

Age and growth of king nase, *Condrostoma regium* (Cyprinidae), from Bibi-Sayyedon River of Semirom, Isfahan, Iran

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Introduction

Age determination is an important step in fisheries management (Polat *et al.*, 1999). The cyprinid fish *Chondrostoma regium* (Heckel, 1843) is widely distributed in Tigris-Euphrates basin and the Mediterranean basins of southeastern Turkey and the northern Levant (Suiçmez *et al.*, 2011). In Iran, it is found in Karun and Karkheh Rivers, the Hoor-al-Azim Marsh and also in Zayandehrud River and Bushehr basin (Ghorbani Chafi, 2000; Keivany *et al.*, 2015a). This species is not found in other basins of Iran (Esmaili *et al.*, 2014a). However, there is little information about its habitat requirements. Length-Weight relationship and condition factor of *C. regium* in Euphrates was investigated by Özedmir (1982), age determination

by Sen (1993) and Polat and Gumus (1995) in the Bafra Altinkaya Reservoir in Turkey using vertebrae, otoliths, scales, opercle and subopercle. Oymak (2000) examined growth characteristics of this species in Ataturk Reservoir on the Turkish Euphrates River. Age, growth and reproduction properties of this species living in Sır Reservoir were reported by Kara and Solak (2004). Ünlu (2006) reported that this species prefers stone grounds and still waters in rivers and lakes in Turkey. It is a benthopelagic species inhabiting both lentic and lotic environments (Suiçmez *et al.*, 2011). This species is omnivorous taking insect larvae and eggs and fry of other fishes. However, Gumus *et al.* (2002) in Suat Ugurlu Reservoir, Turkey, found that *Navicula*, *Cymbella* and *Synedra* were the most

frequent consumed organisms. This species feeds often on *Bacillariophyta* in this reservoir, but also on *Chlorophyta*, *Cyanophyta*, *Xanthophyta*, *Euglenophyta* and *Rotifera* (Gumus *et al.*, 2002). Diet varied with seasonal availability of food items. The aim of the present study was to investigate the length-weight relationship and age and growth of *C. regium* population in Bibi-Sayyedana River of Semirom, Isfahan as a tributary of Tigris basin in Iran.

Materials and methods

Fish samples were collected monthly from Bibi-Sayyedana River of Semirom County, at 51°24'00"E and 31°10'48"N in Isfahan Province, Iran, from 2010 to 2011. A total of 471 specimens were sampled. The sampling was performed using seine (15 m long, 2 m wide and 1 cm mesh size) and gill-nets of various mesh sizes (2-3 cm). After being caught, fish samples were transported to the laboratory and their total length (L) and weight (W) were measured to the nearest 0.001 cm and 0.01 g, respectively. The length-weight relationship was calculated by $W = aL^b$ where W is weight of fish (g), L is total length (cm), *a* Intercept and *b* the slope of regression line. Pauly (1984) equation was used to determine the growth pattern:

$$T = (sdLnLT / sdLnW) \times (lb - 31 / \sqrt{1 - r^2}) \times \sqrt{n - 2}$$

where sdLnLT is standard deviation of log length of fish, sdLnW is standard

deviation of log weight, *b*, is slope of LWR and r^2 is regression coefficient.

Some 11–15 scales from left side of body between lateral line and dorsal fin were removed and read under a binocular microscope for age determination by three persons to verify the correctness of readings. Also, some otoliths were removed from left side of fish and studied under a binocular microscope after cutting them. The Von Bertalanffy (1938) growth equation was used to determine age-length relationship as:

$L_t = L_\infty [1 - e^{-k(t-t_0)}]$ where L_t is total length at age *t*; L_∞ is asymptotic length (cm), *k* is body growth coefficient (year^{-1}) and t_0 is theoretical age at zero length (year^{-1}). The growth performance index was used to compare growth of fish (Pauly and Munro, 1984):

$$\Phi' = \log k + 2 \log L_\infty$$

Sex was determined by visual and microscopic examination of gonads. For sex ratio calculation, the Chi square test was used. To compare mean length, weight and age of different months, Analysis of variance followed by Duncan test was used at 95% confidence level by SPSS 19 software.

Results and discussion

Total length of males and females was between 6.1–18.1 (11.29 ± 0.19 ; mean \pm SD) cm, and 5.5–21.5 (12.30 ± 0.27) cm, respectively. The majority of specimens were in 18.1 and 21.5 cm length groups. The weight ranged between 1.87–64.93 (17.52 ± 0.87) g for males and between 1.43–90.53 ($20.91 \pm$

21.18) g for females. The LWR was $W = 0.007 L^{3.088}$ for males, $W = 0.007 L^{3.086}$ ($r^2 =$ for females and $W = 0.007 L^{3.079}$ ($r^2 = 0.98$) for all specimens (Fig. 1). Correlation coefficient value (b) was very close in males and females and more than 3 indicating a positive allometric growth pattern in all specimens ($p < 0.05$). The smaller size of the males may be due to the halting of growth at maturity and higher male mortality rates. Length and weight ranges of *C. regium* in Euphrates River was reported as 11.5-29.2 cm and 17-283 g (Sevik, 1997), in Ataturk Reservoir as 13.0-30.5 cm and 23-385 g (Oymak, 2000), in Karakaya Reservoir as 20.4-31.8 cm and 109-314 g (Kalkan and Erdemli, 2003), in Savur Stream as 2.8-29.0 cm and 11-296 g (Ünlü, 2006), in Seyhan River as 14.64-21.00 cm, 36.93-97.68 g and 16.00-23.55 and 48.74-131.20 g (Ergüden *et al.*, 2010). As it appears, the Bibi-Sayyedani River population reaches a smaller size relative to river. Differences in the length and weight compositions could be due to many factors, including habitat, ecological properties of the study areas, season, the numeral and size of samples, sampling time and method, types of length measured, degree of stomach fullness, sex, gonad maturity, well-being, conservation techniques and differences in observed length ranges (Suiçmez *et al.*, 2011; Tabatabaei *et al.*, 2014), and environmental conditions such as temperature and photoperiod and intraspecific difference with other

individuals in different geographic regions (Keivany and Soofiani, 2004; Keivany *et al.*, 2015b). The value of b can be variable between 2.5 and 4 and as a result of changes in fish shape, season, age, food availability, feeding, geographical location and growth (Özcan, 1987). Also, it is likely that in Bibi-Sayyedani River, dietary behavior and competition for food increase the b value (Suiçmez *et al.*, 2011; Esmaili *et al.*, 2014b).

The age and sex of 471 specimens were determined during a whole year. The coincident age determinations of the two methods was used. Age ranged between 1⁺-4⁺ years in males and 1⁺-5⁺ years in females. Undetermined specimens belonged to 0⁺ age group. The 3⁺ year class was dominant in both males and females (Table 1). Age ranges for this species from different habitats in Turkey were determined as 1⁺-8⁺ years in Euphrates (Oymak, 2000), 2⁺-5⁺ years in Karakaya Reservoir (Kalkan and Erdemli, 2003), 1⁺-5⁺ years in Sir Reservoir (Kara and Solak, 2004), 2⁺-5⁺ years in Koban River (Sen, 1993), 1⁺-4⁺ years in Seyhan Reservoir (Ergüden, 2010), and 1⁺-6⁺ years for females and 1⁺-5⁺ years for males in the Almus Reservoir (Suiçmez *et al.*, 2011). The slight differences in the age distribution may be due to differences in habitat, nutrients, genetic, populations, fishing tools, mesh size and error in age determination (Kara and Solak, 2004; Ghanbarzadeh *et al.*, 2014).

Some 320 specimens (68%) were females, 138 (29%) males, and 13 (3%) were undetermined sexes (Fig. 1).

The overall sex ratio M:F was 1:2.3, which is significantly different from 1:1 ratio ($p < 0.05$). Females were dominant in all age groups (Table 1) and all months. Sex ratio in *C. regium* in other regions is summarized in Table 1. Males had a short lifetime and earlier sex maturation, this difference could increase the ratio of females to males. Another reason could be the easier catch of one sex relative to another. Also, when food is abundance in the ecosystem, females outnumber the males and vice versa. Effect of temperature, selective mortality through sexual variable fishing, different behavior between the sexes, stopping of one sex in spawning zone and seasonal patterns of spawning migration are among the factors affecting the sex ratio in different geographical areas. Also, the differences in sex ratio may be due

to fishing tools, predation season and time-location dispersal. This index may differ from one species to another, one population to another and can vary from year to year within the same population. Other instances include variation in spatial distribution, different response to the given net color or differences in their feeding behavior (Nikolsky, 1963).

The Von Bertalanffy growth equation for length at age relationship in males and females was estimated as $L_t = 18.97 [1 - e^{-0.279(t + 0.580)}]$ and $L_t = 23.85 [1 - e^{-0.196(t + 0.535)}]$ and for weight at age relationships as $W_t = 61.9113 [1 - e^{-0.279(t + 0.580)}]^{3.088}$ and $W_t = 124.7462 [1 - e^{-0.196(t + 0.535)}]^{3.086}$, respectively (Fig. 2, Table 2).

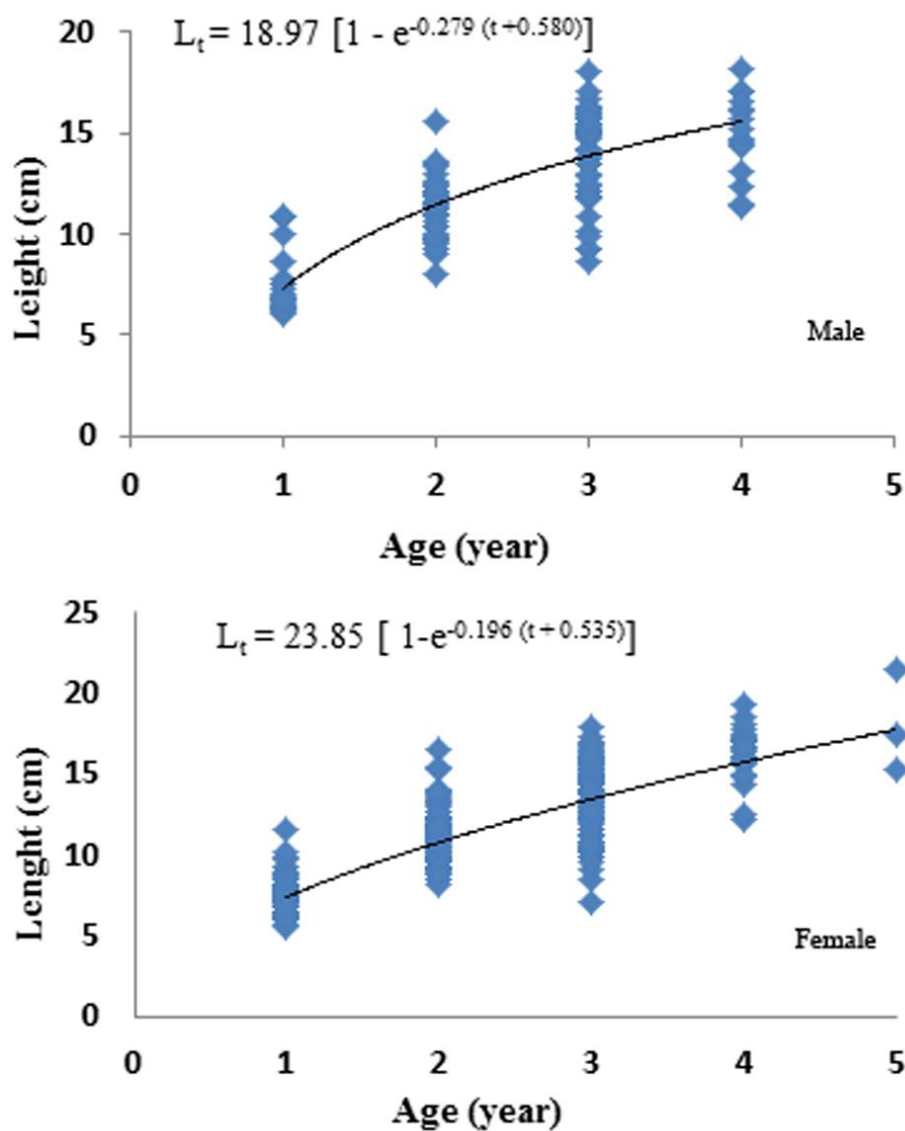


Figure 1: Age–Length relationships of males (Top) and females (Bottom) of *Chondrostoma regium* in the Bibi–Sayyedana River.

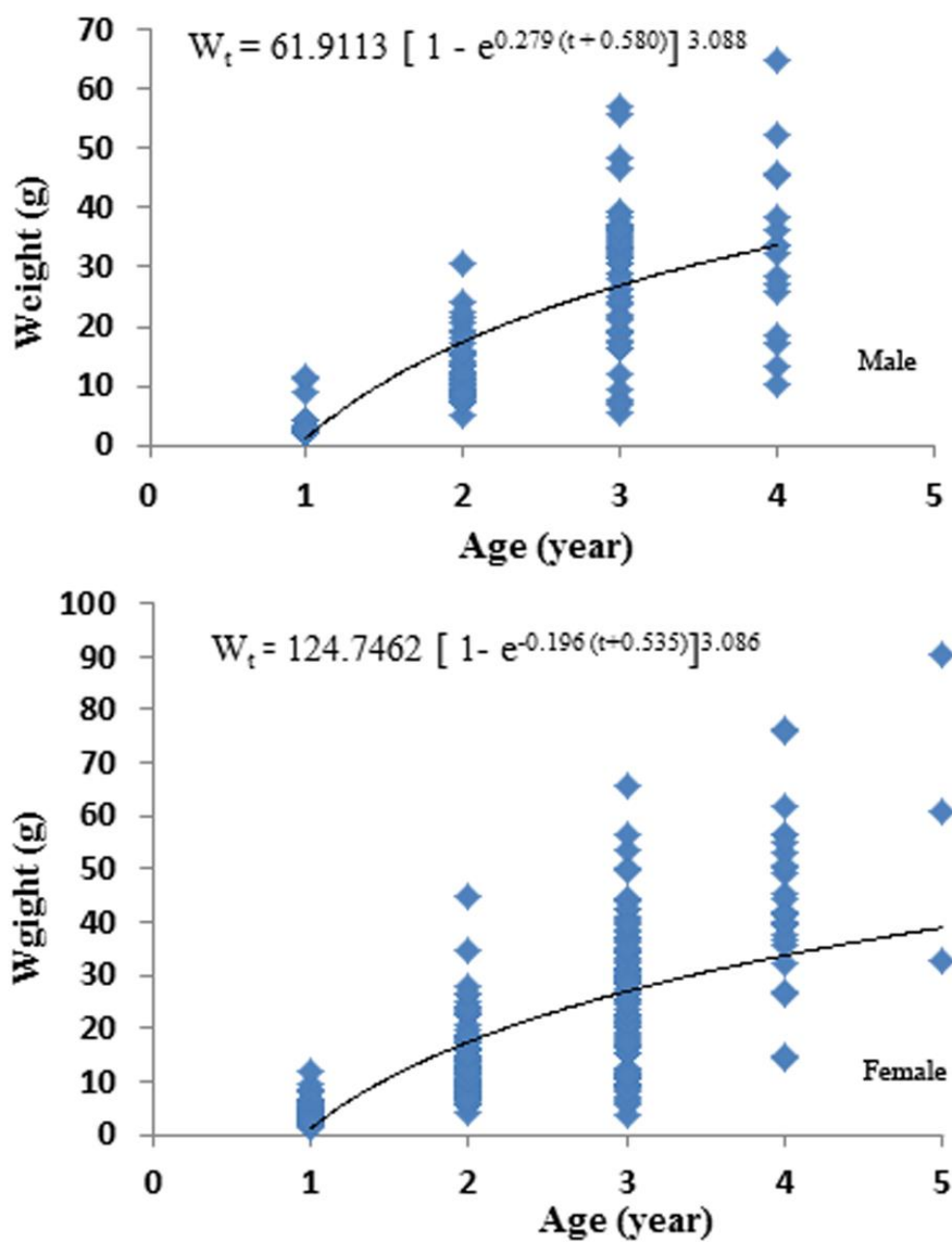


Figure 2: Age–Weight relationships in males (Top) and female (Bottom) of *Chondrostoma regium* in the Bibi-Sayyedani River.

Table 1: Age and sex composition of *Chondrostoma regium* population from Bibi-Sayyedani River.

Age	Male		Female		Sex ratio M:F	Undetermined sexes		All specimens	
	n	%	n	%		n	%	n	%
1 ⁺	22	4.7	90	19.1	1:4.1	10	2.2	122	26.0
2 ⁺	40	8.5	96	20.4	1:2.4	3	0.6	139	29.5
3 ⁺	60	12.7	105	22.3	1:1.7	-	-	165	35.0
4 ⁺	16	3.4	26	5.5	1:2.4	-	-	42	9.0
5 ⁺	-	-	3	0.6	-	-	-	3	0.5
Total	138	29.3	320	67.9	1:2.3	13	2.8	471	100.0

Table 2: The Von Bertalanffy growth parameters and growth performance index values of *Chondrostoma regium* reported from different studies.

Studies	Sex	n	L _∞ (cm)	t ₀ (year)	K (year ⁻¹)	Φ'
Ünlü (1990)	F	188	28.35	-3.30	0.430	2.53
(Savur Stream)	M	101	23.76	-3.08	0.670	2.57
Oymak (2000)	F	422	38.67	-3.07	0.136	2.30
(Attaturk Reservoir)	M	303	35.01	-2.75	0.168	2.31
Kara and Solak (2004)	F	252	31.89	-3.44	0.178	2.55
(Sir Reservoir)	M	209	38.13	-4.03	0.117	2.23
Ergüden (2010)	F	89	29.83	-1.98	0.262	2.36
(Seyhan Reservoir)	M	75	26.85	-1.63	0.255	2.26
Suiçmez <i>et al.</i> (2011)	F	194	33.50	-2.36	0.219	2.39
(Almus Reservoir)	M	128	27.50	-1.45	0.397	2.47
Present study	M	103	18.97	-0.580	0.279	2.35
	F	192	23.87	-0.535	0.196	2.23

n: number of specimens, L_∞: asymptotic length, K: Growth rate, t₀: Hypothetical age at zero length, Φ': Growth performance index.

Based on the growth performance index (Φ'), males showed a higher (2.35) growth rate than females (2.23). Length and weight differences between males and females for ages 1⁺ and 2⁺ years were not significant ($p>0.05$). There is little data on age and growth parameters and growth performance index of this species in the literatures (Özdemir, 1982; Froese and Pauly, 2016). The growth rate for males was higher than females in the early life, but in later phases, this rate declined in males and increased in females. Asymptotic length and weight estimated for females ($L_{\infty} = 23.87$ cm and $W_{\infty} = 124.75$ g) was higher than for males ($L_{\infty} = 18.97$ cm and $W_{\infty} = 61.91$ g) and the growth coefficient for females ($k = 0.20$) was less than that of males ($k = 0.28$). This could be related to the faster growth and longer lifespan of females (Ricker, 1975). The Φ' values of present study are not significantly different from other studies (Table 2) ($p>0.05$).

Growth differences in Ergüden *et al.* (2010) are probably due to animate environmental conditions, fishing period and lentic systems. Population of *C. regium* in Bibi-Seyyedani River grow relatively slower than other areas. Fish in standing waters, grow better than flooding streams because of more abundant food, higher temperatures and less activity requirements in standing waters (Noltie, 1988; Keivany *et al.*, 2015c).

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