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Age, Growth and Early Life History of the Waccamaw Darter, *Etheostoma perlongum*

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The examination of scales, otoliths and length frequency histograms indicates that *Etheostoma perlongum* is an annual darter. Adults die soon after spawning. Growth is rapid. Darters reach half average adult size between four and eight weeks. Females attain most of their adult size by month 5, and males continue to grow through month 9 (with the exception of "stunted" males in the population). Fertilized eggs are spherical, 1.2 mm in diameter, and hatch between 120 and 168 hours at 20–23 C in aquaria. Laboratory reared larvae show a full complement of 38 myomeres by 4.9 mm SL, and become juvenile by 10.2 mm SL.

DETAILS of the life history, especially age and growth information, of many of the nearly 130 described percid fishes of the tribe Etheostomatini are poorly known. Some studies of the fishes of the genus *Percina,* including age and growth information, are reported by Page and Smith (1970, 1971), Page (1978) and Thomas (1970). Other reports of age information of fishes in the genus *Etheostoma* include the subgenera: *Catonotus* (Lake, 1936; Karr, 1964; Page, 1974, 1975; Page and Burr, 1976; Flynn and Hoyt, 1979); *Etheostoma* (Fahy, 1954; Lachner et al., 1950); *Hololepis* (Braasch and Smith, 1967; Schmidt, 1979); *Oligocephalus* (Pflieger, 1978); *Microperca* (Burr and Page, 1978, 1979); and *Nothonotus* (Raney and Lachner, 1939).

Length frequency histograms have been used to determine age classes of darter species by Fahy (1954), Flynn and Hoyt (1979), Lachner et al. (1950), Raney and Lachner (1943) and Starnes (1977).

Difficulties in the scale method of aging fish were discussed by Carlander (1974) and problems caused by little variation in seasonal water temperature were alluded to by Starnes (1977), however, the scale method of age determination has been used successfully on darters. The first study of this type was done by Raney and Lachner (1943) who reported that *E. longimanum* lives two years and *E. olmstedi* lives two to four years.

Darters known that may not survive to a second breeding season are those of the subgenus *Microperca*. The oldest reported specimens of *E. microperca* are two years (Winn, 1958). Burr and Page (1979) reported that only 17.6% of males and 25.7% of females of *E. microperca* survive to a second growing season. *Etheostoma proeliare* is also shortlived. The oldest reported

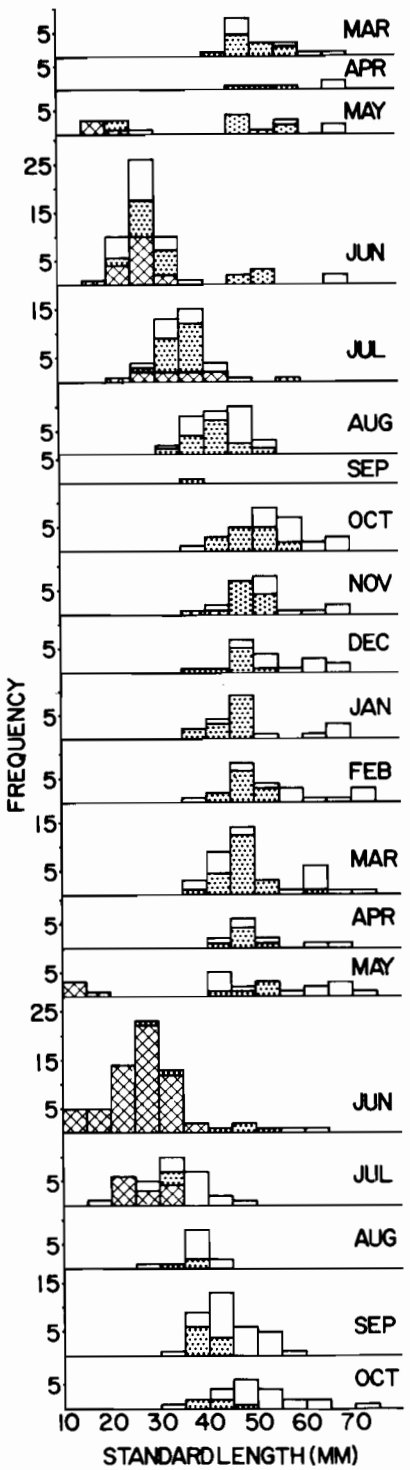

Fig. 1. Length frequency distribution of *Etheostoma perlongum* by month, from March 1979 to Oct. 1980. Open bars represent males, stippling represents females and crosshatch represents unsexed juveniles.

specimens are 18 months, and only 2.7% of males and 11.4% of females reach a second growing season (Burr and Page, 1978). The oldest reported specimen of *E. smithi* is 24 months, and Page and Burr (1976) reported that 19.2% of males and 24.7% of females survive to a second growing season. Page (pers. comm.) has found that *E. atripinne* also does not live to a second reproductive season. Collette (1958) indicated that *E. fusiforme* may survive to a second year in Maine, but is an annual species in southern areas.

To date, the life histories of three of the five darters of the subgenus *Boleosoma* have been studied, and their age and growth has been reported. Raney and Lachner (1943) found *E. longimanum* and *E. olmstedi* to live two years and two to four years, respectively. Speare (1960) and Karr (1963) reported *E. nigrum* to live two to four years. In our paper, age, growth and early life history stages of a fourth species of *Boleosoma, Etheostoma perlongum* (the Waccamaw darter) are presented.

The Waccamaw darter is one of three species of fishes endemic to Lake Waccamaw, North Carolina. *Etheostoma perlongum,* which may have evolved from an isolated stock of *E. olmstedi* (Cole, 1972), is common in the offshore waters in fall and winter, and along the shoreline where they breed in spring and summer (Lindquist et al., 1981).

Lake Waccamaw is a large, shallow coastal plain lake in southeastern North Carolina, with an area of 3,618 ha, and a maximum depth of approximately 3.3 m. In comparison with similar coastal plain lakes, the near neutral pH of Lake Waccamaw is a factor contributing to its relatively high level of fish diversity. The extreme differences in the seasonal water temperatures of Lake Waccamaw (average lake temperature of 2.3 C in February 1980 to 30.9 C in August 1980) are favorable for scale annulus formation. See Frey (1949) for more complete information on the hydrography of Lake Waccamaw.

Materials and Methods

Darters were collected monthly by trawling in Lake Waccamaw, Columbus County, North

Carolina from six mid-lake stations and by seining at eight shoreline stations. Some individuals were also captured with the use of SCUBA and dip nets. Stations were selected to represent a cross-section of habitat types.

A total of 523 fish were collected from March 1979 to October 1980. Specimens were preserved in 10% formalin. Measurements were taken with dial calipers, and sex was determined by examining the genital papillae (Lindquist et al., 1981) with a binocular dissecting microscope. An average size for each month was calculated for both sexes, and these points were used to generate growth curves.

An area on the right side of the individual, posterior to the first dorsal insertion and approximately three scales above the lateral line was selected for age readings. Three or four scales were removed and dry-mounted between two glass microscope slides and read with a projecting and/or dissecting microscope. Otoliths (sagittae) were also removed from eight specimens collected in April 1981. Specimens were kept on ice until removal of otoliths, and otoliths were stored for 24 hours in glycerin for clearing before examination for age. See Williams and Bedford (1974) for methodology and discussion of the use of otoliths for aging fish.

Eggs in different stages of growth were removed from the nests of spawning individuals maintained in laboratory aquaria (Lindquist et al., 1981). Larvae were reared in 100 × 190 mm crystalizing dishes filled with approximately 0.8 l of water from Lake Waccamaw. Individuals at various stages of development were removed for study. Eggs and larvae were preserved in 5% buffered formalin and illustrated with the use of a camera lucida and binocular dissecting microscope. Larval terminology used is that described by Hubbs (1943).

Results and Discussion

Age.—The scales from 170 Waccamaw darters showed annulus formation occurring only on 13 adult males ranging in size from 58 mm to 69 mm SL. The earliest annulus formation was found on a 61 mm SL male taken in March 1979 and the oldest fish captured with an annulus was taken in June 1979. Otoliths from three nuptial males (67.2–76.1 mm SL), two "stunted" males (42.8–46.0 mm SL), and three ripe females (46.1–55.6 mm SL) were interpreted as being "not quite" to "just over" one year of age.

To further corroborate our scale and otolith readings, a length frequency histogram was constructed (Fig. 1). There is an influx of young-of-the-year darters (age class 0) in May (breeding season is late March to early June). The oldest adults linger until July. Apparently age class 1 of *E. perlongum* dies soon after spawning, and by Aug. the population is composed entirely of young-of-the-year fish (3 month, assuming a May hatching). Extensive collections throughout the lake in Aug. and the remainder of the year revealed only young-of-the-year specimens.

Most males reach a larger size, showing clearly in March, April, May and June 1979 (Fig. 1). In October (or month 5), when female growth slows, the more rapid growth of males again separates them from females (Fig. 1). Approximately 33% (33 from a total of 101) of the males collected from October to June 1979 and 1980 represent an exception to this trend (Fig. 1). These "stunted" males do not assume nuptial coloration during breeding season, even though their gonads are well developed in comparison with larger, territorial males. Underwater observations showed these "stunted" males appearing to mimic females.

These "stunted" males may exhibit a behavioral adaptation such as that described by Constantz (1975, 1979) and Van den Assem (1967). A population of *Etheostoma olmstedi,* a close relative of *E. perlongum,* was observed to contain smaller "subordinate" males. These males, when displaced from a territory by a larger, dominant male, would assume female coloration, and would often be allowed to invert beside a spawning pair (Constantz, 1979). In this manner, the subordinate male may be able to fertilize eggs without the energy expenditure necessary for maintaining territories, breeding coloration and courtship. This has also been reported for the three-spined stickleback. Males in rival situations may resort to "sneaking" into the nest of another male and may attempt to fertilize eggs himself by mimicking a female (Van den Assem, 1967). As in the case of the Gila topminnow, *Poeciliopsis occidentalis,* this mating strategy may be caused by environmental stresses such as a high male : female ratio resulting in more competition between males (Constantz, 1975). Another factor may be the length of growing season (Constantz, 1975). Males hatched in June may still mature at the same time as males a few months older, and spend more energy on developing gonads than on attaining a larger size.

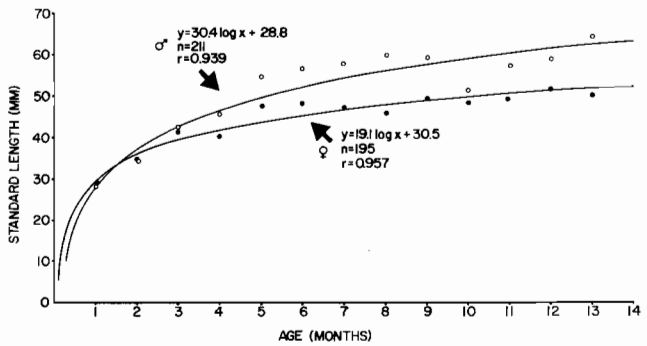

Fig. 2. Growth curves for male and female *Etheostoma perlongum*. Open circles represent monthly averages for males, closed circles represent monthly averages for females. June is month one.

According to the results of our scale and otolith readings and length frequency histogram, *E. perlongum* is an annual species of darters. The Waccamaw darter is unique among those *Boleosoma* studied and indeed among most other darters whose longevity has been reported. Fourteen month-old fish collected in July 1979 represent the oldest specimens, assuming May hatching. Because of the annual nature and limited distribution of this species, a critical factor in their survival includes a successful spawning season every year.

Growth.—Growth is rapid, and the darters reach half average adult size between four and eight weeks (Fig. 2). Female darters attain most of their year's growth by the end of their fifth month. Males and females grow at a similar rate through August (month 3). When the growth of females slows (month 5), however, males continue to grow through month 9 (Figs. 1, 2). A deviation from the average is the appearance of stunted males in the population. The male population grew at a steady rate until October (month 5), when 33% (33 from a total of 101 males collected from October to June 1979 and 1980) of the males grew at a much slower rate. The average length for these stunted males at one year (12 months) is 44.6 mm SL compared to 64.3 mm SL for the normal size males.

In comparison with other *Boleosoma,* the growth of *E. perlongum* is more rapid. Raney and Lachner (1943) reported that males of *E. olmstedi* collected in northern localities averaged 34.9 mm SL at the end of their first year. Females of the same age averaged 32.8 mm SL. After the first year, growth is slower. They found that males and females that survived to a third year averaged 58 mm and 48.6 mm SL, respectively.

The growth of *E. longimanum* from the James River System was similar, with one year old males averaging 37.6 mm SL, and at the end of their second year attaining an average length of 54.9 mm SL. Females reached 35.4 mm at one year, and 46.3 mm SL at the end of their second year (Raney and Lachner, 1943).

Speare (1960) found that in the fall of their second year, male *E. nigrum* collected in Michigan reached an average size of 43.9 mm SL. Females averaged 41.4 mm SL. Again, further growth is much slower. A maximum size of only 55 mm SL was attained, with males averaging 49.3 mm SL at two years, and females averaging 46.0 mm SL.

Eggs and larval stages.—Fertilized *E. perlongum* eggs are spherical and approximately 1.2 mm in diameter. The gastrula stage of embryonic development is shown in Fig. 3A. The flattened area is the well developed attachment disc that was attached to the nest cover (in this case, submerged wood). The tail-free stages are illustrated in Fig. 3B, C. Pigmentation appears along the sides and on the head. A late embryo is shown in Fig. 3D. Pectoral fin buds are evident. The lense of the eye has formed and is pigmented.

Larvae reared from aquarium spawning hatched between 120 and 168 hours at 20–23 C. A 4.1 mm SL prolarva preserved at hatching (Fig. 3E) has a translucent body with numerous stellate chromatophores on the head, yolk sac and myomeres. The origin of the dorsal finfold is in approximately the same position as the first myomere. The anal finfold originates just

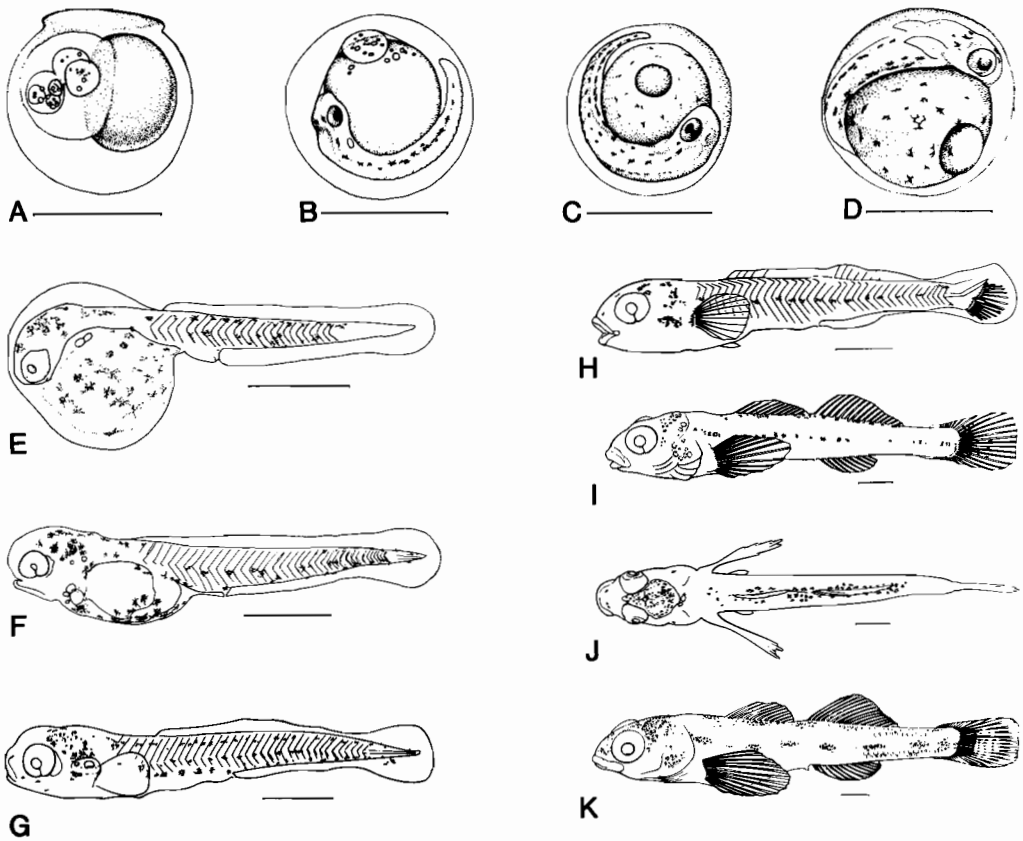

Fig. 3. Egg and larval stages of laboratory raised *Etheostoma perlongum*. A) 17 hours; B) 48 hours; C) 72 hours; D) 96 hours; E) hatchling; F) prolarva (48–96 hours from hatching); G) postlarva (5–7 days old); H) postlarva (12–14 days old); I) and J) juvenile (22–24 days old); K) juvenile (33–35 days old). Scale = 1 mm.

posterior to the anus. The yolk sac remains evident in the 4.9 mm SL prolarva (Fig. 3F). The origin of the finfolds are in the same position as the hatchling, and pigmentation is similar. At this stage the mouth has begun to develop, and this specimen shows a full complement of 38 myomeres. The 6.0 mm SL postlarva (Fig. 3G) has a well developed subterminal mouth and otoliths are visible in the auditory vesicle. The yolk sac has disappeared. At this stage, the dorsal finfold originates between the fifth and sixth myomeres. A 7.1 mm SL postlarva has 12 pectoral fin rays (Fig. 3H), and 15 caudal fin rays. A few dorsal fin rays and spines are beginning to develop. Well developed melanophores are present on the head and side. The urostyle is upturned. A 10.2 mm SL juvenile (Figs. 3I, J) has its full complement of fin rays and spines. Pigmentation is well developed on the occiput, opercle, and along the base of the dorsal fins. The characteristic lateral blotches are apparent. A few scales are apparent on the caudal peduncle of a juvenile at 13.3 mm SL (Fig. 3K).

Egg and larval development for the closest relative to *E. perlongum*, *E. olmstedi*, is described and figured by Hardy (1978). Only yolk-sac larvae "from 5.1 mm to 5.8 mm TL" are figured, and no information is given for postlarvae. Hatching length for *E. olmstedi* is unknown. In comparison, the 4.9 mm SL prolarva of *E. perlongum* appears more advanced than the "5.1 mm TL" prolarva of *E. olmstedi*. The yolk sac of *E. perlongum* at this stage has largely been absorbed. Hardy's (1978) illustrated individual of *E. olmstedi* has a large yolk sac. The mouth of *E. perlongum* has begun to develop at 4.9 mm SL (Fig. 3F). *Etheostoma olmstedi* shows mouth

development beginning between "5.3 and 5.5 mm TL" (Hardy 1978). An *E. olmstedi* individual figured by Hardy (1978) shows 45 myomeres with 17 of these preanal. All larval stages of *E. perlongum* appear to have more pigmentation on the lateral body surface in comparison to *E. olmstedi* larvae figured by Hardy (1978).

Larvae and eggs of *E. fusiforme,* the only other darter found in Lake Waccamaw, are easily differentiated from *E. perlongum.* The eggs of *E. fusiforme* are smaller (0.94–1.18 mm diameter, Wang and Kernehan, 1979) than those of *E. perlongum* and are attached to aquatic vegetation rather than wood or other submerged cover. Preanal myomeres number 18 or more for *E. fusiforme* (Wang and Kernehan, 1979) as compared to 17 for *E. perlongum,* and the total number of myomeres are 40 or more for *E. fusiforme* (Wang and Kernehan, 1979) and 38 for *E. perlongum.*

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