

Age and growth of the Mesopotamian barb, *Capoeta damascina*, in central Iran

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Abstract

Age and growth of Mesopotamian barb, *Capoeta damascina*, were studied in the Zayandehrud River, in central Iran, from March 2007 to April 2008. Among the 689 specimens studied, age groups in males ranged from 1⁺ to 9⁺ and that in females ranged from 1⁺ to 10⁺. The sex ratio (1M:1.6F) was not significantly different from 1:1 ratio. Maximum fork length and weight was 39 cm and 1,115 g for males and 54.2 cm and 2,340 g for females. In all age classes, females were larger than males. The most frequent age groups were 3⁺ in males and 4⁺ in females. The highest value for condition factor was observed in June. The growth of *C. damascina* was described by von Bertalanffy growth curve as $k=0.01$, $L_{\infty}=56.2$ cm, $t_0=-0.63$ for males and $k = 0.05$, $L_{\infty}=117.1$ cm and $t_0 = -0.43$ years for females. The length-weight relationship was described as $W=0.0169L^{2.95}$ ($r^2=0.98$) for males and as $W=0.0155L^{2.99}$ ($r^2=0.99$) for females, indicating an isometric growth pattern in both sexes. Growth performance index ϕ' was estimated as 5.73 for males and 6.53 for females, indicating a faster growth rate in females.

Keywords: Ageing, Age at maturity, Cyprinidae, Growth pattern, Von bertalanffy curve, Zayandehrud River.

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Introduction

The Mesopotamian barb, *Capoeta damascina*, is the most abundant species of native cyprinids in Iranian waters. It is known as siahmahi (black fish) and sardeh, in Iran, and is mainly caught for consumption and sport fishing. Despite its abundance in Iranian waters, there is some scattered information on its distribution, feeding and parasites (Mehdipoor *et al.*, 2004; Jalali *et al.*, 2007; Masoumian *et al.*, 2007; Keivany *et al.*, 2016). There are few publications on age and growth in this species (Asadollah and Soofiani, 2008). *Capoeta damascina* is also widely distributed in Lebanon, Israel, Syria, Turkey, and Iraq. Stoumboudi *et al.* (1993) and Fishelson *et al.* (1996) described a relatively full detail of the reproductive biology of similar species in Israeli waters. Nonetheless, little is known about *C. damascina* in Iranian waters, especially, in the Zayandehrud River. The present study is the first on basic biological characteristics such as age, growth and von Bertalanffy growth parameters of *C. damascina* in the Zayandehrud River. It should be noted that Alwan *et al.* (2016a,b) and Esmaeili *et al.* (2017) suggested that *C. damascina* is restricted to Domusscus and Iranain species are in fact *C. saadii*.

Materials and methods

This study was performed on specimens of *C. damascina* from the Zayandehrud River which is the largest river of the entire interior basins of Iran. This river flows eastward from the high central part of the Zagros Mountain, passing

through Isfahan plain, and terminating in Gavkhouni Wetland, a depression near the centre of the watershed. Sampling was carried out on the Zayandehrud River near Pirbakran town (32° 45' 43" E, 51° 54' 93" N) where the water temperature ranged from 2.5 to 19.5°C.

A total of 689 specimens of *C. damascina* were captured monthly from March 2007 to April 2008 using gillnets (10-80 mm mesh size). Fish samples were anesthetized and transported to the laboratory on ice for further analyses. Routine laboratory measurements, including standard (SL) and fork length (FL) to the nearest 0.1 cm and total body weight to the nearest 0.1g, were carried out. For each specimen, 10-15 scales were removed from above the lateral line below the anterior extent of the dorsal fin on the left side of the fish, washed in water and dried between two slides for microscopic studies (Lagler, 1956). Scales, mounted dry between glass slides, were used for age estimation. Upon examination of the type of relationships between SL and scale diameter, the Fraser-Lee model was used for back-calculating corresponding lengths attained in the previous years of life. This method is believed to describe accurately the linear body-scale relationship, which is given by Ricker (1975), Francis (1990), Holčík (1998) and Klumbs *et al.* (1999) as $SL_i = c + (SL - c) \times (S_i / S)$, where SL_i is the standard length of the fish when annulus i was formed, SL is the standard length at time of capture, S_i is

the distance from the scale focus to the annulus i , S is the total scale radius, and c is the intercept (correction term) on the length axis of the linear regression between SL and S .

The von Bertalanffy growth parameters were calculated using $L_t=L_\infty[1-e^{-K(t-t_0)}]$ for FL and $W_t=W_\infty[1-e^{-K(t-t_0)}]^b$ for weight, where L_t is the length of fish in cm at age t , L_∞ is asymptotic fish length in cm, e is the base of natural log (2.71828), t is the fish age (year), t_0 is the hypothetical time at which the length of the fish was zero, K is the rate at which the growth curve approaches the asymptote, W_t is the weight of the fish in g at age t , W_∞ is asymptotic weight of the fish in g and b is the constant in the length-weight relationship (Ricker, 1975; Sparre and Venema, 1992).

The growth pattern in both sexes was determined using the Pauly's model (Pauly, 1984):

$$t = \frac{\text{sd ln } L_f}{\text{sd ln } W_t} \times \frac{|b-3|}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

Where $\text{sd ln } L_f$ and $\text{sd ln } W_t$ are the standard deviation of the natural logarithm of the fork length and body weight, respectively; b is the slope, calculated from the length and weight relationship.

Growth performance index (phi-prime index) ϕ' was computed from the equation: $\phi' = \text{Ln}k + 2 * \text{Ln}L_\infty$ (Pauly and Munro, 1984). Condition coefficients were calculated for both sexes using the equation $K = (W/FL^3) * 100$ (Ricker, 1975).

For comparisons of two means, t-test,

and for multiple comparison of means, one-way ANOVA at 95% of confidence level was used. Statistical analyses were carried out in SPSS 18 and Excel 2010 computer software.

Results

Among the 689 specimens measured, maximum length-frequency for males and females was 20.1-25 cm and 25.1-30 cm, respectively. Fork length and weight of males ranged from 10.3 to 39 cm and from 19.3 to 690 g, respectively and that in females ranged from 10 to 48.8 cm and from 16.18 to 1935 g, respectively. However, the difference between mean FL in females and males for all year-classes was not significantly different ($p > 0.05$, t-test) (Table 1).

Length-weight relationships were calculated using the lengths and weights of 689 specimens as $W = 0.0169L^{2.9469}$ ($n=241$, $r^2=0.9769$) for males, $W = 0.0155L^{2.9867}$ ($n=379$, $r^2=0.9853$) for females and $W = 0.012L^{3.0596}$ ($n=689$, $r^2=0.9962$) for all fish. The length-weight curves for females and males are plotted in Fig.1.

The mean condition factor for males and females was not significantly different ($p > 0.05$, t-test: Fig. 2). In general, monthly condition coefficients exhibited a similar pattern in both sexes, showing a peak during the spawning season and somewhat lower values after the spawning period and during the winter.

Table 1: Mean fork length (FL, cm) and weight(W, g) for different age groups of *Capoeta damascina* males and females in Zayandehrud River.

Age group	Sex	N	FL± SE	W± SE	N	Back-calculated (FL±SE)	Back-calculated (W±SE)	P ^a	P ^b
+1	M	10	12.20±0.99	26.0±1.38		8.30±0.15	9.10±0.21	<i>p</i> >0.05	<i>p</i> <0.05
	F	21	11.90±0.27	26.30±1.77	292	8.10±0.11	8.90±0.13	<i>p</i> >0.05	<i>p</i> <0.05
+2	M	30	16.10±0.46	65.80±4.71		12.40±0.15	29.83±0.93	<i>p</i> >0.05	<i>p</i> <0.05
	F	26	14.90±0.78	58.60±4.71	273	13.18±0.12	39.50±0.97	<i>p</i> >0.05	<i>p</i> <0.05
+3	M	73	22.50±0.22	156.40±4.91		17.20±0.16	78.20±2.72	<i>p</i> >0.05	<i>p</i> >0.05
	F	69	22.40±0.37	171.30±7.44	258	18.25±0.12	103.40±2.42	<i>p</i> >0.05	<i>p</i> >0.05
+4	M	52	24.90±0.22	209.20±5.05		20.50±0.21	130.80±5.23	<i>p</i> >0.05	<i>p</i> >0.05
	F	119	27.20±0.29	304.70±10.19	207	23.33±0.13	213.20±4.84	<i>p</i> >0.05	<i>p</i> >0.05
+5	M	31	26.80±0.30	277.2±10.02		23.30±0.33	190.00±1.00	<i>p</i> >0.05	<i>p</i> >0.05
	F	71	30.50±0.31	433.10±12.38	96	27.47±0.19	340.90±7.99	<i>p</i> >0.05	<i>p</i> >0.05
+6	M	34	28.60±0.43	339.70±13.23		26.20±0.49	261.90±14.21	<i>p</i> >0.05	<i>p</i> >0.05
	F	38	33.60±0.35	557.30±25.53	38	31.84±0.311	528.20±17.12	<i>p</i> >0.05	<i>p</i> <0.05
7+	M	9	32.40±0.84	478.10±4.82		30.10±0.77	387.80±5.17	<i>p</i> >0.05	<i>p</i> >0.05
	F	20	37.10±0.54	796.6±36.46	15	36.56±0.47	788.40±14.58	<i>p</i> <0.05	<i>p</i> <0.05
+8	M	2	34.30±0.55	505.30±8.15		32.00±0.83	462.60±17.94	<i>p</i> <0.05	<i>p</i> >0.05
	F	14	39.90±1.05	1080.00±106.44	12	40.45±0.55	1066.10±19.00	<i>p</i> <0.05	<i>p</i> <0.05
+9	M	8	37.60±0.74	758.80±13.65		34.50±1.74	577.30±22.93	<i>p</i> >0.05	<i>p</i> >0.05
	F		44.50±0.43	1372.50±54.61	8	43.45±0.68	1319.30±26.08	<i>p</i> <0.05	<i>p</i> <0.05
+10	M								
	F	3	49.20±0.82	1792.90±110.39	3	46.11±1.11	1575.50±6.19	<i>p</i> >0.05	<i>p</i> >0.05

^aSignificant values of FL.^bSignificant values of W.

The mean fork length and total weight in different age classes in males, females and all fish are summarized in Table 1. In the early stages, males were longer than females, but in the later stages this was reversed. The differences between the individual lengths and weights of males and females of the same ages were statistically significant, except for age groups 1⁺, 3⁺ and 4⁺ for length and 1⁺ to 4⁺ for weight (Table 1). The von Bertalanffy growth equations and length-weight relationships were found as $L_t = 56.18 [1 - e^{-0.098(t+0.628)}]$ for males and as $L_t = 117.12 [1 - e^{-0.050(t+0.432)}]$ for females. Females grew to a greater asymptotic length and weight (L_∞ , W_∞) than the males. Growth performance

index was also estimated as $\phi' = 5.73$ for males and $\phi' = 6.53$ for females. The slope *b* in the length-weight equations, using Pauly's formula, indicated isometric growth in both sexes (*p*>0.05)

Discussion

Age determinations based on scale readings showed 10 age classes in the *C. damascina* population in the Zayandehrud River. The age of the population ranged from 1-9 in males and from 1-10 in females.

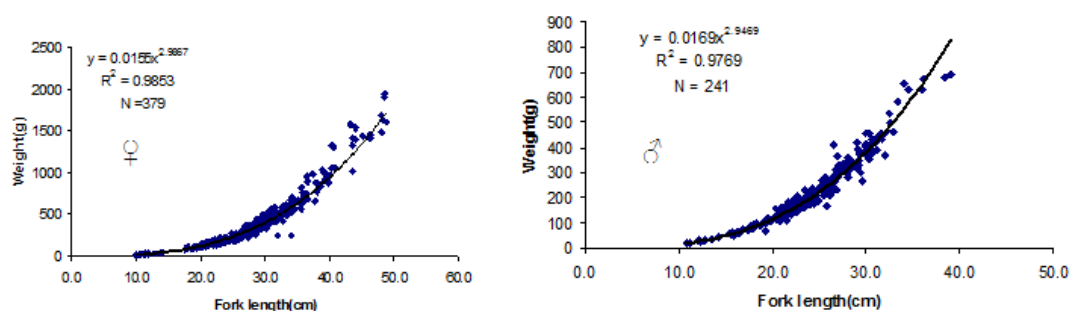


Figure 1: Length–weight relationships in females and males of *Capoeta damascina* from Zayandehrud River.

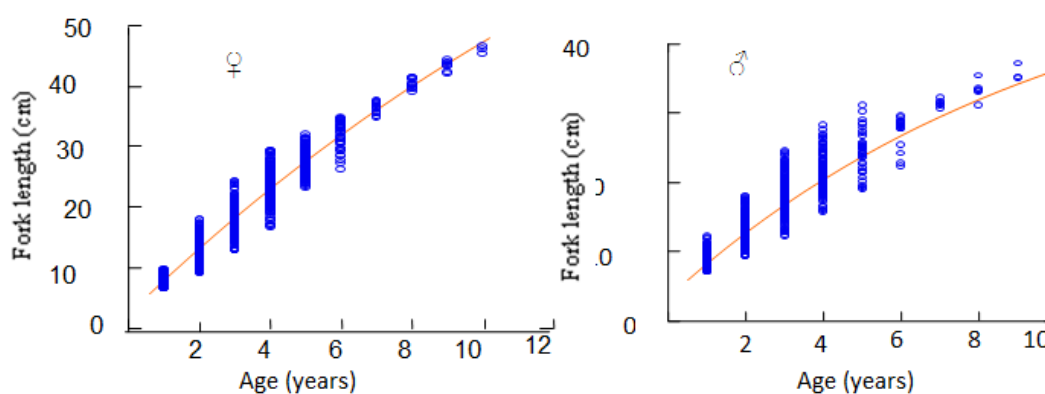


Figure 2: Age-length relationships in females and males of *Capoeta damascina* from Zayandehrud River.

The age structure of *C. damascina* specimens caught in the Zayandehrud River differed from that observed in Hanna Wetland which ranged from 1-6 years in males and from 1-7 in females (Soofiani and Asadollah, 2010). Fork length in males ranged from 10.3 to 39 cm and the population was dominated by males of 20.1-25 cm in length. The fork lengths of females ranged from 10 to 48.8 cm and the majority of the samples were composed of the 25.1-30 cm FL group. The results were virtually similar to the outcomes of the previous study by Soofiani and Asadollah (2010) where fork length values varied from 9.4 to 40 cm in males and from 10.2 to

44.2 cm in females. The maximum length was 39cm in males and 54.2 cm in females, and was in particular higher in females compared to the maximum length of this species in Hanna Wetland (40.0 cm in males and 44.2cm in females). Variations in maximum age and fish size can usually be explained by differences in food resource availability, individual growth rates, natural selection processes, and/or exploitation patterns (Patimar and Farzi, 2011).

Differing from one population to another of the same species (Table 2), males usually predominate in the younger group because they mature

earlier but live shorter (Nikolsky, 1963). Males were longer and heavier in the early stages than females, but in later stages this was reversed. This situation was similar to the one reported for *C. c. umbla* (Turkman *et al.*, 2002; Alp *et al.*, 2005). Variations in fish growth in terms of length and weight can be explained as an adaptive response to different ecological conditions such as temperature and the quantity and quality of food (Nikolsky, 1963; Wootton, 1992).

The maximum weight of males was 690 g and that of females was 1935 g. The maximum weight in Hanna Wetland was 1300 g in males and 1545 g in females (Soofiani and Asadollah, 2010). The observed differences in maximum weight and length of this species in these two localities can be explained by their different habitats, i.e., river and wetland, and use of different fishing gears. Fishing for this species in the Zayandehrud River occurs occasionally by locals and the largest captured fish was reported from behind the dam such as the Neko-Abad Dam. On the other hand, in Hanna Wetland, this fish is subject to illegal fishery.

The *b* values for *Capoeta* species are often 3.0 and generally between 2.5 and 3.5 (Table 2). The calculated values of the *b* parameter for other species of *Capoeta* range from 2.54 for *C. c. umbla* in Karakaya Dam (Girgin *et al.*, 1997) to 3.23 in Kalecik Lake (Şen, 1988) or from 2.83 to 3.05 for *C. c. Capoeta* in different habitats (Erdoğan, 1988; Abdoli *et al.*, 2008).

Even though the change in *b* values

depends primarily on the shape and fatness of the species, the *b* values in fish vary according to species, sex, age, stage of maturity, seasons and feeding. In addition, changes in fish shape, physiological conditions, and different amounts of available food, life span or growth increment can all affect the *b* growth exponent (Le Cren, 1951; Tesch, 1968; Ricker, 1975; Sparre, 1992). Length–weight relations are useful in determining weight and biomass when only length measurements are available, and allow comparisons of species growth rate between different habitats and/or regions (Koutrakis and Tsikliras, 2003). To the best of our knowledge, length–weight relations of *Capoeta damascina* inhabiting the Zayandehrud River were reported for the first time in this study. The growth of *C. damascina* in the Zayandehrud River is isometric (females: $b=2.987$, males: $b= 2.947$). As the fish grows, changes in weight are relatively greater than changes in length due to a cubic relationship between fish length and weight.

Our results are in accordance with the previous ones on this species, where the authors showed the length-weight relationships were $W = 0.0094L^{3.169}$ for males and $W=0.0143L^{3.048}$ for females. Comparing the results in Table 2 indicated that the *b* value of *C. damascina* in Hanna Wetland is higher than others. The variation in the exponents (*b*) may have resulted from differences in ecological factors and nutrition levels (Pauly, 1984).

Table 2: Some parameters of age, growth, length and weight relationships of *Capoeta* species from different regions in Turkey and Iran.

Species	Study area	Author	Sex	Age	b	L _∞ (cm)	K (year ⁻¹)	t ₀	φ'
<i>C. c. umbla</i>	River Karasu	Türkman <i>et al.</i> (2002)	M	1-10	2.94	42.3	0.146	-0.98	5.565
			F	1-12	2.99	45.7	0.139	-0.83	5.671
<i>C. c. umbla</i>	Kalecik	Şen (1988)	M	1-7	3.23				
<i>C. trutta</i>	Lake		All	1-8	2.99				
<i>C. c. umbla</i>	Şuğul Stram	Korkmaz and Atay (1999)	M	0-5	3.032	42.55	0.166	-0.562	5.709
			F	0-5	2.996	44.33	0.163	-0.536	5.769
<i>C. c. umbla</i>	Karakaya Dam	Girgin <i>et al.</i> (1997)	M	2-5	2.85				
			F	1-7	2.54				
<i>C. Capoeta</i>	Lake Nazik	Şen <i>et al.</i> (1999)	All	0-11	2.96	69.75	0.091	-0.357	6.093
<i>C. c. Capoeta</i>	Çildir lake	Canbolat <i>et al.</i> (1999)	All	1-9					
<i>C. c. Capoeta</i>	River Aras	Erdoğan (1988)	M	1-11	2.98	44.30	0.116	-1.21	5.428
			F	1-11	2.83	48.40	0.111	-0.79	5.561
			All	1-11	2.86	47.5	0.112	-1.02	5.532
<i>C. c. Sieboldi</i>	Sariyer Dam	Ekmekçi (1996)	M	1-7					
			F	2-8					
<i>C. c. angorae</i>	River Ceyhan	Alp <i>et al.</i> (2005)	M	1-7	2.81	47.25	0.133	-0.761	5.693
			F	1-10	2.68	62.25	0.101	-0.598	5.970
<i>C. trutta</i>	Karakaya Dam	Kalkan (2008)	M	0-7	2.93	76.40	0.057	-2.651	
			F	1-7	3.03	89.50	0.0604	-2.4138	
<i>C. damascina</i>	Hana Dam	Asadollah and Soofiani (2008)	M	1 ⁺ -6 ⁺	3.23	52.39	0.177	-0.299	6.460
			F	1 ⁺ -6 ⁺	3.17	64.91	0.151	-0.447	6.190
<i>C. c. Capoeta</i>	Gorganrud River	Abdoli <i>et al.</i> (2008)	M	0-3	3.05	19.00	0.462	-1.000	
			F	0-3	3.05	23.00	0.472	-0.740	
<i>C. damascina</i>	Zayandehr ud River	Present study	M	1 ⁺ -9	2.95	56.18	0.098	-0.628	5.730
			F	1 ⁺ -11 ⁺	2.99	117.12	0.05	-0.432	6.530

Since b value indicates fatness of fish, the values obtained for *C. damascina* in this habitat is a good condition in terms of feeding and other factors. It can also be a sign of adaptation of this species to the new environment of this man-made artificial wetland.

The sex ratio of *C. damascina* collected in this study was not significantly different from the equal sex ratio. In contrast, the sex ratio of this species in Hanna Wetland was in favour of females (1M:2.2F). This might be due to differential fishing time, place and facilities, migration of matured fish and differential behaviour of sexes (Dopeikar *et al.*, 2015; Siami *et al.*, 2017), differential growth of sexes and

environmental conditions.

Growth performance index was higher in females and it is congruent with the findings of Soofiani and Asadollah (2008), indicating a faster growth rate in females. The slope b in the length-weight equations, using Pauly's formula, indicated an isometric growth in both sexes. These values were higher than those of the other species like *Capoeta capoeta* (Alp *et al.*, 2005). He reported the φ' values from 5.43 to 6.09 for different populations of *C. Capoeta*. Higher values of φ' confirm that fish were in good physiological conditions, in particular for *C. damascina* in Hanna Wetland.

The fish spawns during May and June

(Khalaf, 1987; Fishelson *et al.*, 1996; Soofiani and Asadollah, 2008; Asadollah *et al.*, 2011; Siami *et al.*, 2017). In general, monthly condition coefficients exhibited a similar pattern in both sexes, showing a peak during the spawning season and somewhat lower values after the spawning period and during the winter. Significant statistical differences in condition factors between sexes were not found ($p > 0.05$, t-test: Fig. 2).

The value of L_{∞} for females was higher than that of males which is congruent with findings of Soofiani and Asadollah (2008) and Siami *et al.* (2017). The reason may be that females grow faster than males, and live longer (Weatherley, 1972; Kiani *et al.*, 2016). The theoretical maximal length values (L_{∞}) were close to the size of the largest fish examined and the growth coefficient values indicated a relatively low attainment of maximal size and differed from those obtained by Soofiani and Asadollah (2010). The differences in growth between regions can be attributed to the difference in size of the largest individual sampled in each area and to the differences between species. On the other hand, it is also possible that the variations in population parameters of the species of *Capoeta* represent epigenetic responses (Bruton, 1990) to different conditions (temperature and food) prevailing in different areas. According to reports from local fishermen in the Zayandehrud River, females reach 18000 g and males 2200 g which confirms the calculated W_{∞} (23337 g for females and 2420 g for males). A possible reason for this difference is the lower maturity age in males (2 years)

compared to females (7 years) (Asadollah *et al.*, 2011).

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