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Age, growth and reproduction of the black goby, *Gobius niger*, from Óbidos Lagoon, Portugal.

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Abstract: Black gobies (*Gobius niger*) were sampled monthly between November 1992 and December 1994 using a beach seine net. Length distribution varied between 3.5 and 15 cm total length. Age determined from direct reading on 671 female and 750 male otoliths was comprised from less than one year to three years. There were no significant differences in mean lengths at age group for the two sexes, which allowed the use of combined data. A von Bertalanffy growth equation, based on the data of all individuals, was established: $L_t = 16.657[1 - e^{-0.337 (t + 1.910)}]$.
The spawning season occurred between March and September. In this population, the sex ratio was 1.1: 1. However, during the spawning season, the females were in majority in the samples (53.2%) while, in the resting period, males were present in 71.7 % of the catches.

Résumé : *Age, croissance et reproduction du Gobie noir,* Gobius niger, *dans la lagune de Óbidos (Portugal).*
Des récoltes de gobie noir (*Gobius niger*) ont été effectuées en utilisant une seine de plage, entre novembre 1992 et décembre 1994. La distribution de tailles varie de 3,5 à 15 cm de longueur totale. L'âge déterminé par l'examen de 671 otolithes de femelles et de 750 otolithes de mâles était compris entre moins de un an et trois ans. Il n'y a pas de différences significatives entre mâles et femelles en ce qui concerne les longueurs moyennes par classe d'âge, ce qui a permis de réunir toutes les données. Une équation de croissance de von Bertalanffy a été établie en utilisant tous les individus : $L_t = 16.657[1 - e^{-0.337 (t + 1.910)}]$.
La période de ponte s'étend de mars à septembre. Dans cette population la sex ratio annuelle est de 1.1 : 1 en faveur des mâles. Cependant, au cours de la période de reproduction, les femelles sont en plus grand nombre (53,2 %) alors qu'en période de repos sexuel, les mâles dominent (71,7 %).

Keywords : age ; growth ; reproduction ; black goby ; Portugal.

Introduction

The Óbidos lagoon is the largest coastal lagoon of Portugal (Fig. 1) with an area of 7 Km^2. The lagoon is shallow (mean depth 1.5 - 2 m), a characteristic of most lagoons in the area, with water temperature ranging from 10° C in January/February to 31° C in July/August.

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The seaward and central section of this lagoon is influenced by the marine environment (salinities up to 37‰) whereas the landward is brackish (salinities down to 5‰). These conditions lead to a diverse fish community with grey mullets (*Liza* spp.) and the black goby, *Gobius niger* (Linné, 1758) as dominant species.

The black goby is widely distributed, occurring from Norway and the Baltic Sea to Mauritania and also in the Mediterranean and Black Seas (Miller, 1986). However,

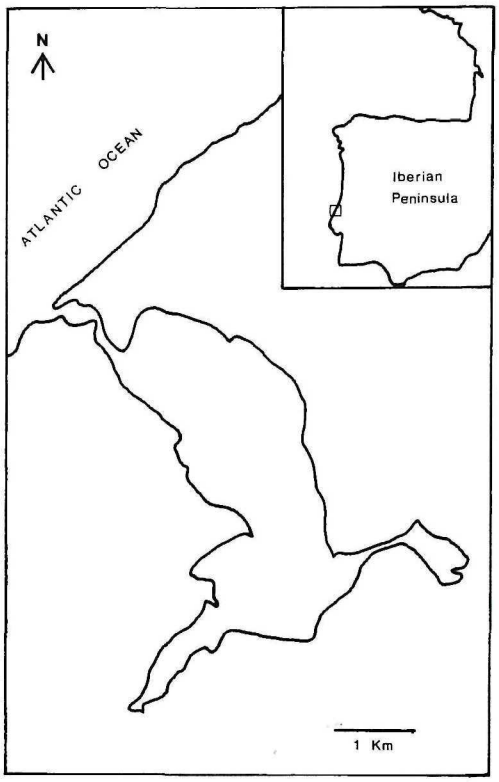

Figure 1. Map showing the location of the Óbidos lagoon.
Figure 1. Carte montrant l'emplacement de la lagune de Óbidos.

except for Arruda *et al.* (1993) data on black gobies in the Aveiro lagoon, there is little information on populations living along the Iberian Peninsula.

This paper provides information on the biology of the black goby, an important species of the Óbidos lagoon in Portugal, specifically on its age, growth and reproduction.

Material and methods

The Óbidos lagoon was sampled monthly between November 1992 and December 1994, using an artisanal gear named "redinha". This net consists of a 50 m long beach seine, 1 m height and with a 16 mm mesh size. Every month, six hauls were made during low tide, when the lagoon is at its lowest depth. Temperature and salinity values were recorded using an oceanographic salinity and temperature probes.

In the laboratory, the total length of all individuals was measured to the nearest millimeter below (later grouped in 0.5 cm length classes) and weighed to the nearest 0.1 g total weight. Sex was recorded and the gonads were weighed to the nearest 0.01 g (in the males, sperm-duct gland was not included in the gonadal weight). Sagittal otoliths were removed, cleaned, dried and stored in plastic tubes.

For age determination, the otoliths were examined under a stereoscope microscope with a reflected light (x18 magnification). The otoliths were read by both authors and when there was no agreement between the two observations, the otolith was excluded. Age was expressed in years, the birthday of the fish being considered to be 1 January (Hile, 1950).

The mean lengths at age were analysed separately per sex and were compared statistically using Student's t test ($P>0.05$). When there were no significant differences between the age groups, data for the two sexes were pooled.

To examine fish growth, a von Bertalanffy growth equation (VBGE) (Bertalanffy von, 1938) was calculated using the iterated least square method (Sparre, 1987). The VBGE model was chosen in this study as it has been shown to conform to the observed growth of most fish species in previous studies.

The length-weight relationship was calculated using all individuals caught in the samples.

To quantify the changes that occurred in the gonads during the annual sexual cycle and to determine the spawning season, the gonadosomatic index (GSI) (expressing gonadal weight as a percentage of total weight minus gonadal weight) was calculated, between November 1992 and December 1993, monthly and per sex, their mean values being calculated from the individual ones.

Sex ratio (number of males/number of females) was calculated monthly.

Results

The mean values of temperature and salinity recorded for the lagoon during the sampling period are shown in Fig. 2. The lowest value of temperature (10.5 °C) was found in February 1993 and the highest (27.6 °C) in August 1994. The salinity varied between 18.7 PSU in February 1994 and 36.7 PSU in August 1993.

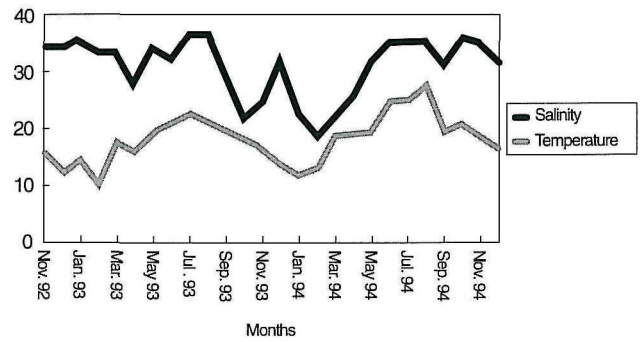

Figure 2. Mean values of temperature (°C) and salinity (PSU) recorded in the Óbidos lagoon between November 1992 and December 1994.
Figure 2. Valeurs moyennes de la température (°C) et de la salinité (PSU) enregistrées dans la lagune d'Óbidos de novembre 1992 à décembre 1994.

Among the 1426 *G. niger* which were caught, 5 individuals (0.35 %) could not be aged. Thus 671 females and 750 males were used for direct reading on the otoliths (Tables 1 and 2). There were no black gobies with a total length lower than 3.5 cm in the samples and no individuals longer than 15 cm. The smaller female was 3.5 cm total length and the largest one 14.0 cm. Regarding the males, the smaller was 4.0 cm and the largest one, 15.0 cm.

Table 1. Results from direct reading on the otoliths of females of *G. niger* from Óbidos lagoon. Age expressed in years. Lt = total length of animals in centimetres.

Table 1. Résultats de la lecture directe des otolithes de femelles de *G. niger* de la lagune de Óbidos. Lt = longueur totale des animaux en centimètres.

	AGE GROUPS				
Lt (cm)	0	I	II	III	Total
3.5	1				1
4.0	5				5
4.5	3				3
5.0	9				9
5.5	10				10
6.0	17	1			18
6.5	27	3			30
7.0	38	9			47
7.5	24	7			31
8.0	33	12			45
8.5	30	19			49
9.0	25	20			45
9.5	15	26	2		43
10.0	14	54	3		71
10.5	10	82	5		97
11.0	6	66	7		79
11.5	3	38	8		49
12.0		4	19	1	24
12.5		1	8		9
13.0			3		3
13.5			1		1
14.0			2		2
14.5					
15.0					
N	270	342	58	1	671

The length range by age group for both males and females was similar. Application of the Student's *t* test to the mean lengths and standard deviations per age group shows

Table 2. Results from direct reading on the otoliths of the males of *G. niger* from Óbidos lagoon.

Table 2. Résultats de la lecture directe des otolithes de mâles de *G. niger* de la lagune de Óbidos.

	AGE GROUPS				
Lt (cm)	0	I	II	III	Total
3.5					
4.0	3				3
4.5	2				2
5.0	10				10
5.5	24				24
6.0	29	3			32
6.5	26	5			31
7.0	35	9			44
7.5	20	10			30
8.0	31	6			37
8.5	32	12			44
9.0	20	14			34
9.5	20	28	2		50
10.0	12	29	8		49
10.5	8	38	13		59
11.0	4	32	21		57
11.5	1	24	25		50
12.0		20	28	3	51
12.5		11	22	9	42
13.0		10	24	15	49
13.5		4	6	10	20
14.0		3	5	13	21
14.5		1	3	6	10
15.0			1		1
N	277	259	158	56	750

that there are no significant difference between sexes (Table 3). The test was not applied to both males and females of age group III because there was only one female in the group. So results from direct reading on the otoliths were pooled (Table 4) and this shows that 80.8 % of the individuals belong to age groups 0 (less than one year) and 1 (one year).

To describe the growth of the black goby population found in Óbidos lagoon, a VBGE, based on the data of all individuals, was established :

$L_t = 16.657[1 - e^{-0.337\,(t + 1.910)}]$ $\quad r = 0.99$

The relationship between the total length and the total weight was : $W_t = 0.0072\ L_t^{3.258}$ $\quad r = 0.98$.

Table 3. Results of the application of the Studen's *t* test to the mean lengths per age group for females and males of *G. niger* from Óbidos lagoon.

Table 3. Résultats de l'application du test *t* de Student aux longueurs moyennes par classe d'âge pour les femelles et les mâles de *G. niger* de la lagune de Óbidos.

	Females		Males		
Age Group	Mean (SD)	Number	Mean (SD)	Number	t
0	8.000 (1.627)	270	7.797 (1.580)	277	1.481
I	10.338 (1.194)	342	10.541 (1.710)	259	1.712
II	11.956 (0.982)	58	12.189 (1.103)	158	1.342

Table 4. Results from direct reading on the otoliths for both females and males of *G. niger* from Óbidos lagoon.

Table 4. Résultats de la lecture directe des otolithes de femelles et de mâles de *G. niger* de la lagune de Óbidos.

	AGE GROUPS				
Lt (cm)	0	I	II	III	Total
3.5	1				1
4.0	8				8
4.5	5				5
5.0	19				19
5.5	34				34
6.0	46	4			50
6.5	53	8			61
7.0	73	18			91
7.5	44	17			61
8.0	64	18			82
8.5	62	31			93
9.0	45	34			79
9.5	35	54	4		93
10.0	26	83	11		120
10.5	18	120	18		156
11.0	10	98	28		136
11.5	4	62	33		99
12.0		24	47	4	75
12.5		12	30	9	51
13.0		10	27	15	52
13.5		4	7	10	21
14.0		3	7	13	23
14.5		1	3	6	10
15.0			1		1
N	547	601	216	57	1421
X	7.897	10.426	12.127	13.574	
s.d.	1.605	1.441	1.075	0.723	

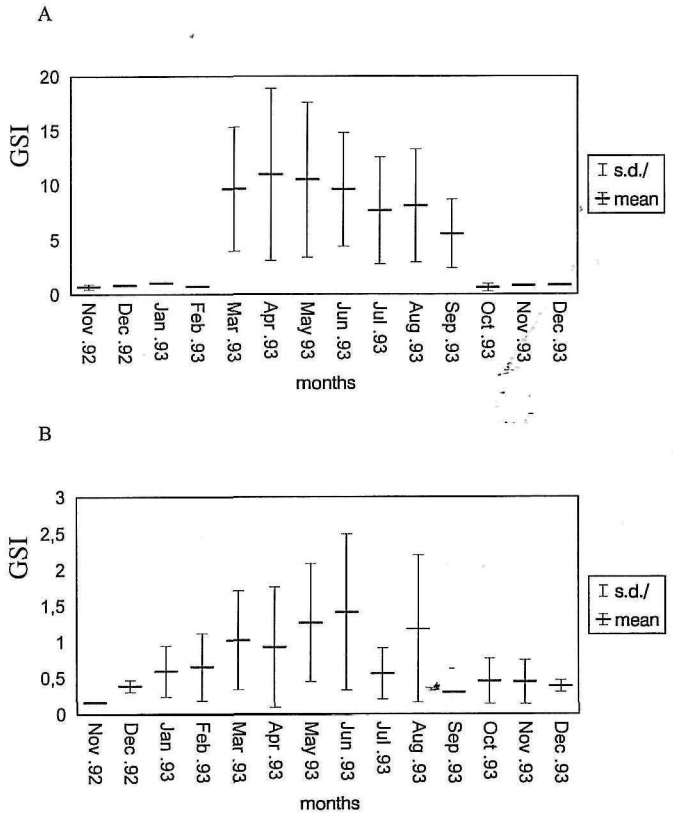

Figure 3. Seasonal variation in gonadosomatic index, GSI for *G. niger* in the Óbidos lagoon: A - females; B - males.

Figure 3. Variation saisonnière du rapport gonadosomatique de *G. niger* dans la lagune de Óbidos. A - femelles ; B - mâles.

To estimate the growth in weight, and replacing L_t by L_∞, a $W_\infty = 68.754$ g can be expected.

If we compare the seasonal variation of the GSI for females and males (Fig. 3 a, b), it is obvious that the male GSI values increase gradually from November to March, whereas female GSI values remain similar between November and February, and then show a marked increase in March. Therefore, this month seems to be the beginning of the spawning season which lasts until August-September.

Comparing the GSI values attained by both sexes (Fig. 3 a, b) it can be noticed that, during the reproduction period, the females reach GSI values of about 15 %, while the males only achieve values 10 times lower (1.5 %) than those observed in females.

Although the annual sex ratio is close to 1 (1.1:1), the percentage of females and males is not the same every month (Fig. 4). During the reproduction period, from March to September, the females are present in most of the samples (with the exception of June, where values are below 50%). In Autumn and Winter, males were found to dominate (mean value of 71.7 %).

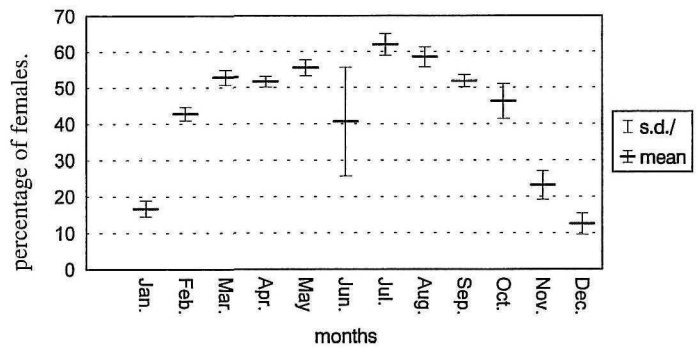

Figure 4. Monthly evolution of the mean sex ratio of *G. niger* from Óbidos lagoon.

Figure 4. Évolution mensuelle de la sex ratio moyenne de *G. niger* dans la lagune de Óbidos.

Discussion

Age determination from direct observation on the otoliths resulted in the establishment of 4 age groups for both males and females. Although in terms of mean length per age

Table 5. Mean lengths per age group (in cm) for males (M) and females (F) of *G. niger* obtained for different areas and according to several authors.

Table 5. Tailles moyennes (en cm) par classe d'âge pour les mâles (M) et les femelles (F) de *G. niger* obtenues pour d'autres régions et par différents auteurs.

Age Group	Nash 1984 Oslofjorden Norway	Vaas et *al.* 1975 Veersemeer Netherlands	Doornbos & Twisk 1987 Lake Grevelingen Netherlands	Vesey & Langford 1985 Stanswood Bay England	Arruda *et al.* 1993 Aveiro lagoon Portugal	Joyeux et *al.* 1991 a Mauguio lagoon Mediterranean	Fabi & Giannetti 1985 Adriatic Sea	Present Paper Óbidos lagoon Portugal
0		5.5	4.7	≈ 3	M 7.6 F 7.2		M 7.7 F 6.2	M 7.8 F 8.0
I	4.4	M 8.2 F 8.1	8.0 - 8.5	5.6	M 10.8 F 10.5	M 8.8 - 9.6 F 8.4 - 9.2	M 9.4 F 7.8	M 10.5 F 10.3
II	7.1	M 9.5 F 9.6	11.2 - 12.5	9.0	M 11.8 F 11.5	M 9.6 - 12.0 F 9.2 - 11.6	M 11.9 F 9.5	M 12.2 F 11.9
III	8.6	M 12.0 F 10.5		10.9		M 12.0 - 13.2 F 11.6 - 12.4	M 13.5 F 10.4	M 13.5 F 12.0*
IV	9.6	F 11.1				M 13.6	M 14.5 F 11.8	
V	9.3						M 15.5	

* only one indvidual recorded.

Table 6. Comparison of the spawning season of *G. niger* obtained from different areas and according to several authors. X = occurrence of spawning season; + - possible occurrence of spawning season.

Table 6. Comparaison de la période de reproduction de *G. niger* obtenue pour d'autres régions et suivant différents auteurs. X = période de reproduction ; + - période de reproduction probable.

	Nash 1984 Oslofjorden Norway	Vaas *et al.* 1975 Veersemeer Netherlands	Vesey & Langford 1985 Stanswood Bay England	Le Menn 1979 Arcachon Bay Atlantic coast of France	Arruda *et al.* 1993 Aveiro lagoon Portugal	Joyeux *et al.* 1991 b Mauguio lagoon Mediterranean	Fabi & Froglia 1983 Adriatic Sea	Present Paper Óbidos lagoon Portugal
March						X		X
April	X		X			X	X	X
May	X	X	X	X	X	X	X	X
June	X	X	+-	X	X	X	X	X
July		X	+-	X	X	X	X	X
August		X	+-	X	X	X	X	X
September			+-			X		X

group no significant differences were found between the two sexes, the results obtained for the Óbidos lagoon suggest that males attain a bigger length than females.

These differences between male and female growth rates and life span have already been noticed by other authors. Joyeux *et al.* (1991 a, b), in the Mauguio lagoon, found that females grew less than the males (due to the fact that females fed less than males) and died sooner, since females aged 2+ have already spent too much energy during the reproductive activity (six to eight spawnings per season) and consequently only a few can survive their third year of life.

Comparing life span in the Óbidos lagoon with that found by other authors (Table 5), some differences in the number of age groups can be found. Fabi & Giannetti (1985) determined 6 age groups; Doornbos & Twisk (1987), Joyeux *et al.* (1991a), Nash (1984) and Vaas *et al.* (1975) recorded 5 age groups; Vesey & Langford (1985) 4 age

groups and Arruda *et al.* (1993) 3 age groups. From these results, it can be concluded that the population living in the Adriatic Sea is the one that reaches the maximum age (5) and the maximum length ever recorded (16.5 cm).

Analysing the same table, it can be seen that the growth rate from the black goby population living in Óbidos lagoon is more similar to those from the Mediterranean and Adriatic Seas than to those from Britain, the Netherlands and Norway. These high growth rates found in Óbidos lagoon can not be dissociated from the mean water temperature during Spring and Summer that, due to the low depth of the lagoon, is usually above 18 °C (Fig. 2). In fact, Joyeux *et al.* (1991 a) had already pointed out that the growth rate of the black goby seemed to be inversely proportional to latitude.

During the whole spawning period of the black goby from Óbidos lagoon, it seems that there is a mixed population of ripe and spent fish since the mean GSI values are followed by high standard deviation values. From October onwards, all fish are in the spent condition which is revealed by low GSI and standard deviation values. This situation has already been reported to the black goby population from Oslofjorden by Nash (1984).

Comparing the GSI values attained by both males and females, the low values of males GSI, even during the spawning season, (about 1.5%), must be pointed out. This situation has already been noticed by Joyeux et al. (1991 b) who pointed out that, in the Mauguio lagoon, the male GSI rarely reached values above 2% which, according to Lejeuve (1985 in Joyeux *et al.* 1992) are characteristic of males in nidification with low spermatic loss due to fecundation.

A comparison between the spawning season of the black goby population living in Óbidos lagoon with those from other areas (Table 6) shows that there is a certain homogeneity in the spawning period, although the Northern populations have a shorter breeding season than the Southern ones. The longer spawning period of the latter can not be dissociated from the climatic conditions. In fact, the warmer temperature and longer day length have a large influence on gonadal development, favouring a longer spawning period (Joyeux *et al.*, 1992).

The differences found in the sex ratio values between, on one hand, Spring and Summer months (spawning period) and, on the other hand, Autumn and Winter months, are due to a decrease in the availability of the males. According to Miller (1984), this fact is very common among gobioid fishes since during the breeding season, there is a marked reduction in the proportion of males due to the egg protection behaviour, because they guard eggs under shells or stones and so are less easily caught. Autumn and Winter months period is considered as the best informative for the evaluation of the sex ratio in the black goby population, as already pointed out by Joyeux *et al.* (1991a).

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