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Reproductive biology of *Menticirrhus littoralis* in southern Brazil (Actinopterygii: Perciformes: Sciaenidae)

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Menticirrhus littoralis is an important sport and commercial fish species in southern Brazil. This paper aims to analyze the reproductive biology of the species in Rio Grande do Sul coastal waters. Captures were carried out at Cidreira's fishing pier (30º 08' S; 50º 11' W) located on the Northern Coast of Rio Grande do Sul, where sport-fishing takes place throughout the year. Sport fishermen using hook-and-line with different hook sizes and varied baits exclusively made the captures. A total of 807 individuals were obtained from June 1997 to May 1998. Sexual proportion was 0.67 female for each male (323 females and 484 males; χ^2_c = 32.120; DF=1; P<0.001). The smallest individual (total length) for captured animals was a male of 13 cm whereas the largest was a female of 46 cm. The minimum size (total length) for a mature female was 19.8 cm. The size at first maturation (L_{50}) was 23 cm and females larger than 27 cm spawned at least once (L_{100}). The reproductive period for *M. littoralis* is from September to March. Gonadosomatic index (GSI) showed a clear seasonal pattern. Mean ovarian weight was highest in November when it reached 5% of total body weight. Apparently, there is a size gradient for *M. littoralis* in the area. Larger individuals inhabit deeper water, and they move to the coast mainly for spawning.

Menticirrhus littoralis é uma espécie importante para a pesca esportiva e comercial no sul do Brasil. O presente trabalho objetiva estudar a biologia reprodutiva da espécie nas águas costeiras do Rio Grande do Sul. As capturas foram efetuadas na plataforma de pesca de Cidreira (30º 08' S; 50º 11' W), localizada na costa nordeste do Rio Grande do Sul, onde a pesca esportiva desenvolve-se ao longo de todo o ano. As capturas foram efetuadas exclusivamente por pescadores esportivos, utilizando linhas e anzóis de diferentes tamanhos e empregando iscas variadas. Um total de 807 indivíduos foi capturado entre junho de 1997 e maio 1998. A proporção sexual foi de 0,67 fêmea para cada macho (323 fêmeas e 484 machos; χ^2_c = 32,120; DF=1; P<0,001). O menor indivíduo capturado (comprimento total) foi um macho com 13 cm, enquanto que o maior foi uma fêmea com 46 cm. O menor tamanho (comprimento total) para uma fêmea madura foi 19,8 cm. O tamanho de primeira maturação (L_{50}) foi 23 cm e fêmeas maiores que 27 cm já reproduziram pelo menos uma vez (L_{100}). O período reprodutivo de *M. littoralis* é de setembro a março. O índice gonadossomático (GSI) apresenta uma clara tendência sazonal. O peso médio ovariano apresentou maiores valores em novembro, quando atingiu 5% do peso corporal. Aparentemente existe um gradiente de tamanho para *M. littoralis* na região, com indivíduos maiores ocorrendo em águas mais profundas e deslocando-se para águas mais rasas para desova.

Key words: Reproduction, Rio Grande do Sul, first maturation, gonadosomatic index.

Introduction

The genus *Menticirrhus* comprises 9 species and inhabits tropical and temperate waters of the Eastern Pacific and Western Atlantic. Two species are found in Brazilian waters: *M. americanus* and *M. littoralis* (Menezes & Figueiredo, 1980; Jardim, 1988).

Menticirrhus littoralis (Holbrook, 1860) presents a known distribution from Florida (USA) to southern Brazil. The species prefers shallow water with sandy or muddy bottoms (Menezes & Figueiredo, 1980). The reproductive biology of the species is still unknown, despite its abundance in coastal waters and surf zones (Lewis *et al.*, 1999). *M. littoralis* larvae are found in all seasons off the Paraná state coast, although they are more abundant during the spring (Godefroid *et al.*, 2001). In Rio Grande do Sul, larvae were captured in summer and fall (Ibagy & Sinque, 1995; Sinque & Muelbert, 1998). For comparison purposes, a summary of the available information on the spawning period and size at first maturation for *M. americanus* is given (Table 1).

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This study will describe the reproductive cycle and sex ratio of *M. littoralis* in the coastal waters of Rio Grande do Sul. The spawning period will be identified through the seasonal variation of the gonadosomatic index, condition factor and relative frequency of reproductive to non-reproductive females. Size at first maturation will be determined by the relative frequency of reproductive females to non-reproductive ones by size-class intervals.

Material and Methods

Samples were obtained from the Cidreira's fishing pier (30º 08' S; 50º 11' W) located on the Northern Coast of Rio Grande do Sul, where sport fishing is conducted throughout the whole year. A total of 807 individuals of *Menticirrhus littoralis* (323 females; 484 males) were caught from June 1997 to May 1998. A voucher specimen is deposited at the Museu de Ciências e Tecnologia, PUCRS: MCP 17269. Captures were exclusively made by sport fishermen using hook-and-line with hooks of different sizes (7.6 mm to 24.4 mm in width) and varied baits (mainly Annelida: cf. *Diopatra;* Mollusca: *Mesodesma mactroides;* Crustacea: *Emerita brasiliensis, Sergio mirim, Farfantepenaeus paulensis, Artemesia longinaris*).

Total lengths (snout to upper caudal fin) were taken to the nearest millimeter, using a measurement board. Fish weight was determined to the nearest 0.1g. Gonads and liver were removed and stored in 4% formalin. In laboratory, ovaries and livers were weighted to the nearest 0.01g. Ovarian maturity stages were determined macroscopically as follows: immature, developing, mature (fully developed, ripe and semi-spent), spent and resting (for a general description of each stage see Vizziano *et al.*, 2002).

Sexual proportion was estimated by month and by size classes, difference from 1:1 being tested using Chi-square. Size of first maturation was determined using the relative frequency of mature females by size classes, fitted trough a logistic function: $F = 1/(1+ e^{a-b.L})$ where F = reproductive (developing + mature + spent) female frequency by size class; L = middle point of the size class interval; *a* and *b* = parameters estimated by unconstrained non linear regression routine of SPSS 11.0 (Statistical Package for Social Sciences; loss function was sum of squared residuals; bootstrap estimates of standard errors). Size at first maturation (L_{50}), the length at witch 50% of individuals reproduce at least once, was determined as follow: $L_{50} = -a/b$.

Reproductive period was estimated through the monthly variation of the relative frequency of mature/spent females and gonadosomatic index (GSI). Monthly changes in the hepatosomatic index and condition factor (K) were also analyzed as clues of the energy budget during the reproductive cycle. GSI, HSI and K were calculated as follows: $GSI = (G_W/T_W).100$, where G_W = ovarian weight (grams), T_W = total weight (grams); $HSI = (L_w/T_w).100$, where L_w = liver weight (grams); $K = T_W/T_L^b.100$, where; T_L = total length (cm), *b* = slope of the weight-length relation (3.059, according to Braun, 2000).

Table 1. Information synthesis for the reproductive biology of *Menticirrhus americanus*. M – male; F – female.

Authors	Locality	Size at first maturation	Reproductive period
Giannini & Paiva-Filho, 1992	SP	14.0 cm	
Lunardon-Branco & Branco, 1993	PR		Fall, Winter and Spring
Harding & Chittenden, 1987	Gulf of Mexico	15 to 22 cm	Spring, Summer and Fall
Castillo, 1986	SP	17.5 cm	
Smith & Wenner, 1985	North Atlantic	13.5 cm(M) 19.0 cm (F)	Summer
Matsuura & Nakatani, 1979	SP		Summer

Results

Sexual proportion was 0.67 females for each male (323 females for 484 males; $\chi^2_c = 32.120$; DF=1; P<0.001). Males were dominant from 12 to 27 cm throughout the year (Table 2), except during the summer, when females were caught in a greater number, although without statistical significance. In the classes from 27 to 32 cm there were more than 2 females for each male during the winter, spring and autumn. During the summer this proportion increased to 9 females for each male. For lengths of over 37 cm, only females were caught.

Minimum size of a mature/spent female was 19.8 cm in total length. From 27 cm on almost all females were reproductive. The fit of a logistic function (Fig. 1) estimated the size at first reproduction (L_{50}) as 23 cm (a=12.3403; STE_a=2.6792; b=-0.5362; STE_b=0.1159).

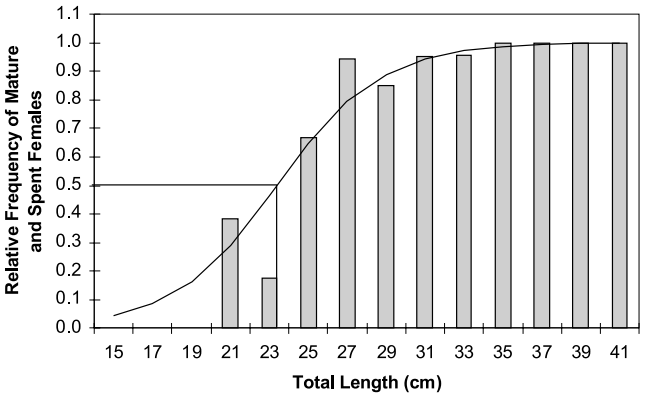

Fig. 1. Relative frequency of mature and spent females of *Menticirrhus littoralis* by size class. Animals captured at Cidreira's fishing pier, Rio Grande do Sul, Brazil, from June 1997 to May 1998.

The reproductive period for *Menticirrhus littoralis* is from September to March (Fig. 2, Table 3). The gonadosomatic index (GSI) (Fig. 3) showed a clear seasonal pattern, with the highest average of 5% in November. The hepatosomatic index (HSI), measured in males and females, showed a similar seasonal pattern, with the highest average of 1.3% also in November.

Seasonal variation of the condition factor (K) for females (Fig. 4) presents the lower value (0.715) in July, increasing from August and attaining a peak in October/November (0.763), falling markedly soon after. Males (Fig. 5) show a general pattern similar to females, although with minor variations during the reproductive period.

Monthly variation of the average length of all adult females (> 23cm) and mature females only (Fig. 6) shows a decreasing pattern from September to March. Comparing the average length of mature females with all adult females, it can be seen that mature females are larger both at the beginning and at the end of the reproductive period.

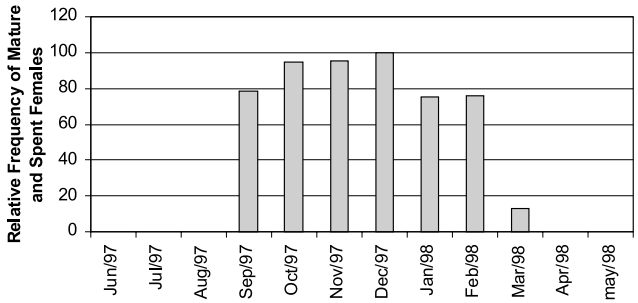

Fig. 2. Monthly relative frequency of mature and spent females of *Menticirrhus littoralis*. Animals captured at Cidreira's fishing pier, Rio Grande do Sul, Brazil, from June 1997 to May 1998.

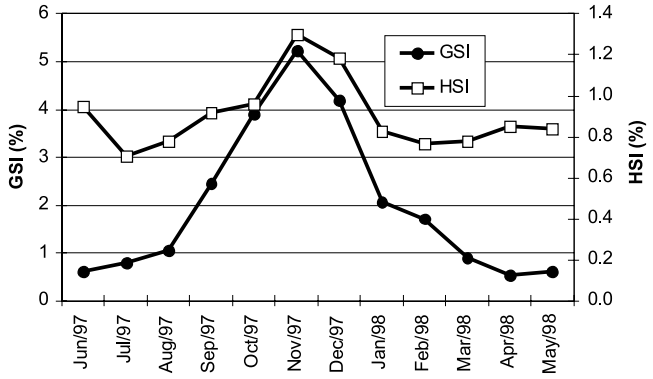

Fig. 3. Monthly average gonadosomatic index (GSI) of females and monthly average of hepatosomatic index of males and females of *Menticirrhus littoralis*. Animals captured at Cidreira's fishing pier, Rio Grande do Sul, Brazil, from June 1997 to May 1998.

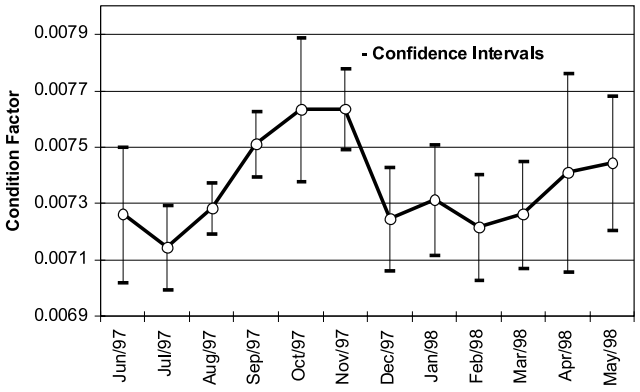

Fig. 4: Monthly average condition factor of females of *Menticirrhus littoralis*. Animals captured at Cidreira's fishing pier, Rio Grande do Sul, Brazil, from June 1997 to May 1998.

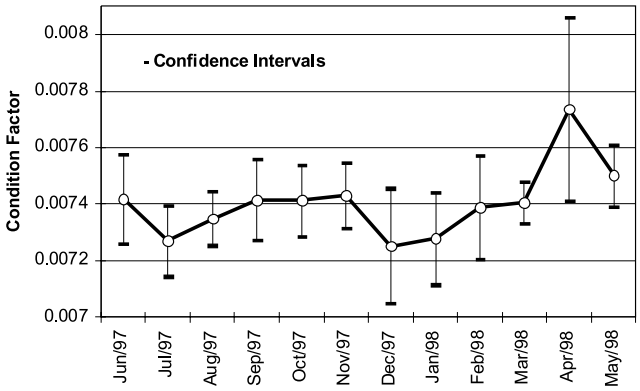

Fig. 5: Monthly average condition factor of males of *Menticirrhus littoralis*. Animals captured at Cidreira's fishing pier, Rio Grande do Sul, Brazil, from June 1997 to May 1998.

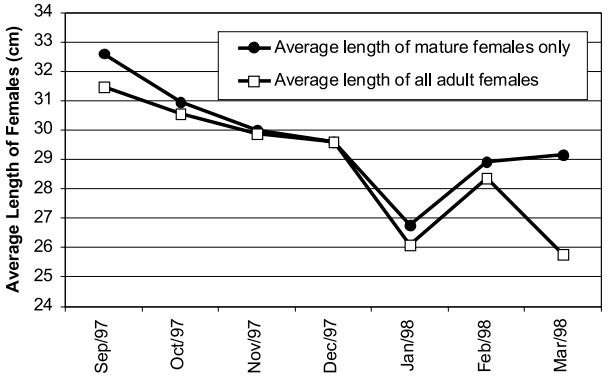

Fig. 6: Monthly average total length of adult females of *Menticirrhus littoralis*. Animals captured at Cidreira's fishing pier, Rio Grande do Sul, Brazil, from June 1997 to May 1998.

Table 2: Sex ratio of *Menticirrhus littoralis* for different size classes and seasons (* Significant at 0.05 level).

	Winter		Spring		Summer		Fall	
Class	F:M	X^2	F:M	X^2	F:M	X^2	F:M	X^2
12 |– 17	0.20	5.23*	0.00	4.00*	0.00	4.00*	0.25	1.80
17 |– 22	0.47	83.15*	0.46	7.74*	0.27	15.51*	0.28	15.68*
22 |– 27	0.21	91.16*	0.36	19.32*	1.10	0.10	0.24	30.49*
27 |– 32	2.33	41.10*	2.45	13.47*	9.50	13.76*	2.67	4.55*
32 |– 37	1.20	6.72*	25.00	22.15*	∞	8.00*	∞	2.00
37 |– 42	∞	1.00	∞	7.00*				
42 |– 47			∞	1.00				

Table 3: Number of *Menticirrhus littoralis* by gender and reproductive status captured each month (June 1997 to May 1998) at Cidreira's Pier, Rio Grande do Sul, Brazil. Seasons, as used in the present work, are defined as follows.

Season	Month	Total Males	Total Females	Adult Females	Developing Females	Mature Females	Spent Females	Resting Females
Winter	Jun 97	39	21	8	0	0	0	8
	Jul 97	48	19	7	0	0	0	7
	Aug 97	72	52	40	7	0	0	33
Spring	Sep 97	25	50	37	8	29	0	0
	Oct 97	43	25	18	1	17	0	0
	Nov 97	59	50	41	1	39	0	1
Summer	Dec 97	17	18	15	0	15	0	0
	Jan 98	23	19	12	0	9	1	02
	Feb 98	23	23	21	0	16	4	01
Fall	Mar 98	80	18	15	0	2	3	10
	Apr 98	15	11	7	0	0	0	7
	May 98	40	17	10	0	0	0	10
	Total	484	323	231	17	127	08	79

Discussion

The reproductive cycle of *M. littoralis* is evident since the relative frequency of mature/spent females and the gonadosomatic index follow a clear seasonal pattern. The gonadosomatic seasonal pattern is also corroborated by larvae abundance in coastal waters as reported by Ibagy & Sinque (1995) and Sinque & Muelbert (1998). Smith & Wenner (1985) observed that *M. americanus* reproductive period occurs in the spring and summer, attaining its maximum at the beginning of summer (June, North Atlantic), showing a relative similarity to our results. Differences in reproductive period peaks, spring for *M. littoralis* and early summer for *M. americanus*, may be due to lower water temperatures in the North Atlantic, not only causing a delay of reproductive activities but also a shortening of the reproductive cycle. In the Gulf of Mexico, due to higher temperatures, *M. americanus* reproductive period is longer, taking place from February through to November, as reported by Harding & Chittenden (1987).

The GSI of *M. littoralis* decrease from December to February, whereas mature females were caught in relatively greater numbers. Spent females were only caught at the end of the reproductive period: from January to March. In spite of the lack of histological studies or oocyte measurement, the absence of spent females just after the maturation peak (November) suggests that the species has partial spawning, in the same way as other sciaenids already studied in the South Atlantic.

The condition factor showed two periods of increase, one from July to November and the other from January to February. The combined increase of the condition factor, hepatosomatic index and gonadosomatic index from July to November indicates that feeding activities are the main energy source for ovarian maturation. From November, the decrease in the gonadosomatic index, when mature females are still frequent, indicating that the species is actively loosing energy as spent oocytes. At this point, as there is a common decrease in both the gonadosomatic and the hepatosomatic index, there is probably some kind of energy transference from the liver to the developing oocytes.

Lunardon (1990), considered the condition factor as a clue of the reproductive period for *M. littoralis* on the Paraná

coast, and reported high values of this parameter throughout warmer seasons and low values throughout cold ones. However, analyzing the figures presented by the author, increasing values can be observed during spring and decreasing values in December. In this paper, *M. littoralis* also showed this same pattern for both sexes. However, there is a second rise of the condition factor from December to May that was not observed on the Paraná coast, indicating that, at least for Rio Grande do Sul, there is a weight gain after the end of the reproductive period.

An interesting fact about the reproductive biology of *M. littoralis* is the female mean length decrease during the reproductive period (Fig. 6). The data suggests that the reproductive period starts with larger and older females, as observed by the fact that in September mature females are larger than the average total sizes (considering only females over the size at first maturation, 23 cm). The latter maturation of smaller females causes a fall in the average total length, as seen in Fig. 6. In December all captured females were reproductive, so there was no length difference between total and reproductive females. From December to March there is again an increasing difference favoring reproductive females over total females, a pattern that could suggest that larger animals have an extended spawning period.

As mentioned by Haimovici *et al.* (1996) and Lewis *et al.* (1999) for *Micropogonias furnieri*, a distribution pattern related to water depth could be present in *M. littoralis*, larger individuals being found in deeper water and coming to coast for spawning. This hypothesis is supported by the fact that the sexual proportion is more propitious for males for most of the year (Table 2). At the beginning of the reproductive period (September), not only is the female total length higher but there is also an inversion in sexual proportion, favoring females two to one, an indicator of reproductive migration.

Size at first maturation (L_{50}) for *M. americanus* on the coast of São Paulo was 17.5 cm (Castillo, 1986). Smith & Wenner (1985) found L_{50} to be 19.2 cm in the North Atlantic and Harding & Chittenden (1987) found individuals attaining sexual maturity ranging from 15 to 22 cm in the Gulf of Mexico. It is possible that first maturation in *M. littoralis* is delayed when compared to *M. americanus*, besides the average temperature difference in the available data, a fact that could interfere strongly with the reproductive timing even among fish of the same species (Nikolsky, 1963).

The age at first maturation of sciaenids in Rio Grande do Sul are reported by Haimovici (1997). White mouth croaker *Micropogonias furnieri* and the South American striped weakfish *Cynoscion striatus* mature at three years. Argentine croaker *Umbrina canosai* mature at two years and king weakfish *Macrodon ancylodon* at one or two years. Different values are presented by Lizama & Vazzoler (1993), proposing five to seven years as the age of first maturation of *M. furnieri*, two to three for *U. canosai* and two to four for *M. ancylodon*. With 23 cm of total length, females of *M. littoralis* have two growth rings on the scales (Braun, 2000) although the age of the animals is still unknown. So on, *M. littoralis* shows a maturation age compatible to other species of the family, as listed by Haimovici (1997), if scale rings are annual and formed during the first year of life.

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