Marine Ecology. ISSN 0173-9565

ORIGINAL ARTICLE

Reproductive biology of *Symphodus mediterraneus* (Teleostei, Labridae) in the Azores

Pedro M. V. M. Raposeiro & José Manuel N. Azevedo

Departamento de Biologia, Universidade dos Açores, R. Mãe de Deus, Ponta Delgada, Portugal

Keywords
Azores; first sexual maturity; Labridae; spawning period; *Symphodus mediterraneus*.

Correspondence
Pedro Raposeiro, Departamento de Biologia, Universidade dos Açores, R. Mãe de Deus, 9501-801 Ponta Delgada, Portugal.
E-mail: raposeiro@uac.pt

Conflicts of interest
The authors declare no conflicts of interest.

doi:10.1111/j.1439-0485.2009.00309.x

Abstract

A description of the colour patterns, reproductive behaviour, spawning season and size at first maturity is given for an Atlantic population of *Symphodus mediterraneus*, based on underwater observations and animals collected by spear-fishing and photographed. Gonad histology was used to determine the sex and maturity stages. Size at first maturation was estimated as the length at which 50% of the individuals are mature. General appearance was a brown or brownish-red body, with a series of large brown transverse stripes, a conspicuous yellow-ringed black spot on the base of the pectoral fins and a black spot on the caudal peduncle. Terminal males could be distinguished from females by the blue tones on the extremities of the median fins and on the throat. Differences from the colour pattern of the Mediterranean population are noted. This is probably a gonochoric species: the larger males are territorial, building algal nests and defending them from conspecific males and from other microbenthic carnivorous fishes; the smaller mature males did not show sneaking or satellite behaviour. Reproduction takes place in late spring and summer, after the spring productivity peak, suggesting that the feeding biology of the adults may be the main determinant factor of the timing of spawning. Total length at first maturity is 12.1 cm for males and 9.6 cm for females.

Introduction

Symphodus mediterraneus is a shallow water wrasse, one of the nine species of Labridae represented in the Azorean coastal waters (Porteiro *et al.* 1996). Originally described from the Mediterranean, *S. mediterraneus* is know to occur also in the Northeastern Atlantic, from the Bay of Biscay to Northern Morocco, and also in Madeira and the Canaries (Quignard & Pras 1986; Westneat 2008). Some aspects of its biology in the Mediterranean were first studied by Quignard (1966), who published data on diet, age and growth, and reproduction, the latter including first sexual maturation and spawning period. The behaviour of this species, particularly in connection with its reproductive cycle, was subsequently described by Helas *et al.* (1982) and Lejeune (1985), again based on Mediterranean specimens. These authors describe the colour patterns associated with the different life cycle stages, based on field observations.

There is no published information on the biology of the species in the Atlantic. Moreover, there are contradictions in the available literature. Quignard (1966) stated that about 3% of the animals with a female colour pattern are in fact males, based on the presence of well developed testicles. He went on to suggest that all *Symphodus* were protogynous hermaphodites, although only a small proportion of the females actually changed sex. Lejeune (1985), however, found no evidence of sex change in a group of four species from this genus, with the possible exception of *Symphodus tinca*. This was further supported by the work of Warner & Lejeune (1985), who looked at the effect of parental care on sex change and concluded that the two factors are negatively related. In species like *Symphodus melanocercus*, the terminal males defend territories and monopolize access to the females. Smaller males, unable to compete, have a much lower reproductive success than females of the same size. Thus natural selection should favour the individuals that are born females and change for males above a certain size, maximizing their lifetime reproductive output (Warner *et al.* 1975). The opposite situation was found in species such as *Symphodus ocellatus* or *Symphodus roissali*: the larger males build complex nests and display elaborate parental care, ventilating and defending the nest. The smaller males parasitize the spawnings on the nests of the territorial males, leading to a reproductive success similar to that of the females. In these cases there is no sex change.

The present paper presents data from a study of the reproductive biology of an Atlantic population of *S. mediterraneus*, aimed at describing the colour patterns of the different life-cycle phases, determining the reproductive season and size at first maturation, looking for evidence of sex , and giving a description of the reproductive behaviour.

Material and Methods

A total of 169 specimens were obtained by spear-fishing in São Miguel Island from May 2001 to April 2002. Collected fish were placed in buckets with seawater and transported to the laboratory where they were measured (total length, Lt, to the nearest mm), weighed (total weight, Wt, with 0.01 g of precision). To analyse the relationship between colour patterns, sex and gonad development stage, each animal was photographed using a technique modified from Emery & Winterbottom (1980) and Svoboda (1992). The fish were then dissected and the gonads removed, weighed (Wg, with 0.01 g of precision) and processed histologically: fixed in 10% buffered formalin for 24 or 48 h (Hopwood 1996), dehydrated and embedded in paraffin (Anderson & Gordon 1996). Longitudinal sections 7 μm thick were stained with haematoxylin and eosin (Stevens & Wilson 1996).

The gonadosomatic index (GSI) was calculated to complement the determination of the reproductive season using the formula given by Sparre & Venema (1992):

$$GSI = \frac{Wg}{(Wt - Wg)} * 100.$$

Thesize at first maturity was estimated from L50, the length at which 50% of the individuals are mature, calculated from a logistic function that relates the proportion of mature individuals with the fish length (Ghorbel *et al.* 2002),

$$P = \frac{1}{1 + e^{-(b+aLt)}}$$

where P = proportion of mature individuals; a and b = constants. The proportion of mature individuals in each length class of 1 cm was calculated based on the microscopic examination of the histological preparations. The adjustment between the observed and predicted maturity proportions was assessed using the chi-squared test.

Reproductive behaviour was studied with underwater observations conducted while SCUBA-diving. Observations were recorded on polyester paper attached to an acrylic clipboard, and by underwater photography. Approximately 40 h of observations were made.

Results

Colour patterns

The colour patterns are described based on histologically confirmed ripe specimens (Fig. 1). General appearance was a brown or brownish-red body with yellow-brownish eyes and white lips. All specimens presented a conspicuous yellow-ringed black spot on the base of the pectoral fins and a black spot on the caudal peduncle, above the lateral line. A series of large brown transverse stripes was also present, darker in the dorsal region and continuing and interconnecting down the body. There were five under the dorsal fin, one on the caudal peduncle, sometimes almost masking the dark spot.

Terminal males could be distinguished from females by the blue tones on the extremities of the median fins and the throat, and by reduced size of the urogenital papilla. Initial phase males have less marked blue tones on the median fins and the throat is the same colour as the body. No evidence for sex change was seen in any of the specimens observed.

Reproductive behaviour

Only the terminal phase males were observed building algal nests. Nests were built on crevices or on small gullies between adjacent boulders. The algae were either ripped off the substrate or collected from the water column with the mouth. In the beginning of the nest construction the male collected the algae usually not farther than 6–7 m away. By the end of the construction the algae were collected up to 20 m away. The algae were pushed amongst the nest material with the mouth, aided by lateral movements of the body using short and quick caudal fin movements. Shell fragments, sand and small stones were visible over the nest. The nests were composed of several species of algae, mainly *Stypocaulon scoparia*, *Dictyota* spp., *Halopteris filicina*, *Pterocladiella capillacea* and *Asparagopsis armata*. They were globular in shape (width 20–36 cm, length 20–56 cm) and had a reddish general coloration. The nesting male was always seen at or near the nest. When the nest was partially

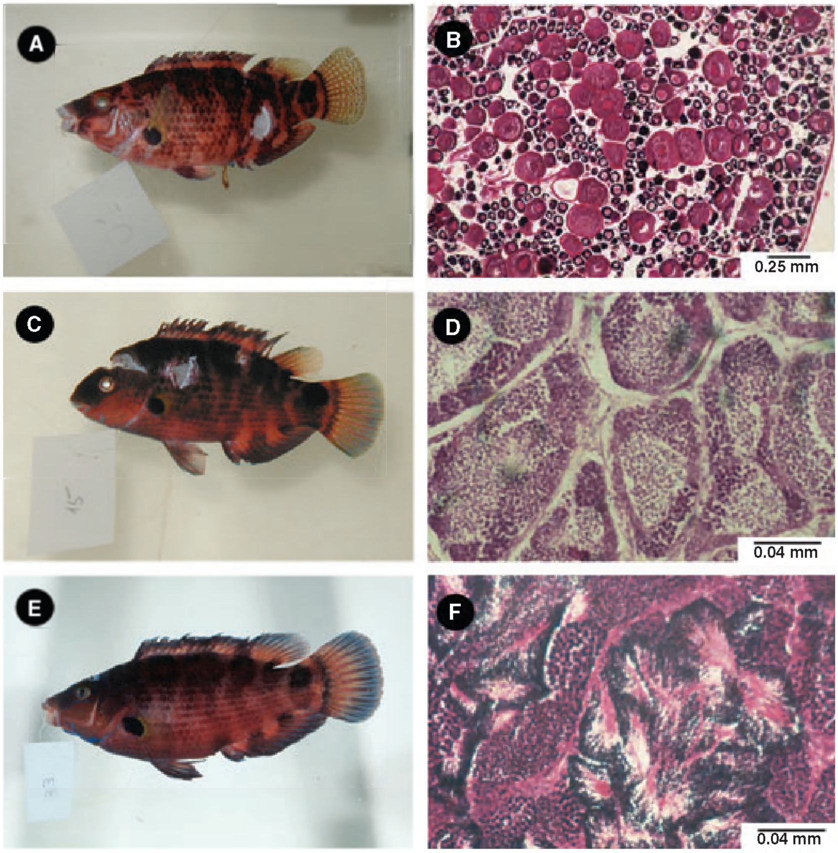

Fig. 1. Colour patterns and life cycle stages in *Symphodus mediterraneus*: mature female (A), initial phase male (C) and terminal phase male (E). Corresponding gonad histology in (B, D, and F).

constructed the males started to show aggressive behaviour, chasing and biting other fish that approached the nest. This behaviour was directed towards conspecifics and other species, such as *Coris julis, Symphodus caeruleus, Thalassoma pavo, Labrus bergylta* and *Chromis limbata*.

Males would leave the nest to meet passing females, with dorsal and anal fins distended, and try to direct them towards the nest. Courtship consisted of the two fishes circling in and out of the nest. Eventually, the female entered the nest, pressing her belly against it, closely followed by the male. Possibly, this was when spawning and fertilization took place. After this the female would swim away. The whole process took less than 2 min. On some occasions, initial phase males hovered around the nest. These were never seen helping with nest construction or defence.

Reproductive season

Symphodus mediterraneus reproduces in late spring and summer, as recorded in underwater observations of nest building, courtship and spawning behaviours from April to August. The highest values of GSI were recorded in May and June (Fig. 2), a period when the seawater temperature was between 17 and 18 °C and then starts to decrease from the spring peak (Fig. 3). Histologically mature gonads were observed from May to August. The first juveniles were observed in September.

Size at first maturity

Figure 4 shows the evolution of sexual maturation with size. The adjustment of the logistic function to the data is highly significant (χ^2, $P > 0.99$). The size at first maturity is estimated to be 9.6 cm for females and 12.1 cm for males. Terminal phase males were at least 15 cm in total length (Fig. 5). A class of mature initial phase males was therefore present.

Discussion

The fact that no histological evidence of sex change was found in the present study supports the predictions of the Warner & Lejeune (1985) model, given the high intensity of parental care in this *Symphodus* species, where terminal males build and maintain elaborate nests. We conclude that *Symphodus mediterraneus* is a gonochoric species. The initial phase males were never seen sneaking on the spawning of the territorial males, as recorded by Lejeune (1985) in the Mediterranean, where the frequency of this

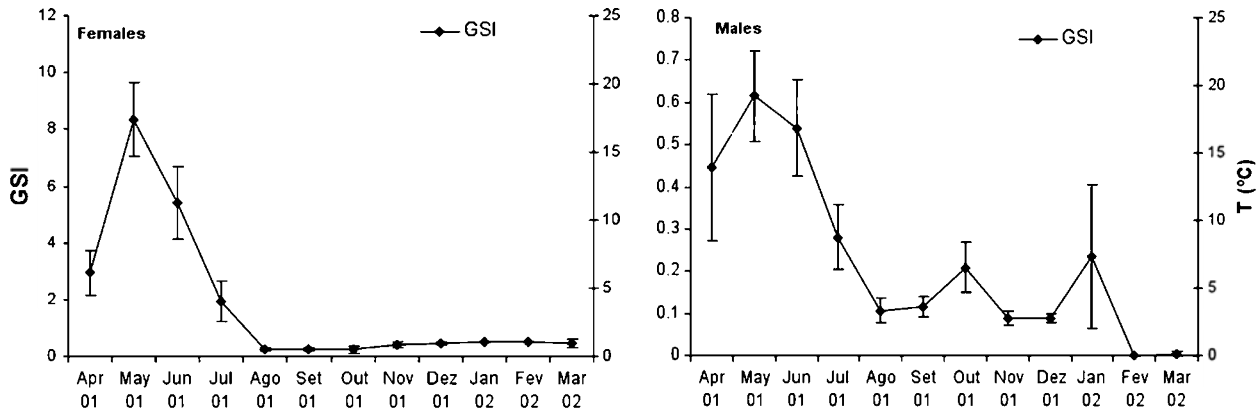

Fig. 2. Mean monthly values of GSI (±SE). Note different GSI scale on graphs.

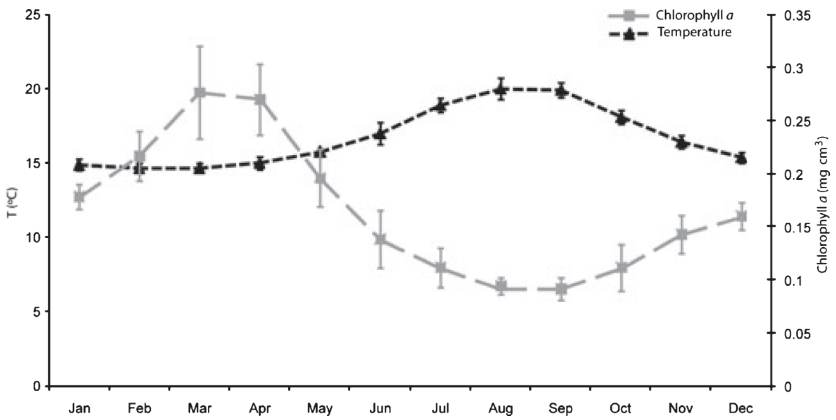

Fig. 3. Mean monthly values of seawater surface temperature and chlorophyll *a* concentration (±SD). Data from the DETRA Project (http://oceano.horta.uac.pt/detra), 2002–2007.

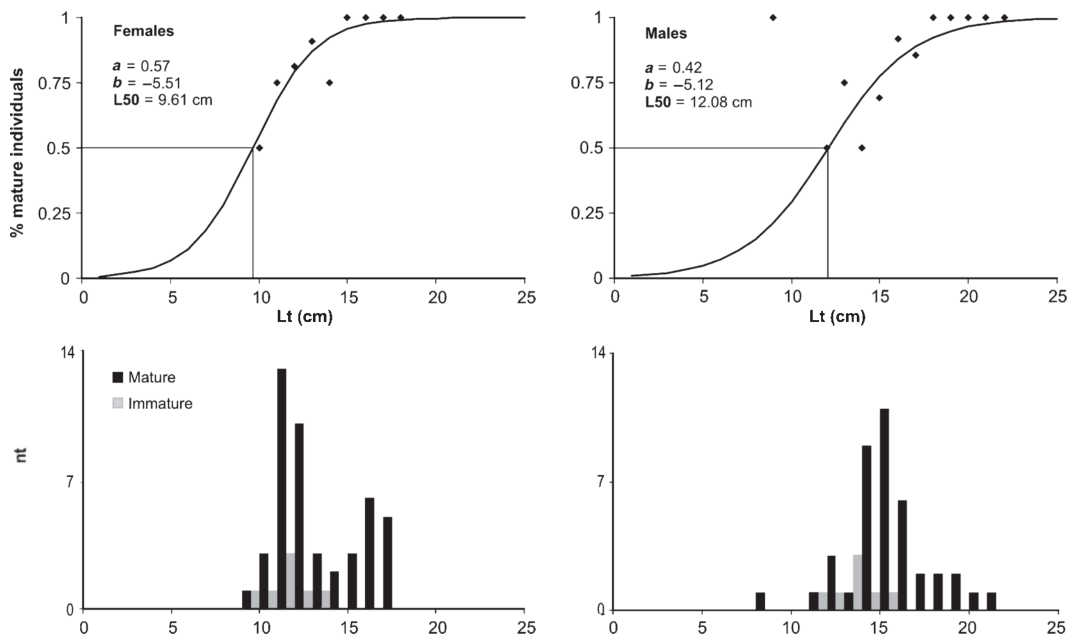

Fig. 4. Proportion of mature individuals per length class and adjusted logistic function (A) and size frequency by sexual maturity (B).

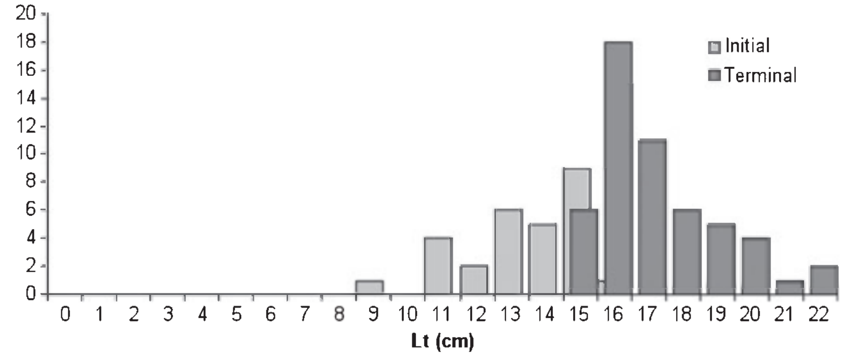

Fig. 5. Length frequency distribution of initial and terminal phase males.

kind of behaviour may be high in certain periods. This difference may be linked to differences in density at each location, as it can be expected that at low densities the large dominant males can control most of the spawning (Warner *et al.* 1975).

Differences were found between the fresh colouration of the Mediterranean and Atlantic specimens. The latter have a strong reddish background, with a series of dark brown vertical bars, whereas the Mediterranean specimens have a lighter coloration, with marked dorso-ventral contrast. The colour differences between the territorial males of both regions are also clear, with the Azorean specimens lacking most of the distinct lines of blue dots clearly seen on their Mediterranean counterparts. The taxonomic importance of these differences is being investigated, taking into account the work of Macpherson & Raventos (2006). These authors have determined the pelagic larval duration of several Mediterranean littoral fishes and noted a correlation between this predictor of a species' dispersal potential and its distribution range. It may be that the demersal eggs and short larval duration of *S. mediterraneus* (13.6 days on average) are reducing the gene flow between the island and mainland populations of this species, thereby favouring morphological differentiation.

The reproductive biology of the two populations, on the other hand, was rather similar. In both the Azores and the European mainland, females matured to a smaller size than males, which is typical from European wrasses as a consequence of the slower growth rate of the females (Quignard 1966; Treasurer 1993). The reproductive season is the same for both populations (May to August, Quignard 1966) and starts in both areas when the seawater temperature is rising from the winter low and ends when the summer peak is reached. However, there are differences in the absolute values. The highest GSI values, for instance, were observed in the Azores in May and June, when the surface seawater temperature was between 17 and 18 °C, a much narrower interval than that reported by Quignard (1966) for the corresponding period (May to July): 12 to 23 °C.

Macpherson & Raventos (2006) link the spawning in spring and summer of most species of littoral Mediterranean fish with the higher phyto- and zooplanktonic productivities in those seasons. An alternative hypothesis, based on the adult biology, has also been proposed to explain the reproductive seasonality (Robertson 1991). In the present study, the spawning starts immediately after the spring chlorophyll *a* peak, and the larvae are released when the primary productivity is decreasing. Therefore, the theory of a spawning period adapted to maximize larval survival seems unlikely. The higher productivity of spring should give adults more opportunities of feeding, increasing the energy available for gonad development. Thus, the feeding biology of the adults may be the main factor determining the timing of spawning.

Acknowledgements

We thank Dr Ana Neto for the algal species determination, and Dr Armindo Rodrigues for his support of the histology work. We would also like to acknowledge J. Brum, A. Quintela, G. Martins and R. Lacerda, who helped with data collection in the field.

References

Anderson G., Gordon K.C. (1996) Tissue processing, microtomy and paraffin sections. In: Bancroft D., Stevens A. (Eds), *Theory and Practice of Histological Techniques*. Churchill Livingstone, New York: 47–67.

Emery A.R., Winterbottom R. (1980) A technique for fish specimen photography in the field. *Canadian Journal of Zoology*, **58**, 2158–2162.

Ghorbel M., Bradai M.N., Bouain A. (2002) Période de reproduction et maturité sexuelle de *Symphodus* (*Crenilabrus*) *tinca* (Labridae), des côtes de Sfax (Tunisie). *Cybium*, **26**, 89–92.

Helas T.C., Michel C., Voss J. (1982) A propos de quelques poissons de la Méditerranée: *Symphodus (Crenilabrus) mediterraneus* (Linné, 1758). *Revue Francais d'Aquariologie*, **9**, 33–36.

Hopwood D. (1996) Fixation and fixatives. In: Bancroft D., Stevens A. (Eds), *Theory and Practice of Histological Techniques*. Churchill Livingstone, New York: 23–45.

Lejeune P. (1985) Le comportement social des Labridés méditerranéens. *Cahiers d'Ethologie Applique*, **5**, 208.

Macpherson E., Raventos N. (2006) Relationship between pelagic larval duration and geographic distribution of Mediterranean littoral fishes. *Marine Ecology. Progress Series*, **327**, 257–265.

Porteiro F.M., Barreiros J.P., Santos R.S. (1996) Wrasses (Teleostei: Labridae) of the Azores. *Arquipélago – Life and Earth Sciences*, **10**, 101–111.

Quignard J.P. (1966) Recherches sur les Labridae (Poissons, Téléostéens, Perciformes) des côtes européenes – systématique et biologie. *Naturalia Monspeliensia (Séries Zoologique)*, **5**, 7–247.

Quignard J.P., Pras A. (1986) Labridae. In: Whitehead P.J.P., Bauchot M.-L, Hureau J.-C, Nielsen J., Tortonese E. (Eds), *Fishes of the North-eastern Atlantic and the Mediterranean*. UNESCO, Paris: 919–942.

Robertson D. R. (1991) The role of adult biology in the timing of spawning of tropical reef fishes. In: Sale P.F. (Ed.), *The Ecology of Fishes on Coral Reefs*. Academic Press, San Diego, 356–386.

Sparre P., Venema S.C. (1992) *Introduction to Tropical Fish Stock Assessment Part I. Manual. FAO Fisheries Technical Paper No. 306*. FAO, Rome: 376 pp.

Stevens A., Wilson I. (1996) The haematoxylins and eosin. In: Bancroft D., Stevens A. (Eds), *Theory and Practice of Histological Techniques*. Churchill Livingstone, New York: 47–67.

Svoboda A. (1992) Close-up photography of marine life on board research vessels. *Scientia Marina*, **56**, 239–244.

Treasurer J.W. (1993) The distribution, age and growth of wrasse (Labridae) in inshore waters of west Scotland. *Journal of Fish Biology*, **44**, 905–918.

Warner R.R., Lejeune P. (1985) Sex change limited by paternal care: a test using four Mediterranean labrid fishes, genus *Symphodus*. *Marine Biology*, **87**, 89–99.

Warner R.R., Robertson D.R., Leigh E.G. Jr (1975) Sex change and sexual selection. *Science*, **190**, 633–638.

Westneat M.W. (2008) Labridae. In: Froese R., Pauly D. (Eds), *FishBase*. World Wide Web electronic publication. http://www.fishbase.org, version (09/2008).