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SHORT REPORT

Age and growth of the axillary wrasse, *Symphodus mediterraneus* (L.) from the eastern Adriatic Sea

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Abstract
The age and growth of *Symphodus mediterraneus* were determined by examining the sagittal otoliths of 245 specimens (81 males, 160 females and four individuals of indeterminate sex) collected in the eastern Adriatic Sea between October and December 2009. Total lengths of males and females ranged from 74 to 154 mm and from 51 to 131 mm, respectively. Polished otoliths displayed well-defined alternating opaque and translucent rings. Age was determined by two independent readers who considered one opaque and one translucent ring to represent one year's growth. In order to determine the first annual ring we examined daily rings and concluded that the first opaque annulus roughly corresponds with the first year of life. Most of the specimens were between two and three years old, with the maximum observed age of three years for males and five years for females. The length-at-age was described by the von Bertalanffy growth curve and significant differences were found between males (L_∞ = 16.09 cm, k = 0.50 and t_0 = –0.83) and females (L_∞ = 14.11 cm, k = 0.33 and t_0 = –1.42).

Key words: *Adriatic Sea, age, growth, Labridae,* Symphodus mediterraneus

Introduction

The axillary wrasse, *Symphodus mediterraneus* (Linnaeus, 1758) is a littoral species of the family Labridae found throughout the Mediterranean, as well as in the Northeast Atlantic along the coasts of Portugal, Northern Morocco, Madeira and the Canaries (Quignard & Pras 1986; Raposeiro & Azevedo 2009). It is a common species in the eastern Adriatic Sea, especially abundant around the islands (Jardas 1996). It inhabits a wide variety of habitats at depths from 1 to 50 m, but it is more commonly found below 10 m (Porteiro et al. 1996).

Symphodus mediterraneus is a gonochoric species with pronounced sexual dimorphism between females and terminal-phase males (Raposeiro & Azevedo 2009). It is not commercially targeted, but it is sporadically caught by anglers (Cerdà et al. 2010) and it is often caught and discarded in some small-scale commercial fisheries, e.g. beach seining (Cetinić et al. 2011). As in the case of many non-commercial species, little information is available on the biology of *S. mediterraneus*. Previous reports are limited to the general biological characteristics of the species (Quignard & Pras 1986), one paper on the reproductive biology of the Atlantic population (Raposeiro & Azevedo 2009) and data on diet composition based on several specimens sampled in the French Mediterranean waters (Bell & Harmelin-Vivien 1983). The only available data on the age and growth of this species were published almost half a century ago, for the Gulf of Lion (French Mediterranean coast) (Quignard 1966; Pauly 1978). This study aims to fill this gap by investigating the age and growth of *S. mediterraneus* from the eastern Adriatic Sea, in order to gain better insight into the life history of the species.

Material and methods

Samples of *Symphodus mediterraneus* were collected from the beach seine catches and during commercial fishing trips in the eastern Adriatic Sea (north-central Mediterranean Sea), between October and December 2009. The total length of each fish was

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measured to the nearest 1 mm, weight to the nearest 0.1 g and sex was determined either by macroscopic analysis of the gonads or by the examination of gonadal tissue smears under a compound microscope when the gonads were poorly developed. Sagittal otolith pairs were removed from each fish and stored dry for later examination. Length frequency distributions of males and females were compared using the Kolmogorov–Smirnov two-sample test.

The medial face of a single, randomly selected otolith from each pair was polished and photographed under a stereo microscope with reflected light against a dark background. Otoliths displayed well-defined alternating opaque and translucent rings. We decided to use images for age reading because their size, quality and ability to adjust contrast and brightness made it easier to interpret zoning patterns rather than from direct observations under the microscope.

In order to determine the first annual ring we examined daily rings of five otoliths belonging to different fish. These otoliths were glued to microscope slides, finely ground using lapping films with grit grades of 30 and 12 μm, and photographed under the transmitting light microscope (100–400×). This revealed a pattern of narrow alternating light and dark zones assumed to represent daily growth rings, as Raventós & Macpherson (2001) confirmed the existence of daily rings and the absence of subdaily rings for this species. By comparing the photographs of daily and annual growth rings we determined the first annual ring based on the number of daily rings counted from the core.

The age of each fish was determined from the number of annuli, the assumed birth date and the date of capture, without knowledge of the fish length or sex. The spawning period of *S. mediterraneus* lasts from May to August, with a peak in May–June (Raposeiro & Azevedo 2009), so the birth date was assigned to 1 June. Otoliths with poorly defined annual growth rings were considered unreadable and were discarded. To minimize reading errors, age estimation was carried out by two readers independently and only the coinciding interpretations were accepted. The relative precision between the two readings was estimated by the index of average percentage error (IAPE; Beamish & Fournier 1981) and the coefficient of variation (CV; Chang 1982).

Length-at-age was described by the von Bertalanffy growth model using a non-linear least-square procedure of a Gauss–Newton algorithm. The multivariate Hotelling's T^2-test was used to compare growth parameters between males and females (Bernard 1981).

Results

A total of 245 specimens of *Symphodus mediterraneus* were collected for the age analysis: 81 males, 160 females and four individuals of indeterminate sex. Total lengths of males and females ranged from 74 to 154 mm and from 51 to 131 mm, respectively. Length frequency distributions were significantly different between sexes (Kolmogorov–Smirnov test; $P < 0.001$), with a higher proportion of females in the $\leq$ 11 cm length classes and males more abundant in the $\geq$ 12 cm length classes (Figure 1).

All otoliths that were examined had a distinctive opaque core and, according to daily ring counts, consisted of 138.6 ± 16.6 (mean ± sd) daily rings. Because the assumed birthdate is 1 June, the core roughly corresponded with the period June–October, which indicated that the opaque zones were formed during the warmer period of the year. Overall 275.5 ± 41.0 daily rings were counted from the core to the end of the first opaque annual ring. Taking into account the high variability of daily ring counts, we concluded that the first opaque ring roughly corresponds with the first year of life; consequently, fish age was estimated by counting opaque annual rings, starting with the first one (Figure 2).

Of the 245 obtained otoliths, 36 (14.7%) were considered unreadable and discarded, and for the remaining 209 (85.3%), age was successfully determined by two independent readers. Both readers estimated the same age for 169 fish (80.9%), for 36 fish (17.2%) age estimates differed by one year, and for the remaining four fish (1.9%) by two years. The

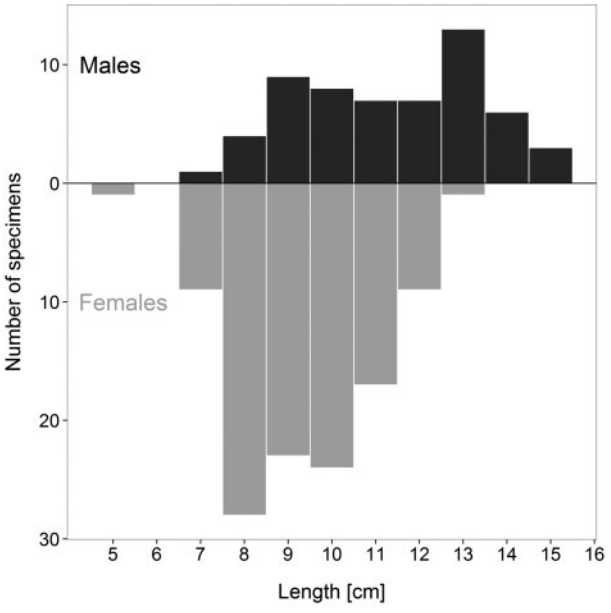

Figure 1. *Symphodus mediterraneus*. Length structures of males and females sampled between October and December 2009 in the eastern Adriatic Sea.

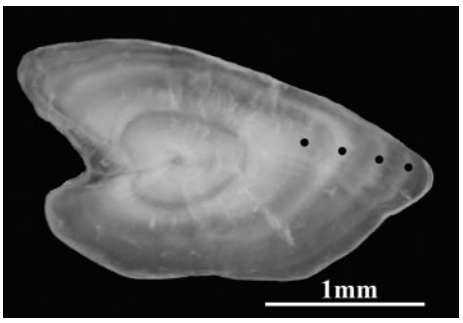

Figure 2. *Symphodus mediterraneus*. Sagittal otolith of a 4+-year-old male; opaque rings are indicated by black dots.

variability indices IAPE and CV were quite low, 4.9% and 6.9%, respectively. Only the age counts which were agreed on by the two readers were considered reliable, so in the analysis we used age data for 169 fish (58 males and 111 females). Most of the fish were between two and three years old (71% males and 76% females) and the maximum observed age was three years for males and five years for females.

The von Bertalanffy growth parameters were calculated separately for both sexes and all specimens combined (Table I). The von Bertalanffy growth curve explained a higher proportion of the variance when fitted for each sex separately (R^2 = 0.83 for males and 0.78 for females) than when fitted to all specimens pooled together (R^2 = 0.50) (Figure 3). Hotelling's T^2-test found significant differences between male and female growth parameters ($T^2 = 3902.50 > {T_0}^2_{0.05,3,165} = 8.08$).

Discussion

The use of sagittal otoliths for *Symphodus mediterraneus* age determination proved both reliable and precise once we had determined that the first opaque ring represented the first annulus. Age validation by counting daily rings in labrid species is recommended due to the reported problems in determining the first annulus, mainly concerning the formation of false rings influenced by biological or physiological changes in the individuals rather than seasonal changes in environmental factors (Gordoa et al. 2000; Škeljo et al. 2012; Matić-Skoko et al. 2013). The two readers who counted the rings already had experience in ageing labrid species, which was reflected in the relatively low values of IAPE and CV in comparison to many ageing studies (Campana 2001).

By counting the daily rings, we have validated that the first opaque ring represents the first year annulus. Although this type of age validation was done for the first time for *S. mediterraneus*, our results can be compared with those available for other labrid species in the Mediterranean Sea. Gordoa et al. (2000) found that the opaque otolith core consisted of 49–85 daily rings for *Symphodus tinca* (Linnaeus, 1758), *Symphodus roissali* (Risso, 1810) and *Coris julis* (Linnaeus, 1758), while the first translucent ring is deposited in the following 62–83 days. The authors have suggested that the core corresponds to the pelagic larval duration (PLD), while the first translucent ring has been interpreted as a settlement mark indicating the change of habit from a pelagic larval phase to a benthopelagic juvenile phase. Furthermore, they determined that the second translucent ring corresponds to the first annual ring, but the numbers of daily rings were not reported, so it was not possible to compare them with our results. In our study, the period of the core formation was much longer (approximately five months) and it cannot represent the pelagic larval duration of *S. mediterraneus* because the estimated PLD for this species is only 13.6 ± 1.1 days (Macpherson & Raventós 2006). However, formation of the opaque core was associated with the summer–autumn season, and this connection of opaque ring formation with the warmer months has also been reported for *S. tinca* (Pallaoro & Jardas 2003) and *C. julis* (Škeljo et al. 2012) in the Adriatic Sea.

The maximum lengths and ages recorded in our study were much lower than the values reported for the Gulf of Lion, 18 cm standard length and eight years (Quignard & Pras 1986), or the Aegean Sea, 20.2 cm total length (Ilhan et al. 2008). This is probably not explained by the sample size, because a much greater number of specimens were analysed in our study, nor by the sampling technique, as similar types of fishing gear were used and depths covered in our and the Aegean Sea study. However, differences in maximum age and size could be due to the various ecological conditions or different levels of

Table I. *Symphodus mediterraneus*. Von Bertalanffy growth parameters for males, females and all specimens estimated by otolith reading.

	L_∞ (cm)	se	k (year^{-1})	se	t_o (year)	se	R^2	N
Males	16.09	1.63	0.50	0.18	–0.83	0.35	0.825	58
Females	14.11	1.40	0.33	0.10	–1.42	0.43	0.779	111
All specimens	13.76	1.36	0.46	0.18	–1.08	0.49	0.498	169

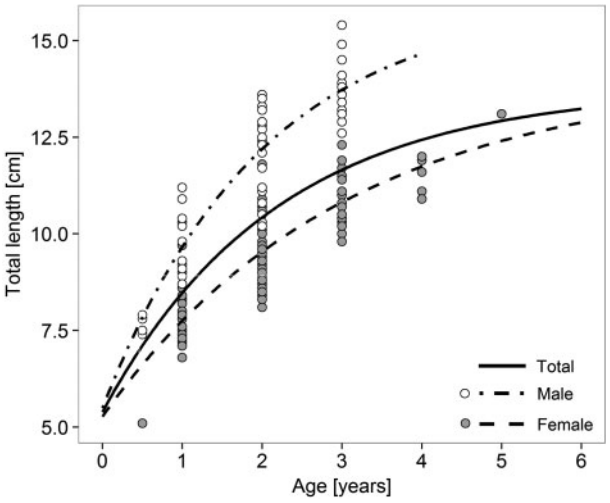

Figure 3. *Symphodus mediterraneus*. Observed length-at-age data fitted with von Bertalanffy growth curves for males, females and all specimens.

fishing pressure in the studied areas and time periods.

The von Bertalanffy growth parameters obtained in our study are very similar to the only available growth data on this species, for the Gulf of Lion (French Mediterranean coast): L_∞ = 17.0 cm and k = 0.63 for males; L_∞ = 15.7 cm and k = 0.47 for females (Quignard 1966; Pauly 1978). The growth increments were greatest in the first two years, with declining annual increments after maturation as in wrasse from French waters (Quignard 1966). In general, growth studies providing the von Bertalanffy growth parameters for other *Symphodus* species are scarce, and still the main point of reference are data provided by Quignard (1966).

The von Bertalanffy curves fitted separately to female and male growth data provided a much better fit than when used for all specimens pooled together, indicating differences in growth dynamics between sexes. This was confirmed by Hotelling's T^2-test, and a comparison of growth rates (k) between sexes showed that males grow faster than females and achieve a larger mean size in all age groups. The faster growth rate of *S. mediterraneus* males has already been reported (Quignard & Pras 1986) and the same has been noted for many *Symphodus* species (Quignard 1966; Pauly 1978) and several other wrasse species in the inshore waters of west Scotland (Treasurer 1994; Sayer et al. 1996). Quignard & Pras (1986) and Treasurer (1994) attributed this to the earlier maturation of females (one year earlier than males, normally at age 2), reducing the investment available for somatic growth and leading to their smaller size at age compared to males. However, Sayer et al. (1996) found little evidence to support the earlier maturation of females, and instead suggested that different growth rates between the sexes may be due to the large difference in relative sizes of male and female annual gonadal development. Although sexual maturity has not been analysed in our study, we compared length-at-age data with the lengths of the first maturity reported by Quignard & Pras (1986) (9 cm for females and 12 cm for males) and Raposeiro & Azevedo (2009) (9.6 cm for females and 12.1 cm for males). These lengths almost exactly correspond to the average length of two-year-old specimens of both sexes in our study (9.5 cm for females and 12.1 cm for males), implying that males and females of *S. mediterraneus* achieve sexual maturity at the same age, as suggested by Sayer et al. (1996) for wrasse species in Scottish waters.

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