Length-weight Relationships, Condition and Population Structure of the Genus *Atlantoraja* (Elasmobranchii, Rajidae, Arhynchobatinae) in Southeastern Brazilian Waters, SW Atlantic Ocean

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Abstract

During the present study, 107 specimens of *Atlantoraja castelnaui*, 188 of *A. platana*, and 770 of *A. cyclophora*, were obtained by commercial vessels operating in Southeastern Brazil from March 2005 to April 2006. Males of *A. castelnaui* ranged from 17.9–111.0 cm and females from 17.4–116.0 cm total length. Males of *A. platana* ranged from 13.1–70.0 cm and females from 12.5–76.0 cm total length. Males of *A. cyclophora* ranged from 13.3–58.5 cm and females from 11.5–68.0 cm total length. Length-weight curves were sexually dimorphic in the three species. The analysis of the angular coefficient (b) demonstrated that growth (in weight) in relation to length was allometric ($b > 3$) in males of *A. castelnaui* and *A. platana*, while isometric ($b = 3$) in females of these species. Conversely, growth of *A. cyclophora* was isometric in males, while in females it was allometric ($b > 3$). The condition factor varied significantly throughout the year only in females of *A. castelnaui*.

Key words: angular coefficient, condition factor, elasmobranch, morphometrics, skates.

Introduction

The genus *Atlantoraja* Menni, 1972, comprises three species, the Eyespot skate *A. castelnaui* (Ribeiro 1907), the La Plata skate *A. platana* (Günther 1880) and the Spotback skate *A. cyclophora* (Regan 1903) (Compagno, 2005). All are endemic to the Western Atlantic coast of South America. *Atlantoraja castelnaui* ranges from Rio de Janeiro State in Brazil to Argentina at depths of 20–220 m (Vooren, 1998), where it is the largest and one of the most common rajids in the Southern Brazilian and Bonaerensean districts (Figueiredo, 1977; Menni, 1973; Menni *et al.*, 1981). *Atlantoraja platana* ranges from the littoral of São Paulo State in Brazil to Argentina (Figueiredo, 1977), where it is part of the Bonaerensean fauna (Menni and Lopez, 1984). In Southern Brazil, it is found between 40–100 m depth (Vooren, 1998), although Marçal (MS 2003) has recorded the occurrence of this species at depth of up to 231 m. *Atlantoraja cyclophora* occurs from Cabo Frio in Rio de Janeiro State, Brazil, to Argentina (Figueiredo, 1977) and is found from the coast to depths of up to 300 m (Oddone and Vooren, 2004). However, the observed upper limit of its depth distribution in Southern Brazil is 40 m (Vooren, 1998). Furthermore, Gosztonyi (1981) recorded the occurrence of *A. cyclophora* off the Buenos Aires Province at depths of 26–71 m. In Argentinean waters, *A. cyclophora* is distributed within the Southern Brazilian and Bonaerensean zoogeographical districts. Menni and Lopez (1984) have placed this species within the inner shelf mixed fauna, where it has been observed at depths of up to 89 m.

In Southern Brazilian waters, the three species are sympatric and occur throughout the year without seasonal variations in abundance, sex, or size (Vooren, 1998; Vooren and Klippel, 2005). In the Uruguayan inner shelf, *Atlantoraja castelnaui* along with *A. cyclophora* and *Rioraja agassizi* are distributed in 30–60% of the area, with abundances between 1 000–5 000 kg/square nautical miles (Paesch, MS 2006).

Atlantoraja castelnaui, A. platana and *A. cyclophora* all have a high commercial value. In Southern Brazil, *A. castelanui* has been commercially landed at least since 1986 and was frequently observed in trawler landings in 2002 and 2003, while in Argentina, this species has been landed since 1994 (Hozbor *et al.*, 2004). Detailed landing statistics are not available because all species of batoids are recorded as "unidentified rays and skates". Trawl fishing in the habitat of *A. castelanui* is intense, and off the coast of Uruguay and Argentina, the biomass of *A. castelnaui* decreased by 75% from 1994–1999 (Hozbor *et al.*, 2004). *Atlantoraja* spp., particularly the larger individuals, are commonly landed in Santos and Guarujá (Oddone, unpublished data). Since 1999, the meat of the three species has been exported to Asia, in particular to South Korea. In Santos alone, just one fishing company exported 100 tons of skates of the genera *Atlantoraja* and *Rioraja* during 2002 (Casarini, MS 2006). Intensive fisheries in the Southwestern Atlantic have led to the overexploitation of several species of demersal elasmobranchs (Vooren and Klippel, 2005), leading *A. castelnaui* and *A. cyclophora* to become endangered (Hozbor *et al*., 2004) and a matter of concern for the conservation of these species. Yet no information on the conservation status of *A. platana* is available.

The aims of the present work were to analyze the composition, length-weight relationships and general condition of the species in the genus *Atlantoraja* present in the area exploited by the fishing fleet of Santos and Guarujá (Southeastern Brazil).

Materials and Methods

One hundred and seven specimens of *A. castelnaui*, 188 of *A. platana*, and 770 of *A. cyclophora* were obtained by seven commercial vessels operating at the Southeastern Brazilian waters. The number of individuals per species, sex and month is presented in Table 1.

Monthly samples were taken from March 2005 to April 2006 by single and pair trawlers ranging in length from 19.5–22.5 m and beam trawlers from 5.3–13 m. The stretched mesh of the trawl net varied from 45–90 mm and the ground-rope ranged from 22–70 m. Data collected by fishermen for each trawl were: date, depth, latitude and longitude. Data on number of hauls and number of hauls with occurrence of the species are uncertain. The study area was situated between latitudes 23° 37' S and 27° 40' S, covering the States of Rio de Janeiro, São Paulo, Paraná and Santa Catarina, at depths varying between 10–146 m (Fig. 1).

Biometric measurements collected were total length (TL, cm), total disc width (DW, cm), total weight (W_T, g), and gutted weight (W_G, body weight without digestive tract, liver and reproductive organs, g). Gutted weight is considered to be a more appropriate variable than total weight because the former is not influenced by individual variation of mass in the digestive tract, liver, and reproductive organs (Perez and Vooren, 1991). Linear measurements were carried out with 0.1 cm precision. Two electric scales were used, with 1 and 5 g precision.

The Condition Factor based on total weight (CF_T) and gutted weight (CF_G) was, respectively, calculated according to King (1995) from:

$$CF_T = W_T/TL^b$$

and

$$CF_G = W_G/TL^b,$$

where *b* is the angular coefficient of the potential curve adjusted to the respective length-weight relationships.

Parametric/non-parametric tests were chosen by testing the normality and homogeneity of variance in the variables using the Lilliefors' and Levene's tests, respectively. To compare length-weight curves, the data were log-transformed to linearize the regression and the *F*-test used (Souza 1998). Sex ratio (M:F) was tested using the chi-squared test (χ^2). To assess the nature of the growth in weight with TL (isometry/allometry), the value of the angular coefficient *b* was compared with the theoretical value of 3. Comparisons among median CF, obtained monthly for all individuals, were performed using Kruskal-Wallis' H-test and *post-hoc* Mann-Whitney's U-test Bonferroni corrected (Sokal and Rohlf, 1995) using the freeware software PAST (Hammer *et al.*, 2001). In all analyses, the significance level considered was 0.05.

Results

Total length and sex composition

The size distribution, and sex ratio by month, for the three species are presented in Fig. 2 and Table 1, respectfully.

Atlantoraja castelnaui was captured at depths of 24–120 m Males ranged from 17.9–111.0 cm TL and

TABLE 1. Length (cm) and number (*n*) of male and female *Atlantoraja castelnaui, A. platana* and *A. cyclophora* captured by month. Range, mean and standard deviation of total lengths, and male:female sex ratio, are given.

	Males				Females				Sex ratio
Month	*n*	range	mean	SD	*n*	range	mean	SD	M:F
Atlantoraja castelnaui									
Mar 2005	–	–	–	–	–	–	–	–	–
Apr 2005	6	24.9–80.5	40.1	20.5	7	52.9–116.0	92.2	23.2	0.9:1
May 2005	1	48.0	–	–	5	44.0–113.0	80.4	32.2	0.2:1
Jun 2005	3	34.0–60.0	44.8	13.4	2	28.0–49.8	38.9	15.4	1:0.7
Jul 2005	4	36.2–86.0	60.2	24.0	7	33.0–94.5	55.9	19.7	0.6:1
Aug 2005	5	38.8–95.5	72.6	23.3	1	–	–	–	1:0.2
Sep 2005	7	50.0–77.0	65.3	11.6	8	44.3–106.0	66.5	19.9	0.9:1
Oct 2005	7	48.0–106.0	74.0	22.0	10	48.0–106.0	73.9	21.9	0.7:1
Nov 2005	6	45.2–111.0	79.0	25.4	4	45.2–111.0	79.0	25.4	1:0.7
Dec 2005	–	–	–	–	–	–	–	–	–
Jan 2006	5	43.0–95.0	68.4	21.6	4	49.0–61.4	55.4	6.6	1:0.8
Feb 2006	–	–	–	–	–	–	–	–	–
Mar 2006	9	48.5–101.0	78.0	19.3	6	84.0–104.0	96.0	8.1	1:0.7
Apr 2006	–	–	–	–	–	–	–	–	–
TOTAL	53	17.9–111.0	65.3	23.6	53	17.4–116.0	68.8	24.8	0.9:1
Atlantoraja platana									
Mar 2005	3	24.3–34.2	29.7	5.0	4	16.8–31.4	24.3	6.0	0.75:1
Apr 2005	–	–	–	–	1	26.1	26.1	–	–
May 2005	5	36.6–69.0	48.0	12.8	2	25.5–21.1	19.8	6.1	1:0.4
Jun 2005	6	36.1–63.5	36.1	20.5	6	12.5–75.0	56.0	9.9	1:1
Jul 2005	6	44.6–48.6	42.2	10.6	13	12.5–75.0	45.8	16.7	0.5:1
Aug 2005	5	44.6–48.6	46.9	1.8	13	20.8–74.5	45.1	18.8	0.4:1
Sep 2005	5	31.5–67.0	48.9	14.1	5	28.8–73.0	51.8	19.4	1:1
Oct 2005	7	48.0–106.0	74.0	22.0	14	19.7–76.0	42.5	15.7	0.5:1
Nov 2005	6	40.0–55.8	44.8	5.9	9	21.8–75.5	40.0	14.7	0.7:1
Dec 2005	13	15.5–70.0	42.6	17.1	4	39.4–75.0	52.3	16.5	1:0.3*
Jan 2006	16	29.5–68.0	40.5	8.6	4	45–75.5	55.9	13.4	4:1
Feb 2006	15	13.1–62.0	30.3	11.9	5	22.0–72.0	39.2	19.3	3:1*
Mar 2006	7	15.8–49.5	30.3	11.9	6	24.6–51.0	36.6	12.7	1:0.9
Apr 2006	6	45.7–59.4	50.4	5.4	2	43.2–49.0	46.1	4.1	3:1
TOTAL	100	13.1–70.0	42.8	12.6	88	12.5–76.0	43.6	16.2	1:0.9
Atlantoraja cyclophora									
Mar 2005	5	36.9–51.4	43.6	5.5	5	11.6–59.8	44.4	19.9	1:1
Apr 2005	3	28.8–54.3	38.2	14.0	16	12.0–57.5	39.3	12.4	0.2:1*
May 2005	1	–	24.4		14	25.6–60.0	44.8	12.1	1:3.6
Jun 2005	16	17.0–57.2	37.2	12.7	5	15.0–58.5	27.5	19.9	1:4.4*
Jul 2005	16	29.1–58.3	47.8	9.2	18	27.0–60.4	49.4	10.9	1:1.9*
Aug 2005	63	22.9–58.5	43.9	9.7	48	18.8–62.7	42.5	12.8	1:2.3*
Sep 2005	27	28.9–54.5	47.3	7.4	36	30.2–61.5	47.3	7.7	1:2.4
Oct 2005	46	26.0–56.0	40.2	7.9	38	19.5–61.0	38.4	9.5	1:1.9
Nov 2005	34	27.0–55.0	42.7	7.2	23	25.5–61.0	42.0	9.7	1:2.2
Dec 2005	25	30.5–56.0	43.1	6.7	27	12.1–59.9	42.8	10.4	1:2.3
Jan 2006	42	13.4–54.5	39.0	9.6	59	22.0–68.0	37.3	9.8	1:2.4*
Feb 2006	18	23.5–55.4	39.2	9.6	23	25.0–57.5	40.9	9.6	1:2.5
Mar 2006	28	30.5–55.0	51.5	8.3	33	24.5–60.3	36.5	7.3	1:2.6
Apr 2006	47	17.2–56.0	43.3	11.2	54	14.2–62.0	50.1	11.1	1:2.7*
TOTAL	371	13.3–58.5	42.2	9.7	399	11.5–68.0	42.3	11.9	0.9:1*

* significant difference from 1:1 sex ratio at 5% level.

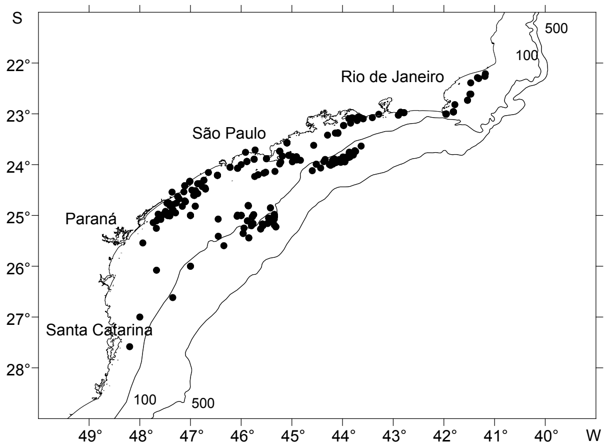

Fig. 1. Map of the study area, Southeastern Brazil, Southwestern Atlantic Ocean. Symbols represent the total number of fishing hauls (when registered by fishermen) in the area where samples of *Atlantoraja castelnaui*, *A. platana* and *A. cyclophora* were collected.

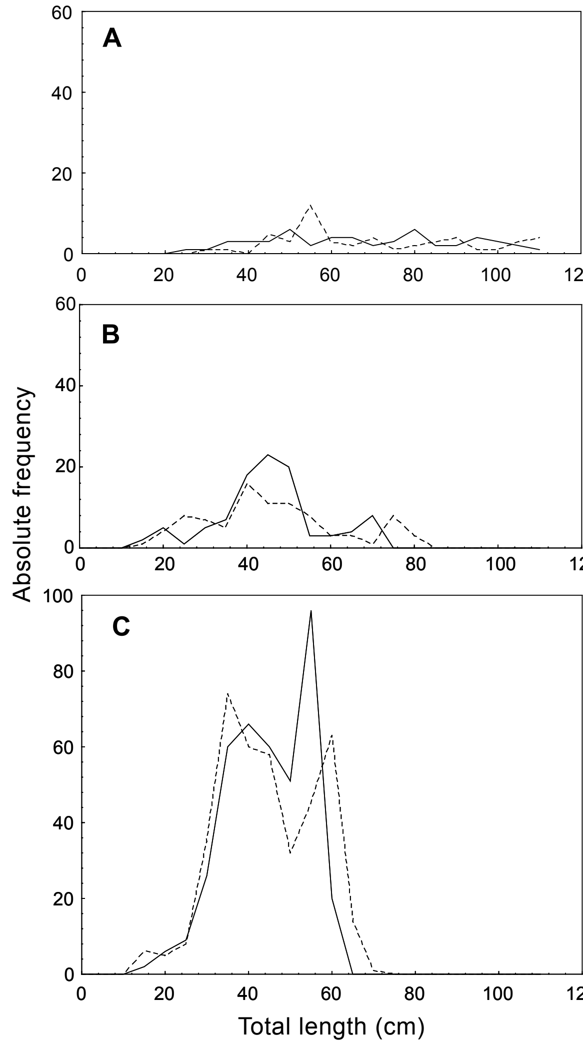

Fig. 2. Absolute frequency of total length (cm) for males (solid lines) and females (dashed lines) for grouped samples of (**A**) *Atlantoraja castelnaui*; (**B**) *Atlantoraja platana* and (**C**) *Atlantoraja cyclophora*.

females from 17.4–116.0 cm TL, with no significant difference in the mean total length between sexes. Sex ratio for the total sample resulted in 0.9:1 favoring the females, though not statistically different from 1:1.

Atlantoraja platana was captured at depths between 20–120 m. Males ranged from 13.1–70.0 cm TL and females from 12.5–76.0 cm TL. Males and females did not differ significantly in their mean total length. Sex ratio for the total sample resulted in 1:0.9, favoring the males, but this difference was not statistically different from 1:1.

Atlantoraja cyclophora was captured between 10–130 m deep. Males ranged from 13.3–58.5 cm TL and females from 11.5–68.0 cm TL, with no significant difference in the mean total length between sexes. Sex ratio of this species for the entire sampling was significantly different from 1:1 in favor of the females.

Length-weight and length-width relationships

For a given length, females of all three species studied were significantly heavier than males (Table 2, Fig. 3). In addition, and with the exception of male *A. platana*, there were significant differences for all comparisons of total length - total weight and and total - gutted weights relationships (Fig. 3).

For *A. castelnaui*, curves for the relationship TL-DW were significantly different between sexes, and females were slightly wider than males, with the exception of neonates and juveniles (Table 2, Fig. 4A). In *A. platana*, there was no significant difference in the TL-DW curves between males and females (Table 2, Fig. 4B). Similarly to the patterns observed in *A. castelnaui*, TL-DW curves were sexually dimorphic in *A. cyclophora*, with females being wider than males for lengths >31.4 cm TL and males wider than females for lengths <31.4 cm TL (Table 2, Fig. 4C).

According to the comparison of the angular coefficient *b* with the theoretical value of 3, males of *A. castelnaui* were found to increase in weight in relation to length with positive allometry ($b > 3$) when W_T was considered. However, when considering W_G, growth became isometric ($b = 3$), and the same result was observed for

TABLE 2. Relationships analyzed for *Atlantoraja* spp.: TL = total length (cm); DW = disc width (cm); W_T = total weight (g); W_G = gutted weight (g) for males (M) and females (F) along with the respective potential regression equation and correlation coefficient (R^2), sample number (n).

Curve	Sex	Equation	R^2	n	Comparison
A. castelnaui					
TL–DW	M	$DW = -0.933+0.706TL$	0.991	51	$F = 27.8$, d.f. = 2,96, $p = 0.00$
	F	$DW = -0.883+0.716TL$	0.992	49	
TL–W_T	M	$W_T = 0.0089TL^{3.193}$	0.999	50	$F = 1714.8$, d.f. = 2, 94, $p = 0.00$
	F	$W_T = 0.0150TL^{3.117}$	0.987	50	
TL–W_G	M	$W_G = 0.0910TL^{3.114}$	0.919	49	$F = 1.8$, d.f. = 2, 92, $p = 0.18$
	F	$W_G = 0.0170TL^{3.087}$	0.986	49	
A. platana					
TL–DW	M	$DW = 2.623+0.778TL$	0.975	100	$F = 2.2$, d.f. = 2, 185, $p = 0.11$
	F	$DW = 4.378+0.730TL$	0.976	89	
TL–W_T	M	$W_T = 0.0023TL^{3.307}$	0.981	94	$F = 49.0$, d.f. = 2, 168, $p = 0.00$
	F	$W_T = 0.0023TL^{3.016}$	0.983	86	
TL–W_G	M	$W_G = 0.0070TL^{3.289}$	0.965	96	$F = 10.0$, d.f. = 2, 177, $p = 0.00$
	F	$W_G = 0.0140TL^{2.879}$	0.927	86	
A. cyclophora					
TL–DW	M	$DW = 2.881+0.678TL$	0.988	397	$F = 73.0$, 2, d.f. = 2, 786, $p = 0.00$
	F	$DW = 0.952+0.742TL$	0.992	405	
TL–W_T	M	$W_T = 0.0044TL^{3.056}$	0.987	397	$F = 77.0$, 2, d.f. = 2, 786, $p = 0.00$
	F	$W_T = 0.0027TL^{3.197}$	0.988	393	
TL–W_G	M	$W_G = 0.0044TL^{3.039}$	0.973	385	$F = 19.5$, 2, d.f. = 2, 786, $p = 0.00$
	F	$W_G = 0.0031TL^{3.139}$	0.988	384	

females. In *A. platana*, males grew with positive allometry while females grew isometrically considering both W_T and W_G. In *A. cyclophora*, male growth was found to be isometric, while in females, growth was positively allometric (Table 3).

Condition factor

For males of *A. castelnaui*, CF_T and CF_G did not vary significantly thorough the year. Conversely, females showed significant variations in both the CF_T and CF_G throughout the year ($H_{(11,\ N = 51)} = 0$, $p < 0.01$; and $H_{(11,\ N = 49)} = 0$, $p < 0.01$, respectively). Significant differences in the CF_T and the CF_G were detected in September by the post-hoc pair-wise comparisons, when the condition factor reached its lowest value for the females (Fig. 5A).

For *A. platana*, CF_T and CF_G did not vary significantly throughout the year for males or for females (Fig. 5B).

For of *A. cyclophora*, the CF_T did not vary significantly for the female W_T. For males, CF_T did not vary significantly among month. However, the Kruskal-Wallis test detected a slightly significant difference in the CF_G throughout the year ($H_{(13,\ N = 398)} = 24.46$, $p = 0.02$, respectively), but it was assumed that no differences were observed among months. This is because the *post-hoc* Bonferroni corrected tests did not show any significant differences (Fig. 5C).

Discussion

According to the depth of occurrence, *A. cyclophora* was more proximal to the coast, whereas *A. castelnaui* and *A. platana* occurred at depths greater than 24 m in this area. For *A. castelnaui*, this fact is reinforced by the observation of Vooren (pers. com., *Fundação Universidade Federal do Rio Grande, Brazil*) of a 20.2 cm TL male caught at a depth of 29 m (33° 51' 24" S, 52° 54' 36" W) off the coast of Chui, in Rio Grande do Sul State

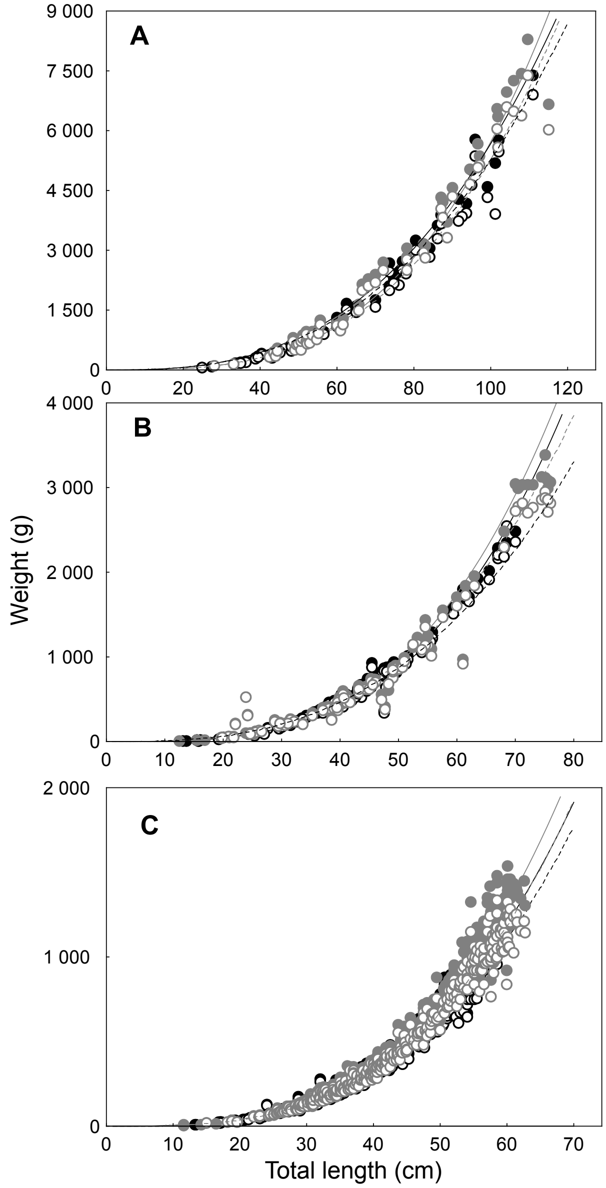

Fig. 3. Comparison of length and total (males = black full circles; females = grey full circles), and length and gutted (g) (males = black empty circles; females grey empty circles) weight relationships, for (**A**) *Atlantoraja castelnaui*; (**B**) *Atlantoraja platana* and (**C**) *Atlantoraja cyclophora*. Black lines, represent the adjusted potential curve for males regarding to total weight (solid lines) and gutted weight (dashed lines). Grey lines represent the adjusted potential curve for the females regarding total weight (solid lines) and gutted weight (dashed lines).

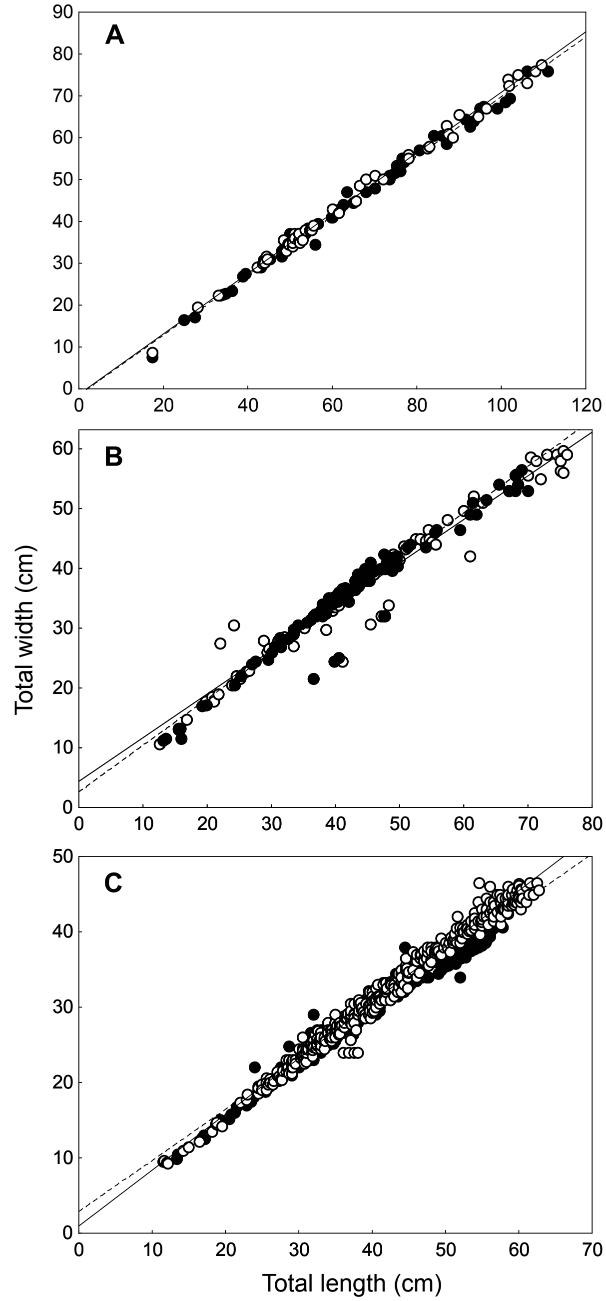

Fig. 4. Relationship between disc width (cm) as dependent variable of total length (cm) for males (black solid symbols, solid lines) and females (black empty symbols, dashed lines) for (**A**) *Atlantoraja castelnaui*; (**B**) *Atlantoraja platana* and (**C**) *Atlantoraja cyclophora*.

(Brazil). Ponz Louro (MS 1995) reported the presence of *A. castelnaui* in the range of 35–100 m, but the upper limit of the surveys was only 100 m. According to the author, this species is rarely found in groups, being found solitary or at most in pairs (in Southeastern Brazil) with juveniles presumably distributing in areas of up to 50 m deep and adults between 50 and 100 m. According to Vooren (1998), *A. platana* is known to occur at depths of up to ~110 m in Southern Brazil, though Marçal (MS 2003) recorded the presence of this species at depths of

TABLE 3. Estimate of the angular coefficient (*b*) for males and females of *Atlantoraja* spp.; standard error (SE) of the regression total length-total/gutted weight, t_1 = *t*-test value of the regression and p_1 = probability of the regression regarding *b*, correlation coefficient of the regression *r*, d.f. = degrees of freedom and probability (p_1), t_2 = *t*-test's value of the comparison with the theoretical value 3 and probability (p_2) and the nature of growth according to *b*.

Sex	Ratio	*b*	SE	t_1	p_1	*r*	d. f.	t_2	p_2	growth
A. castelnaui										
Males	W_T	3.193	0.048	67.1	0.00	0.99	49	4.15	<0.05	allometric+
	W_G	3.114	0.077	40.6	0.00	0.99	49	1.49	>0.05	isometric
Females	W_T	3.117	0.058	53.9	0.00	0.99	50	2.02	<0.05	allometric+
	W_G	3.087	0.058	53.2	0.00	0.99	50	1.50	>0.05	isometric
A. platana										
Males	W_T	3.307	0.045	73.0	0.00	0.99	94	6.78	>0.05	allometric+
	W_G	3.289	0.047	69.3	0.00	0.99	96	6.10	>0.05	allometric+
Females	W_T	3.016	0.062	48.4	0.00	0.98	87	0.26	<0.05	isometric
	W_G	2.879	0.131	36.0	0.00	0.97	85	0.92	<0.05	isometric
A. cyclophora										
Males	W_T	3.056	0.032	94.0	0.00	0.99	392	1.75	<0.05	isometric
	W_G	3.039	0.032	96.0	0.00	0.99	384	1.24	<0.05	isometric
Females	W_T	3.197	0.037	86.6	0.00	0.99	393	5.39	>0.05	allometric+
	W_G	3.139	0.034	89.1	0.00	0.99	384	4.07	>0.05	allometric+

up to 231 m. *Atlantoraja cyclophora* is found as deep as 300 m in Southern Brazil (Oddone and Vooren, 2004) and no shallower than 35 m off the Southeast coast of Brazil (Ponz Louro, MS 1995).

Based on the landing data, the three *Atlantoraja* species occurred sympatrically throughout the year in Southeastern Brazil. Moreover, the presence of egg-bearing females and young individuals suggests that these species (Oddone, pers. obs.) complete their life cycles in the same area, as observed by Vooren (1998) in Southern Brazilian waters.

In spite of the sex ratio being different from the expected 1:1 for the three species, this difference (though statistically significant in some cases) may have no biological significance because of the small sample size. Therefore, it can be assumed that males and females share the same area throughout the year and total segregation between sexes does not occur. This has been previously documented for *A. castelnaui* and *R. agassizi* (Ponz Louro, MS 1995; Oddone *et al*., 2007) in this area and for *A. cyclophora* (Oddone, MS 2003; Oddone and Vooren, 2004) and *A. platana* (Marçal, MS 2003) in Southern Brazilian waters.

Although the complete range of lengths was represented in the current study, no definitive conclusions on the population structure can be made at this time. When an analysis is dependent on the commercial fishing fleet, information is patchily distributed in time and space, and our perception of the ecology of skates is based just on 'fleeting images' (Walker, MS 1999). Moreover, due to the commercial importance of these species, larger specimens are retained for commercial use. Therefore, only juveniles of each species are provided to researchers by the commercial fishing industry. Thus, the samples obtained in the present study, are biased by fishermen selection. Further research surveys are, therefore, needed to determine the stock size of these species, in South and Southeastern Brazil.

In most rajids, sexual dimorphism is commonly reflected in the mean size (Jardas, 1973; Nottage and Perkins, 1983; Oddone and Vooren, 2004; Oddone *et. al*., 2007) and the length-weight and length-width curves (Braccini and Chiaramonte, 2002; Mabragaña *et al*., 2002; Oddone and Vooren, 2004; Oddone *et al*., 2007). A growth pattern in which males have a wider disc width than females in the first life stages, and in later stages females become wider, was also observed for *R. agassizi* and for samples of *A. cyclophora* from Southern Brazil (Oddone, MS 2003; Oddone and Vooren, 2004; Oddone *et al*., 2007).

Allometric growth with *b* >3 means that fish become more rotund when length increases, and at the same time, condition factor increases with increasing length (Jones

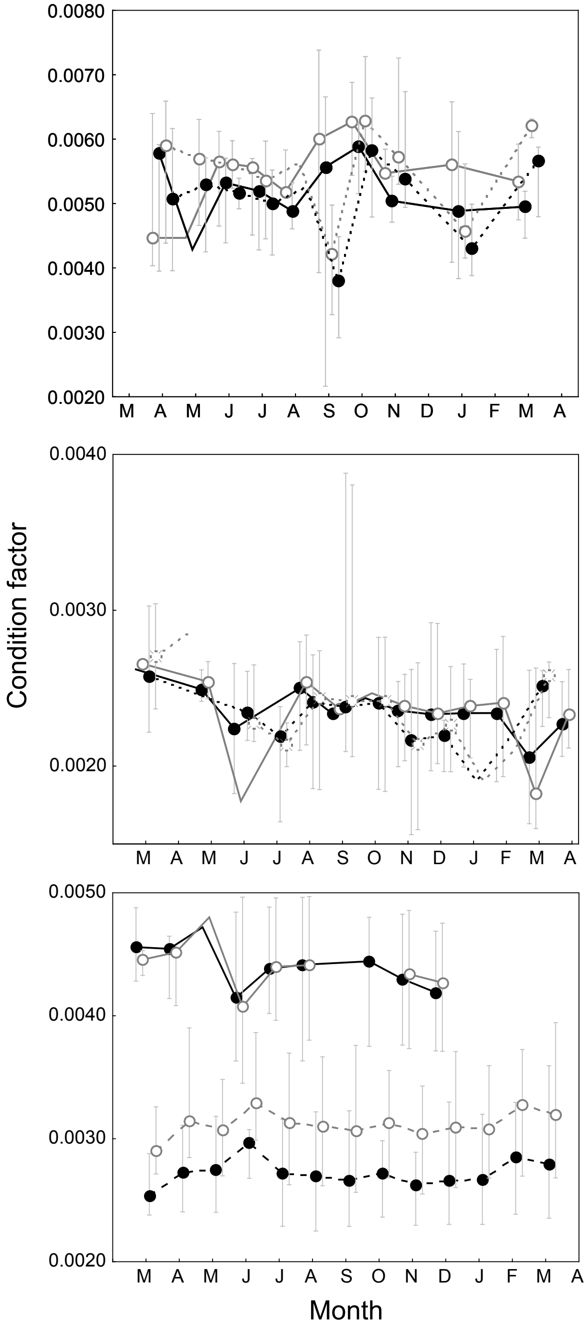

Fig. 5. Median condition factor by month (from March 2005 to April 2006) considering total (W_T, g, black lines, dotted black circles) and gutted weight (W_G, g, grey lines, empty grey circles) for males (solid lines) and females (dashed lines) of (**A**) *Atlantoraja castelnaui*; (**B**) *Atlantoraja platana* and (**C**) *Atlantoraja cyclophora*. Vertical bars represent the data interval.

et al., 1999). In the present work, the data available indicated that males and females of *A. castelnaui* grow with positive allometry with length when considering total weight, however, when gutted weight was considered, growth became isometric. On the other hand, males of *A. platana* were found to grow allometrically with length (*b* >3) while females grew isometrically. In *A. cyclophora*, growth was isometric for males and allometric *(b* >3) for females.

In addition, it was observed that condition factor significantly varied among months for females of *A. castelnaui*, and in males and females of *A. cyclophora*, which showed significant variation in males only when considering CF_T. These facts could be reflecting variations in food abundance or reproductive stage of the stock (King, 1995). Apparently, the reproductive cycle for this species is annual and therefore, there are neither specific periods for vitellogenesis nor delimited spawning season (Oddone and Vooren, 2005; Oddone, unpublished data), which would reflected in the overall condition of the skates. This detected variation may be better related with food availability or other extrinsic factors ruling the population level. Possible effects of stomach contents on the weight of the skates were avoided by considering gutted weight in the calculations of *b* and condition factor. This hypothesis is reinforced by the samples of *A. cyclophora* in Southern Brazil, where values of *b* <3 were obtained. Templeman (1987) noted that in *Amblyraja radiata*, there was not only a dimorphic length-weight relationship but also variations among maturity stages. Mature specimens have lower average weights than immature individuals of the larger size-groups. Overall condition could also be related to alterations in population density (Braga, 1986). Seasonal variation of the diet seems to be associated with the availability of prey, whose distribution and abundance are related to the dynamics of the water masses in the region (Muto *et al*., 2001). Braccini and Chiaramonte (2002) recorded isometric growth for males and positive allometry in females of *Psammobatis extenta*. In *R. agassizi*, growth was allometric, with *b* <3 for both sexes (Oddone *et al*., 2007). The study of fish condition assumes that heavier fish of a given length are in better state, and this has been used by fish culturists as indicators of the general 'well-being or fitness' of the population under consideration (Jones *et al*., 1999).

The background of biological data of Southwestern Atlantic rajids is still limited. For most species, life history trends are still unknown and this is a matter of concern because fisheries have negatively affected the rajids, which in part is because of their sedentary nature. As a result, the local extinction of several species has occurred, leaving another portion of the population in a critical situation (Brander, 1981; Dulvy and Reynolds, 2002).

As early as 1933, Steven (1933) was already aware that skates would be rapidly and more severely affected than any other fish by intense fishing in a particular area, in the view that migrations would be restricted or non-existent. Dulvy and Reynolds (2002) demonstrated that the skate species that have disappeared from substantial parts of their ranges ("locally extinct") have large body sizes compared with all other skates, but that latitudinal and depth ranges were similar to those of other species. According to these authors, the body size correlations may be due to higher mortality rates and correlations with life-history parameters, such as late age at maturity. This is a matter of concern especially fo*r A. castelnaui*, which attains more than 110 cm TL, is the largest rajid inhabiting that depth range in the area, and fits in the Dulvy and Reynolds' category of vulnerable skates to overexploitation and subsequent population depletion.

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