

Growth and reproduction of sandsmelt *Atherina boyeri* Risso, 1810 in Lake Egirdir, Isparta, Turkey

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ABSTRACT

Growth and reproduction in the sandsmelt *Atherina boyeri* from Lake Egirdir, Turkey, are described in this paper. The proportion of male, female and sexually immature fishes in the sampled population were 48.54, 48.19 and 3.27%, respectively. The fork length, weight and age of the individuals ranged between 1.6 and 9.8 cm, 0.15 and 9.42 g and 0 and 4 years, respectively. Length-weight relationship was calculated as $W = 5.9 \times 10^{-3} FL^{3.202}$ and the average condition factor as 0.84 ± 0.007 . The von Bertalanffy growth equation obtained was $L_t = 111.6 [1 - e^{-0.27(t+0.48)}]$. Growth index Φ estimated was 8.13. Gonadosomatic index values indicated that reproduction period of sandsmelt was between March and September. The average relative fecundity was calculated to be $60.61 \text{ eggs g}^{-1} \text{ year}^{-1}$. The relationship between length and fecundity was determined as $F = 0.5859 * L^{2.8652}$ ($r = 0.525$) and between weight and fecundity was $F = 56.548 * W^{0.947}$ ($r = 0.541$). The egg diameters varied from 0.20 to 1.61 mm (average 0.83 ± 0.027 mm).

Keywords: *Atherina boyeri*, Fecundity, Growth, Lake Egirdir, Reproduction

Introduction

The sandsmelt, *Atherina boyeri* Risso, 1810 is a commercially important fish found throughout the Mediterranean and adjacent seas. It is euryhaline, mostly inhabiting coastal and shallow brackishwaters including coastal lagoons, salt marshes and inland waters (Leonardos and Sinis, 2000; Pallaoro *et al.*, 2002; Andreu-Soler *et al.*, 2003; Bartulovic *et al.*, 2004a). As a carnivorous or opportunistic predator species, it feeds on zooplankton and benthic organisms (Pallaoro *et al.*, 2002; Bartulovic *et al.*, 2004b; Doulka *et al.*, 2012). Studies based on the stable isotope ratios of nitrogen and carbon suggest feeding preference for benthic organisms, generally Isopods and Mysids (Bartulovic *et al.*, 2004b; Vizzini and Mazzola, 2005). Reproduction is known to take place in spring (March-July) in brackishwater lagoons (Fernandez-Delgado *et al.*, 1988; Tomasini *et al.*, 1996) and inland waters (Ozeren, 2009; Kucuk *et al.*, 2012). *A. boyeri* populations have been researched in lake Kucukcekmece (Altun, 1986), in the estuary of the Guadalquivir (Fernandez-Delgado *et al.*, 1988), in brackish lagoons of southern France

(Tomasini *et al.*, 1996), in Pantana Lagoon (Pallaoro *et al.*, 2002), in Adriatic (Bartulovic *et al.*, 2004a), in northern Greece (Koutrakis *et al.*, 2004), in western Greece (Leonardos and Sinis, 2000), in south-east Iberian Peninsula (Andreu-Soler *et al.*, 2003), in Homa Lagoon (Sezen *et al.*, 2004; Sezen, 2005), in Lake Iznik (Ozeren, 2009), in Aegean Sea (Taskavak *et al.*, 2012) and in Lake Egirdir (Kucuk *et al.*, 2012). In this study, we present information on age, growth, condition factor and reproduction of *A. boyeri* from Lake Egirdir.

Materials and methods

Samples of sandsmelt were obtained at monthly intervals, during the period January-December, 2010. Samples were collected from four stations in the lake (Fig. 1).

Fork length was measured to the nearest 'cm' and total weight recorded to the nearest 'g'. Sex was determined macroscopically and gonad weight was recorded to the nearest 'g'. Further, the total length of 12,041 specimens was measured to analyse the length frequency distribution

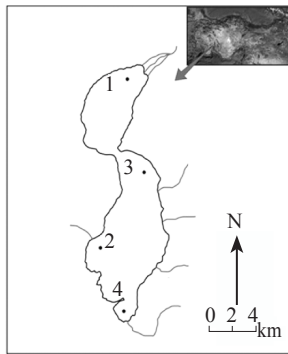


Fig. 1. Map of the study area showing the sampling stations

of sandsmelt. Age validation was attempted using the length frequency based method available in the FISAT II (1.2.2 version). Cohorts were determined following Bhattacharya's method. Length-weight relationship was estimated from 1,681 individuals according to the equation given by Le Cren (1951): $W=a*L^b$, where a and b are constants of the regression analysis. Growth was described by the von Bertalanffy growth equation ($L_t = L_\infty [1 - \exp^{-K(t-t_0)}]$) where, L_t = length at time 't', L_∞ = asymptotic length and K = annual growth coefficient, t_0 = the hypothetical age at zero length. Gonadosomatic index (GSI), was calculated using the formula $GSI = (GW/GW-W)*100$, where GW = weight of gonad and W = weight of fish (Lagler, 1966; Chakravarty *et al.*, 2013). Length at first maturity was estimated using the logistic function $P = 100/[1 + \exp^{-r(L - L_m)}]$, where, P = percentage mature at length 'L'. The length at 50% maturity was estimated as: $L_m = a/b$.

Relative fecundity was calculated following Bagenal (1978) and Avsar (1998). The eggs were preserved in 4% formaldehyde solution. The diameters of 171 eggs of female sandsmelt were measured using Nikon Profile Projector V-10 model. Condition factor was estimated according to the equation given by Ricker (1975): $CF=(W/L^3)*100$. Growth performance index (Φ) was estimated as $\Phi = \ln K + 2 * \ln L_\infty$, where K = growth coefficient

(Munro and Pauly, 1983). The data were analysed with the Jump version 8 software. A t-test was used for comparison of length, weight and condition factor in the different age groups of male and female fishes.

Results and discussion

Sex ratio

Among the sampled fishes, 48.19% were females, 48.54% males and 3.27% of indeterminate sex. Male to female ratio was 0.99:1. Female: male ratio of samples was calculated as 0.99:1. Female:male ratios were reported as 1: 1.12 in Mesolongi and Etolikon lagoons (Leonardos and Sinis, 2000), 1:0.86 in Mar Menor Lagoon (Andreu-Soler *et al.*, 2003), 1.6:1.00 in Lake Iznik (Ozeren, 2009), 1: 1.39 in Lake Egirdir (Kucuk *et al.*, 2012).

Length-weight relationship

The total length and total weight of the sampled fishes ranged from 1.6 to 9.8 cm and from 0.15 to 9.42 g. The length-weight equations derived were $W=5.5 \times 10^{-3} FL^{3.2686}$ for females, $W=7.1 \times 10^{-3} FL^{3.0649}$ for males and $W=5.9 \times 10^{-3} FL^{3.2015}$ for all individuals (Fig. 2). The slope of the length-weight relationship indicates allometric growth. Similar observations were made by Leonardos and Sinis (2000) in the Mesolongi and Etolikon lagoons ($b=3.18$), Koutrakis *et al.* (2004) in the Northern Greece ($b=3.22$) and Ozeren (2009) in the Lake Iznik ($b=3.20$).

Condition factor

Monthly condition factor varied from 0.73 to 0.94 (Fig. 3) with two notable peaks in May and August. It was found that the condition factor increased with size of fish which differed significantly between males and females in the I, II and III year age groups ($p < 0.01$). The mean condition factor decreased in November. The observations in the present study are similar to earlier reports recording two annual peaks (Fernandez-Delgado *et al.*, 1988; Andreu-Soler *et al.*, 2003; Koutrakis *et al.*, 2004).

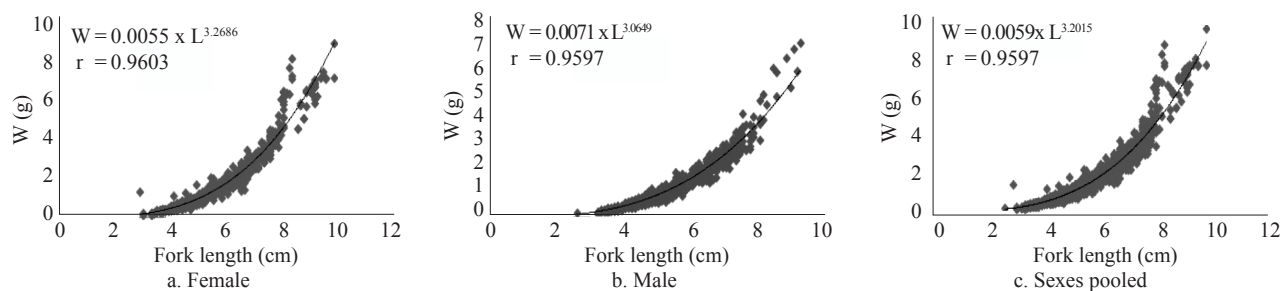


Fig. 2. Length-weight relationship of sandsmelt in Lake Egirdir a. Female; b. Male; c. Sexes pooled

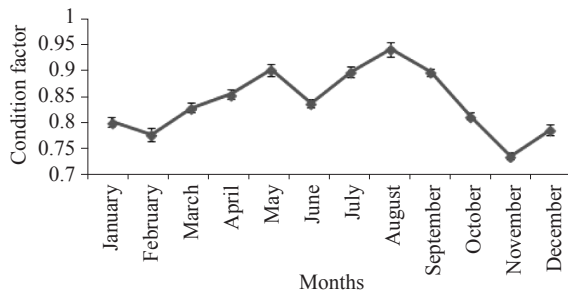


Fig. 3. Average monthly condition factor of sandsmelt in Lake Egirdir

Gonadosomatic index

Gonadosomatic index (GSI) in females was minimum (GSI=0.59) in September and maximum (GSI=7.62) in May (Fig. 4). In the present study, reproductively active individuals were found to occur between March and September. The spawning season extended from May to September with a peak in May (Fig. 4).

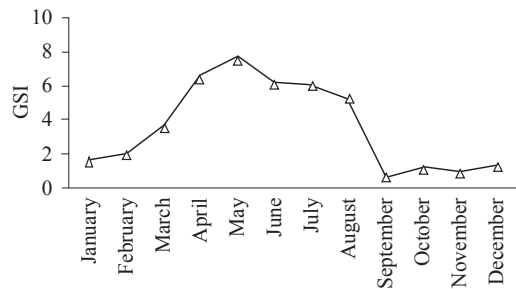


Fig. 4. Monthly gonadosomatic index (GSI) of sandsmelt in Lake Egirdir

Spawning season of sandsmelt was reported to be April-September in Aberthaw Lagoon (Creech, 1992), May-September in the estuary of the Guadalquivir (Fernandez-Delgado *et al.*, 1988), April-August in Mesolongi and Etolikon lagoons (Leonardos and Sinis, 2000), February-Temmuz in Homa Lagoon (Sezen, 2005), April-August (Gaygusuz, 2006), April-July (Ozeren, 2009) and March-July (Anon., 2007) in Lake Iznik and in March-August in Lake Egirdir (Kucuk *et al.*, 2006, Kucuk

et al., 2012) in Turkey. Bartulovic *et al.* (2004a) reported the spawning season of *A. boyeri* to be May-September in estuaries. The spawning period of *A. boyeri* population in Ria de Aveiro, Portugal was reported to be April-August (Pombo *et al.*, 2005). The observations made in the present study are in agreement with earlier reports.

Length at first maturity

The length at first maturity of sandsmelt was determined as 3.2 cm. This is close to that reported in Mesolongi and Etolikon lagoons (3.4 cm) by Leonardos and Sinis (2000). It is however, lower than that reported from the estuary of the Mala Neretva River (5.2 cm) (Bartulovic *et al.*, 2004a) and from Lake Egirdir (4.6 cm) (Kucuk *et al.*, 2006). This variation could be attributed to the influence of environmental factors.

Fecundity and egg size

Relative fecundity of sandsmelt ranged from 52.48 g⁻¹ (III year age group) to 62.39 g⁻¹ female (II year age group). Linear relationships were established between fecundity and weight and fork length (Fig. 5). The regression equations were $F=0.5869*L^{2.8652}$ ($r=0.52$) for fecundity and fork length and $F=56.548*W^{0.947}$ ($r=0.54$) for fecundity and weight (W). Ozeren (2009) reported that fecundity of sandsmelt ranged from 450 to 1724 eggs in Lake Iznik. Fecundity of *A. boyeri* was positively correlated to weight and length (Fig. 5). A positive correlation between fecundity and fish weight and length has been found in brackish lagoons (Tomasini *et al.*, 1996).

In the present study, the diameter of eggs ranged from 0.20 to 1.61 mm with a mean value of 0.83 ± 0.027 mm. Egg diameters of *A. boyeri* were reported as 1.25-2.08 mm in Aberthaw Lagoon (Creech, 1992), >1.0 mm (Fernandez-Delgado *et al.*, 1988) and 1.34-1.94 mm in brackish lagoons of Southern France (Tomasini *et al.*, 1996). Egg sizes in this study are consistent with *A. boyeri* populations in Turkey and smaller than estuarine populations of *A. boyeri* in brackish lagoons (Tomasini *et al.*, 1996).

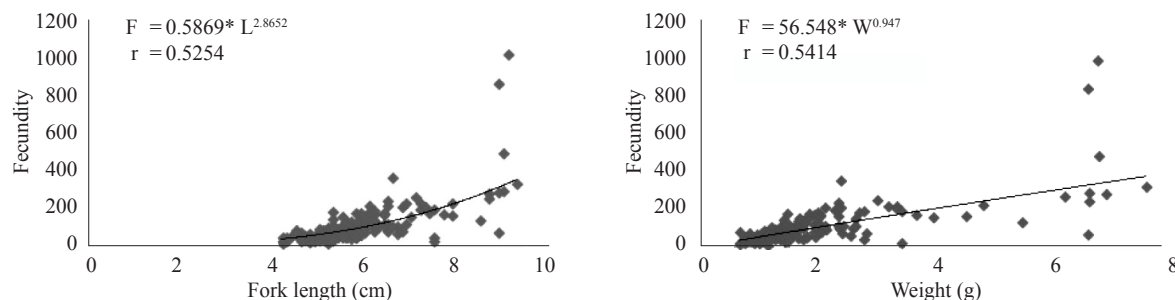


Fig. 5. Relationship between fecundity and fork length and weight of sandsmelt in Lake Egirdir

Growth

In our computations, the asymptotic length L_{∞} , of *A. boyeri* was found to be 11.2 cm (Table 1). Growth parameters for *A. boyeri* from different regions are presented in Table 1. The von Bertalanffy parameters calculated in this study show that sandsmelt is a relatively slow growing fish compared to other similar species (Koutrakis *et al.*, 2004; Bartulovic *et al.*, 2004a; Gaygusuz, 2006; Sezen, 2005; Kucuk *et al.*, 2006; Patimar *et al.*, 2009). The growth performance index (Φ) observed in the present study was lower compared to reports from other areas (Table 1). The difference between mean total lengths of males and the females in the same age groups

was statistically significant in the II and III years of ages ($p < 0.01$).

The maximum age estimated in this study was 4 years which compares well with those reported from the estuary of Guadalquivir and the Aberthaw Lagoon. Leonardos and Sinis (2000), Andreu-Soler *et al.* (2003) and Pombo *et al.* (2005) examined 3 year old specimens of sandsmelt in the Mesolongi and Etolikon lagoons, Man Menor Coastal Lagoon and Ria de Aveiro, respectively, which validates the observation that sandsmelt has a life span of 4 years. The results of this study will be of use in assessing and managing the fishery and stock of *A. boyeri* in Lake Egirdir.

Table 1. Comparison of von Bertalanffy growth parameters and growth performance index (Φ).

Source	Location	Sex	Age	N	a	b	L_{∞} (cm)	k	t_0	Φ	First mature length (cm)
Fernandez-Delgado <i>et al.</i> (1988) ^c	Estuary of Guadalquivir, Spain	F,M	2	2510	7.0×10^{-3}	2.98	-	-	-	-	
Creech (1992) ^b	Aberthaw Lagoon, South Wales	F,M	2	329	3.5×10^{-6}	3.27	9.2	-	-	-	
Leonardos and Sinis (2000) ^a	Mesolongi and Etolikon Lagoons, Western Greece	F,M	3	4269	4.2×10^{-3}	3.15	11.6	0.240	-1.270	8.08	3.4
Leonardos (2001) ^a	Trichonis Lake, Western Greece	F,M	4	503	3.6×10^{-3}	3.18	11.2	0.42	-0.40	8.57	
Pallaoro <i>et al.</i> (2002) ^a	Pantana Lagoon, Croatia	F	4	572	8.4×10^{-3}	2.94	13.8	0.347	-0.593	8.80	
Andreu-Soler <i>et al.</i> (2003) ^c	Mar Menor Coastal Lagoon, SE Iberian Peninsula	F	3	598	3.30×10^{-6}	3.25	8.4	0.81	-0.61	8.65	
		M	3	519	3.56×10^{-6}	3.22	8.1	0.91	-0.45	8.69	
Koutrakis <i>et al.</i> (2004) ^a	Estuarine system of Northern Greece	F,M	4	761	2×10^{-6}	3.22	16.7	0.16	-1.90	10.4	
Bartulovic <i>et al.</i> (2004a) ^a	Estuary of the Mala Neretva River, Croatia	F,M	4	1200	3.4×10^{-3}	3.24	13.5	0.37	-0.97	8.82	5.2
Pombo <i>et al.</i> (2005) ^a	Ria de Aveiro, Portugal		3	2503	3.3×10^{-3}	3.35	11.6	0.099	-3.797	7.19	
Gaygusuz (2006) ^a	Lake Iznik, Turkey	F,M	4	1136	3.2×10^{-3}	3.336	12.8	0.30	-0.089	8.50	
Sezen (2005) ^a	Homa Lagoon, Turkey	F,M	3	1640	5.2×10^{-3}	3.08	13.5	0.23	-1.89	8.34	
Kucuk <i>et al.</i> (2006) ^a	Lake Egirdir, Turkey	F,M	4	1481	6.6×10^{-3}	2.96	13.7	0.24	-1.59	8.41	4.6
Patimar <i>et al.</i> (2009) ^a	Gomishan Wetland, South-east Caspian Sea	F,M	4	2256	5.3×10^{-3}	3.06	16.3	0.27	-0.727	8.88	
Ozeren (2009) ^a	Lake Iznik, Turkey	F,M	4	922	4×10^{-3}	3.20	14.1	0.27	-0.49	8.59	
Present study ^c	Lake Egirdir, Turkey	F,M	4	1681	5.9×10^{-3}	3.20	11.2	0.27	-0.48	8.13	3.2

M: males; F: females; L_{∞} : asymptotic length; K: annual growth coefficient; t_0 : theoretical age at length zero; Φ : growth performance index

^a Total length, ^b Standard length, ^c Fork length

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