

Reproductive biology of *Atlantoraja cyclophora* (Regan 1903) (Elasmobranchii: Rajidae) off southern Brazil

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A total of 459 (245 females, 214 males) *Atlantoraja cyclophora* was captured by bottom trawl off the coast of Rio Grande do Sul between 30°40' S and 34°30' S during surveys conducted in winter 2001 and summer/autumn 2002 at depths of 100–300 m. Total length at maturity was 52.8 cm for females and 48.5 cm for males. Symmetry and functional parity of the gonads were observed in both sexes, but there was no significant temporal variation in either sex for any of the reproductive parameters studied. Ovulation and egg-deposition were similarly intensive in both seasons. In adult females, there was an ovarian resting period at an individual level, though it was not synchronized at a population level. Distribution of egg-bearing females was not related to depth or species' range.

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Introduction

Skates (Rajidae) are important in mid-temperate waters. Their life history and ecological characteristics differ significantly from those of commercial bony fish (Walker, 1999) and, like other elasmobranchs, they are very sensitive to fishing pressure (Hoenig and Gruber, 1990). Fisheries can have strongly negative effects on their abundance and distribution (Walker and Heessen, 1996) if fishing effort is disproportional to the ability of the stock to replenish itself. However, successful sustainable fisheries for sharks are feasible, particularly for smaller species that mature early and have a relatively large number of young (Musick, 2004). The first species of elasmobranch to have been reported to become locally extinct was *Dipturus batis* in the Irish Sea, followed by *Dipturus laevis* off the Atlantic coast of Canada, both becoming extremely rare in their overall distribution areas (Brander, 1981; Casey and Myers, 1998). Dulvy *et al.* (2000) recently confirmed the disappearance of *D. laevis* from the Irish Sea, and reported that two more species had disappeared from substantial parts of their ranges: *Dipturus oxyrinchus* and *Rostroraja alba*. As a result of overfishing, seven additional species of large

skates are likely to disappear if they continue to be exploited in the same manner as the four that are already extinct (Dulvy and Reynolds, 2002).

Knowledge of the reproduction and development of elasmobranch fish is crucial in developing responsible management strategies (Leonard *et al.*, 1999), and estimates of mean length at first maturity are required for stock assessment. Skates are taken as bycatch in all demersal (bottom trawl) fisheries, and in recent years they have been landed for human consumption from the North Sea, the Irish Sea, and the Mediterranean Sea (Walker, 1999). In the port of Rio Grande (Rio Grande do Sul State, Brazil), the quantity of skates (and rays) landed depends on the size of the teleost catch; when the teleost catch is small, more skates are landed and sold. The exploitation of immature skates is a serious problem for management; their survival on being returned to the sea is crucial if they are to contribute to the next generation (Walker and Hislop, 1998).

International demand for skate and ray meat (Rajidae and Myliobatiforms) has led to an increasing interest in elasmobranch fisheries in Brazil (Mazzoleni and Schwingel, 1999). In Santa Catarina State, skate and ray landings

derived mainly from the Rio Grande do Sul shelf made up 71% of the total fish landings in 1992, varying from 420 to 507 t between 1984 and 1991, though falling to 259 t in 1992 (IBAMA, 1995). Recently, the quantity landed has increased noticeably, attaining 776 t in Rio Grande do Sul State and 1458.5 t in Santa Catarina (19% and 34% of the total demersal elasmobranchs landed, respectively; CEPsul/IBAMA, 2001). Although nowadays the quantity landed depends on the teleost fish catch, the situation was different in the 1980s; all skates were then returned to the sea immediately after being caught (Haimovici and Palacios, 1981). *Atlantoraja cyclophora*, together with other rajids, is landed in Rio Grande and used mainly for local consumption and also in the processing of blue crab meat (*Callinectes* spp.; known locally as siri).

Atlantoraja cyclophora (Rajidae: Arhynchobatinae), formerly classified in the genus *Raja*, is endemic to the Southwest Atlantic, from Cabo Frio, Rio de Janeiro State, southern Brazil (22°S), southwards to 47°S, the Gulf of San Jorge in Argentina (Menni and Stehmann, 2000), where it is more frequently encountered in coastal waters. However, it is found up to 200 m deep off Uruguay (Cousseau and Perrotta, 2000). Off southern Brazil it completes its life cycle entirely in local waters (Vooren, 1997) and is abundant in coastal waters (Figueiredo, 1977) at depths to 300 m (Vooren, 1997; Oddone, 2003). Maximum total lengths (TL) observed by Figueiredo (1977) were 55 cm for females and 46 cm for males off southeastern Brazil. Oddone (2003), however, recorded maximum total lengths of 64.5 cm and 63.5 cm for females and males, respectively, off southern Brazil. The egg capsule of *A. cyclophora* is dorsally convex and ventrally flat, with marked longitudinal striation and mean dimensions of 68 mm (length) and 39 mm (width), with a pronounced velum that distinguishes it from the egg capsule of *A. platana* (Oddone *et al.*, 2004).

Material and methods

Two bottom trawl surveys were carried out by the RV “Atlântico Sul” at depths of 100–600 m over the outer shelf and upper slope of southern Brazil in 2001 and 2002, and samples of *A. cyclophora* were obtained from off Rio Grande do Sul State and used to study sexual development and reproduction. In all, 459 *Atlantoraja cyclophora* (245 females, 214 males) were caught. The main catch area for the species was situated between Chuí and Cabo Santa Marta Grande (Figure 1), between 30°40'S and 34°30'S. Detail of the trawling stations, showing presence and absence of *A. cyclophora* by season and sex during the surveys, is given in Figure 1 of Oddone and Vooren (2004).

Cruises were undertaken in August/September 2001 and March/April 2002 (Table 1). Hereafter, these surveys are referred to as “winter” and “summer” surveys, respectively. The stretched mesh of the trawlnet was 160 mm at

the mouth of the net and 70 mm in the codend, but the latter was fitted with a liner of 27 mm mesh. The groundrope was 39 m long and fitted with short lengths of chain to a rockhopper gear. Sampling was conducted in two stages in eight latitudinal strata (each 100 km wide) perpendicular to the coast, subdivided into seven depth strata of 100–149 m, 150–199 m, 200–249 m, 250–299 m, 300–399 m, 400–499 m, and 500–599 m. A single 30-min tow was made within each depth stratum at a speed of 5.4 km h⁻¹.

Skates were measured immediately after capture: total length (mm), disc width (DW, mm), and gonad weight (GW, g), including the epigonal organ. In males, the length and rigidity of the clasper, the siphon gland length, the number of alar thorns, the number of rows of alar thorns, and the diameter of the biggest lobule of the testis were recorded. Alar thorns that were soft or not fully formed were recorded as “developing”, appearing as a circular mark darker than the surrounding epidermis. The length of the clasper was measured *sensu* Compagno (1984), from its insertion to its distal end. Claspers were classified manually as “rigid” when the organ resisted deformation, and “flexible” when it was soft and easily bent. In order to see and measure the siphon gland, the musculature of the ventral side of the pelvic fin was removed. In females, the widths of the nidamental gland (NGW) and uterus, the diameter of the largest follicle of each ovary and its colour, and the presence or absence of egg capsules in uteri and/or the cloaca were recorded. Length measurements had a precision of 0.1 cm. In the analysis, TL was grouped in classes of 1.0 cm. Weights were determined with a beam balance with a precision of 0.1 g for weights up to 18 g, 1 g for weights from 18 to 240 g, and 2 g for weights > 240 g.

The gonadosomatic index (GSI) of each individual was calculated as (gonad weight/viscerated weight) × 100. Viscerated weight is a more appropriate variable than TW because it is not influenced by individual variation of the mass of the digestive tract, liver, and reproductive organs (Perez and Vooren, 1991).

Reproductive variables were analysed in relation to TL as the independent variable. Hubbs and Ishiyama (1968) recommend DW as the most suitable variable for studying morphometry in skates, but Templeman (1987a) recommends the use of TL because, in trawl-caught fish, DW is greatly influenced by muscular contraction on capture. A logistic growth model was fitted to the relationship between the fraction of mature males or females as a function of TL:

$$P_{TL} = 1 / (1 + e^{(a+bTL)})$$

where P_{TL} is the fraction mature in length class TL, and a and b are the model parameters. With this model, mean size at first maturity, TL_{50} , was estimated by $-a/b$, which represents the body size at which 50% of the fish are mature (Restrepo and Watson, 1991; White *et al.*, 2001). A second meaningful parameter that can be calculated to characterize

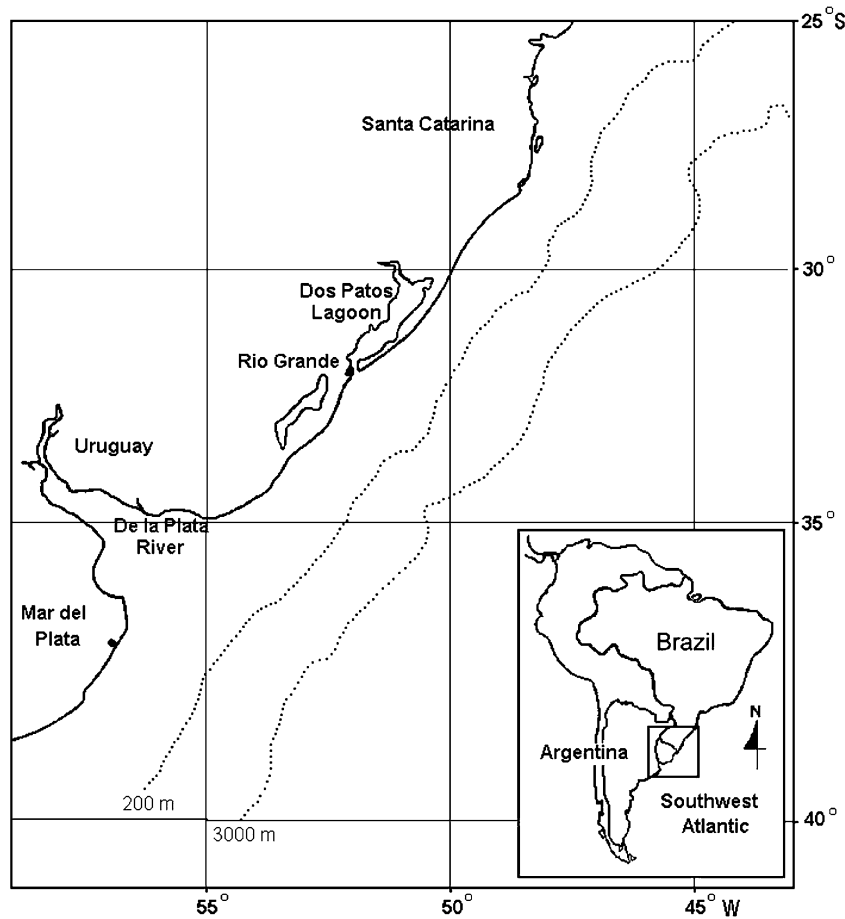


Figure 1. Map of the study area where the cruises were carried out.

maturation level is the value of the parameter b , i.e. the slope at TL_{50} ($S = b/4$; Mollet *et al.*, 1999). Therefore, the value of parameter b was calculated. The analysis of the relationship between clasper length and TL is the most common method for estimating size-at-maturity in male elasmobranchs, size-at-maturity corresponding to the inflexion point of the resulting sigmoid curve (Capapé, 1974; Capapé and Quignard, 1974; Templeman, 1987b).

Table 1. Dates of the surveys from which data were collected for this study.

Cruise	Date		
	First leg	Second leg	Third leg
Winter	8–11 August 2001	14–24 August 2001	31 August–12 September 2001
Summer	24–28 March 2002	2–11 April 2002	16–26 April 2002

Therefore, the logistic model described above was fitted to the relationship between clasper length and TL.

The significance tests used were “one-way” and “two-way” ANOVA (Zar, 1984), Student’s t -test (Sokal and Rohlf, 1987), and χ^2 (Chase, 1976). The degrees of freedom (d.f.) and F value for the ANOVAs, the value of t and d.f. for the t -test, and the χ^2 value for the χ^2 test, are presented where appropriate. In the case of the χ^2 test, the sub-index indicates the degrees of freedom. The significance level used for the tests was 0.05. Means and standard deviations are expressed as mean \pm s.d., and n is in all cases the size of the sample.

Results

Sexual development of the male

There were 1–6 rows of alar thorns, all males ≥ 47.0 cm TL having at least one row well-developed. For all TL classes, the mean number of rows of alar thorns was 3 (right pectoral fin ± 1.24 ; left pectoral fin ± 1.18 ; $n = 182$) and

the mean number of alar thorns in each pectoral fin was 35 (right pectoral fin ± 15.4 ; left pectoral fin ± 14.7 ; $n = 182$). Fish from 29.0 to 52.0 cm TL had a single row of developing alar thorns, but from a TL of 52.0 cm, there were developing alar thorns in all TL classes, though only in the parts of the rows with well-developed thorns (Figure 2a).

The siphon gland length increased rapidly at lengths of 42.0–47.0 cm TL, but thereafter more slowly (Figure 2b). To a TL of 45.0 cm, the gland was thin, with length varying between 1.0 and 3.0 cm and a maximum width of 0.5 cm, translucent white, and totally imbedded in the musculature. Most of the fish of TL ≥ 47.0 cm had fully developed siphon glands 4.0–5.0 cm long, light yellow, visible through the skin on the ventral side of the pelvic fins, and fixed to the musculature on their dorsal side, but with their ventral side exposed to the cavity of the siphon.

Both testes were functional, inserted in the epigonal organ, and there was no significant difference in the mean weight of the right and left testes ($t = 0.87$; $p = 0.3831$; d.f. = 425). There were two phases in the relationship between gonad weight and TL (Figure 3a). Up to 44.0 cm TL, testes weight varied between 0.2 and 3.2 g, with lobules of diameter 0.1–0.3 cm. In the second phase, the increase in the gonad weight was rapid: from 4 g at a TL of

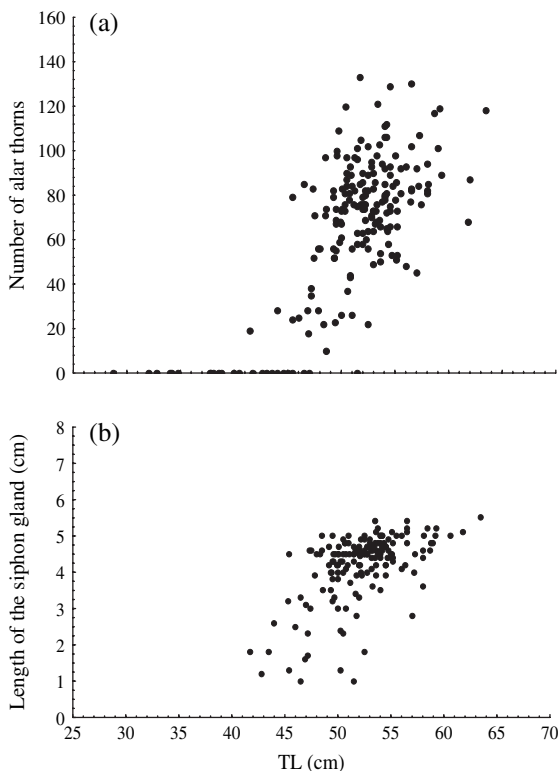


Figure 2. Relationship between total length (TL) and (a) number of alar thorns and (b) length of the siphon gland in male *Atlantoraja cyclophora*.

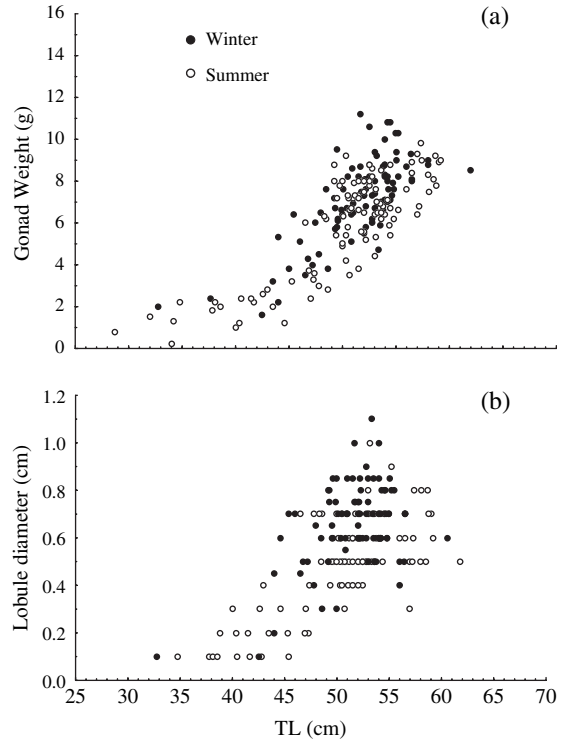


Figure 3. Relationship between total length (TL) and (a) gonad weight and (b) lobule diameter for male *Atlantoraja cyclophora*.

45 cm to 8–10 g at a TL > 55 cm, and lobule diameters to 0.3–1.2 cm at a TL of 48–55 cm. At TLs of 45.0–47.0 cm, the lobule diameters increased rapidly to 0.5–0.9 cm (Figure 3b).

The relationship between GSI and TL also changed at around 45.0 cm TL, values of 0.3–0.8 dominating at a TL < 45 cm, and values of 0.8–1.4 at a TL > 45.0 cm (Figure 4a). Therefore, gonads fully develop from 45.0 cm TL, when gonad weight is > 4 g, testicular lobule diameter > 0.5 cm, and GSI > 0.8 . However, from 45.0 cm TL, testes continued to grow proportionally with the rest of the body, so the same GSI level of 0.8–1.2 was maintained, but with GW increasing to as much as 8–10 g at TLs > 55.0 cm. The growth of the claspers in relation to the TL occurred in three phases: (i) slow growth from 28.0 to ~ 47.0 cm TL, with the clasper length varying from 1.0 to 7.0 cm; (ii) rapid growth, i.e. an inflexion point of the sigmoid curve, at a TL of 42 cm ($b = 0.33$, $r^2 = 0.93$, $n = 201$), with the clasper length increasing from 7 to 13 cm; (iii) a second phase of slow growth from ~ 49.0 TL (Figure 4b). The smallest male with a calcified clasper was 47.0 cm TL, and the largest male with an uncalcified clasper was 53.0 cm TL. Claspers longer than 12.0 cm were always calcified. The siphon gland and alar thorns were fully developed by the second slow growth phase, but full gonadal development was also found at a smaller size of 45.0 cm TL. From the relationship between the fraction of

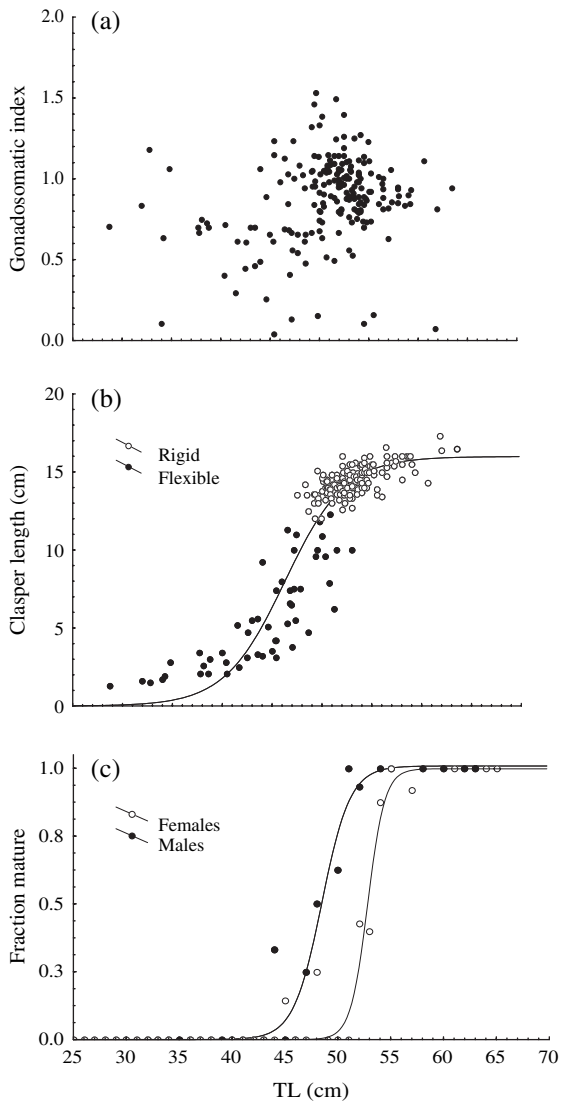


Figure 4. Relationship between total length (TL) and (a) male gonadosomatic index, (b) clasper length, and (c) proportion mature for each sex of *Atlantoraja cyclophora*.

mature specimens and size classes, TL_{50} was estimated to be 48.5 cm ($b = 0.75$, $r^2 = 0.98$, $n = 26$; Figure 4c).

Sexual development of the female

Both ovaries were functional in *Atlantoraja cyclophora*, and there was no significant difference between the weight of the right and the left ovary ($t = 0.28$; $p > 0.05$, d.f. = 462). The relationship between GW and TL reveals two phases of growth, in weight, of the ovaries: (i) slow growth of 0.6–9 g at TLs < 51.0 cm; (ii) rapid growth from 10 to 63 g from a TL of 52.0 cm, with vitellogenic follicles being observed (Figure 5a). In terms of the relationship between GSI and TL, there were also two phases, the

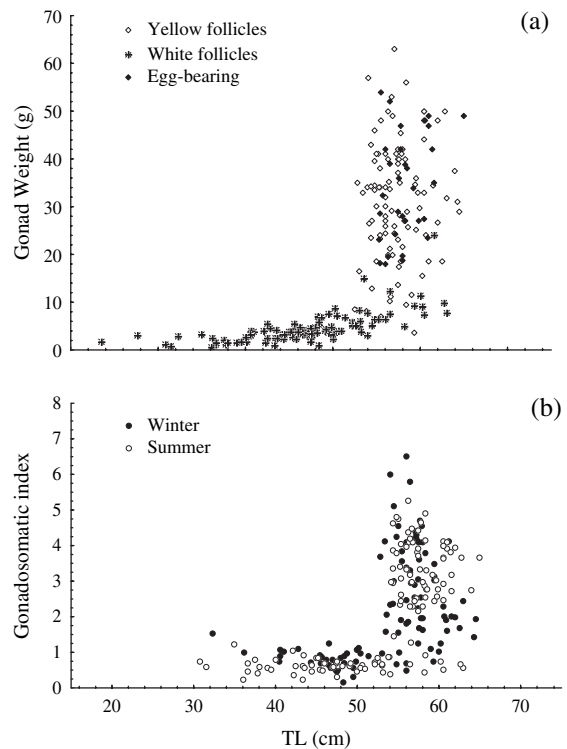


Figure 5. Relationship between total length (TL) and (a) gonad weight and (b) gonadosomatic index for female *Atlantoraja cyclophora*.

change occurring at a TL of 52.0 cm (Figure 5b). At TLs < 52.0 cm, the GSI remained constant, with values of 0.5 dominating, but from 52.0 cm TL there was a marked increase, GSI values reaching 1–7.5. Therefore, gonads were fully developed at 52.0 cm TL, when the GW was > 10 g. Thereafter, GW no longer increased with TL, but varied between 10 and 57 g in all the TL classes. Consequently, the GSI diminished with TL, from a mean value of 3.07 at 53.0–59.0 cm TL to 2.54 at 60.0–65.0 cm TL, a statistically significant decrease ($t = 2.01$; $p < 0.05$, d.f. = 121).

The relationship between TL and the largest follicle diameter developed in two phases: (i) slow growth, varying from 0.1 to 0.8 cm follicle diameter at 28.0–51.0 cm TL; (ii) rapid growth from a TL of 52.0 cm, vitellogenic follicles of 2–3 cm diameter being found in all TL classes (Figure 6a). All follicles with diameters ≥ 0.9 cm were vitellogenic. Ovaries containing only white, non-vitellogenic follicles with diameters < 0.9 cm were found up to a TL of 63.0 cm, i.e. at TL classes greater than the TL at which gonads were fully developed. All egg-bearing females had vitellogenic follicles with diameters ≥ 1.5 cm. Mean uterus width increased slowly with TL at TLs < 52.0 cm, values varying between 2 and 6 mm, and thereafter more rapidly. From 52 cm TL, the uterus varied greatly in width, from 7 to 29 mm in females without egg capsules but with vitellogenic

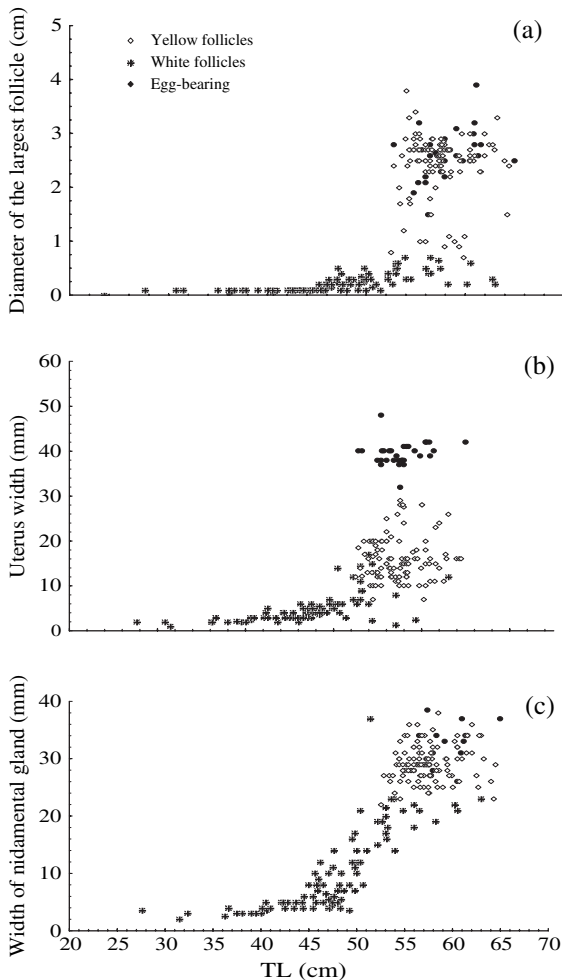


Figure 6. Relationship between total length (TL) and (a) diameter of the largest ovarian follicle, and the width of the (b) uterus and (c) nidamental gland of female *Atlantoraja cyclophora*.

follicles, and from 31 to 48 mm in females with egg capsules (equal to the width of the egg case). Females with egg capsules in the uterus or cloaca were found from a TL of 54.0 cm (Figure 6b).

The NGW varied in relation to TL in three phases: (i) up to 45.0 cm TL, width varying from 2 to 5 mm, (ii) from 50 to 52.0 cm TL, NGW increasing rapidly and varying from 6 to 20 mm (these two phases were notable for the presence of white, non-vitellogenic ovarian follicles); (iii) from 53.0 cm TL, width varying from 20 to 40 mm, with no relation to TL and vitellogenic follicles dominating (Figure 6c). As a consequence of the presence of some females with white follicles and no vitellogenic activity at all TL ranges, the presence or absence of vitellogenic follicles could not be used as a unique criterion for classifying a female as sexually mature in this species. Instead, females were classified as mature when they showed one or more of the following characteristics: (i) ovary weight ≥ 10 g; (ii) uterus width

≥ 6 mm; (iii) nidamental gland width ≥ 20 mm; and (iv) vitellogenic follicles ≥ 9 mm.

From the relationship between the fraction of mature specimens and total length classes, the TL_{50} of females was estimated to lie at 52.8 cm ($b = 1.24$, $r^2 = 0.98$, $n = 37$; Figure 4c).

Reproductive variability

Statistical tests for comparing mean values of reproductive variables for males between seasons were not appropriate for this study, because there were considerably more males in summer ($\chi^2_1 = 0.53$; $p < 0.05$). For adult females the differences between winter and summer means were not significant for GW (of vitellogenic ovaries; $t = -0.76$; d.f. = 106; $p > 0.05$), largest follicle diameter ($t = 0.5390$; $p > 0.05$; d.f. = 133), NGW ($t = -1.04$; $p > 0.05$; d.f. = 140), or uterus width ($t = 1.13$; $p > 0.05$; d.f. = 143). Of the 63 adult females caught in winter, 21% were egg-bearing, 13% had white ovarian follicles with diameters < 0.9 cm, and 66% had yellow vitellogenic ovarian follicles. In summer, of the 67 adult females, 27% were egg-bearing, 12% had white ovarian follicles with diameters < 0.9 cm, and 61% had yellow ovarian vitellogenic follicles. The relative frequency of egg-bearing females with egg capsules did not differ significantly between winter and summer ($F = 1.60$; $p > 0.05$; d.f. = 12). Similarly, among the adult females that did not carry egg capsules, the frequency of fish with white ovarian follicles did not differ significantly between seasons ($\chi^2_1 = 0.011$; $p > 0.05$). The modal value of the diameter of the largest follicle in adult females was 2.6 cm in both egg-bearing females and those that did not carry egg capsules (Figure 7); it is evident that follicles with diameters ≥ 2.6 cm were mature and ready for ovulation. In females with vitellogenic ovarian follicles, mature follicles were found with a relative frequency of 52.0% in females without egg capsules and 65.6% in egg-bearing females, neither being statistically significant ($\chi^2_1 = 5.7$; $p < 0.05$).

Egg-bearing females were found at depths of 100–299 m, without any seasonal trend, so there is clearly no relationship between depth and the distribution of egg-bearing females within the depth range of the species in the study area.

Discussion

Similar to the results of this study, *Mabragaña et al.* (2002) observed that mature male *Sympterygia bonapartii* had between 1 and 6 rows of alar thorns. An increase in the number of rows during sexual maturation was also registered for *Raja radiata* (Templeman, 1987b). Symmetry and functionality of both testes, as observed in *Atlantoraja cyclophora* males, have been observed in other male skates (Teshima and Tomonaga, 1986; Braccini and

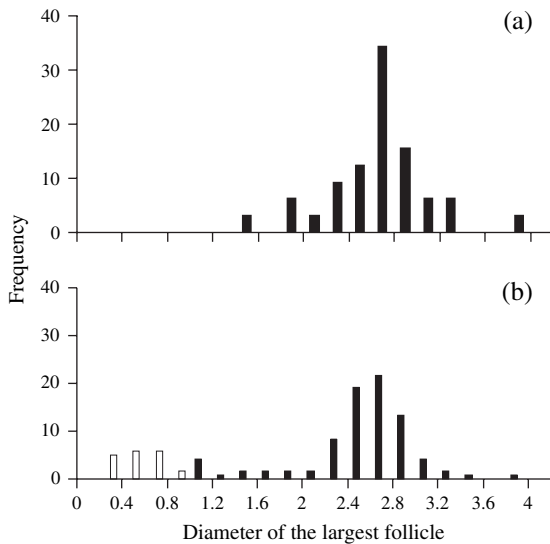


Figure 7. Relative frequency of the diameter of the largest follicle in (a) egg-bearing and (b) non-egg bearing female *Atlantoraja cyclophora*.

Chiaromonte, 2002), suggesting it to be a common pattern in rajids. Similar to the belief of Pratt (1988), lobular diameter of the testis in skates is clearly a good indicator of maturity (if the diameter of the largest lobule is recorded), despite the greater variability with increasing TL. Comparisons with other authors of the relationship between siphon gland and TL are not yet possible, because we could find no such studies in the literature.

Unlike in sharks, symmetry and functional parity of the ovaries are common in skates (Hobson, 1930; Teshima and Tomonaga, 1986; Walmsley-Hart *et al.*, 1999; Braccini and Chiaromonte, 2002; Mabrugaña *et al.*, 2002; Marçal, 2003). An abrupt increase in the GW immediately after the onset of sexual maturity has been reported for species such as *Raja asterias*, *R. wallacei*, and *R. pullopunctata* (Capapé, 1980; Walmsley-Hart *et al.*, 1999). Here, female *A. cyclophora* matured at a larger size than males. This is common in elasmobranchs (Jardas, 1973; Nottage and Perkins, 1983), and skates are no exception (Capapé, 1974; Fuentealba and Leible, 1990; Walker, 1999; Walmsley-Hart *et al.*, 1999; Marçal, 2003; Oddone and Velasco, 2004; Oddone *et al.*, 2005).

The presence of females with white follicles in TL classes where vitellogenesis and even egg-deposition had already begun, as well as the variation in GSI within adult females, indicates that some of our adult females contained ovaries in the resting stage, i.e. not producing vitellogenic follicles. An ovarian resting period has been noted for *Raja radula*, *R. miraletus*, *R. clavata*, *R. brachyura*, and *R. montagui*, and for seven *Bathyraja* species (Holden *et al.*, 1971; Capapé, 1974, 1976; Capapé and Quignard, 1974; Ebert, 2005). For the genus *Atlantoraja*, *A. platana* showed no evidence of an ovarian resting period (Marçal,

2003), and the situation for the third member of the genus, *A. castelnaui*, is as yet unrecorded.

In egg-bearing female *A. cyclophora*, the relative frequency of mature follicles was greater than in females not bearing eggs, so it is concluded that formation of the mature follicles is a continuous process that takes place throughout egg-deposition. The lesser frequency of mature follicles in egg-bearing females, as well as the presence of adult females with low GSI, indicates that this category includes (i) young females in the initial phase of their first reproductive cycle, and/or (ii) adult females ending their sexual resting period, described below. Because of this, special care should be taken in using data on the presence or absence of mature vitellogenic follicles as a criterion for discerning between mature and immature female rajids. The duration of the ovarian resting period in *A. cyclophora* is not defined temporally, but it appears to take place at an individual level, because sexually resting females were found at the same percentage in both winter and summer. The same proportion of egg-bearing but sexually resting females was found in winter and at the end of the summer, when sampling for this study was carried out (13% and 12% of adult females, respectively). This leads to us formulating two hypotheses on the reproduction of *A. cyclophora*: (1) an annual cycle with continued reproductive activity throughout the year, but with no peaks; (2) an annual cycle with at least one peak in reproductive activity in spring and/or autumn, though in neither of which season was sampling carried out for this study. Both hypotheses agree with two of the three reproductive cycles proposed for elasmobranchs by Wourms (1977). In *Raja clavata*, *R. montagui*, *R. navesus*, and *R. radiata*, there were no seasonal trends in GSI (Walker, 1999). Annual reproductive cycles have been described for *Raja clavata*, *Dipturus chilensis*, *A. platana*, and *A. cyclophora* (Holden, 1975; Fuentealba and Leible, 1990; Ponz Louro, 1995; Marçal, 2003), so these references support hypothesis (1).

Holden *et al.* (1971) demonstrated that the rate and peaks of egg-deposition in *Raja clavata*, *R. brachyura*, and *R. montagui* are dependent on water temperature. In years of higher mean water temperature, females with vitellogenic follicles were observed during winter. Further, the same proportion of egg-bearing females of *A. cyclophora* observed over winter and summer has been related to an absence of variation in bottom water temperature between sampling seasons (Oddone, 2003). Before drawing definitive conclusions, however, it should be noted that, within a single species, egg production can vary from one year to the next (Walker and van Steenbergen, 1999).

A. cyclophora size-at-maturity has not been recorded before. For the other two species of the genus *Atlantoraja*, size-at-maturity has been recorded for *A. castelnaui* from the Argentina–Uruguay Common Fishing Zone (34°30'S–39°30'S; Oddone *et al.*, 2005), and for *A. platana* from southern Brazil (Marçal, 2003). Female and male

A. castelnaui mature at 110–114 cm and 91–95 cm, respectively, whereas female *A. platana* reach maturity at 69 cm TL and males at 63 cm TL. Size-at-maturity in skates is an important parameter for distinguishing different populations of a single species, and for estimating whether changes in this parameter for a given population are attributable to fishing pressure (Templeman, 1987b).

Survivorship analysis of *A. cyclophora* is not yet possible because of the absence of data on age and growth. As age classes for this sample cannot yet be determined, we were unable to construct a catch curve. Future research on age and growth may make it possible to obtain age-at-50% maturity, in order to construct the life table basic to developing and advising suitable management strategies for the species. In any event, reproductive activity of *A. cyclophora* is not limited to depths of 100 m. Ponz Louro (1995) recorded mature specimens and oviposition at depths ranging from 10 to 100 m off the Ubatuba coast, São Paulo State, Brazil.

Oddone and Vooren (2004) noted the absence of neonates and the scarcity of small juvenile *A. cyclophora* in samples obtained with bottom trawls, indicating that this type of fishery could have a low direct impact on juveniles. This fact, previously observed for other skates (Braccini and Chiamonte, 2002), has important implications for management of skates, because fishing mortality on young skates could be avoided.

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