The Reproductive Biology of Baitfish Species in Bermuda

La Biología Reproductiva de las Especies de Carnada en las Bermudas

Biologie de la Reproduction des Espèces de Poissons-appâts aux Bermudes

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EXTENDED ABSTRACT

Small bony fishes are important ecologically, forming a key link in coastal food webs and providing food for larger fishes and waterbirds. These species are also known as baitfishes because they are exploited by both commercial and recreational fishers for use as bait. In Bermuda, baitfishes include five clupeoid species: the endemic Bermuda anchovy, *Anchoa choerostoma*; Dwarf herring, *Jenkinsia lamprotaenia*; Redear herring, *Harengula humeralis*; Round sardinella, *Sardinella* aurita; and Threadfin herring, *Opisthonema oglinum*. There is also one atherinid species, the Reef silverside, *Hypoatherina harringtonensis*. Baitfishes aggregate seasonally in multispecies shoals in shallow coastal waters, where they are targeted by fishers. However, despite their ecological and economic importance, the life history characteristics of these species are poorly understood.

Bermuda's location at 32.3°N means that coastal waters experience seasonal fluctuations in temperature (Coates et al. 2013), and most fish species for which data are available reproduce during the warmer summer months (Smith et al. 2013). However, it should be noted that these data are generally from larger reef fish species of commercial importance. The Bermuda anchovy, Dwarf herring and Reef silverside attain maximum sizes of less than 10 cm Total Length (TL), which might be expected to influence their reproductive strategies. The Redear herring, Round Sardinella and Threadfin herring attain maximum sizes of 20 – 30 cm TL. This study aimed to describe the annual reproductive cycle for these species, as well as female size-at-maturity and fecundity, with a view to informing management.

Cast net sampling took place at least weekly over two years, at various locations around Bermuda. The gonads in these small species deteriorate rapidly, so, unless it was possible to dissect fish within 30 minutes, they were preserved whole immediately in 10% formalin for later dissection. Fishes were weighed and measured, and extracted ovaries that were in good condition were weighed separately, allowing calculation of the Gonado-Somatic Index (GSI) for those individuals. Using a dissecting microscope, gonads were classified visually according to the standardized stages in Brown-Peterson et al. (2011), with 585 specimens processed for histology using standard staining techniques for verification. To estimate batch fecundity for each species, 20 ovaries from females that appeared to be in active spawning condition (where available) were evaluated for oocyte diameter under a dissecting microscope. Where a distinct size class of hydrating or late maturation oocytes could be observed, these were enumerated, and a mean diameter calculated based on a sample of 20.

Female Bermuda anchovy were mature from 48 mm total length (TL), and immature individuals larger than 60 mm TL were rare. This species exhibits some sexual size dimorphism, with the mean size of females (60.93 mm) being 3.85 mm, or 6.7%, larger than that of mature males (57.08 mm). The largest male measured was 75 mm TL, yet samples included females up to 82 mm TL. Spawning capable females were found year round. The numbers of actively spawning individuals were greatest between March and July, as were the GSI values. Actively spawning individuals were found around the full moon, and occasionally around the new moon.

Female Dwarf herring were mature from 37 mm TL and the largest individual sampled was a female of 77 mm TL. Larger individuals were predominantly female, and the mean size of mature females (51.24 mm) was 3.95 mm, or 8.4%, larger than that of mature males (47.29 mm). For this species, fish in active spawning condition were found year round. Mean monthly GSI values were highest between January and June, but only dipped below 3 in August. However, ovaries examined in the late fall / early winter appeared to have fewer oocytes compared to samples from the first half of the year, and some reproductively inactive individuals were found in December. Dwarf herring are partial spawners, and appear to spawn every six weeks around the full or new moon.

As members of the Atheriniformes, Reef silversides have a single gonad, in contrast to typical paired ovaries or testes. The gonads of this species deteriorate extremely rapidly on capture, resulting in low numbers of samples of sufficient quality for histological processing. The smallest mature females were 48 mm TL, but immature individuals were found as large as 54 mm. Fish at the upper end of the size range were predominantly female, and the largest individual sampled was a female of 71 mm TL, but there was little difference between the mean sizes of mature males and females. Reef silversides that were confirmed as actively spawning by histological analysis were found from February through May and also in August and September, but large gaps in the data preclude an accurate assessment of how activity patterns vary through the year. Further, the gonad appears to regress to such an extent in October and November that it is not visible even in large individuals under magnification, which bears further investigation. Reef silversides are partial spawners, and appear to spawn very small batches of eggs every two weeks, around the new and full moon, when they are reproductively active. However, additional data on this species are clearly needed.

In all of these species, the mean size of hydrating eggs (0.5 - 1.0 mm diameter) is large relative to the size of the ovary (typically 1 - 1.5 cm long) (Figure 1) and of the individual fish. Batch fecundity is thus limited by size in these small species, although female-biased sexual size dimorphism helps to maximize spawning capacity, and even moderate increases in fish total length (1 - 2 cm) can result in a doubling of batch size (Figure 1). Importantly, while the spawning season for most fishes in Bermuda is constrained to the late spring / early summer, spawning in these small species occurs over an extended season, or even year round, to compensate for the small batch sizes.

Female Redear herring were mature from 111 mm TL and the largest individual sampled was a female of 201 mm TL, but individuals larger than 150 mm were uncommon in samples. Combined visual, GSI and histology data detected spawning capable and actively spawning fish from February through July. Small juveniles were observed from June through October, with the largest pulse between July and August. Larger juveniles and immature subadults were common during the fall and winter.

Threadfin herring and Round sardinella were much less abundant than the other species, and unfortunately these species remain data deficient. Small juveniles were found primarily between late May and August, suggesting late spring / early summer spawning. Males with vascularized testes were found in July but no reproductively active females were found. However, there is data to indicate that these species do not spawn in the winter months, when they are most abundant near shore, because the GSI values for females sampled at that time were all less than 1.

For fisheries managers, one of the primary applications of understanding the annual spawning cycles of fishes is to determine if and when a seasonal fishery closure could be used as an effective management tool. Although reproductive activity in baitfishes generally appears to peak in the late spring /early summer, there is a degree of variability in the reproductive cycles of these species, despite their superficially similar life history strategies. Further, given the low batch fecundity and extended spawning seasons or year-round spawning observed in the smaller baitfish species, a short seasonal closure of the fishery for them might not actually help much. It must also be recognized that bait fishing is a seasonal activity that precedes or co-occurs with primary fishing effort and, in Bermuda, the late spring and early summer months are the time when most bait fishing occurs (Pitt and Welch, in press). The data from this study will inform management of these ecologically and economically important species going forward, but that process is likely to be complex.

KEYWORDS: Baitfish, Clupeiformes, Atheriniformes, reproduction, Bermuda

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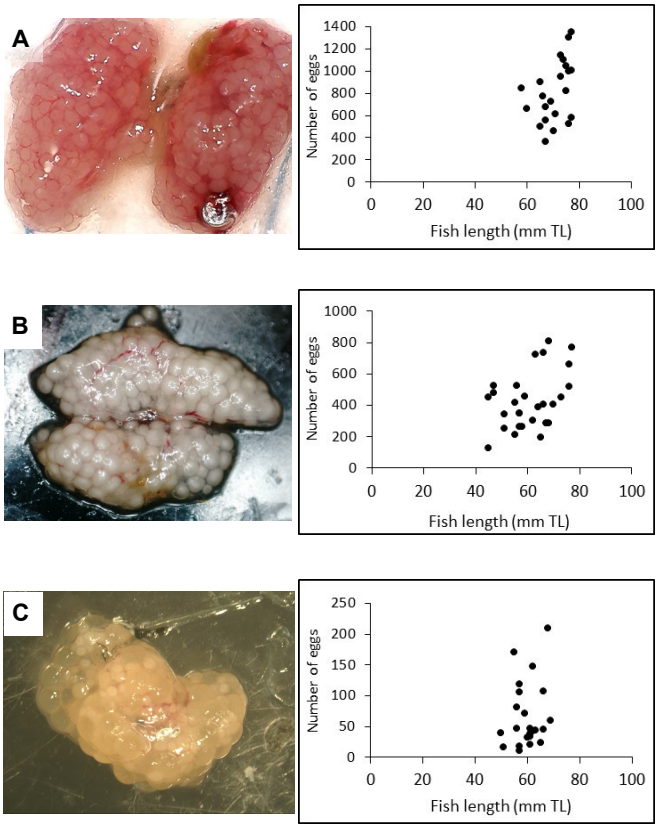

Figure 1. Photomicrographs of ripe ovaries and graphs showing changes in estimated batch fecundity with size for A) *Anchoa choerostoma,* B) *Jenkinsia lamprotaenia* and C) *Hypoatherina harringtonensis*.