

Biology of *Chirocentrodon bleekermanus* (Poey, 1867) (Clupeiformes: Pristigasteridae) in a Continental Shelf Region of Southern Brazil

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ABSTRACT

This study provides information on the biology of C. bleekermanus from Paraná State coast, Brazil, assembling data about its abundance, size structure, diet and reproduction. Monthly collections were accomplished in 1999 and 2000 in the internal continental shelf, with trawl net. The catch-per-unit-effort did not vary significantly among the seasons. In the summer, the individuals were larger, followed by autumn, spring and winter. C. bleekermanus was predominantly planktivorous and the most frequent items in its diet were copepods followed by diatomaceous algae. Seasonal variation in the frequency values of the gonad maturation stages, gonadosomatic index and gonadal condition factor indicated that the reproductive period encompassed spring and summer. The mean total length at first maturity of females was estimated to be 76 mm.

Key words: Abundance, Brazil, *Chirocentrodon*, Clupeiforms, feeding, reproduction

INTRODUCTION

In a survey carried out by Chaves et al. (2001) it was observed that in the region of the internal continental shelf of Paraná State during the years 1999 to 2000, *Chirocentrodon bleekermanus* was one of the most abundant species (16.5% in number and 4.5% in biomass). This species is also common in the region of Paranaguá Bay and the adjacent beaches of Shangri-lá and Leste, and areas that are further away from the coast (close to the Currais islands) (Corrêa, 1987).

With the exception of the genus *Ilisha*, the individuals of which reach 70 cm in length, the

family Pristigasteridae is made up of small sized fish, and consequently show little economic value as fishing resources (Whitehead, 1985; Cérignon et al., 1992). The Pristigasteridae form schools and inhabit coastal waters, commonly entering bays and estuaries (Figueiredo and Menezes, 1978; Whitehead, 1985). It is known that they represent a wide portion of the diet of many pelagic species of commercial importance, as well as birds and marine mammals (Crawford et al., 1992; Friedlander and Beets, 1997). *C. bleekermanus* reaches 12 cm in total length, has a silverish stripe on its side, distributed range from Panama to off Rio Grande do Sul State, Brazil (Figueiredo and

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Menezes, 1978), and is found at depths of up to 40 m (Cérvigon et al., 1992).

In spite of the extensive literature on taxonomy, fishing and biology regarding the Clupeiformes (Whitehead, 1985), many genera are still not very well known, mainly the tropical and subtropical ones (Blaber et al., 1998), as is the case of *Chirocentrodon*. This study aims to supply data about abundance, size structure, feeding and reproduction of *C. bleekermanus* in a region of the internal continental shelf of southern Brazil.

MATERIAL AND METHODS

The study area is located on the Paraná coast, South of Brazil (25°45'S;48°20'W). Its climate is humid subtropical; the mean temperature oscillating from 17°C in the coldest month to 24°C in the warmest month (Bigarella, 1978). The water, however, usually shows lower temperatures, due to the influence of sub-Antarctic currents, rich in nutrients (Brandini, 1990).

The collections were carried out monthly, between March 1999 and January 2000 (except in September), at depths of 10 and 15 meters, using trawl net (mesh size 20 mm). Three bottom-trawls of 10 minutes each were used at each depth, totalizing six trawls per month, always in the morning. Individuals from an area close to the experimental collections were acquired in the fish market of Guaratuba, in January 2002, in order to obtain additional material for the accomplishment of the study on the length at first maturity.

The fishes were identified, counted and measured for total length (LT) and total weight (WT). Stomachs were removed and preserved in 4% formaline for content identification. The sex and maturation stage were recognized macroscopically according to the Vazzoler (1996) scale, and gonads were weighed (WG).

The monthly catch-per-unit-effort was calculated, in number of individuals - CPUE_n and in biomass - CPUE_g, being the unit effort the trawl time, in minutes. The data were log transformed and the mean values compared among seasons (spring: October, November and December, and so forth). For evaluating the seasonal differences, the tests of analysis of variance (one-way ANOVA) with $\alpha=0.05$ and Tukey-Kramer were used. Barlett's test was used to verify data homocedasticity.

Seasonal distribution in size of the individuals was evaluated using the non-parametric statistical test of Kolmogorov-Smirnov, with $\alpha=0.05$.

The diet was characterized based on the stomach content, using the Frequency of Occurrence (F.O.) method of Hynes (1950). To evaluate the similarities in the diet throughout the seasons, a cluster analysis was made based on a similarity matrix, built with the use of the Jaccard coefficient. To evaluate differences in F.O. of the main food items between young and adults, the χ^2 test of independence was used, with $\alpha=0.05$, where all the individuals that had gonads in stages B - in maturation or C - mature, were considered to be adults.

To detect seasonal differences in the sex ratio, the test χ^2 of independence was used, with $\alpha=0.05$. As the amount of males obtained was small, the indicators of spawning periods and size of first maturation were only calculated for females. Seasonal averages of: Gonadosomatic Index, $GSI=WG/WT \times 100$ (i); Gonadal Condition Factor (ii), $\Delta K=WG/LT^b$, being "b" the angular coefficient of length/weight relationship; and seasonal frequency of gonadal maturation stages (iii) were calculated (Vazzoler, 1996). The χ^2 test of independence was used, with $\alpha=0.05$, to estimate the frequencies of gonadal maturation stages dependence according to season. The reproductive period was estimated by analyzing the mean seasonal variation of the values of (i), (ii) and (iii). The length at first maturity was determined through the curve that relates the mean point of the TL classes to the relative frequency of the adult individuals (with gonads from the B stage). For the adjustment of this curve, the following equation was used:

$Fr=1-e^{-aL_i \exp b}$; where: Fr= relative frequency of adult females, e= base of the neperian logarithm, a and b= coefficients linear and angular of length/weight relationship and L_i = medium point of the total length classes.

RESULTS

The largest values of CPUE_n and CPUE_g were detected in the spring, while the smallest ones occurred in the summer (Fig. 1). However, in terms of mean values, there were no significant differences between seasons either in number of individuals ($F=0.95$; $DF=3$; $p>0.05$), or in biomass ($F=0.68$; $DF=3$; $p>0.05$).

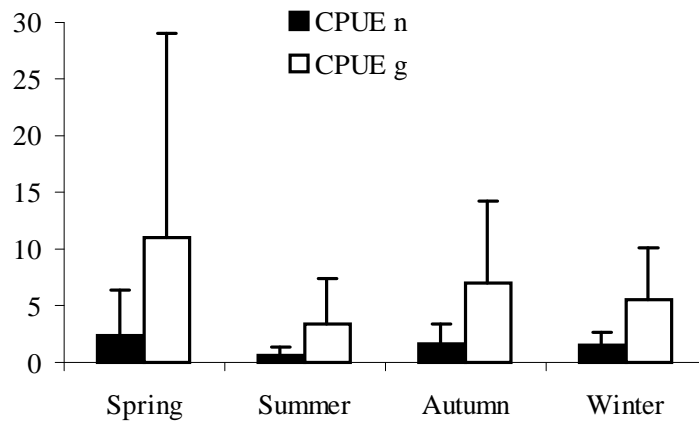


Figure 1 - Catch-per-unit-effort in number of individuals (CPUE_n) and in biomass (CPUE_g) (average + confidence interval) of *C. bleekermanus* in a continental shelf region of Paraná State.

The non-parametric test of Kolmogorov-Smirnov showed that size distributions were different among seasons: there were larger individuals in summer, followed by autumn, spring and winter (Fig. 2). In spring, most of the captured individuals belonged to the intermediary length classes (80-99 mm) and in summer, to intermediary and large length classes (85-109 mm) (Fig. 2). In autumn and winter most of the captured individuals belonged to the small and intermediary length classes (70-99 mm) (Fig. 2).

Copepoda, followed by Diatomacea algae, were the more frequent food items in the diet of the species, followed by fish, Amphipoda, Crustacea larvae, non-Brachyura Decapoda and Mysidacea. Except for the former, these items occurred in all the seasons (Table 1). Three items reached the largest frequency values: Copepoda throughout the year, fish in summer and autumn, and Diatomacea algae in autumn (Table 1). The diet of the individuals collected in spring, winter and autumn presented a similarity of 85.7%, whilst that of the individuals collected in spring and winter had a similarity of 100%. Between summer and the other seasons, the similarity was of 52% (Fig. 3).

The occurrence frequency of the non-identified Crustacea and Copepoda items was significantly

larger in the young individuals than in adults; on the other hand, the F.O. of the fish item was significantly larger in the adult individuals (Fig. 4).

With the exception of autumn, significant differences in the sex ratio occurred in all other seasons, being that in spring and summer a larger proportion of females was observed and in winter the opposite occurred (Fig. 5). The frequencies of gonadal maturation stages were dependent on the season ($\chi^2=94.01$; DF=6; $p<0.05$). Mature individuals (stage C) occurred with a larger frequency in spring and summer and immature individuals (stage A) occurred with a larger frequency in autumn and winter (Fig. 6). In the present study, individuals with emptied gonads were not found.

Both the GSI and the ΔK presented larger values in spring and in summer (Fig. 7 and 8).

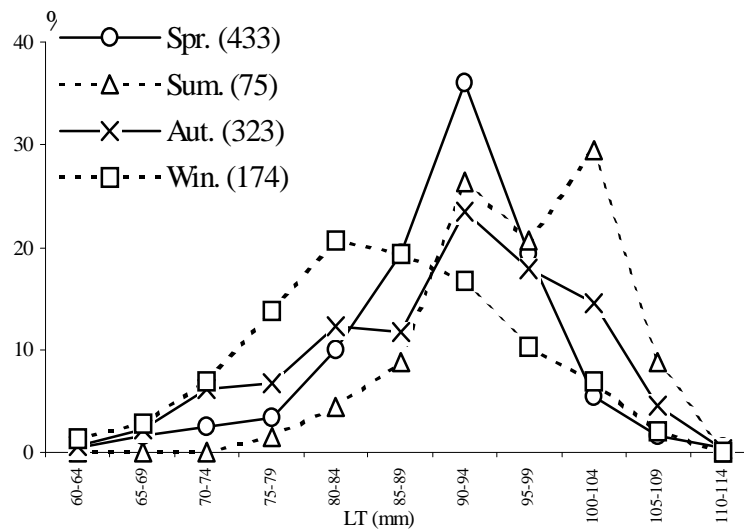


Figure 2 - Distribution of the total length classes of *C. bleekermanus* in the study area in each season. Brackets: number of caught individuals.

Table 1 - Occurrence Frequency (in percentage) of present items in the stomach content of *C. bleekermanus* grouped by season. n = number of analyzed stomachs. Beside the main items are the abbreviations that will be used posteriorly.

Stomach contents	Spring	Summer	Autumn	Winter
	n = 91 LT(mm) 75-114	n = 14 (LTmm) 86-109	n = 162 (LTmm) 60-107	n = 166 (LTmm) 60-105
Mysidacea (Mys.)	11.6	0	2.52	2.42
Copepoda (Cop.)	65.3	21.4	29.6	84.9
Amphipoda (Amp.)	10.5	0	4.40	6.06
Decapoda Brachyura	2.11	0	0	0
Non-Brachyura	4.21	14.3	3.77	2.42
Decapoda (Dec.)				
Cirripedia	0	0	0	0.61
Unidentified	7.37	0	0	1.21
Crustacea Larvae (Lar.)				
Non-identified	26.3	35.7	37.7	24.9
Crustacea (N.I.C.)				
Fish (Fish)	3.16	28.6	25.8	2.42
Eggs	0	0	1.26	0.61
Diatomacea (Dia.)	10.5	0	20.8	12.1
Others algae	0	0	0	0.61
Digenia	0	0	1.89	0
Nematoda	0	0	0	1.82
Sand	5.26	0	3.77	2.42
Non-identified items	94.7	100.0	92.5	59.4

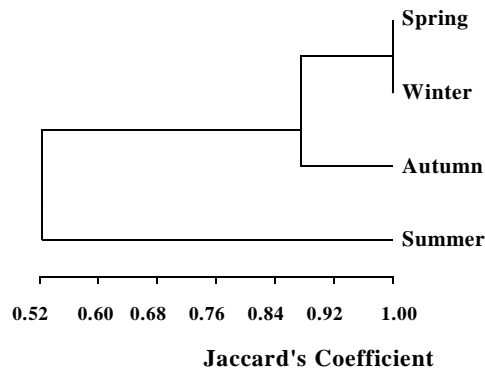


Figure 3 - Similarity in the diet of *C. bleekermanus* among seasons.

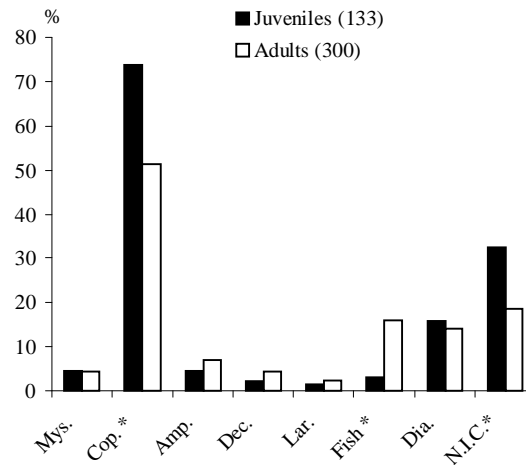


Figure 4 - Occurrence frequency of the main food items found in the stomachs of *C. bleekermanus* juveniles and adults. For abbreviations see table 1 (Number of analyzed stomachs). * $p < 0.05$ (χ^2).

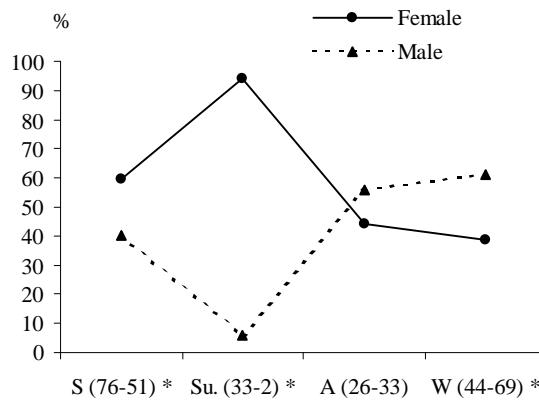


Figure 5 - Seasonal variation in the sex ratio of *C. bleekermanus*. Brackets: number of females and males, respectively, in each season. * $p < 0.05$ (χ^2).

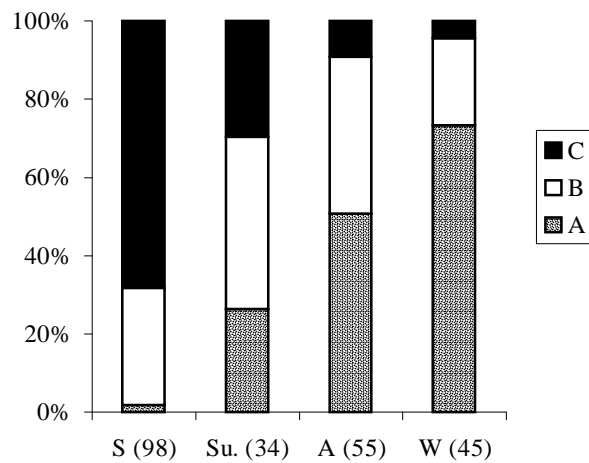


Figure 6 - Seasonal frequency of female gonadal maturation stages of *C. bleekermanus*. In brackets: number of females in each season.

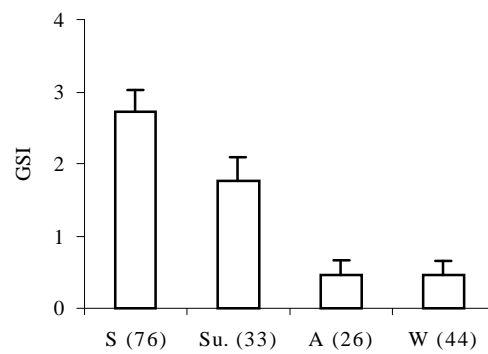


Figure 7 - Variation in the females gonassomatic index (average + confidence interval) of *C. bleekermanus*. In brackets: number of females in each season.

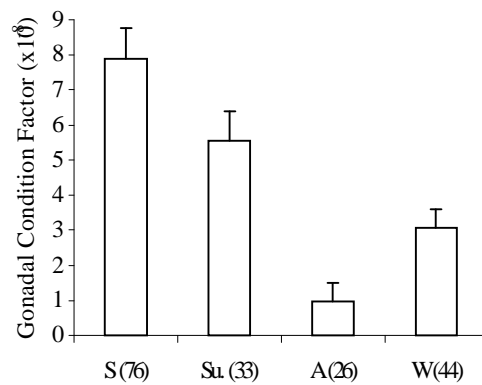


Figure 8 - Variation in the females gonadal condition factor (average + confidence interval) of *C. bleekermanus*. In brackets: number of females in each season.

Based on the frequencies of gonadal maturation stages, GSI and ΔK , the reproductive period of the species in that region can be estimated to extend from spring to summer. The length at first maturity (L_{50}) estimated for the females, was 76 mm. The mathematical equation of the linear transformation of the maturation curve is $Y=5.81X - 25.77$ ($n=364$; $R^2=0.80$), being the curve of first maturation adjusted by the equation $Fr = 1 - e^{-10.76 \text{ Lt}^{5.81}}$.

DISCUSSION

The Clupeiformes are pelagic fish, therefore, it would be unlikely that large numbers would be captured using bottom-trawl nets. However, there are records of abundant occurrence of *Chirocentrodon bleekermanus* in other regions with similar fishing modalities (Manickchand-Heileman and Julien-Flus, 1990). In the internal continental shelf of Paraná State, the high capture of this species is possibly being favored by low depth of the area, an adverse condition for a stratified distribution.

The largest capture in the study area occurred in spring and the smallest in summer. Other studies (Maravelias and Reid, 1995; Power et al., 2000; Corten, 2001) stated that in certain regions, Clupeiformes were more abundant during periods of high temperatures. Nevertheless, in the internal continental shelf of Paraná State, the smallest capture values occurred in summer. As the decrease in capture coincides with the progress of gonadal maturation, the low numbers could suggest a probable migration of the species from the area in order to spawn elsewhere.

With regard to the distribution of size classes, the capture of bigger individuals in summer could be associated to the largest concentration of adults close to spawning. This has been reported for another Clupeiformes in Mexico (García-Abad et al., 1998) and in Chile (Cubillos et al., 2001).

Based on the items found in the stomach content of *C. bleekermanus*, the species could be classified as predominantly planktivorous, which is common amongst Clupeiformes (James, 1988). Seasonal changes in the diet are generally a consequence of the actual availability of food (Zavala-Camin, 1996).

The values of the Jaccard coefficient indicated high similarity in the diet of *C. bleekermanus*

between autumn, winter and spring. However, the coefficient was qualitative, which meant that it only evaluates the presence and absence of food items in common between the seasons, without considering the relative abundance of the items in the stomach content.

A variation of the food items according to size was observed and, whereas copepods were significantly more frequent in the diet of juveniles, fishes were significantly more frequent in the diet of adults. Changes in the diet relative to size are common in fish, being that the main change is in the actual size of the items eaten, which may or may not influence a change in the nature of the food (Zavala-Camin, 1996). Changes in the diet according to size have been related to ontogenetic changes that occur in the digestive tract of the fish (Kaiser and Hughes, 1993).

C. bleekermanus presented a larger proportion of females in the spring in relation to males, a fact that, according to García-Abad et al. (1998), could represent an adaptive strategy of the species to have a larger stock of eggs and therefore a larger recruitment of young. In another species of tropical Clupeiformes, a larger proportion of females was also observed (García-Abad et al., 1998; García-Abad et al., 1999).

The high frequencies of mature females in the spring and summer and the high values of the Gonadosomatic index and of the Gonadal Condition factor in these seasons, indicated that the reproductive period of the species occurred at this time. As females with emptied ovaries were not found in the present study, and because the species was not found in shallower areas than those of the present study (Godefroid, 1997, 2002; Corrêa, 1987; Chaves and Corrêa, 1998; Chaves and Vendel, 2001), it was possible that spawning occurred at depths more than 15 meters.

More studies on the biology of *C. bleekermanus*, as well as of other species of Clupeiformes, are necessary for a better understanding of the ecosystems where they occur, since they are, as a rule, abundant species. Such studies could contribute to the elaboration of more complete management plans for these environments.

RESUMO

Este trabalho fornece dados sobre a biologia de *C. bleekermanus* do litoral do Estado do Paraná, reunindo dados sobre sua abundância, estrutura em

tamanho, dieta e reprodução. Coletas mensais foram realizadas em 1999 e 2000 na plataforma continental interna, com rede de arrasto de fundo com portas. A captura por unidade de esforço não variou significativamente entre as estações do ano. No verão os indivíduos eram maiores, seguido do outono, primavera e inverno. *C. bleekermanus* é predominantemente planctívora, sendo copépodos seguidos de algas diatomáceas os itens alimentares mais frequentes em sua dieta. As variações sazonais de valores da frequência de estádios de maturação gonadal, do índice gonadosomático e do fator de condição gonadal indicam que o período reprodutivo compreende primavera e verão. O comprimento total médio de primeira maturação das fêmeas é estimado em 76 mm.

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