LIFE HISTORY OF *ETHEOSTOMA COOSAE* (PISCES: PERCIDAE) IN BARBAREE CREEK, ALABAMA

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ABSTRACT

Collections of *Etheostoma coosae* (Coosa darter) were made from April 1977 to April 1978 in Barbaree Creek (Coosa River system), Clay County, Alabama. The principal habitat of this species was cobble and/or gravel raceways, riffles and pools. Spawning occurred on the surface of rocks and small boulders from mid March to late May with peak activity in mid April. The spawning position was either inclined or semi-inverted horizontally. Individuals reached sexual maturity and spawned by the first year. Maximum age was three years. By the end of the second year, the average size of males and females was 41.0 mm and 36.5 mm SL, respectively. The sex ratio, 1:1.3, was significantly different from 1:1. The principal diet consisted of Copepoda, Cladocera, Ephemeroptera *(Isonychia)* and Diptera (Chironomidae, Simuliidae).

INTRODUCTION

Etheostoma (Ulocentra) coosae is endemic to the Coosa River system of Alabama, Georgia, and Tennessee. The biology of the subgenus as a whole is largely unknown. Published papers include studies by Winn (1958a, 1958b) on the reproduction of two undescribed forms, Stiles (1975) on the reproductive behavior of *Etheostoma simoterum,* and Ultsch et al. (1978) on habitat selection by *Etheostoma duryi.* This study reports on the life history of *E. coosae* in Barbaree Creek, an eastern Alabama stream..

STUDY AREA

A section along Barbaree Creek, T.18S., R.7E, Sec. 22, Clay County, Alabama (Coosa River system) was chosen as the study site. Barbaree Creek is a perennial stream flowing through northern Piedmont physiography. Its headwaters originate in the Talladega Mountains.

The substrate consisted of gravel and sand shoals interspersed with patches of cobble and boulders that were regularly broken by cobble or slab riffles. Bedrock was usually exposed below riffles whereas the pools contained unconsolidated material. The ranges of measured water quality values were: disssolved oxygen, 7.9-13.0 ppm; pH, 6.8-7.3; turbidity, 0.7-2.8 JTU; conductivity, 17-45 umhos; and stream temperature 3.7-25 °C (Boschung and O'Neil, 1980).

METHODS

Specimens of *E. coosae* were collected monthly from April 1977 through April 1978. Small mesh minnow seines, 3/16 inch delta weave, and a backpack shocker were each operated approximately 1.5 hours during each monthly collection, sampling a variety of habitats. Upon capture the fishes were preserved in a 20-percent formalin solution.

In the lab, fishes were blotted dry and then weighed to the nearest .01 g on a Mettler electronic balance. Standard length (SL) and sex were determined. The specimens are deposited in the University of Alabama Ichthyological Collection.

Aging to year class was determined by

scale annuli. From 5 to 10 scales per fish were analyzed to reduce the chance of aging error due to the presence of false annuli and regenerated scales. Aging to month was accomplished by the technique outlined by Page (1974). The following symbols were used to indicate year classes: -1, 0 to 12 months; 1+, 13 to 24 months; 2+, >24 months.

Reproductive condition and length of the spawning season were determined by field observations and by determination of female gonosomatic indices (GSI). The GSI is the ratio of gonad weight to corrected body weight. Corrected body weight is total weight minus the viscera and gonad weight (Mathur and Ramsey, 1974).

Fecundity is defined as the number of ova equal to or exceeding 0.2 mm diameter. A large number of ova less than 0.2 mm diameter were present in each ovary, but past studies of darters with retracted spawning seasons (Fahy, 1954; Winn, 1958a; Scalet, 1973) have suggested that these minute oocytes never differentiate into fully yolked, enlarged ova and were, therefore, not spawned that year. The smallest differentiating ova of the larger egg group was 0.2 mm diameter, so this size was used as the lower limit.

For food and feeding studies, whole stomachs were removed, and the contents were identified to family and enumerated.

RESULTS AND DISCUSSION

Habitat

Etheostoma coosae adults and juveniles were consistently collected over rubble in raceways and around boulders, near sand bars and occasionally in the foot of riffles. This habitat preference was maintained seasonally with no indication of age or size specific habitat utilization for foraging or reproduction.

The basis of habitat selection by darters is influenced, if not determined, by physiological and/or ecological requirements of the species. Ultsch et al. (1978) conducted a series of critical 0_2 experiments with six species of *Etheostoma* and observed that four ecological groups exist with respect to oxygen requirements versus habitat selection. They suggested that one such group, typified by *E. (Ulocentra) duryi* and *E. (Catonotus) flabellare,* preferred relatively fast water but maintained its ability to tolerate periods of hypoxia. This group was the most diverse physiologically in terms of oxygen use strategies. As a result of this, these darters maintained a diverse array of habitat types. The applicability of this explanation to habit selection by *E. coosae* lies in the close phylogenetic and ecological relationships between it and *E. duryi.*

Demography

Etheostoma coosae was the dominant percid species in Barbaree Creek. It comprised 5.9 percent of the total number of fish specimens collected (Table 1). The overall age class distribution of *E. coosae* for the year studied is seen in Table 2. Approximately 64 percent of the population occupied the −1 age class, 29 percent the 1+ age class, and 7 percent the 2+ age class.

Seasonal changes in age class composition (Figure 1) indicate that maximum contribution to population size occurred during winter in the −1 age class as it approached 12 months of age. From this point, percent contribution to population size declined throughout the older age classes.

Of the 750 specimens examined, 32.9 percent and 55.6 percent of the males and females, respectively, survived from the −1 to the 1+ age class, whereas 10.8 percent and 10.3 percent of the males and females respectively, survived from the 1+ to the 2+ age class (Table 2).

The overall sex ratio, 1:1.3, was significantly different ($\chi^2 = 9.86$; $p < .01$) from the expected 1:1. This skewed sex ratio was most evident in the 1+ age class, 1:1.8 ($\chi^2 = 18.96$; $p < .01$), whereas the −1 and 2+ age class sex ratios were not statistically different from 1:1.

Age and Growth

The oldest individuals collected, two females and one male (Figure 2), were 36

Table 1. Percent relative abundance and frequency of occurrence of fishes collected in Barbaree Creek from April 1977 through April 1978.

Species	Abundance	Occurrence
Family Cyprinidae		
Campostoma anomalum	1.69	91.7
Notropis asperifrons	5.87	100.0
Notropis callistius	8.81	100.0
Notropis lirus	0.19	25.0
Notropis stilbius	2.97	75.0
Notropis trichroistius	45.62	100.0
Notropis venustus	0.34	41.7
Notropis xaenocephalus	16.90	100.0
Phenacobius catostomus	0.01	8.3
Semotilus atromaculatus	0.09	25.0
Family Catostomidae		
Hypentelium etowanum	2.00	100.0
Moxostoma duquesnei	0.39	66.7
Family Ictaluridae		
Ictalurus natalis	0.04	8.3
Family Centrarchidae		
Ambloplites rupestris	0.07	41.7
Lepomis cyanellus	0.01	8.3
Lepomis gulosus	0.07	33.3
Lepomis macrochirus	0.04	8.3
Lepomis megalotis	0.76	66.7
Micropterus coosae	1.11	91.7
Micropterus punctulatus	0.06	25.0
Family Cyprinodontidae		
Fundulus stellifer	0.02	25.0
Family Percidae		
Etheostoma coosae	5.93	100.0
Etheostoma jordani	1.18	100.0
Etheostoma stigmaeum	0.97	100.0
Percina caprodes	0.31	66.7
Percina nigrofasciata	0.96	91.7
Family Cottidae		
Cottus carolinae	2.94	100.0
Total	99.35	

Table 2. Age-class distributions and survival of *Etheostoma coosae* collected in Barbaree Creek from April 1977 through April 1978. S_1 and S_2 equal survival calculated from the −1 and 1+ age classes, respectively.

Sex	Year class	Number of specimens	Survival S_1	Survival S_2
Males	−1	231	1.000	–
	1+	76	0.329	1.000
	2+	25	0.108	0.329
Females	−1	252	1.000	–
	1+	140	0.556	1.000
	2+	26	0.103	0.185
Combined Sexes	−1	483	1.000	–
	1+	216	0.447	1.000
	2+	51	0.106	0.236

months of age assuming a May hatching. Each specimen had two annuli and the third was in the process of being established. Scale studies of *E. coosae* in Barbaree Creek indicated that annuli are established in early to middle spring.

Males grew faster than females, and were on the average significantly longer ($p < .05$) by the first spawning season (Figure 3). Females attained 70.3 percent and 90.0 percent of their average maximum standard length (40.5 mm) in 12 and 24 months, respectively, whereas males attained 69.5 percent and 94.5 percent of their average maximum standard length (43.1 mm) in 12 and 24 months. The longest male and female were 47.0 mm and 44.1 mm, respectively (Figure 2). There were no significant differences ($p > .05$) between male and female length-weight equations as tested by analysis of covariance ($F_S = 0.867$, df = 1,136). The relationship for combined sexes was log wt. (grams) = 3.1657 log SL − 5.1200, N = 140, r = .978.

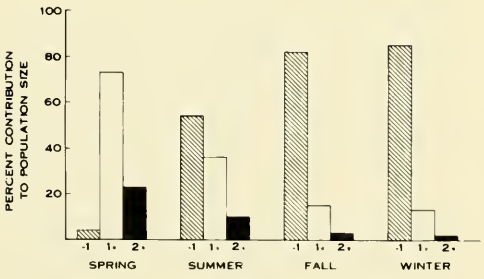

Figure 1. Seasonal changes in age-class composition of *Etheostoma coosae* collected in Barbaree Creek. Age-class designations are: −1, 1 to 12 months; 1+, 13 to 24 months; and 2+, >24 months.

Page and Schemske (1978) stated that one possible factor affecting size in darters of the subgenus *Catonotus* was interspecific competition. They concluded that maximum size in sympatric populations of *Catonotus* was determined by the presence or absence of *Etheostoma squamiceps*. In the presence of *E. squamiceps,* other *Catonotus species* were reduced in size, whereas in the absence of *E. sqamiceps* their maximum size was greater. They suggested that the major function of the size differences was for size-specific utilization of potential reproductive habitats.

The overall growth trend of *E. coosae* was for rapid growth, both sexes reach-

ing approximately 70 percent of the average maximum standard length, the first year of life, with a subsequent reduction of this rate in later years (Figure 3). This pattern is quite common in darters (Page, 1974 and 1975; Page and Burr, 1976; Starnes, 1977) and in fishes generally. As Ricker (1971) has pointed out, this phenomenon is usually attributed to physiological size limitations primarily influenced by the heavier reproductive effort by older individuals.

Reproduction

Female gonosomatic indices (Figure 4) and field observations indicate that *E. coosae* spawned from mid March through early to mid May with peak spawning in April. The spawning periods for species of the subgenus *Ulocentra* are similar. Winn (1958a, 1958b) reported that males of *Etheostoma* sp. (Barren River form) in Tennessee established territories near the beginning of April, and spawning began in about one week. Stiles (1975) reported that *E. simoterum* spawned from early April to the end of May throughout its entire range. *Etheostoma duryi* females had ripe ova and males were in extreme breeding color in late April in Cypress Creek, Lauderdale County, Alabama (pers. obs.).

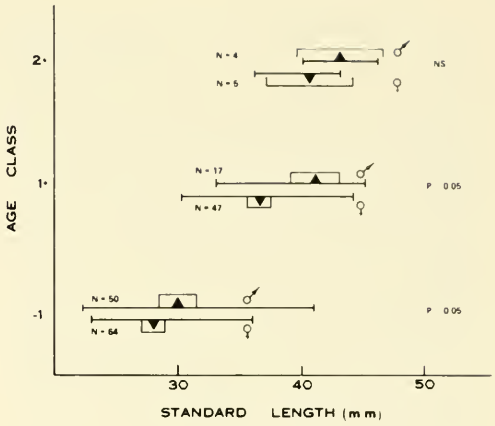

Figure 3. Annual growth of *Etheostoma coosae* males and females collected in Barbaree Creek. N equals sample size; NS equals not significant; and P equals probability level. Solid line equals range; triangle equals mean; and rectangle equals 95% confidence interval.

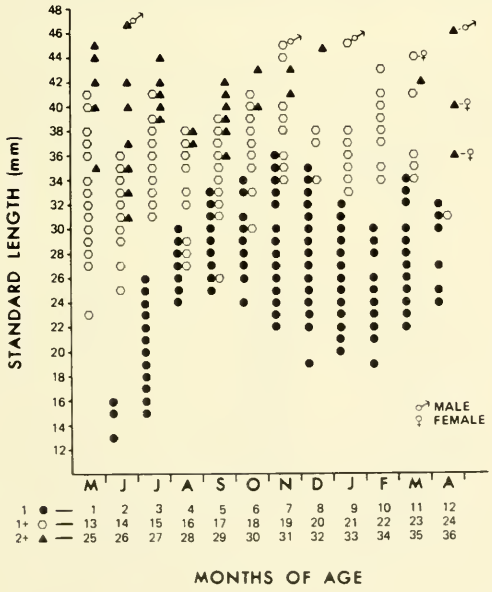

Figure 2. Length-age relationship of *Etheostoma coosae* collected in Barbaree Creek.

One month prior to spawning, male testicular tissue was swollen with a white granular appearance. During spawning, the tissue was extremely swollen with a subdued beige color. Approximately two months after spawning the testes were reduced to transparent, filamentous structures. The reproductive cycle of females was shorter in length when compared to males. Fully yolked mature ova were present for about 6 to 8 weeks. Mature testes and fully yolked ova were present in yearling darters indicating the possibility of spawning within the first year of life.

The spawning site of *E. coosae* consisted of almost any inclined, creviced surface within pools or raceways. Aquarium observations revealed that *E. coosae* spawned at angles from 0° to 90°, or in a horizontally inverted position while wedged in rock crevices or under ledges.

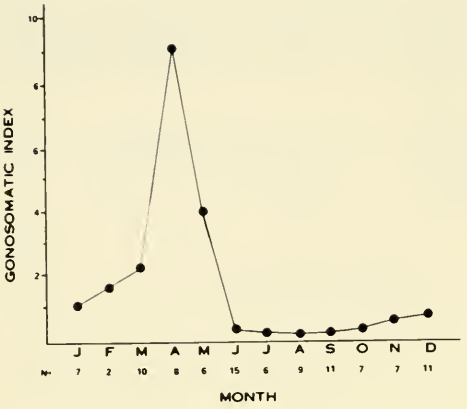

Figure 4. Monthly average gonosomatic index of *Etheostoma coosae* females collected in Barbaree Creek. N equals sample size.

In typical percid fashion, a male would display to a female as well as physically stimulate her nape with his head, attempting to elicite a spawning response. On occasion, a female would assume the dominate courtship role nudging and displaying her dorsal fins to a male, attempting to incite responses from him. Once an egg site, usually a small protective nook or crack, was selected, the female arched her body, placed the genital papilia over the site, and deposited one egg. The male quickly arched his body, placed the genital papilia over the egg and fertilized it. The eggs were deposited with no definable pattern or arrangement.

At the approach of spawning season *E. coosae* males acquired a light aqua-green tint around the gular region, along the tips of the spinous dorsal fin, on the first three membranes of the anal fin, and on

Table 3. Standard length, egg-size distribution, total egg complement (TEC), and age in years of selected *Etheostoma coosae* females collected in Barbaree Creek during March, April, and May, 1977 and 1978.

Standard length	Egg diameter in mm			TEC	Age
	0.2-0.4	0.5-1.0	>1.0		
40.1	194	156	72	422	2
38.5	300	116	80	496	2
36.0	278	56	4	330	2
35.9	320	118	54	492	2
34.5	284	92	34	410	1
33,7	220	92	42	354	1
33.5	172	78	38	288	1
31.5	280	46	22	348	1
30.5	260	39	0	299	1
Mean	256.4	88.0	38.4	382.8	
Percent	67.0	23.0	10.0	100.0	

the anterior dorsal and ventral interradial membranes of the caudal fin. The interradial membranes throughout the length of the spinous and soft dorsal fins had rusty-red quadrate spots. Females maintained a ground color of light tan overlaid by brown to black lateral blotches and mottling above the lateral line.

The total egg complement increased proportionally with length, r = .682 (Table 3).Fecundity studies of other darters have substantiated positive size-fecundity relationships: *E. squamiceps,* r = .692 (Page, 1974); *E. barbouri,* r = 530 (Flynn and Hoyt, 1979); *E. kennicotti,* r = .631 (Page, 1975); and *Percina nigrofasciata,* r = .721 (Mathur, 1973). An exception to this general relationship was reported for *E. proeliare* (r <.1) by Burr and Page (1978). This vagary was attributed to the short life span (one year) of the population studied, which yielded females of a similar size.

Feeding

The overall diet of *E. coosae,* consisted of 78 percent Diptera (Chironomidae and Simuliidae), 12 percent Crustacea (Copepoda and Cladocera), 3 percent Ephemeroptera (Baetidae and Siphlonuridae) and 5 percent miscellaneous items (Acarina, Mollusca, Nematoda, Trichoptera, and sand). The diet of various size classes as well as the seasonal diet of combined age and size classes is seen in Figure 5.

Etheostoma coosae consumed midge larvae as juveniles and expanded their diet as adults to include mayflies and caddisflies. Midge larvae decreased whereas crusaceans increased in importance from spring to winter. Mayflies, caddisflies, and molluscs were important items during summer months.

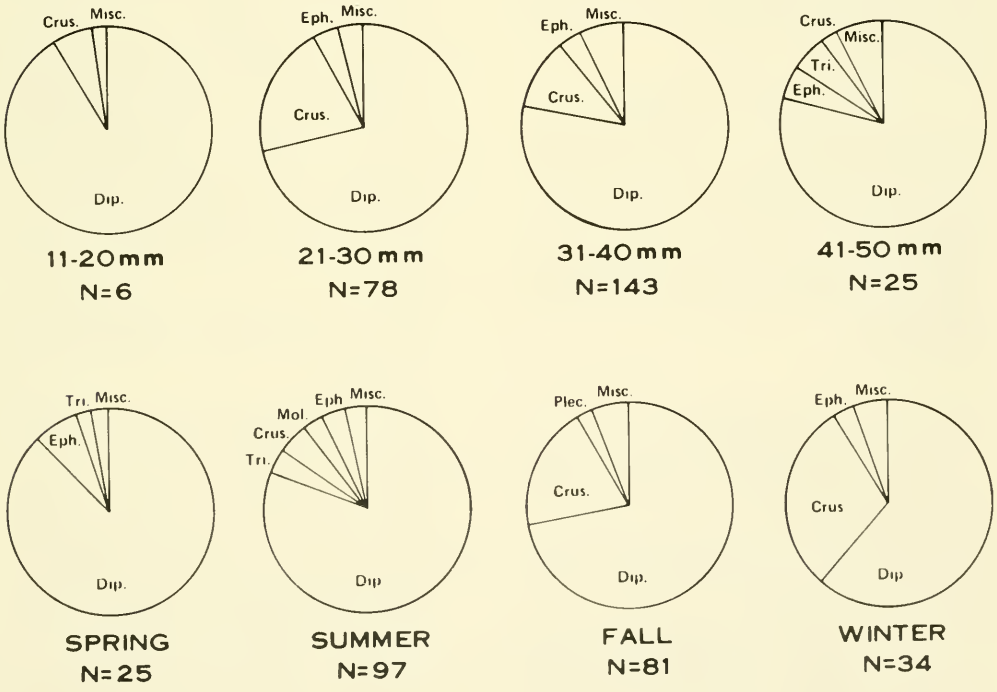

Figure 5. Stomach contents of *Etheostoma coosae* collected in Barbaree Creek by size class of darter and season collected. Seasonal analyses include all size and age classes. Food items are abbreviated as follows: (Crus)tacea, (Dip)tera, (Eph)emeroptera, (Mis)ellaneous, (Mol)lusca, (Plec)optera, and (Tri)choptera. N equals sample size.

The feeding mode of darters has been reported to be largely selective in some species: *E. fonticola* (Schenck and Whiteside, 1977), *E. nigrum* (Roberts and Winn, 1962), and *E. radiosum cyanorum* (Scalet, 1972); and largely opportunistic in others: *E. acuticeps* (Bryant, 1979), *E. blennioides* (Fahy, 1954), and *E. gracile* (Braasch and Smith, 1967). These papers have illustrated that within the genus *Etheostoma* feeding behaviors are quite variable and complex. Based on the literature and my own studies, I believe that feeding behavior is not so restrictive but rather lies along a dynamic continuum between selectivity and opportunism. Species will adapt to prey abundance and type assuming the most energetically rewarding feeding response. Prey switching as a possible behavioral mechanism involved in feeding is supported by the studies of Murdoch et al. (1975) on *Poecilia reticulatua* and Roberts and Winn (1962) on the role of visual cues in the feeding of *E. nigrum*.

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