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ABSTRACT

Total length-scale radius, and length-weight relationships were determined for smallmouth bass from the Buffalo River. The back calculated lengths were used in analyzing the age-length data by the Bertalanffy growth formula. Asymptotic length and weight were estimated as 58.3 cm and 4.6 lbs, respectively. Annual mortality of 36 percent was estimated by the catch curve method.

Insects (54%), fishes (16%), and crayfish (14%) were the abundant food organisms by frequency of occurrence; while fishes (64%) and crayfish (29%) were the dominant food items by the gravimetric method.

Based on the gonosomatic indices and frequency distribution of ovum diameter measurements, smallmouth bass spawn during April-June. All ova greater than or equal to 1.1 mm were considered mature and the relationships between total length, weight, and age to fecundity were estimated as: log F = 5.05 log L -8.89301; F = 18.56 W -1680.4; log F = 3.84 log A + 1.51560, respectively.

INTRODUCTION

The Buffalo River, originating in the Ozark plateau, flows northeastward for 238 km to its confluence with the White River. The Buffalo River was declared a National River (Public Law 92-237) in 1972, by the Congress of the United States. As a national river, its use for recreational and land development activities may alter the quality of the aquatic habitat.

The smallmouth bass *Micropterus dolomieue* Lacepede is an important game fish of the Buffalo River. Except for the study by Peek (1966) on growth, there has been no detailed study on the life history of this fish from Arkansas streams. This paper reports growth, mortality, maximum attainable size, spawning time and fecundity, and the food habits of the Buffalo River Smallmouth bass. These parameters will serve as baseline information for future studies in evaluating changes brought about by an altered aquatic habitat.

MATERIALS AND METHODS

Smallmouth bass were collected from Buffalo River at Ponca, Hasty, and Rush pools representing upstream, midstream, and downstream stations, respectively, from January 1975 through February 1976. Bass collections were made by electroshocker, using a boat-mounted 115-Volt AC generator coupled to a Coeffelt Model II C Variable Voltage pulsator. Upon capture, total length in millimeters and total weight in grams were recorded and 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 a temperature of 95C under 1050 kg/cm^2 pressure. Scale radius and distance from focus to each annulus were measured in the anterior field at 40X using an Eberbach Scale Projector.

Stomachs were preserved in 10% formalin for later study. Stomach content analysis was performed by the frequency of occurrence and gravimetric methods.

The ovaries, preserved in AFA solution (Cable 1961) earlier, were blotted dry and weighed to the nearest 0.1 mg. Approximately a 10% sample was taken from the middle region of the ovary and weighed to the nearest 0.1 mg. The ova in the sample were measured to the nearest 0.05 mm by an ocular micrometer, and the mature ova were used for fecundity determination. Fecundity was defined as the estimated total number of mature ova contained in both ovaries.

RESULTS AND CONCLUSIONS

Time of annulus formation

A sharp decrease in the monthly average scale increments was evident during May and June for age groups 2+ and 3+ and during May for age group 1+ (Figure 1). Although data were insufficient, age groups 4+ and 5+ showed decreasing marginal scale increments during May and June. Hence, smallmouth bass from the Buffalo River formed annuli in May and June. It is generally believed that the time of annulus formation is correlated with low water temperature (Rounsefell and Everhart 1953). However, nesting by smallmouth bass during April-July (Phlieger 1966) indicates that spawning activity may be one of the factors influencing annulus formation.

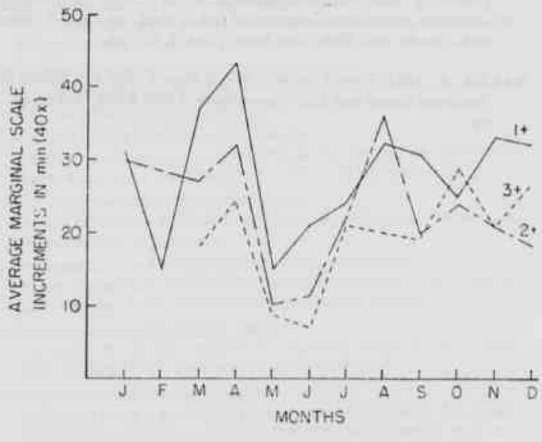
Total length-scale radius and length-weight relationships

The total length-scale radius relationship is expressed by the equation:

$$TL = a + bS$$

where TL = total length, S = scale radius, and a and b are empirically determined constants.

Figure 1. Average monthly marginal scale increments for three age groups of smallmouth bass from the Buffalo River.



There was no difference in the total length-scale radius relationship among the sexes. Therefore, the data were pooled and the resulting relationship based on 146 smallmouth bass was:

$$L = 40.33 + 1.86S$$

The estimated length-weight relationship for the pooled data was:

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

Annual growth and growth parameters

Table I shows the back calculated lengths using the total length-scale radius relationship. The age-length data were analyzed by the Von Bertalanffy growth formula (Ricker 1975):

$$L_t = L_{oo}(1 - e^{-K(t - t_o)})$$

where

L_t = Length at age t

L_{oo} = Asymptotic length

t_o = Age when length is zero

K = Growth constant

The Bertalanffy growth formula for smallmouth bass was estimated as:

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

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 1). First year growth was greater for the Buffalo River bass than from other areas; lengths attained by age group 2 and above were less than those of the other studies. However, comparison of the Bertalanffy growth formula of the Buffalo River smallmouth bass with those of North American averages showed no significant difference ($F_{2,4}$ = 0.86). Hence, the asymptotic length of Buffalo River smallmouth bass is similar to the average North American smallmouth bass and is attained at the same rate.

Mortality and survival

Instantaneous mortality rate (Z) was estimated by the catch curve method (Ricker 1975). In our catches, smallmouth bass of age group 1 were fully recruited. The instantaneous mortality rate for the Buffalo River smallmouth bass was 0.43 with survival and annual mortality rates of 0.64 and 0.36, respectively. The annual mortality rate for the smallmouth bass of our study was lower than reported for bass populations from Michigan, Wisconsin, Ohio, Ontario, and Missouri in which the mortality rate 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 waters listed by Coble (1975).

Table 1. Growth of smallmouth bass from different waters.

Locality and Reference	Total length (mm) at each annulus								
	1	2	3	4	5	6	7	8	9
Buffalo River, Ark. (Present Study)	109	177	221	259	313	347			
Arkansas Streams *(Peek 1966)[1]	87	181	257	329	400	500	534	594	
Iowa Streams (Cleary 1951)[1]	91	175	224	282	348	432			
Missouri Streams (Purkett, Jr. 1958)[1]	89	170	244	290	343	371			
North America Averages (Coble 1975)	93	168	230	275	318	353	375	398	423

*An erroneous method of calculating length was used (Carlander 1972).

[1] From Carlander (1972)

Time of spawning and fecundity

Based on pooled monthly gonosomatic indices for age groups 3-5 (Figure 2), smallmouth bass spawns between April and June. Monthly distribution of ovum diameters (Figure 3) shows that spawning was completed by the latter part of June and the fish were in spent condition by July. Since the ovum equal to a greater than 1.1 mm were extruded, this size was considered as the lower limit of mature ova.

Fecundity estimates were made from eight mature smallmouth bass (Table 2). The fecundity-length relationship was non-linear and was calculated as $\log F = 5.05 \log L - 8.89301$. The correlation coefficient and standard error of estimate were 0.94 and 0.198, respectively.

Fecundity-weight relationship was linear and was expressed as $F = 18.56\ W - 1680.41$ with 0.99 correlation coefficient and 0.101 standard error of estimate.

The relationship between fecundity and age was estimated as, $\log F = 3.84 \log A + 1.51560$. The correlation coefficient and standard error of estimate were 0.90 and 0.252, respectively. There was a great variation in fecundity within age groups. Based on correlation coefficient and standard error of estimate, weight and length were better estimates of fecundity for the Buffalo River smallmouth bass.

Fecundity-length relationship for the Catherine Lake smallmouth bass (Clady 1975) was calculated as $\log F = 1.77 \log L - 0.72852$. This relationship was significantly different ($F_{2,13}$ = 6.92) from that of the Buffalo River smallmouth bass. Hubert (1976) described the fecundity-length relationship for the Wilson Dam Tailwaters smallmouth bass as a linear function. However, the data were better fitted by a curvilinear relationship as $\log F = 3.28 \log L - 4.5745$ and this was significantly different ($F_{2,37}$ = 4.55) from the Buffalo River smallmouth bass fecundity-length relationship. The fecundity-weight relationship was also significantly different ($F_{2,37}$ = 10.99) between the Wilson Dam Tailwaters and the Buffalo River smallmouth bass. For a given length and/or weight, the Buffalo River smallmouth bass were more fecund than those of the Wilson Dam Tailwaters. This was probably due to the small size of mature ovum compared to the ovum size of 1.56 mm for the Wilson Dam Tailwaters smallmouth bass.

Seasonal and yearly food habits

Of the 128 smallmouth bass stomachs examined, 74 contained food.

Table 2. Age, total length, weight and estimated fecundity of smallmouth bass from Buffalo River.

Age in Years	Total length (mm)	Total weight (g)	Fecundity
3	229	130	1,884
3	239	158	1,951
3	268	232	2,102
3	286	257	2,026
4	354	510	7,723
4	408	1,006	18,437
5	335	454	5,509
5	373	1,378	23,366

Details of seasonal trends in food habits are given in Table 3.

Fishes constituted the major food by weight for the immature smallmouth bass (45-170 mm) during spring and summer; crayfish were the second most abundant food item except for summer when insects were second most abundant in the diet.

For the adult (176-382 mm) smallmouth bass, fishes and crayfish were major food items in that order during all the seasons except winter with crayfish being most abundant in the diet.

On a yearly basis both the immature and adult bass fed primarily on fishes followed by crayfish. A list of organisms encountered in the diet is given in Table 4.

Our findings, that immature and adult smallmouth bass feed primarily on fish and secondarily on crayfish, are in accord with the reports of Applegate et al. (1967), Mullan and Applegate (1968) and Reynolds (1965).

Although insects constituted 32.9% of the summer diet of the immature fish, we feel that insects do not contribute greatly to the annual diet as the Buffalo River supports an extremely low standing crop of benthic macroinvertebrates (Schmitz 1973; Kittle 1975).

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Figure 2. Pooled monthly gonosomatic indices of smallmouth bass.

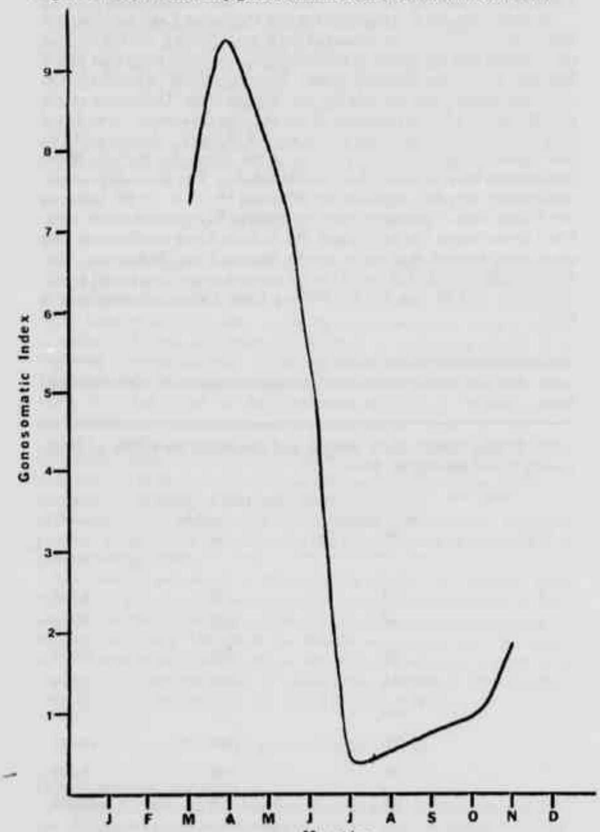

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Figure 3. Monthly ovum diameters of smallmouth bass.

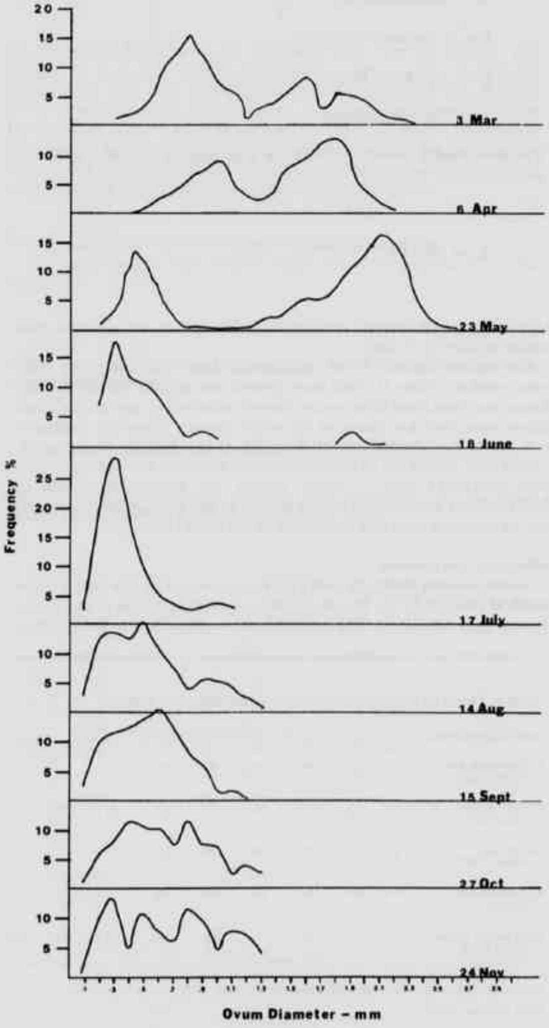

Table 3. Percent composition of total diet of immature and adult smallmouth bass in Buffalo River. ( ) = % number; without parenthesis are % wt.

	Immature				Adult			
	Fishes	Crayfish	Insects	Unidentified	Fishes	Crayfish	Insects	Unidentified
Winter	64.8 (17.7)	--	0.4 (41.2)	34.8 (41.1)	10.7 (7.1)	89.2 (21.4)	0.1 (71.4)	---
Spring	78.4 (12.2)	17.3 (2.4)	0.1 (78.1)	4.3 (7.3)	72.5 (11.1)	24.2 (16.7)	0.4 (44.4)	2.9 (27.8)
Summer	56.6 (6.7)	10.1 (5.7)	32.9 (80.0)	2.6 (8.6)	78.3 (30.8)	20.2 (11.5)	0.5 (34.6)	1.1 (23.1)
Fall	65.6 (40.4)	28.4 (10.7)	2.5 (31.9)	3.5 (17.0)	76.6 (61.5)	23.0 (30.8)	---	0.3 (7.7)
Year	67.3 (13.1)	21.1 (5.3)	7.2 (69.4)	4.4 (12.2)	60.2 (19.1)	37.6 (22.5)	0.3 (39.3)	1.9 (19.1)

Table 4. Number of organisms in the diet of smallmouth bass of Buffalo River.

	Immature				Adult			
	W	Sp	S	F	W	Sp	S	F
Lepomis sp.	1					1		
Campostoma sp.						2		
Notropis sp.						1	2	
Noturus sp.					1			
Etheostoma sp.		3						
Unidentifiable fish	1	4	7	17			6	4
Decapoda		2	6	5	3	6	3	8
Cladocera		1						
Hydracarina			1					
Ephemeroptera	2	2	65	5		11	7	
Odonata			17	5		1		
Megaloptera			1	2				
Trichoptera				1	1		1	
Coleoptera						1		
Diptera	5	61			9	3		
Hymenoptera				2				
Unidentifiable Material	7	6	9	8		10	6	1

W=winter; Sp=spring; S=summer; F=fall

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