ORIGINAL ARTICLE

Reproductive biology of *Raja clavata* (Elasmobranchii: Rajidae) from Southern Black Sea coast around Turkey

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Abstract Specimens of *Raja clavata* were monthly collected at the coast of Havaalanı (Trabzon/Turkey) from January 2009 to December 2009 at depths between 20 and 40 m. A total of 230 individuals of thornback ray (131 females and 99 males) were collected by bottom trawls during research cruises. Using logistic regression, it was determined that TL at 50% maturity of males was 718 mm TL and of females 746 mm TL. The ovarian fecundity ranged from 27 to 60 yellow follicles in both ovaries. Females carrying egg cases were found in July and October. Variations in the gonadosomatic and hepatosomatic indices indicated a continuous reproductive cycle during the year.

Keywords *Raja clavata* · Thornback ray · Size at sexual maturity · Reproduction · SE Black Sea

Introduction

Even though elasmobranches are found in a variety of marine ecosystems, many aspects of their biology are poorly known. Many of elasmobranches have important ecological roles as top predators or opportunistic scavengers (Camhi et al. 1998). As a group, elasmobranches

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can be classified as equilibrium (K-selected) strategists and typically share the biological characteristics of low fecundity, late maturity, high juvenile survivorship, slow body growth, and long life span (Hoenig and Gruber 1990; Winemiller and Rose 1992; Camhi et al. 1998). Equilibrium strategists tend to have slow rates of population growth and generally cannot sustain high levels of fishing pressure (Holden 1974; Hoenig and Gruber 1990).

Thornback rays, *Raja clavata*, are found in coastal waters of the northeast Atlantic and the Mediterranean and Black Seas (Stehmann and Bürkel 1984). Thornback ray is a bottom-dwelling species on the shelf and upper slope from inshore to depths of 300 m but occurs mainly from 10 to 60 m (Stehmann and Bürkel 1984). Temperature was the main factor determining the distribution of this species (Jardas 1973).

All Rajids (skates) are oviparous and enclose their internally fertilized eggs within a tough case before laying them on the seafloor. Most of the embryonic development occurs after oviposition and may take up to 15 months (Conrath 2004; Musick and Ellis 2005). Their egg cases are laid in pairs with each egg case containing a single embryo. However, Janez and Sueiro (2009) observed in their studies that fanskate, *Sympterygia bonapartii*, (0.8%) contained two embryos per capsule. Juvenile skates emerge from the egg case resembling miniature adults. Fecundity estimates for other skate species range from 48 to 150 young per year (Holden et al. 1971; Holden 1975; Ellis and Shackley 1995). These estimates of fecundity are quite low when compared with most teleosts, although juvenile survival is substantially higher due to the protective egg case and large size at hatching (Matta 2006). Embryos develop within the egg case for extremely long periods of time (Berestovskii 1994) with all the nutritive sources supplied by the large yolky mass.

Knowledge of the reproduction and development of elasmobranches 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 (Oddone and Vooren 2005).

Thornback ray is the dominant skate species across the southeastern Black Sea coast, accounting for over 80% of total skate biomass (Aydin et al. 2009). Although thornback ray is not directly targeted by the fisheries, it is one of the most abundant skates taken as by-catch in this region (Bingel et al. 1993).

The reproductive biology of *R. clavata* was previously studied from specimens caught off the British coast (Holden et al. 1971; Holden 1975; Gallagher et al. 2005; Whittamore and McCarthy 2005; Serra-Pereira et al. 2010), the Atlantic coast (Du Buit 1968; Nottage and Perkins 1983), Mediterranean Sea (Capapé et al. 2007), and Adriatic Sea (Jardas 1973; Krstulovic Sifner et al. 2009). However, a little information is available about the reproductive biology of this species in the Black Sea of Turkey (e.g., Demirhan et al. 2005).

The aims of this paper were to describe the sexual development of males and females of thornback ray, *R. clavata*, to estimate its size at maturity and to assess the reproductive cycle of this species on an annual basis in southeastern Black Sea of Turkey.

Materials and methods

Sampling

Samples of thornback ray were collected from 20 bottom-trawl surveys carried out by RVs ''SÜRAT'' (Central Fisheries Research Institute, Turkey). Samplings were undertaken monthly between January and December 2009. The study area was situated in Havaalanı (40°59′N; 39°50′E) (southeastern Black Sea, Trabzon) at depths between 20 and 40 m.

Reproductive data recorded

A total of 230 thornback rays (131 females and 99 males) were examined to figure out sexual development and reproduction cycle. Total length (TL, mm), total weight (TW, g), liver weight (g), and sex of the each individual ray were measured after capture. Total length was measured as the distance from the tip of the snout to the end of the tail.

For females, the nidamental (oviducal) gland width (NGW, mm), nidamental gland weight, uterus width (UW, mm), ovaries weight (OW, g), and liver weight (g) were recorded. Nidamental gland width was measured at the widest part of the nidamental gland. Uterus width (UW)

was measured at approximately the midpoint of the uterus, halfway between the nidamental gland and the cloaca. Presence of egg capsules in the uteri or cloaca was recorded. The number of mature follicles per ovary and color of the follicle was also recorded from mature females. The fecundity of the rays was estimated by counting the number of yellow follicle in the each ovary. Counts of yellow follicle were summed from both ovaries.

For males, the inner claspers length (CL, mm), as measured from the apex of the cloaca to claspers tip, vas deferens weight (VW, g), and testes weight (TW, g) were recorded for each fish.

Sexual development of males and females

Maturity was assessed macroscopically for females and males. Maturity status was assessed according to criteria defined by Zeiner and Wolf (1993) and summarized in Table 1. Three reproductive classifications were determined for each sex: i.e., immature, maturing, and mature. Immature specimens of both sexes had undifferentiated gonads, maturing individuals had gonads that were starting to enlarge and differentiate, and mature specimens had fully developed and reproductively functional gonads.

Estimation of size at maturity

Size at maturity was determined by using maturity ogives. Length at 50% maturity was estimated by fitting binomial maturity to length data (Mollet et al. 2000). Immature and maturing represent immature specimens and mature represents mature specimens. A logistic equation was fitted using least-squares non-linear regression in the following form:

$$Y = \frac{1}{(1 + e^{-(a+bx)})}$$

where Y is the maturity status and x is the TL in cm, and the mean size with this model at first maturity, L50, was estimated by $-a/b$, which represents the body size at which 50% of the fish are mature. For both sexes, the proportion of mature individuals in 50-mm TL intervals was calculated.

Reproductive cycle

Gonadosomatic index (GSI) and hepatosomatic index (HSI) were calculated for the mature specimens from the seasonal averages throughout the year as: GSI = (gonad weight/eviscerated weight) × 100 and HSI = (liver weight/eviscerated weight) × 100, respectively. Eviscerated weight is a more appropriate variable than TW because it is not influenced by individual variation of the

Table 1 Criteria used to define maturity stages in male and female *R. clavata*, adapted from Zeiner and Wolf (1993)

Stage	Male characteristics	Female characteristics
Immature	No coiling of vas deferens	Small undeveloped ovaries and nidamental glands
	Testes small and undeveloped	No differentiated ova present
	Claspers do not extend past posterior edge of pelvic fin	
Maturing	Some coiling of vas deferens	Ovaries beginning to enlarge and differentiate
	Testes enlarging	Ova white, distinguishable but small
	Claspers extend past pelvic fin edge but are only somewhat calcified	Nidamental glands widening but still gelatinous in appearance
Mature	Complete coiling of vas deferens	Large yellow (yolked) ova, greater than 2.0 cm in diameter
	Large developed testes	Large, solid, functional nidamental glands
	Calcified claspers	

mass of the digestive tract, liver, and reproductive organs (Peres and Vooren 1991). The significance test used was ANOVA (Zar 1999). The variables range was expressed, along with the mean value and the standard error, as "range (mean ± SE)". The significance level considered in all cases was 0.05.

Results

Specimens of *R. clavata* ranged in size from 143 to 930 mm TL. Figure 1 shows the size frequency

Fig. 1 The length frequency distribution of the thornback ray analyzed, discriminated by sex and maturity stages

distributions analyzed of both males and females by maturity stages.

Sexual development of the male

A total of 99 males ranging in size from 143 to 920 mm TL (657 ± 18.2) were sampled. The claspers length and testis weight increased significantly with total length (CL = 2E-05TL$^{2.36}$; $r^2 = 0.90$; TW = 2E-9TL$^{3.46}$; $r^2 = 0.87$). The relationship between the vas deferens and total length were VW = 2E-07TL$^{2.60}$; $r^2 = 0.62$).

Immature stage

Immature males ranged from 143 to 575 mm TL ($n = 24$; 325 ± 20.9). Clasper length for specimens classified as immature did not exceed 50 mm, and uncalcified clasper length varied from 0.5 to 50 mm (20 ± 2.8) (Fig. 2). In this stage, flexible clasper lengths did not extend beyond the posterior edge of the pelvic fins that grew slowly relative to TL. Undeveloped testes weight varied from 0.1 to 5.2 g (1.50 ± 0.33). The vas deferens was not coiled, but a thin straight tube. Its weight varied from 0.2 to 0.8 g (0.4 ± 0.09) (Fig. 2).

Maturing stage

Individuals from 446 to 790 mm TL ($n = 17$; 665 ± 24.5) were maturing males. In these specimens, testes weights were 8.8 and 38 g (18.8 ± 2.84) and clasper lengths varied from 30 to 115 mm (84 ± 8.8). The vas deferens showed some coiling and varied from 2 to 7.8 g in weight (Fig. 2).

Mature stage

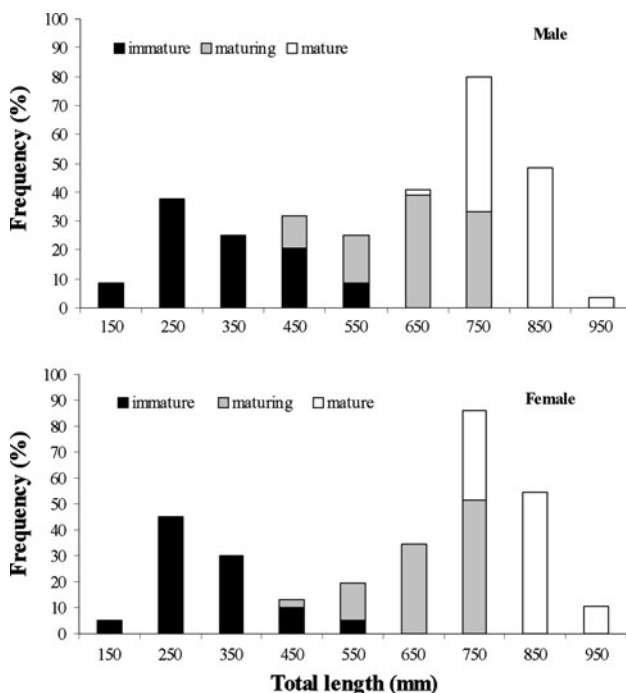Mature males measuring 680 to 920 mm of TL ($n = 58$; 792 ± 6.79) were recorded. Claspers varied from 95 to
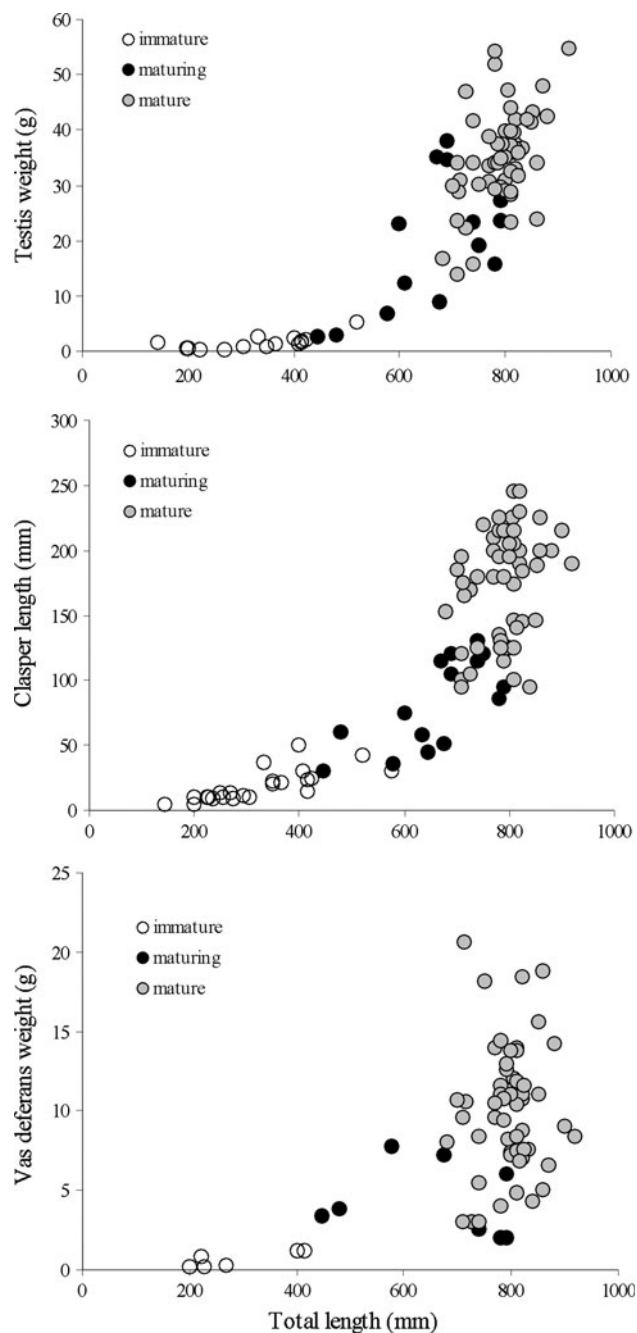
Fig. 2 Relationship between total length, testis weight, clasper length, and vas deferens weight for males of *Raja clavata* from southeastern Black Sea

245 mm in length (173 ± 5.72). Mature males had developed testes ranging from 13.8 to 54.8 g (34.8 ± 1.13) in weight. Some overlap was observed among maturing and mature stages, especially testes weights and total length, clasper lengths and total lengths. Complete coiled vas deferens varied from 3 to 20.6 g in weight (9.8 ± 0.56); however, the shape was used as indication for maturation (Fig. 2). Claspers grew gradually in animals <350 mm TL,

followed by rapid growth until 385 mm TL and 27 mm CL, which several indicators suggest is the TL for the onset of maturity.

Sexual development of the female

A total of 131 females ranging in size from 156 to 930 mm TL (702 ± 16.6) were sampled. Ovary weight increased with total length (OW = 1E-10TL$^{3.94}$; r^2 = 0.82). Uterus width varied highly with TL (UW = 8E-06TL$^{2.14}$; r^2 = 0.63). Egg-bearing female with term egg capsules reached the largest uterus width values due to the width of the egg capsules. The width of the nidamental gland (mm) also increased with total length (mm) (NG = 2E-06TL$^{2.47}$ r^2 = 0.61). Nidamental gland width and uterus width to TL relationships revealed sharp increases in size of these reproductive organs at or near 800 mm TL.

Immature stage

Immature females ranged from 156 to 540 mm TL (n = 20; 310 ± 21.1). Undeveloped ovary with small and indistinct whitish follicle varied from 0.1 to 8 g (1.3 ± 0.71). Small nidamental gland width varied between undifferentiated and 4.6 mm in this stage (4.1 ± 0.57). In this stage, the nidamental gland was opaque in color. Uterus width varied between 1 and 2 mm (1.5 ± 0.20) (Fig. 3).

Maturing stage

Maturing females varied in TL from 470 to 782 mm (n = 36; 675 ± 12.8). In this stage, many small white and light yellow follicles start to become visible in ovary. Ovary weight varied between 3.2 and 53.2 g (15.6 ± 1.93), and uterus had a width of 2.7–16.2 mm (6.9 ± 1.05). Nidamental gland width varied between 3.5 and 37.2 mm in maturing (17.3 ± 2.44).

Mature stage

Mature females varied from 720 to 930 mm TL (n = 75; 817 ± 5.8). Ovary weight with very large and yellowish-orange vitellogenic follicle varied between 11 and 193.2 g (46.4 ± 3.89) (Fig. 3). Maturation of females was characterized by enlargement of the nidamental gland and uterus. Uteri of mature females varied between 9 and 58 mm in width (16.5 ± 1.04). The nidamental gland was enlarged, kidney shaped, and white colored, and its width varied between 22.3 and 49.72 mm in mature females (34.5 ± 0.75). Nidamental gland widths measuring approximately ≥20 mm were among those females that were assigned a maturity status of adults (Fig. 3). The

Fig. 3 Relationship between total length (TL), ovarium weight, uterus width, nidamental gland width, and nidamental gland weight for females of *Raja clavata* from southeastern Black Sea
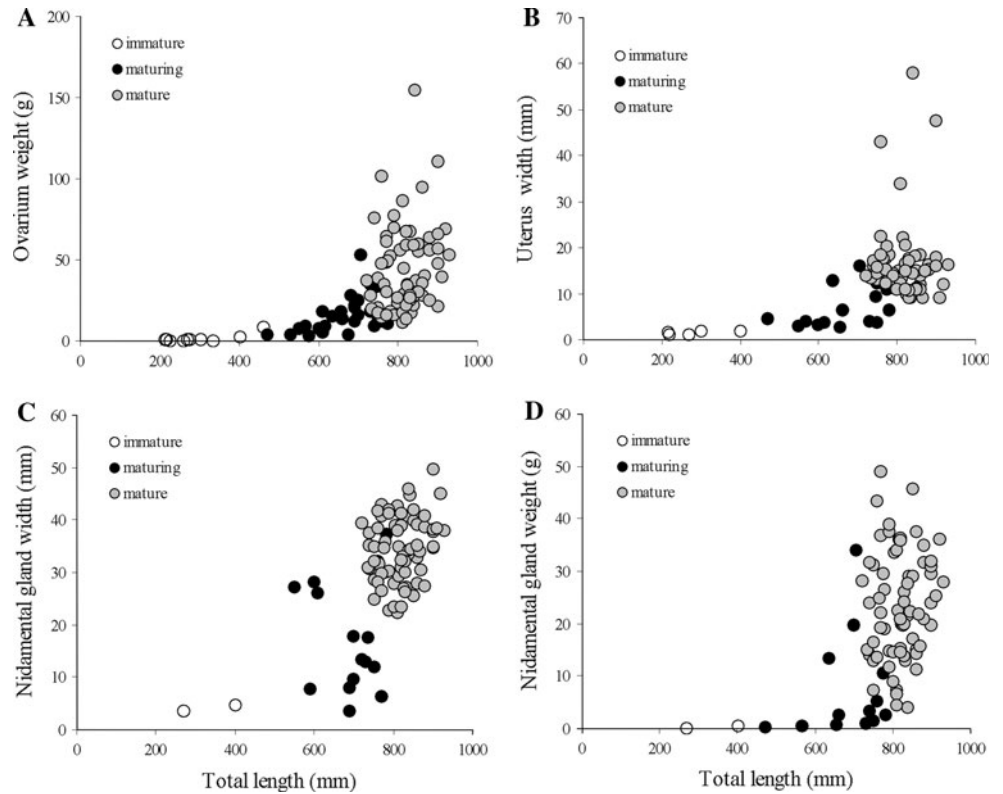
ovaries contained light and dark yellow follicle of different sizes, the largest follicle in adult female measuring 23 mm in diameter.

In both sexes of *R. clavata*, the development pattern of the reproductive variables studied showed a similar trend (Figs. 2, 3) with no overlap in the variables among maturity stages in relation to total length.

Estimation of size at maturity

The smallest observed mature male and female were 680 and 720 TL, respectively. The largest immature male and female were 575 and 540 mm TL, respectively. The estimate of female L50 from the logistic curve was 746 mm, 80.2% of the maximum total length observed (930 mm) ($R^2 = 0.99$, $n = 99$; Fig. 4). The fitted logistic curve produced an estimated L50 of 718 mm ($R^2 = 0.99$, $n = 131$; Fig. 4), which is 78.0% of the maximum total length observed for males (920 mm).

Mature yellow follicles in ovary were frequently damaged during processing, limiting the number of specimens from which accurate counts could be obtained to 20 individuals. Average ovarian fecundity was highly variable among months. Counts ranged from 27 to 60 yellow follicles (45.1 ± 2.33) in both ovaries. The relationship between ovarian fecundity and female TL was not correlated. Mature yellow follicles were observed in females
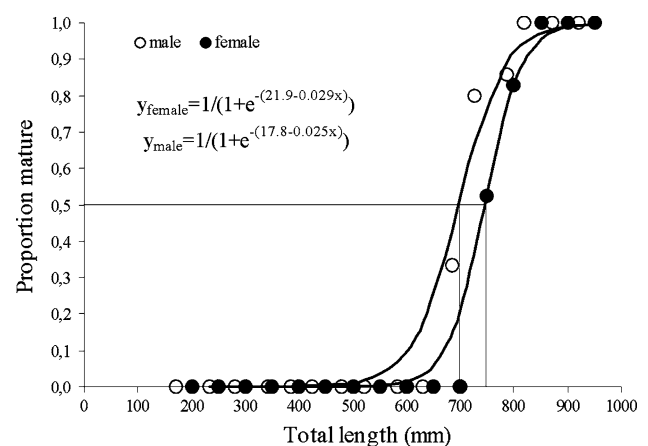

$$y_{female} = 1/(1 + e^{-(21.9-0.029x)})$$
$$y_{male} = 1/(1 + e^{-(17.8-0.025x)})$$

Fig. 4 Proportion of mature *R. clavata* at given total length (TL) based on catches in 2008. *Lines* represent length at maturity for males (*open circle*) and females (*filled circle*)

during all months sampled. No trend was detected between yellow follicle diameter and month. Average mature yellow follicle diameter values were largest among September and July specimens. However, variance among specimens and months was high.

Examination of 76 mature females revealed 2 (2.6%) to contain egg cases in uterus. Two females carrying one egg case per oviduct (single oviparity) were observed, one caught in late July and one in late October of 2009.

Fig. 5 Egg capsule in uterus and nidamental gland of a female *Raja clavata* at the actively spawning stage

Egg-bearing females' length was 760 and 900 mm. Egg capsule in uterus is shown in Fig. 5. The egg capsule was 150 mm long (with horns) and 50 mm wide, they weighed 12 g, and their color was brown to dark brown. In Fig. 5, we observed one egg capsule in each of the two uteri, each containing one embryo per egg capsule. We can conclude that *R. clavata* reproduces in a single oviparity mode.

Reproductive cycle

The GSI varied between 1.0 (winter) and 1.3 (spring) for females and between 1.1 (summer) to 1.2 (autumn) for males. The annual variation of the female and male's GSI did not significantly differ between seasons (ANOVA: $P > 0.05$) (Fig. 6). The HSI of the females varied between 6.5 (summer) and 7.7 (autumn), and the HSI of males varied between 6.2 (autumn) and 7.2 (winter). The HSI did not vary appreciably during the year, for both males and females, and this fact was evidenced by the analysis of variance (ANOVA: $P > 0.05$) (Fig. 6). The analysis of both GSI and HSI of mature specimens throughout the year showed that a continuous reproductive cycle took place.

Discussion

Sexual development of males and females

Immature, maturing, and mature of *R. clavata* did not exhibit a significant overlap among maturity stages in present study. Well-delimited maturity stages with regard to TL were also noted in *Raja clavata*, *Raja binoculata*, *Raja rhina*, *Atlantoraja platana*, and *A. cyclophora* (Capapé et al. 2007; Oddone and Amorim 2008; Oddone et al. 2008; Ebert et al. 2008). Conversely, a high overlap
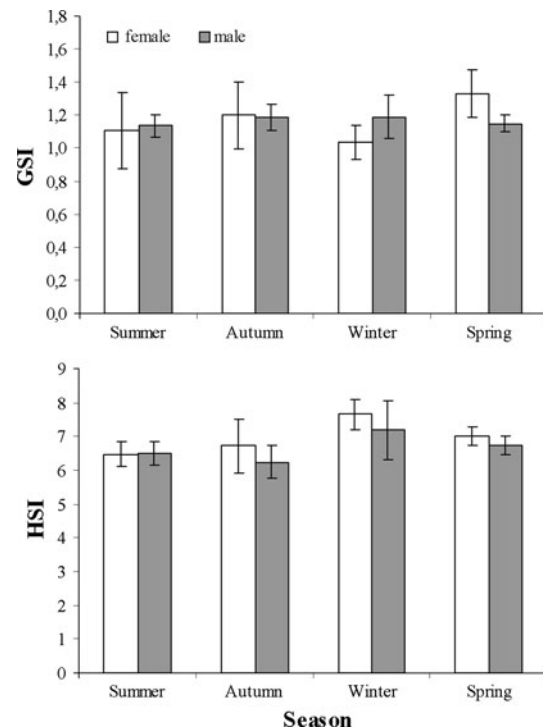

Fig. 6 Seasonal variations of the gonadosomatic index (GSI) and hepatosomatic index (HSI) over a 1 year period of mature specimens of *Raja clavata*. The *error bars* represent the standard error

among maturity stages occurring in both sexes in species like *Rioraja agassizi* was noted (Oddone et al. 2007).

Ebert (2005) and Oddone and Vooren (2005) reported for some rajid species that they undergo a relatively extended immature stage followed by a short maturing stage prior to full maturity. Based on the findings of this present study, the results about the size range of the different maturity stages do not demonstrate this statement, and based on their slow growth presented by some growth studies on this species (e.g., Walker 1999; Serra-Pereira et al. 2008).

Both clasper lengths in males and nidamental gland width in females increased with increasing total length. This finding in this study was similar to previous studies for this species (Gallagher et al. 2005; Capapé et al. 2007; Serra-Pereira et al. 2010; Whittamore and McCarthy 2005). An abrupt increase in the gonad weight immediately after the onset of sexual maturity has been reported for species such as *Raja asterias*, *R. wallacei*, *R. pullopunctata*, and *Atlantoraja cyclophora* (Capapé 1980; Walmsley-Hart et al. 1999; Oddone and Vooren 2005). Similar results are observed in present study.

The general pattern observed in several rajid species for the relationship between clasper and TL is a three-phased sigmoid curve, the middle phase of the sigmoid representing maturing individuals (Capapé and Quignard 1974;

Templeman 1987; Oddone and Velasco 2004; Oddone and Vooren 2005; Oddone et al. 2007). Contrasting to general pattern, claspers in *R. clavata* appear to be growing continuously in the mature phase in this study. Although there may well be natural variations among populations or species, estimation of size at maturity can be affected by the use of different methodologies to measure claspers.

The relationship between yellow follicle diameter or ovarian fecundity and maternal size for *R. clavata* did not indicate any consistent pattern. Similar results were reported by Ebert et al. (2008) for *Raja rhina*. Holden (1975) examined the relationship between maternal length and fecundity for *R. clavata* and concluded that body size was not a limiting factor. However, Ebert (2005) found a relationship between number of mature follicle and maternal size for several eastern Bering Sea *Bathyraja* species. Matta and Gunderson (2007) also found a slight but significant relationship for *Bathyraja parmifera*. Elsewhere, an increase in maximum follicle diameter with increasing maternal TL has also been reported for *Psammobatis extenta* (Braccini and Chiaramonte 2002) from the southwest Atlantic and *Dipturus laevis* (Gedamke et al. 2005) from the western North Atlantic.

As other oviparous elasmobranches species, *R. clavata* is a serial spawner (Holden 1975). The ovarian fecundity in the present study ranged from 27 to 60 yellow follicles with an average of 45, an estimate similar to that reported by Licandeo et al. (2006), Oddone et al. (2007), Oddone et al. (2008), Ebert et al. (2008) for Rajid species in which ovarian fecundity ranged from 18 to 68. Holden (1974) and Capapé et al. (2007) reported the number of maximum mature follicle per two ovaries was 77 and 32 for thornback ray, respectively. Holden (1975) estimated an average annual fecundity of 140 eggs for thornback ray based on the number of ovarian eggs present throughout the year.

In this present study, fecundity is estimated by counting the number of mature follicles in the both ovaries. Some authors reported that uterine and ovarian fecundity has been found to be very similar (Capapé et al. 1990; Peres and Vooren 1991; Wilson and Seki 1994). However, ovarian fecundity is notably higher than uterine fecundity, indicating that some of the developing ovarian follicles will be reabsorbed (Abdel-Aziz et al. 1993; Castro 1993).

Size at maturity

In this study, female and male *R. clavata* mature at 746 and 718 mm, respectively. Female *R. clavata* attained 50% maturity at 80.2% of their maximum observed size, while males were mature at 78% of their maximum observed size. Cortés (2000) noted that elasmobranches generally mature at 75% of their maximum size, while Frisk et al. (2001) observed that dogfishes, skates, and rays mature at 73% of their maximum size. Holden (1974) noted that most elasmobranches matured between 60 and 90% of their maximum total length. Oddone et al. (2007) reported that males and females of *Raja agassizi* matured at 68% of the maximum TL observed.

Previous studies suggest that the length at first sexual maturity ranged between 540 and 735 mm in males and between 612 and 910 mm in females TL (Table 2). According to Demirhan et al. (2005), males and females of *R. clavata* in the Black Sea mature at 640 and 667 mm TL, respectively. When compared to the results of the present study, it appears that a significant increase in total length at first sexual maturity in males and females of *R. clavata* in the Black Sea. Studies in other areas indicate that thornback ray reaches maturity earlier (Lesser 1967; Jardas 1973; Nottage and Perkins 1983; Ryland and Ajayi 1984; Krstulovic Sifner et al. (2009)).

Table 2 A comparison of total length at maturity for *Raja clavata* reported from different areas

References	Male (L50, mm)	Female (L50, mm)	Area
Steven (1934)	735	910	British waters
Lesser (1967)	648	635	Irish Sea
Jardas (1973)	540	730	Adriatic Sea
Holden (1975)	–	720	British waters
Nottage and Perkins (1983)	620	650	Irish Sea
Ryland and Ajayi (1984)	605	595	British waters
Gallagher et al. (2005)	657	718	Irish Sea
Whittamore and McCarthy (2005)	588	705	Irish Sea
Demirhan et al. (2005)	640	667	Black Sea
Capapé et al. (2007)[a]	410–440	540–560	Northern Mediterranean
Krstulovic Sifner et al. (2009)	593	612	Adriatic sea
Present study	718	746	Black Sea

[a] Disk width

As in other rajid species, females of *R. clavata* attained size at maturity at larger lengths than males. Whittamore and McCarthy (2005) reported that male and female thornback rays grow at a similar rate when young (1-4 year), but growth rates in male rays appear to be slow down after four years of age. The corresponding ages at 50% maturity were estimated to be 4 y and 5 y, respectively (Whittamore and McCarthy 2005). The differences in growth observed between the sexes may be related to the timing of maturity. According to Walmsley-Hart et al. (1999) female skates attain a larger size and grow slower as a consequence of their reproductive strategy; females grow larger to hold the egg cases within the body cavity, and males grow faster to reach sexual maturity. Our results demonstrating that females mature at smaller sizes than males are similar to the results obtained by Steven (1934); Lesser (1967); Jardas (1973); Nottage and Perkins (1983); Ryland and Ajayi (1984); Whittamore and McCarthy (2005); Demirhan et al. (2005); Capapé et al. (2007); Krstulovic Sifner et al. (2009) (Table 2). However, exceptions exist within the Rajidae family. For instance, Ebert (2005) and Ruocco et al. (2006) noted that in *Bathyraja* species, males and females attained maturity at the same size. The opposite case, with males maturing at larger sizes than females, has also been described for skates, such as for *Psammobatis extenta* (Braccini and Chiaramonte 2002). These differences between studies may be from the different environmental conditions, size frequency of fish examined, area, and species.

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 1987).

Reproductive cycle

The thornback ray is a serial spawner (Holden 1975) such as other oviparous elasmobranch species, and a reproductive cycle could not be clearly estimated. Hamlett and Koob (1999) stated that the general trend for most oviparous species of sharks and skates is for year-round egg production with seasonal periods when a greater proportion of adult females are laying eggs. As in the findings of Du Buit (1976), Braccini and Chiaramonte (2002) and San Martín et al. (2005), for some rajid species (*Raja naevus* and *P. extenta*), in this study of *R. clavata*, no seasonal variation was found in the GSI of males and females, indicating that the species may reproduce during the entire year. Two females carrying an egg case were found in July and October for *R. clavata* in present study. More data are needed to identify the egg-deposition season for this species. However, Holden et al. (1971) demonstrated that the

rate and peaks of egg deposition in *R. clavata, R. brachyura,* and *R. montagui* are dependent on water temperature with increased deposition in warmer temperatures. Holden (1975) reported a more protracted spawning period for *R. clavata* (February–September) with a peak in June in British waters. Ryland and Ajayi (1984) reported a similar spawning period for *R. clavata* (May–September). In *R. clavata*, *R. montagui*, *R. naveus*, and *R. radiata*, there were no seasonal trends in GSI (Walker 1999). Capapé et al. (2007) observed that vitellogenic activity occurred practically all year round, with a diminution in April and August just when the production of egg capsules was not observed for thornback ray in northern Mediterranean.

In this present study, the reproduction mode of thornback ray is single oviparity (one embryo per egg capsule), which is the only type of reproduction in the Rajidae family. One egg is deposited at a time from each oviduct. Usually, the eggs from the two oviducts are deposited in pairs during the spawning season (Musick and Ellis 2005). However, in the Rajidae species, *Sympterygia bonapartii*, the presence of more than one embryo per egg capsule was reported by Janez and Sueiro (2009).

The elasmobranches liver is a large organ filling a considerable portion of the body cavity in skates (Holmgren and Nilsson 1999; Oddone and Velasco 2006). Sexual dimorphism in liver size is often reported in elasmobranches (Rossouw 1987). The liver is a key organ in female reproduction because it is involved in the production of vitellogenin, the yolk precursor (Koob and Callard 1999). In present study, no differences in HSI between the sexes mean that both sexes seemed to be pretty well nourished. The females did so good that the vitellogenin production did not affect liver weight.

Knowledge of the reproductive biology, namely the cyclicity of the reproduction, together with growth parameters and fishing mortality estimations will be crucial for the development of management plans for protecting the populations of skate (Walker 1999).

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