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THE FECUNDITY AND REPRODUCTIVE SEASON OF *FUNDULUS SCIADICUS* IN NEBRASKA (ACTINOPTERYGII: FUNDULIDAE)

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The reproductive season of *Fundulus sciadicus* in Nebraska was investigated using preserved materials. Ovarian eggs matured in late March or early April. By mid-July all adult females were spent. Females with enlarged eggs were in their second, third, and fourth seasons of life. Eggs were classified on the basis of their morphology and the presence or absence of oil droplets and yolk. "Mature" eggs ranged in size from 1.6 to 2.0 mm in diameter. The largest ovarian complement (mature eggs only) was 88. Evidence of reabsorption (large eggs that have collapsed and have only small amounts of yolk) was seen in fish collected in June, July, and August, and suggests that clutch size is smaller than the ovarian complement in this species.

† † †

INTRODUCTION

The Plains Topminnow is a poorly-known species whose distribution is discontinuous over the Central Plains states. The distribution of *Fundulus sciadicus* is centered in Nebraska. According to Kaufmann and Lynch (1991), this species occurs across most of Nebraska throughout the Platte River system, the Loup River, Niobrara River, and the headwaters of the Republican River in lentic microhabitats (shallow quiet pools and backwaters) with dense submergent vegetation.

The geographic distribution of the Plains Topminnow has received much attention in the past, but little is known about the life history or reproductive biology of this species (Churchill and Over, 1938; Harlan and Speaker, 1956; Cross, 1967; Baxter and Simon, 1970; Miller and Robison, 1973; Cross and Collins, 1975; Pflieger, 1975; Lee, et al., 1980; Philips, et al., 1982; Stribley and Stasiak, 1982; Woodling, 1985). Brightly colored males can be found from early March until late summer (personal observations). Ellis (1914) reported gravid females in mid-July in Colorado. Mayer (1931) bred the species in captivity and noted egg deposition on aquatic vegetation with hatching in 8–10 days at approximately 21°C. Pflieger (1975) reported that spawning occurred in Missouri during May and June. Kaufmann and Lynch (1991) described the courtship behavior, egg deposition, and embryological development in laboratory settings.

MATERIALS AND METHODS

Specimens were collected using aquatic dipnets (25 cm diameter) and seines (2 mm mesh). Additional lots were obtained from the University of Nebraska State Museum. A total of 74 lots was examined from the following months: February (1), March (6), April (9), May (7), June (21), July (17), August (8), September (1), and October (4). Measurements of standard length (mm) were taken with a dial caliper under a stereoscopic dissecting-microscope. Age class was determined by scale-annuli counts with the use of a compound microscope. Females examined were in their second, third, and fourth seasons of life. Ovaries were dissected from females and placed in small petri-dishes. All dissections, gonadal examinations, classification, and measurements were conducted under a stereoscopic dissecting-microscope.

Ova were classified into four classes on the basis of their morphology and the presence or absence

of oil droplets and yolk (Fig. 1). Class 1 eggs were characterized by a well-defined light-yellow to orange-colored spherical yolk-mass with a cluster of oil droplets on the surface of the yolk and a translucent chorion free of oil droplets. In freshly preserved specimens, the yolk-mass was a faint yellow, whereas in older specimens, the yolk mass was dark-yellow to orange in color. This discoloration of the yolk is presumed to be an artifact of lengthy exposure in preservative. Class 2 eggs possessed a well-defined light-yellow to orange-colored spherical yolk mass but differ from Class 1 eggs by the distribution of oil droplets within the chorion and the absence of a concentration of oil droplets on the surface of the yolk. Class 3 eggs were light-yellow to orange in color but did not possess a well-defined spherical yolk-mass, oil droplets, or a translucent chorion. Class 4 eggs are immature ova and are opaque to pale-yellow in color, with no evidence of yolk, oil droplets, or chorion. The estimate of the fecundity and breeding season given here is based on museum specimens pooled for all years. Preserved material was insufficient to estimate the breeding season for any particular year. Thus, beginning in early March, 1991, collections were made once a week in order to document the onset of the breeding season.

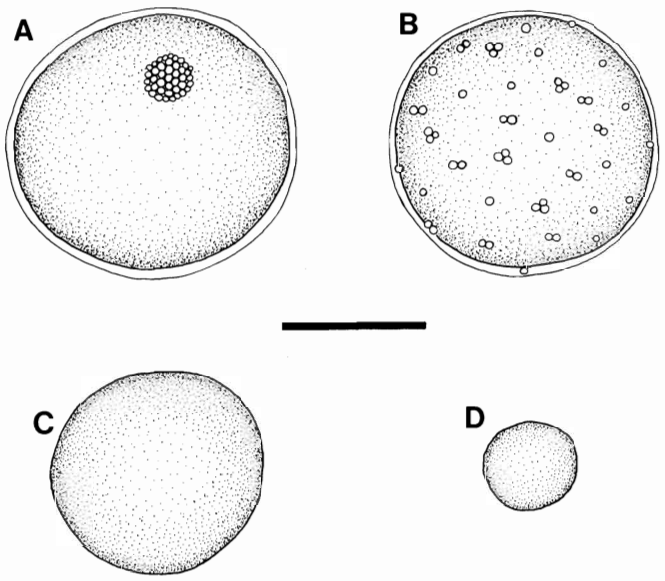

Figure 1. Schematic representation of modal ovarian and oviducal eggs of *Fundulus sciadicus*. (A) Class 1, (B) Class 2, (C) Class 3, and (D) Class 4. Scale equals 1 mm.

RESULTS

Most of the specimens studied were three- and four-year-old fish. The only two-year-old female measured 36.6 mm in standard length; three-year-old females were 35.5–50.8 (mean = 42.9, N = 33) mm in standard length; and four-year-old females were 44.7–57.9 (mean = 52.3, N = 17) mm in standard length. Standard length measurements of females are consistent with Stribley and Stasiak's (1982) larger samples from Keith County (two-year-old females averaged 47 mm in total length; three-year-old females averaged 53 mm in total length; and four-year-old females averaged 62 mm in total length).

Class 1 eggs ranged in size from 1.6 to 2.0 (mean = 1.8) mm in diameter; Class 2 eggs were 1.2–2.0 (mean = 1.6) mm in diameter; Class 3 eggs were 0.7–1.7 (mean = 1.2) mm in diameter. The largest Class 4 egg was 1.2 mm in diameter. The largest Class 4 eggs early in the season are usually 0.8–1.0 mm, but in late July and August they are 0.5–0.7 mm. Class 1 eggs were present in 37 lots. The maximum number of Class 1 eggs was 88 (mean = 22). Class 2 eggs were present in 32 lots. The maximum number of Class 2 eggs was 56 (mean = 20). Class 3 eggs were present in 38 lots. The maximum number of Class 3 eggs was 120 (mean = 50). Class 4 eggs were present in all 74 lots, but were not counted. Only the largest Class 4 egg of each female was measured.

The modal reproductive egg-class combinations are: all four classes and Class 4 only (Table 1). The other four combinations are seen by us as transitional. Immature eggs are always present. Collections made in spring 1991 suggest that egg classes are built-up sequentially. One female collected on June 20 contained only egg-classes 1, 2, and 4. Two individuals collected on July 20 contained only egg-classes 1, 3, and 4. Five individuals collected between June 4 and July 23 contained only egg classes 1 and 4; four of these females have a single Class 1 egg, and the other has three Class 1 eggs. Females from five lots collected between March 9 and March 24, 1991, contained egg-classes 3 and 4.

Gravid females were collected in 1979 in Brown, Garden, Chase, and Keith counties in late spring (April 22) and early summer (July 7). A female collected in Keith County on July 7 had only immature ova (Class 4 eggs). Collections in 1987 from Cherry, Holt, Keya Paha, Knox, and Pierce counties contained gravid females in early to mid-May and June; females with only Class 4 eggs (and no Class

1, 2, or 3 eggs) were seen as early as June 23 (one female collected on June 18 was found with a single mature egg at the opening of the vent), and on June 24 and July 9. Collections in 1988 in early June (2 and 14) from Keith and Chase counties and in late June (27-29) from Polk and Lincoln counties contained gravid females, but two females from Lincoln County on June 27 showed no evidence of Class 1, 2, or 3 eggs (only Class 4 ova). In addition, another female with a single mature egg was collected on June 29. Collections in 1991 on March 24 from Keith County contained gravid females with all four egg classes. Water temperatures in algae in the backwater habitats where the fish were collected, and in midstream, were 19°C and 20°C, respectively. Collections on March 24 in Wheeler County contained only non-gravid females with only Class 3 and 4 eggs. Water temperature at the site of the collection was 15°C. Collections from eastern Nebraska after March 24 contained gravid females with all four egg classes present.

Evidence of egg regression (larger eggs that have collapsed and have little or no yolk) was seen in females collected in June (27), July (4, 20, and 23), and August (3, 6, 9, 12, and 16). This suggests that the clutch size is smaller than the ovarian complement.

DISCUSSION

Based on the comparison of "wild-caught" eggs deposited in filamentous algae in late May (Kaufmann and Lynch, 1991) and eggs laid by captive females in the laboratory, we suspect that Class 1 eggs are mature eggs ready for deposition in algae in lentic habitats where *Fundulus sciadicus* is found. Gravid females with "mature" eggs (Class 1) were seen as early as late March. The latest date on which "mature" eggs were seen in the ovaries of females was July 23. By the end of July, however, all females contained only small ova (Class 4 eggs) in their ovaries, and only Class 4 eggs were present in females collected in the months of August, September, October, and February. Wild-caught embryos found in algal mats collected on May 22 (Kaufmann and Lynch, 1991) provide the earliest evidence of reproduction in Nebraska. Kaufmann and Lynch (1991) collected wild-caught embryos attached to algal mats on May 22 and June 14. Embryos collected on May 22 were in water 18°C and those from June were at 25°C.

Kaufmann and Lynch (1991) found this fish to breed in aquaria at temperatures of 18–22°C. Adult females in the laboratory exhibited retention of large "mature" eggs after breeding for one month. Some of those eggs retained appeared to be in regression (Kaufmann and Lynch, 1991). They suspected that at temperatures much above 22°C, egg deposition ceased and regression of eggs in the ovaries occurred. Although large numbers of "mature" eggs were observed in many museum specimens, we suspect that a single female probably produces 30–50 eggs per year for each of her three reproductive years, but it is unknown if a female releases all her eggs in the wild. Several females collected in late June, July, and August showed evidence of egg regression. These females possessed large eggs, on the order of Class 1 and 2 in diameter, that were collapsed and had little or no yolk. Evidence of egg regression in preserved specimens and captive specimens suggests that females of this species do not lay their entire clutch in a single season and reabsorb eggs retained in the ovaries after the breeding season has ended. The presence of only Class 4 eggs after July 23 indicates that reproduction ceases in mid-July and reproduction is not reinitiated once breeding stops.

Based on specimens pooled for all years and the evidence of spawning in the wild in late May, the reproductive season of *Fundulus sciadicus* appears to be short and is probably controlled by water temperatures. The onset of reproductive potential (presence of Class 1 eggs) in this species in Nebraska occurs in late March, with the termination of

Table I. Distribution of egg-class combinations in females.

Egg class	Number of lots	Dates
Collections between 1977 and 1990		
1+2+3+4	24	22 Apr – 14 Jul
1+2+4	1	20 Jun
1+3+4	2	20 Jul
1+4	3	4 Jun – 23 Jul
4	23	23 Jun – 16 Aug
4	7	30 Sep – 1 Apr
Collections in 1991		
1+2+3+4	7	24 Mar – 4 May
3+4	5	9 Mar – 24 Mar

the breeding season in late July. Pflieger (1975) noted spawning occurs in May and June in Missouri. Ellis (1914) reported females containing "large and well-formed eggs" on July 19 from Julesburg, Colorado. Because Missouri is 300 km south of Nebraska, one would expect the onset of the breeding season to occur earlier in Missouri. It appears that a three-week shift occurs between Missouri and Nebraska in the onset and termination of the breeding season, but in both states the breeding season is around 60 days. Based on the relatively few specimens examined, no seasonal lag in the onset of the breeding season seems to occur in Nebraska in any given year except for the collections made on March 24, 1991, in Keith and Wheeler counties (Table I). The number of specimens available was not sufficient to detect any one- or two-week difference between localities in the southeastern and northwestern portions of the State. Differences in the timing of the breeding season were seen between years (the season appeared to end earlier in 1987 than in 1985), but for all years combined, the breeding season of *Fundulus sciadicus* is approximately 60 days in Nebraska.

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