



THE BEHAVIOUR REPRODUCTIVE OF THE ANCHOA JANUARIA (ACTINOPTERYGII, ENGRAULIDAE) IN A TROPICAL BAY IN SOUTHEASTERN BRAZIL

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INTRODUCTION

The anchovy *Anchoa januaria* (Steindachner) is a small pelagic fish widely distributed in embayment areas of the South East Brazilian coast. At present, there is little information on the reproductive ecology of this species and it is believed that it occurs in less saline water of the bays, migrating to lower rivers reaches to spawn (Esper, 1982). The present work describes behaviour reproductive and the sex ratio of *A. januaria* in Sepetiba Bay. The following questions were asked: 1) Is there sexual segregation during part of the life cycle? 2) If so, is such segregation caused by reproductive behaviour?

MATERIALS AND METHODS

Sepetiba Bay is a sedimentary embayment (22° 54'-23° 04'S; 43°34'-44° 10'W). Fishes were collected between September 1998 and August 1999. Four sandy beaches: Pedra de Guaratiba, Sepetiba, Coroa Grande and Muriqui and 2 lower river sites: São Francisco channel and Guarda river were sampled. For each fish, measurements (0.05 mm) of total length (LT) and total body mass (0.01g). ANCOVA was used to compare the sexes for a given trait, after controlling for a body size. The LT was used as the covariate (body size) in the analyses. Bonferroni correction was applied to the analyses. A chi-square test was performed to test for sex ratio differences by sites and by size classes. Gonads of 269 individuals were removed and weighed and sex was determined. The gonadosomatic index (GSI) was determined. Ovaries of 198 individuals (91 in beaches and 107 in rivers) were classified: immature, mature, ripe and spent. The degree of stomach fullness was estimated visually, considering four categories: empty, full, half-full and full. The repletion index was determined.

RESULTS

A total of 713 anchovies were examined (389 females, 293 males and 31 unidentified). Size ranged from 32.1 to 80.2 mm total length (LT) for females, and from 32.1 to 76.9 mm LT for males. Differences in size structure of the populations between the two types of habitat (beaches versus river sites) were found. Individuals sizes from river sites ranged from 60 to 80.2 mm at São Francisco channel and from 60.1 to 69.0 mm LT at Guarda river and comprised only adults. At the beach sites, sizes ranged from 32.1 to 80.1 mm LT, consisting of both juveniles and adults; the lowest size variability was recorded at Coroa Grande (45.2 - 61.29 LT) where most fishes were juveniles, while the largest size variability occurred at Sepetiba (32.1-79.0 mm LT) where both juveniles and adults occurred. Sex ratio differed significantly ($P < 0.05$) between the two types of habitats, with a predominance of females at the beach sites Sepetiba (1.79 females : 1 male, $\chi^2 = 12.41$, $P < 0.05$), Coroa Grande (4.13 : 1, $\chi^2 = 15.24$, $P < 0.05$) and Muriqui (1.78 : 1, $\chi^2 = 8.68$, $P < 0.05$). The only exception was Pedra de Guaratiba where a non-significant male-biased sex ratio was found (1 : 1.07, $\chi^2 = 0.18$, $P < 0.05$). Considering all the beaches pooled, males outnumbered females in September (1: 2.36), and the reverse of this situation occurred in October (3.88 : 1), December (1.74 : 1) March (2.78 : 1) June (2.33 : 1) and August (2.33 : 1), with differences being highly significant ($P < 0.05$). At the river sites, fish were recorded in June and July only, and no significant differences in sex ratio were found ($P > 0.05$). In July, when all fishes were collected at Guarda river, the sex ratio was well balanced (1.05 : 1). Significant differences ($P < 0.05$) in sex ratios were found for individuals at sizes larger than 67 mm LT, with higher number of

females than males. The overall sex ratio for *A. januaria* in Sepetiba Bay (all sites pooled) was significantly female-biased (1.35 : 1). The Ripe females predominated in rivers (73.83%) and were scarce at beaches (4.4%) where most fishes were immature, mature or spent. The gonadosomatic index (GSI) showed seasonal variations for both males and females, peaking in winter and with decreased values in summer. Significant differences were found for both male and female GSI's between rivers and beaches ($F_{1,265} = 19.14$, $P < 0.000$) with higher values in the rivers, between sexes ($F_{1,265} = 19.37$, $P < 0.000$) and with higher values for females, and between seasons ($F_{3,265} = 78.03$, $P < 0.000$). This trend suggests that spawning takes place in the river because GSI declines from spring, when fish are captured only at beach sites. Fishes with empty or less than half-full stomachs predominated in the rivers (11.9% and 54.76%, respectively). On the other hand, most fishes at beach sites were half-full (45.1%) or full (35.3%). The repletion index averages differed significantly (t -test = 2.69, $P < 0.05$) between the two type of habitats, showing higher values for beaches.

DISCUSSION

According to Nikolsky (1969) larger numbers of females occur in sites with plenty of food. *Anchoa januaria* feeds mainly on zooplankton (Sergipense & Sazima, 1995) and use Sepetiba Bay beaches as feeding areas (Silva *et al.*, 2004), where there is plenty of organic matter brought by tributaries, favouring zooplankton production. Therefore, a female-biased sex ratio in the beaches could be attributed to food availability and high reproductive investment. Spatial changes in the *A. januaria* sex ratio in Sepetiba Bay seem to be related to population behaviour with movements between feeding areas (beaches), where there is a female-biased population, and reproduction areas (rivers) where the population shows a balanced sex ratio (1 : 1). Fishes with a low amount of food (empty and < half-full) predominated at river sites while those showing half-full and full stomachs were common at beach sites. Furthermore, repletion indexes were significantly higher at the beach sites confirming the use of the beaches in the bay as feeding areas. Most ripe females and the highest GSI values were recorded in specimens captured in river sites only during the winter, the probable spawning season for this species. In the remaining seasons this species occurred only at beach sites where only 4.4% of all females were

ripe. These findings did not agree with those from Southern Brazil, where spawning is reported to occur in spring (Esper, 1982). Esper (1982) found this species performing regular seasonal movements into rivers to spawn, using the bay areas during sexual inactivity and reaching first maturity at 65 mm LT. All fishes recorded in river reaches were adults (LT > 60 mm), probably in the process of spawning. According to Aka *et al.* (2004) the regional fluctuation of sex ratio for populations of *Engraulis encrasicolus* (Linnaeus) in Turkish seas is related to their physiological state. They found that males were predominant in the spawning period, whereas females dominated in the inactivity period of the reproductive cycle. Overall, there is no agreement on which sex dominates at a given physiological state, but some relationship between physiological state and sex ratio seems to exist.

CONCLUSION

The well-balanced sex ratio for *A. januaria* at the river sites suggests that this could represent the maximum reproductive yield for this population in the Sepetiba Bay.

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