

ORIGINAL ARTICLE

Age and growth of Isfahan tooth-carp, *Esmaeilius isfahanensis* (Hrbek, Keivany & Coad, 2006) in the Zayandehrud River, Central Iran

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Abstract

Age and growth of the Isfahan tooth-carp, *Esmaeilius isfahanensis*, was studied in the Zayandehrud River, in central Iran, from June 2016 to May 2017. Among the 485 specimens, age groups in both sexes ranged from 0⁺ to 2⁺. The overall sex ratio was 1M: 1.2F. Maximum total length and weight were 44.9mm and 1.6g for males and 53.6mm and 2.4g for females. The Minimum total length and weight was 26.8mm and 0.40g for males and 32.0 mm and 0.5g for females. The most frequent age groups were 1⁺ in both sexes. The highest value for the condition factor was observed in July. The von Bertalanffy growth parameters of *E. isfahanensis* were estimated as $k=0.36$, $L_{\infty}=34.98\text{mm}$, $t_0=1.10$ for males and $k=0.53$, $L_{\infty}=41.02\text{mm}$ and $t_0=0.14$ years for females. The length-weight relationship was described as $W=0.00005L^{2.84}$ ($r^2=0.84$) for males and as $W=0.00005L^{2.84}$ ($r^2=0.83$) for females, indicating an isometric growth pattern in both sexes. The Growth performance index ϕ' was estimated as 6.08 for males and as 6.79 for females, indicating a faster growth rate in females.

Keywords: Length-weight relationship, Growth parameters, *Esmaeilius isfahanensis*, Zayandehrud.

INTRODUCTION

According to the latest checklist, the number of fish species in Iranian inland waters is 292 species, 106 genera, 36 families, 24 orders and 3 classes (Eagderi et al. 2022). The extant and extinct species of the toothcarps genus *Aphaniops* Hoedeman, 1951 (Cyprinodontiformes: Aphaniidae) are widely distributed along the late period Tethys Sea coastlines (Esmaeili et al. 2008). The genus *Aphaniops* and *Esmaeilius* Freyhof & Yoğurtçuoğlu, 2020, are the only genera of Aphaniidae available in Iran which are represented by at least 10 species. *Aphaniops* species diversity is the highest in the endorheic basins of the mountainous regions of central Anatolia and the Iranian plateau (Teimori et al. 2012). *Esmaeilius isfahanensis* (Isfahan tooth-carp) is a species described in the Isfahan basin of Iran in 2006 as *Aphanius isfahanensis*. *Esmaeilius isfahanensis* appears to be restricted to the internal Zayandehrud River basin (Hrbek et al. 2006). The systematics, morphology, ecology and biology of the Isfahan toothcarp, *E. isfahanensis* are summarized in Keivany (2013) and Keivany et al. (2016).

Growth is one of the most important features of fish biology, especially, in economically important

species. Growth information could be used for multiple purposes, e.g., stock assessment, aquaculture and protection (Keivany & Mohamadiyani 2021). Also age determination is an important step in studying age-length keys, survival rate, growth and mortality indices, age composition and stocks reproduction rate which are the key subjects in fisheries management. Length-weight relationships provide basic information in fisheries biology, being beneficial to determine the weight of an individual fish of known length or total weight from length frequency distribution, and to compare specific growth among different regions (Keivany et al. 2018). The Reproduction and feeding properties of this species in Zayandehrud were reported by Ghafouri et al. (2018) and Ghafouri et al. (2019). Alavi-Yeganeh et al. (2011) also studied the relationship between the length and weight of different tooth-carp species in Iran, including *E. isfahanensis*. Nonetheless, little is known about this species and the present study is the first on age and growth characteristics of *E. isfahanensis* in the Zayandehrud River.

Table 1. Total length and weight in males and females of *Esmaeilius isfahanensis*.

Gender	Number	Total weight (g)		Total length (mm)	
		(Average ± SD)	Range	(Average ± SD)	Range
Female	245	1.27±0.4	0.48-2.39	42.05±4.26	32.02-53.58
Male	240	0.74±0.24	0.40-1.56	35.01±3.50	26.81-44.89
Total	485	1.01±0.42	0.40-2.39	38.56±5.25	26.81-53.58

MATERIALS AND METHODS

Fish samples were collected monthly, from June 2016 to May 2017, using a dip net from the fish type locality in the Zayandehrud River (32°25'11" N, 52°38' 54"E), in Isfahan Province, Central Iran. All the collected specimens were anesthetized in 1% clove oil, fixed in 10% neutralized formaldehyde solution and preserved in 70% ethanol. Total length (TL) and standard length (SL) were measured using a digital caliper with a precision of 0.01mm and body weight (W) was taken on a digital scale to the nearest 0.01g. The age determination was carried out through scales from between the lateral line and the dorsal fin. About 5-10 scales were washed with warm water and read under a microscope by counting their annual growth circles. The sex ratio deviation from 1:1 was tested statistically by chi-squared analysis (Sokal & Rohlf 1937). The von Bertalanffy growth parameters were calculated using

$$L_t = L_\infty [1 - e^{-K(t-t_0)}]$$
 for fork length

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 the asymptotic weight of the fish in g and b is the constant in the length-weight relationship (Asadollah et al. 2017). Growth performance index (phi-prime index) ϕ' was computed from the equation: $\phi' = Ln k + 2 * Ln L_\infty$ (Pauly & Munro 1984). Length-weight relationships were determined by applying the equation $W = \alpha L^b$, where W is the total body weight (g), L is the total

body length (cm), α is the intercept and b is the slope (Froese et al. 2011). The t-test was used to determine if the b value was significantly different from 3 (Pauly 1984).

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

Fulton's condition factor (K) was calculated according to Htun-Han (1978) equation as per the formula given below:

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

Where, W = weight of fish (g), L = Length of fish (cm). All the statistical analyses were performed at 95% confidence limits using Excel 2016 and SPSS.16 computer software.

RESULTS

A total number of 485 specimens of *Esmaeilius isfahanensis* were collected from the Zayandehrud River. The TL and W ranged from 26.81 to 53.58mm and 0.40 to 2.39g with an average (\pm SD) of 38.51 \pm 5.25mm and 1.01 \pm 0.42g, respectively (Table 1). Among the specimens measured, maximum length-frequency for males and females was 38.3-42.3mm and 34.2-38.2mm, respectively (Fig. 1). The females were larger in length and weight. The highest frequency in weight was in group 0-1g in both males and females (Fig. 2).

Age of males and females ranged from 0⁺ to 2⁺ years. Among the 485 specimens, 240 were males and 245 were females, indicating a sex ratio of 1M: 1.2F. The sex ratio in different age groups is shown in Table 2. The average condition factor of females and males and all fishes during different months of sampling showed a significant difference ($P < 0.05$) (Fig. 6-7). But there was no significant difference between males and females. The length-weight relationship was $W = 0.00005L^{2.84}$ ($r^2 = 0.84$) for

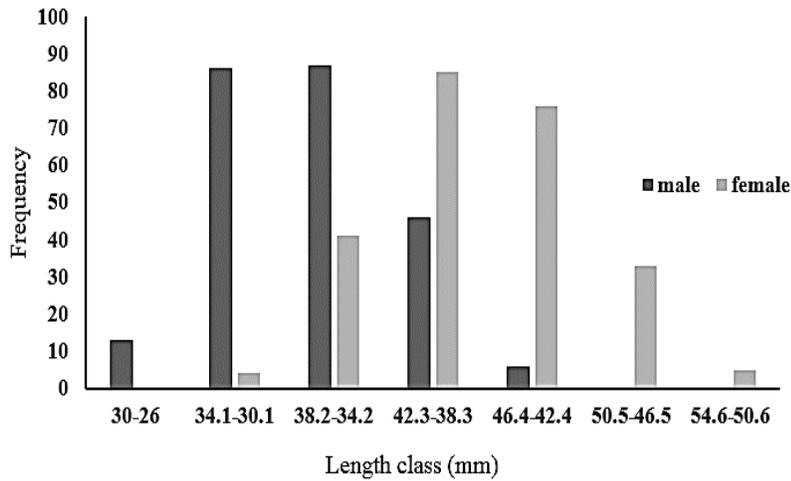


Fig.1. Total Length frequencies of *Esmaeilius isfahanensis* in Zayandehrud River.

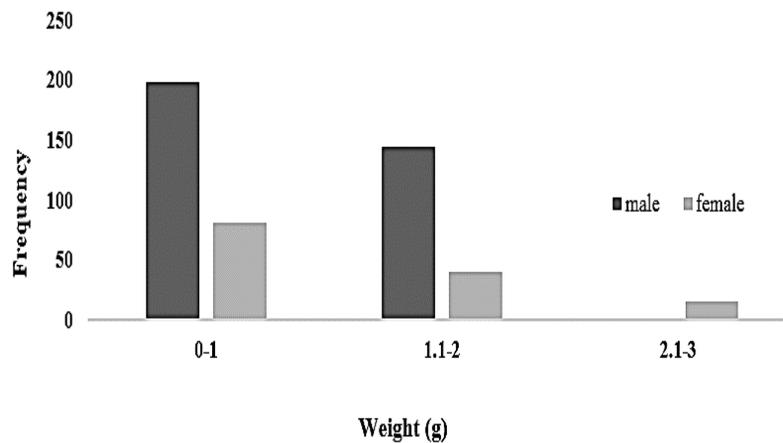


Fig.2. Total weight frequencies of *Esmaeilius isfahanensis* in Zayandehrud River.

Table 2. Number and sex ratios of *Esmaeilius isfahanensis* specimens in different age groups.

Age group	sex	Number	M:F ratio
0 ⁺	M	77	1M:0.6F
	F	44	
1 ⁺	M	153	1M:1.2F
	F	191	
2 ⁺	M	11	1M:0.8F
	F	9	

males and as $W = 0.00005L^{2.84}$ ($r^2 = 0.83$) for females, and $W = 0.00005L^{2.85}$ ($r^2 = 0.85$) for both sexes (Figs. 3-5). This relationship showed that growth of both sexes was isometric. It has been determined that 70% of *E. isfahanensis* caught from the Zayandehrud River belong to 1⁺, 25% to 0⁺ and 5% to 2⁺ age groups. Frequency in age groups for males and females is shown in Fig. 8.

The von Bertalanffy growth parameters were as

$k = 0.36$, $L_{\infty} = 34.98\text{mm}$, $t_0 = 1.1$ for males and $k = 0.53$, $L_{\infty} = 41.02\text{mm}$ and $t_0 = 0.14$ years for females. The von Bertalanffy growth equations were found as $L_t = 34.98[1 - e^{-0.36(t+1.1)}]$ for males and as $L_t = 41.02[1 - e^{-0.53(t+0.14)}]$ for females. The Growth performance index ϕ' was estimated as 6.08 for males and 6.79 for females, indicating a faster growth rate in females.

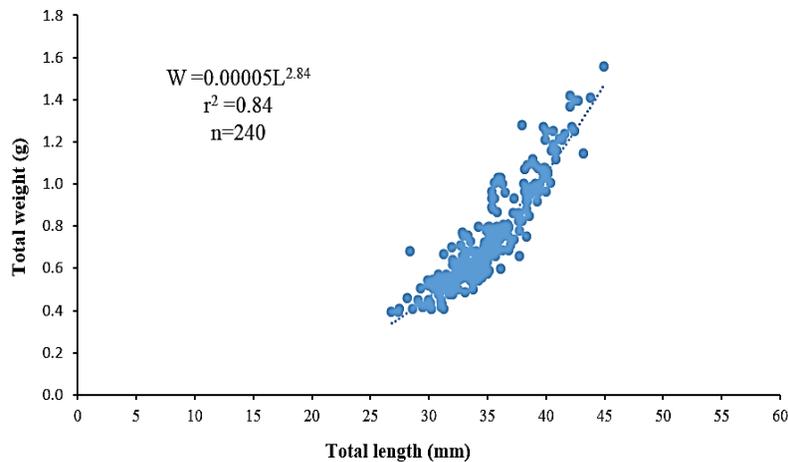


Fig.3. Length-weight relationship in *Esmaeilius isfahanensis* males.

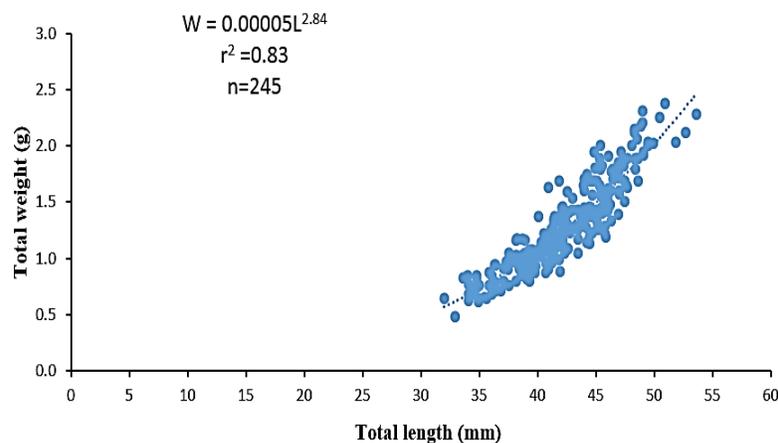


Fig.4. Length-weight relationship in *Esmaeilius isfahanensis* females.

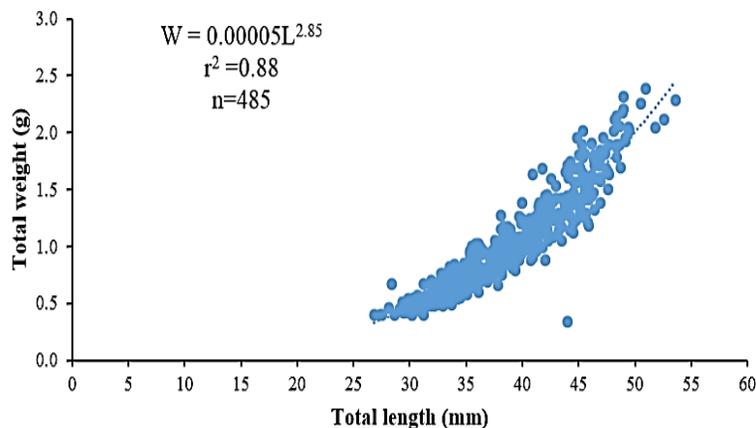


Fig.5. Length-weight relationship in all specimens of *Esmaeilius isfahanensis*.

DISCUSSION

As observed in many other fishes, the females reach a higher length and weight (Keivany et al. 2017; Ghanbarzadeh et al. 2017; Asadollah et al. 2017). The maximum length for females was 53.58mm and that of males was 44.89mm. Alavi-Yeganeh et al.

(2011) reported the maximum length of this species as 42.8mm for females and 41.6mm for males. The differences in the maximum length and weight of the fish could be attributed to differences in sampling time and method. Zare et al. (2015) reported the total length range for *Aphaniops ginaonis* from 15.1 to

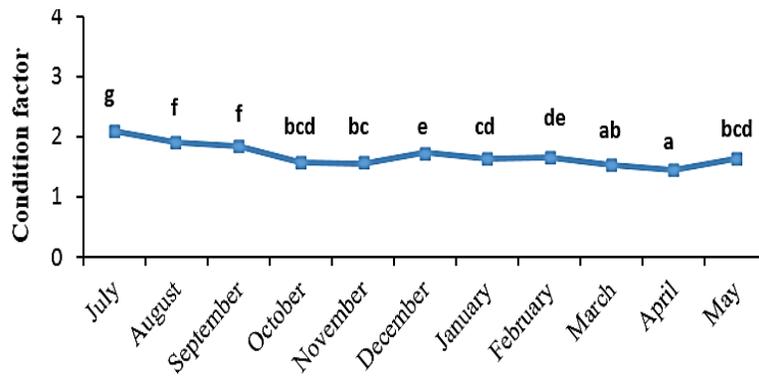


Fig.6. Average condition factor of male *Esmaeilius isfahanensis* in different months of the year (2016-2017).

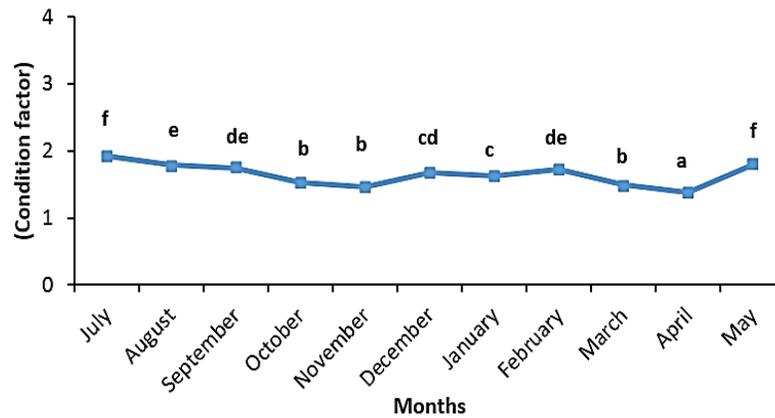


Fig.7. Average condition factor of female *Esmaeilius isfahanensis* in different months of the year (2016-2017).

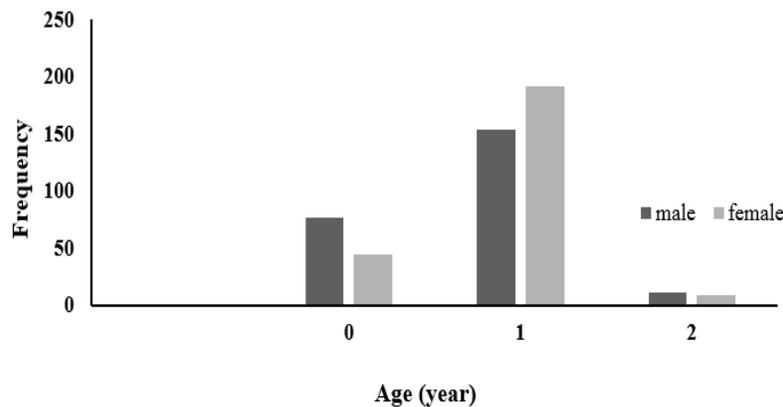


Fig.8. Age frequency of *Esmaeilius isfahanensis* in the Zayandehrud River.

66.8mm for females and from 21.1 to 53.1mm for males. Bibak et al. (2012) reported the maximum total length of 530 specimens of *Aphaniops dispar* as 39mm for females and 49 for males. Karsli & Aral (2010) reported the total length of *Aphaniops danfordii* taken from Sirakaraagaclar stream as 18-50mm. Also, the highest weight recorded in this study was 2.39g in females. Keivany & Soofiani (2004) determined the maximum weight as 7.10g for females and 3.70g for males in *Esmaeilius vladykovi*

specimens. The differences amongst the reported length and weight of fishes are due to the type of the species and their environments (Jewel et al. 2019). Among the specimens measured, the maximum length-frequency for males and females was 38.3-42.3mm and 34.2-38.2mm, respectively. The females were larger in length and weight. The highest frequency was in the weight group 0-1g in both males and females. Age of males and females ranged from 0⁺ to 2⁺ years and the age group of one

year (1⁺) had the highest number. The study of Karsli & Aral (2010) was consistent with our study, the age of *A. danfordii* from the Sirakaraagaclar stream ranged from 0-2 and the individuals in age group 0 were dominant. Esmaeili & Houshang Shiva (2006) recorded an age range of 0⁺ to 3⁺ in the study of the Persian tooth-carp, *Esmaeilius persicus*.

Condition factor (K) is an important biological parameter that indicates the suitability of a specific water body for the growth of fish and is an index of species average size (Mouludi-Saleh et al. 2021). The values of this factor depend on the physiological features of fish, especially, maturity, spawning, life cycle, environmental factors and food availability in a water body (Asadi et al. 2017). In this study the average condition factor of females and males and all fishes during different months of sampling showed a significant difference, but there was no significant difference between males and females. According to this study the overall sex ratio was 1M: 1.2F. In the study of Zare et al. (2015), the sex ratio was 1M: 1.2F for *Aphaniops ginaonis*, which was not significantly deviated from the hypothetical ratio of 1:1 and was consistent with our study. Serkan Guclu & Kucuk (2011) reported the overall male to female ratio for *Aphanius mento* as 1.1M: 1.0F. Spawning period was between May and July. Also, in the study of Bibak et al. (2012), the sex ratio of *Aphaniops dispar* (3:1) was different from 1:1 ratio and showed that the females were dominant.

Alavi-Yeganeh et al. (2011) reported the growth pattern for this species in Zayandehrud River as positively allometric. Reasons for variation in growth types is due to seasonal fluctuations of the environmental parameters, physiological conditions of the fish at the time of collection, sex, gonad development and nutritive condition (Froese 2006), also, Jewel et al. (2019) added some other causes, including habitat, degree of stomach fullness, preservation techniques and differences in the observed length ranges of the specimen. Our results showed that females generally growth faster than males. The results of this study could be used in evaluating the relative condition of this fish for

conservation purposes and fisheries management in the region.

ACKNOWLEDGMENTS

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مقاله کامل

مطالعه سن و رشد کپوردندان ماهی اصفهان (Hrbek, 1966) در رودخانه زاینده‌رود، مرکز ایران (Keivany & Coad, 2006)

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گروه شیلات، دانشکده منابع طبیعی، دانشگاه صنعتی اصفهان، اصفهان، ۸۳۱۱-۸۴۱۵۶، ایران.

چکیده: سن و رشد ماهی کپوردندان اصفهان در رودخانه زاینده‌رود در مرکز ایران از خرداد ماه ۱۳۹۵ تا اردیبهشت ماه ۱۳۹۶ مورد بررسی قرار گرفت. از ۴۸۵ نمونه ماهی صید شده، گروه‌های سنی در دو جنس بین 0^+ و 3^+ متغیر بود. نسبت جنسی کل ۱ نر به ۱/۲ ماده بود. حداکثر طول و وزن کل ۴۴/۹ میلی‌متر و ۱/۶ گرم برای جنس نر و ۵۳/۶ میلی‌متر و ۲/۴ گرم برای جنس ماده بود. حداقل طول و وزن کل ۲۶/۸ میلی‌متر و ۰/۴۰ گرم برای جنس نر و ۳۲/۰ میلی‌متر و ۰/۵ گرم برای جنس ماده بود. بیشترین فراوانی سنی در گروه ماهیان ۱ ساله برای هر دو جنس نر و ماده به‌دست آمد. بیشترین مقدار فاکتور وضعیت در ماه تیر مشاهده شد. پارامترهای رشد برتالانفی گونه *E. isfahanensis* به‌صورت $K=0/36$ ، میلی‌متر $L_{\infty}=34/98$ و $t_0=1/10$ برای جنس نر و $K=0/53$ ، میلی‌متر $L_{\infty}=41/02$ و $t_0=0/14$ برای جنس ماده برآورد شد. رابطه طول و وزن برای جنس نر به‌صورت $W=0/0005 L^{2/84}$ ($r^2=0/84$) و برای جنس ماده $W=0/0005 L^{2/84}$ ($r^2=0/83$) برآورد شد که نشان‌دهنده الگوی رشد ایزومتریک در هر دو جنس است. شاخص عملکرد رشد مونرو (ϕ') برای جنس نر ۶/۰۸ و برای جنس ماده ۶/۷۹ برآورد شد که نشان‌دهنده نرخ رشد سریع‌تر در جنس ماده گونه مورد مطالعه است.

کلمات کلیدی: رابطه طول-وزن، پارامترهای رشد، کپوردندان اصفهان، زاینده‌رود.