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Length at maturity of the greeneye spurdog shark, *Squalus mitsukurii* (Elasmobranchii: Squalidae), from the SW Atlantic, with comparisons with other regions

Luis O. Lucifora^A, Juan L. Valero^B and Verónica B. García^C

^AUniversidad Nacional de Mar del Plata, Departamento de Biología, Casilla de Correo 82, Mar del Plata (7600), Argentina. email: lolucif@mdp.edu.ar

^BUniversity of Washington, School of Fisheries, 357980 Seattle, WA 98195, USA

^CA. Saenz 3250 1ro A, Punta Mogotes, Mar del Plata (7600), Argentina

Abstract. Size at maturity is analysed for *Squalus mitsukurii* from the SW Atlantic. Males mature between 51 and 55 cm total length and females between 52 and 60 cm total length. Hence, *S. mitsukurii* appears to be intermediate in size at maturity among the SW Atlantic squalid sharks. This analysis adds evidence of the plasticity of *S. mitsukurii* in size at maturity. The length–weight relationship did not differ between sexes in the SW Atlantic population, whereas it differed in one population from the NW Pacific. Intersexual differences in size at maturity in the present study were lower than those reported for other regions.

Extra keywords: reproduction, geographic variability, life-history.

Introduction

Different stocks or populations of a species may have different biological characteristics (e.g. Branstetter *et al.* 1987; Bonfil *et al.* 1993), and a species may show high variability in quantitative aspects of its life-history. This plasticity may allow a species to inhabit a variety of environments.

Besides their importance in understanding the dynamics of a population, life-history traits are crucial in fishery management. Length at maturity is of special interest in fisheries, given its wide use as an indicator of minimum permissible size at capture. The life-history traits of elasmobranchs make this group extremely susceptible to overfishing (Hoenig and Gruber 1990), and insufficient knowledge of the life-history traits of elasmobranchs in the SW Atlantic may lead to mismanagement of the species in this group.

The greeneye spurdog shark, *Squalus mitsukurii*, is a widely distributed species; it occurs from southern Japan to Vietnam and the Philippines, western India, southern Australia, New Caledonia, New Zealand, Hawaii, the USA Atlantic coast, the Gulf of Mexico, Peru to northern Chile, Brazil to Argentina, the Gulf of Guinea to northern Namibia, and Kenya to north-eastern South Africa (Compagno 1984; Last and Stevens 1994). Its variability in reproductive parameters has recently been noted by Taniuchi *et al.* (1993) who examined specimens from four NW Pacific localities. In the SW Atlantic *S. mitsukurii* is caught as by-catch in the main fishery of this region, which targets Argentine hake, *Merluccius hubbsi*. In spite of this high fishing pressure, the biology of SW Atlantic populations of *S. mitsukurii* is almost unknown. Thus, the objective of this paper is to present the

first estimates of length at maturity of *S. mitsukurii* from SW Atlantic waters and to compare them with the information available from other regions.

Methods

Sampling was carried out during December 1997 around the La Plata River mouth (36°05'S to 36°39'S and 53°23'W to 53°48'W). The specimens were caught in a bottom-trawl net at depths between 119 and 141 m. Individuals were frozen at sea and subsequently analysed in the laboratory.

In total, 112 specimens (28 females and 84 males) of *S. mitsukurii* were available for examination. The data taken from each specimen were: sex, total length (to the nearest centimetre) and weight (precision: 25 g). Intersexual differences in length–weight relationships were assessed by testing for differences between the slopes of the regression lines made with the ln-transformed data (Zar 1984).

Male maturity was estimated by the following indicators: clasper length relative to total length, degree of clasper calcification and presence of sperm (Yano 1995). Female maturity was estimated by either examining characteristics of uteri and ova or noting the presence of embryos within the uteri (Yano and Tanaka 1987; Yano 1995; Wetherbee 1996). Females were considered mature if they had ribbon-like uteri, developed ovarian eggs or embryos within the uteri. In contrast, females were considered immature when their uteri were thread-like, and when neither ovarian eggs nor embryos were found.

Results

Length–weight relationships did not differ significantly between the two sexes ($t = 0.98$; $df 85$; $P > 0.2$) (Fig. 1), so a pooled length–weight relationship for the two sexes was calculated. This relationship is described by the following equation ($r^2 = 0.92$), with weight in g and total length in cm:

$$\ln(\text{weight}) = 2.7742 \times \ln(\text{total length}) - 4.5536$$

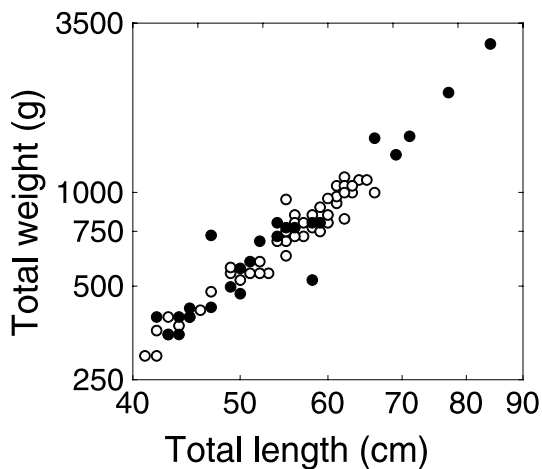


Fig. 1. Length–weight relationship (in ln scales) for *Squalus mitsukurii* from the La Plata River mouth (SW Atlantic). ●, females; ○, males.

The longest measured specimen was a female 84 cm total length (TL). The longest male was 66 cm TL. Male greeneye spurdog sharks mature between 51 and 55 cm TL (Fig. 2). All females smaller than 52 cm TL were immature and all females longer than 60 cm TL were mature (83.3% carrying embryos within uteri) (Fig. 3). Moreover, the smaller mature female was pregnant. All mature females had ribbon-like uteri much wider than 6% of total length and macroscopic ovarian eggs with vitellae. This suggests that the onset of maturity for females is in the range of 50–60 cm TL.

Discussion

These results add evidence of the plasticity of *S. mitsukurii* both in size at maturity and in length–weight rela-

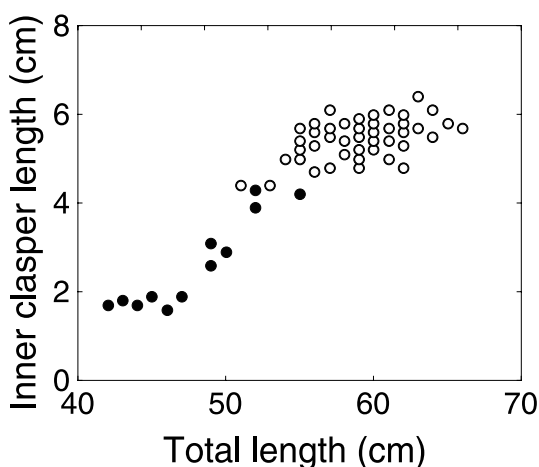


Fig. 2. Relationship between inner clasper length and total length for male *Squalus mitsukurii* from the La Plata River mouth (SW Atlantic). ●, uncalcified claspers; ○, calcified claspers.

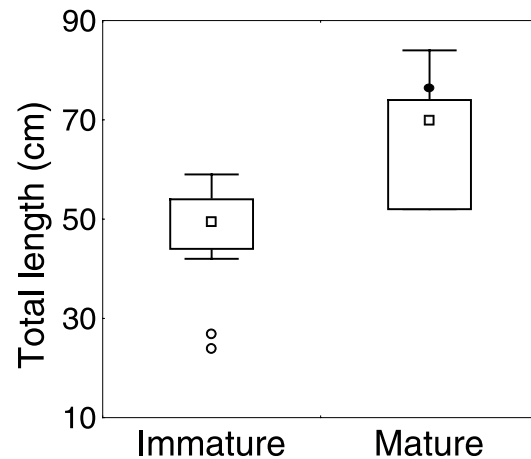


Fig. 3. Total length distributions for immature ($n = 22$) and mature ($n = 6$) female *Squalus mitsukurii* from the La Plata River mouth. All mature females were pregnant excepting the one represented by the black dot. Box plots show median values (white squares) and quartiles (edges of central box).

tionships. Moreover, *S. mitsukurii* appears to be intermediate in size at maturity among the SW Atlantic squalid sharks (as defined by Shirai 1996). Both sexes of *Squalus acanthias* from Argentina mature at a larger size (males 63 cm, females 70 cm; Menni 1985) than *S. mitsukurii*. *Squalus cubensis* has been less studied and its occurrence in the SW Atlantic is under discussion (see Gosztonyi and Kuba 1998). The only male regarded as *S. cubensis* examined by Menni *et al.* (1986) was mature at 47 cm TL. Females considered to be *S. cubensis* matured at about 50.5 cm TL (Menni *et al.* 1986). Females of *Squalus megalops* from the SW Atlantic mature at 45 cm TL (Amorim *et al.* 1995a). Thus, the latter two species mature at a smaller size than *S. mitsukurii*. Only five individuals of *Squalus asper* are known from the SW Atlantic (Amorim *et al.* 1995b); one of those specimens was a juvenile 80.7 cm TL, suggesting a size at maturity much larger than that of *S. mitsukurii*.

Females of *S. mitsukurii* from the La Plata River mouth (i.e. the Uruguayan–Argentine Common Fishing Zone) mature at a smaller size than specimens from six other regions (Table 1). Male *S. mitsukurii* from the La Plata River mouth mature at a smaller size than individuals from Australia, South Africa and one locality from the NW Pacific (Choshi) but they have size-at-maturity values similar to males from Ogasawara (NW Pacific) and higher than males from Hancock Seamount (NW Pacific) (Table 1). Estimates of length at maturity from Compagno (1984) are much higher (females 72 cm, males 65–89 cm) than those reported here (females 52–60 cm, males 51–55 cm). Plasticity in reproductive parameters is also evident in the differences between sexes in maturity length; these differences are very large in NW Pacific and South African populations, but not

Table 1. Length at maturity of *Squalus mitsukurii* in eight regions

Data are from ^Athis study, ^BTaniuchi *et al.* (1993), ^CWilson and Seki (1994), ^DLitvinov (1990) in Wilson and Seki (1994), ^ELast and Stevens (1994), ^FBass *et al.* (1976) and, ^GAmorim *et al.* (1995a).

	La Plata River Mouth ^A	Choshi ^B (NW Pacific)	Ogasawara ^B (NW Pacific)	Hancock Seamount ^{B,C} (NW Pacific)	Sala y Gómez ^D (SE Pacific)	Australia ^E	South Africa ^F	Brazil ^G
Female length at maturity (cm)	52–60	96–100	72–80	68	85	No data	69	63
Male length at maturity (cm)	51–55	68–80	52–56	48–52	No data	61	58–60	No data
Intersexual differences (cm)	1–5	28–20	20–24	20			9–11	

so large in individuals from the La Plata River mouth (see Table 1). Apparently, greeneye spurdog sharks are more sexually dimorphic in size at maturity in the NW Pacific and South Africa than in the SW Atlantic.

Elasmobranch length–weight relationships are usually reported as differing between the sexes, females being heavier than males — although Kohler *et al.* (1995) have not found sexual differences in length–weight relationships of 13 shark species from the USA Atlantic coast. Although we have not found differences in this relationship for *S. mitsukurii* from the La Plata River mouth, Wilson and Seki (1994) found intersexual differences in the length–weight relationship for *S. mitsukurii* from the NW Pacific. This reflects the high variability in life-history traits exhibited by *S. mitsukurii* and reinforces the observation of the occurrence of a lesser sexual dimorphism in size in the La Plata River mouth population.

Adjacent populations of *S. mitsukurii* differ in reproductive parameters (Taniuchi *et al.* 1993). The SW Atlantic *S. mitsukurii* occurs from north-eastern Brazil (Rincón and Lessa 1998) to 47°S in Patagonian waters (Gosztanyi 1981), comprising four zoogeographic provinces (as defined by Menni 1986). Therefore, it is likely that SW Atlantic *S. mitsukurii* is divided into several populations with different life-history parameters. We could not make any conclusive comparison among different SW Atlantic sites because of lack of data from this region. However, the only available estimate for length at maturity from Brazilian waters suggests a slightly larger size at maturity for females (see Table 1). This variability in life-history parameters among very near populations may have important consequences in fisheries management, because life-history parameters used in fishery models would not be interchangeable even among near regions. Size at maturity responds very quickly both to natural selection (Stearns 1992) and to additional selective pressures such as those exerted by fisheries. Unfortunately, the lack of adequate fishery records and the scant knowledge of the biology of this species prevent us from explaining the differences as local adaptations to different environments or as a result of different levels of exploitation.

Alternatively, a species-complex hypothesis (Compagno

1984; Last and Stevens 1994) may explain the variability in life-history parameters of *S. mitsukurii* among different regions. Like *S. mitsukurii*, *S. acanthias* is also widely distributed (Compagno 1984) and similar geographic differences in reproductive parameters have been found (Ketchen 1972). However, morphometric, meristic and electrophoretic analyses have revealed neither specific nor subspecific differences (Jones and Geen 1976). On the other hand, the *Squatina* species assemblage from the SW Atlantic was formerly thought to be only one species on morphological grounds, but a species complex (with three constituent species) was found when morphology, reproduction and other biological parameters were analysed in depth (Vooren and da Silva 1991). Hence, a recognized species that does not show morphological variation may have (e.g. SW Atlantic *Squatina* species) or may not have (e.g. Northern Hemisphere *S. acanthias*) subspecific or specific differentiation. Further comparative work is needed to determine which is the case for *S. mitsukurii*.

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