3(3): 243-265 (2009) DOI: 10.3153/jfscom.2009030

Journal of FisheriesSciences.com

ISSN 1307-234X

RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

AGE AND GROWTH, REPRODUCTION AND DIET OF THE BLACK GOBY, (*GOBIUS NIGER*) FROM AEGEAN SEA, TURKEY

Halit Filiz[1*], Melahat Toğulga[2]

[1] Mugla University, Faculty of Fisheries, Department of Hydrobiology, Kotekli, Mugla, Turkey

[2] Ege University, Faculty of Fisheries, Department of Hydrobiology, Bornova, Izmir, Turkey

Abstract: Black gobies, *Gobius niger* L., 1758, were sampled monthly between March 2003 and February 2004 in Izmir Bay involving 1149 specimens. Length distribution varied between 5.1 and 15.2 cm total length. Age determined from direct reading on otoliths was comprised from zero to five years. There were significant differences in mean lengths at age group for the two sexes, which did not allow the use of combined data. The parameters of the fitted Von Bertalanffy growth equation (with seasonal component, birth date on the 1st of January) were L_∞= 16.69 cm, k= 0.301 yr^{-1}, t_0= -2.205 for males, and L_∞= 14.84 cm, k= 0.321 yr^{-1}, t_0= -1.459 for females. Macroscopic examination of the gonads, and analysis of the monthly values of the gonadosomatic index, indicated that reproduction starts in March and lasts during October, with a maximum in March, followed by August and October. Individuals become sexually mature around 7.80 cm TL (a size that can be reached in less than 1 year) for females. In this population, the sex ratio (male:female) was 3.6:1. Stomach contents were mainly Mollusca (%IRI= 47.53), Crustacea (%IRI= 42.94), Polychaeta (%IRI= 8.26), Foreminifera (%IRI= 1.14) and Teleostei (%IRI= 0.13).

Keywords: Age and growth; reproduction; feeding; black goby; *Gobius niger*; Aegean Sea

***Correspondence to:** Halit FİLİZ, Mugla University, Faculty of Fisheries, Department of Hydrobiology, 48000 Kotekli-Mugla-–TURKEY

Tel: (+ 90 252) 211 18 95 Fax: (+ 90 252) 223 8475

E-mail: halit.filiz@mu.edu.tr

This study is a part of the PhD. thesis of the corresponding author.

Introduction

The black goby is widely distributed in Eastern Atlantic and Mediterranean Sea (include Black Sea), throughout North Africa from Cape Blanc, Mauritania north and eastwards to the Suez Canal; also along the eastern Atlantic coast northwards to Trondheim (Norway) and Baltic Sea (Miller, 1986). It can be found on sandy and muddy bottoms, in depth between 2 and 70 m (Hureau & Monod, 1973, Vesey & Langford, 1985). Also, it is able to live in brackish water down to %o 6 S (Vaas et al., 1975). This species is distributed on all coasts of Turkey (Bilecenoglu et al., 2002).

There are numerous studies about its abundance, distribution and habitat selection (Claridge et al., 1986; Wiederholm, 1987; Costello, 1992; Koutrakis et al., 2000; Gordo & Cabral, 2001; Letourneur et al., 2001; Malavasi et al., 2005), biology (Vaas et al., 1975; Fabi & Froglia, 1984; Vesey & Langford, 1985; Doornbos & Twisk, 1987; Arruda et al., 1993; Silva & Gordo, 1997; Bouchereau & Guelorget, 1998), growth (Fabi & Giannetti, 1985), feeding ecology and behavior (Casabianca & Kiener, 1969; McGrath, 1974; Fabi & Froglia, 1983; Magnhagen, 1988; Fernandez et al., 1995; Labropoulou & Markakis, 1998; Labropoulou & Papadopoulou-Smith, 1999), reproductive biology (Bonnin, 1971a, 1971b, 1975, 1977, 1981, 1984, 1989; Bonnin & Croizet, 1972, 1973; Holt & Byrne, 1988; Magnhagen, 1990, 1991; Joyeux et al., 1991b, 1992; Marconato et al., 1996; Pampoulie et al., 1999; Locatello et al., 2002; Mazzoldi & Rasotto, 2002; Pilastro et al., 2002; Rasotto & Mazzoldi, 2002; Immler et al., 2004; Mazzoldi et al., 2005; Scaggiante et al., 2005), genetic (Colombera & Rasotto, 1982; Vitturi & Catalano, 1989; Hoeglund & Thomas, 1992; Zander & Kesting, 1998; Sorice & Caputo, 1999; Mandrioli et al., 2001), parasites (Leiro et al., 1984; Loubes et al., 1984; Dezfuli et al., 1992; Zander, 2003; Kvach, 2005), and environmental effects and pollution (Bouchereau, 1997; Cunha & Antunes, 1999; Pampoulie et al., 2001; Antunes & Cunha, 2002; Arcos et al., 2002; Katalay & Parlak, 2002, 2004a, 2004b; Carnevali & Maradonna, 2003; Maradonna et al., 2004; Katalay et al., 2005; Migliarini et al., 2005). Also, length-weight relationships were given by Abdallah (2002), Cicek et al. (2006), and Verdiell-Cubedo et al. (2006).

Although this species is common in the Aegean Sea, surprisingly, there is no published study about its biology in Turkish waters. Since it has no commercial value in Turkey, probably, fisheries biologists did not give enough attention of its biology. However, this species has important ecologic values. Black goby is one of the species that used in monitoring pollution (as an indicator species) (Katalay & Parlak, 2002). Also, this species has an important role in the food chain in Izmir Bay (Bilecenoglu, 2003).

This paper provides the first information on the black goby, an important species of the Izmir Bay, in Aegean Sea, specifically on its age, growth, reproduction and feeding.

Material and Methods

Izmir Bay is situated at the western coast of the Anatolian peninsula, and is connected to the Aegean Sea. The bay is roughly ‘‘L’’ shaped. The leg of the ‘‘L’’ is about 20 km wide and 40 km long and the base of the ‘‘L’’ is about 5–7 km wide and 24 km long (Figure 1). The Izmir Bay has been divided into three areas according to their physical characteristics. These are Outer, Middle and Inner Bay (Sayin, 2003).

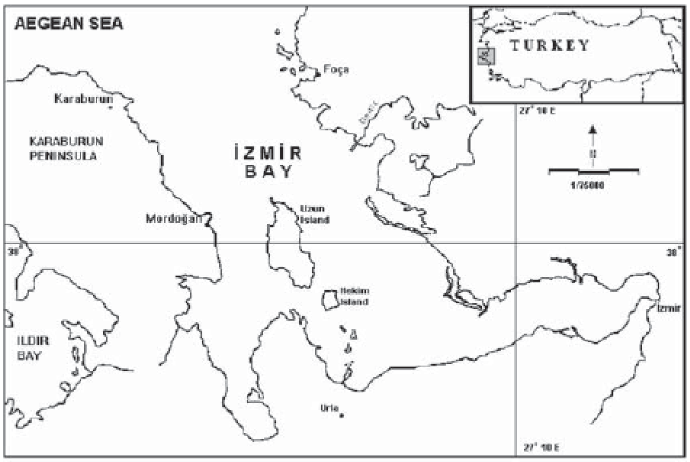

Figure 1. Map showing the location of the Izmir Bay.

All kind of fisheries activity is prohibited in inner part of Izmir Bay because it has highly polluted by both domestic and industrial wastes. Also, southeast part of the line combined Ardıç Cape (38° 31' 58" N - 26° 37' 22" E) and Deveboynu (38° 39' 24" N - 26° 43' 42" E) is prohibited all kind of trawl by the Ministry of Agriculture and Rural Affairs (Anonymous, 2007). Therefore, purse seine, hook-and-line and gill net are important fisheries methods in the Izmir Bay (Bilecenoğlu, 2003). Because presence of economically important demersal fish species, it is known that illegal fisheries can be occurred

(Metin et al., 2000). Main fisheries activity in the Bay rely on pelagic fish stocks (sardine, anchovy, mackerel, etc.) (Cihangir et al., 1999). There is no statistical data about caught fish amount in Izmir Bay (Bilecenoglu, 2003). Therefore, Kara & Gurbet (1999) reported that there is totally 2256 boat in the Bay and nearly 20000 tones fish caught yearly.

Izmir Bay was sampled monthly between March 2003 and February 2004. Specimens obtained via trawl (n= 78), and fishing line (n= 1071). Trawl specimens were sampled by R/V EGESUF (27 m length and 463 HP). A conventional bottom trawl net of 22 mm cod-end mesh size was used and three hauls in same day were carried out and haul durations stabilized 30 minutes. The vessel speed was maintained at 2.5 knots. Depth of the fishing ground was 30 m. fishing line sampling carried out in first, middle and last weeks of every month. A fishing line named "sinek oltasi" was used (no. 18 needle, 0.20 mm main body and 25 g lead weight). Fish were caught in the Izmir Bay (where they abundant) in three locations between 09:00 and 12:00 a.m. (Table 1). All the specimens were injected to abdomen region with 4% alcohol and frozen.

In the laboratory, the total length of all individuals was measured to the nearest millimeter below (later grouped in 1.0 cm length classes) and weighed to the nearest 0.01 g total weight. Sex was recorded and the gonads were weighed to the nearest 0.001 g (in the males, sperm-duct gland was not included in the gonadal weight). Sagittal otoliths were removed, cleaned, dried and stored in labeled plastic tubes.

For age determination, the otoliths of specimens were examined under a stereoscope microscope with a reflected light (x14 magnification). The otoliths were read by three readers and when there was no agreement among the three readings, the otolith was excluded. Age was expressed in years, the birthday of the fish being considered to be 1 January.

The mean lengths at age were analyzed separately per sex and were compared statistically using Student's *t* test ($p>0.05$).

To examine fish growth, a von Bertalanffy growth equation (VBGE) was calculated using the iterated least square method (Sparre et al., 1989).

The relationship between weight and *TL*, $W = aL^b$, was converted into logarithmic expression: $\ln W = \ln a + b \ln L$. Parameters *a* and *b* were calculated by least-squares regression, as was the coefficient of determination (r^2). Significant difference of *b* values from 3, which represent isometric growth, was tested with the *t*-test (Pauly, 1993).

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) (King, 1995) was calculated, between March 2003 and January 2004, monthly and per sex, their mean values being calculated from the individual ones. In order to determine first sexual maturation length and age, a logistic curve equation was used (King, 1995):

$$P = 1 / (1 + \exp[-r (L - Lm)])$$

here, P, proportion of mature individuals; r, slope of curve; L, total length, and Lm, mean length at maturity length or mean length of individuals where 50% of population is reproduced.

Sex ratio (males/females) was calculated by age.

Prey items in each stomach were identified to group level, measured, counted and weighed on an electronic balance (precision 0.0001 g). Diet composition was evaluated using three measures described by Hyslop (1980): the numerical index (%N); the gravimetric index (%W), and frequency of occurrence (%O). Based on Cortes' (1997) suggestion, the index of relative importance (IRI) was calculated and expressed as a percentage (%IRI). Subsequently, food items were grouped into categories of preference using the method proposed by Morato et al. (1998) and described by Sever et al. (2008). The categories were defined as follows:

$IRI \geq 30*(0.15*\sum\%O)$ main important prey (MIP)

$30*(0.15*\sum\%O) > IRI > 10*(0.05*\sum\%O)$ - secondary prey (SP)

$IRI \leq 10*(0.05*\sum\%O)$ occasional prey (OP)

Table 1. Coordinates, depth and floor structure of stations where samples taken (M: muddy; S: sandy; St: Stony; G: grassy)

Method	Coordinates	Depth (m)	Floor
Trawl	38º 26’ N 25º 40’ E / 38º 27’ N 26º 40’ E	30-30	M-S
	38º21’946N 26º46’307E	2	M-S
Line	38º21’960N 26º46’277E	1	S
	38º21’964N 26º46’258E	1.5-2	St-G

Results and Discussion

Age and growth

The mean values of temperature recorded for the bay during the sampling period are shown in Figure 2. The lowest value of temperature (11.3°C) was found in February 2004 and the highest (27.8 °C) in August 2003.

Table 2 shows the descriptive statistics regarding length and weight data of all and sexed individuals.

Among the 1149 black goby which were otolith’s taken, 49 individuals could not be aged since both there were undetermined specimens (n= 26) and there was no agreement between readers (n= 23). Thus, 865 (78.6%) males and 235 (21.4%) females were used for direct reading on otoliths (Table 3 and 4).

The length range by age group for both males and females was different. Application of the Student’s *t*-test to the mean lengths and standard deviations per age groups showed that there was significant difference between sexes (Table 5). The test was not applied to both males and females of age V because there was no female in this age. So, results from direct reading on the otoliths were not pooled, and calculations were made by sex separately.

To describe the growth of the black goby population found in Izmir Bay, a VBGE, based on the males and females data, was established (Table 6).

The length-weight relationships were calculated for each sex (Table 7).

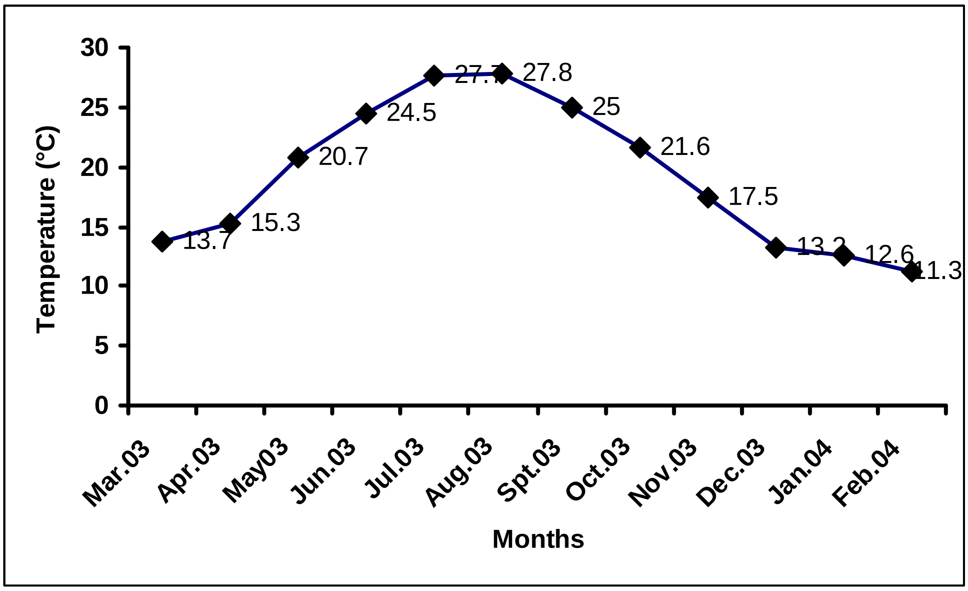

Figure 2. Mean values of temperature recorded in the Izmir Bay between March 2003 and February 2004.

Table 2. Descriptive statistics of length and weight data of specimens obtained from Izmir Bay (Values given are the mean ± SD and range in parenthesis).

Sex	n	Total Length (cm)	Total Weight (g)
♂+♀	1149	11.27±1.62 [5.1 – 15.2]	16.57±6.73 [1.42 – 39.02]
♂	865	11.65±1.50 [5.1 – 15.2]	18.16±6.49 [1.42 – 39.02]
♀	258	9.97±1.24 [5.3 – 14.0]	11.19±4.19 [1.46 – 28.07]
Undetermined	26	10.08 ± 1.88 [6.2 – 13.2]	12.54±6.02 [2.16 – 28.12]

Table 3. Results from direct reading on the otoliths of males *G. niger* from Izmir Bay. Age expressed in years.

TL (cm)	Ages						Total
	0	I	II	III	IV	V	
5.0-5.9	1						1
6.0-6.9							
7.0-7.9	17						17
8.0-8.9	28	1					29
9.0-9.9	6	51					57
10.0-10.9		121	9				130
11.0-11.9		39	197				236
12.0-12.9			203	16			219
13.0-13.9				137	5		142
14.0-14.9					28	4	32
15.0-15.9						2	2
n	52	212	409	153	33	6	865
Mean	8.18	10.34	11.93	13.29	14.14	14.78	
S.D.	0.76	0.63	0.53	0.33	0.23	0.43	
%	6.0	24.5	47.3	17.7	3.8	0.7	100.0

Table 4. Results from direct reading on the otoliths of females *G. niger* from Izmir Bay.

TL (cm)	Ages					Total
	0	I	II	III	IV	
5.0-5.9	3					3
6.0-6.9	8					8
7.0-7.9	9	26				35
8.0-8.9		34				34
9.0-9.9		14	53			67
10.0-10.9			47			47
11.0-11.9			3	27		30
12.0-12.9				4	6	10
13.0-13.9					1	1
n	20	74	103	31	7	235
Mean	6.67	8.10	9.90	11.33	12.26	-
S.D.	0.80	0.78	0.60	0.25	0.51	-
%	8.5	31.5	43.8	13.2	3.0	100.0

Table 5. Results of the application of the Student's t test to the mean lengths per age group for males and females *G. niger* from Izmir Bay.

Age	Males Mean (S.D.)	n	Females Mean (S.D.)	n	P
0	8.19 (0.69)	20	6.67 (0.80)	20	P<0.05*
I	10.20 (0.75)	74	8.10 (0.78)	74	P<0.05*
II	11.74 (0.46)	103	9.90 (0.60)	103	P<0.05*
III	13.31 (0.33)	31	11.33 (0.25)	31	P<0.05*
IV	14.09 (0.24)	7	12.26 (0.51)	7	P<0.05*

* indicates significant importance

Table 6. Growth parameters of *G. niger* in Izmir Bay.

Sex	n	L_∞ (cm)	k	t_0	Φ'
♂	865	16.69	0.301	– 2.205	1.92
♀	235	14.84	0.321	– 1.459	1.85

Table 7. Descriptive statistics and estimated parameters of the length–weight relationship for *G. niger* collected from Izmir Bay of the eastern Aegean Sea, Turkey. *L*min – *L*max = minimum and maximum lengths (cm); Wmin – Wmax = minimum and maximum weights (g); C.I = confidence intervals; *a* = intercept of the relationship; *b* = slope of the relationship; r^2= coefficient of determination; n = sample size.

Sex	n	*L*min – *L*max	Wmin – Wmax	W = aL^b a	b ± 95%C.I.	r^2	Growth Type
♂	865	5.1 – 15.2	1.42 – 39.02	0.0169	2.82 ± 0.06	0.91	A(-)
♀	258	5.3 – 14.0	1.46 – 28.07	0.0197	2.74 ± 0.13	0.88	A(-)
♂ + ♀	1149	5.1 – 15.2	1.42 – 39.02	0.0151	2.86 ± 0.05	0.92	A(-)

Reproduction

Monthly changes in gonadosomatic index (GSI) for females are shown in Figure 3. 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 November.

Comparing the GSI values attained by females it can be noticed that, during the reproduction period, females reach GSI values of about 18.2%.

The sex ratio was found as 3.3:1 males were dominant in all ages (Table 8), as in all months and seasons.

Females reached sexual maturity at 7.80 cm TL and before I year old (0.86 year) (Figure 4 and 5). The smallest female had well developed gonad was 7.50 cm TL.

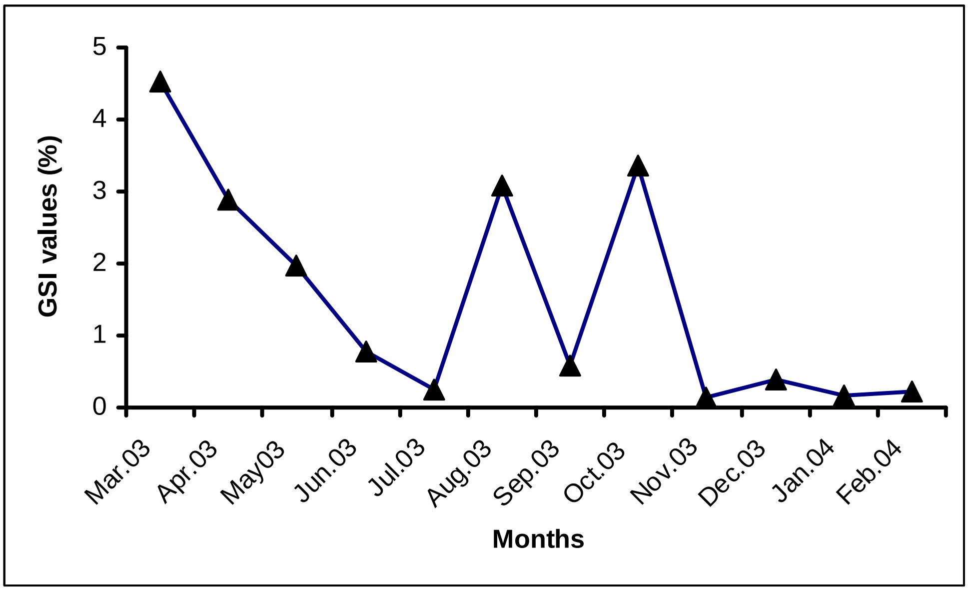

Figure 3. Variation in gonadosomatic index, GSI for female *G. niger* in the Izmir Bay.

Table 8. Age and sex composition of *G. niger* from Izmir Bay.

	♂		♀		♂ + ♀		
Age	**n**	**%n**	**n**	**%n**	**n**	**%n**	**♂ : ♀**
0	52	4.7	20	1.8	72	6.5	2.6 : 1
I	212	19.3	74	6.7	286	26.0	2.9 : 1
II	409	37.2	103	9.4	512	46.6	3.9 : 1
III	153	13.9	31	2.8	184	16.7	4.9 : 1
IV	33	3.0	7	0.7	40	3.6	4.7 : 1
V	6	0.5	-	-	6	0.7	--
Total	865	78.6	235	21.4	1100	100.0	3.6 : 1

Food

Of the 508 black goby stomachs examined, 489 had food (96.3%) and 19 were empty (3.7%). Mollusca, Crustacea and Polychaeta were found to be most important prey group (MIP; IRI≥561) in the diet. Foraminifera constituted the secondary prey group (SP; 561>IRI>63), whereas Teleost fishes were an occasional prey group (OP; IRI≤63). Mollusca, Crustacea and Polychaeta constituted of 98.73% of the diet. Foraminifera and Teleostei comprised 1.14 and 0.13% of the diet, respectively (Table 9).

In order to determine whether any difference between seasons, stomach contents were examined for each season (Table 10-13). Generally, Crustacea and Mollusca were found as important prey items in all seasons. Teleosts never consumed in spring, while they eaten occasionally in other seasons (Table 14).

In order to determine whether any difference between ages, stomach contents are examined for each age group (Table 15-20). Generally, Crustacea and Mollusca were found as important prey items in all ages. While Teleosts were consumed as occasianlly by 1 year old specimens, they became secondary in 3 and important in 4 years old (Table 21).

In order to determine whether any difference between sexes, stomach contents were examined for each sex. Mollusca and Crustacea were found as important prey items in both sexes. Teleosts consumed occasionally (Table 22 and 23).

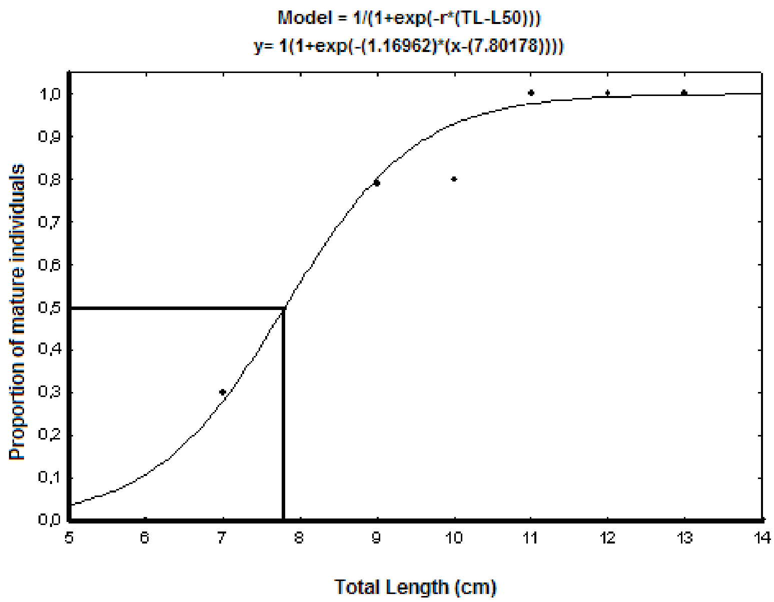

Figure 4. Length of first maturity of females in Izmir Bay.

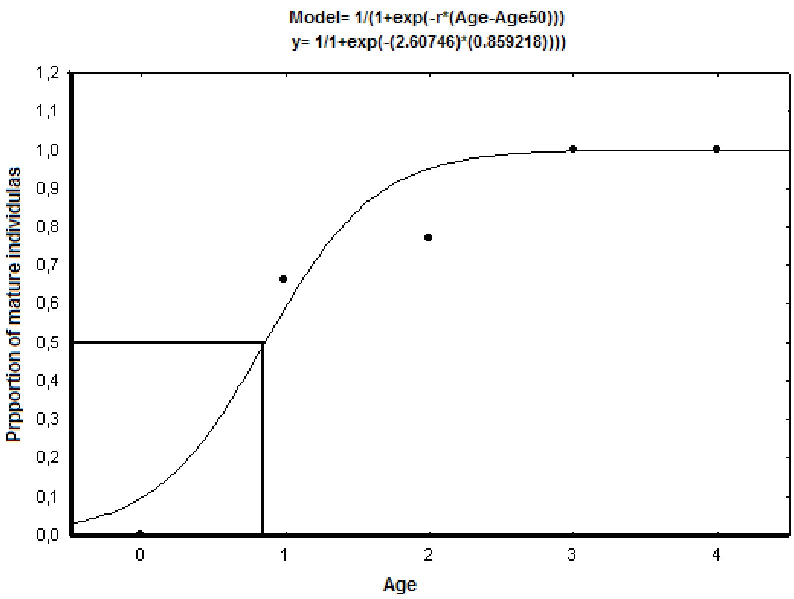

Figure 5. Age of first maturity of females in Izmir Bay

Table 9. General food items found for *G. niger* in Izmir Bay

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	13.62	1.18	5.84	88.18	1.14
Polychaeta	22.27	1.81	26.62	641.01	8.26
Crustacea	29.76	43.56	45.45	3332.39	42.94
Mollusca	33.19	50.33	44.16	3688.40	47.53
Teleost	0.86	3.12	2.60	10.35	0.13
Total	100.00	100.00	124.67	7760.33	100.00

Table 10. Food items found for *G. niger* in Izmir Bay in spring.

Food Items	%N	%W	%O	IRI	%IRI
Polychaeta	40.44	2.06	40.00	1700.00	17.99
Crustacea	43.38	50.93	58.00	5469.98	57.92
Mollusca	16.18	47.01	36.00	2274.84	24.09
Total	100.00	100.00	134.00	9444.82	100.00

Table 11. Food items found for *G. niger* in Izmir Bay in summer.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	16.16	0.05	13.64	221.10	2.47
Polychaeta	4.04	0.17	9.09	38.27	0.43
Crustacea	17.17	48.14	50.00	3265.50	36.49
Mollusca	61.62	46.29	50.00	5395.50	60.29
Teleost	1.01	5.35	4.55	28.94	0.32
Total	100.00	100.00	127.28	8949.31	100.00

Table 12. Food items found for *G. niger* in Izmir Bay in autumn.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	18.92	0.50	2.33	45.25	0.59
Polychaeta	19.82	0.52	20.93	425.72	5.51
Crustacea	19.82	44.99	34.88	2260.57	29.26
Mollusca	40.54	48.70	55.81	4980.48	64.45
Teleost	0.90	5.29	2.33	14.42	0.19
Total	100.00	100.00	116.28	7726.44	100.00

Table 13. Food items found for *G. niger* in Izmir Bay in winter.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	25.15	6.01	17.14	534.08	6.04
Polychaeta	15.34	7.74	31.43	725.40	8.20
Crustacea	36.81	6.81	54.29	2368.13	26.77
Mollusca	22.09	79.34	51.43	5216.54	58.97
Teleost	0.61	0.10	2.86	2.03	0.02
Total	100.00	100.00	157.15	8846.18	100.00

Table 14. Comparison of food preferences of *G. niger* in Izmir Bay according to seasons.

Food Items	Spring	Summer	Autumn	Winter
Foraminifera	-----	SP	OP	SP
Polychaeta	MIP	OP	SP	MIP
Crustacea	MIP	MIP	MIP	MIP
Mollusca	MIP	MIP	MIP	MIP
Teleost	-----	OP	OP	OP

Table 15. Food of “0” year old individuals in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	15.38	0.02	3.33	51.28	0.72
Polychaeta	23.08	4.68	40.00	1110.40	15.56
Crustacea	30.77	13.93	33.33	1489.85	20.87
Mollusca	30.77	81.37	40.00	4485.60	62.85
Total	100.00	100.00	116.66	7137.13	100.00

Table 16. Food of “1” year old individuals in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	17.97	1.05	8.57	163.00	1.82
Polychaeta	28.76	5.13	40.00	1355.60	15.17
Crustacea	32.02	23.82	54.29	3031.55	33.94
Mollusca	20.92	69.30	48.57	4381.99	49.05
Teleost	0.33	0.70	1.43	1.47	0.02
Total	100.00	100.00	152.86	8933.61	100.00

Table 17. Food of "II" years old individuals in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	17.02	0.54	5.56	97.63	1.06
Polychaeta	6.38	1.16	16.67	125.69	1.37
Crustacea	21.28	33.44	41.67	2280.18	24.84
Mollusca	55.32	64.86	55.56	6667.20	72.73
Total	100.00	100.00	119.46	9180.70	100.00

Table 18. Food of "III" years old individuals in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Polychaeta	7.69	0.01	6.67	51.36	0.47
Crustacea	50.00	66.47	66.67	7765.05	71.18
Mollusca	34.62	27.81	46.67	2913.61	26.71
Teleost	7.69	5.71	13.33	178.62	1.64
Total	100.00	100.00	133.34	10908.64	100.00

Table 19. Food of "IV" years old individuals in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Crustacea	37.50	45.45	33.33	2764.72	46.39
Mollusca	50.00	35.25	33.33	2841.38	47.68
Teleost	12.50	19.30	11.11	353.30	5.93
Total	100.00	100.00	77.77	5959.40	100.00

Table 20. Food of "V" years old individuals in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Polychaeta	12.50	0.02	25.00	313.00	2.50
Crustacea	75.00	75.45	75.00	11283.75	90.11
Mollusca	12.50	24.53	25.00	925.75	7.39
Total	100.00	100.00	125.00	12522.50	100.00

Table 21. Comparison of food preferences of *G. niger* in Izmir Bay according to ages.

Food Items	Ages					
	0	I	II	III	IV	V
Foraminifera	OP	SP	SP	OP	-----	-----
Polychaeta	MIP	MIP	SP	------	-----	SP
Crustacea	MIP	MIP	MIP	MIP	MIP	MIP
Mollusca	MIP	MIP	MIP	MIP	MIP	MIP
Teleost	-----	OP	-----	SP	MIP	-----

Table 22. Food of males in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	12.18	0.96	6.93	91.06	1.16
Polychaeta	21.79	1.67	22.77	534.18	6.82
Crustacea	29.49	44.78	45.54	3382.26	43.16
Mollusca	35.58	48.16	45.54	3813.52	48.66
Teleost	0.96	4.43	2.97	16.01	0.20
Total	100.00	100.00	123.75	7837.03	100.00

Table 23. Food of females in Izmir Bay.

Food Items	%N	%W	%O	IRI	%IRI
Foraminifera	17.42	1.70	3.77	72.08	0.94
Polychaeta	23.23	2.10	33.96	860.21	11.28
Crustacea	30.32	40.67	45.28	3214.43	42.13
Mollusca	28.38	55.48	41.51	3481.03	45.63
Teleost	0.65	0.05	1.89	1.32	0.02
Total	100.00	100.00	126.41	7629.07	100.00

Age and growth

There are various studies providing information about maximum lengths of the species both in Mediterranean and Atlantic. These studies give us a chance to make a comparasion (Table 24). As it is seen, maximum length in Izmir Bay is a little higher than those obtained in other parts of Mediterranean (except central Adriatic) and quite higher than those obtained from Atlantic. It seems that Mediterranean populations can be attained much bigger lengths from Atlantic ones. Whereas, expected outcome is that individuals living in Atlantic must be bigger. Sampling methods used may affect to this situation. It can be difficult to obtain bigger individuals in Atlantic by trawls since black gobies possess nest in the sand or under some substratum like stone, rocks or shells. Therefore, we obtained a big part of samples via fishing line in the shallow zone. This allowed us be able to see individuals when fishing and bigger male individuals attacker bait. Additionally, if we consider that most of the Mediterranean studies are made in lagoon areas, temperature and food availability can affect in this outcome.

Age determination from direct observations on the otoliths resulted in the establishment of six age groups (0, I, II, III, IV and V) for the population. Among the 1100 specimen aged, 865 (78.6%) were males and 235 (21.4%) were females. Age group II and I included 46.6% and 26.0% of the population, respectively. Age group V was consisted of only males (Table 25).

The maximum age reached by specimens of black goby (5 years) from the Izmir Bay is within the longevity limits observed over the biogeographical distribution area (Table 26). Indeed, if black goby longevity (5 year) is similar on the Adriatic (Fabi & Giannetti, 1985) and Norwegian coasts (Nash, 1984), the life span seems to be shorter (2-3 years) in the Atlantic lagoons and estuaries. From these results, it can be concluded that the populations living in the Aegean and Adriatic Sea are the ones that reach the maximum age (5) and close to the maximum length ever recorded (16.5cm).

In terms of mean length per age group significant differences were found between the two sexes (Table 5). Males attain a bigger length than females. These differences between male and female growth rates and life span have already been noticed by Vaas et al. (1975), Fabi & Froglia (1984), Fabi & Giannetti (1985), Joyeoux et al. (1991a), Arruda et al. (1993), Silva & Gordo (1997) and Bouchereau & Guelorget (1998) (Table 26). Just about any factor that might possibly influence growth has been shown to have an effect, including temperature, food availability, nutrient availability, light regime, oxygen, salinity, pollutants, current speed, predator density, intraspecific social interactions and genetics (Helfman et al., 1997). These factors, often working in combination, create large variations in size of fishes of the same and different ages (Helfman et al., 1997).

In this study, growth rate of the population has been found relatively low. Since the earlier spawning fish has slower somatic (body) growth (Helfman et al., 1997), this finding was expected. However, the growth coefficient is highly variable among different studies (k= 0.19-0.91) (Table 27). The asymptotic length (L_∞) estimated in this study was within the observed total length of males and females. When compared with the the previous studies made in Mediterranean (Table 27), calculated growth performance index (Φ) value for the Izmir Bay was higher than that found by Fabi & Giannetti (1985). Analyzing the same table for Atlantic, it can be seen that our Φ value was lower than those calculated by Vesey &

Langford (1985) and Silva & Gordo (1997). Although there were observed differences, no significant differences were found among our *Φ* value and ones obtained for Mediterranean and Atlantic from previous studies ($p > 0.05$).

Bouchereau & Guelorget (1998) interpreted the differences in the growth rates: "G. niger growth is different in the Atlantic and the Mediterranean. Growth rate in the Mediterranean populations is, during the first year, clearly higher than of Atlantic populations. Afterwards, it decrases strongly in the Mediterranean but regulate itself in Atlantic. After the third year, differences in size are less evident, but final performances are better in the Mediterranean (136 mm) than in the Atlantic (130 mm).

A comparison of published length–weight relationships for the species is given in Table 28. The values of the slope (*b*) ranged from 2.86 to 3.39 and our results remained within the ranges given. Our *b* value (2.86) has constituted of lowest limit. Concerning growth type, the length-weight relationships revealed negative allometry. The length-weight relationship in fishes can be affected by a number of factors, including season, habitat, gonad maturity, sex, diet and stomach fullness, health and preservation techniques, and differences in the length ranges of the specimen caught (Tesch, 1971; Wootton, 1998), which were not accounted for in the present study. Thus, differences in length-weight relationships between this and other studies could potentially be attributed to the combination of one or more of the factors given above.

Table 24. Comparison of the maximum lengths.

Area	Study	Locality	Length	Lmax.
Mediterranean	Fabi & Froglia (1983)	Adriatic Sea	TL	16.5
	Fabi & Froglia (1984)	Adriatic Sea	TL	16.0
	Fabi & Giannetti (1985)	Adriatic Sea	TL	16.5
	Joyeux et al. (1991a)	Mauguio Lagoon	TL	13.6
	Pompoulie et al. (1999)	Vaccares Lagoon	TL	13.9
	Abdallah (2002)	Off Alexandria	TL	13.3
	Locatello et al. (2002)	Venetian Lagoon	TL	14.9
	Mazzoldi & Rasotto (2002)	Venetian Lagoon	TL	13.5
	Rasotto & Mazzoldi (2002)	Venetian Lagoon	TL	13.9
	Çiçek et al. (2006)	Babadillimanı Bay	TL	12.2
	Verdiell-Cubedo et al. (2006)	Mar Menor Lagoon	TL	9.2
	This study	Izmir Bay	TL	15.2
Atlantic	Vaas et al. (1975)	Verse Meer Lake	TL	13.0
	Vesey & Langford (1985)	England	TL	12.6
	Arruda et al. (1993)	Rio de Aveiro Lag.	TL	14.4
	Silva & Gordo (1997)	Obidos Lagoon	TL	15.0

Table 25. Age and sex composition of the *G. niger* in Izmir Bay.

	♂		♀		♂ + ♀		
Age	**n**	**%n**	**n**	**%n**	**n**	**%n**	**♂ : ♀**
0	52	4.7	20	1.8	72	6.5	2.6 : 1
I	212	19.3	74	6.7	286	26.0	2.9 : 1
II	409	37.2	103	9.4	512	46.6	3.9 : 1
III	153	13.9	31	2.8	184	16.7	4.9 : 1
IV	33	3.0	7	0.7	40	3.6	4.7 : 1
V	6	0.5	-	-	6	0.7	--
Total	865	78.6	235	21.4	1100	100.0	3.6 : 1

Table 26. Comparison of maximum age and age at lengths records.

Area	Study	Locality	Sex	0+	I	II	III	IV	V
Mediterranean	Fabi & Giannetti (1985)	Adriatic Sea	♂	7.7	9.4	11.9	13.5	14.5	15.5
			♀	6.2	7.8	9.5	10.4	11.8	
	Joyeux et al. (1991a)	Mauguio Lagoon	♂	-	8.8-9.6	9.6-12.0	12.0-13.2	13.6	-
			♀	-	8.4-9.2	9.2-11.6	11.6-12.4	-	-
	Rasotto & Mazzoldi (2002)	Venetian Lagoon	♂	-	7.4	10.1	12.2	12.8	-
	This study	Izmir Bay.	♂	8.18	10.34	11.93	13.29	14.14	14.78
			♀	6.67	8.10	9.90	11.33	12.26	
			♂+♀	7.76	9.76	11.52	12.96	13.81	14.78
Atlantic	Vaas et al. (1975)	Verse Meer Lake	♂	5.5	8.2	9.5	12.0		
			♀	5.5	8.1	9.6	10.5	11.1	
	Nash (1984)	Norwegian coasts	♂+♀	-	4.4	7.1	8.6	9.6	9.3
	Vesey & Langford (1985)	Stanswood Bay	♂+♀	~3	5.6	9.0	10.9	-	-
	Doornbos & Twisk (1987)	Grevelingen Lake	♂+♀	4.7	8.0-8.5	12.2-12.5	-	-	-
	Arruda et al. (1993)	Ria de Aveiro Lagoon	♂	7.6	10.8	11.8	-	-	-
			♀	7.2	10.5	11.5	-	-	-
	Silva & Gordo (1997)	Obidos Lagoon	♂	7.8	10.5	12.2	13.5	-	-
			♀	8.0	10.3	11.9	12.0	-	-

Table 27. Comparisons of growth parameters.

Area	Study	Sex	L_∞ (cm)	k (year^{-1})	t_0 (year)	t_{max}^{A}.	Φ' ^{B}	Locality
Mediterranean	Fabi & Giannetti (1985)	♂	18.52	0.30	-1.689	10.1	2.01	Adriatic Sea
		♀	16.58	0.19	-2.571	15.7	1.72	
	Froese & Pauly (2006)	♂	18.5	0.30		10.0	2.01	Adriatic Sea
		♀	16.9	0.19		15.8	1.73	
	This study	♂	16.69	0.30	-2.205	10.0	1.92	Izmir Bay
		♀	14.84	0.32	-1.459	9.3	1.85	
		♂+♀	17.59	0.26	-2.174	11.7	1.90	
Atlantic	Vesey & Langford (1985)	♂	11.7	0.91	0.32	3.3	2.10	Stanswood Bay
		♀	15.1	0.91	0.32	3.3	2.32	
	Silva & Gordo (1997)	♂+♀	16.66	0.34	-1.910	8.9	1.97	Obidos Lagoon

^{A} t_{max}(life-span)= based on 3/k assumption (acoording to Froese & Binohlan 2000)

^{B}Φ' = log$k$+2 log L_∞

Reproduction

The male:female ratios obtained both in Mediterranean and Atlantic have shown in Table 29. In all seasons, including reproduction period, males were found as dominant. In previous studies, a decrease in the availability of the males has been reported, especially in spring and summer months (reproduction period). 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 less easily cauhgt. This egg protection behaviour of males also has been observed in free divings, especially made in reproduction period. So, the dominancy of the males in Aegean Sea does not mean that they have no egg protection. The most important factor in this differency is probably sampling method. Altought, studies claimed a decrease in the availability of the males especially in the reproduction period used beach siene nets (Arruda et al., 1993; Silva & Gordo, 1997; Bouchereau & Guelorget 1998; Pampoulie et al., 1999) and trawl (Vaas et al., 1975; Fabi & Froglia, 1984; Fabi & Giannetti, 1985; Vesey & Langford, 1985), in this study most of specimens was caught by hand line.

Monthly changes in gonadosomatic index for females are shown in Figure 3. A comparison between the spawning season of the black goby population living in Izmir Bay with those from other areas (Table 30) 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; Silva & Gordo, 1997).

Most individuals of the Izmir Bay populations probably reproduce in their first year. Females reached sexual maturity at 7.80 cm TL and before I year old (0.86 year) (Figure 4 and 5). The smallest female had well developed gonad was 7.50 cm TL. Obtained first maturity ages and lengths from previous studies were compared in Table 31.

Vaas et al. (1975) reported that reproduction of the black goby starts when the water temperature exceeds 12 °C (in May in Veerse Meer). Measured water temperatures in Izmir Bay in March appeared to be support the relationship between reproduction and water temperature.

Food

In the Izmir Bay, the diet of black goby is based on small benthic invertebrates, generally similar to that of other populations (Table 32). Therefore, Foraminifera comprised 8.26% of the diet. We believed that those foraminiferans are ingested accidentally, together with the animal constituents of the diet.

Table 28. Comparision of the LW relationships.

Area	Study	Locality	n	W= aL^b		
				a	b	r^2
Mediterranean	Fabi & Froglia (1984)	Adriatic Sea	2873	0.0082	3.12	0.97
	Fabi & Giannetti (1985)	Adriatic Sea	662	0.0081	3.14	0.98
	Abdallah (2002)	off Alexandria	141	0.016	2.89	0.94
	Çiçek et al. (2006)	Babadillimanı Bay	272	0.0047	3.39	0.95
	Verdiell-Cubedo et al. (2006)	Mar Menor Lagoon	225	0.0124	2.97	0.97
	This study	Izmir Bay	1149	0.0151	2.86	0.92
Atlantic	Vaas et al. (1975)	Verse Meer Lake	3234	0.007	3.29	0.93
	Vesey & Langford (1985)	Stanswood Bay	553	0.0001	3.19	0.94
	Silva & Gordo (1997)	Obidos Lagoon	1426	0.072	3.26	0.99

Table 29. Comparison of male:female ratios.

Study	Male:Female
Vaas et al. (1975)	1.04:1.0
Fabi & Froglia (1984)	1.0:1.0
Nash (1984)	0.97:1.0
Fabi & Giannetti (1985)	2.0:1.0
Vesey & Langford (1985)	0.5:1.0
Joyeux et al. (1991a)	1.5:1.0
Joyeux et al. (1992)	1.5:1.0
Silva & Gordo (1997)	1.1:1.0
Pompoulie et al. (1999)	2.0:1.0
This study	3.6:1.0

Table 30. Comparison of the spawning season of *G. niger* obtained from different areas and according to several authors.+ = occurence of spawning season; ?= possible occurence of spaning season.

Area	Study	March	April	May	June	July	August	September
Mediterranean	Fabi & Froglia (1984)		+	+	+	+	+	
	Joyeux et al. (1991b)	+	+	+	+	+	+	+
	Mazzoldi & Rasotto (2002)		+	+	+	+	+	
	Rasotto & Mazzoldi (2002)		+	+	+	+	+	
	Immler et al. (2004)		+	+	+	+	+	+
	This study	+	+	+	+	+	+	+
Atlantic	Duncker & Ladiges (1960)			+	+	+	+	
	Muus (1966)			+	+	+	+	
	Casabianca & Kiener (1969)			+	+	+	+	
	Vaas et al. (1975)			+	+	+	+	
	Le Menn (1979)			+	+	+	+	
	Nash (1984)		+	+	+			
	Vesey & Langford (1985)		+	+	?	?	?	?
	Arruda et al. (1993)			+	+	+	+	
	Silva & Gordo (1997)	+	+	+	+	+	+	+

Table 31. Comparison of the maturity age (tm) and length (Lm) of *G. niger* obtained from different areas and according to several authors.

Area	Study	tm (year)	Lm (cm)
Meditt.	Fabi & Froglia (1984)	1+	6.0
	Joyeux et al. (1991b)		
	Joyeux et al. (1992)	7-13 months	5.4
	Mazzoldi & Rasotto (2002)	--	6.0-8.0
	Rasotto & Mazzoldi (2002)	1	7.4
	This study	0.86	7.8
Atl.	Vesey & Langford (1985)	1+	5.0
	Arruda et al. (1993)	0+	6.0

Table 32. Food items of different populations of *G. niger*. (M): Mediterranean; (A): Atlantic

Study	Locality	Method used	Food Items
Casabianca & Kiener (1969)	Corsica coasts (M)	%N	Mollusca, Crustacea
McGrath (1974)	Baltic Sea	%N	Crustacea
Vaas et al. (1975)	Verse Meer Lake, Holland	%N	Polychaeta, Crustacea, Mollusca, Teleost
Fabi & Froglia (1983)	Adriatic (M)	%O	Crustacea, Polychaeta
Fjosne & Gjosaeter (1996)	Norwegian coasts (A)	%IRI	Crustacea (80.8%), Teleost eggs/larvae (13.0%), Polychaeta (6.2%)
Labropoulou & Markakis (1998)	Heraklion Bay (M)	%IRI	Crustacea (65.1%), Polychaeta (39.9%), Cumacea
Labropoulou & Papadopoulou-Smith (1999)	Heraklion Bay (M)	%IRI	Polychaeta
Stergiou & Karpouzi (2002)	Mediterranean	%IRI	Polychaeta (46.0%), Crustacea (49.0%), others
Froese & Pauly (2006)	----	%IRI	Crustacea, Mollusca, Teleost
This study	Izmir Bay (M)	%IRI	Mollusca, Crustacea, Polychaeta, Foreminifera, Teleost

References

Abdallah M. (2002), Length-Weight Relationship of Fishes Caught by Trawl off Alexandria, Egypt. *Naga The ICLARM Quarterly*, **25**: 19-20.

Anonymous, (2007), Republic of Turkey Ministry of Agriculture and Rural Affairs General Directorate of Protection And Control, “Notification 1/1 Regulating Commercial Fishing”, Ankara, Published in the Official Gazette date: 19.10.2007- 26675 Notification Number: 2007-43

Antunes, M., Lopes Da Cunha, P., (2002), Skeletal anomalies in *Gobius niger* (Gobiidae) from Sado estuary, Portugal. *Cybium*, **26**: 179-184.

Arcos, J. M., Ruiz, X., Bearhop, S., Furness, R.W., (2002), Mercury levels in seabirds and their fish prey at the Ebro Delta (NW Mediterranean): the role of trawler discards as a source of contamination. *Marine Ecology Progress Series*, **232**: 281-290.

Arruda, L. Azevedo, M., J. N., Neto, A. I., (1993), Abundance, age-structure and growth and reproduction of gobies (Pisces; Gobiidae) in the Ria de Averio Lagoon (Portugal). *Estuarine, Coastal and Shelf Science*, **37**: 509-523.

Bilecenoglu, M., Taskavak, E., Mater, S., Kaya, M., (2002), Checklist of the marine fishes of Turkey. *Zootaxa* 113. Magnolia Pres, Auckland, 194 p.

Bilecenoglu, M., (2003), Modelling Trophic Relationships Among Fishes Inhabiting Izmir Bay (in Turkish). *PhD Thesis*, Supervisor Kaya, M., Ege University Graduate School of Natural and Applied Sciences. Izmir, 156 pages.

Bonnin, J. P., (1971a), Organotypic cultures of thyroids of a marine teleostean fish: *Gobius niger* L. Effects of TSH and prolactin. *Comptes Rendus des Séances de la Société de Biologie et de ses Filiales,* **165**: 1284-1291.

-----(1971b), Study of the thyreotropic function in *Gobius niger* L. by means of the association in vitro association of pituitary glands and thyroids. *Comptes Rendus des Séances de la Société de Biologie et de ses Filiales,* **165**: 2321-2327.

----(1975), Association in organ culture of the hypophysis and glandular tissue of the testis of *Gobius niger* L. *Comptes Rendus des Séances de la Société de Biologie et de ses Filiales,* **169**: 920-923.

----(1977), Radioimmunoassay of hormonal activity of *Gobius niger* L. testicular interstitial tissue in organ culture: spontaneous activity and stimulation by pituitary gland. *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Série D: Sciences naturelles*, **284**: 1827-1830.

----(1981), Effect of ovine prolactin on plasma testosterone and the male genital tract of *Gobius niger* L. *Comptes Rendus des Séances de l'Académie des Sciences. Série III: Sciences de la vie,* **292**: 319-322.

----(1984), Response of the seminal vesicles of *Gobius niger* L. to castration, followed or without treatment with free or conjugated testosterone. *Comptes Rendus des Séances de l'Académie des Sciences. Série III: Sciences de la vie,* **298**: 119-122.

----(1989), Prolactin and specific binding of testosterone in cultured cells of the seminal vesicle of *Gobius niger* L. *Comptes Rendus des Séances de l'Académie des Sciences. Série III: Sciences de la vie,* **309**: 435-440.

Bonnin, J. P., Croizet, M., (1972), Evaluation of hormonal activity in culture of thyroid explants of *Gobius niger* L. *Comptes Rendus des Séances de la Société de Biologie et de ses Filiales,* **166**: 347-350.

----(1973), In vitro action of dibutyryl-3'-5'-AMPc on thyroid explants of *Gobius niger* L. *Comptes Rendus des Séances de la Société de Biologie et de ses Filiales,* **167**: 1106-1109.

Bouchereau, J. L., (1997), Biodiversity of tactics used by three Gobiidae (Pisces; Teleostei): *Pomatoschisthus minutus* (Pallas, 1770), *P. microps* (Kroyer, 1838), *Gobius niger* Linnaeus, 1758, to survive in a Mediterranean lagoon environment. *Oceanological Studies*, **2/3**: 153-170.

Bouchereau, J-L., Guelorget, O., (1998), Comparision of three Gobiidae (Teleostei) life history strategies over their geographical range. *Oceanologia Acta*, **21**: 503-517.

Carnevali, O., Maradonna, F., (2003), Exposure to xenobiotic compounds: looking for new biomarkers. *General and Comparative Endocrinology*, **131**: 203–209.

Casabianca, M. L., Kiener, A., (1969), Gobides des etangs corses: systematique,.ecologie, regime alimentaire et position dans les chaines trophiques. *Vie et Milieu*, **20**: 611-634.

Cihangir, B., Önen, M., Kocataş, A., Ergen, Z., Mater, S., Koray, T., Katağan, T., Özel, İ., Demirkurt, E., Tıraşın, E.M., Ünlüoğlu, A., Çınar, M.E., Çolak, F., Çoker, T., Öztürk, B., Doğan, A., (1999), Some biological properties of Izmir Bay. *Ecosystem '99: Workshop On The Role Of The Physical, Chemical And Biological Processes In Marine Ecosystems*, 19-48, Izmir.

Claridge, P.N., Hardisty, M.W., Potter, I.C., Williams, C.V., (1986), Abundance, Life History and ligulolsis in the gobies (Teleostei) of the inner seven estuary. *Journal of the Marine Biological Association of the United Kingdom*, **65**: 951-968.

Colombera, D., Rasotto, M., (1982), Chromosome studies in males of *Gobius niger jozo* (Padoa) and *Gobius paganellus* (Linneo) (Gobiidae, Osteichthyes). *Caryologia*, **35**: 257-260.

Cortes, E., (1997), A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. *Canadian Journal of Fisheries and Aquatic Sciences*, **54**: 726-738.

Costello, M. J., (1992), Abundance and spatial overlap of gobies (Gobiidae) in Lough Hyne, Ireland. *Environmental Biology of Fishes*, **33**: 239-248.

Cunha, P., Antunes, M.M., (1999). Occurrence of vertebral deformities in Gobiidae (Pisces) from the Tagus Estuary. *Aquatic Ecology,* **33**: 281–285.

Cicek, E., Avsar, D., Yeldan, H., Ozutok, M., (2006), Length-weight relationships for 31 teleost fishes caught by bottom trawl net in the Babadillimani Bight (northeastern Mediterranean). *Journal of Applied Ichthyology*, **22**: 290-292.

Dezfuli, B.S., Boldrini, P., Rossi, R., (1992), A morphological study of *Acanthocephaloides propinguus* (Acanthocephala) parasite of *Gobius niger* from the Northern Adriatic Sea. *Parassitologia*, **34**: 203-204.

Doornbos, G., Twisk, F., (1987), Density, growth, and annual food consumption of gobiid fish in the saline lake Grevelingen, Netherlands. *Netherlands Journal of Sea Research*, **21**: 45-74.

Duncker, G.W., Ladiges, W., (1960), Die Fische der Nordmark. Hamburg.

Fabi, G., Froglia, C., (1983), Food and feeding of *Gobius niger* L. in the central Adriatic Sea (Osteichthyes: Gobiidae). *Rapports Commission Internationale pour l'Exploration Scientifique de la Mer Méditerree*, **28**: 99-102.

Fabi, G., Froglia, C., (1984). A note on the biology and fishery of the black goby (*Gobius niger*) in the Adriatic Sea. *Fish. Rep./FAO Rapp*., **290**: 167-170.

Fabi, G., Giannetti, G., (1985), Groth parameters of the balck goby (*Gobius niger* L.) in the Adriatic Sea, based on otolith readings. *Rapports Commission Internationale pour l'Exploration Scientifique de la Mer Méditerree*, **29**: 87-90.

Fernandez, L., Freire, J., Gonzalez, G.E., (1995), Diel feeding activity of demersal fishes in the Ria de Arousa (Galicia, NW Spain): an area of intense mussel raft culture. *Cahiers de Biologie Marine*, **36**: 141-151.

Fjosne, K., Gjosaeter, J., (1996), Dietary composition and the potential of food competition between)-group cod (*Gadus morhua* L.) and some toher fish species in the littoral zone. *ICES Journal of Marine Science*, **53**: 757-770.

Froese, R., Binohlan, C., (2000), Empirical relationships to estimate asymptotic length, length at first maturity, and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. *Journal of Fish Biology*, **56**: 758-773.

Froese, R., Pauly, D., (2006), Fishbase World Wide Web electronic publications. www.fishbase.org, 20 Sept. 2006.

Gordo, L.S., Cabral, H.N., (2001), The fish assemblage structure of a hydrologically altered coastal lagoon: the Obidos lagoon (Portugal). *Hydrobiologia*, **459**: 125-133.

Helfman, G. S., Collette, B.B., Facey, D.E., (1997), The diversity of fishes. Blackwell Science, United States of America.

Hoeglund J., Thomas, K., (1992), The black goby *Gobius niger* as a potential paratenic host for the parasitic nematode *Anguillicola crassus* in a thermal effluent of the Baltic. *Diseases of Aquatic Organisms*, **13**:175-80.

Holt, E.W.L., Byrne, L.W., (1988), Notes on the reproduction of Teleostean fishes in the South-western district. *Mittheil. Zool. Neap*., **8**: 333-340.

Hureau, J-C., Monod, T., (1973), Check-list of the Fishes of the North-Eastern Atlantic and Mediterranean (CLOFNAM I), Unesco, Paris.

Hyslop, E. J., (1980), Stomach content analysis – a review of methods and their application. *Journal of Fish Biology*, **17**: 411-429.

Immler, S., Mazzoldi, C., Rasotto, M.B., (2004). From sneaker to parental male: change of reproductive traits in the black goby, *Gobius niger* (Teleostei, Gobiidae). *Journal of Experimental Zoology*, **301**: 177-185.

Joyeux, J.C., Bouchereau, J.L., Tomasini, J.A., (1991a), Croissance et structure demographie de la population de *Gobius niger* Linne, 1758. (poission teleosteen) dans uno lagune nord mediterraneene. *Cahiers de Biologie Marine*, **32**: 415-437.

Joyeux, J.C., Bouchereau, J.L., Tomasini, J.A., (1991b), La reproduction de *Gobius niger* (Pisces, Gobiidae) dans lagune de Mauguio-France: rapports gonosomatiques, fecondites, ponte, oeufs et larves. *Vie et Millieu*, **41**: 97-106.

Joyeux, J.C., Tomasini, J.A., Bouchereau, J.L., (1992), Modalites de la reproduction de *Gobius niger* (Teleostei, Gobiidae) dans une lagune mediterraneenne. *Vie et Milieu*, **42**: 1-13.

Kara, Ö.F., Gurbet, R., (1999), Investigation on Industrial Fishery of the Aegean Sea (in Turkish). Republic of Turkey Ministry of Agriculture and Rural Affairs **5**: 1-135.

Katalay, S., Parlak, H., (2002), The effects of water pollution on blood paremeters of black gobby (*Gobius niger* Linn, 1758) (in Turkish). *E.U. Journal of Fisheries & Aquatic Sciences*, **19**: 115-121.

Katalay, S., Parlak, H., (2004a), The effects of cadmium on erythrocyte structure of black goby (*Gobius niger* L., 1758) (in Turkish). *E.U. Journal of Fisheries & Aquatic Sciences*, **21**: 99-102.

Katalay, S., Parlak, H., (2004b), The Effects of Pollution on Haematological Parameters of Black Goby (*Gobius niger* L., 1758) in Foça and Aliağa Bays. *E.U. Journal of Fisheries & Aquatic Sciences*, **21**: 113-117.

Katalay, S., Parlak, H., Çakal Arslan, Ö., (2005), The accumulation of some heavy metals in the liver tissues of black gobby (*Gobius niger* L., 1758) living in the Aegean Sea (in Turkish). *E.U. Journal of Fisheries & Aquatic Sciences*, **22**: 385-388.

King, M.., (1995), Fisheries Biology Assesment and Management. Fishing News Books, Oxford.

Koutrakis, E.T., Kokkinakis, A.K., Eleftheriadis, E.A., Argyropoulou, M.D., (2000), Seasonal changes in distribution and abundance of the fish fauna in the two estuarine systems of Strymonikos gulf (Macedonia, Greece). *Belgian Journal of Zooogy*, **130**: 41-48.

Kvach, Y., (2005), A comparative analysis of helminth faunas and infection parameters of ten species of gobiid fishes (Actinopterygii: Gobiidae) from the North-western Black Sea. *Acta Ichthyologica et Piscatoria*, **35**: 103-110.

Labropoulou, M., Markakis, G., (1998), Morphological-dietary relationships within two assemblages of marine demersal fishes. *Environmental Biology of Fishes*, **51**: 309-319.

Labropoulou, M., Papadopoulou-Smith, K.N., (1999). Foraging behaviour patterns of four sympatric demersal fishes. *Estuarine Coastal and Shelf Science*, **49**: 99-108.

Le Menn, F., (1979), Some aspects of vitellogenesis in a teleostean fish: *Gobius niger* L. *Comparative Biochemistry and Physiology*, **62**: 495-500.

Leiro, J., Bos, J., Peris, D., Estevez, J., Santamarina, M.T., Sanmartin, M.L., (1984), Infection of black goby (*Gobius niger*) from NW coast of Spain by *Loma dimorpha* (Protozoa: Microspora). *Research and Reviews in Parasitology*, **54**: 217-223.

Letourneur, Y., Darnaude, A., Salen-Picard, C., Harmelin-Vivien, M., (2001), Spatial and temporal variations of fish assemblages in a shallow Mediterranean soft-bottom area (Gulf of Fos, France). *Oceanologica Acta*, **24**: 273-285.

Locatello, L., Mazzoldi, C., Rasotto, M.B., (2002), Ejaculate of sneaker males is pheromonally insconspicuous in the black goby, *Gobius niger* (Teleostei, Gobiidae. *Journal of Experimental Zoology*, **293**: 601-605.

Loubes, C., Maurand, J., Gosc, C., De Burun, I., Borral, J., (1984), Etude ultrastructurale de *Loma dimorpha* n. Sp., microsporidie parasite de poissons Gobiidae languedociens. *Protistologica* **4**: 579-589.

Magnhagen, C., (1988), Changes in foraging as a response to predation risk in two gobiid fish species, *Pomatoschistus minutus* and *Gobius niger*. *Marine Ecology Progress Series*, **49**: 21-26.

Magnhagen, C., (1990), Reproduction under predation risk in the sand goby, *Pomatoschistus minutus*, and the black goby, *Gobius niger*: the effect of age and longevity. *Behavioral Ecology and Sociobiology*, **26**: 331–335.

Magnhagen C., (1991), Predation risk as cost of reproduction. *Trends in Ecology and Evolution*, **6**:183–186.

Malavasi, S., Franco, A., Fiorin, R., Franzoi, P., Torricelli, P., Mainardi, D., (2005), The shallow water gobiid assemblage of the Venice Lagoon: abundance, seasonal variation and habitat partitioning. *Journal of Fish Biology*, **67**: 146-165.

Mandrioli, M., Manicardi, G.C., Machella, N., Caputo, V., (2001), Molecular and cytogenetic analysis of the goby *Gobius niger* (Teleostei, Gobiidae). *Genetica,* **110**: 73–78.

Maradonna, F., Polzonetti, V., Bandiera, S.W., Migliarini, B., Carnevali, O., (2004), Modulation of the hepatic CYP1A1 system in the marine fish *Gobius niger,* exposed to xenobiotic compounds. *Environmental Science and Technology*, **38**: 6277-6282.

Marconato, A., Rasotto, M.B., Mazzoldi, C., (1996), On the mechanism of sperm release in three gobiid fishes (Teleostei: Gobiidae). *Environmental Biology of Fishes*, **46**: 321-327.

Mazzoldi, C., Rasotto, M.B., (2002), Alternative male mating tactics in *Gobius niger. Journal of Fish Biology*, **61**: 157–172.

Mazzoldi, C., Petersen, C.W., Rasotto, M.B., (2005), The influence of mating system on seminal vesicle variability among gobies (Teleostei, Gobiidae). *Journal of Zoological Systematics*, **43**: 307-314.

McGrath, D., (1974), Preliminary studies on the feeding of *Gobius niger* L. and *Gobius flavescens* (Fabricius) (Pisces, Gobiidae) in the Northern Baltic proper. *Contr. Asko Lab*., **4**: 25 pp.

Metin, C., Tosunoğlu, Z., Tokaç, A., Lök, A., Aydın, C., Kaykaç, H., (2000), Seasonal variations of demersal fish composition in Gülbahçe Bay (İzmir Bay). *Turkish Journal of Zoology*, **24**: 437-446.

Migliarini, B., Campisi, A.M., Maradonna, F., Truzzi, C., Annibaldi, A., Scarponi, G., Carnevali, O., (2005), Effects of cadmium exposure on testis apoptosis in the marine teleost *Gobius niger*. *General and Comparative Endocrinology*, **142**:241-247.

Miller, P.J., (1984), The tokology of gobioid fishes. *in Potts, G.W., Wootton, R.J (eds), Fish reproduction: strategies and tactics*, 119-153, London.

Miller, P. J., (1986), Gobiidae, *in Whitehead et al., eds*, Fishes *of the Northern-Eastern Atlantic and the Mediterranean*, UNESCO, 1019-1085, Paris.

Morato, T. M., Sola, E., Gros, M.P., Menezes, G., Pinho, M.R., (1998), Trophic relationships and feeding habits of demersal fishes from the Azores: importance to multispecies assessment. *In. International Council for the Exploration of the Sea* ICES CM 1998/O: 7, 34 pp.

Muus, B.J., (1966), Zeevissengids. Elsevier, Amsterdam.

Nash, R.D.M., (1984), Aspects of biology of the black goby, *Gobius niger* L., in: Oslofjorden, Norway. *Sarsia*, **69**: 55-61.

Pampoulie, C., Priour, F., Bouchereau, J.L., Rosecchi, E., Crivelli, A.J., (1999), Reproductive traits of *Gobius niger* (Teleostei: Pisces) following a salinity stress: is it really a sedentary lagoon species. *Journal of the Marine Biological Association of the United Kingdom*, **79**: 961-962.

Pampoulie, C., Chauvelon, P., Rosecchi, E., Bouchereau, J.L., Crivelli, A.J., (2001), Environmental factors influencing the gobiid assemblage of a Mediterranean Lagoon: Empirical evidence from a long-term study. *Hydrobiologia*, **445**: 175–181.

Pauly D., (1993), Use of Fish Base in the context of the BDRM. Annexe IX5. Page 141 *in* Atelier sur la Mise en Ouvre de la Base de Donnée Régionale Maritime (BDRM), Dakar, Sénégal, 15-19 février 1993. Conference Ministerielle sur la Coopération entre les Etats africains riverains de l'Océan atlantique, Dakar/Brussels.

Pilastro, A., Scaggiante, G., Rasotto, M.B., (2002), Individual adjustment of sperm expenditure accords with sperm competition theory. *Proceedings of the National-Academy of Sciences of the United States of America*, **99**: 9913-9915.

Rasotto, M.B., Mazzoldi, C., (2002), Male traits associated with alternative reproductive tactics in *Gobius niger. Journal of Fish Biology*, **61**: 173–184.

Sayın, E., (2003), Physical features of the Izmir Bay. *Continental Shelf Research*, **23**: 957-970.

Scaggiante, M., Rasotto, M.B., Romualdi, C., Pilastro, A., (2005), Territorial male gobies respond aggressively to sneakers but do not adjust their sperm expenditure. *Behavioral Ecology*, **16**: 1001-1007.

Sever, T.M., Filiz, H., Bayhan, B., Taskavak, E., Bilge, G., (2008), Food habits of the hollowsnout grenadier, *Caelorinchus caelorhincus* (Risso, 1810), in the Aegean Sea, Turkey. *Belgian Journal of Zoology*, **138**: 81-84.

Silva, M. N., Gordo, L.S., (1997), Age, growth and reproduction of the black goby, *Gobius niger*, from Obidos Lagoon, Portugal. *Cahiers De Biologie Marine*, **38**: 175-180.

Sorice, M., Caputo, V., (1999), Genetic variation in seven goby species (Perciformes: Gobiidae) assessed by electrophoresis and taxonomic inference. *Marine Biology*, **134**: 327-333.

Sparre, P., Ursin, E., Venema, S.C., (1989), Introduction to tropical fish stock assesment. Part 1-Manual. *FAO Fish. Tech. Pap*. No: 306/1: 1-163.

Stergiou, K. I., Karpouzi, V.S., (2002), Feeding habits and trophic levels of Mediterranean fish. *Reviews in Fish Biology and Fisheries*, **11**: 217-254.

Tesch, F.W., (1977), The eel. Biology and management of anguillid eels (Translated by P.H. Greenwood). Chapman and Hall, London.

Vaas, K.F., Vlasbom, A.G., Koeijer, P.de., (1975), Studies on the black goby (*Gobies niger*, Gobiidae, Pisces) in the Verse Meer, SW Netherlands. *Netherlands Journal of Sea Research*, **9**: 56-68.

Verdiell-Cubedo, D., Oliva-Paterna, P.J., Torralva, M., (2006), Length-weight relationships for 22 fish species of the mar menor lagoon (western Mediterranean Sea). *Journal of Applied Ichthyology*, **22**: 293-294.

Vesey, G., Langford, T.E., (1985). The biology of the black goby, *Gobius niger* L. in an English south-coast bay. *Journal of Fish Biology*, **27**: 417-429.

Vitturi, R., Catalano, E., (1989), Multiple chromosome polymorphism in the gobiid fish *Gobius niger jozo* L. 1758 (Pisces, Gobiidae). *Cytologia*, **54**: 231-235.

Wiederholm, A.M., (1987), Habitat selection and interactions between three marine fish species (Gobiidae). *Oikos*, **48**: 28-32.

Wootton, R.J., (1998). Ecology of Teleost fishes. Kluwer Academic Publishers, Dordrecht, Netherlands.

Zander, C. D., Kesting, V., (1998), Colonization and seasonality of goby (Gobiidae, Teleostei) parasites from the southwestern Baltic Sea. *Parasitology Research*, **84**: 459-466.

Zander, C. D., (2003), Four-year monitoring of parasite communities in gobiid fishes. of the south-western Baltic. *Parasitology Research*, **90**: 502–511.