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Sex and reproductive aspects in *Serranus cabrilla* (Osteichthyes: Serranidae): macroscopic and histological approaches

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Abstract The gonads of *Serranus cabrilla* (Linnaeus, 1758) from the Canary Islands were studied between September 1992 and July 1993. Macroscopic classification of the maturity stages was compared with histological classification of gonad characteristics, and the effect of the classification method on the determination of the spawning season and size at maturity was investigated. Analysis of gonad organization and development confirmed that this species is synchronously hermaphroditic. Ovarian-tissue development is asynchronous, and testicular tissue consists of continuous spermatogonia. Six stages of oogenesis and five of spermatogenesis are described, based on differences in staining and in size and on differences in the nucleus and cytoplasm structure as viewed through a light microscope. Two types of atretic degeneration of eggs are also described. Agreement between macroscopic and histological staging was low, although both methods provided similar results in spawning-season determination and size at maturity. The spawning season of *S. cabrilla* is from February to July, with a peak in May. Fish size at first maturity (size at which 50% of all fish sampled are in relevant maturity stage) is 152 mm standard length (SL), and size at mass maturity (size at which 95% of all fish sampled are in relevant maturity stage) is 167 mm SL.

Introduction

Studies of reproduction in fishes, such as duration of spawning season, size at maturity and fecundity, require knowledge of the stage of gonad development in individual fish. The methods used in such studies are generally based on the visual external appearance of the gonad. This is probably the most rapid but least certain technique, and a more detailed analysis requires the use of histological methods (West 1990).

There is a wide range of literature on oogenesis and spermatogenesis in teleosts (e.g. Grier 1981; Wallace and Selman 1981; Bruslé 1983; Coetzee 1983; Howell 1983; Billard 1986; Bentivegna and Benedetto 1989; Billard et al. 1992). Despite this, there have been very few attempts to assess the accuracy of macroscopic staging (West 1990). June (1953), Macer (1974), Hilge (1977), and DeMartini and Fountain (1981) performed some research in this field, and described differences between macroscopic and histological classifications.

The present study compares the macroscopic classification of maturity stages with the histological characteristics of the gonads of *Serranus cabrilla* (Serranidae) from the Canary Islands, and examines the effects of classification method on the determination of spawning season and size at maturity. Despite the relative abundance of this species and its importance to commercial fisheries in the Canary Islands (Pérez-Barroso et al. 1993), biological information is scarce (Tuset et al. 1996).

Materials and methods

Between September 1992 and July 1993, 259 specimens of *Serranus cabrilla* (Linnaeus, 1758) ranging in size between 125 and 213 mm standard length, were studied from Canary Island commercial samples.

Standard length (SL) was measured to the nearest millimeter, for each specimen, together with gutted weight (GW) and gonad weight (GNW) to and accuracy of 0.1 g. Sex and maturity stage (MS) were determined; firstly macroscopically, according to the five-point scale of Holden and Raitt (1975), and subsequently by histological analysis. Gonads of 241 specimens were fixed in buffered formaldehyde (24 h) or in Bouin's solution (12 to 24 h). After fixation, the gonads were dehydrated and embedded in paraffin wax. Longitudinal or cross-sections, 4 to 5 μm thick, were stained with Harris' haematoxylin–Puttis's eosin and with periodic acid-Schiff–haematoxylin.

Oocytes were classified according to their morphology, their affinity for the dyes used, and the presence of specific inclusions (lipid droplets, yolk granules, yolk vesicles). In five fish randomly

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chosen from the monthly samples, the diameters of the first 50 oocytes encountered were measured to the nearest millimeter using an ocular micrometer; the mean diameter of each type of oocyte was then calculated. Measurements were taken only on oocytes sectioned through the nucleus.

Histological identification of the various maturity stages was determined according to the development of the ovary and testis and also by the presence/absence of different types of oocytes (i.e. whether organised by ovarian lamellae or not) and spermatocytes.

For each individual, the gonadosomatic index (GSI) was calculated as:

$$\mathrm{GSI} = (\mathrm{GNW} \times 100) \div \mathrm{GW} \ . \quad (1)$$

The mean GSI was calculated for each month of the study period.

The monthly variation in the percentage of mature individuals, the mean diameter of oocytes, and the GSI were studied to determine the spawning season.

A maturity curve was determined using the balanced logistic function (Astudillo and Sánchez 1989):

$$p = 100/(1 + \exp\,(a + b \times \mathrm{SL})) \ , \quad (2)$$

where p = percentage of mature individuals as a function of size class (SL), and a and b = specific parameters which can change during the lifecycle. A logarithmic transformation was applied to Eq. (2) in order to calculate the parameters a and b by means of linear regression (Sokal and Rohlf 1981).

Size at first maturity (SFM) and size at mass maturity (SMM) were also calculated. They are defined as the sizes (SL) at which 50 (SFM) and 95% (SMM) of all fish sampled are in relevant maturity stage (i.e. developing, ripe or spent) (e.g. González and Lozano 1992). Both spawning season and size at maturity were determined separately from macroscopic and histological data.

Results

Sex

Macroscopic examination confirmed that the gonads from *Serranus cabrilla* consist of ovotestes dominated by the ovary, while the testis, in a ventrolateral position, is restricted to the anterior region. Each ovotestis is fairly cylindrical, and is covered by the tunica albuginea. Both gonad lobes are of similar size, and lead to a common orifice at the level of the anus. Ovarian and testicular tissue are separated by connective tissue only.

Histology of ovarian tissue

The ovary consists of a series of ovarian lamellae, radially oriented towards the lumen and containing oocytes at different stages of development (Fig. 1a). This type of ovary is classified as asynchronous, in accordance with Marza (1938).

A description of the different stages of development of the oocyte follows. The terminology proposed by Yamamoto (1956) is used, but the terminology used by Zanuy and Carrillo (1973) for *Serranus cabrilla* is given in parentheses (Oocyte Type A, B, etc.) as a reference:

Oogonia (Fig. 1b). Spherical to slightly oval in shape. Cytoplasm lightly dyed. Very large nucleus, with single very prominent nucleolus. Sited on periphery of the ovarian lamellae, isolated or forming cysts.

Chromatin nucleolar stage (Oocyte Type A: Fig. 1b). Similar to oogonia, although somewhat larger (mean diam = 8 ± 4 μm). Large nucleus, with single nucleolus. Reduced cytoplasm, with little or no affinity with dyes used.

Perinucleolar stage (Fig. 1c). In the early stage (Oocyte Type B), size increases (mean diam = 26 ± 8 μm). Cytoplasm with strong affinity for haematoxylin. Nucleus more evident, with multiple nucleoli, generally peripheral, next to nuclear membrane. Yolk nucleus or Balbiani body (Wallace and Selman 1981) present in cytoplasm. Follicular layer present but difficult to observe. Late stage (Oocyte Type C) exhibits rapid growth (mean diam = 67 ± 13 μm). There is progressive loss of affinity for haematoxylin. Disintegration of Balbiani body. Follicle or follicular layer is easier to observe, and consists of internal layer (granular layer) and a further external layer (theca) (Hunter and Macewicz 1985).

Oogonia, chromatin nucleolar and perinucleolar stages are present in the ovary throughout the entire annual cycle, and are referred to as "primary growth phase" (Wallace and Selman 1981), "first growth phase" (Zanuy and Carrillo 1973; Forberg 1982), and as "slow growth phase" or "previtellogenesis phase" (Febvre et al. 1975), respectively.

Yolk-vesicle formation (Oocyte Type D: Fig. 1d). Yolk vesicles (see Selman et al. 1988) containing "intravesicular yolk" (Marza et al. 1937) present in cytoplasm. Vesicles increase progressively in both number and size. Mean diameter of oocyte is 129 ± 28 μm. Progressive loss of affinity by cytoplasm for haematoxylin. Follicular layer and zona radiata are visible, although zona radiata is not yet stained by eosin. Accumulation of lipid inclusions in cytoplasm has begun.

Vitellogenesis (Fig. 1d). In early stage (Oocyte Type E), yolk granules, also called yolk spheres or yolk globules, containing "intervesicular yolk" (Marza et al. 1937) are present. Mean diameter of oocyte is 217 ± 40 μm. Yolk vesicles increase in size and gravitate towards periphery while the yolk granules grow. Zona radiata is dyed with eosin and consists of two layers: internal light-pink layer and external darker layer. In late stage (Oocyte Type F), perpendicular striations are apparent in zona radiata. Mean diameter of oocyte is 372 ± 58 μm.

Ripe (Oocyte Type G: Fig. 1d). Nucleus migrates towards animal pole together with a large oil droplet formed by fusion of lipid inclusions. Mean diameter of oocyte is 491 ± 53 μm. Yolk granules are fused in homogeneous mass, creating "hyaline oocyte" (Howell 1983) or "hydrated oocyte" (Hunter and Macewicz 1985; Tricas and Hiramoto 1989) with mean diameter of 595 ± 69 μm; nucleus is often not visible due to disintegration of nuclear membrane and dispersion of its contents in the cytoplasm (Hunter and Macewicz

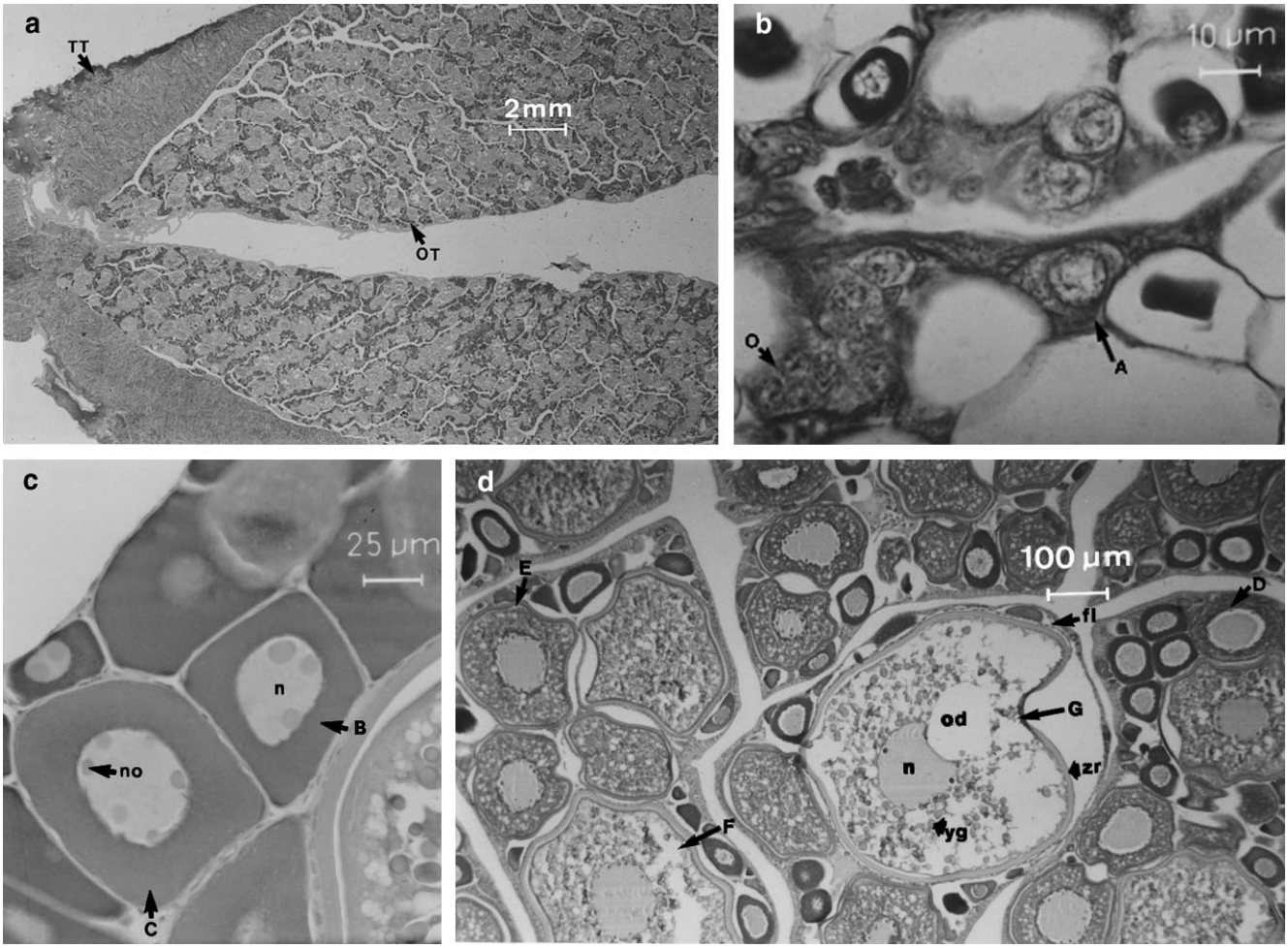

Fig. 1 *Serranus cabrilla*. **a** Longitudinal section of ovotestis (*OT* ovarian tissue; *TT* testicular tissue); **b** primary-growth oocytes at various stages of development (*O* oogonia; *A* chromatin nucleolar stage); **c** larger primary-growth oocytes (*B* early perinucleolar stage; *C* late perinucleolar stage; *n* nucleus; *no* nucleoli); **d** secondary-growth oocytes in various stages of development (*D* yolk-vesicle formation; *E* early-vitellogenesis; *F* late-vitellogenesis; *G* ripe; *fl* follicular layer; *n* nucleus; *od* oil droplet; *yg* yolk granules; *zr* zona radiata) (Haematoxylin and eosin stain)

1985). When oocyte reaches hydrated stage, spawning is imminent (Hunter et al. 1986; Pérez-Contreras and Cal-Rodríguez 1988).

Yolk-vesicle formation and the vitellogenic stages have been included in the so-called "second growth phase" (Zanuy and Carrillo 1973) or "vitellogenesis phase" (Febvre et al. 1975). The ripe stage constitutes the "ovulation phase" (Zanuy and Carrillo 1973), although it has also been included in the "vitellogenesis phase" (Febvre et al. 1975).

The mature oocytes are forced into the lumen of the ovary, and are then extruded from the follicular layer, leaving an empty space; this becomes filled with granular matter which is ultimately reabsorbed. Those oocytes that (although at an advanced stage of vitellogenesis) have not been expelled are in different stages of disintegration. *Serranus cabrilla* displays different types of atresia identical to those described for other teleosts species (e.g. Hunter and Macewicz 1985; Tricas and Hiramoto 1989): (a) alpha (α)-stage atresia: the zona radiata begins to lose its perpendicular striations and becomes irregular in diameter; in a more advanced stage the nucleus disappears, the zona radiata breaks up, and the cells of the granular layer undergo hypertrophy and invade the oocyte; (b) beta (β)-stage atresia: the cells of the granular layer migrate to the interior of the ooplasm, absorbing the yolk; at the end of this stage the zona radiata disappears.

Histology of testicular tissue

In accordance with the description of Grier (1981) for teleosts, the testis of *Serranus cabrilla* consists of continuous or unrestricted spermatogonia, forming a network of tubules. Spermatogenic cells appear in the interior of the seminiferous tubules at different stages during spermatogenesis (spermatogonia, primary and secondary spermatocytes, spermatids and spermatozoa), forming cysts (Fig. 2). Each cyst is bounded by a layer of

connective tissue and contains cells at the same stage of development. In mature testes, the seminiferous tubules are filled with spermatozoa.

The annual reproductive cycle of *Serranus cabrilla* has five stages of testicular development that agree with those described by Grier (1981) for teleosts. Grier's terminology has been adopted for the present study. The five stages are:

Spermatogonial proliferation. Appearance of spermatogonia, generally associated with tunica albuginea, with voluminous nucleus containing scattered chromatin and several peripheral nucleoli.

Mid-recrudescence. All stages of development present. Spermatocytes smaller than spermatogonia. Primary spermatocytes: nucleus is strongly stained with haematoxylin and cytoplasm has little affinity for dyes. Secondary spermatocytes somewhat smaller, with nucleus that stains weakly. Nucleus of spermatids has denser and more uniform chromatin.

Late-recrudescence. Tubules full of sperm. Fewer cysts with developing sperm. Small spermatozoa with very basophilic nucleus and large eosinophilic tail.

Functional maturity. Tubules full of sperm beginning to accumulate in deferent duct. All cellular types present.

Spent. No cellular types discernable, since non-ejected spermatogenic cells have been reabsorbed.

Accuracy of macroscopic staging

Table 1 describes the different stages of maturity in the ovotestis determined by macroscopic observations and histological analysis.

Comparison of the determination of maturity stages (MS) by macroscopic and by histological criteria revealed an overall conformity of 64.7%; in the case of ripe gonads this increased to 79.2%. The most frequent discrepancies or errors between the two classification methods fell into the following categories.

Error Type a. Using macroscopical criteria, an ovary partially filled with oocytes visible to the naked eye is assigned MS III (developing); using histological criteria, an ovary containing atretic oocytes is assigned MS V (early-spent): a total of 29.4% of ovaries macroscopically classified as MS III are classified as MS V by histological criteria.

Error Type b. Macroscopy classifies extended, narrow and firm gonads as MS II (developing virgin, or recovering-spent); histology classifies oocytes in a stage of reabsorption and with empty testicular tissue or cellular remains as V (late-spent): a total of 29% of the gonads macroscopically classified as MS II are classified as MS V by histological criteria.

Error Type c. Macroscopy assigns flaccid and empty gonads to MS V (spent); histology assigns recovering oocytes to MS II (recovering-spent): a total of 21.4% of

Table 1 *Serranus cabrilla*. Comparison of macroscopic and histological appearance of ovotestis

Maturity stage		Macroscopic appearance	Histological appearance
I	Immature	Gonad occupies less than one-third of abdominal cavity. Ovary whitish and translucent. Testis unrecognizable. Eggs invisible to naked eye	Ovary contains oogonia. Testis formed by spermatogonia, not organized in tubules. Ovary and testis joined by connective tissue
II	Developing virgin, or recovering-spent	Gonad takes up half of abdominal cavity. Ovary whitish-yellow. Testis not recognizable. Eggs invisible to naked eye	Ovary begins to acquire ovarian lamellae. Oocytes in nucleolar chromatin and perinucleolar stages. Testis arranged in tubules with spermatogonia, spermatocytes and spermatids
III	Developing, maturing	Gonad fills two-thirds of abdominal cavity. Ovary reddish-yellow, granular appearance. Testis, white and developed, occupies less than half of gonadal length	Ovary formed in ovarian lamellae with oocytes from nucleolar chromatin to vitellogenic stage. Seminiferous tubules contain all spermatogenic cells
IV	Ripe	Gonad takes up two-thirds of abdominal cavity. Ovary from white to pink, with superficial blood vessels. Large, white and transparent eggs. Highly developed, cream-colored testis; occupies more than one-third of gonadal length	Ovary with ovocytes at all stages. Testis completely mature, tubules filled with spermatozoa which accumulate in deferent duct next to gonadal wall, from which they will be expelled
V	Spent	Flaccid gonad occupies nearly half of abdominal cavity; sometimes with remains of opaque, mature eggs in a state of disintegration, dark or translucent. Testis difficult to recognize with naked eye	Oocytes in regression and reabsorption. Atresic oocytes appear. Testis in regression, cells appear fused; form semi-continuous mass

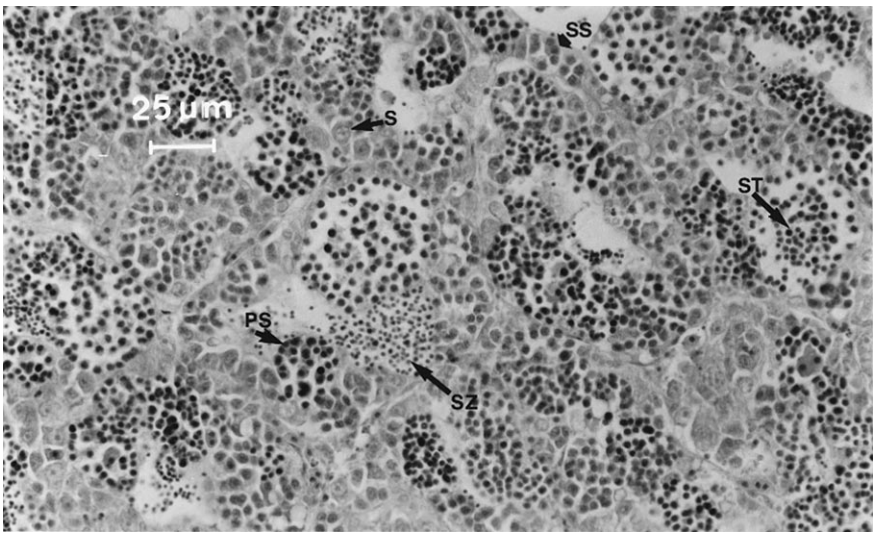

Fig. 2 *Serranus cabrilla*. Section of testis. Tubules containing all stages of spermatogenesis (*S* spermatogonia; *PS* primary spermatocytes; *SS* secondary spermatocytes; *ST* spermatids; *SZ* spermatozoa) (Haematoxylin and eosin stain)

the gonads macroscopically classified as MS V are classified as MS II by histological criteria.

Spawning season

Table 2 shows the monthly distribution of specimens as a function of maturity, and Fig. 3 the monthly variation in percentage of specimens in MS III (developing) or MS IV (ripe), determined from macroscopic and histological data. Overall, the histological data did not differ greatly from the macroscopic data. However, there were differences in February when macroscopic criteria indicated that 72% of the fish were mature, while histological criteria classified only 50.1% as mature. Mature fish were found from February to July, with the highest percentage recorded in May (94.4 and 94.1% by macroscopic and histological criteria, respectively).

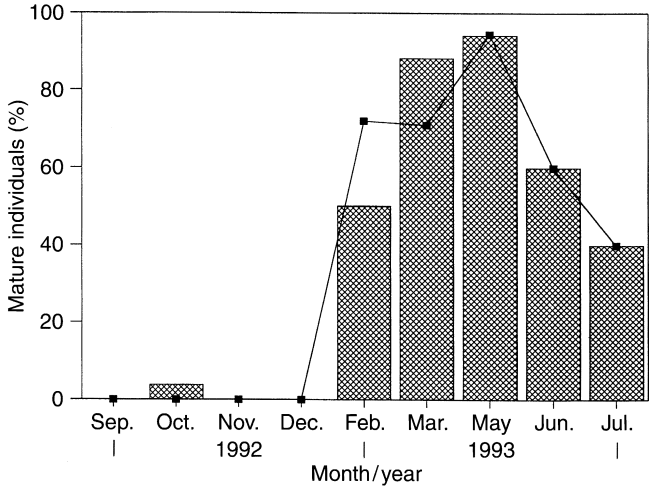

Fig. 3 *Serranus cabrilla*. Monthly variation in percentage of mature individuals (Stages III and IV) (*data points* macroscopic data; *shaded histograms* histological data)

Fig. 4 shows seasonal changes in mean diameter of oocyte and in gonadosomatic index (GSI). Both parameters exhibited similar trends, with lowest values

Table 2 *Serranus cabrilla*. Monthly distribution of individuals as a function of maturity stage (*I* immature virgin; *II* developing virgin or recovering-spent; *III* developing, maturing; *IV* ripe; *V* spent)

Year / month	Maturity stage	Macroscopic examination		Histological analysis	
		N	(%)	*N*	(%)
1992					
Sep	II	7	(24.1)	10	(34.5)
	V	22	(75.9)	19	(65.5)
Oct	I	1	(3.7)	0	(0)
	II	5	(18.5)	5	(19.2)
	III	0	(0)	1	(3.8)
	V	21	(77.8)	20	(77.0)
Nov	I	3	(3.5)	0	(0)
	II	62	(72.1)	42	(55.3)
	V	21	(24.4)	34	(44.7)
Dec	V	2	(100)	2	(100)
1993					
Feb	I	2	(8.0)	0	(0)
	II	4	(16.0)	4	(16.6)
	III	6	(24.0)	1	(4.2)
	IV	12	(48.0)	11	(45.9)
	V	1	(4.0)	8	(33.3)
Mar	II	18	(29.0)	1	(2.0)
	III	24	(38.7)	28	(54.9)
	IV	20	(32.3)	17	(33.3)
	V	0	(0)	5	(9.8)
May	II	1	(5.6)	0	(0)
	III	1	(5.6)	5	(29.4)
	IV	16	(88.8)	11	(64.7)
	V	0	(0)	1	(5.9)
June	II	2	(40.0)	2	(40.0)
	III	2	(20.0)	0	(0)
	IV	1	(40.0)	3	(60.0)
July	II	0	(0)	2	(40.0)
	III	1	(20.0)	1	(20.0)
	IV	1	(20.0)	1	(20.0)
	V	3	(60.0)	1	(20.0)

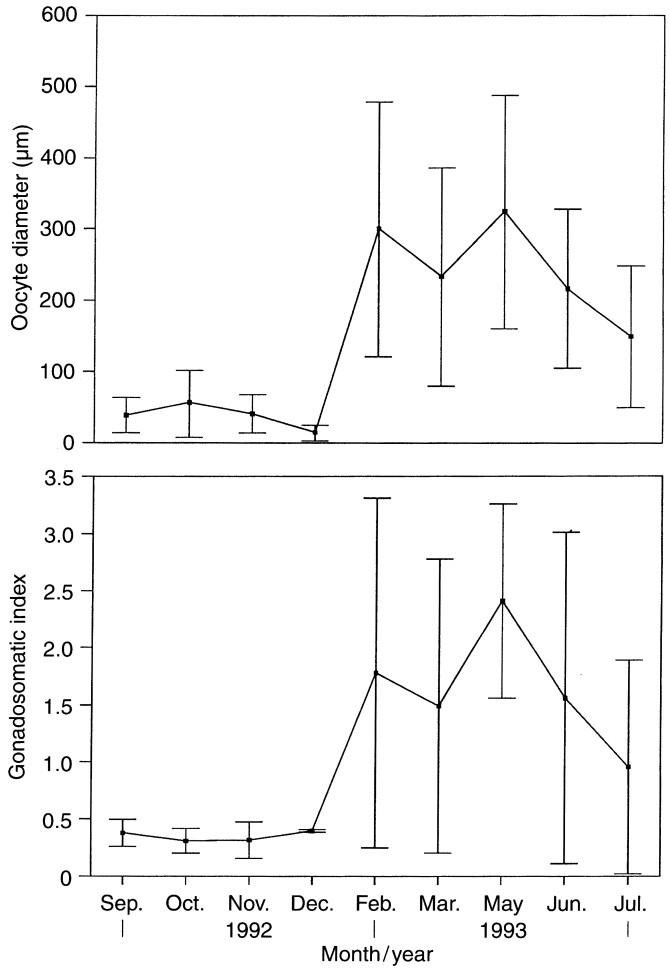

Fig. 4 *Serranus cabrilla.* Seasonal changes in mean diameter of oocyte and in gonadosomatic index

between September and December and highest values between February and July, and a peak in May.

Size at maturity

Table 3 presents the number and percentage of mature individuals as a function of size class as determined by macroscopic and histological data. These data were used to generate the maturity curve in Fig. 5. Both methods produced similar values for size at first maturity (154 and 152 mm SL for macroscopic and histological methods, respectively), and for size at mass maturity (171 and 167 mm SL, respectively), achieving very high correlations in both cases ($r = 0.9519$ and $r = 0.9915$, respectively: Table 4).

Discussion

Macroscopic examination and histological analysis of the ovotestes of *Serranus cabrilla* revealed a single sexual

Table 3 *Serranus cabrilla.* Distribution of mature individuals (Maturity Stages III–V) as a function of size class, determined by macroscopic and histological data (*N* total individuals; *m* mature specimens; *% m* percentage of mature specimens)

Size class (mm)	Macroscopic examination			Histological analysis		
	N	m	(% m)	*N*	m	(% m)
124–128	3	2	(66.7)	3	2	(66.7)
129–133	4	4	(100)	4	4	(100)
134–138	5	1	(20.0)	5	2	(40.0)
139–143	5	2	(40.0)	5	3	(60.0)
144–148	8	6	(75.0)	7	4	(57.1)
149–153	16	9	(56.3)	13	10	(76.9)
154–158	17	12	(70.6)	17	12	(70.6)
159–163	25	15	(60.0)	25	19	(76.0)
164–168	27	16	(59.3)	26	18	(69.2)
169–173	31	15	(48.4)	29	22	(75.9)
174–178	31	15	(48.4)	30	19	(63.3)
179–183	30	17	(56.7)	26	21	(80.8)
184–188	20	15	(75.0)	19	12	(63.2)
189–193	12	7	(58.3)	11	7	(63.6)
194–198	11	9	(81.0)	9	8	(88.9)
199–203	4	4	(100)	4	3	(75.0)
204–208	6	4	(66.7)	2	2	(100)
209–213	3	0	(0)	3	0	(0)

type: hermaphroditic. This has already been reported by numerous authors (e.g. D'Ancona 1949, 1950; Dufossé 1956; Reinboth 1962; Smith 1965; Zanuy and Carrillo 1973; Febvre et al. 1975; Zanuy 1977; Bauchot 1987). The observation of Ezzat et al. (1988) that this species includes both hermaphroditic and female specimens in varying proportions depending on size and time of year, thus appears to be incorrect.

The asynchronous development of oocytes and spermatocytes reflects the partially reproductive character (heterochronous species) of *Serranus cabrilla* in the Canary Islands. This has also been reported for this species by Zanuy and Carrillo (1973) and Zanuy (1977) in the western Mediterranean.

The developmental events observed in the oocytes and spermatocytes of *Serranus cabrilla* are very similar

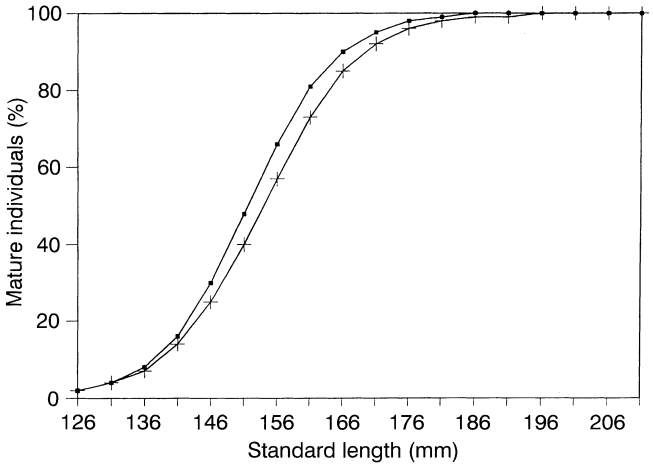

Fig. 5 *Serranus cabrilla.* Maturity curves as a function of size (+ macroscopic data; ■ histological data)

Table 4 *Serranus cabrilla*. Parameters of maturity curves, size at first maturity (*SFM*), and size at mass maturity (*SMM*), determined by macroscopic examination (*top row*) and histological analysis (*bottom row*) (*SL* standard length; *r* correlation coefficient)

SL (mm)	No. mature	*r*	*a*	*b*	SFM	SMM
136–176	91	0.9519	21.7544	–0.1413	154	171
136–171	90	0.9915	23.4574	–0.1547	152	167

to those described for most other teleosts (Grier 1981; Wallace and Selman 1981; Howell 1983). The classification system applied in the present study is based on the previtellogenetic and vitellogenetic changes described by Yamamoto (1956). In the literature, the various stages of oocyte development have been classified using different systems, frequently causing great confusion. Although most authors agree on the basic characteristics incorporated into such a system, schemes used are often too brief, or incomplete, or too complicated (Coetzee 1983).

Development of ovarian tissue in *Serranus cabrilla* can be divided into two phases, as for other teleosts (Febvre et al. 1975; Zanuy and Carrillo 1973; Wallace and Selman 1981; Forberg 1982; Howell 1983). During the first phase, the previtellogenic phase, growth is comparatively slow, with few cytoplasmic changes. The second phase, the vitellogenic phase, is characterized by faster growth and the deposition of large amounts of yolk in the ooplasma.

The ovarian and testicular tissue mature simultaneously, indicating that *Serranus cabrilla* is a synchronous hermaphrodite species. This has also been reported by other authors (D'Ancona 1950; Dufossé 1956; Reinboth 1962; Smith 1965; Zanuy 1977), who also mentioned the possibility of self-fertilization in this species.

The low percentage (64.7%) of agreement between the two sets of criteria in staging maturity of the sampled gonads revealed a low precision or/and accuracy of macroscopic criteria based on external characteristics of the gonads. Histological examination revealed a great complexity in the degree of development of the various stages of maturation that are not discernable on a macroscopic scale. West (1990) pointed out that in studies of the reproductive biology of fishes histological techniques are the most accurate, even though they are expensive and time-consuming. West recommended the use of a stereomicroscope to classify the appearance of the oocytes, with later validation by means of histological analysis.

The percentage of agreement between the two methods in the classification of ripe gonads was high (79.2%). In this connection, using both macroscopic and histological procedures, June (1953) obtained 90% concordance for yellowfin tuna (*Thunnus albacares*) and unpublished CSIRO studies (*in* West 1990) reported 61% agreement for snapper *Lutjanus vittus*.

Analysis of seasonal variations in the percentage of mature specimens (from macroscopic and histological data), the mean diameter of oocytes, and the gonadosomatic index indicates a spawning season for *Serranus cabrilla* in the Canary Islands from February to July. The spawning season may also extend to January and August, but due to the characteristics of the small-scale local fisheries (with seasonal substitution of target species and a very complicated commercialization of captures), it is difficult to obtain samples in these months. Nevertheless, as a result of Type a errors of classification, there is a marked difference in the percentage of mature specimens in February, which is a month of high reproductive intensity according to macroscopic criteria but of only moderate activity according to histological data. The macroscopic and histological data on the percentage of mature specimens, together with mean oocyte diameter and GSI, revealed that mass spawning is in May. Seasonal changes in mean oocyte diameter and in gonadosomatic index displayed a similar trend.

A review of the literature on the spawning season of *Serranus cabrilla* in different regions suggests that, as latitude decreases the length of the spawning season increases, clearly reflecting environmental conditions: 2 mo (July and August) in the English Channel (Wheeler 1968), 5 mo (April to August) in the Mediterranean (Bertolini 1932; Dieuzeide et al. 1954; Bini 1968; Bruslé and Bruslé 1975; Tortonese 1975; Bouain 1981; Bauchot 1987), 6 mo (March to August) in the south-east Mediterranean (Egypt) (Ezzat et al. 1988), and from 6 to 7 mo in the Canary Islands (present study). Nevertheless, the mass spawning periods are very close: April in the Mediterranean (Bruslé and Bruslé 1975; Ezzat et al. 1988) and May in the Canary Islands (present study).

Maturity curves calculated from both sets of criteria exhibited a similar tendency, insofar as the values obtained for SFM and SMM were similar for both methods; the slight differences found were due to Type b and Type c errors.

The size at first maturity (152 mm SL) as determined by histological criteria is significantly greater than that reported by Bouain (1981: 100 mm SL, Tunis), but almost identical to that recorded by Bauchot (1987: 150 mm SL, Mediterranean).

The agreement between macroscopic and histological classifications of maturity in this species is low, although for ripe gonads the classification discrepancies are notably less. Despite the subjectivity and inaccuracy of the macroscopic method compared to histological examination, in the present study macroscopic classification proved more practical because of its ease of application.

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