest parasite community in each fish occurred at Hasty during the combined seasons. The least complex organization within the community and the highest predominance of certain species of parasites in the community during the combined seasons occurred at Rush. The most complex organization within the community for the combined collecting sites was recorded for the spring and summer, but the largest parasite community in each fish was recorded during the winter. For the combined collecting sites, the highest predominance of certain species of parasites in the community occurred in the winter. The most complex organization within the community was found during the summer for each collecting site. The highest predominance of certain species was encountered in the spring at Ponca and Rush and during the winter at Hasty. The largest ichthyoparasite communities were encountered during the summer at Ponca and Hasty, and in the winter at Rush.

Parasite, host and water quality correlations

The following physicochemical parameters (Appendix 3) were monitored at both pools and riffles at the collecting sites: air temperature, water temperature, dissolved oxygen, and pH. Also, water velocity at riffles was measured. The ages and sexes of the host fish were also determined. Correlation coefficient analyses revealed no significant correlations between any of the parasites and any of the above parameters.

SUMMARY

Asymptotic length and weight of smallmouth bass were estimated as 583 mm and 2,091 g, respectively. Compared to other studies, the Buffalo River smallmouth bass showed slower growth. Annual mortality rate for these smallmouth bass was 36% as compared to 50% in Michigan, Wisconsin, Ohio, Ontario, and Missouri waters; this was probably due to less fishing intensity on the Buffalo River.

There was no difference among the pool stations in the seasonal abundance of species of fish. Species distribution among the pool stations was not influenced by seasons, but winter and spring seasons yielded the least and most number of fishes, respectively. There were no differences in the number of species collected either among the seasons or the riffle stations.

Although the number of species collected from the pool and riffle stations was not different, species of fish were not the same. Cyprinids and centrarchids were dominant in the pool habitats while percids and cyprinids dominated the riffle collections. There was a distinct difference in the pool and riffle ichthyofaunal composition.

The three riffle stations differed in the fish diversity indices. In contrast to pool stations, the riffle stations had high diversity indices during spring and summer and low indices during winter and fall. Riffle water velocity was negatively correlated with community diversity of the Ponca station, and showed no effect at the Rush and Hasty stations.

Average monthly community species diversity for fishes of the riffle habitats was greater than that of pool habitats. This difference was attributed to the greater number of specimens obtained from the riffle stations.

Thirty-two species of helminth and copepod parasites were taken from 127 smallmouth bass of the Buffalo River with all hosts infected with at least one species of parasite. Another survey of this host in the White River in northwestern Arkansas revealed only 15 species.

Parasites infecting high percentages of hosts, occurring in large average numbers of parasites per fish, or a large maximum number of parasites per fish during all seasons at the combined collecting sites were: the monogenean Urocleidus principalis, the digeneans Cryptogonimus chyli and Rhipidocotyle sp., the acanthocephalan Neoechinorhynchus cylindratus, and an unidentified nematode cyst.

There appeared to be no significant set pattern of the percentage of fish infected among the collecting sites during the combined seasons except for the digenetic trematode Crepidostomum cornutum which decreased in a progressive fashion downstream.

Significant seasonal distribution patterns of percentages of fish infected were noted for certain parasites for the combined collecting sites and for each collecting site.

Ichthyoparasite mean diversity indices revealed a very rich and diverse fauna with certain site and seasonal distributions indicating a very complex ecosystem in the Buffalo River.

Selected parasite, host, and water quality parameters were correlated, revealing no significant correlations between any of the parasites and any of the parameters.

A richly complex and diverse ichthyoparasitic fauna in the Buffalo River is indicative of an ecosystem commensurate with the wilderness status of this magnificent river. The present investigation will provide baseline information necessary for future comparative studies to determine man's impact on the present intricate and complex balance of nature in this superb and unique river.

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APPENDIX 1. Families, species, common names and occurrence of fishes in pools and riffles of Ponca (P), Hasty (H), and Rush (R).

Family and Species	Common Name	Pools P	Pools H	Pools R	Riffles P	Riffles H	Riffles R
Noropis greenei Hubbs & Ottenburger	Wedgespot shiner	-	-	x	-	x	x
Notropis ozarcanus Meek	Ozark shiner	-	x	-	-	x	-
Notropis pilsbryi Fowler	Duskystripe shiner	x	x	x	x	x	x
Notropis rubellus (Agassiz)	Rosyface shiner	-	x	x	x	x	x
Notropis telescopus (Cope)	Telescope shiner	x	x	x	x	x	-
Notropis whipplei (Girard)	Steelcolor shiner	-	-	-	-	-	x
Pimephales notatus (Rafinesque)	Bluntnose shiner	x	x	x	-	x	-
Castastomidae							
Hypentelium nigricans (LeSueur)	Northern hog sucker	x	-	x	x	x	x
Moxostoma duquesnei (LeSueur)	Black redhorse	x	x	x	-	x	-
Moxostoma erythrurum (Rafinesque)	Golden redhorse	x	x	x	-	-	-
Centrarchidae							
Ambloplites rupestris (Rafinesque)	Rock bass	x	x	x	-	x	-
Lepomis cyanellus Rafinesque	Green sunfish	x	x	x	-	-	-
Lepomis macrochirus Rafinesque	Bluegill	-	x	x	-	-	-
Lepomis megalotis (Rafinesque)	Longear sunfish	x	x	x	x	x	-
Micropterus dolomieui Lacepede	Smallmouth bass	x	x	x	x	x	x
Micropterus punctulatus (Rafinesque)	Spotted bass	x	x	x	-	-	-
Micropterus salmoides (Lacepede)	Largemouth bass	-	x	x	-	-	-
Ictaluridae							
Ictalurus melas (Rafinesque)	Black bullhead	-	-	x	-	-	-
Ictalurus natalis (LeSueur)	Yellow bullhead	x	-	x	x	-	-

Family and Species	Common Name	Pools P	Pools H	Pools R	Riffles P	Riffles H	Riffles R
Percidae							
Etheostoma blennioides Rafinesque	Greenside darter	x	x	x	x	x	x
Etheostoma caeruleum Storer	Rainbow darter	-	x	-	x	x	x
Etheostoma zonale (Cope)	Banded darter	-	x	-	x	x	x
Etheostoma euzonum (Hubbs & Black)	Arkansas saddled darter	-	-	-	x	x	x
Etheostoma juliae Meek	Yoke darter	-	-	-	x	x	x
Etheostoma stigmaeum (Jordan)	Speckled darter	-	-	-	x	-	-
Percina caprodes (rafinesque)	Logperch	x	x	-	-	x	x
Percine evides (Jordan & Copeland)	Gilt darter	-	-	-	-	-	x
Cyprinidae							
Campstoma anomalum (Rafinesque)	Stoneroller	x	x	-	x	x	x
Campstoma oligolepis (Hubbs & Greene)	Largescale stoneroller	x	x	x	x	x	x
Dionda nubila (Forbes)	Ozark minnow	-	x	x	x	x	x
Hybopsis amblops (Rafinesque)	Bigeye chub	x	x	x	-	x	-
Hybopsis dissimilis (Kirtland)	Streamline chub	-	-	-	-	x	x
Nocomis biguttatus (Kirtland)	Hornyhead chub	x	x	x	x	x	-
Notropis boops Gilbert	Bigeye shiner	x	x	x	x	x	x
Notropis chrysocephalus (Rafinesque)	Striped shiner	x	x	x	-	x	-
Notropis galacturus (Cope)	Whitetail shiner	x	x	x	x	x	x

Family and Species	Common Name	Pools P	Pools H	Pools R	Riffles P	Riffles H	Riffles R
Noturus albater Taylor	Ozark madtom	-	x	-	x	x	x
Noturus exilis Nelson	Slender madtom	-	x	-	x	x	x
Noturus flavater Taylor	Checkered madtom	x	-	-	x	-	x
Pylodictis olivaris (Rafinesque)	Flathead catfish	-	x	x	-	-	-
Cyprindontidae							
Fundulus catenatus (Storer)	Northern studfish	-	-	x	-	x	x
Fundulus olivaceus (Storer)	Blackspotted topminnow	-	x	x	x	-	-
Cottidae							
Cottus bairdi Girard	Mottled sculpin	-	-	x	-	-	-
Cottus carolinae (Gill)	Banded sculpin	-	x	x	x	x	x
Lepisosteidae							
Lepisosteus osseus (Linnaeus)	Longnose gar	-	x	x	-	-	-
Atheridae							
Labidesthes sicculus (Cope)	Brook silverside	-	x	x	-	-	-
Anguillidae							
Anguilla rostrata (LeSueur)	American eel	-	x	x	-	-	-
Petromyzontidae							
Ichthyomyzon castaneus Girard	Chestnut lamprey	-	-	-	-	-	x

x Present

\- Absent

APPENDIX 2. Helminth and copepod parasites of the smallmouth bass of the White and Buffalo rivers in Arkansas.

Annelida				
Class Hirudinea				
Family Piscicolidae				
Myzobdella moorei (Meyer, 1940)	Leech	Fins and mouth	Yes	Yes
Piscicola punctata (Verrill, 1871)	Leech	Mouth	No	Yes
Arthropoda				
Class Crustacea				
Subclass Copepoda				
Order Lerneopodidea				
Family Lerneopodidae				
Achtheres micropteri Wright, 1882	Copepod	Gill bars, gill rakers, and mouth	Yes	Yes
Order Cyclopidea				
Family Ergasilidae				
Ergasilus centrarchidarum Wright, 1882	Copepod	Gill filaments	Yes	Yes
Order Caligidea				
Family Lernaeidae				
Lernaea cruciata (Le Sueur, 1824)	Anchor worm	Tail	No	Yes

*Becker, Heard, and Holmes 1966

Rhipidocotyle septpapillata Krull, 1934	Fluke	Intestine	No	Yes
Rhipidocotyle sp. Diesing, 1858	Fluke	Intestine	No	Yes
Class Cestoda				
Order Psuedophyllidea				
Family Bothriocephalidae				
Bothriocephalus cuspidatus Cooper, 1917	Cestode or tapeworm	Intestine	No	Yes
Order Proteocephalidea				
Family Proteocephalidae				
Proteocephalus ambloplitis (Leidy, 1887)	Bass tape-worm	Adult: intestine; larva: viscera	Yes	Yes
Acanthocephala				
Order Neoechinorhynchidea				
Family Neoechinorhychidae				
Neoechinorhynchus cylindratus (Van Cleave, 1913)	Spiny-headed worm	Intestine	Yes	Yes
Nematoda				
Order Spiruridea				
Family Camallanidae				
Camallanus oxycephalus Ward and Magath, 1916	Red worm	Stomach and intestine	No	Yes
Family Rhabdochonidae				
Rhabdochona cascadilla Wigdor, 1918	Round worm	Intestine	No	Yes
Spinitectus carolini Holl, 1928	Round worm	Stomach and intestine	Yes	Yes
Order Trichuridea				
Family Trichuridae				
Capillaria catenata Van Cleave and Mueller, 1932	Round worm	Intestine	No	Yes
Order Ascaridea				
Family Heterochelidae				
Contracaecum sp. Raliett and Henry, 1912	Round worm	Stomach and intestine	No	Yes
Order Filariidea				
Family Philometridae				
Philometra sp. Costa, 1845	Round worm	Eye and mouth	No	Yes
Nematode cyst	Round worm	Viscera	No	Yes
Mollusca				
Class Pelecypoda				
Order Eulamellibranchia				
Family Unionidae				
Glochidia	Glochidia	Gill filaments	Yes	Yes

PARASITE	COMMON NAME	SITE OF INFECTION	IN WHITE RIVER*	IN BUFFALO RIVER
Platyhelminthes				
Class Trematoda				
Order Monogenea				
Family Calceostomatidae				
Acolpenteron ureteroecetes Fischthal and Allison, 1940	Gyros or gyrodactyls	Kidneys	No	Yes
Family Dactylogyridae				
Actinocleidus fusiformis (Mueller, 1934)	Gyros or gyrodactyls	Gill filaments, gill bars	Yes	Yes
Clavunculus bursatus (Mueller, 1936)	Gyros or gyrodactyls	Gill bars	No	Yes
Cleidodiscus banghami (Mueller, 1936)	Gyros or gyrodactyls	Gill filaments	No	Yes
Leptocleidus megalonchus Mueller, 1936	Gyros or gyrodactyls	Gill filaments	No	Yes
Urocleidus principalis (Mizelle, 1936)	Gyros or gyrodactyls	Gill filaments	Yes	Yes
Order Digenea				
Family Clinostomatidae				
Clinostomum marginatum (Rudolphi, 1819)	Yellow grub	Subcutaneous cysts around gill and fin insertions	Yes	Yes
Family Alocreadiidae				
Crepidostomum cornutum (Osborn, 1903)	Fluke	Intestine	Yes	Yes
Family Cryptogonimidae				
Cryptogonimus chyli Osborn, 1910	Fluke	Pyloric caeca	No	Yes
Family Azygiidae				
Leuceruthrus micropteri Marshall and Gilbert, 1905	Fluke	Stomach	Yes	Yes
Family Diplostomatidae				
Neascus sp. Hughes, 1927	Black spot	Cutaneous and muscles	Yes	Yes
Family Paramphistomidae				
Pisciamphistoma reynoldsi Bogitsch and Cheng, 1959	Fluke	Intestine	No	Yes
Family Strigeidae				
Posthodiplostomum minimum (MacCallum, 1921)	Liver grub or white liver grub	Viscera	Yes	Yes
Family Bucephalidae				
Rhipidocotyle papillosum (Woodhead, 1929)	Fluke	Intestine	Yes	Yes

APPENDIX 3. Physicochemical data from collecting stations, 1974.

PHYSICOCHEMICAL DATA

STATION Upstream Station 1 Ponca, Ark.	AIR TEMP C		WATER TEMP C		D.O. PPM.		pH		WATER VELOCITY (CM/SEC)
	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Riffle
Jan.	15.5	15.5	8.0	8.0	13.6	13.6	7.6	7.6	99.3
Feb.	10.5	10.5	7.5	7.5	10.8	10.8	7.5	7.5	154.3
Mar.	15.0	15.0	12.5	12.5	10.4	10.4	7.2	7.2	158.5
Apr.	16.0	16.0	11.6	11.6	10.8	10.8	7.5	7.5	104.8
May	27.0	27.0	21.0	21.0	9.6	9.6	7.4	7.4	150.8
June	23.0	23.0	20.0	20.0	9.5	9.6	7.4	7.4	126.5
July	29.0	29.0	28.5	28.5	7.6	8.0	7.4	7.4	57.2
Aug.		33.0		26.0		8.5		7.5	63.3
Sept.		29.0		19.0		9.5		7.3	125.7
Oct.	27.0	27.0	16.5	16.5	10.0	10.0	7.4	7.4	75.5
Nov.	10.0	10.0	10.0	10.0	11.8	11.8	7.5	7.5	171.7
Dec.	6.0	6.0	5.0	5.0	12.6	12.6	7.5	7.5	167.7

STATION	AIR TEMP C		WATER TEMP C		D.O. PPM.		pH		WATER VELOCITY (CM/SEC)
Midstream Station 2 Hasty, Ark.	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Riffle
Jan.	11.0	11.0	7.8	7.8	12.9	12.8	7.6	7.6	115.3
Feb.	7.5	7.0	7.0	7.5	9.7	9.7	7.6	7.6	105.1
Mar.	15.0	15.5	14.5	14.5	9.5	9.5	7.5	7.5	118.3
Apr.	14.0	14.0	10.0	11.0	10.2	10.6	7.6	7.5	107.8
May	19.0	19.0	20.0	20.0					82.3
June	22.0	18.0	18.5	18.5	8.3	8.4	7.5	7.5	119.1
July	19.5	28.5	26.0	27.0	7.5	7.6	7.5	7.6	51.0
Aug.	18.0	29.0	23.0	26.0	7.5	8.3	7.5	7.8	52.8
Sept.	11.5	16.0	17.5	17.5	8.0	8.4	7.6	7.5	49.3
Oct.	9.0	9.0	14.0	13.5	9.0	9.6	7.4	7.6	80.8
Nov.	7.0	7.0	11.0	11.0	10.8	11.2	7.5	7.4	71.8
Dec.	2.0	2.0	5.0	5.0	10.2	11.8	7.4	7.5	114.3

STATION Downstream Station 3 Rush, Ark.	AIR TEMP C		WATER TEMP C		D. O. PPM.		pH		WATER VELOCITY (CM/SEC)
	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Riffle
Jan.	15.8	15.8	8.0	8.0	14.0	14.2	7.7	7.7	118.0
Feb.	10.5	10.5	8.5	8.3	12.1	11.9	7.6	7.6	166.0
Mar.	22.0	23.0	14.2	16.0	10.2	9.6	7.8	7.8	128.0
Apr.	16.0	16.5	12.5	13.5	10.9	11.2	7.6	7.6	153.8
May	26.0	26.0	20.0	23.8	8.6	9.0	7.5	7.5	155.1
June	22.0	22.0	20.0	20.8	8.5	8.7	7.5	7.6	178.0
July	29.5	34.0	28.5	29.3	7.7	8.7	8.0	7.8	127.2
Aug.	28.0	28.0	25.0	26.0	7.5	7.5	7.6	7.5	102.8
Sept.	17.0	17.0	20.0	21.0	8.0	8.3	7.3	7.2	120.7
Oct.	20.0	20.0	15.0	15.0	9.2	9.6	7.6	7.6	125.3
Nov.	19.0	19.0	12.0	12.0	10.4	12.2	7.5	7.5	148.2
Dec.	12.0	12.0	6.0	6.0	11.9	12.2	7.5	7.5	148.2

	Uninfected/Infected Fish			Combination Site Chi-Square Values		
(Fish Examined)	(12)	(76)	(39)			
Parasite	Ponca	Hasty	Rush	Ponca-Hasty	Ponca-Rush	Hasty-Rush
Monogenetic Trematodes						
Acolpenteron ureteroecetes	12/0	75/1	38/1			
Actinocleidus fusiformis	8/4	46/30	33/6			6.96* +
Clavunculus bursatus	10/2	61/15	36/3			
Cleidodiscus banghami	7/5	56/20	34/5	1.20	4.84* +	2.76
Leptocleidus megalonchus	11/1	76/0	39/0			
Urocleidus principalis	8/4	41/35	38/1			
Digenetic Trematodes						
Clinostomum marginatum	7/5	53/23	25/14	6.21* +	1.31	3.75
Crepidostomum cornutum	6/6	41/35	31/8	6.49* +	4.01* +	7.18* +
Cryptogonimus chyli	11/1	56/20	3/36			
Leuceruthrus micropteri	11/1	39/37	19/20			6.96* +
Neascus sp.	4/8	15/61	8/31			9.70* +
Pisciamphistoma reynoldsi	10/2	67/9	37/2			
Posthodiplostomum minimum	9/3	69/7	39/0			
Rhipidocotyle papillosum	9/3	59/17	33/6			7.86* +
Rhipidocotyle septpapillata	11/1	69/7	37/2			
Rhipidocotyle sp.	6/6	16/60	23/16	4.63* +	3.01	1.65
Cestodes						
Bothriocephalus cuspidatus	11/1	73/3	39/0			
Proteocephalus ambloplitis adult	12/0	62/14	33/6			1.65
Proteocephalus ambloplitis larva	10/2	67/9	32/7			8.03* +
Acanthocephalan						
Neoechinorhynchus cylindratus	6/6	7/69	13/26	1.37	1.09	1.04
Nematodes						
Camallanus oxycephalus	12/0	29/47	29/10			1.35
Capillaria catenata	12/0	70/6	36/3			
Contracaecum sp.	11/1	57/19	34/5			2.32
Philometra sp.	11/1	68/8	32/7			1.25
Rhabdochona cascadilla	12/0	73/3	39/0			
Spinitectus carolini	5/7	21/55	25/14	9.81* +	1.91	1.43
Nematode cyst	1/11	6/70	1/38			
Molluscs						
Glochidia	11/1	70/6	36/3			
Leeches						
Myzobdella moorei	11/1	55/21	23/16			2.12
Piscicola punctata	12/0	75/1	38/1			
Copepods						
Achtheres micropteri	9/3	36/40	23/16			1.39
Ergasilus centrarchidarum	7/5	40/36	37/2	1.35		
Lernaea cruciata	12/0	70/6	39/0			