SEX RATIO AND SIZE STRUCTURE OF *Micropogonias furnieri* (DESMAREST, 1823) (PERCIFORMES, SCIAENIDAE) IN SEPETIBA BAY, RIO DE JANEIRO, BRAZIL

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ABSTRACT

Sex ratio and size structure constitute basic information in assessing reproductive potential and estimating stock size in fish populations. One hundred fifty-one individuals of *Micropogonias furnieri* caught by experimental otter trawls, in three zones (inner, central, and outer) of Sepetiba Bay between October 1998 and September 1999 were examined. Males outnumbered females (1.3:1.0) in all zones but no significant differences were detected. Only in the outer zone (5.0:1.0) were male/female rates significantly different according to the chi-square test. No temporal differences were observed in sex ratio. Fish size ranged from 81 to 244 mm total length (TL) with significant differences in 155 to 185 mm TL size classes, where males predominated, and a slightly higher number of females were observed for the smaller size class (TL = 95-150 mm). Size distribution varied according to the zone, with juveniles predominating in the inner and adults in the outer zone. Spatial difference in size structure observed in this study indicates that the inner bay is a rearing ground during the first life-cycle period, and movement toward the sea occurs as fish increase in size.

Key words: sex ratio, size structure, Sciaenidae, coastal fishes, bay, Sepetiba Bay.

RESUMO

Proporção sexual e estrutura de tamanho da corvina *Micropogonias furnieri* (Desmarest, 1823) (Perciformes, Sciaenidae) na Baía de Sepetiba, RJ

A proporção sexual e a estrutura de tamanho são informações básicas para avaliação do potencial reprodutivo e para estimativa do tamanho do estoque das populações de peixes. Foram utilizados 151 indivíduos de *Micropogonias furnieri*, capturados em arrastos de fundo padronizados, nas zonas interna, central e externa da Baía de Sepetiba, entre outubro de 1998 e setembro de 1999. A proporção entre machos e fêmeas para toda a Baía foi de 1,3:1,0, não apresentando diferença significativa. Somente a zona externa (5,0:1,0) apresentou maior número de machos que o de fêmeas de acordo com o teste χ^2. Não se observou um padrão temporal de diferenciação na proporção sexual ao longo do ano. A população variou de 81 a 244 mm de comprimento total (CT) com diferença significativa entre os sexos apenas entre 155 e 185 mm de CT onde os machos predominaram. Observou-se gradativo aumento do tamanho dos peixes da zona interna para a externa. A diferenciação da estrutura de tamanho apresentada indica o uso da zona mais interna da baía como área de criação das corvinas nas primeiras fases de vida e um padrão de deslocamento para fora da baía à medida que estes peixes vão crescendo.

Palavras-chave: proporção sexual, estrutura de tamanho, Sciaenidae, peixes costeiros, baías, Baía de Sepetiba.

INTRODUCTION

The white croaker *Micropogonias furnieri* is one of the most important fishery resources in southeast Brazil, being abundant in artisanal catches in semi-closed areas such as bays and estuaries. It presents demersal habits and is widely distributed in the Western Atlantic, from the Caribbean to the Argentinian coast (Menezes & Figueiredo, 1980), inhabiting sandy and muddy bottoms of up to 60 m depth on the continental shelf (Godoy, 1987). Despite its importance to fisheries, little is known of the ecology of this species, particulary concerning sex ratio and size structure. Departure from 1:1 sex ratio is not expected for most fish species, although some fish populations may present a strong bias in this ratio. Such differences may be attributed to various causes, namely temperature influences on sex determination (Conover & Kynard, 1981), selective mortality by sex through differential predation (Schultz, 1996), and differentiated sexual behavior, growth rate, or longevity expectation (Schultz, 1996).

Sex ratio and size structure constitute information basic in assessing reproductive potential and estimating stock size populations (Vazzoler, 1996). Most studies available on this subject were done in temperate zones (Oliveira & McCleave, 2000; Aburto-Oropeza *et al.*, 2000). This study aims to determine sex ratio and size structure of the white croaker (*Micropogonias furnieri*) in Sepetiba Bay, in order to test the null hypothesis that no sex difference exists among size groups and bay zones, in the ontogenetic development of this species.

MATERIAL AND METHODS

Sepetiba Bay (22°54'-23°04'S and 43°34'-44°10'W), is located in Rio de Janeiro State, southeast Brazil, with a 520 km^2 area housing a wide range of habitats including mangroves, sandbanks, and small estuarine areas (Fig. 1). Depth overall is below 5 m, and waters are rich in organic nutrients from continental drainage; bottom is predominantly muddy (Barbiéri & Kronemberger, 1994). The bay plays an important role in regional aquatic ecology, mainly for juvenile fishes that use the area as a rearing ground.

Using an otter trawl, monthly fish samplings were performed from October 1998 to September 1999, in three zones in Sepetiba Bay (inner, middle, and outer) (Fig. 1). A 12 m long boat, provided with a net of 25 mesh size in the 8 m long wings, and 12 mm mesh size at the cod end, was used. One hundred fifty-one individuals of the white croaker *Micropogonias furnieri* were caught and identified according to Menezes & Figueiredo (1980). Sex was determined macroscopically by gonad observation after dissection; gonad stage was determined according to Vazzoler (1982).

Sex ratio was determined for all fish pooled and for each bay zone and month. Comparisons if sex ratio depared from the expected 1:1 rate were determined by Chi-square test at 95% significance level. Size structure was assessed by length frequency distribution in 12 size classes, with numerical fish abundance also compared by Chi-square test for each class. Principal component analysis and one-way analysis of variance ANOVA followed by an a posteriori Tukey test (Zar, 1984) were used for spatial and temporal assessing of fish distribution by size class.

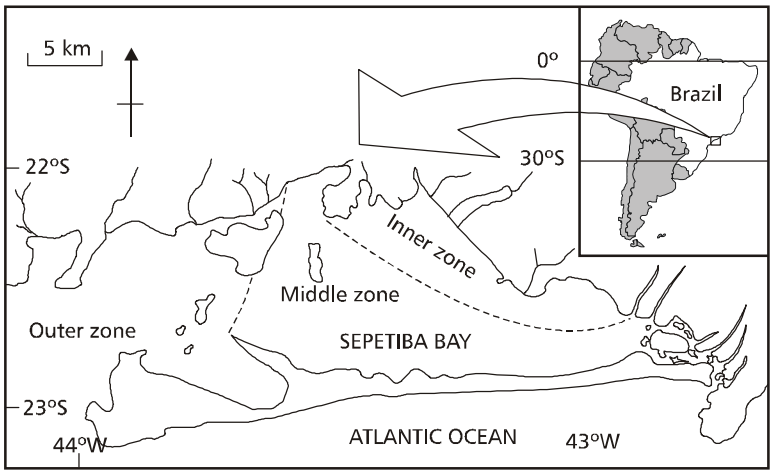

Fig. 1 — Study area; Sepetiba Bay, Rio de Janeiro, with indications of the three bay zones (inner, middle, and outer).

RESULTS

The sex ratio (male:female) for population distribution in the whole bay area was 1.3:1.0 and did not depart from the expected 1:1 rate (Table 1). A similar 1:1 sex ratio was found for inner and middle zones, but in the outer zone males outnumbered females (5.0:1.0) significantly according to χ^2 test (Table 1). Overall, there was no significant departure from the expected 1:1 sex ratio during the study months, but males were significantly ($p < 0.05$) more numerous than females in May and July. In August, males also outnumbered females but the examined fishes were numerically insufficient to permit a reliable conclusion (Fig. 2; Table 2).

Size structure ranged from 81 to 246 mm total length (TL) with significant difference in sex ratio which departed from (1:1) for fish measuring between 155 and 185 mm TL, within which range males outnumbered females. A nonsignificant trend with females outnumbering males was shown for the size class from 95 to 150 mm TL (Fig. 3; Table 3).

Fishes increase in size from the inner to the outer zone (Fig. 4). The inner zone is near recruitment grounds since only the inner bay beaches showed *M. furnieri* recruits; in this zone 45% of all fish presented 80 to 125 mm TL.

In the middle zone approximately 70% of all fish showed 125 to 170 mm TL, while in the outer zone, where individuals were of larger size, 20% of all fish showed 200 to 215 mm TL, and approximately 45% presented 110 to 155 mm TL (Table 4). Significant differences, detected by ANOVA, were found in fish abundance among size zones, with the inner zone presenting a higher number of fishes than the central and outer zones for class sizes from 80 to 125 mm TL, with the situation inverted for 185 to 200 mm TL.

TABLE 1

Chi-square (c^2) test for *M. furnieri* sex ratio comparisons by zones in Sepetiba Bay. Ef = expected frequency. * 95% level of significance.

Zones	Males	Females	Total	Ef	c^2
Inner	35	34	69	34.5	0.01
Middle	31	27	58	29.0	0.27
Outer	20	4	24	12.0	10.66*
Total	86	65	151	75.5	2.92

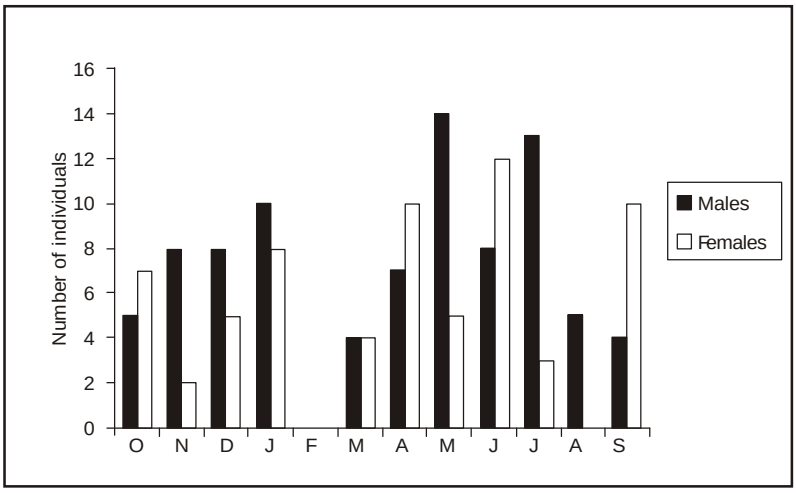

Fig. 2 — Temporal distribution of *M. furnieri* by sex in Sepetiba Bay.

TABLE 2

Chi-square (c^2) test for *M. furnieri* sex ratio comparisons by months in Sepetiba Bay. Ef = expected frequency. * 95% level of significance.

Months	Males	Females	Total	Ef	c^2
October	5	6	11	5.5	0.1
November	8	2	10	5.0	3.6
December	8	5	13	6.5	0.7
January	10	8	18	9.0	0.2
February	–	–	–	–	–
March	4	4	8	4.0	0.0
April	7	10	17	8.5	0.5
May	14	5	19	9.5	4.3 *
June	8	12	20	10.0	0.8
July	13	3	16	8.0	6.3 *
August	5	0	5	2.5	5.0 *
September	4	10	14	7.0	2.6
Total	86	65	151	75.5	2.9

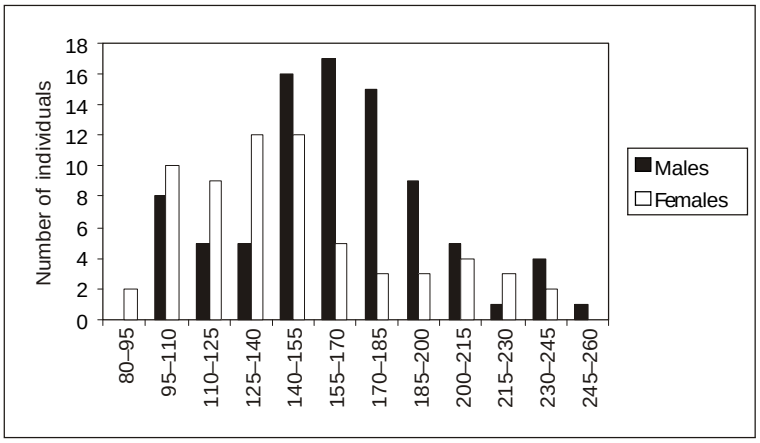

Fig. 3 — Size structure for *M. furnieri* in Sepetiba Bay.

Plots of samples scores from axis I and II performed by principal components analysis were performed, with samples labeled by zones and months to assess spatial and temporal pattern of size groups (Fig. 5). No indication of seasonality per size group was found, indicating a long spawning period extending over several months. On the other hand, a spatial pattern was shown with samples of the inner zone distributed in the upper part of the diagram, while the middle and outer zone samples were shown clustered next to the origin and in the lower part of the diagram. Component I comprised 22.7% of the total explained variance and showed a direct relationship with largest size groups, with high weight for individuals > 140 mm TL. Negatives weights for Component I were shown for smaller sized groups (TL < 140 mm). Component II comprised 21.8% of the explained variance, and showed high weight for the smallest sized groups (TL < 140 mm) and negative weights for highest sized groups (TL > 200 mm) (Table 5).

TABLE 3

Chi-square (c^2) test for *M. furnieri* sex ratio comparisons by size class in Sepetiba Bay. Ef = expected frequency. * $p < 0.05$

Size class	Males	Females	Total	Ef	c^2
80-95	0	2	2	1.0	2.0
95-110	8	10	18	9.0	0.2
110-125	5	9	14	7.0	1.1
125-140	5	12	17	8.5	2.9
140-155	16	12	28	14.0	0.6
155-170	17	5	22	11.0	6.5 *
170-185	15	3	18	9.0	8.0 *
185-200	9	3	12	6.0	3.0
200-215	5	4	9	4.5	0.1
215-230	1	3	4	2.0	1.0
230-245	4	2	6	3.0	0.7
245-260	1	0	1	0.5	1.0
Total	86	65	151	75.5	2.9

DISCUSSSION

The fish populations of *M. furnieri* in Sepetiba Bay presented a sex ratio of 1:1 (overall) but some departure from this equilibrium was recorded depending on bay zone or size class. When this trend is not followed, one should take in to account that some factor is modifying the equilibrium.

One highly likely factor to be analyzed is fish growth. Differentiation in growth rate between sexes can cause an unbalanced proportion since the sex presenting faster growth rate will go through the most vulnerable smaller size phase quickly and, therefore, diminish the predation proportion. On the other hand, the sex with slower growth rate will be more likely to undergo predation, with its abundance decreased disproportionately in next development phases. Additionally, if male size differed from that of females, the mean fish size for commercial fisheries would be displaced towards one direction resulting in differentiated captures of a determined sex and modifying the stock sexual composition (Nikolsky, 1963). Although aspects of growth rate were not investigated in this study, it is possible that *M. furnieri* males in Sepetiba Bay present a higher growth rate than females, since a slight male predominance in the largest size class and a nonsignificant trend towards female predominance in smaller size class occurred. Vazzoler (1991) reported that in the *M. furnieri* population I, distributed between latitude 23º-29º, which includes Sepetiba Bay, females present a faster growth rate than that of males, which is the opposite of that found in the present work. Growth rate by sex for *M. furnieri* has not been consistent, based on the conclusions found in several studies. For population II (distributed between latitude 29º-33º), Vazzoler (1991) reported that up to 2 years old males grow faster than females; afterwards this situation reverses.

A similar growth pattern rate was observed by Castello (1986) for the Patos Lagoon estuary. In northern Brazil, along Maranhão State coast, among *M. furnieri* of up to two years old no difference in growth rate was found between the sexes; after that, females showed faster growth (Juras, 1984). On the Ceará State coast, in northeastern Brazil, males showed faster growth than females throughout their life cycle (Rodrigues, 1968).

Another factor that could influence sex ratio is food availability. Nikolsky (1963) reported that when it is abundant, females predominate, with the situation inverting in regions where food is limited. Feeding activity, in this case, would be influencing metabolism through hormonal activity, resulting in changes in production of individuals of a given sex. Some research has reported that females require better environmental conditions than males, suffering in their development when environmental conditions deteriorate. Nikolsky (1963) cited the example of *Perca fluviatilis* which

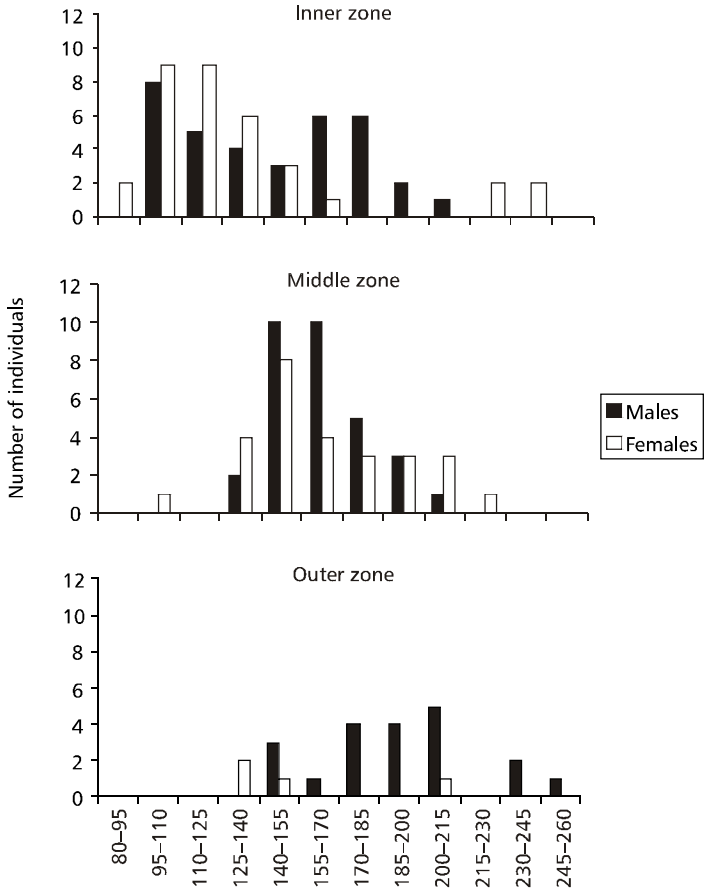

Fig. 4 — Size structure for *M. furnieri* by sex in three zones of Sepetiba Bay.

apparently under worsening feeding conditions, showed a high proportion of atrophied females which served as food for several faster growing individuals of the same species. In the case of Sepetiba Bay, the predominance of males in the outer zone and the slight trend towards female predominance in the inner zone virtually fit this theory, since in the inner zone of the bay presents much organic material from river and sewage channel drainage, favoring high food availability. As prevously seen, this could be suitable for greater female development. On the other hand, the outer zone, situated farthest from these organic influxes, show lesser food availability, a situation less favorable for females and resulting, therefore, in male predominance. Additionally, the population breeding habits should be taken into account. According to Fisher (1930 *apud* Edwards, 1998), if a shortage of either sex occurs in a given population, the progeny would re-program genetically to produce individuals of the nondominant sex until equilibrium is reached. This equilibrium would be associated with breeding behavior, with the number of males and females such that the maximum reproduction yield is made possible. For populations presenting monogamy as a breeding habit, this equilibrium would be reached at a 1:1 sex ratio. On the other hand, if the breeding habit is polygamous, this ratio could change to one adequate for the number of individuals involved in each reproduction period (Darwin, 1871 *apud* Edwards, 1998).

From this point on, the greater number of individuals of one sex represents no further imbalance, but the maximum reproductive yield of a given population. No seasonality in size structure population was observed over the studied period, indicating that different size fishes coexist in the same area year-round. The distribution pattern throughout the bay zones was detected by principal components analysis, which explained only 43.5% of it, suggesting that different size fishes occur throughout the three zones.

TABLE 4

F-values and significance from ANOVA and a posteriori Tukey test on fish abundance by size class and (%) of *M. furnieri* in each zone in Sepetiba Bay. * p < 0.05.

Size class (mm)	Inner zone (IZ)	Middle zone (MZ)	Outer zone (OZ)	Total	F-values	Tukey test
80-95	2.9	0	0	1.0	2.22*	IZ > MZ,OZ
95-110	24.7	1.8	0	8.8	3.09*	IZ > MZ,OZ
110-125	20.4	0	0	6.8	6.33*	IZ > MZ,OZ
125-140	14.5	10.6	25.0	16.7	1.63	ns
140-155	8.7	31.0	20.0	19.9	1.83	ns
155-170	10.0	23.6	2.5	12.0	1.72	ns
170-185	8.6	13.6	10.0	10.7	0.72	ns
185-200	2.8	10.4	10.0	7.8	2.16*	MZ,OZ > IZ
200-215	1.5	7.2	25.0	11.2		ns
215-230	2.9	1.9	0	1.6		ns
230-245	2.9	0	5.0	2.7		ns
245-260	0	0	2.5	0.8		ns
Total	100	100	100	100		

TABLE 5

Variables loads (multiplied by 3) on axes I and II from principal component analysis on abundance by size groups of *M. furnieri* in Sepetiba Bay.

Size class	Component I	Component II
0-80	–0.24	2.23
80-110	–0.44	1.90
110-140	–0.01	2.16
140-170	1.36	1.48
170-200	1.70	0.27
200-230	2.48	–0.19
230-260	1.99	–0.34
> 260	1.11	–0.25
Eigenvalues	1.81	1.75
Explained variance (%)	22.7	21.8

In spite of this, increasing size distribution occurs from the inner to the outer zone in Sepetiba Bay, as detected by principal component analysis and ANOVA. This latter analysis detected differences in fish abundance among the three zones; smaller size fish were more abundant in the inner zone when compared with the central and outer zones, although in other size groups no differences were found. Size structure differentiation in, with smaller fish concentrated in the inner bay and larger fishes concentrated in the outer part, indicate fish movement from the bay to the sea as fish grow to larger sizes. Araújo & Costa (2001), studying *M. furnieri* recruitment in Sepetiba Bay based on length-frequency distribution, concluded that this species uses the bay for recruitment and rearing, thus corroborating the findings of this study.

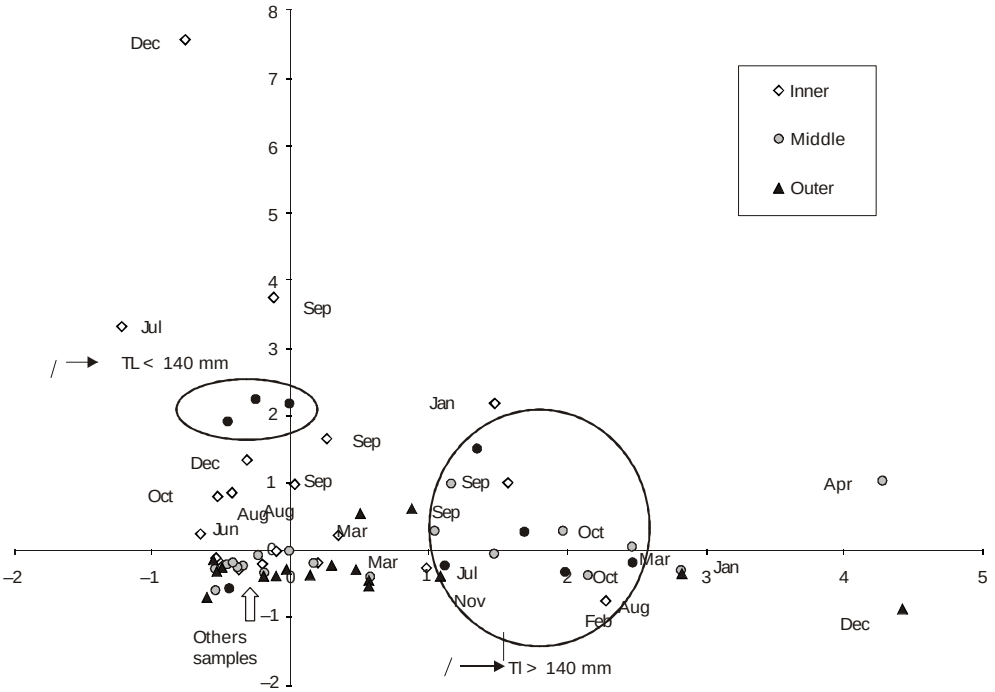

Fig. 5 — Diagram of ordination on samples scores of abundance of *M. furnieri* by size class from axes I and II, from principal component analysis, coded by months and sites in Sepetiba Bay.

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