

# Reproductive biology of *Sympterygia bonapartii* (Chondrichthyes: Rajiformes: Arhynchobatidae) in San Matías Gulf, Patagonia, Argentina

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This study estimates and analyses the reproductive parameters and cycle of *Sympterygia bonapartii* in San Matías Gulf, northern Patagonia, Argentina. A total of 827 males and 1,299 females were analysed. Males ranged from 185 to 687 mm of total length (TL) and females from 180 to 742 mm TL. Sexual dimorphism was detected; females were larger, heavier, exhibited heavier livers, wider discs and matured at larger sizes than males. Immature females ranged from 180 to 625 mm TL, maturing females from 408 to 720 mm TL, mature ones from 514 to 742 mm TL and females with egg capsules from 580 to 730 mm TL. Immature males ranged from 185 to 545 mm TL, maturing ones from 410 to 620 mm TL and mature males from 505 to 687 mm TL. Size at which 50% of the skates reached maturity was estimated to be 545 mm TL for males and 594 mm TL for females. According to the reproductive indexes analysed, *S. bonapartii* exhibited a seasonal reproductive pattern. Mating may occur during winter-early spring and the egg-laying season, during spring and summer.

**Keywords:** Elasmobranchii, Reproduction, Skate, South Western Atlantic Ocean.

El presente estudio estima y analiza los parámetros reproductivos y el ciclo reproductivo de *Sympterygia bonapartii* en el Golfo San Matías, Patagonia norte, Argentina. Se analizaron 827 machos y 1.299 hembras. Los machos midieron entre 185 y 687 mm de largo total (LT) y las hembras entre 180 y 742 mm LT. Se detectó dimorfismo sexual; las hembras fueron más grandes y pesadas que los machos y presentaron anchos de disco, pesos de hígado y tallas de madurez sexual mayores a los de los machos. Las hembras inmaduras midieron entre 180 y 625 mm LT, las hembras en maduración entre 408 y 720 mm LT, las maduras entre 514 y 742 mm LT y las hembras con cápsulas entre 580 y 730 mm LT. Los machos inmaduros midieron entre 185 y 545 mm LT, los machos en maduración entre 410 y 620 mm LT y los maduros entre 505 y 687 mm LT. La talla media de madurez sexual fue estimada en 545 mm LT para los machos y 594 mm LT para las hembras. De acuerdo con los índices reproductivos analizados, *S. bonapartii* se reproduce estacionalmente. El apareamiento ocurriría durante el invierno y la primavera y la temporada de puesta durante la primavera y el verano.

**Palabras claves:** Atlántico Sudoccidental, Elasmobranchii, Rayas, Reproducción.

## Introduction

Skates (Chondrichthyes: Rajiformes) are the most diverse group of batoids comprising 27 genera and 245 species (Ebert, Compagno, 2007). The genus *Sympterygia* (Arhynchobatidae) is composed of four species endemic to South America. *Sympterygia brevicaudata* (Cope, 1877) and *S. lima* (Poeppig, 1835) are distributed in the Southeast Pacific, while *S. bonapartii* Müller & Henle, 1841 and *S. acuta* Garman, 1877 are found in the Southwest Atlantic.

The smallnose fanskate *S. bonapartii* is distributed from Rio de Janeiro (23°S), Brazil, to Santa Cruz (54°S), Argentina (Figueiredo, Menezes, 1977; Menni, Stehmann, 2000). This skate is one of the most abundant and fished along the Argentine coast. It is caught and landed by bottom

trawlers in mixed-species fisheries and in fisheries targeting the common hake *Merluccius hubbsi* Marini, 1933, where it is part of the bycatch (Massa *et al.*, 2004; Tamini *et al.*, 2006; Estalles *et al.*, 2011). It is also caught and discarded in the fishery of the Patagonian red shrimp *Pleoticus muelleri* (Bate, 1888), where its discards are thought to represent an important fraction of its stock (Cedrola *et al.*, 2005).

Biological information of *S. bonapartii* has been reported for some areas of its distribution. According to previous studies, it presents a seasonal reproductive cycle in the wild while it is able to reproduce throughout the year in captivity (Mabragaña *et al.*, 2002; Jañez, Sueiro, 2009). Estimations of size at maturity also vary among studies and they were performed in the northern area of its distribution (Mabragaña *et al.*, 2002; Oddone, Velasco, 2004; Díaz

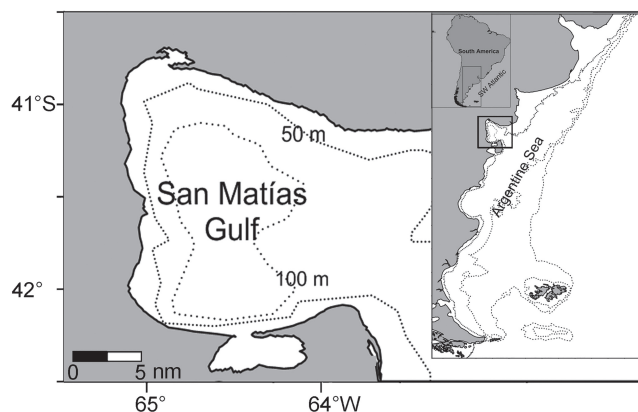
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Andrade, 2011; Basallo, Oddone, 2014). In Patagonia, the biological information on the species is scarce. The aim of the present study is to provide information on the reproductive parameters and reproductive cycle of *S. bonapartii* in San Matías Gulf, northern Patagonia, Argentina.

### Materials and methods

San Matías Gulf (SMG; 41°-42°S; 64°-65°W; Fig. 1) is a semi-closed basin separated from the continental shelf by an 80 m-deep sill. During spring and summer a NE-SW thermohaline front divides the gulf into a northern and southern water mass (1 to 3°C; 2‰ salinity difference). During autumn and winter the front disappears and the water mass of the gulf become homogeneous (Piola, Scasso, 1988).



**Fig. 1.** Geographic location of the study area, San Matías Gulf (Argentina).

Samples of *S. bonapartii* came from three different sources: bottom trawl research surveys, the on-board observer programme (OBP) of Río Negro Province, and local fish-processing industries. All the samples were captured by bottom trawlers. Research surveys were conducted during spring (October-December) from 2004 to 2007. Hauls were carried out covering the area of SMG at a depth-range of 40-175 m. The OBP of Río Negro Province provided samples of juveniles of *S. bonapartii* caught by commercial vessels during 2007 and 2008. Individuals composing the commercial fraction were sampled monthly from April 2007 to April 2008, June 2008 to October 2008, and December 2008 to February 2009 at local fish-processing industries.

Skates were measured and weighted in order to assess their morphological characteristics. Total length (TL; mm) was measured from the tip of the snout to the tip of the tail and disc width (DW; mm) as the maximum distance between wing tips. Total weight (TW; g), liver weight (LW; g) and the sex of each individual were recorded. The TL-DW, TL-TW and TL-LW relationships were estimated for each sex and compared between sexes with an ANCOVA (Zar, 1984). Before comparing the curves data were log-transformed. Analyses were performed using the R statistical software (R Core Team, 2010). Complete metrics were not obtained

from every individual, and thus, every test and analysis was presented with its sample size.

The maturity condition of the individuals was assessed by the macroscopic observation of the reproductive organs. Males and females were classified into three and four reproductive stages respectively, modifying the scale of maturity stages proposed by Stehmann (2002) as follows:

Immature males: flexible claspers shorter than the pelvic fins; small testes with abundant epigonal organ and straight and thread-like sperm ducts. Maturing males: claspers larger than the pelvic fins but flexible; enlarged testes with differentiated lobules and straight sperm ducts. Mature males: claspers larger than pelvic fins and calcified; testes enlarged and coiled sperm ducts.

Immature females: small ovaries without differentiated follicles; oviducal glands undifferentiated from uteri and narrow and thread-like uteri. Maturing females: ovaries with ovarian follicles becoming differentiated but lacking yolked oocytes; narrow uteri and developing oviducal glands. Mature females: large ovaries with yolked mature oocytes of different sizes; uteri enlarged and oviducal glands fully developed. Mature females with egg capsules: presence of egg capsules beginning to be formed or fully formed in their uteri.

For males, the length of the left clasper was measured (CL; mm) from the end of the cloaca to its tip and the weight of the paired testes recorded (GW; g). For females, the maximum width of the left oviducal gland was measured (OGW; mm). The number of yolked ovarian oocytes was counted and a mean value was estimated (NYO). The diameter of the largest yolked ovarian oocyte was also measured, in each ovary, and a mean value was estimated (MOD; mm). The weight of the paired ovaries (GW; g) and oviducal glands (OG; g) were recorded. For TL-MOD and TL-NYO relationships, the correlation coefficient Pearson's ( $r$ ) was estimated since variables were normally distributed (Zar, 1984). Normality was tested with Kolmogorov-Smirnov ( $KS$ ) test (For TL  $KS=0.05$ , for NYO  $KS=0.08$  and for MOD  $KS=0.07$ ;  $n=255$ ;  $P>0.05$ ; Zar, 1984).

When egg capsules were found their length and width were measured, according to Hubbs, Ishiyama (1968), and their weight recorded.

The length at which 50% of the skates reached maturity ( $TL_{50\%}$ ) was estimated using a logistic model for each sex. To fit the model binomial maturity data (immature 0, mature 1) was determined by sex at 10 mm intervals (Estalles, 2012). The model used was:

$$P = \frac{1}{1 + e^{-r(TL - TL_{50\%})}}$$

Where:  $P$  is the proportion of mature skates at a given length-class interval,  $r$  is a fitted parameter,  $TL$  is the length-class interval for which the proportion of mature individuals is estimated, and  $TL_{50\%}$  is the length-class interval at which 50% of the skates are mature. The model was fitted for each sex with FISHPARM 3.05 (Prager *et al.*, 1989).

Several indexes were estimated to assess the reproductive cycle of the species. Only mature individuals sampled during 2007, 2008 and 2009 were included in these analyses (Tab. 1).

Monthly variations in the gonadosomatic (GSI) and hepatosomatic (HSI) indexes were analysed in both sexes:  $GSI = 100 \times GW \times TW^{-1}$  and  $HSI = 100 \times LW \times TW^{-1}$ . For females, the oviducal gland index (OGI) was also estimated:  $OGI = 100 \times OG \times TW^{-1}$ . Monthly changes in the ovarian condition were assessed by analysing the NYO and MOD (Conrath, 2005). The samples taken during September and October were analysed together, since only two NYO and MOD values were obtained during October.

The hypothesis of no interannual variation in reproductive indexes was analyzed with Mann-Whitney test for unpaired samples (Zar, 1984). The test compared the mean values of indexes between months of consecutive years for both sexes. Since in most cases no significant differences were found data was analyzed pooled (S1-3 - Available only as online supplementary files accessed with the online version of the article at <http://www.scielo.br/ni>).

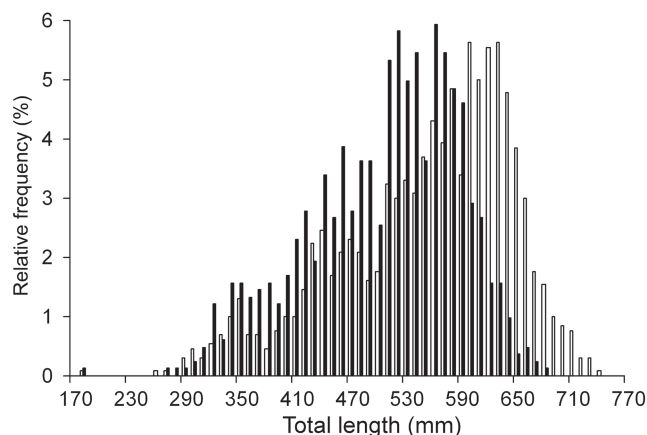
Non-parametric analyses of variance, Kruskal-Wallis test ( $H$ ), were used to determine significant differences in the monthly variation of the reproductive indexes (GSI, HSI, OGI, NYO, MOD; Zar, 1984).

**Tab. 1.** Number of individuals sampled for estimating the reproductive indexes of *Sympterygia bonapartii* from San Matías Gulf (Argentina).

Sex	Year	Number of individuals sampled											
		Month											
		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Male	2007	34	18	5	17	6	1	19	42	8	-	-	-
	2008	1	-	-	13	1	8	-	-	6	3	-	-
	2009	-	-	-	-	-	-	-	-	-	6	7	-
Female	2007	10	27	31	37	16	28	34	32	4	-	-	-
	2008	33	-	17	10	12	6	2	-	19	18	28	25
	2009	-	-	-	-	-	-	-	-	-	10	9	-

## Results

A total of 2,126 individuals (827 males and 1,299 females) were sampled. Males ranged from 185 to 687 mm TL and females from 180 to 742 mm TL (Fig. 2). Females were heavier, showed wider discs and heavier livers than males of the same length (Tab. 2).



**Fig. 2.** Size frequency distribution of the individuals analyzed of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Males (■)  $n = 827$  and females (□)  $n = 1,299$ .

The smallest mature male was 505 mm TL and the largest maturing one 620 mm TL (Tab. 3). The relationship TL-CL showed a continuous increase, with a range between 490 and 620 mm TL at which the reproductive

stages overlapped (Fig. 3). Size at 50% of maturity was estimated to be 545 mm TL (Fig. 4).

The onset of vitellogenesis for *S. bonapartii* could be set when the diameter of the largest yolkec ovarian oocyte is greater than 6.5 mm and the ovulation could be set when oocytes are greater than 38 mm (Tab. 4).

The width of the oviducal gland was an indicator of the maturity condition of the females and it showed an abrupt increase between 520 and 620 mm TL (Fig. 5). The smallest mature female was 514 mm TL and the largest maturing one 720 mm TL (Tab. 4). Size at 50% of maturity was estimated to be 594 mm TL (Fig. 4).

Females with egg capsules were recorded during spring and summer. This stage of maturity presented less ovarian oocytes than mature females but, these oocytes were of larger sizes (Tab. 4). Eight egg capsules were found completely formed. They measured  $77.90 \pm 5.10$  mm in length,  $47.30 \pm 2.40$  mm in width and their weight was  $24.50 \pm 4.90$  g (mean  $\pm$  standard deviation).

Positive correlations were detected between the TL of the female and MOD and NYO respectively ( $r = 0.37$ ;  $P < 0.001$  for MOD and  $r = 0.30$ ;  $P < 0.001$  for NYO;  $n = 255$ ).

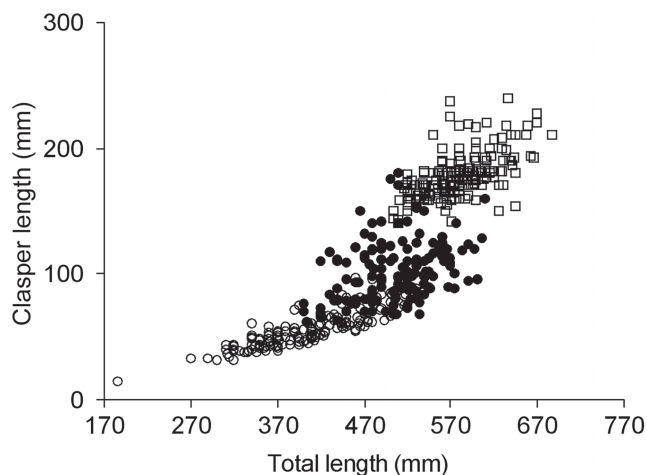
The HSI differed significantly throughout the year ( $H = 46.87$ ;  $d.f. = 11$ ;  $P < 0.001$  and  $H = 91.96$ ;  $d.f. = 12$ ;  $P < 0.001$  for males and females respectively). For males, the HSI alternated between high and low values from April to August. After that, the HSI decreased until February (Fig. 6). For females, the HSI increased from July to September and then, it decreased until February when its lowest value was recorded (Fig. 6).

**Tab. 2.** Relationships analyzed for *Sympterygia bonapartii* from San Matías Gulf (Argentina). Total length (TL; mm), disc width (DW; mm), total weight (TW; g); liver weight (LW; g) for males (M) and females (F); correlation coefficient (R<sup>2</sup>) and sample number (n); F- test results.

Curve	Sex	Equation	R <sup>2</sup>	n	F value	df <sub>(1,2)</sub>	P<
TW-TL	M	TW= 9x10 <sup>-6</sup> TL <sup>2.9577</sup>	0.97	580	13.87	1; 1,612	0.001
	F	TW= 4x10 <sup>-6</sup> TL <sup>3.1007</sup>	0.97	1,036			
DW-TL	M	DW= (0.6236x TL) + 28.308	0.97	264	13.80	1; 708	0.001
	F	DW= (0.6578x TL + 17.473	0.97	448			
LW-TL	M	LW= 6x10 <sup>-8</sup> TL <sup>3.1644</sup>	0.82	454	55.45	1;323	0.001
	F	LW= 9x10 <sup>-10</sup> TL <sup>3.8735</sup>	0.84	873			

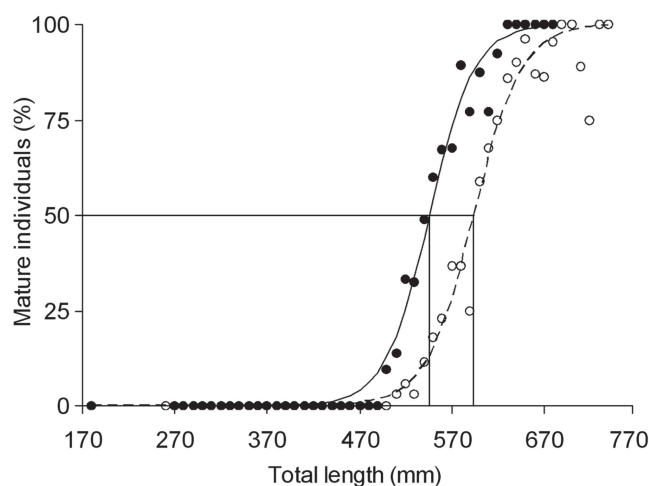
**Tab. 3.** Characteristics of the maturity stages of males of *Sympterygia bonapartii* from San Matías Gulf (Argentina). TL= total length; CL= clasper length; GW= weight of the paired testes.

Males	Immature	Maturing	Mature
TL range (mm)	185-545	410-620	505-687
CL range (mm)	15-97	62-180	140-240
GW range (g)	0.18-8.38	2.68-26.27	3.80-64.39
mean ± SD	3.17±2.15	10.77±5.73	21.44±11.44
Presence	Year round	Year round	Year round
n (%)	286 (35%)	258 (31%)	283 (34%)
NT		827	

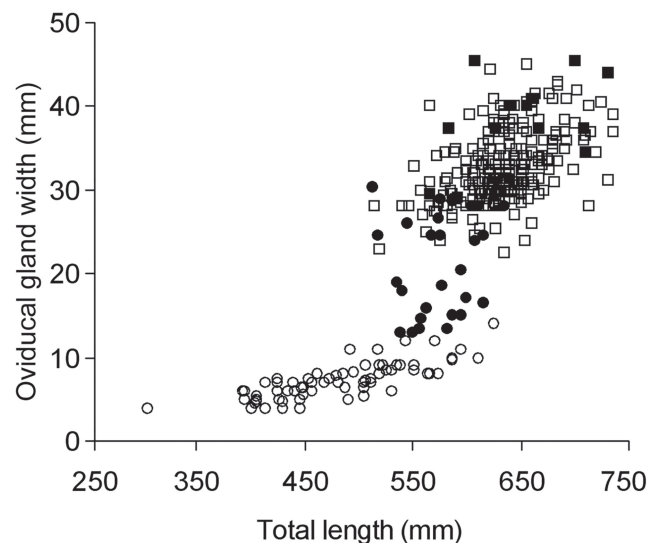


**Fig. 3.** Total length (TL) and clasper length (CL) relationship of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Immature (○) n= 166, maturing (●) n= 145 and mature (□) n= 193.

The GSI differed significantly throughout the year ( $H=123.25$ ;  $df=11$ ;  $P<0.001$  and  $H=145.30$ ;  $df=12$ ;  $P<0.001$  for males and females respectively). For males, the GSI exhibited its minimum values from July to November. After that it increased until April, when the maximum value was recorded (Fig. 7). In contrast, the maximum values of GSI for females were recorded from August to December. After that, the GSI decreased until May, when it reached its minimum value (Fig. 7).



**Fig. 4.** Size at maturity (TL<sub>50%</sub>) of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Males (●): TL<sub>50%</sub>(-)= 545 mm; R<sup>2</sup>= 0.99; n= 825. Females (○): TL<sub>50%</sub>(-)= 594 mm; R<sup>2</sup>= 0.98; n= 1,268.

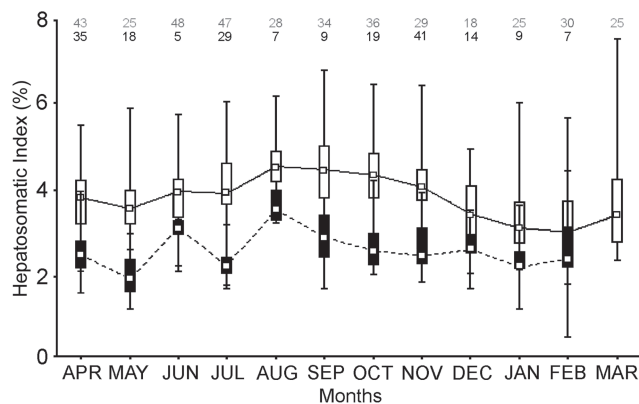


**Fig. 5.** Total length (TL) and width of the oviducal gland (OGW) relationship of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Immature (○) n= 69, maturing (●) n= 30, mature (□) n= 263 and mature females with egg capsules (■) n= 11.



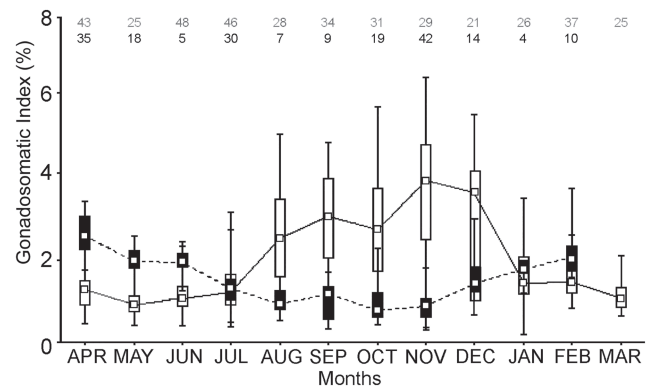
**Tab. 4.** Characteristics of the maturity stages of females of *Sympterygia bonapartii* from San Matías Gulf (Argentina). *TL*= total length; *OG*= width of the left oviducal gland; *GW*= weight of the paired ovaries; *MOD*= diameter of the largest yolked ovarian oocyte; *NYO*= mean number of yolked ovarian oocytes.

Females	Females	Maturing	Mature	Mature with egg capsules
<i>TL</i> range (mm)	180-625	408-720	514-742	580-730
<i>OG</i> range (mm)	4.00-14.00	13.00-31.50	22.50-45.00	34.50-45.50
mean ± SD	7.26±2.15	22.01±6.22	32.72±4.26	40.05±3.64
<i>GW</i> range (g)	0.37-9.27	1.50-16.10	4.95-136.67	42.47-144.42
mean ± SD	3.05±1.71	7.20±2.92	37.39±28.30	79.19±29.90
<i>NYO</i> range	-	-	1-28	5-16
mean ± SD	-	-	1- 26.0±2.82	5- 16.5±0.71
<i>MOD</i> (mm) min	-	-	6.50±0.70	24.00±3.54
<i>MOD</i> (mm) max	-	-	38.00±0.52	38.00±3.27
n (%)	327 (26%)	429 (34%)	484 (38%)	28 (2%)
Presence	Year round	Year round	Year round	November to February
NT			1,268	

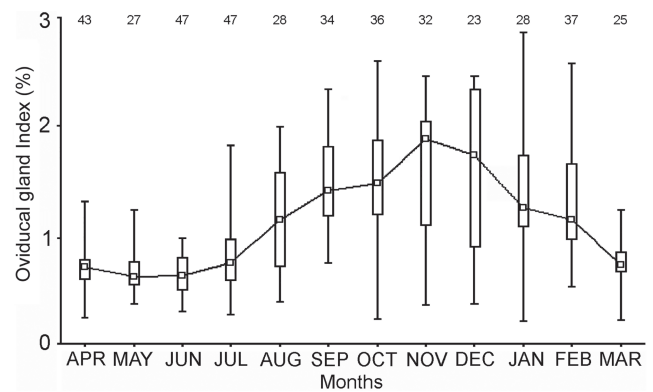


**Fig. 6.** Monthly variation of the hepatosomatic index (HSI) of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Mature males (■) and mature females (□). Boxes indicate the percentiles 25- 75%; the inner square indicates the median value and bars the range of data distribution. The number of individuals analysed is given in dark grey for females and black for males.

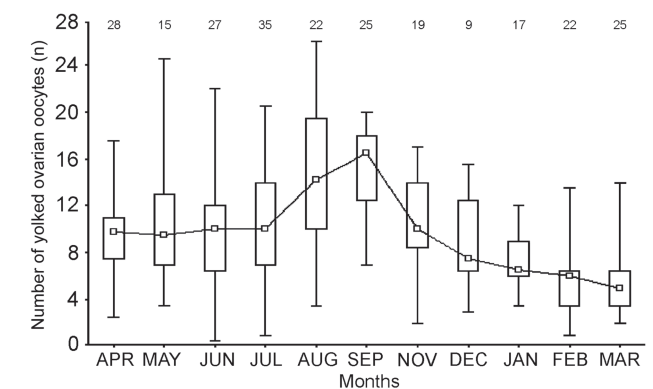
The OGI differed significantly throughout the year ( $H= 181.42$ ;  $d.f.= 12$ ;  $P< 0.001$ ). It increased from July to November, when its maximum value was recorded, and then decreased until March (Fig. 8). The NYO and MOD also varied significantly throughout the year ( $H= 79.918$ ;  $d.f.= 11$ ;  $P< 0.001$  for the NYO and  $H= 95.73$ ;  $d.f.= 11$ ;  $P< 0.001$  for the MOD). The NYO increased from July to September-October and after that, decreased until March, when the minimum value was recorded (Fig. 9). The MOD increased from July to December, it remained stable during January and February and it decreased after those months (Fig. 10).



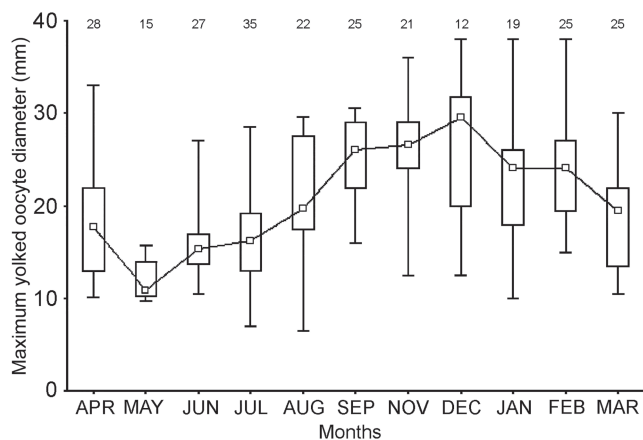
**Fig. 7.** Monthly variation of the gonadosomatic index (GSI) of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Mature males (■) and mature females (□). Boxes indicate the percentiles 25-75%; the inner square indicates the median value and bars the range of data distribution. The number of individuals analysed is given in dark grey for females and black for males.



**Fig. 8.** Monthly variation of oviducal gland index (OGI) of mature females of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Boxes indicate the percentiles 25-75%; the inner square indicates the median value and bars the range of data distribution. The number of samples is given in black.



**Fig. 9.** Monthly variation of the mean number of yolked ovarian oocytes (NYO) of mature females of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Boxes indicate the percentiles 25-75%; the inner square indicates the median value and bars the range of data distribution. Individuals sampled during September and October were analyzed together. The number of samples is given in black.



**Fig. 10.** Monthly variation of the mean diameter of the maximum yolked ovarian oocyte (MOD) of mature females of *Sympterygia bonapartii* from San Matías Gulf (Argentina). Boxes indicate the percentiles 25-75%; the inner square indicates the median value and bars the range of data distribution. Individuals sampled during September and October were analyzed together. The number of samples is given in black.

**Discussion**

Individuals of *S. bonapartii* exhibited maximum sizes and sizes at maturity smaller than those reported in previous studies (Tab. 5). At least three hypotheses may account for the differences noted. First, the studies differ in the extension of the sampling area, depth range, the sampling procedure and the fishing gear employed. As a result, different sizes of fish may be selected, modifying the size frequency distributions obtained in each work. The differences between the present study and the one of Estalles *et al.* (2011) are included in this category since in 2011 only the commercial fraction was analysed. The

differences may be due to a bias in the size frequency distributions of the skates as a result of the selection of the largest sizes carried out by fishermen on board. The second hypothesis is the presence of geographic variations in the morphological characteristics of the individuals. Increments of skate’s size along latitudinal gradients have been reported for many species. They are the consequence of temperature induced changes in growth and metabolism (Frisk, 2010). On the contrary, in SMG, skates exhibited smaller sizes than those recorded in northern locations. This can be related to the unique hydrographic characteristics of the SMG which during spring and summer presents temperatures higher than northern locations.

The last hypothesis is related to fishing. Fish populations under fishing pressure can exhibit changes in their growth rates, size at maturity and reductions in their maximum sizes as a consequence of the selective removal of fish (Kuparinen, Merilan, 2007). During the period 1995-2005, *S. bonapartii* from SMG experienced a significant reduction in size, probably as a consequence of fishing mortality (Estalles, 2012). A change in size at maturity was already recorded for other skate, the yellownose skate *Zearaja chilensis* (Guichenot, 1848) as a consequence of decades of heavy exploitation in the South Western Atlantic (Paesch, Oddone, 2008).

Individuals from SMG exhibited sexual dimorphism. Females were larger, heavier and presented heavier livers and wider discs than males of the same TL. Females also matured at larger sizes than males. This pattern of sexual dimorphism in elasmobranch fishes is usually related to an increment in fecundity of the females with larger sizes (Cortés, 2004). However, in skates this trend is not as clear and there are well documented cases of sexes maturing at similar sizes and cases of males maturing at larger sizes than females (Frisk, 2010).

**Tab. 5.** Comparative size ranges and sizes at maturity reported for *Sympterygia bonapartii* from San Matías Gulf (Argentina). TL<sub>50%</sub>: Size at which 50% of the individuals reach maturity. AUCFZ: Argentine-Uruguayan Common Fishing Zone. GSM: San Matías Gulf. Estimated using clasper length (\*).

Sex	n	TL range (mm)	TL <sub>50%</sub> (mm)	Sampling year	Location	Reference
M	92	472-768	584	2011-2012	Southern Brazilian coast (31°29'-34°28'S)	Basallo, Oddone, 2014
F	125	308-791	599			
M	282	200-746	651	1999-2000	AUCFZ and Buenos Aires Province (34°-42°S)	Mabragaña <i>et al.</i> , 2002
F	245	227-808	636			
M	123	410-780	520-570(*)	1994-1998	AUCFZ (34°30'-39°30'S)	Oddone, Velasco, 2004
F	436	300-790	655			
M	210	155-734	580	2004-2010	Buenos Aires Province, Bahía Blanca estuary (39°S)	Díaz Andrade, 2010
F	387	155-780	625			
M	489	320-690	560	2007-2009	Río Negro Province, GSM (41°-42°S)	Estalles <i>et al.</i> , 2011
F	1168	340-750	590			
M	812	185-687	545	2004-2009	Río Negro Province, GSM (41°-42°S)	Present study
F	1254	180-742	594			

Several indexes and the presence of females with egg capsules were analysed to assess the reproductive cycle of *S. bonapartii*. In aquaria, the species is able to reproduce throughout the year (Jañez, Sueiro, 2009). However, in this study the analysis indicated that the species presents a seasonal reproductive cycle. The present findings are consistent with those obtained in another study in which wild fishes were analysed (Mabragaña *et al.*, 2002). The differences between individuals held in captivity and those from the wild may be the result of the constant environmental conditions of temperature, photoperiod and salinity of the aquaria (Jañez, Sueiro, 2009).

The mating season of *S. bonapartii* may be set from July to December (winter-spring). During this period, males recorded the minimum values of GSI while females recorded their maximum ones. For males, the minimum values of GSI were used as indicators, since during mating; the weight of the gonads decreases as the sperm moves down the reproductive tract. For females, the maximum values of GSI served as indicators, since as ovulation approaches, the ovaries increase their weight as a result of the storage of yolk in the oocytes (Wilk *et al.*, 1990). For females, HSI showed a seasonal pattern similar to that observed in GSI, NYO and MOD, suggesting a relationship between the liver and reproduction. The liver as well as ovaries are involved in yolk production. Thus, the decrease in HSI values may be due to the constant requirement of vitellogenin, the principal component of yolk, during the egg-laying season (Hamlett, Koob, 1999). In addition, the liver is the organ of energy reserve, and variations in HSI values are associated with the amount of lipids in it (Bone, Roberts, 1969). The irregular pattern observed in HSI values for males make the interpretation difficult. It may be the case that HSI values may be modified as a consequence of a variation in the lipid reserves.

The egg-laying season of *S. bonapartii* may be set from September-October to February (spring-summer). During these months, an increment in the values of the OGI and MOD was recorded together with the presence of females bearing egg capsules. The increment in the values of OGI may be related to the enlargement of the oviducal glands recorded during the mating and the egg-laying season (Galíndez *et al.*, 2010). The increment in MOD values may point out that oocytes were accumulating yolk and were ready to be ovulated when the maximum values were reached. In addition, the NYO diminished after September-October indicating that ovulation was undergoing. During March, the GSI, OGI, MOD and NYO in females exhibited low values, suggesting the end of the reproductive season.

Coinciding with the interpretation of the indexes analysed, females with egg capsules were only recorded from November to February. During these months, their proportion among mature females was <23%. These low records could be the result of a short- distance seasonal migration of *S. bonapartii* to a spawning area. According to previous studies, this species uses shallow areas <50 m near estuaries as egg-laying zones (Mabragaña *et al.*,

2002). Within the limits of SMG there are no estuaries and there is no evidence that *S. bonapartii* could migrate long-distances outside SMG boundaries to use a spawning area. Moreover, according to mark-recapture studies conducted in other species that reach similar sizes, skates live in confined areas and only make short- distance migrations, probably to reproduce (Templeman, 1984; Walker *et al.*, 1997).

Within the limits of the gulf, a spawning area could possibly be settled in its northern region. This particular environment, which is influenced seasonally by the dynamics of the thermohaline front, has been reported as the spawning area of the chondrichthyan *Callorhynchus callorhynchus* (Linnaeus, 1758) (Di Giacomo, Perier, 1994).

If *S. bonapartii* uses a spawning area in the northern region of the gulf, females bearing egg capsules will be outside the operating range of the local fleet. During spring (October and November) the fleet is restricted to operate in its southern area (41°30' S) due to the establishment of a seasonal closure to protect the reproduction of *M. hubbsi*, the target species of the bottom trawl fishery. In addition, during summer (January to March) the fleet operates in its southeast region at a depth range averaging from 125 to 135 m, where the maximum yields of *M. hubbsi* are obtained (Romero *et al.*, 2013). Most of the samples of *S. bonapartii* collected in this study came from fishing vessels. The movement of the species beyond the fishing grounds could thus explain the low proportion of females bearing egg capsules recorded.

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