Biology of Redbreast Sunfish in Beaver Ponds[1]

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Abstract: Redbreast sunfish (*Lepomis auritus*) is an abundant member comprising 30% of total biomass of the fish community in beaver ponds in piedmont South Carolina. Total length-weight relationship for 534 redbreast sunfish collected from 36 beaver ponds was: $\log_{10}W_g = -5.06 + 3.12 \log_{10}TL_{mm}$. Mean back-calculated TL for age classes I–V were 41, 75, 102, 128, and 147 mm, respectively. Growth of males was faster than the growth of females, and males appeared to have better survival. Sex ratio favored males 1.00:1.32. Redbreast sunfish spawned from May through August after water temperatures reached 23° C. Mature females (>76 mm TL) contained approximately 3,000 ova. Most of the redbreast sunfish (96.6%) examined contained food. Redbreast sunfish feed primarily on aquatic insects such as chironomids, ceratopogonids, ephemeropterans, trichopterans, and odonate larvae. Fish occurred infrequently in redbreast stomachs but comprised 26.5% of the total stomach volume.

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Redbreast sunfish, a popular game fish, occurs in a variety of habitats from headwater streams to lakes and coastal rivers throughout the Southeast (Eddy 1957, Manooch 1984). The redbreast sunfish sport fishery has declined in some southeastern states (Davis 1972, Sandow et al. 1974). The number of redbreast, however, is expected to increase along with other centrarchids in those states which have extensive beaver populations (Hanson and Campbell 1963, Pullen 1971). Beaver numbers have increased (Woodward 1977) and increased numbers of redbreast have also been observed in beaver impounded waters in South Carolina (Hayes 1980).

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The increased number of beaver ponds and redbreast sunfish in these habitats prompted the initiation of this study to learn more about the species in beaver ponds, and the feasibility of maintaining a fishery in beaver ponds as suggested by Patterson (1951). Objectives of the study were to provide age, growth, reproductive, and food habit information for redbreast sunfish inhabiting beaver ponds in South Carolina. This information will also contribute to our understanding of the life history of this popular game species and, hopefully, provide some insight into the relative importance of this species in palustrine systems.

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Methods

Study Sites

Redbreast sunfish were sampled from 36 beaver ponds on Little Beaverdam and Beaverdam creeks in Anderson and Oconee Counties in South Carolina. These 2 creeks empty into the Seneca River branch of Lake Hartwell (approx. 3431N 8257W). Beaver ponds were classified as young ponds (0.5–3 years), middled-aged ponds (4–6 years) and old ponds (>6 years). Most pond ages were known by landowners; others were estimated by counting annual growth rings on beaver girdled trees, documenting their appearance on aerial photographs and/or observing the abundance of standing trees within the beaver pond complex (Hayes 1980). Ponds of each age classification were located in similar numbers in each creek system.

Canopy over young ponds resembled that of the original stream. Less water-tolerant trees died and canopy cover decreased with pond age. Hydrophytes such as willows (*Salix sericea*) and alders (*Alnus cerifera*) dominated the tree community in older ponds. Substrates of middle- and old-aged ponds contained considerable silt and decaying organic matter and supported abundant submergent and emergent vegetation throughout the pond. Aquatic vegetation was mostly restricted to edges of young ponds.

Beaver ponds ranged from 0.04 to 0.36 ha. Dissolved oxygen averaged 8.0 mg/liter and dipped below the critical level of 3.5 mg/liter (Moore 1942) once during the year (July). Dissolved CO_2 ranged from 5.0 to 30.0 mg/liter and water temperature ranged from 4° C in January to 24° C in July. Secchi disc readings were relatively constant ($\bar{x}$ = 45 cm) as were pH values ($\bar{x}$ = 6.5).

Sampling

One pond from each age group per month was sampled over a 12-month period. Rotenone was applied at 2 mg/liter from February to October and at 4 mg/liter November to January after pond outlets were blocked with 0.6-cm mesh seines.

Fish were counted and weighed by taxa and redbreast sunfish were fixed in 10% buffered formalin. Redbreast from the middled-aged and old ponds were subsampled (30 fish); if less than 30 were collected, all fish were used. Low numbers of redbreast sunfish collected from young ponds restricted analysis to only middle-aged and old beaver ponds.

Total length (TL, mm) and wet weight (g) were recorded and scales were removed from the left side below the lateral line behind the operculum of individual fish. Impressions of scales were examined with a projector (42 ×) and annuli were counted according to Lagler (1956) and Carlander (1981). Annuli formation was validated by examining scale samples taken throughout the year (Jearld 1983). Scale radii from the focus to the anterior edge and to each annulus were measured, and the fish lengths after each year of life were calculated. The correction factor for these calculations (i.e., TL at which squamation occurred) was determined by least squares regression method with fish less than 90 mm. The estimate of this correction factor would therefore not be biased by those environmental stressors affecting the growth rate of older fish.

Gonads were excised from both males and females and weighed to the nearest milligram and maturity indices were calculated by dividing gonad weight by fish weight. Ova from each ovarian lobe and junction between the 2 lobes were subsampled and classified as: primary oocytes-translucent irregular-shaped sex cells with visible nucleus; mature ova—large, dark orange spherical cells with visible oil droplets; or recruitment ova—ranging from white opaque spherical cells to yellow oval-shaped cells with oil droplets. Number of mature and recruitment ova in an ovary was estimated gravimetrically (Lagler 1956) for 64 females during the spawning season. Diameters of 20 mature and 20 recruitment ova were measured (0.1 mm) for each of these fish.

Stomach contents from 534 redbreast sunfish were measured volumetrically then sorted and counted by taxa. Volumetric determinations were made for each taxon. Stomach content data were calculated according to Larimore's (1957) methodology and expressed as frequency of occurrence (percent occurrence of each taxon), number of food items per stomach, stomach volume comprised by each taxon, and an average of percent stomach volumes of each taxon.

Data were compiled and analyzed statistically with SAS (Barr and Goodnight 1972). Specific statistical tests included: analysis of variance for comparison of means (e.g., mean lengths for males and females); analysis of covariance to compare slopes and intercepts of regression equations (e.g., total length-weight regressions of males and females); and x^2 tests for sex ratios and food habit comparisons. Level of significance was set at 0.05 level.

Results and Discussion

Approximately 7,500 redbreast sunfish were collected from the 36 beaver ponds. A total of 534 redbreast sunfish were examined from the 24 old and middle-aged ponds. Only 150 redbreast were collected from young beaver ponds, and 7 of

12 ponds had no redbreast and few other centrarchids. Pullen (1971) and Hayes (1980) observed few fish in young beaver ponds. Young beaver ponds generally lacked the protective vegetation and aquatic food organisms common in older beaver ponds (Hayes 1980).

Redbreast sunfish are generally considered a riverine species (e.g., Bass and Hitt 1974), and in Little Beaverdam Creek they were the fourth most abundant fish species of 18 species collected (Hayes 1980). Redbreast also was a dominant species in the fish community of the beaver ponds. They comprised 30% of the total catch which constituted 27 species and was outranked only by the brown bullhead (*Ictalurus nebulosus*) in biomass. The other dominant species (biomass) were the creek chubsucker (*Erimyzon oblongus*), golden shiner (*Notemigonus crysoleucas*), green sunfish (*L. cyanellus*), chain pickerel (*Exos niger*), bluegill (*L. macrochirus*), yellow bullhead (*I. natalis*), warmouth (*L. gulosus*), and creek chub (*Semotilus atromaculatus*).

Abundance of redbreast sunfish was highest in the middle-aged beaver ponds and lowest in the young ponds. Timmons et al. (1977) observed a progressive increase in redbreast abundance over a 2-year period after the Chattahoochee River was impounded to form West Point Reservoir. Increased redbreast abundance and dominance appears to be a characteristic feature of the hydroseral stage represented by the initial post-impoundment period of West Point Reservoir and middle-aged beaver ponds in South Carolina.

Total length of 534 redbreast sunfish collected from beaver ponds ranged from 24–215 mm and the total length-weight relationship ($r = 0.99$) was $\log_{10}W_g = -5.06 + 3.12 \log_{10}TL_{mm}$. This regression slope was within the range (2.81–3.23) found for other redbreast populations in the Southeast (Swingle 1965, Bass and Hitt 1974, Sandow et al. 1974, Hiranvat 1975).

Slope of the length-weight regression for redbreast from old ponds was significantly greater ($P \leq 0.05$) than for redbreast from middle-aged ponds. Hodkinson (1975) indicated productivity increased with beaver pond age, and greater productivity would be expected with the accumulation of organic matter in beaver ponds (Hanson and Campbell 1963).

Slopes of the total length-weight regressions for male ($\log_{10}W_g = -5.15 + 3.16 \log_{10}TL_{mm}$; $r = 0.99$) and female redbreast sunfish ($\log_{10}W_g = -4.93 + 3.05 \log_{10}TL_{mm}$; $r = 0.99$) were significantly different ($P \leq 0.05$) indicating males weighed more than females per unit length. This phenomenon has been reported for redbreast sunfish (Sandow et al. 1974) and is probably due to differences in the partitioning of energy between growth and reproduction by the sexes, especially with such a long spawning period. Length frequency distributions of male and female redbreast also revealed males grew to larger sizes and were more abundant than females (Fig. 1a).

Annulus formation occurred from February to June with approximately 90% of the annuli formed by April. Redbreast sunfish from the Satilla River and Chattahoochee River formed new annuli by April and May, respectively (Sandow et al. 1974, Hiranvat 1975). Ages ranged from <1 year to 6 years (Fig. 1b). Males domi-

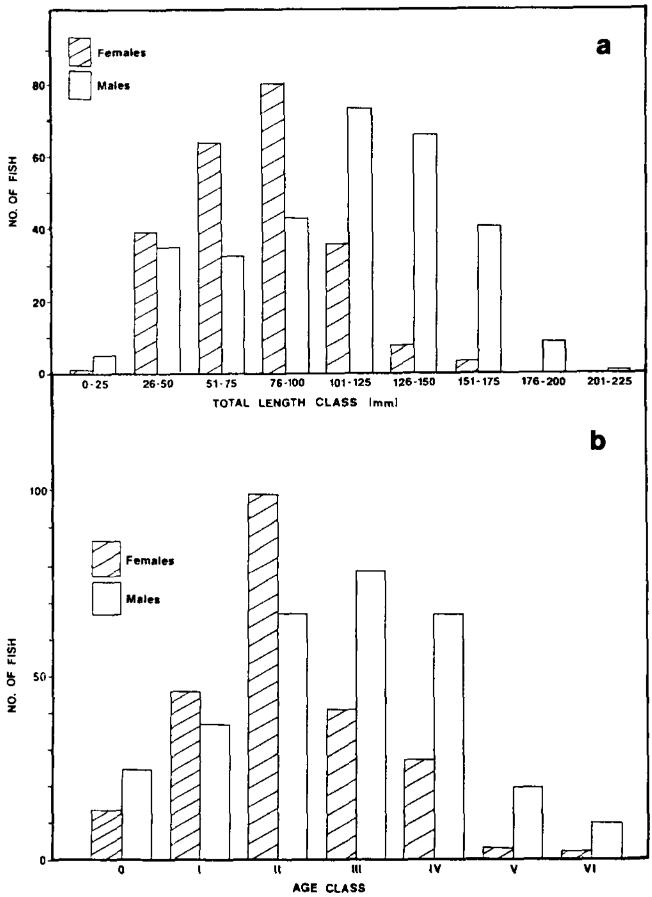

Figure 1. Length- (a) and age- (b) frequency distribution for redbreast sunfish from 24 old and middle-aged beaver ponds in South Carolina.

nated the older age classes (III–VI) while females were more abundant in the younger age classes (II–III) indicating males live longer than females. Sex ratio (1.00:1.32) favored males as expected and differed significantly ($P \leq 0.05$) from the expected ratio of 1:1. In contrast, Sandow et al. (1974) and Hiranvat (1975) found females significantly outnumbered males in the Satilla and Chattahoochee rivers in Georgia.

Total length-anterior scale radius (ASR) relationship of 256 redbreast sunfish was: TL = 16.60 + 1.06 ASR. The value of 16.6 mm was used as the correction factor to back-calculate length when redbreast sunfish completed squamation. Sandow et al. (1974) and Hiranvat (1975) reported 17.0 mm and 16.4 mm TL for squamation, respectively. Average back-calculated lengths for 497 redbreast sunfish in age classes I through V were 41, 75, 102, 128 and 147 mm, respectively. Some

37 fish were <1 year old. Average back-calculated length for age class VI redbreast is not reported because most of the sample was collected in the spring after annuli formation. These TL were considerably lower than mean calculated lengths for redbreast from Satilla and Chattahoochee rivers in Georgia (Sandow et al. 1974, Hiranvat 1975) and Hickory and Lookout Shoals lakes in North Carolina (Richardson and Ratledge 1961), but higher than those values reported for redbreast from New York (Bernhardt 1957). No significant difference was detected in the back-calculated length for redbreast sunfish from middle-aged and old beaver ponds. Mean back-calculated length for males, however, were significantly greater ($P \leqslant 0.05$) than females for each year of life. Hiranvat (1975) found significant differences in male and female growth only after the third year of life.

Annual growth increments of redbreast sunfish decreased through life, increments averaged 41, 33, 24, 23, and 23 mm from year 1 through 5. Although the annual growth increments of females were consistently smaller than males, the rate at which growth decreased was very similar for both sexes. Obviously, male and female redbreast exhibit the same type of growth curve, but grow at different rates in South Carolina beaver ponds.

Redbreast sunfish mature at approximately 2 years of age and 75 mm. Although smaller fish (26–50 mm TL) may have developing ova, 69% of the fish $\leqslant 75$ mm had no mature ova and 39% had neither mature or recruitment ova. Davis (1972), Bass and Hitt (1974), and Hiranvat (1975) all found redbreast to mature at 2 years of age in the Southeast.

Redbreast sunfish go through considerable gonadal development in April as indicated by the rapid increase in the maturity index (Fig. 2). Water temperature averaged 16° C at this time. Spawning occurred in May when water temperatures were 23° C and continued through much of the summer (Fig. 2). Redbreast are reported to spawn at 21° C in North Carolina streams (Davis 1972) and as 22° C in Florida and Georgia rivers (Bass and Hitt 1974, Sandow et al. 1974).

Mean maturity index for females was approximately 10 times greater than that for males. In addition to maintaining larger gonads per unit body weight, females also appeared to contribute more energy to reproduction as indicated by the 45% decrease in the maturity index of females compared to only 5% for males over the spawning period (Fig. 2).

Diameters of mature ova and recruitment ova averaged 1.12 mm (0.4–1.6) and 0.32 mm (0.2–0.8), respectively. Mean size for mature ova compares well with the 1.20 mm mean diameter reported by Sandow et al. (1974). No significant relationship was detected between the size of ova and fish size.

Number of mature and recruitment ova for females considered sexually mature (>76 mm TL) ranged from 433–6,205 ($\bar{x}$ = 2,989). This mean is close, considering the number of ova varies with the age and size composition of the redbreast sample, to that 3,175 ova per female redbreast from Florida (Bass and Hitt 1974) and 3,302 per female from south Georgia (Sandow et al. 1974). Number of ova (fecundity) increased significantly ($P \leqslant 0.05$) with TL and the regression ($r = 0.77$) was Ova No. = $-1640.90 + 36.34\ TL_{mm}$. Sandow et al. (1974) also ob-

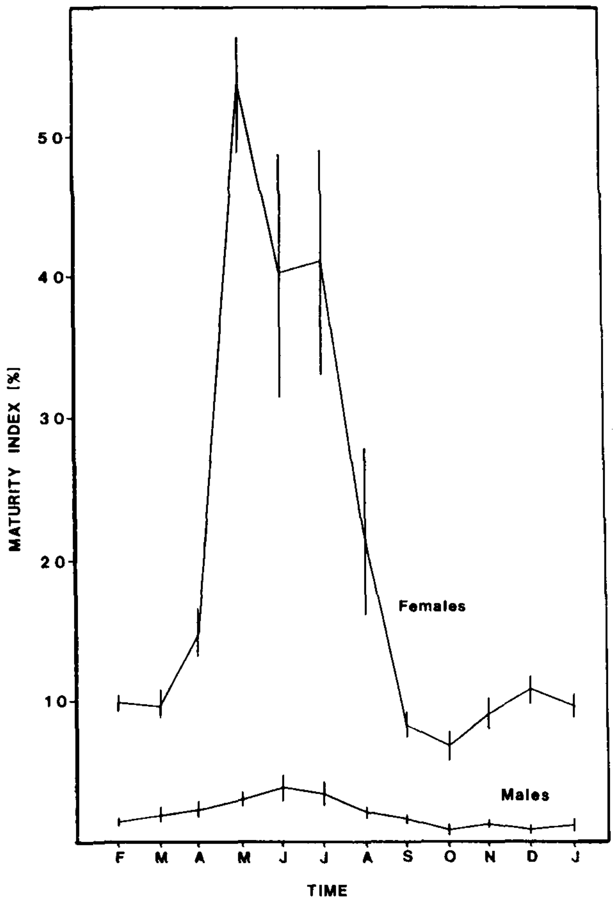

Figure 2. Mean (± se) maturity indices for male and female redbreast sunfish from 24 old and middle-aged beaver ponds in South Carolina.

served fecundity to increase with fish length. No statistical difference in fecundity was detected between redbreast from old and middle-aged ponds.

Stomachs of 96.6% of 534 redbreast sunfish from South Carolina beaver ponds contained food. The most common food items (% occurrence) were chironomids (81.6%), ceratopogonids (41.1%), copepods (32.9%), cladocerans (25.2%), ephemeroptera (24.4%), trichoptera (20.5%), odonates (19.4%), terrestrial insects such as ants (16.1%), coleopterans (15.7%), ostracods (15.3%), pelecypods (9.7%), gastropods (7.0%), and fish (6.0%). These 13 food items comprised 76.2% of the total volume of food in redbreast stomachs. Mud, organic debris, hemipterans, oligochaetes, crawfish, isopods, and plecopterans comprised the remaining

23.8% of the volume. Volumetrically, the 4 most abundant food items (i.e. chironomids, ceratopogonids, copepods, and cladocerans) comprised less than 10% of the total, while the less abundant ephemeropteran, coleopteran, trichopteran, and odonate larvae comprised 36.4% of the total food volume. Fish appeared to be the most important food item energetically with 26.5% of the total food volume. Redbreast may be opportunistic insectivores throughout the southeastern United States as reported by Davis (1972), Bass and Hitt (1974), Sandow et al. (1974), and Coomer et al. (1977), but fish are also important food items, especially, for the larger redbreast (>76 mm TL). Small sunfish and shiners were the most numerous fish found in the stomachs of the larger redbreast. Unlike fish, cladocerans and copepods occurred primarily in smaller redbreast (0–75 mm TL). No significant differences were detected between sexes in the composition of food items.

Chi-square tests revealed significant differences ($P \leq 0.05$) in only 2 food taxa between redbreast from middle-aged ponds and old ponds. Trichopterans were found in significantly ($P \leq 0.05$) more stomachs of redbreast from middle-aged ponds where there was generally less sedimentation than in old ponds. In contrast, terrestrial insects occurred significantly ($P \leq 0.05$) more frequently in fish from old ponds. Old ponds characteristically had more emergent vegetation which could serve as habitats for terrestrial insects.

Chironomids had the highest frequency of occurrence throughout the year (Fig. 3). Copepods were the second most frequently occurring food item in fall, winter and spring, but its occurrence declined significantly ($P \leq 0.05$) in summer when other food organisms were more abundant. Coomer et al. (1977) found that redbreast fed more heavily on copepods in fall than during other seasons. Distinct seasonality was also observed in the volume of fish and ephemeropterans consumed by redbreast (Fig. 3). Seasonal differences in the volume of ephemeropterans consumed appear related to availability of different mayfly genera. For example in winter, the large mayflies (*Hexagenia* spp.) were common in redbreast stomachs and would be abundant in ponds (Hudson and Swanson 1972). Different emergence patterns accounted for much of the seasonal variation in the volume of insects consumed by redbreast. Redbreast contained greater volumes of fish in the spring and summer than in fall and winter. Fish small enough to be utilized by redbreast sunfish would be more abundant after the spawning season, which is spring and summer for most of the fish species found in beaver ponds (Hayes 1980).

Redbreast sunfish are opportunistic feeders which prey on the most readily available food resource (e.g., Bass and Hitt 1974). Beaver ponds are productive habitats (Wesley 1967) providing food sources to redbreast not commonly available in their riverine habitat (Hayes 1980). Programs targeted for stocking redbreast sunfish in beaver ponds would take advantage of this productivity and add impetus to the growth of the redbreast sunfish sport fishery as beaver pond numbers increase in the Southeast.

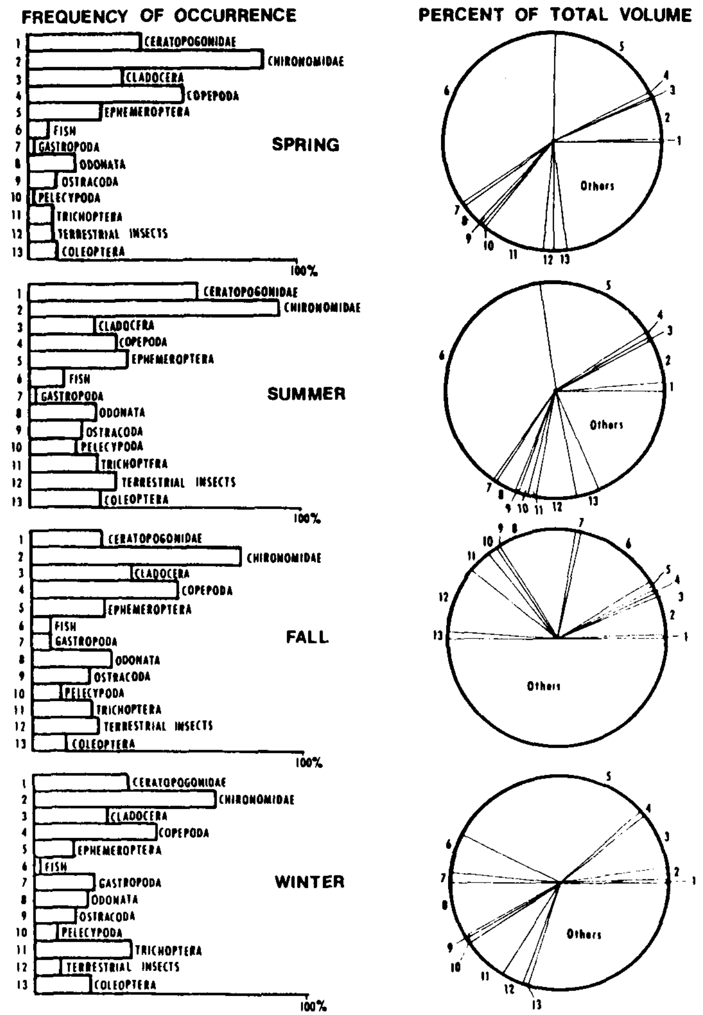

Figure 3. Frequency of occurrence (%) and total volume (%) by season for 13 most abundant food items found in redbreast sunfish stomachs from 24 old and middle-aged beaver ponds in South Carolina.

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