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Abundance, Age-structure and Growth, and Reproduction of Gobies (Pisces; Gobiidae) in the Ria de Aveiro Lagoon (Portugal)

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Biological data concerning the abundance, age, growth and reproduction of seven species of gobies in the Ria de Aveiro lagoon (Portugal) are presented and discussed.

The seasonal changes in species abundance are ascribed either to recruitment and mortality or to sporadic occurrence. *Gobius niger*, *Pomatoschistus minutus* and *P. microps* are included in the first case, and *P. pictus*, *P. lozanoi*, *Aphia minuta* and *G. paganellus* in the second.

Only *G. niger* and *G. paganellus* were found to live more than 1 year. Growth took place all year round, although it was slow in winter. There is an indication that temperature influenced the start of growth in spring.

Almost all the species (except *G. paganellus* and *P. lozanoi*) were found to spawn inside the lagoon. Spawning seasons were found to be shorter for *G. niger* and *A. minuta* (summer only) than for species of *Pomatoschistus* (with reproductive periods in winter and summer).

Introduction

The Gobiidae is a particularly successful teleost family in both tropical and temperate seas, and it is well represented in estuarine and freshwater environments (Nelson, 1976; Wheeler, 1978). However, little attention has been given to the Gobiidae from the Portuguese coast. New occurrences have been recorded by Arruda and Azevedo (1987), Gonçalves (1941) and Ré (1980–81); the gut contents of *Gobius niger*, *Pomatoschistus minutus* and *P. pictus* trapped on the filtering screens of a power plant were examined by Cunha (1984); and the use of scales for age-determination in *P. microps* and *P. minutus* was studied by Moreira *et al.* (1991).

Ria de Aveiro is a large marine lagoon system on the western coast of Portugal. The total area varies between 42 km^2 at low tide and 47 km^2 at high tide. The depth is only 1 m in most of the lagoon. The three main channels are: the Canal de Mira, the Canal de São Jacinto and the Canal de Ilhavo. All three channels open into a man-made connection

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between the lagoon and the sea. During a survey of the ichthyological resources in this lagoon, the material collected provided a wealth of information on some aspects of the biology of species belonging to the Gobiidae.

Considering the importance of these species in the marine and estuarine ecosystems (Muus, 1967; Miller, 1972) and their role as intermediate predators in the food-web, connecting microbenthos with larger predatory fish (Casabianca & Kiener, 1969; Miller, 1972; Raffaelli & Milne, 1987; Raffaelli *et al.*, 1989) the present study was undertaken to obtain information on the abundance, including seasonal occurrence, the age and growth, and the reproduction of the gobies occurring in this lagoon.

Material and methods

Seven species were caught: *G. niger* (Linnaeus, 1758) ($n = 1003$), *G. paganellus* (Linnaeus, 1758) ($n = 137$), *Aphia minuta* (Risso, 1810) ($n = 42$), *P. minutus* (Pallas, 1770) ($n = 862$), *P. lozanoi* (de Buen, 1923) ($n = 94$), *P. microps* (Krøyer, 1838) ($n = 411$) and *P. pictus* (Malm, 1865) ($n = 27$).

Fish samples were collected monthly between November 1985 to October 1987 during morning low water tide. The three sampling zones (Costa Nova, S. Jacinto and Ilhavo) were chosen as representative of the three main channels and water depths in the lagoon (see details in Arruda *et al.*, 1988).

A standard 20 m long purse-seine was used. Between the edge and the centre of the seine, the width increases from 0·5 to 2·5 m and the mesh size decreases from 2·5 to 2·0 cm. A conical net is set into the middle of the seine which has an even smaller mesh size of 1·0–1·5 cm (see details in Arruda *et al.*, 1988). The seine was set from land and allowed fish to escape only when the lower edge lost contact with the bottom. Six hauls were made in each sampling zone at each sampling. Homogeneity of the fishing effort was achieved because the same number of hauls was made at each sampling during the whole sampling period. Both temperature and salinity of the water surface were recorded before sampling. The fish were identified using the characteristics described by Miller (1986).

Length, weight, sex and age were recorded for each individual: (1) The total length of all fish was measured to the nearest mm and the individuals were subsequently grouped into 0·5 cm interval length classes; (2) Fish weight was determined to the nearest 0·01 g; (3) Sex was determined by the shape of the urogenital papilla (Healey, 1971*a*). Sex ratio was expressed as a percentage of males in the sample. The test of significance of a binomial proportion according to Snedecor and Cochran (1967) was used to denote a significant difference between sexes. The normal deviate with the correction for continuity was computed as

$$z_c = [(f - p) - 1/(2n)]/\sqrt{(pq/n)}$$

where f = observed proportion of males, n = total number of individuals per sample, p = expected proportion of males and q = expected proportion of females. The null hypothesis was that the proportion of males was equal to the proportion of females and thus $p = q = 0{\cdot}5$. The value of z_c was then referred to the normal tables to compute the probability of getting a sample proportion as divergent as the observed one. In order to analyse gonad weight variations, the gonadosomatic index (GSI) was used: gonad weight as a percentage of the fish's weight after the removal of the gonads. In order to determine the length at first spawning, ' ripening ' and ' non-ripening ' fish were studied. Thus, the mean value and standard deviation of the GSI were calculated for each length class. The

observation of ripe individuals was used as an indication of the onset of breeding; (4) Age was evaluated by observing the growth marks in the otoliths for the genus *Gobius* and on the scales for the genus *Aphia* and *Pomatoschistus*. Five scales were then taken from the dorsolateral or ventrolateral rows of the caudal peduncle of each animal. As an age reference, the chronological appearance of the rings in otoliths and annuli on sclaes was used. Monthly series including specimens ranging from the smallest to the largest ones captured were used to study the chronological appearance of the rings and annuli.

Otoliths of gobies in their second growing season (as determined by reference to size group analysis) show a fairly definite ring, easily distinguished from the thin translucent lines or growth rings between successive shells of opaque substance. The otoliths of specimens in their third growing season show two of such rings. Comparison of otoliths removed from different individuals showed rings on identical position when referred to the nucleus.

Scale examination of the 1985 year-class showed absence of annulus formation during December 1985 and March 1986. Instead, the anterior edge of the scales was formed of somewhat narrower sclerites. The spring annulus, of very narrow sclerites, was laid down at the edge of almost all scales in April 1986, and was followed by one or two wide sclerites. The spring annulus was evident on all scales in May, and bordered at its periphery of wide sclerites, including the terminal series. The annuli formed on the scales of the 1986 year-class were similar to those on the scales of 1985 year-class.

The chronological appearance of the ring in the otoliths and annuli on the scales support the view that only one ring and one annulus are formed yearly, validating both the otolith and scale reading methods for age determination. The observations agree with those of Fabi and Giannetti (1985), Fouda and Miller (1981), Miller (1961, 1975), Moreira *et al.* (1991) in the genera *Gobius, Aphia* and *Pomatoschistus*.

Growth parameters were not estimated because there were not sufficient number of the year-classes observed in the different species.

Results

Temperature and salinity

Figure 1 shows both the monthly mean temperature and the mean salinity of surface lagoon water. Mean temperature followed a seasonal cycle ranging from 10 °C in January 1987 to 20 °C in July 1987 while salinity varied from about 8·5‰ in January 1986 to 18·5‰ in July 1986.

Abundance

Table 1 shows the relative abundance of the different species as percentages of individuals in the three sampling zones, and for the total numbers of the fish caught in the three zones together. In the three sampling zones, *G. niger* was dominant at Ilhavo (75·2%) and *P. minutus* at S. Jacinto (61·1%). At Costa Nova, the dominance by one species was not so clear. The greatest percentage of individuals among the three sampling zones, was recorded in Costa Nova. However, the total number of fish sampled as well as the relative abundance of the species were different in the three sampling zones. For all samples (or fish) together, *G. niger* and *P. minutus* were the most abundant species.

Figure 2 shows the monthly occurrence of the species by the percentage frequency of individuals. *Gobius niger, G. paganellus, P. minutus* and *P. microps* occurred throughout

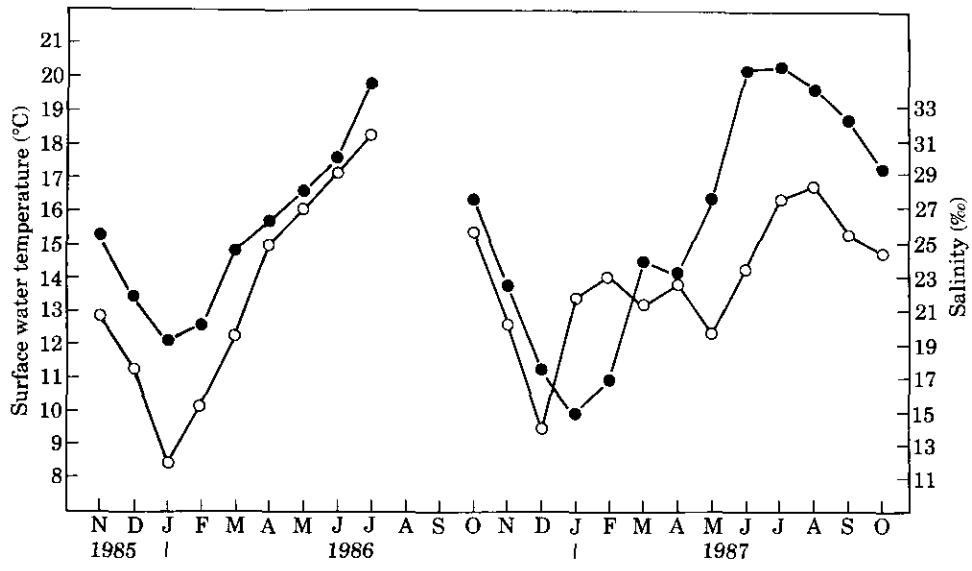

Figure 1. Variation in surface water temperature (●) and salinity (○) in the Ria de Aveiro expressed as mean values of the three sampling zones taken monthly.

TABLE 1. Percentage abundance of the gobiid species from the Ria de Aveiro lagoon

	Sampling zone			
	Costa Nova	Ilhavo	S. Jacinto	All three
G. niger	36·0	75·2	22·6	38·9
	(560)	(303)	(140)	(1003)
G. paganellus	6·0	0·5	6·6	5·3
	(94)	(2)	(41)	(137)
A. minuta	1·9	1·0	1·3	1·6
	(30)	(4)	(8)	(42)
P. minutus	27·9	12·4	61·1	33·5
	(434)	(50)	(378)	(862)
P. lozanoi	5·9	—	0·5	3·6
	(91)	—	(3)	(94)
P. microps	20·8	10·2	7·6	16·0
	(323)	(41)	(47)	(411)
P. pictus	1·5	0·7	0·3	1·1
	(22)	(3)	(2)	(27)
Total fish	60·4	15·6	24·0	—
	(1554)	(403)	(619)	(2576)

Numbers of individuals are given in brackets.

the year, showing seasonal variations in the percentage frequency of the individuals. The highest frequency of *G. niger* was observed from May to August, while *G. paganellus*, *P. minutus* and *P. microps* were most abundant in winter. *Aphia minuta* was caught mainly in spring, *P. lozanoi* only in winter, and *P. pictus* was absent in late summer and autumn.

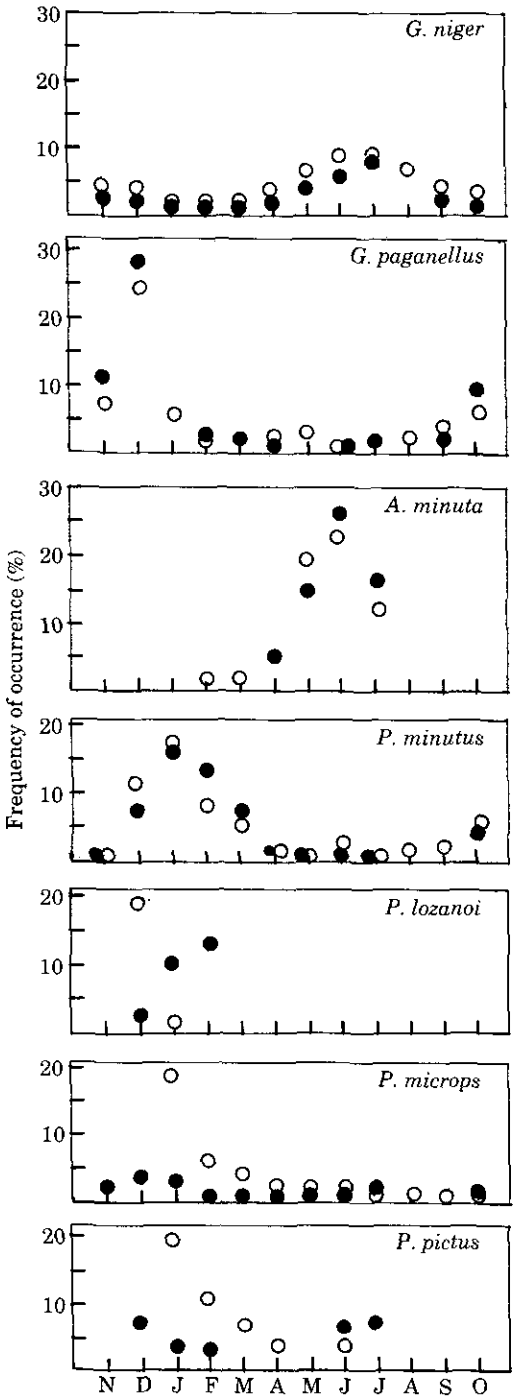

Figure 2. Percentage frequency of occurrence of each species of gobies in monthly samples from the Ria de Aveiro lagoon. ●, 1985–86; ○, 1986–87.

Age-structure and growth

Table 2 shows the mean size by age group for both males and females. The mean size of the males was always slightly higher than for females but the difference was not statistically significant.

(1) *Gobius niger*. Figure 3 shows the changes in the monthly mean length of fish from three year-classes (1984, 1985 and 1986). The length distributions show that O-group juveniles were first caught in early autumn, with a mean total length of 5·9 cm (SD ± 1·4; $n = 482$). Growth in length was slow in winter but increased again in the following spring. The I-group fish reached a mean size of 10·7 cm (SD ± 1·1) at the beginning of their second winter of life (age 1+) ($n = 473$). The oldest individuals of 2+ years old had reached a mean size of 12·7 cm (SD ± 0·4; $n = 48$). Maximum length recorded was 14·4 cm. The length-for-age data are shown in Table 2.

(2) *Gobius paganellus*. Two year-classes of *G. paganellus* were found. The mean length for the O-group juveniles was 6·1 cm (SD ± 0·8; $n = 97$) and 7·0 cm for age group 1+ (SD ± 1·2; $n = 40$). Both minimum and maximum total lengths recorded were 3·8 and 10·5 cm respectively.

(3) *Pomatoschistus minutus*. Changes in the monthly mean length of fish from three year-classes (1985, 1986 and 1987) are shown in Figure 4. The two first year-classes showed a rapid growth in length until December and little growth in winter. O-group juveniles were first caught in July 1986 and in June 1987. Maximum length recorded was 8·9 cm. Length-for-age data are shown in Table 2. Judged from scale annuli, fish of more than 1 year old were never caught in the purse-seine samples.

(4) *Aphia minuta*, *P. lozanoi*, *P. microps*, and *P. pictus*. The individuals of these species were juveniles in the first year of life. *Aphia minuta* had a mean length of 5·9 cm (SD ± 0·8), *P. lozanoi* had a mean length of 5·3 cm (SD ± 0·8), *P. microps* had a mean length of 3·8 cm (SD ± 0·6) and *P. pictus* had a mean length of 3·8 cm (SD ± 0·6). Both minimum and maximum total lengths recorded were (a) *A. minuta* 4·1 and 7·9 cm; (b) *P. lozanoi* 4·4 and 7·1 cm; (c) *P. microps* 2·3 and 5·5 cm; (d) *P. pictus* 3·0 and 5·4 cm, respectively.

Reproduction

Sex ratio. Table 3 shows the sex ratio of the monthly samples. There was no seasonal trend in the numbers of males and females for *G. niger*, but for *P. minutus* a marked decrease in the number of males coincided with the highest value of the ovary weights in females (see also Figure 6). *Pomatoschistus microps* showed a low number of males in the second winter–early spring of the sampling period.

Gonad cycle and length at first spawning. (1) *Gobius niger*. The monthly changes in mean gonad weight are shown in Figure 5. In both males and females, the highest mean values occurred between May and August. After this period the weight of the gonads fell abruptly, remaining low throughout the autumn and winter. The length at first maturity was 6·0 cm, but ripening fish of only 5 cm were occasionally found.

(2) *Gobius paganellus*. Ripe gonads were not observed in the individuals of this species. The GSI for both females and males did not exceed 3·0 and 2·4% respectively.

(3) *Aphia minuta*. All individuals of this species in our samples showed well developed or ripe gonads. The GSI for females reached 28·4%, the index for males did not exceed 2·3%.

(4) *Pomatoschistus minutus*. Figure 6 shows the monthly changes in mean gonad weight for both males and females. For females, the highest mean values occurred in February to

TABLE 2. Comparison of the mean total lengths by age groups for both males and females of the gobiid species from the Ria de Aveiro lagoon

	G. niger			*G. paganellus*		*A. minuta*	*P. minutus*	*P. lozanoi*	*P. microps*	*P. pictus*
Age (yr)	0+	1+	2+	0+	1+					
Males										
Mean length	7·6	10·8	11·8	6·2	7·3	6·5				
± SD	1·7	1·3	1·3	0·6	1·4	0·6	6·5	5·3	3·7	4·3
Females										
Mean length	7·2	10·5	11·5	6·0	6·8	6·3	6·4	5·1	3·5	4·1
± SD	1·6	1·2	0·7	0·6	1·3	0·6	0·6	0·9	0·6	0·6
Student's *t*-test significance level	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Mean total lengths were compared using Student's *t*-test according to Simpson *et al.* (1960). ns, Not significant.

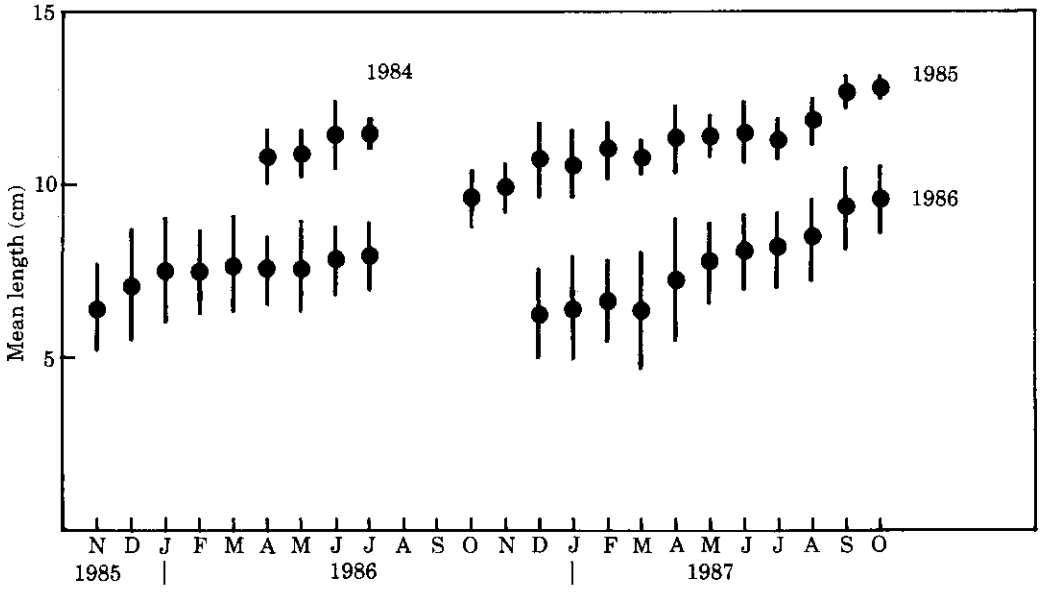

Figure 3. Monthly mean length of *Gobius niger* for year-classes 1984–86. Vertical bars show two SD.

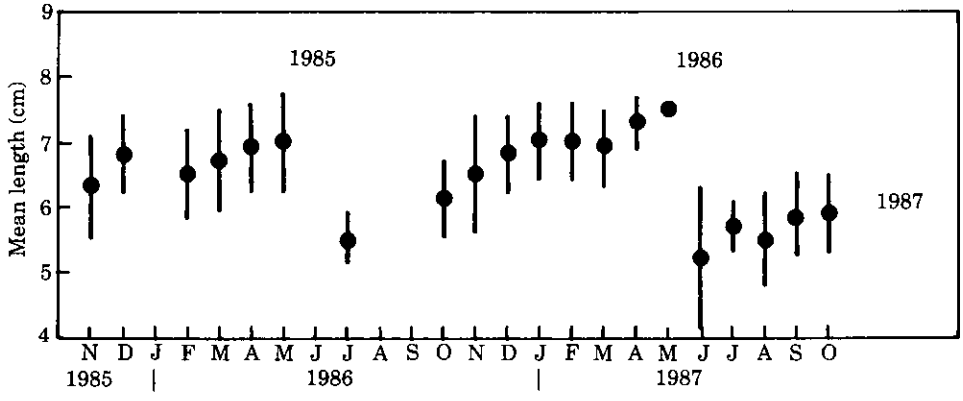

Figure 4. Monthly mean length of *Pomatoschistus minutus* for year-classes 1985–87. Vertical bars show two SD.

March and again in August. The fall of the mean gonad weight is slow especially after the first maximum in spring indicating that oocytes were released over a long period of time. Maximum values of the GSI were 3·5% for males and 24% for females. The mean length at first maturity was 4·5 cm for females and 5·5 cm for males.

(5) *Pomatoschistus microps*. Figure 7 shows the monthly changes in mean percent weight of the ovaries, which are indicative of a long breeding season. The length at first maturity for females was 3 cm. The GSI mean values for males were always low and with a small variation in range. The maximum GSI value found for males was 1·4%.

TABLE 3. Monthly variation of the sex ratio of *Gobius niger*, *Pomatoschistus minutus* and *P. microps* from the Ria de Aveiro lagoon as the percentage of males in the samples

Sample	*G. niger*			*P. minutus*			*P. microps*		
November 1985	50	(30)		50	(8)		17	(9)	
December 1985	60	(24)		58	(28)		59	(13)	
January 1986	100	(4)		51	(218)		45	(11)	
February 1986	41	(15)		45	(39)		33	(3)	
March 1986	59	(32)		18	(44)	***	50	(4)	
April 1986	40	(14)		0	(10)	**	0	(2)	
May 1986	39	(58)		0	(4)		0	(2)	
June 1986	38	(71)		25	(4)		100	(2)	
July 1986	42	(46)		50	(4)		50	(8)	
August 1986									
September 1986									
October 1986	42	(11)		45	(21)		56	(9)	
November 1986	28	(10)		55	(9)			—	
December 1986	68	(71)	**	45	(46)			—	
January 1987	31	(19)		45	(109)		32	(274)	****
February 1987	45	(40)		33	(72)	**	6	(17)	***
March 1987	38	(13)		0	(46)	****	12	(22)	***
April 1987	50	(49)		46	(11)		7	(13)	**
May 1987	51	(189)		49	(20)		12	(8)	
June 1987	58	(58)		50	(48)		0	(3)	
July 1987	44	(71)		55	(9)		0	(1)	
August 1987	35	(85)	**	56	(35)		64	(6)	
September 1987	56	(50)		61	(18)		57	(3)	
October 1987	52	(43)		46	(57)		100	(1)	

Asterisks denote significant difference from the null hypothesis (proportion of males equal to proportion of females) at the levels of *, 5%; **, 1%; ***, 0·1%; ****, 0·01%. Total number of fish of each monthly sample is given in brackets.

(6) *Pomatoschistus lozanoi* and *P. pictus*. The individuals of *P. lozanoi* had immature gonads (the GSI values for females reaching 13·2%). All individuals of *P. pictus* showed ripening gonads, the GSI values for females reaching 32·4%. For both species the mean values of GSI for males were lower than 1%.

Discussion

The Ria de Aveiro lagoon has a rich gobiid fauna. The total abundance and the frequency of the different species were different in different sampling zones and showed seasonal variations. Differences in abundance of gobies between localities may be due to differences in the supply of food. A seasonal variation in abundance can be related to both recruitment and mortality, such as for *G. niger*, *P. minutus* and *P. microps* which occur all year round in the lagoon. Other species, such as *P. pictus*, *A. minuta*, *P. lozanoi* and *G. paganellus*, were only found temporarily and their sporadic occurrence suggests that they migrated from elsewhere. However, the occurrence of both *P. microps* and *P. pictus* was probably underestimated due to mesh size selection of the purse-seine.

The increase in number of *G. niger* in spring coincided with the breeding season. This suggests that this species enters the lagoon for spawning. One-year-old fish, spawning for the first time, made up the bulk of the fish caught in the breeding season. Two-year-old fish, showing a second maturation, were scarce and they disappeared from the samples

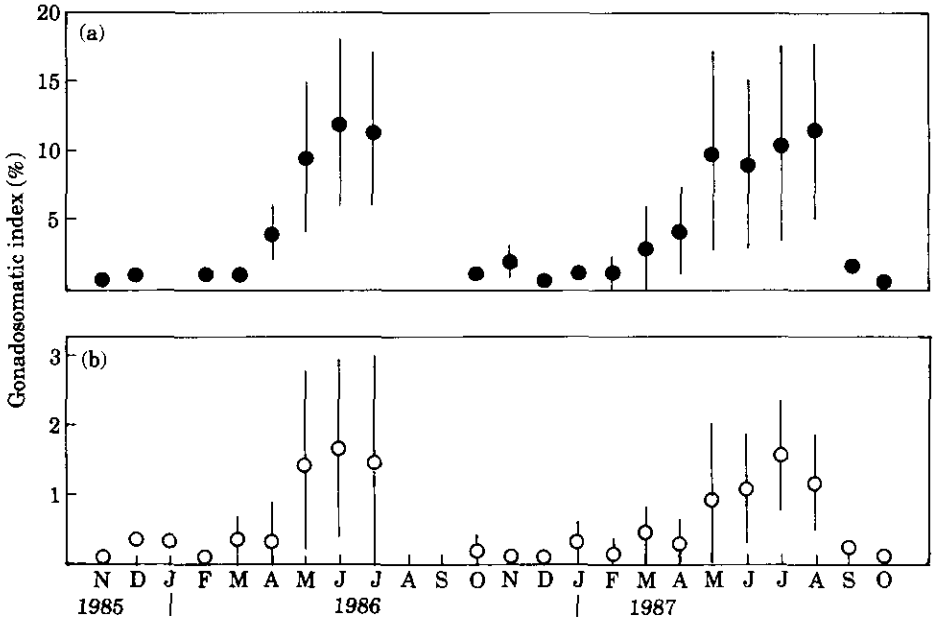

Figure 5. Monthly variations in the gonadosomatic index (GSI) of (a) female (●) and (b) male (○) of *Gobius niger*. Means ± two SD are represented. Dots denote one individual.

shortly after spawning. The disappearance of *G. niger* suggests that they migrated elsewhere after spawning, or that a high proportion of *G. niger* died after spawning. The second explanation has also been used by Vesey and Langford (1985) for a population in Stanswood Bay (southern coast of England).

Both the growth marks on scales and the variation in body length of *P. minutus* give evidence of a short maximum age in the lagoon (never more than 16 months). Bouchereau *et al.* (1989*a*) also refer to the fact that the oldest individuals of this species migrating from the brackish lagoon of Mauguio (French Mediterranean coast) toward the sea are 15–16 months old and that they die after their first spawning. The conspicuous decrease in mean length from May to June indicates the arrival of the new generation, the decrease in numbers of older fish may indicate a selective mortality after spawning. Hesthagen (1975) describes a similar phenomenon for a population in the Oslofjord (Norway), where a drop in the mean length from May to June was ascribed to selective mortality among the first year spawners.

The maximum age of both *G. niger* and *P. minutus* in the Ria de Aveiro lagoon was found to be shorter than that of other populations of these species studied by other authors. Vaas *et al.* (1975) record a maximum of five year-classes of *G. niger* in the Veerse Meer (Netherlands); Doornbos and Twisk (1987) record five year-classes of which a maximum of three are present at the same time in the Lake Grevelingen (Netherlands); Vesey and Langford (1985) record only four year-classes in Stanswood Bay; Joyeux *et al.* (1991) record 4 years for males and only 3 years for females in the lagoon of Mauguio. For *P. minutus*, Healey (1972) records a maximum age of 22 months in the Ythan Estuary (Scotland); Hesthagen (1975) 23 months in the Oslofjord; Fonds (1970; 1973) 2 years in the Dutch Wadden Sea but only with a survival of about 2% after the first spawning; Doornbos and Twisk (1987) approximately 1·5 years in the Lake Grevelingen but with an

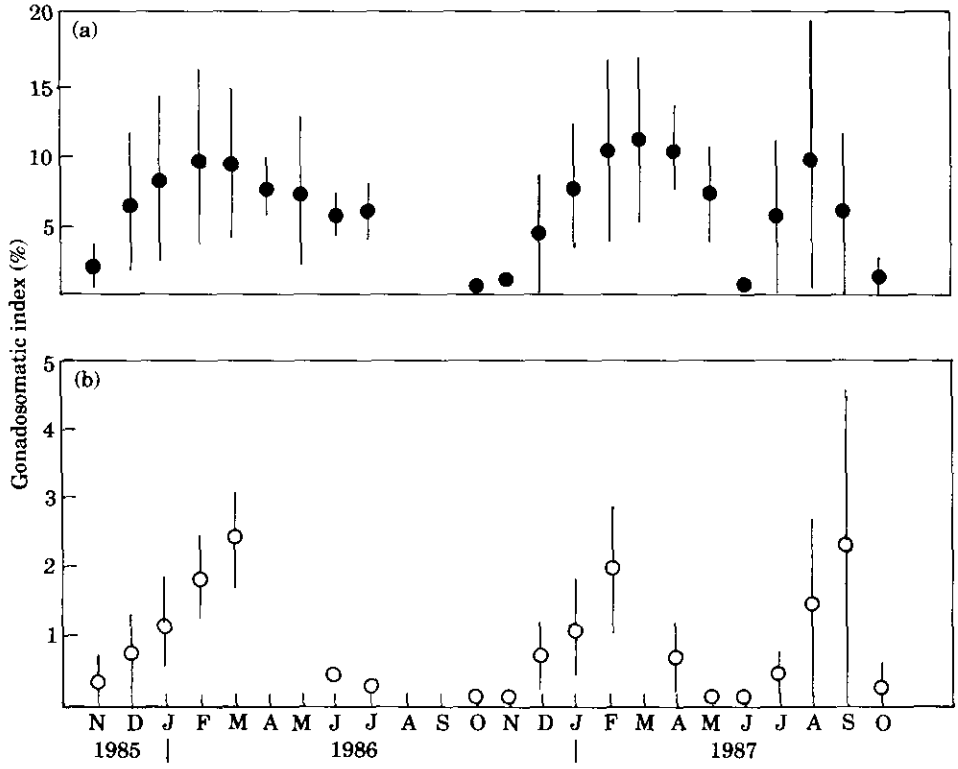

Figure 6. Monthly variations in the gonadosomatic index (GSI) of (a) female (●) and (b) male (○) of *Pomatoschistus minutus*. Means ± two SD are represented. Dots denote one individual.

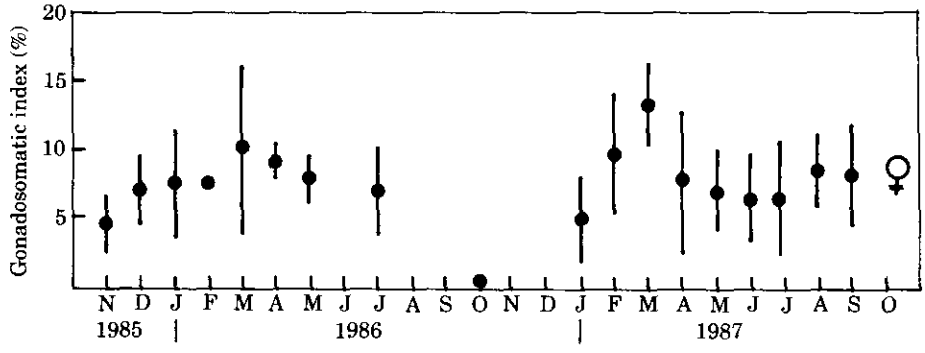

Figure 7. Monthly variations in the gonadosomatic index (GSI) of female of *Pomatoschistus microps*. Means ± two SD are represented. Dots denote one individual.

average of only 0·1% of the O-group individuals present in August surviving until the next summer; Bouchereau *et al.* (1989*a*) 15–16 months in the lagoon of Mauguio. Swedmark (1958, 1968) when studying the species in several localities of the geographical distribution area did not record individuals older than 1 year, as in the population of

Brittany and in the brackish lagoon of Sigean (south France). Moreover, according to this author most individuals live for 1 year, dying after the breeding season, except in the Gullmarfjord where a small number of individuals survive a second year.

The reproductive cycle of *P. minutus* showed two peaks (see also Healey, 1971*a*,*b*), one in February to March and another in summer. The majority of the fish spawn in spring at an age of about 1 year and reproduction in summer is by individuals hatched in August the previous year. The appearance of an annulus on their scales helps to identify them as fish from the previous year. Moreover, the gonads of larger females underwent their most rapid increase in weight considerably earlier than those of smaller females. There is the possibility that the second spawning is by immigrants from elsewhere outside the lagoon, but the hypothesis of a reproductive period lasting for as long as 6 months from March to August, as suggested by Russell (1976) for some populations of fish, is not supported by present data.

The growth rates of *G. niger* and *P. minutus* in the Ria de Aveiro lagoon are high when compared with other populations from higher latitudes. Individuals of *G. niger* at the beginning of the second winter of life (age 1 +) reached a mean size of 10·7 cm in the Ria de Aveiro lagoon, while the 1 + year-old-individuals from Stanswood Bay reached only 5·6 cm (Vesey & Langford, 1985), and the O-group individuals of *P. minutus* in the lagoon reached a mean size of 6·5 cm in September, while individuals of the same species from the Faröe Islands at about 62°N, attained a length of only 2–3 cm in September of their first year of life, and in Gullmarfjord (Swedish coast, about 58°N) a mean total length of about 5·0 cm in September (Hesthagen, 1975).

The mesh size of the purse-seine may have caused a selection of juveniles of *G. niger* and *P. minutus* larger than 5 cm, but the maximum length recorded for *G. niger* (14·4 cm) in the lagoon is greater than that found at other localities. Thus, Vesey and Langford (1985) refer to females of *G. niger* up to 12·6 cm in Stanswood Bay and Joyeux *et al.* (1991) in the lagoon of Mauguio, found that males live longer than females and reach a greater body length: a maximum age of 4 years and 135 mm length for males, only 3 years and 122 mm for females. The maximum length found for *P. minutus* (8·9 cm) is greater than found in populations from the Faröe Islands (7·5 cm) (Taning, 1940), Gullmarfjord (8·3 cm), English Channel (5·9 cm) and lagoon of Sigean (7·9 cm, males and 7 cm, females) but smaller than those from Penpoull (9·5 cm) (Brittany, France) (Swedmark, 1958, 1968). According to Swedmark (1958) there is a negative relationship between the latitude and maximum size of *P. minutus* but present data contradict that generalization. The maximum total length (8·3 cm) recorded by Bouchereau *et al.* (1989*a*) in the lagoon of Mauguio agrees with the generalization but it is not confirmed by data of Doornbos and Twisk (1987) since growth in Lake Grevelingen was, apart from being highly variable between years, largely similar to other north-western European areas.

A comparison of the growth curves for *G. niger* and *P. minutus* and temperature shows that most of the annual growth took place at a time when temperature was the highest. For both species most of the growth occurred above 15 °C. Fonds (1970, 1973) concludes that the growth in length of pelagic larvae of *P. minutus* shows a positive correlation with water temperature from 12 to 21 °C in rearing experiments. In following rearing experiments all larvae were reared at a temperature of 14·5 to 16 °C. The growth in fish probably stops in autumn when the temperature drops below 10 °C (Fonds, 1973). However, according to Doornbos and Twisk (1987) although growth may depend primarily on water temperature and food supply, marked differences in growth rate between two successive year-classes could be due to intraspecific competition.

The mesh size of the purse-seine may also have caused a selection for individuals larger than 2·3 cm and so it was not possible to determine when a new year-class joins the demersal population. Moreover, the length–frequency distribution for each monthly sample did not clearly indicate the pattern of seasonal growth. However, inspection of the scale-types and comparison with the descriptions of Miller (1975) suggest that for much of the year the population is formed by one single age-class. Furthermore, the population is dominated by juveniles in the first year of life that will be mature after the first winter season, and a more precise statement of age in months is impossible because of the long breeding season. This age-structure is comparable to that found at a Dublin Bay locality by Kunz (1969) where only individuals in the first winter of life were recorded.

The maximum length recorded (5·5 cm) is less than recorded from the Isle of Man (6·4 cm) (Jones & Miller, 1966), but higher than recorded from both the Severn Estuary (west coast of England) (5·2 cm) (Claridge *et al.*, 1985) and the lagoon of Mauguio (4·9 cm) (Bouchereau *et al.*, 1989*b*). The largest individuals obtained by Miller (1975) from the Isle of Man were one female 5·4 cm in standard length and a male 4·6 cm. Fouda and Miller (1981) recorded from the Teign Estuary (south coast of England) a female 5·1 cm in standard length and a male 4·5 cm. This comparison suggests a relationship between the latitude and maximum size of *P. microps* (comparable to that referred to for *P. minutus* by Swedmark (1958).

A long breeding season for *P. microps* was also found by Jones and Miller (1966) (April–September) and Bouchereau *et al.* (1989*b*) (April–July), suggesting that females, as in *P. minutus*, may produce more than one batch of eggs. Jones and Miller (1966) also associate this long breeding season with the production of several batches of eggs. According to Muus (1967) the sporadic propagation of the species in Danish estuaries and lagoons during summer is caused by late-developed individuals hatched in July–August the previous year and possibly by a few second-time spawners. The sex ratio of *P. microps* is in favour of females in winter and spring. Bouchereau *et al.* (1989*b*) also refer to a sex ratio permanently in favour of females particularly during the breeding season.

Aphia minuta, *P. lozanoi* and *P. pictus* were captured inside the lagoon in short periods of the year. The occurrence of well-developed or ripe gonads in *A. minuta* suggests that the species possibly entered the lagoon for spawning. The incidental occurrence of *P. lozanoi* with immature gonads may relate to environmental factors. In fact, as noted by Fonds (1971), this species is not typically estuarine but better classified as ' neritic '.

The presence of *G. paganellus* in the samples was restricted to both immature and ripening individuals, probably related to the habitats preferred by the adults. Wheeler (1969) states that the species is common on rocky shores from mid tide-level to low water and Miller (1986) refers to it as occurring inshore and intertidally, under stones and in pools on sheltered rocky shores with much weed cover. Juveniles caught in the lagoon can be considered as stray individuals showing a sporadic occurrence on muddy and sandy bottoms of the lagoon.

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