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# Age, growth and reproduction of *Chondrostoma regium* (Heckel, 1843) from the Zayandeh Roud River, Iran

**Mahboobi Soofiani N.; Pooramini M.; Asadollah Nasrabadi S.; Ahmadi S.; Hatami R.** *

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**Abstract**

Age, growth and reproduction were investigated for *Chondrostoma regium*, collected monthly (November 2007- August 2008) from the Dimeh Spring region, Zayandeh Roud River, Iran. The maximum age of collected female and male fish were estimated based on scale increments as five and four years respectively. Von Bertalanffy growth equations were calculated as $L_t = 246[1 - e^{-0.206(t-0.034)}]$, $W_t = 163.29[1 - e^{-0.206(t-0.034)}]^{2.77}$ for females and $L_t = 253.1[1 - e^{-0.206(t-0.175)}]$, $W_t = 188.25[1 - e^{-0.206(t-0.175)}]^{2.99}$ for males. Size ranges of the male and female specimens were almost similar. The fork length range for females was 10.5-18.0 cm and 10.7-19.7 cm for males; and the weight range was 15.7-85.4 g in females, and 14.5-88.5 g in males. The female-male ratio was 1.8:1 ($p$<0.05), and for both sexes gonadal development and sexual maturity occurred in the second year of their life. Length-weight relationships revealed isometric growth pattern for males and a negative allometric growth for females. Monthly data of Gonadosomatic Index, and ovary condition suggested that spawning occurred during May and June. The mean absolute and relative fecundity was calculated as 2429±1512 (eggs/female) and 78.1±18.7 (egg/g), respectively, and fecundity was significantly correlated with both body weight ($r^2$=0.90) and fork length and ($r^2$=0.84).

**Keywords:** Reproduction, *Chondrostoma regium*, Fecundity, Length-weight relationships, Age, Growth

Department of Natural Resources, Isfahan University of Technology, Isfahan 84156-83111, Iran
*Corresponding author email: rezvan.hatami_iut@yahoo.com

## Introduction

Zayandeh Roud River is located in the central region of Iran, originating from high altitudes of Zagrus Mountains. *C.regium* (Heckel, 1843) with local name of "Nazak" (Abdoli, 2000), is economically important in some countries, but not in Iran (Najafpour, 1997; Kara and Solak, 2004;). This species is relatively widespread in Iran, with populations occurring in the Tigris basin and Kor River (Coad, 1995), Marun River (Abdoli, 2000), Bazoft and Kuhrang basin (Ghorbani Chafi, 2000). They are reported to be omnivorous and their diet may vary with season (Gümüs *et al*., 2002). *C. regium* mature at the age of three years and spawn in freshwater (Coad, 1995; Najafpour, 1997; Abdoli, 2000; Ghorbani Chafi, 2000).

Biological characteristics of similar species have been previously reported. The reproduction, GSI peak, spawning period and population structure have been reported from Syria (Beckman, 1962), Pakistanian (Aydin *et al*., 2004) and Turkish waters (Polat and Gümüs, 1995; Sevick, 1997; Oymak, 2000; Kara and Solak, 2004;). Nonetheless, there is still a lack of basic knowledge about this species in many areas, especially from Iran, where little information is available for age, growth and reproduction. This information is critical for understanding the life history, morphological and geographical variability among populations from different locations (Petrakis and Stergiou, 1995).

This study investigated the age structure, growth and some reproductive criteria needed for *C.regium* stock management, conservation strategies and more broadly, river management.

## Materials and methods

Sampling was carried out from November 2007 to August 2008 at the Dimeh Spring region, which is a key tributary of the Zayandeh Roud River (32°, 30′, 47″ latitude and 50°, 12′, 45″ longitude) (Fig. 1).

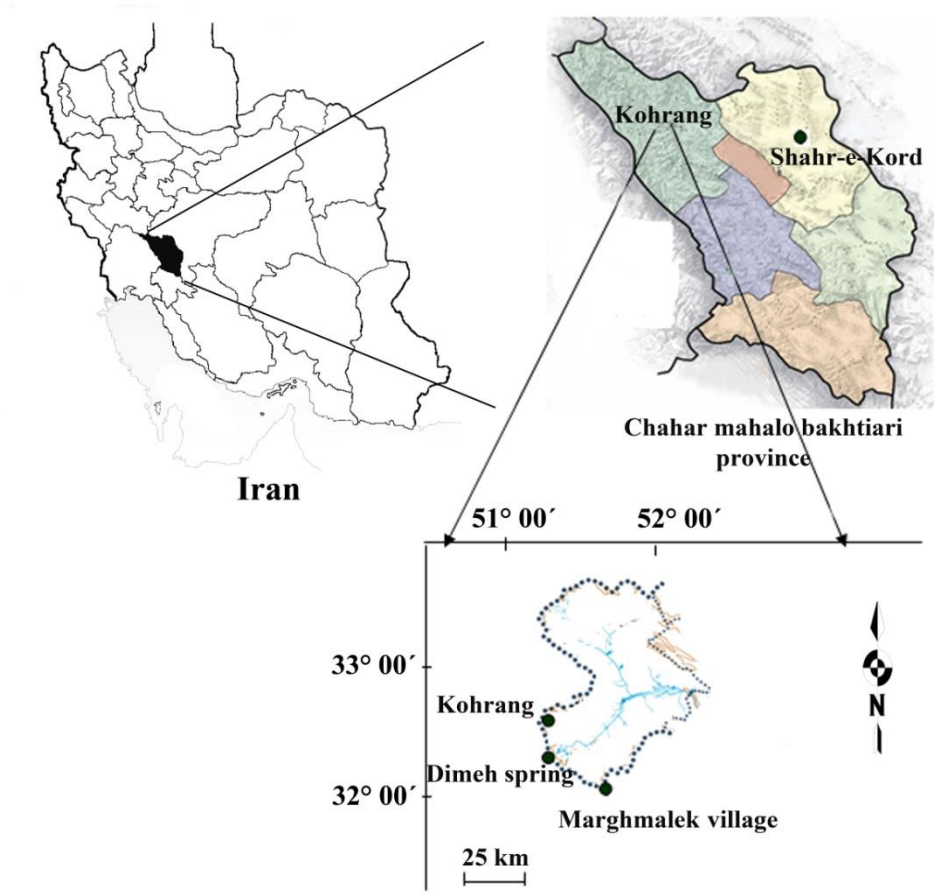


**Figure 1: Location of study area.**

A total of 221 specimens of *C.regium* were captured using a cast net (5m diameter and 1cm rectangular side mesh) and an electric shocker. Captured specimens were transported alive to the fisheries laboratory of the Isfahan University of Technology. The fork length (FL) was measured to the nearest 0.1cm and total body weight to the nearest 0.1g. Gonads were removed and weighed on a digital scale to the nearest 0.01g after removal of surface moisture. Sex of each specimen was determined by visual inspection. The gonado-somatic index (GSI) was calculated for both sexes, using the equation $GSI = (W_g / W_t) \times 100$, where $W_g$ is gonad weight and $W_t$ is total body weight in grams. Absolute fecundity ($F_a$), the number of ripe eggs ( in ovary at stage 4/5) produced by a female in one spawning season, was calculated by taking 3 sub samples (each weighing 0.1g) from anterior, middle and posterior sections of the gonad and counting the eggs. After calculating the mean number of eggs per sub sample it was then multiplied by total weight of ovary. Relative fecundity ($F_r$) was calculated using the formula $F_r = F_a / W_t$, where $F_a$ is absolute fecundity and $W_t$ is total body weight (g). The length-weight relationship was calculated using logarithmic transformed data of FL and W and is expressed by the equation: $W=aL^b$; where, W is the weight (g), L is length (cm), a is the intercept (constant) and b is the

regression coefficient (slope) of the generalized linear model (Ricker, 1973). A log-log plot of data was made for length-weight relationship (LWR), outliers were identified and removed and the regressions were redone (Froese, 2006). Growth in both sexes was determined using Pauly's model (Pauly, 1984).

$$t = \frac{sdLnFL}{sdLnW} \times \frac{|b-3|}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

Where sd ln FL and 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-weight relationship. The condition factor (*K*) of each sex was assessed using the following equation (Froese, 2006):

$$K = 100\ W / L^3$$

Where W is total weight (g) and L is fork length (cm). Age of fish was determined from the increments on scales (for each specimen, 10-15 scales) taken from the region above the lateral line below the anterior extent of the dorsal fin on the left side of the fish (Lagler, 1956). Two readers independently measured the increments on each scale, and only congruent measurements were accepted.

The relationship between fork length (FL) and scale diameter was back-calculated using the widely used Fraser–Lee formula (Ricker 1979 and Francis 1990): $FL_t = c + (FL_c - c) \times (Si/S)$, where $FL_t$ is the fork length of the fish when annulus i was formed, $FL_c$ is the fork length at time of capture, Si is the distance from the scale focus to the annulus i, S is the total scale radius, and *c* is the intercept on the length axis of the linear regression between FL and *S*.

The von Bertalanffy growth parameters were calculated according to: $L_t = L_\infty[1-e^{-K(t-t_0)}]$ 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, $L_\infty$ represents asymptotic fish length in cm, e is the base of natural log (2.71), t is the fish age (year), $t_0$ is the hypothetical age at which the length of the fish was zero, K is the relative growth coefficient, the rate at which the growth curve approaches the asymptote, $W_t$ is the weight of the fish in g at age t, $W_\infty$ is asymptotic weight of the fish in g and b is the slope of the length-weight relationship (Ricker, 1975). Back-calculated data on length were used to calculate growth parameters ($L_\infty$, K, $t_0$) using Systat 9 software.

Growth performance index (phi-prime index) φ` was computed from the equation: $\varphi` = \log k + 2*\log L_\infty$ (Munro and Pauly, 1983).

*Statistical analysis*

Data was analyzed using the software package SPSS 15 and functions of Microsoft Excel 2007 and Minitab. Biological characteristics data were subjected to the analysis of variance (ANOVA). The appropriate regression model was selected according to the coefficient of determination ($R^2$) and Mallow's Index (C-P). Mean comparisons of the biological parameters among sexes was performed by T-test and Chi- square test with $\alpha = 0.05$.

**Results**

The size of collected specimens ranged from 10.5 to 19.7cm FL and females dominated all size classes. The sex ratio of the total sample was 1:1.8 (M: F) and female fish prevailed the catch ($p$<0.05) in all months, except December, February, March and June (Fig. 2). Both female and male populations were dominated by 11.1-12.0 cm FL fish (Fig. 3) and the largest male and female specimen caught was 19.7 and 18.0cm FL, respectively. Age of females ranged between one and five years, and for males between one and six years. Both sexes reached first maturity at age two.

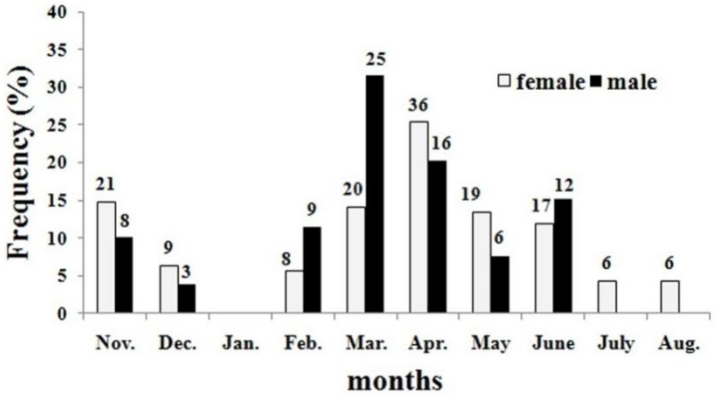


**Figure 2: Sex ratio for *Chondrostoma regium* caught at different months of the year in the Zayandeh Roud River (the number of fish specimens are given above the columns).**

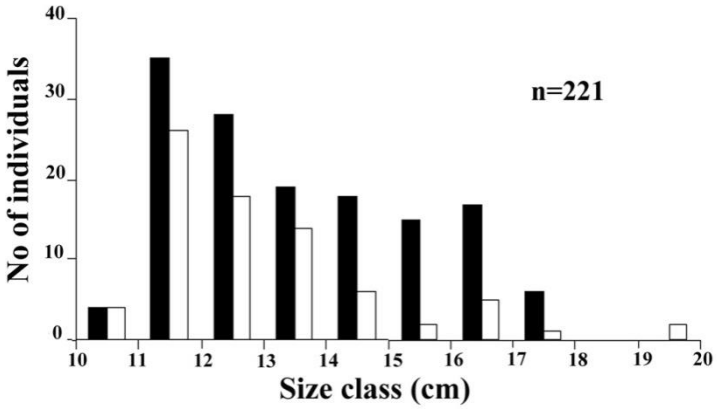


**Figure 3: Size-class (fork length) distribution of female (■) and male (□) of *Chondrostoma regium* in the Zayandeh Roud River.**

Mean length and weight of males and females did not vary statistically throughout the sampling period and significant length weight relationships were derived for both female ($r^2$=0.93) and males ($r^2$=0.96) (Fig. 4). Considering the slope (b) in length-weight equations in both sexes, a negative allometric growth for females ($p$<0.05) and

an isometric growth for males ($p$>0.05) are indicated. The general relationship for the pooled data was described by the following equation:$W=0.0168\ L^{2.845}$ (r=0.95, $p$<0.01)

Mean condition factor was estimated to be 1.26 (±0.17SD) for females and 1.25 (±0.11SD) for males. In general, monthly condition factors exhibited a similar pattern for both sexes; reached the maximum value in April prior to the spawning season. Gender differences in condition factor were only identified in April where the condition factor of females was significantly greater than that of males (Fig. 5).

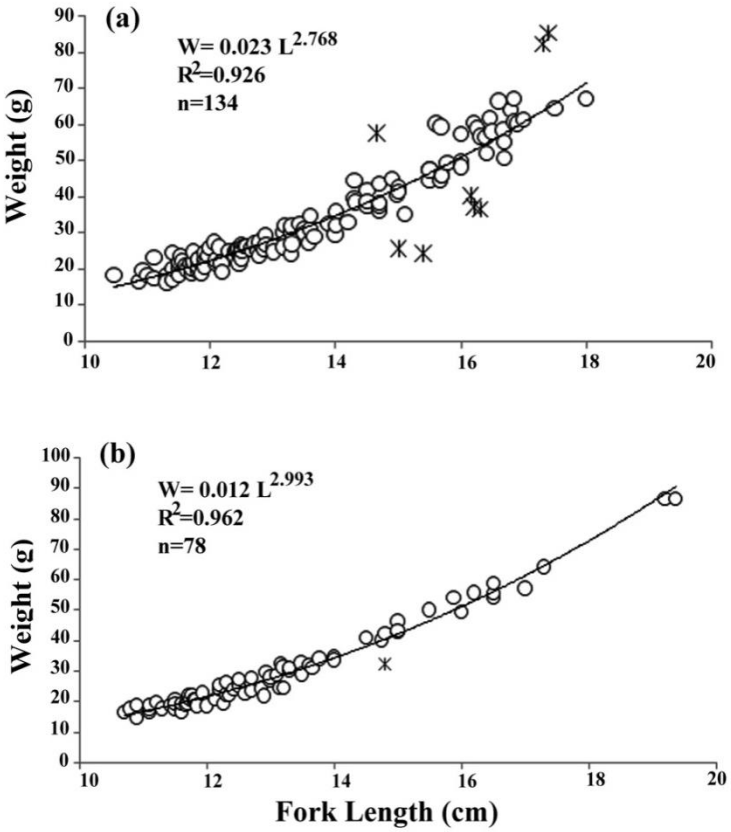


**Figure 4: Length-weight relationship of (a) female and (b) male *Chondrostoma regium* in the Zayandeh Roud River. The outliers are not included in the calculation of equation but shown by stars. n= sample size excluding outlier data.**

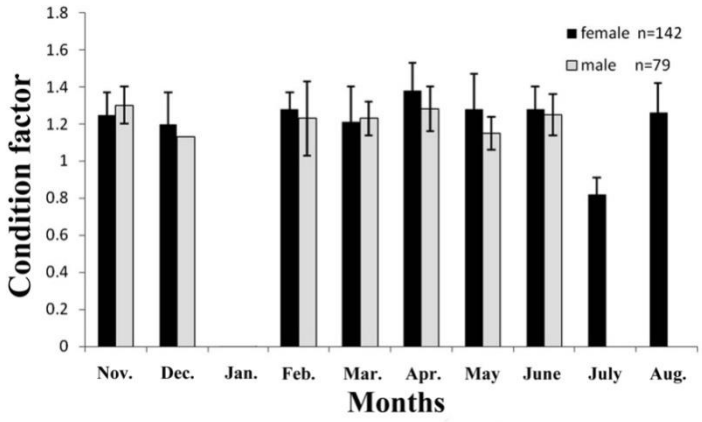


**Figure 5: Changes in condition factor of *Chondrostoma regium* at different months of the year in the Zayandeh Roud River, columns=means, bars= standard deviations**

Mean GSI ranged from 2.75 to 16.77, varied significantly among months (d.f.: 8; F: 32.002; $p<0.05$) and reached a maximum in May and a minimum in June (Fig. 6). The absolute fecundity ranged from 661 to 7671 (mean 2429±1512 SD) eggs per individual and was significantly correlated to both weight ($r^2=0.9$) and *FL* ($r^2=0.86$) (Fig. 7a, b), and to a lesser extent with age $r^2=0.74$ (Fig. 7c). Relative fecundity varied from 41 to 144 (mean 78.1±18.7SD) eggs per gram of body weight.

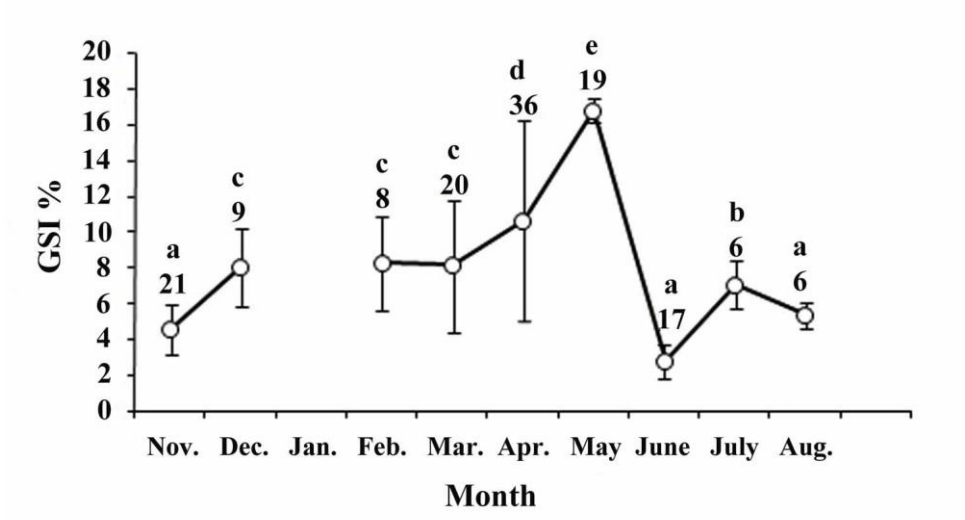


**Figure 6: Mean monthly gonado-somatic index for female *Chondrostoma regium* in the Zayandeh Roud River. Sample sizes (n) for each month are indicated above each monthly column. Mean (±SD) values with different letters are significantly different ($p<0.05$). (No data recorded for January).**

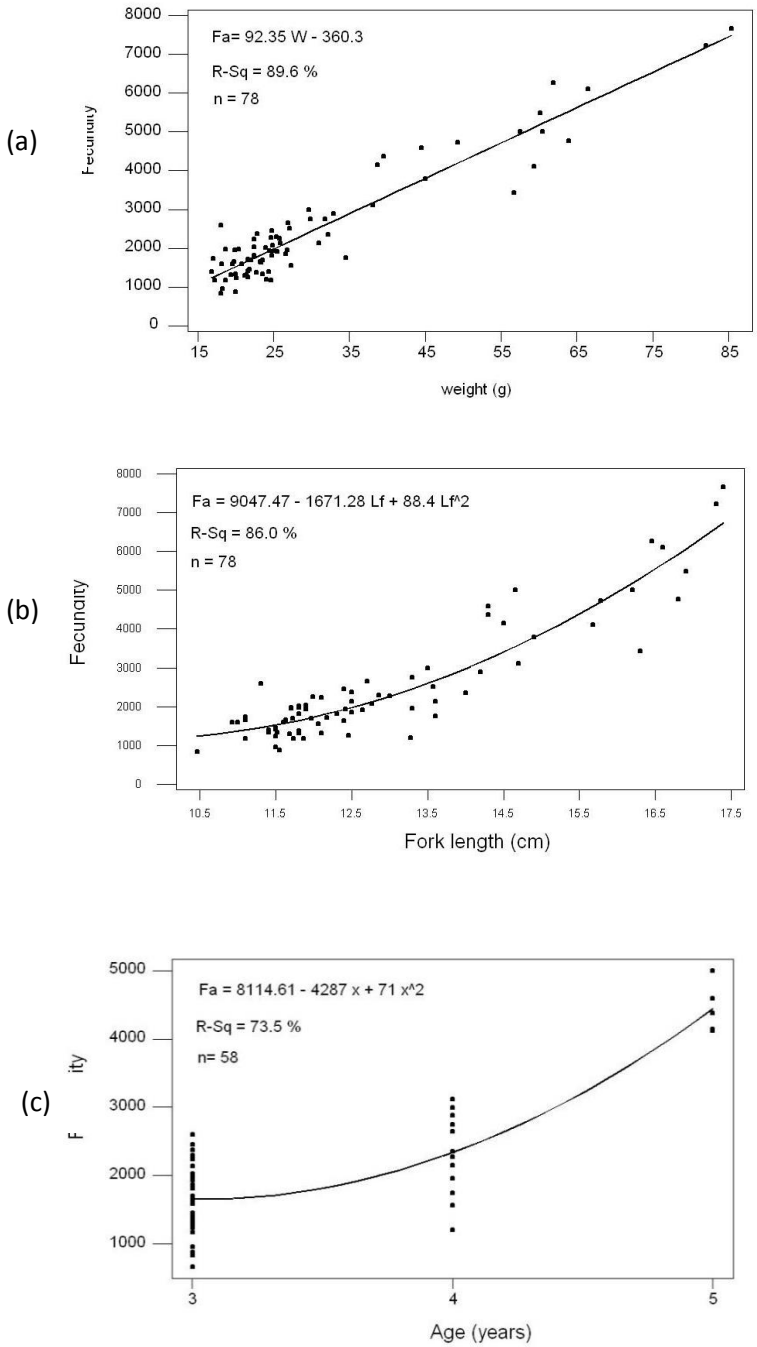


**Figure 7: Relationships between absolute fecundity and weight (a), length (b) and (c) age of *Chondrostoma regium* in the Zayandeh Roud River.**

The growth performance index values (Φ') were estimated at 2.12 for males and 2.10 for females. The von Bertalanffy growth equations of the population were computed as $L_t = 246[1 - e^{-0.206(t-0.034)}]$ for females and $L_t = 253.1[1 -$

$e^{-0.206(t-0.175)}]$ for males (Fig. 8). The age-weight in females and males were estimated as;

$W_t = 163.29[1 - e^{-0.206(t-0.034)}]^{2.77}$, $W_t = 188.25[1 - e^{-0.206(t-0.034)}]^{2.99}$, respectively.

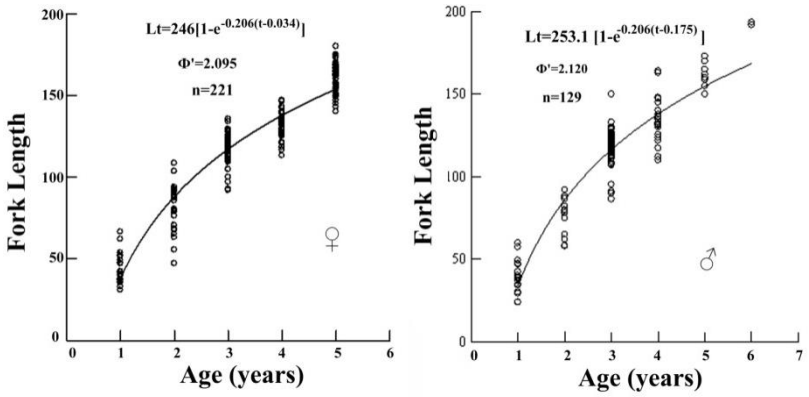


**Figure 8: Age-fork length relationships in male (♂) and female (♀) of *Chondrostoma regium* in the Zayandeh Roud River.**

## Discussion

The maximum and minimum weights and lengths of females and males reported here are substantially less than those values previously reported for the similar species by Kara and Solak (2004). Such discrepancies could perhaps be attributed to the differences in age structure, geographical and ecological condition in the two regions, but also to the differences in fishing gear and methods employed (Nikolsky, 1963; Weatherley, 1972).

The asymptotic length ($L_\infty$) calculated in our study were somehow lower than those reported for similar species in Turkey (Suiçmez *et al*., 2011). Similarly, $W_\infty$ values calculated by Kara and Solak (2004) were higher than that of present study. Such differences could also be due to the fact that the fish in reservoirs and lakes may generally attain a larger size than the riverine forms (Minns, 1995).

The length-weight relationship values, however, are rather low compared to other studies for similar species from Turkish waters (Oymak, 2000). Moreover, Özcan (2008) reported a relatively higher value for length-weight exponent ($b$ = 3.282) for *C. regium*, from the Hatay province, Turkey. This finding was based on examination of 128 specimens ranging from 18.4 to 33.8 cm in total length and 68 to 467 g in weight, much larger than specimens examined in this study. These variations among the "*b"* exponent evaluated for either similar or different species of fish could be related to different stages of growth, age ranges, maturity phases, geographical and environmental conditions, sampling season, the degree of the stomach fullness, quality and quantity of available food, diseases and parasites infections (Nikolsky ,1963). However, the *b* values reported here lies within the general range of 2.5 and 3.5 mentioned for the fish (Koç *et al*., 2007).

The age ranges reported here are similar to those reported in previous studies (Kara and Solak, 2004; Suiçmez *et al*., 2011). However the growth performance index (Φ') values observed in this study were

lower than the values report by Kara and Solak (2004) (2.25 and 2.23 for females and male, respectively) and Suiçmez *et al*. (2011) (2.39 for females and 2.57 for males) for similar species. These variations could possibly be related to differences in geographical and ecological conditions that may, in turns influence growth through variations in availability of food, temperature, level of competition for food etc (Weatherley, 1972).

Variations in monthly and seasonal pattern of condition were expected due to interactions between gonad maturity and environmental conditions (Bagenal and Tesch, 1978). We conclude that reproduction of the *C. regium* occurs between May and June since the condition factor declines exactly after the expected April peak. Results are consistent with the outcomes of the GSI index, except for July which showed a slight increase in value. Consequently, the results presented here suggest *C. regium* as a total spawner over a short spawning period. Studies on similar species in other regions generally confirmed our results (Beckman, 1962; Sevick,1997).

Similarity in monthly condition factors for both sexes supports previous findings of minimal gender differences throughout the year (Kara and Solak, 2004). Although the sex ratio showed substantial variability between months, the overall sex ratio (1:1.8 M: F) was significantly different from 1:1 ($\chi^2$ test, $p<0.05$). In contrast, Kara and Solak (2004) reported a ratio of 1:1.2 for the similar species in Sir Lake, Turkey. Although the sex ratio in most of the species is reported to be close to 1 (Koç *et al*., 2006), this may vary from species to species, from one population to another of the same species, and may also differ year after year within the same population (Nikolsky, 1963). However, the reason for this difference between presents results and Kara and Solak (2004) might be a bias in the data collection in our study due to the low number of fish caught per month. In our study, females dominated the population, particularly in April and May potentially indicating sexual segregation during the reproductive process (Freitas *et al*., 2011).

Limited published data are available on fecundity of *C. regium* for comparisons. However, our results (661-7671) show some discrepancies with the sporadic data in the literatures (Abdoli, 2000; Ghanbary *et al*., 2012). This, of course can be expected even among similar species as the fecundity is affected by many factors (Nikolsky, 1963; Thorpe *et al*., 1984; Jonsson and Jonsson, 1999).

Our finding of linear and significant correlation between fecundity and fork length, total weight and age, are supported by Bagenal and Braum (1978). Such results should be expected as usually the amount of energy available for egg production and the body cavity accommodating the eggs increases with the fish size (Jonsson and Jonsson, 1999).

The present work provides new information of *C. regium* in Iran and will aid in understanding the management needs for their populations.

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