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SHORT PAPER

Reproductive Features of Big Scale-Sand Smelt, *Atherina boyeri* (Risso, 1810), an Exotic Fish in Lake Eğirdir (Isparta, Turkey)

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Abstract

Reproductive features of Big-Scale sand smelt, *Atherina boyeri* (Risso, 1810), which is an exotic fish species in Lake Eğirdir (Turkey) were studied between March 2006 and August 2007 using 1433 individuals. According to 18 month GSI results, egg maturation starts in March of both 2006 and 2007 (2.74 and 1.67), and peaking in late June (9.16 and 13.44), decreases to its minimum level in July (4.61 and 1.41); spawning occurs late July. First mature length of females (Lm) was determined as 45.93 mm and relative fecundity 29.05 eggs g^{-1}. Relationships of total length (TL), weigth (W) and gonad weigth (GW) with fecundity were calculated respectively as $F=181.63xGW^{0.5478}$, $F=0.104xTL^{1.5439}$ and $F=55.443xW^{0.4082}$; mean egg diameter was 1.03±0.016 mm.

Keywords: *Atherina boyeri*, big-scale sand smelt, reproduction biology, Lake Eğirdir.

Eğirdir Gölü (Isparta, Türkiye)'nün Yabancı Türlerinden Gümüş Balığı, *Atherina boyeri* (Risso, 1810)'nin Üreme Özellikleri

Özet

Eğirdir Gölü'nün yabancı türlerinden gümüş balığı, *Atherina boyeri* (Risso, 1810)'nin üreme özellikleri Mart 2006-Ağustos 2007 tarihleri arasında 1433 birey incelenerek araştırıldı. 18 aylık GSİ bulgularına göre yumurta gelişiminin her iki yılın Mart ayında (2,74 ve 1,67) başladığı, Haziran ayı sonunda (9,16 ve 13,44) en yüksek, Temmuz ayında ise (4,61 ve 1,41) en düşük düzeyine ulaştığı, populasyonun Mayıs sonu ve Temmuz sonu olmak üzere yılda iki kez yumurta döktüğü belirlendi. Dişi gümüş balıklarının ilk eşeysel olgunlaşma boyu (L_m) 45,93 mm ve nispi fekondite 29,05 yumurta g^{-1} olarak hesaplandı. Fekondite-tam boy (mm), ağırlık (W) ve gonad ağırlığı (GW) ilişkileri sırasıyla; $F=181,63xGW^{0,5478}$, $F=0,104xTL^{1,5439}$ ve $F=55,443xW^{0,4082}$, ortalama yumurta çapı ise 1,03±0,016 mm olarak belirlendi.

Anahtar Kelimeler: *Atherina boyeri*, gümüş balığı, üreme biyolojisi, Eğirdir Gölü.

Introduction

Atherina boyeri (Risso, 1810) is a small (total length 14-15 cm at maximum), short-lived and euryhaline fish species inhabiting mainly coastal and estuarine waters including coastal lagoons, salt marshes, and, more rarely, inland waters, over a wide range of salinities from freshwater to hypersaline conditions (Henderson and Bamber, 1987). Becoming mature in their first year, *A. boyeri* spawn during April-July period in seas and May-September in inland waters (Tomasini and Laugier, 2002). In coastal brackish lagoons, as in southern France, an extended reproductive season lasting from February to September is seen (Tomasini and Laugier, 2002).

Forming dominant populations due to its abilities to quickly adapt and reproduce in inland waters, *A. boyeri* is considered a potential threat to lentic ecosystems (Küçük *et al*., 2007).

This exotic species for Turkish inland waters was firstly reported from Sapanca Lake (Geldiay and Balık, 1996); following records were from Güzelhisar Stream in Menemen and Köyceğiz Lake (Balık, 1979), Küçükçekmece Lake (Altun, 1986), Lake İznik (according to verbal information of local fishermen in 1988; Özeren, 2004), Lake Eğirdir (Anonymous, 2005), and Homa Lagoon (Sezen, 2005). At the present, it is a common invading exotic fish species throughout Turkey (Küçük *et al*., 2007).

10 fish species all native to the lake was reported in the first ichthyofaunal study on Lake Eğirdir (Kosswig and Geldiay, 1952). Drastic effects of the

piscivorous alien fish species *Sander lucioperca*, officially introduced in 1955 as the pilot study in Turkey, led to extirpation of two endemic fishes (*Hemigrammocapoeta kemali*, during late 1950s; *Pseudophoxinus handlirschi*, in early 1970s) from the lake (Küçük *et al*., 2009; Küçük, 2012). With following introductions of *Gambusia affinis*, *Carassius gibelio*, *Knipowitschia caucasica* and recent addition of *A. boyeri* (reportedly in 2003; Anonymous, 2005), possibly through illegal ways (Küçük *et al*., 2007), the total number of exotic fish species has now reached 5 (Küçük *et al*., 2009).

The species adapted to the lake in a relatively short period (within 2 years) and commercial fishing began in 2005, amounts of annual total catch were 34.5 tons in 2006 and 26 tons in 2007 (Küçük *et al*., 2007). Fairly low takes despite the size of the lake can be attributed to decrease in fishing effectiveness due to expansion of macrophytes on the bottom.

The study presented here aims to describe reproductive features of the Lake Eğirdir *A. boyeri* population surveyed in 2006-2007 period.

Materials and Methods

A total of 1433 individuals were caught with drift nets of tulle of 2 mm mesh size from Köprübaşı, Yeşilada and Boyalı Village shores of Lake Eğirdir, between March 2006 and August 2007. The total lengths of all fish were measured with 0.01 mm (nearest) sensitive calipers, whereas body and gonad weights were recorded with an electronic balance at the nearest 0.01 g. Age determination was made using scales at the bottom of silvery band posterior to the left pectoral fin (Andreu-Soler *et al*., 2003). The gonadosomatic index (GSI) was calculated as: GSI=GW/Wx100, where GW was the gonad weight and W the total body weight of the fish (Gibson and Ezzi, 1980). Spawning periods were determined from monthly evolution of GSI. Fecundity was estimated by gravimetry from the number of mature oocytes in 70 mature-ripe females. The diameter of eggs taken from fish samples of various sizes caught throughout the study were measured with micrometer of profile projector (Nikolsky, 1980). The relationships of fecundity with body length, body weight, gonad weight size among ready to spawn females collected in May and June was expressed by the equation $F=ax^b$, where F is the fecundity per specimen, x is the length (TL), body weight or gonad weight, 'a' is the constant and 'b' the slope. The relative fecundity was calculated by equation F/W, where F is fecundity and W is body weight (in grams) (Bagenal and Braum, 1978; Elliott, 1995). The overall ratio of males to females was evaluated with χ^2 - test (0.05) (Düzgüneş *et al*., 1995).

In order to determine the first maturity length, the length at which 50% of the fish become mature, only individuals collected during the spawning period were used. The mean length at 50% maturity was calculated by $L_m = -a/b$. A logistic curve was fitted to the proportion of sexually mature individuals by length and the parameters were estimated using a least square method applied to a non-linear fit (King, 1995). The function used is below:

$$PL=100/[1 + e^{-r(L-Lm)}],$$

where PL is percentage mature at length L, and a and r (b) are regression parameters.

Results

According to examined specimens, ovary is single lobed, cylindrical, and in form of a capsule covered by a thick black membrane; testis without a capsule, multilobed and beige in colour (Figure 1a, b). Ripe eggs are cream coloured and covered by long chorionic filaments on the surface.

According to 18 month GSI calculations, during both 2006 and 2007, egg development started in March (2.74 and 1.67), peaked in late June (9.16 and 13.44) and decreased in July (4.61 and 1.41) (Figure 2). According to field observations, *A. boyeri* spawn in shallow parts of the lake and the larvae develop in coastal and bay areas of the lake. In age classes 0 to

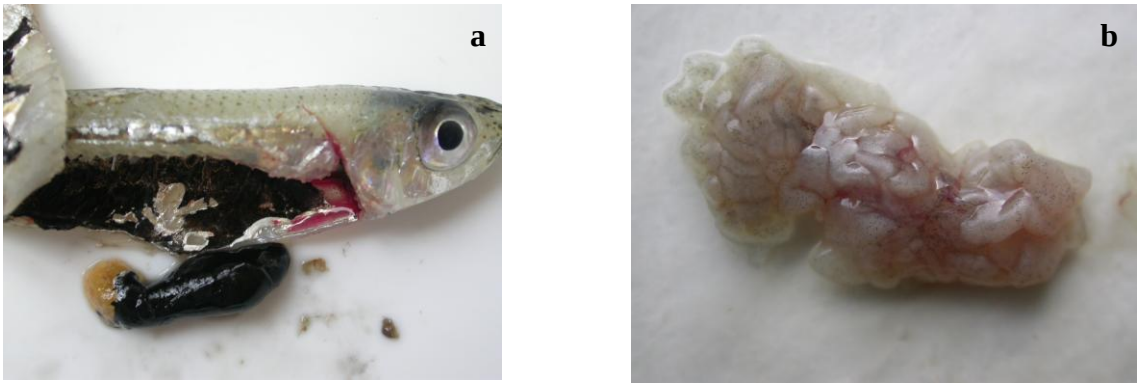

Figure 1. Gonads of the *A.boyeri* (a: ovary, b: testis)

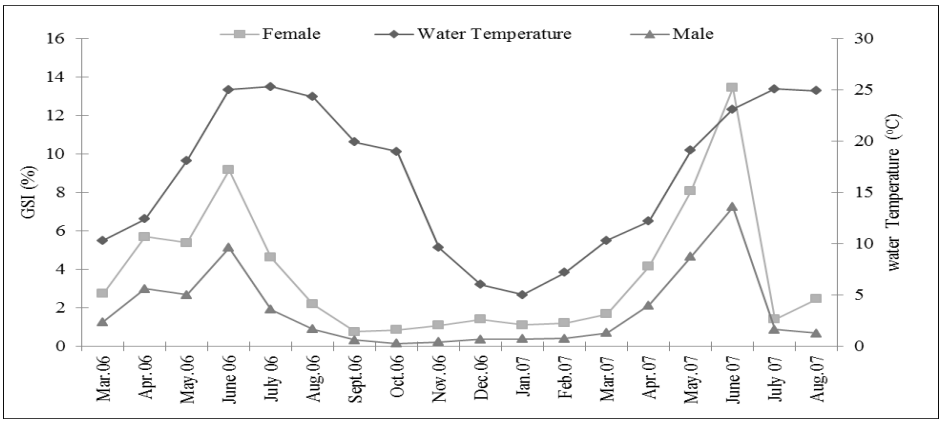

Figure 2. Monthly variations in the GSI of female and male *A.boyeri* in Lake Eğirdir.

IV, ratio of females to males was 1:1.39 (χ^2, SD=1, P>0.05); 41.87% of the population was formed by females (n=600) and 58.13% by males (n=833).

The females reached sexual maturity at 42.5 mm TL. The rate of mature females in this length was about 29.4%, all females larger than 60 mm were sexually mature (Table 1).

The length of female *A. boyeri* at 50% maturity was determined as 45.93 mm (L_m = -a/b= -8.648/-0.1883). Percentages of mature fish from different lengths were calculated using the formula $P_L = 100/[1+e^{-0.01883*(L-45.93)}]$ and then the maturity ogive (Figure 3) was drawn from these values.

Average fecundity value from 70 female individuals ready to spawn was 110.4 and highest fecundity was calculated as 182.18 in III. age class. Mean egg diameter of the specimens was 1.03±0.016 (min: 0.78 and max: 1.16 mm). Specimen numbers, the mean total length, weight, gonad weight, relative fecundity of fish samples relevant to age classes are given in Table 2.

Relationships of fecundity with total length (TL), weigth (W), gonad weight (GW) were calculated respectively as $F=181.63xGW^{0.5478}$, $F=0.104xTL^{1.5439}$ and $F=55.443xW^{0.4082}$; relative fecundity was 29.05 eggs g^{-1}.

Discussion

Female:male sex ratio (1:1.39) of Lake Eğirdir *A. boyeri* population is close to that of Mesolongi and Etolikon lagoons in Greece (1:1.12, Leonardos and Sinis, 2000) and distinctly higher than that of Mar Menor Lagoon in France (1:0.86; Andreu-Soler *et al*., 2003), although it is distinctly lower than the populations of Lake İznik (1.6:1, Özeren, 2004; 3.01:1, Gaygusuz, 2006) and Lake Uluabat (2.5:1, Anonymous, 2007).

According to 18 month GSI values, egg maturation starts to increase in March, and, peaking in June, decreases in July when the surface temperature reaches 24–25°C (See Figure 2).

Our results shows that the reproductive period of Lake Eğirdir *A. boyeri* population is partially similar to other studied populations in Europe and Turkey. As a general pattern, it is seen that the reproductive periods of, mainly estuarine, populations from western Europe and Mediterranean Region extend to September, even October (Creech, 1992; Rosecchi and Crivelli, 1992; Fouda, 1994; Tomasini and Laugier, 2002). However, as with other studied fresh and estuarine water bodies of Turkey, reproductive period of Lake Eğirdir population on average begins (in March) and ends (in August) somewhat earlier. As compared to other studied Turkish water bodies, except for Lake İznik population (Gaygusuz, 2006), reproductive period of Lake Eğirdir somewhat ends later (around August, Table 3).

Weak relationship between gonad weight and fecundity in Lake Eğirdir *A. boyeri* population is resulted from interrupted development of eggs and using of mature eggs for calculation.

As *A. boyeri* reach sexual maturity lengths earlier in seas and lagoons (Table 3), habitat features like salinity and temperature are thought to be most effective on first maturity length.

The maximum GSI value was determined to be higher than that of other comparable populations except for Camargue Lagoon in southeastern France (13.3%) (Rosecchi and Crivelli, 1992). Reasons of such a bias are difficult to determine (Bartulović *et al*., 2006); but along with differences of ecological features like temperature and salinity, having no competition for food, population explosion of *A. boyeri* in Lake Eğirdir is thought to be nutrition related.

There is no dominant pelagic fish other than zooplanktivorous *A. boyeri* in Lake Eğirdir. The hunting pressure on the lake zooplankton results in disappearance of zooplankton from food web and accordingly abnormal development of the phytoplankton, which leads to loss of water quality and transparency in the lake. Furthermore, feeding habits of the *A. boyeri* from a broad spectrum may have further negative impacts on larvae and juveniles of other fish species in the lake. Potential of leading to

Table 1. Percentages of mature female *A. boyeri* population of Lake Eğirdir

Length (mm)	Immature	Mature	Total	% of mature fish
11-20	10	0	10	0
21-30	7	0	7	0
31-40	5	0	5	0
41-50	12	5	17	29.4
51-60	18	51	69	73.9
61-70	0	50	50	100
71-80	0	91	91	100
81-90	0	121	121	100
91-100	0	89	89	100
101-110	0	20	20	100

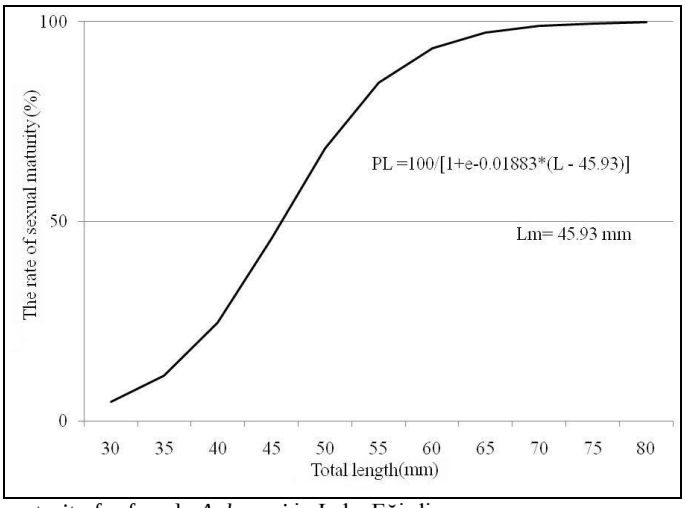

Figure 3. Ogive of first sexual maturity for female *A. boyeri* in Lake Eğirdir.

Table 2. The specimen numbers (n), mean total length (TL), mean weight (W), mean gonads weight (GW) and relative fecundity (F) *A.boyeri* samples captured prior to spawning (SE: Standart Error)

Age	n	TL ± SE	W ± SE	GW ± SE	F ± SE
I	12	70.91±1.27	2.43± 0.12	0.24± 0.01	84.5±4.07
II	42	84.63±0.84	4.06±0.11	0.39± 0.02	102.74±7.06
III	11	90.32±1.96	4.90±0.28	0.39±0.04	182.18±32.73
IV	5	89.11±3.79	4.64± 0.47	0.17± 0.03	79.4±21.59
Mean		83.5±0.99	3.96±0.12	0.35±0.02	110.4±7.71

Table 3. Reproductive periods and first mature length of *A.boyeri* in different habitats

Habitats	Months											First mature length (mm)	Authors
	F	M	A	M	J	J	A	S	O	N	D		
Guadalquivir River				x	x	x	x	x				-	Fernandez *et al*., 1988
Aberthaw Lagoon			x	x	x	x	x	x				-	Creech, 1992
Camarque Lagoon			x	x	x	x	x	x				-	Rosecchi and Crivelli, 1992
Suez Canal			x	x	x	x	x	x				27	Fouda, 1994
Mesolongi-Etolikon Lagoon			x	x	x	x	x					34	Leonardos and Sinis, 2000
Southern France Lagoon				x	x	x	x	x	x			38	Tomasini and Laugier, 2002
Mala Neretva River				x	x	x	x	x				52	Bartulović *et al*., 2004
Lake Küçükçekmece		x	x	x	x	x						-	Altun, 1986
Homa Lagoon		x	x	x	x	x						-	Sezen, 2005
Lake İznik			x	x	x	x						-	Özeren, 2004
Lake İznik			x	x	x	x	x					-	Gaygusuz, 2006
Lake İznik		x	x	x	x	x						-	Anonim, 2007
Lake Eğirdir		x	x	x	x	x	x					45.93	This study

various changes in the lake ecosystem due to its invasiveness resulting from extremely fast adaptation and rapid breeding capability of the species can be inferred from our results.

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