Length-specific brood size and winter parturition in pink seaperch (*Zalembius rosaceus*) (Perciformes: Embiotocidae)

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The viviparous pink seaperch (*Zalembius rosaceus*) is considered unusual among other embiotocids because of its deep-water habitat (Tarp, 1952), winter parturition (Goldberg and Ticknor, 1977), small brood size (Baltz, 1984), and apparent lack of a positive relationship between brood size and female size (Baltz, 1984). In the present study, I present further support that parturition in pink seaperch occurs in winter and new evidence indicating length-specific brood sizes in the species.

Pink seaperch are found in deep water (to 229 m: Miller and Lea, 1972) over soft bottom (Allen, 1982) year-round off the coasts of California and Baja California (Eschmeyer et al., 1983). Mating occurs in spring and parturition occurs in winter (Goldberg and Ticknor, 1977)—a unique breeding schedule among surfperches. Other surfperches mate in summer or fall and give birth the following spring or summer when food for offspring is plentiful. For reasons that remain unclear, brood size for pink seaperch is considered low (mean=3.5: Goldberg and Ticknor, 1977) compared to other small-size (<160 mm) surfperches (reviewed in Baltz, 1984).

A positive relationship between brood size and female size is generally the rule among fishes (Bagenal, 1978) and is observed in all surfperches with the exception of pink seaperch (Baltz, 1984). However, data for the species are dubious because near-term females tend to abort their young during the time of collection (Baltz and Knight, 1983; Baltz, 1984)—a behavior that can result in both underestimates in brood sizes and high variability in length-specific brood size.

The goal of this study was to evaluate characteristics of the reproductive biology of pink seaperch using samples taken during periods both early and late in the breeding season. I predicted that estimates in length-specific brood size for females collected later in the season should be significantly smaller than those collected earlier if, in fact, near-term females have a high probability of aborting embryos. Similarly, I expected to see higher variability in relationships between length-specific brood size and female size in the late, compared to early, period of the breeding season.

Materials and methods

Specimens of female pink seaperch were collected with a 7.6-m (headrope) otter trawl with 1.3-cm codend mesh on the Palos Verdes shelf near Point Fermin, CA (33°41′N, 118°19′W) in fall (September and October, at 54 and 60 m depth, respectively) 1994 and in winter (January, at 66 m depth) 1995. Females were distinguished from males by having either a rounded belly or by lacking a fleshy reproductive organ on the anterior portion of the anal fin (Tarp, 1952). Gravid females collected in winter were stored separately in sealable bags to ensure that any embryos subsequently born were included in brood size records; females collected in fall had no evidence of premature births nor were there any premature embryos present in fall collections (see Results section). Individuals were placed on ice, frozen, and processed within 10 days. Females were dissected and the following information was recorded: standard length (SL ±1 mm), body mass (±1 g), brood size, embryo SL (±1 mm), embryo mass (±0.01 g), and evidence of premature birthing. From the appearance of females that had evidently expelled their broods while in storage bags, I recorded a female as having prematurely given birth if her ovary was devoid of embryos, flaccid, and contained traces of fresh blood. The relationships between female and brood size for fall and winter were analyzed separately by using regression analyses (SPSS, vers. 10, SPSS, Inc., Chicago, IL). Females showing evidence of recent expulsion were not included in brood size analyses.

Results

The size distribution of females captured varied between seasons (Fig. 1). The mean standard length (SL) of females in fall and winter was 125 mm (±15 mm SD, n=27) and 96 mm (±21 mm SD, n=76), respectively, and this difference was significant (t-test: t=6.82, df=101, P<0.001). All females greater than or equal to 100 mm SL (n_{fall}=26, n_{winter}=31) were sexually mature, having either embryos or evidence of recent expulsion of embryos. Among the mature females, the mean SL in fall and winter was 127 mm (±14 mm SD, n=26) and 117 mm (±9 mm SD, n=31), respectively, and this difference was also significant (t-test: t=3.19, df=55, P=0.002).

Both mean brood size and the relationship between female size and brood size varied between seasons (Fig. 2A). Mean brood sizes in fall and winter were seven (±3 SD) and three (±1 SD), respectively, and this

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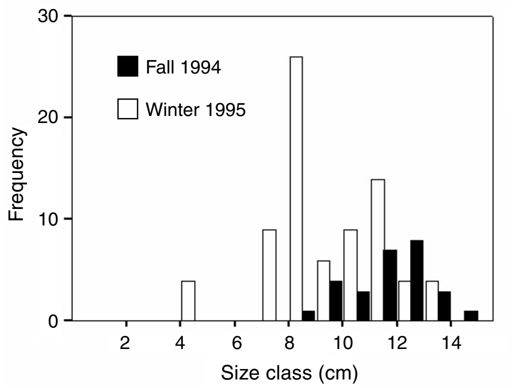

Figure 1

Size distribution for mature female pink seaperch (*Zalembius rosaceus*) (n=103) collected in fall 1994 (black bars) and winter 1995 (white bars). Bars represent 1-cm size classes.

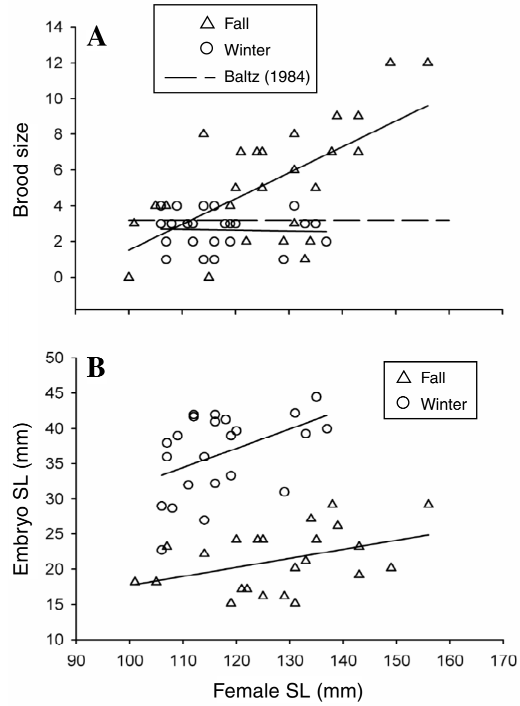

Figure 2

Linear regressions of (**A**) brood size (fall: r^2=0.39, brood size=−12.9 + 0.14x, n=26; winter: r^2= 0.00, n=31), and (**B**) embryo size (fall: r^2=0.17, embryo SL=4.9 + 0.13x; winter: r^2=0.20, embryo SL=4.2 + 0.28x) on female size for fall (triangles) and winter (circles) collections of pink seaperch (*Zalembius rosaceus*). Dashed line in A represents data from Baltz (1984).

difference was significant (t-test: t=5.15, df=55, P<0.001). The incidence of premature births for winter females was 18% (seven of 38 females) compared to 0% (0 of 27 females) for fall females, and differed significantly (Fisher's exact test: P=0.04). Female size was a good predictor of brood size in fall but not in winter (fall: r^2=0.39; winter: r^2=0.00, Fig. 2A).

Embryos were more developed and larger in winter than fall, and larger females brooded larger-sized embryos (Fig. 2B). Fall embryos had a mean SL of 21.3 mm (±4.2 mm SD) and were characterized by pale pink coloration, translucent tissue, and the absence of distinct scales. Winter embryos had a mean SL of 36.4 mm (±5.8 mm SD) and had firm and opaque tissue, distinct scales, iridescent pink coloration, and appeared as miniature adults. In both fall and winter, linear regressions of embryo-on-female size were significant (fall: r^2=0.17; winter: r^2=0.20, Fig. 2B).

Discussion

Both embryo characteristics and female reproductive condition provided evidence of winter parturition in pink seaperch and confirmed conclusions made by Goldberg and Ticknor (1977). Winter embryos had advanced morphological characteristics similar to those of adults, compared to embryos examined in fall, and were similar in size to those reported by Goldberg and Ticknor (1977). Evidence of a relatively high incidence of abortion and presence of many embryos (n=51) in winter collections provided further evidence that parturition occurs in or around January. Winter parturition is unique among surfperches yet no studies, to the author's knowledge, have provided an explanation for the unusual breeding schedule of pink seaperch.

Results from this study demonstrate a positive relationship between brood size and female size in pink seaperch, contrary to results of previous reports. Brood size increased with female size in fall but not in winter (Fig. 2A) in this study. The lack of a relationship observed in winter was similar to previous conclusions (See Fig. 2 in Baltz, 1984). Baltz and others (Goldberg and Ticknor, 1977; Baltz and Knight, 1983) speculated that sample effects may have explained the lack of a relationship between brood size and female body size, but no clear evidence was provided. In the present study, there was a high incidence of females (18%) that had aborted all embryos (i.e., complete abortion) among winter collections, and these females were excluded from analyses. However, partial abortions may occur in embiotocids (Schultz, 1993) presenting the possibility of underestimating brood size. Females with partially aborted broods were not identified nor excluded from the present study. Therefore, if such behavior occurred among large winter females, it would provide a reasonable explanation for the lack of relationship observed between brood size and female size.

Winter females had larger brood sizes than their fall counterparts and a higher frequency of abortion, providing evidence that winter females had partial rather than complete broods. Individuals smaller than the mesh size of the net were present in winter collections, probably aborted by females stressed during capture. The number of embryos (n=51) present in the winter collections was higher than would be expected if they had been aborted by females having shown evidence of complete abortions (n=7). Therefore, pink seaperch have length-specific brood sizes as observed in other surfperches, and this finding is supported by the more reliable fall data from the present study.

Mean brood size for pink seaperch in the present study was higher than previously reported for the species. Goldberg and Ticknor (1977) reported that females had an average brood size of 3.5, which was similar to mean brood sizes obtained for winter collections in this study; however, according to arguments already presented, winter data likely resulted in an underestimation of brood size. Both mean and maximum fall brood sizes (max=10) were greater than winter brood sizes and greater than the brood size in samples examined in Goldberg and Ticknor's (1977) study. If brood size estimates in the Goldberg and Ticknor (1977) study included females collected in winter, the authors probably underestimated brood size, as well. The mean brood size of pink seaperch is similar to that of other deep water fishes (Koslow et al., 2000) but is considered relatively small compared to other embiotocids (reviewed in Baltz, 1984).

An unexpected result from the present study was evidence that large female pink seaperch have an earlier breeding schedule than small females. Reproductively active females in fall were larger on average than winter females (Fig. 1), indicating that large females left breeding sites earlier or that small females arrived at breeding sites later. Although greater temporal resolution of changes in size distribution would have been desirable, further evidence for size-dependent breeding was apparent from female- and embryo-size relations. In both fall and winter, embryos in large females were larger than embryos in small females (Fig. 2B), which would be expected if the reproductively active females in fall bred earlier than those in winter. An alternative explanation for the positive relationship between female size and embryo size would be that embryos in large females develop faster than those in small females because of greater maternal investment. I did not have sufficient data on embryo development because this was not the focus of my study; however, it is a hypothesis that warrants further investigation. Delayed breeding by smaller females of pink seaperch is a pattern observed in other surfperches (Eigenmann and Ulrey, 1894; Hubbs, 1921; Schultz, et al., 1991) and may arise from both energetic limitations on the time of reproduction and fitness advantages accrued by postponing reproduction and diverting additional energy towards growth (Schultz, et al., 1991).

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