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On the growth of the scaldfish *Arnoglossus laterna* (Walbaum, 1792) from İzmir Bay, central Aegean Sea

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Abstract: Scaldfish (*Arnoglossus laterna*) (n = 1892) were caught in İzmir Bay (Aegean Sea) from January 2005 to December 2006. Total length and weight of all specimens ranged from 3.9 to 16.0 cm and from 0.47 to 41.63 g, respectively. The overall ratio of females to males was 1:1.91. The length-weight relationships for females, males, and all specimens combined were estimated, respectively, as $W = 0.0096 \times L^{2.921}$, $W = 0.0111 \times L^{2.857}$, and $W = 0.0096 \times L^{2.917}$; and the parameters of the von Bertalanffy growth equations were, respectively, $L_{\infty} = 17.58, 15.36, \text{ and } 17.19$ cm; $k = 0.412, 0.461, \text{ and } 0.495$ year⁻¹; and $t_0 = -0.379, -0.332, \text{ and } -0.380$ year. The growth performance index values (Φ') were 2.105, 2.036, and 2.165, respectively.

Key words: Scaldfish, *Arnoglossus laterna*, growth, İzmir Bay, central Aegean Sea

İzmir Körfezi'ndeki (Ege Denizi) küçük pisi balığının (*Arnoglossus laterna* (Walbaum, 1792)) büyüme özellikleri üzerine

Özet: Küçük pisi balıkları, *Arnoglossus laterna* (n = 1892), Ocak 2005-Aralık 2006 tarihleri arasında İzmir Körfezi'nde gerçekleştirilen trol çekimleriyle yakalanmıştır. Örneklerin total boy ve ağırlıkları 3,9 ile 16,0 cm ve 0,47 ile 41,63 g arasında dağılım göstermiştir. Dişi erkek oranı 1:1,91'dir. Dişi, erkek ve tüm bireyler için boy-ağırlık ilişkileri sırasıyla; $W = 0,0096 \times L^{2,921}$, $W = 0,0111 \times L^{2,857}$ ve $W = 0,0096 \times L^{2,917}$, boy ve ağırlığa göre von Bertalanffy büyüme parametreleri; $L_{\infty} = 17,58, 15,36$ ve $17,19$ cm; $k = 0,412, 0,461$ ve $0,495$ yıl⁻¹; $t_0 = -0,379, -0,332$ ve $-0,380$ yıl olarak hesaplanmıştır. Büyüme performans indeksi değerleri (Φ') ise; 2,105, 2,036 ve 2,165 olarak bulunmuştur.

Anahtar sözcükler: Küçük pisi balığı, *Arnoglossus laterna*, büyüme, İzmir Körfezi, orta Ege Denizi

Introduction

The scaldfish *Arnoglossus laterna* is distributed in the Black Sea and in the Mediterranean Sea along the west coast of Europe to Norway (Bowman, 1923; Nielsen, 1973). It is a benthic species and extends from the shallow sublittoral zone down to about 200 m (Whitehead et al., 1986). Bilecenoğlu et al. (2002)

reported that among the territorial waters of Turkey this species is distributed in the Mediterranean, Aegean, Marmara, and Black seas.

There are few studies concerning scaldfish in other seas. Gibson and Ezzi (1980) studied the biology of scaldfish off the west coast of Scotland and Deniel (1990) examined its growth in Brittany. Valuable

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information on *A. laterna* age, growth, and mortality was reported by Djabali et al. (1993). Özütok and Avşar (2002) reported on the growth, mortality, and exploitation rates of the scldfish in the Yumurtalık Bight (Adana, Mediterranean coast). Çiçek et al. (2006), Karakulak et al. (2006), Özeydin and Taşkavak (2006), and Özeydin et al. (2007) have reported its length-weight relationship. İlhan et al. (2007) reported its length and growth parameters in İzmir Bay. The present study presents the results of an investigation on the growth of scldfish based on a collection of samples from İzmir Bay (Aegean Sea).

Materials and methods

Scldfish specimens were caught by trawl surveys performed between January 2005 and December 2006 in İzmir Bay (central Aegean Sea). A traditional, commercially used bottom trawl (600 mesh around the mouth) was operated onboard the R/V EGESÜF at depths of 40-70 m over sandy-muddy bottoms (Figure 1).

In total, 1892 samples were measured (total length in mm [TL]), weighed to the nearest 0.01 g (total weight [W]), and dissected in the laboratory. The sex of the samples was determined by visual and microscopic examination of the gonads. Von Bertalanffy growth equations were estimated using length distribution data. Values of t_0 were estimated

from L_∞ and k using the empirical formula provided by Pauly (1979):

$\log(-t_0) = -0.392 - 0.275 \times \log L_\infty - 1.038 \log k$; where L_∞ represents asymptotic length, k is the relative growth coefficient, and t_0 is the theoretical age when fish length is zero. The length-weight relationship was calculated using the formula $W = a \times L^b$, in which the parameters a (constant proportionality) and b (regression coefficient) were estimated based on the least squares regression method and growth type was identified using the t-test (2-sided) (Sparre et al., 1989). In the formula W is total weight (g), L is total length (cm), and a and b are the regression coefficients. The widely used growth performance index value

$(\Phi' = \log_{10} k + 2\log_{10} L_\infty)$, which is used to compare fish growth, was computed with FISAT II software.

Results

Of the 1892 scldfish specimens measured, 513 were female (27.1%), 978 were male (51.7%), and 401 were undetermined (21.2%). Total length of all scldfish specimens ranged from 3.9 to 16.0 cm (Figure 2). Most of the captured female and male specimens ranged from 7.0 to 8.0 cm and from 9.0 to 10.0 cm in length, respectively. Total weight distribution of the specimens varied between 0.47 and 41.63 g.

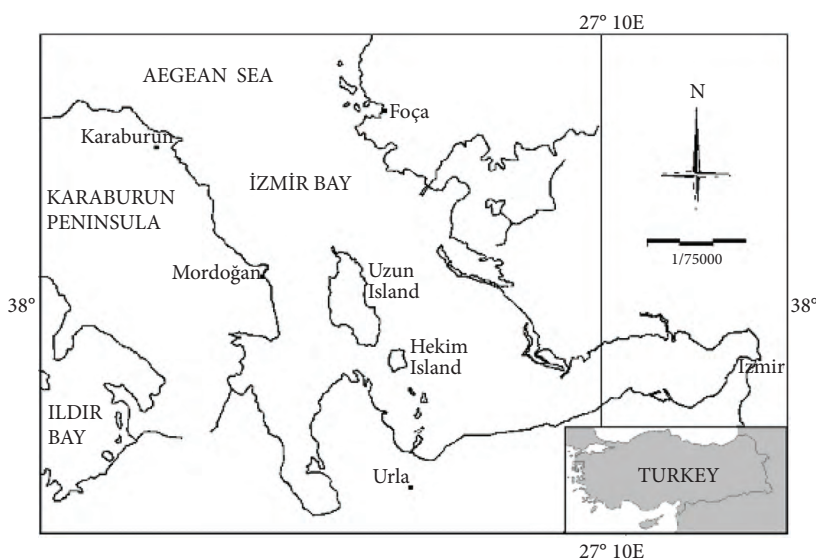


Figure 1. The sampling area (İzmir Bay, central Aegean Sea).

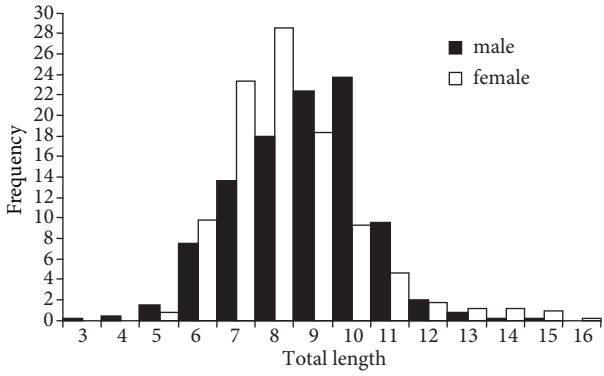


Figure 2. Length distributions of female and male scaldfish in İzmir Bay.

The von Bertalanffy growth parameters computed for females, males, and both sexes combined are shown in Table 1.

The length-weight relationships calculated using the total lengths and weights were as follows: $W = 0.0096 \times L^{2.921}$, $W = 0.0111 \times L^{2.857}$, and $W = 0.0096 \times L^{2.917}$ for females, males, and both sexes combined, respectively (Figure 3). According to Student's t-test, there was negative allometric growth for females ($b = 2.921$; $\pm SE(b) = 0.0303$; $P < 0.05$), for males ($b = 2.857$; $\pm SE(b) = 0.0196$; $P < 0.05$), and for all specimens combined ($b = 2.917$; $\pm SE(b) = 0.0142$; $P < 0.05$).

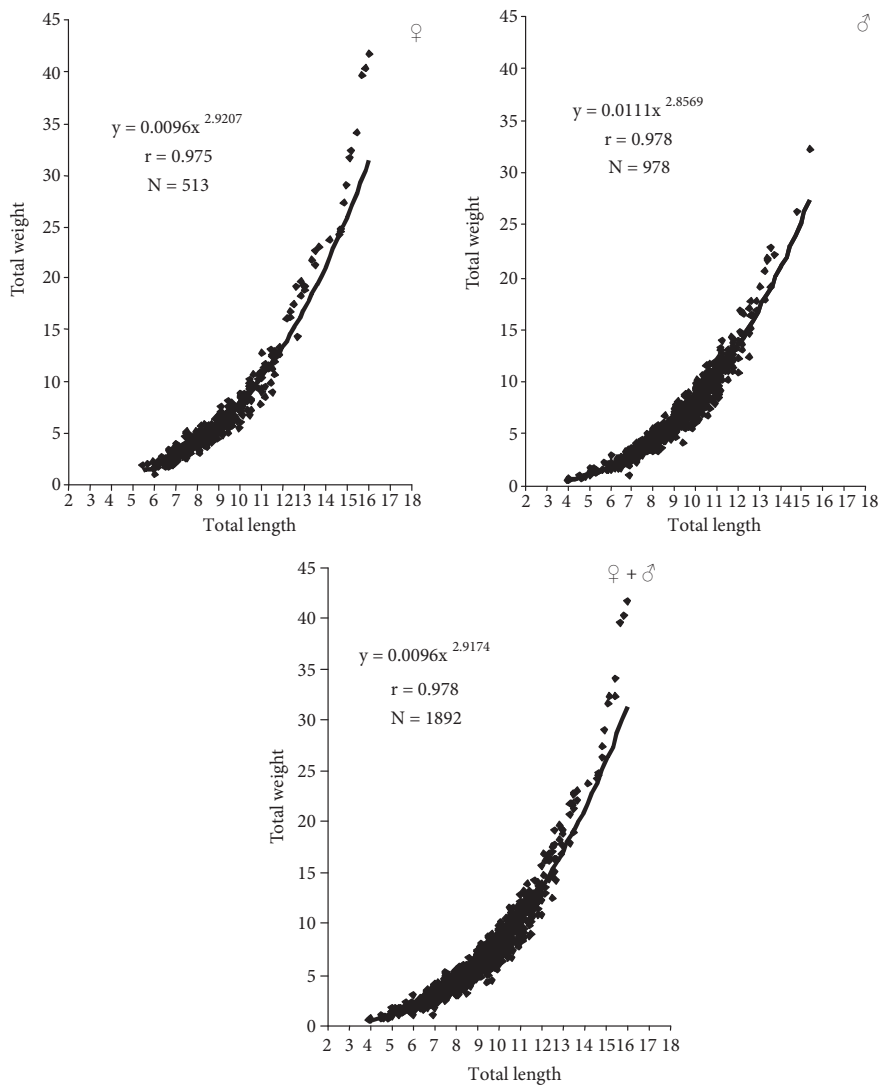


Figure 3. Length-weight relationships of scaldfish in İzmir Bay.

Table 1. The von Bertalanffy growth parameters and growth performance index values of *A. laterna*.

	N	k	t_0	L_∞	Φ'
♀	513	0.412	0.379	17.58	2.105
♂	978	0.461	0.332	15.36	2.036
Total	1892	0.495	0.38	17.19	2.165

N, number of specimens; L_∞ , the asymptotic length; k, a relative growth coefficient; t_0 , theoretical age; Φ' , growth performance index.

The growth performance index value (Φ') was calculated as 2.105 for females, 2.036 for males, and 2.165 for both sexes combined.

Discussion

Total length of the specimens in the present study varied between 3.9 cm and 16.0 cm. This range was compared with those given by Gibson and Ezzi (1980) for the west coast of Scotland (2.6-14.2 cm), Özütok and Avşar (2002) for Yumurtalık Bight (3.9-13.8 cm), Çiçek et al. (2006) for Babadillimanı Bight (2.2-11.8

cm), Karakulak et al. (2006) for the northern Aegean Sea (7.6-18.3 cm), and Özeydin and Taşkavak (2006) and Özeydin et al. (2007) for İzmir Bay (6.8-21.9 cm and 4.5-14.9 cm). All the previously reported values are similar to those observed in the present study.

Table 2 lists the von Bertalanffy growth parameters of scaldfish reported in different studies.

Regarding the measure of the rate at which length approaches L_∞ and the growth performance index, the growth of scaldfish was somewhat slower in İzmir Bay ($k = 0.412$ and 0.461) than that off the west coast of Brittany ($k = 0.840$ and 1.032) (Deniel, 1990).

The growth performance (Φ') of scaldfish observed in the present study (2.105 and 2.036) is in accordance with that given for the Adriatic Sea (2.155 and 2.150) by Giovanardi and Piccinetti (1983), and Djabali et al. (1993), and for Duarnenez Bay (2.322 and 2.377) (Deniel, 1990). However, that given by Özütok and Avşar (2002) for Yumurtalık Bight (Mediterranean) (1.500) is lower than we observed. The growth of fish and other marine populations is directly or indirectly affected by environmental conditions (supply of available food, temperature, level of competition for food) and by fishing

Table 2. Values for the von Bertalanffy growth parameters of *A. laterna*.

Author(s)	Sex	Locality	L_∞ (cm)	k	t_0	Φ'
Giovanardi and Piccinetti (1983)	T	Adriatic Sea	15.81	0.572	-	2.155
Deniel (1990)	F	Douarnenez Bay	15.80	0.840	0.690	2.322
	M	(France)	15.20	1.032	0.773	2.377
Djabali et al. (1993)	T	Adriatic Sea	15.80	0.570	-	2.150
Ozutok and Avsar (2002)	F	Yumurtalık Bight	15.88	0.14	1.71	1.548
	M	(Mediterranean)	14.55	0.15	1.00	1.502
	T		15.60	0.13	1.54	1.500
İlhan et al. (2007)	F		16.34	0.388	-	2.015
	M	İzmir Bay	14.07	0.212	-	1.623
	T		16.70	0.392	-	2.039
This study	F	İzmir Bay	17.58	0.412	0.379	2.105
	M	(Central Aegean	15.36	0.461	0.332	2.036
	T	Sea)	17.19	0.495	0.380	2.165

L_∞ , represent the asymptotic length; k, is a relative growth coefficient; t_0 , theoretical age when fish length is zero; Φ' , Growth performance index.

(Weatherley, 1972), making geographical comparisons difficult.

The correlation coefficient of the length-weight relationship we calculated for the sculdfish in İzmir Bay ($r = 0.978$ for overall specimens) is in accord with that reported by other researchers (Table 3).

Various factors might be responsible for the differences in the parameters of the length-weight relationship between seasons and years, such as stage of maturity, sex, temperature, and salinity, as well as food quality, quantity, and size (Dulcic and Kraljevic, 1996). According to Gonçalves et al. (1997), parameter b , unlike parameter a , may vary

seasonally—even daily—and between habitats. Therefore, the length-weight relationship in fish is affected by a number of factors, including diet, stomach fullness, gonad maturity, health, and preservation techniques, as well as season and habitat, none of which were taken into consideration in the present study.

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Table 3. Length-weight parameter estimates of *A. laterna* for different geographic areas.

Author(s)	Sex	N	a	b	r	Area
Matta (1959)	T	-	0.00000046	3.534	-	Tuscan archipelago (Italy)
Giovanardi and Piccinetti (1983)	F	-	0.0020	3.280	-	Adriatic Sea
	M	-	0.0068	3.030	-	
Merella et al. (1997)	T	20	0.0025	3.450	0.962	Balearic Islands (Spain)
Pereda and Villamor (1991)	T	35	0.0024	3.389	0.970	Cantábrico (Spain)
Özütok and Aşar (2002)	F	161	0.0050	3.103	0.934	Yumurtalık Bight (Mediterranean)
	M	225	0.0060	3.062	0.912	
	T	390	0.0050	3.117	0.923	
Çiçek et al. (2006)	T	594	0.0080	3.007	0.986	Babadillimanı Bight (NE Mediterranean)
Karakulak et al. (2006)	T	8	0.0150	2.747	0.995	Northern Aegean Sea
Özaydın and Taşkavak (2006)	T	721	0.0052	3.168	0.980	İzmir Bay (Aegean Sea)
Özaydın et al. (2007)	T	1078	0.0097	2.906	0.962	İzmir Bay (Aegean Sea)
İlhan et al. (2007)	F	323	0.0081	2.986	0.974	İzmir Bay (Aegean Sea)
	M	554	0.0093	2.925	0.980	
	T	877	0.0087	2.949	0.980	
This study	F	513	0.0096	2.920	0.975	İzmir Bay (Central Aegean Sea)
	M	978	0.0111	2.857	0.978	
	T	1892	0.0096	2.917	0.978	

N, number of specimens; a, intercept of the relationship; b, slope of the relationship; r, correlation coefficient.

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