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AGE AND GROWTH OF *CAPOETA ERHANI* (ACTINOPTERYGII: CYPRINIFORMES: CYPRINIDAE) FROM THE MENZELET RESERVOIR, TURKEY

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Background. *Capoeta erhani* Turan, Kottelat et Ekmekçi, 2008 has an economic importance in commercial and recreational fisheries in Turkey. Knowledge of the biology of this species is very scarce. Despite the importance of this species, no research on the population dynamics such as age and growth rates has been conducted. The aim of this study was to determine the age, growth rate, and the relations between the fish size and the otolith size for *C. erhani* from the Menzelet Reservoir, Turkey.

Materials and methods. This study was carried out seasonally in the Menzelet Reservoir, between January and December 2012. Samples were collected using gill nets with mesh sizes ranging from 18 to 30 mm.

Results. A total of 134 otoliths obtained from *Capoeta erhani* that ranged from 15 to 33.8 cm TL were used in the analyses. The overall male : female ratio ($M : F = 1.25 : 1.00$) was biased in favour of males. The Mann–Whitney test revealed significant differences between sexes, regarding TL ($P < 0.05$). The calculated length–weight relations were $W = 0.0097TL^{3.0015}$ ($r^2 = 0.986$) for females, $W = 0.0054TL^{3.2011}$ ($r^2 = 0.975$) for males and $W = 0.0075TL^{3.0892}$ ($r^2 = 0.979$) for all specimens. The von Bertalanffy growth models were $L_\infty = 33.83$ cm (TL), $K = 0.964$, $t_0 = –0.573$ for females; $L_\infty = 32.02$ cm (TL), $K = 0.843$, $t_0 = –0.562$ for males; $L_\infty = 33.85$ cm (TL), $K = 0.821$, $t_0 = –0.482$ for all specimens.

Conclusion. This study provides the first information on age, growth, and otolith morphometric parameters of *Capoeta erhani*. Determining the parameters of *C. erhani* age and growth rates will lead to the estimates of relevant parameters of population dynamics and to better understanding of the long-term changes of the stock sizes.

Keywords: growth rate, sagittal otolith, otolith morphometrics

INTRODUCTION

Age information is the most important biological variable for estimating growth rates of fishes (Homauni et al. 2011). Determination of the age and growth parameters of fish populations is a very important issue for fisheries management. Fish age is usually estimated using the periodicity of the formation of increments in scales, otoliths, fin rays, and vertebrae (Campana 2001). Otoliths, however, are the structures that are the most preferred by fisheries scientists because of the precision of age estimates (Maceina and Sammons 2006, Čikeš Keč and Zorica 2013).

The genus *Capoeta* Valenciennes, 1842 is distributed in southern China, northern India, Turkmenistan, Lake Aral, the Middle East, and Anatolia. These fishes inhabit gravel and stony zones of fast flowing rivers (Türkmen et al. 2002), but some species may also be found in lakes and springs (Turan et al. 2008). In the inland waters of Turkey there are five species and six subspecies of the genus *Capoeta* (see Türkmen et al. 2002, Elp and Sen 2009). *Capoeta erhani* Turan, Kottelat et Ekmekçi, 2008 was described from the Ceyhan River, Turkey (Turan et al. 2008). This species has an economic importance in commercial and recreational fisheries for the local people around the

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Ceyhan River. The knowledge of the biology of this species is very scarce. Despite its importance, no study on the population dynamics such as age and growth rates has been conducted.

The aim of this study was to determine the age, growth rate, and the relations between the fish size and the otolith size for *Capoeta erhani* from the Menzelet Reservoir, in the Ceyhan River drainage.

MATERIAL AND METHODS

This study was carried out seasonally in the Menzelet Reservoir, located at 37°43′N, 36°51′E and 700 m altitude (above sea level) in the Ceyhan River at the eastern Mediterranean region of Turkey, between January and December 2012. Samples were collected using gill nets with mesh sizes ranging from 18 to 30 mm. Total length (TL) of specimens was measured to the nearest 0.1 mm and the fish were weighed to the nearest 0.01 g. Sex determination was performed by direct observation of gonads. The sex ratio (number of males to each female; $M : F$) of the samples was analysed. The Mann–Whitney test was applied to test the existence of significant differences between sexes according to total length. The relation between total length and total weight was calculated for each sex separately using a power function

$$W = a\mathrm{TL}^b$$

where: b is the regression coefficient and a is the regression constant.

Age and growth. Sagittal otoliths (left and right) were removed, cleaned of adhering tissue, dried, and stored in plastic vials. From each pair, one otolith was randomly selected and immersed in plastic vial with glycerine solution for 1 month. Counts of rings in each otolith were blind-read by two readers, who did not know the fish length or the date of capture. All otoliths were read twice and final age estimates achieved when the same results were obtained from the two readers. A light microscope with objective lenses with nominal magnifications ranging from 0.5 × to 5.6 × were used for the counts.

Otolith length (OL), width (OW), and radius (OR) were measured to the nearest 0.001 mm below using Q Capture Imaging Software. OL was defined as the longest axis between the anterior and posterior otolith edge and OW as a distance from the dorsal to the ventral edge. OR was measured as the longest axis between the nucleus and posterior edge. The results were separated according to sex and statistically tested with t-test. The relation between the somatic growth and the otolith growth was investigated by linear regression.

Age was determined by counting the number of increments from the nucleus to the outer edge of the otolith (Fig. 1). The von Bertalanffy growth function was used to fit the length at age data using non-linear least squares parameter estimation (von Bertalanffy 1938);

$$\mathrm{TL} = L_\infty [1 - e^{-K(t - t0)}]$$

where: TL is the fish length at age t (year), L_∞ the theoretical asymptotic length, K the growth rate coefficient, and t_0 the theoretical age when fish length is zero. Separate analyses were carried out for males, females and all specimens.

RESULTS

Length–weight relation. A total of 135 otoliths (75 males and 60 females) were processed for age counts, however, a single pair of sagittal otolith was unreadable. Thus, 134 otoliths obtained from *Capoeta erhani* that ranged from 15 to 33.8 cm TL were used in the analyses. Males were smaller than females, ranging from 15–32 cm and 15.2–33.8 cm TL, respectively (Fig. 2). The Mann–Whitney test revealed significant differences between sexes, regarding TL ($U = 1778$; $P < 0.05$). The overall male : female ratio ($M : F = 1.25 : 1.00$) was biased in favour of males.

The length–weight relations were calculated as, $W = 0.0097\mathrm{TL}^{3.0015}$ ($r^2 = 0.986$) for females, $W = 0.0054\mathrm{TL}^{3.2011}$ ($r^2 = 0.975$) for males, and $W = 0.0075\mathrm{TL}^{3.0892}$ ($r^2 = 0.979$) for all specimens. Our data suggested that *Capoeta erhani* showed positive allometric growth (Fig. 3).

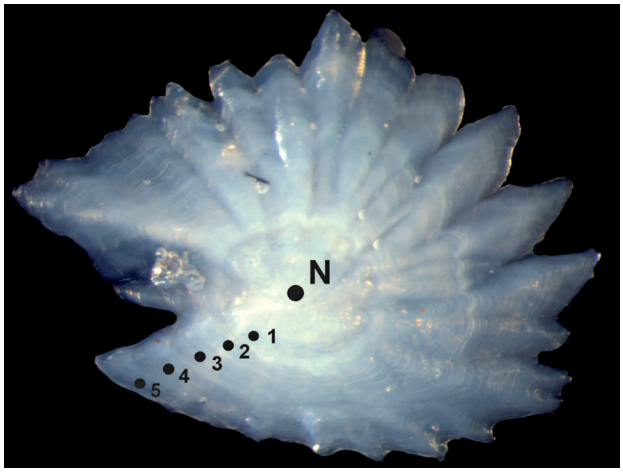

Fig. 1. Sagittal otolith of *Capoeta erhani* from the Menzelet Reservoir (TL = 32.5 cm, W = 326 g, age 5+, 15 August 2012), N = nucleus

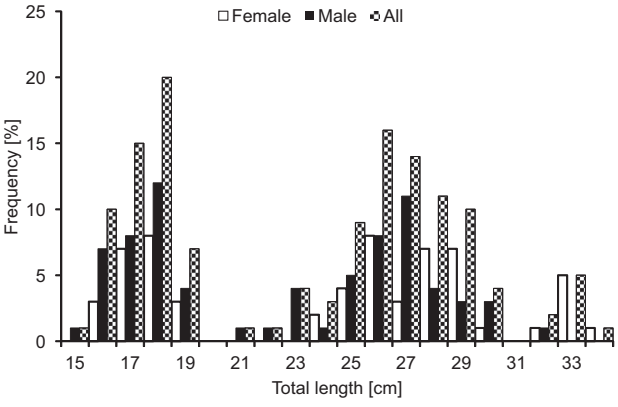

Fig. 2. Length–frequency distribution of males, females, and all specimens combined of *Capoeta erhani* collected in the Menzelet Reservoir from January through December 2012; Number of fish studied = 135

Age and growth. The total lengths of aged specimens ranged from 15 to 33.8 cm (Table 1). The age-classes in the otolith samples ranged from 0+ to 6+ years, while the samples were dominated by the 1+ and 3+ age-classes (36.6% and 32.8%, respectively). There were no difference between the age distributions of males and females, as the majority of females were 1+ (14.2%) and 3+ (13.4%) years old, while males were mostly the same 1+ (23.1%) and 3+ (19.4%) years old (Fig. 4). Otoliths of smaller individuals showed a regular growth pattern with clearly identifiable increments in the first six years and an increasing complexity afterwards (Fig. 4).

Sagittal otolith length, width, and radius were 2.31–4.59 mm, 1.90–3.59 mm, and 1.00–2.30 mm, respectively. The different otolith measurements (OL, OW, and OR) showed significant linear relations with the fish length (TL) (Table 2). The effect of sex on the otolith size (OL, OW, and OR) of *C. erhani* was not statistically significant ($P > 0.05$). The von Bertalanffy growth curves (Fig. 5) were fitted to the length at age data for both sexes separately. The estimated parameters of the equation were: L_∞ = 33.83 cm (TL), K = 0.964, t_0 = –0.573 for females; L_∞ = 32.02 cm (TL), K = 0.843, t_0 = –0.562 for males; L_∞ = 33.85 cm (TL), K = 0.821, t_0 = –0.482 for all specimens.

DISCUSSION

The largest *Capoeta erhani* reported in the literature as 28 cm standard length (SL), was caught in the Ceyhan River (Turan et al. 2008). In our study, the largest fish was 33.8 cm in total length and 412 g in total weight. The overall male : female ratio was found as 1.25 : 1.00 in favour of males. Maximum length of 32.0 cm TL for males and 33.8 cm TL for females were determined.

The exponent of the total length–weight relations showed that growth is positive allometric for males (b = 3.2011) and isometric for females (b = 3.0015). The b-values estimat-

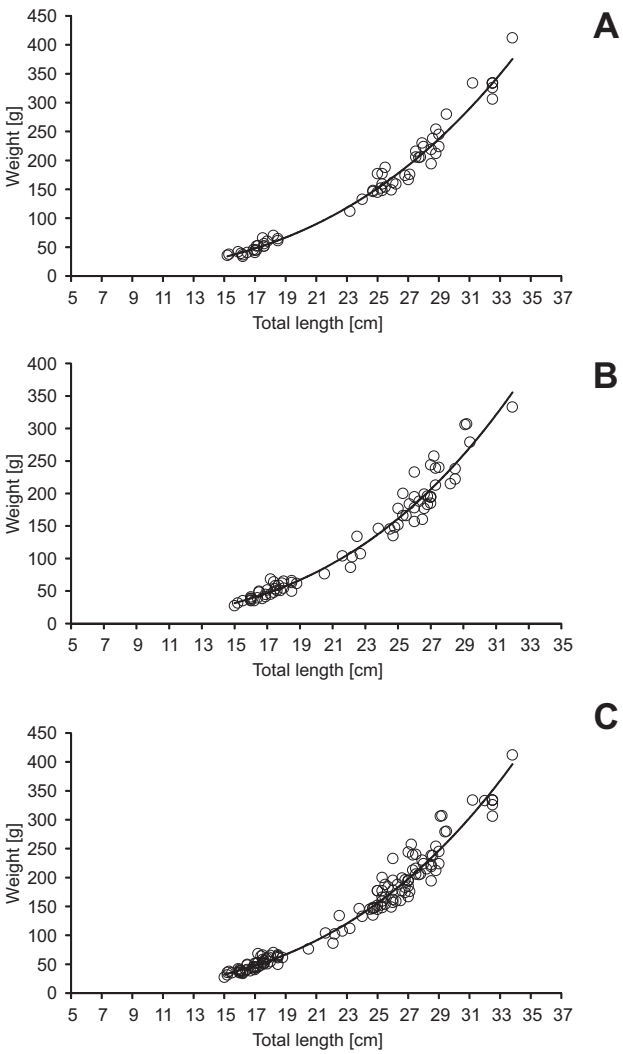

Fig. 3. Length-weight relations of *Capoeta erhani* from the Menzelet Reservoir; **A:** females, **B:** males, **C:** both sexes combined

Table 1

Age–length key for *Capoeta erhani* from the Menzelet Reservoir, Turkey

TL [cm]	Age class						
	0+	1+	2+	3+	4+	5+	6+
15–16.9	5	18					
17–19.9		29	1				
20–21.9		1	1				
22–23.9		1	4	1			
24–25.9			2	19			
26–27.9			4	19	6		
28–29.9				5	9	1	
30–31.9						1	
32–33.8						5	2
n	5	49	12	44	15	7	2
Mean TL	15.2	17.3	23.5	26.2	28.5	31.7	32.9
Mean *W*	33.5	51.6	131.5	184.4	237.0	328.2	372.5
Growth [%]		12.35	36.47	15.88	13.52	12.94	7.05

TL = total length, *W* = total weight, *n* = fish number.

ed from this study are closely similar from those found for *Capoeta capoeta* from Karasu Stream, Turkey (Elp and Sen 2009) and from Zernek Dam Lake (Sen et al. 2008), for *C. fusca* from eastern Iran (Patimar and Mohammadzadeh 2011), but were different from those found by Patimar and Farzi (2011) for *C. trutta* from western Iran, and for *C. umbla* from Lake Hazar, Turkey (Çoban et al. 2013). The variations in the exponents could be affected by ecological factors such as temperature, food supply, spawning conditions, and habitat characteristics within the year (Bagenal and Tesch 1978, Wootton 1992, İşmen 2005). Geographic locations and the different species belonging to the same genus can also possibly affect the value of "*b*".

The sagittal otoliths of the *Capoeta erhani* showed opaque and translucent bands, which could be used for age determination. These seasonal bands are generally associated with changes in water temperature. In the presently reported study, we determined that whole otoliths are suitable for age and growth studies for this species. In addition, this process was not time consuming.

In the presently reported study, one pair of the largest otoliths could not be read. The analysis of the other 134 otoliths revealed maximum age and length as 6+ years and 33.8 cm TL for females, and 6+ years and 32 cm TL for males, respectively. In the analysed samples, males were the dominant until the age 4+, but after then females were the dominant in the population (Fig. 4). In the wild populations the younger age-class is expected to be more abundant than the older ones (Čikeš Keč and Zorica 2013). However, in our study, the 2+ age class specimens were very low. It might be explained by the characteristics of the gill nets. Since no data of the *Capoeta erhani* age and growth rates were available for comparison with this study, data on the different species of the genus *Capoeta* were used. Maximum ages of *C. erhani* are lower than those reported for the *C. capoeta* from Zernek Dam Lake Van, Turkey (Sen et al. 2008), for the *C. trutta* from Karakaya Dam Lake (Kalkan 2008), and for the *C. umbla* from the Lake Hazar, Elazığ, Turkey (Çoban et al. 2013) and from the Aşkale region of the Karasu River, Turkey (Türkmen et al. 2002). Also, some of the other studies have been reported with the similar results of the maximum ages of *C. erhani,* for the *C. capoeta* from Karasu Stream, Turkey (Elp and Sen 2009) and for the *C. trutta* from the Meymeh River, western Iran (Patimar and Farzi 2011). The maximum age results of *Capoeta erhani* from this study differed from those of the other species of the *Capoeta* genus probably due to the different ageing methods (scales) or/and different species used.

Otolith size–fish size relations were significantly linear, demonstrating that otolith growth was proportional to the growth of fish for *Capoeta erhani* from the Menzelet Reservoir. This result showed that fish size could be estimated by using the otolith size. The similar results have been reported, for example, by Homauni et al. (2011) for clupeids and Amouei et al. (2013) for cyprinids.

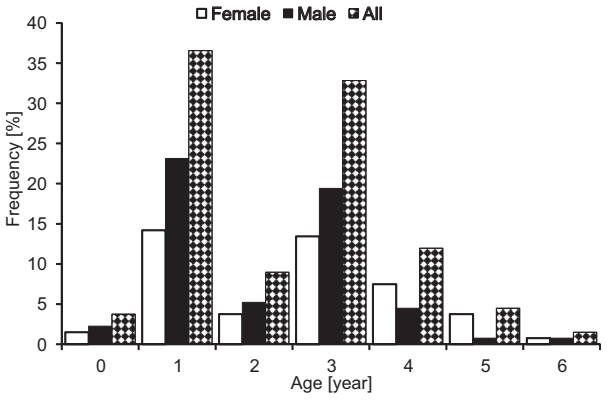

Fig. 4. Age structure of *Capoeta erhani* from the Menzelet Reservoir for males, females, and both sexes combined

Table 2

Parameters of the linear relation between the otolith measurements and the fish total length for *Capoeta erhani* from the Menzelet Reservoir, Turkey

Otolith–fish length relations	*n*	*a*	*b*	r^2	*P*
OL–TL	134	8.479	–5.326	0.914	<0.01
OW–TL	134	12.568	–9.437	0.926	<0.01
OR–TL	134	15.892	–3.118	0.944	<0.01

n = number of specimens, *a* = slope of the regression line, *b* = *y*-intercept, r^2 = coefficient of determination; TL = fish total length, OL = otolith length, OW = otolith width, OR = otolith radius.

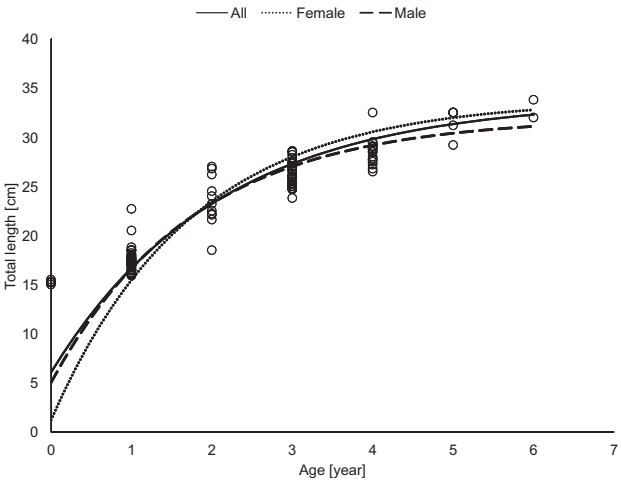

Fig. 5. The von Bertalanffy growth curves for *Capoeta erhani* from the Menzelet Reservoir for males, females, and both sexes combined

Table 3

Von Bertalanffy growth parameters for *Capoeta* species from different regions in Turkey

Species	Study area	Sex	Age	L_∞	K	t_0	Author
C. c. umbla	Karasu River	M	1–10	42.30	0.146	–0.98	Türkmen et al. 2002
		F	1–12	45.70	0.139	–0.83	
C. c. capoeta	Aras River	M	1–11	44.30	0.116	–1.21	Erdoğan unpublished*
		F	1–11	48.40	0.111	–0.79	
		M + F	1–11	47.50	0.112	–1.02	
C. c. angorae	Ceyhan River	M	1–7	47.25	0.133	–0.76	Alp et al. 2005
		F	1–10	62.25	0.101	–0.59	
C. erhani	Menzelet Reservoir	M	0–6	32.02	0.843	–0.57	Presently reported
		F	0–6	33.83	0.964	–0.56	study
		M + F	0–6	33.85	0.821	–0.48	

L_∞ = theoretical asymptotic length, K = growth rate coefficient, t_0 = theoretical age when fish length is zero.

The von Bertalanffy growth functions that were calculated for *Capoeta erhani* males and females in this study showed that the female theoretical maximal length value (L_∞ = 33.83 cm) was a little higher than the males (L_∞ = 32.02 cm). Generally, the growth coefficient (K) is considered a genetic feature of a species, while L_∞ is phenotypic and can be limited by environmental conditions (Čikeš Keč and Zorica 2013). Growth parameters for all analysed material given in this paper were compared with the results of the other authors for *Capoeta* genus in Turkey (Table 3). The values of growth constant (K) obtained in this study differed from those estimated from the other researches (Türkmen et al. 2002, Alp et al. 2005, Erdoğan unpublished*). Some species, most of them short-lived, have a high value of K (Sparre and Veneme 1998). In this study, K values were higher than the same values observed in literature, probably, due to obviously smaller maximum ages of fishes from the Menzelet Reservoir. The differences in the theoretical infinitive length value between regions can be attributed to the difference in the size of the largest individuals sampled in each area or the differences of species.

This study provides the first information on age, growth and otolith morphometric parameters of *Capoeta erhani* from Menzelet Reservoir, Turkey. Determining the parameters of *C. erhani* age and growth rates will lead to the estimates of relevant parameters of population dynamics and to better understanding of the long-term changes of the stock sizes in this reservoir. Further investigations are necessary to compare age and growth rates of *C. erhani* from different areas.

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