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# AGE AND GROWTH OF BERG LOACH (*OXYNOEMACHEILUS BERGIANUS*) IN KORDAN RIVER OF NAMAK BASIN IN IRAN

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Key words: Ageing; Alborz Province; growth pattern; Nemacheilidae.

Abstract

The age and growth of *Oxynoemacheilus bergianus* were examined in 358 specimens collected monthly from Kordan River in 2013–2014. The total length range was 32.36–74.36 mm (50.95 ±10.3 SD), and the total weight 0.31–4.06 g (1.12 ±0.68 SD). The maximum age based on otolith readings was $5^+$ years for females and $4^+$ years for males. The most frequent age groups were $2^+$ and $3^+$ in males and females, respectively. The total length–weight relation for females was $W = 0.0079TL^{2.99}$ ($r^2 = 0.92$) and for males was $W = 0.0093TL^{2.84}$ ($r = 0.92$), indicating an isometric pattern for females and a negative allometric growth for males. The Von Bertalanffy growth model was estimated as $L_t = 86.9[1\text{-}e^{-0.16(t+3.1)}]$ and $Lt = 94.3[1\text{-}e^{-0.15\ (t+2.5)}]$ for males and females, respectively. The growth performance index was estimated as 7.1 for males and as 7.2 for females, indicating a faster growth rate for females. The fastest growth rate for this species was in the first and second year of life.

## Introduction

The loaches are found in most rivers throughout Iran, including Caspian Sea, Tigris, Kor and Bushehr river basins (KEIVANY et al. 2016a). Recently, six genera including *Ilamnemacheilus*, *Oxynoemacheilus*, *Paracobitis*, *Paraschistura*, *Turcinemacheilus* and *Triplophysa* with at least 40 species has been reported, many of them being endemic (ESMAEILI et al. 2017). The Nemacheilids inhabit a variety of inland waters including turbulent mountain streams to lowland salty rivers and are the second dominant fish species in the freshwater fishes of Iran. However, there is little information on their biology in Iran (TABIEE and Abdoli 2005, HEYDARNEJAD 2009, JAMALI et al. 2015, KEIVANY et al. 2016a).

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Berg loach, *Oxynoemacheilus bergianus* (Derzhavin, 1934) is an endemic widespread member of the nemacheilids reported from Caspian Sea, Urmia and Namak basins (KEIVANY et al. 2016a, ESMAEILI et al. 2014 2017). Some information on the biology of *Oxynoemacheilus bergianus* has been provided (TABATABAEI et al. 2013, KAMALOO and KEIVANY 2014, ZAMANI-FARADONBE et al. 2015, JAMALI et al. 2015), but, in general, very little is known about its distribution and biology. There are also some works on related species such as *Oxynoemacheilus kiabii* (ABBASI et al. 2013), *Paracobitis iranica* (MARMAEI et al. 2014) *Turcinoemacheilus hafezi* (PATIMAR et al. 2014), *Oxynoemacheilus angora* (HASANKHANI et al. 2014). Detailed description of its life history has not been given in the literature. Thus, providing information on the basic biological parameters of this loach species is fundamental for understanding its life history patterns and implementing effective management. Hence, the aim of this study was to examine and describe the age and growth parameters of *O. bergianus* population inhabiting Kordan River in Namak basin of Iran.

## Materials and Methods

A total of 358 specimens of *Oxynoemacheilus bergianus* from Kordan River were captured monthly during September 2013 to August 2014 by dip and seine nets (1 mm mesh size). *Oxynoemacheilus bergianus* is the only species of *Oxynoemacheilus* in Kordan River. Fish samples were anesthetized in 1% clove oil and transported to the laboratory after fixation in 10% formalin for further analyses. Routine laboratory measurements, including standard (SL) and fork length (FL) to the nearest 0.01 cm and total body weight to the nearest 0.01g, were carried out. For ageing, the sagittal otoliths were removed and studied under microscope (LAGLER 1956). The sex was distinguished by examining the gonads under a stereomicroscope.

The von Bertalanffy growth parameters were calculated using $L_t = L_\infty [1\text{-}e^{-K\,(t\text{-}t_0)}]$ for FL and $W_t = W_\infty [1\text{-}e^{-K\,(t\text{-}t_0)}]^b$ for weight,

where:
$L_t$ – the length of fish in cm at age $t$
$L_\infty$ – asymptotic fish length in cm
e – the base of natural log (2.71828)
$t$ – the fish age (year)
$t_0$ – the hypothetical time at which the length of the fish was zero
$K$ – the rate at which the growth curve approaches the asymptote
$W_t$ – the weight of the fish in $g$ at age $t$
$W_\infty$ – asymptotic weight of the fish in $g$ and $b$ is the constant in the length–weight relationship (RICKER 1975, SPARRE and VENEMA 1992). Pattern of growth in both sexes was determined using the Pauly's model (PAULY 1984):

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

where:

sd ln $L_f$ and sd ln $W_t$ – the standard deviation of the natural logarithm of the fork length and body weight, respectively

$b$ – the slope, calculated from the length and weight relationship.

For calculating instant growth, $r = \text{Ln}(W_{(t+1)}) - \text{Ln}(W_{(t)})/\Delta t$ was used, in which $r$ = special growth, $W_{(t+1)}$ = average weight of fish at the age of $(t+1)$, $W_t$ = average weight of the fish at the age of t and $\Delta t$ = time differences which usually equals 1.

$K$ and $t_0$ were obtained according to BERTALANFFY (1938). Growth performance index (phi-prime index) φ` was computed from the equation: $\varphi` = \text{Lnk} + 2 \cdot \text{Ln}L_\infty$ (PAULY and MUNRO 1984). Condition coefficient was calculated for both sexes using the equation $K = (W/FL^3) \cdot 100$ (Ricker 1975). For comparison of two means, after Normality test, $t$-test, and for multiple comparison of means, one-way ANOVA, followed by Dunkan test, at 95% confidence level was used. Statistical analyses were carried out in SPSS 20 and Excel 2016 computer software.

## Results

The length, weight, age and sex of 358 specimens (179 males, 168 females and 12 unidentified) of *O. bergianus* in Kordan River were determined during a full year (Table 1 and Table 2). The total length for males ranged between 3.62–7.07 (5.13 ± 0.92 SD), for females 3.65–7.44 (5.17 ± 0.14), 3.24–3.78 (3.52 ± 0.15) for unidentified and 3.24–7.44 (5.10 ± 1.00) for all.

Table 1

The length and weight of *O. bergianus* from Kordan River

| Sex | No. | TL [cm] | | Weight [g] | |
|---|---|---|---|---|---|
| | | min–max | mean±sd | min–max | mean±sd |
| Immature | 12 | 3.24–3.78 | 3.52±0.15 | 0.31–0.56 | 0.38±0.08 |
| Male | 179 | 3.62–7.04 | 5.13±0.92 | 0.32–2.41 | 1.07±0.56 |
| Female | 167 | 3.65–7.44 | 5.17±1.04 | 0.31–4.06 | 1.23±0.77 |
| All | 358 | 3.24–7.44 | 5.10±1.03 | 0.31–4.06 | 1.12±0.68 |

Table 2

Specific growth rate of *O. bergianus* in different ages in Kordan River

| Sex | Ages | | | | | |
|---|---|---|---|---|---|---|
| | – | $1^+$ | $2^+$ | $3^+$ | $4^+$ | $5^+$ |
| Male | CF | 0.75 | 0.72 | 0.75 | 0.73 | |
| | annual growth rate | 0.31 | 0.44 | 0.2 | | |
| Female | CF | 0.85 | 0.78 | 0.78 | 0.81 | 0.78 |
| | annual growth rate | 0.37 | 0.38 | 0.43 | 0.13 | |

The total weight for males ranged between 0.32–2.41 (1.07 ± 0.56), for females 0.31–4.06 (1.23 ± 0.77) and 0.31–0.56 (0.38 ± 0.08) for unidentified specimens. The length class 3.95–4.64 for males and 5.34–6.04 for females were the dominant classes (Fig. 1). There was a significant difference between males and females in total length and weight.

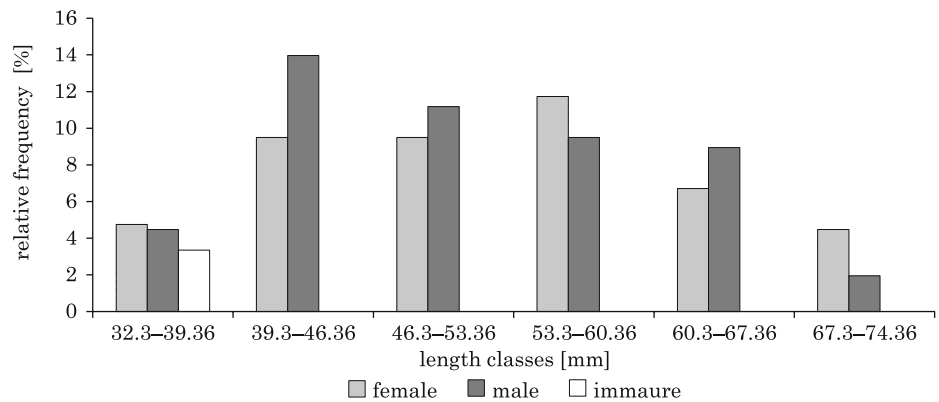


Fig. 1. The frequency for each length group of *O. bergianus* from Kordan River

Age ranged between $1^+$-$4^+$ years in males and $1^+$-$5^+$ years in females. Undetermined specimens belonged to $0^+$ age group. The $2^+$ and $3^+$ year class was dominant in males and females, respectively (Table 2). Some 179 specimens (52%) were females and 168 (48%) males (Fig. 1). The sex ratio was about 1M:1.1F, which was not significantly different from 1:1 ratio ($p > 0.05$) – Table 1. Males were dominant in age groups 1–3 (Fig. 2). The length–weight relationship for females, males and all individuals was as $W = 0.0079L^{2.99}$ ($r^2 = 0.92$), $W = 0.00932L^{2.84}$ ($r^2 = 0.92$) and $W = 0.0001L^{2.89}$ ($r^2 = 0.92$), respectively, indicating an isometric growth pattern for the females and a negative allometric growth for the males and all fish, based on Pauly (1984) – Figure 3–5.

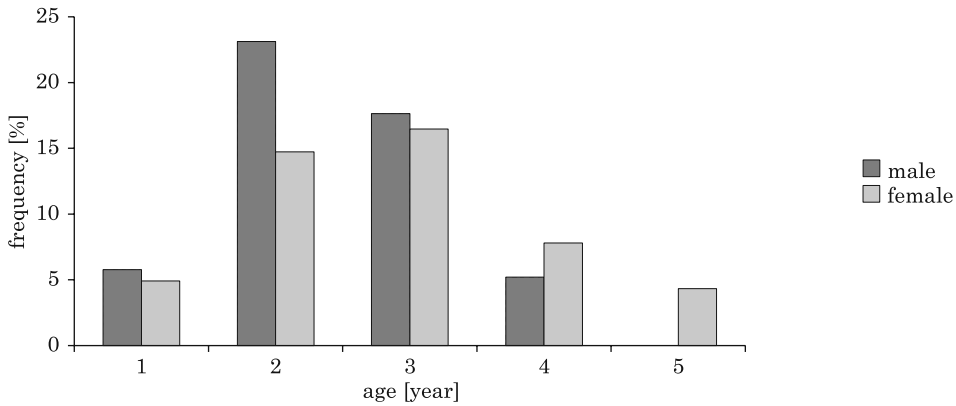


Fig. 2. The frequency for each age group of *O. bergianus* from Kordan River

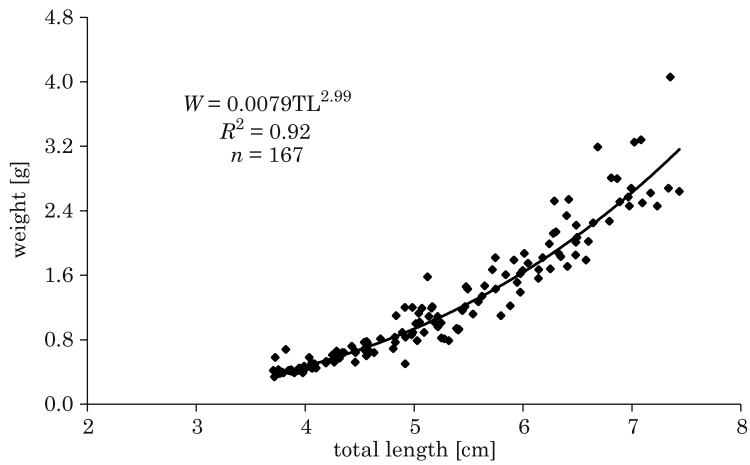


Fig. 3. Length–weight relationship of female *O. bergianus* in Kordan River

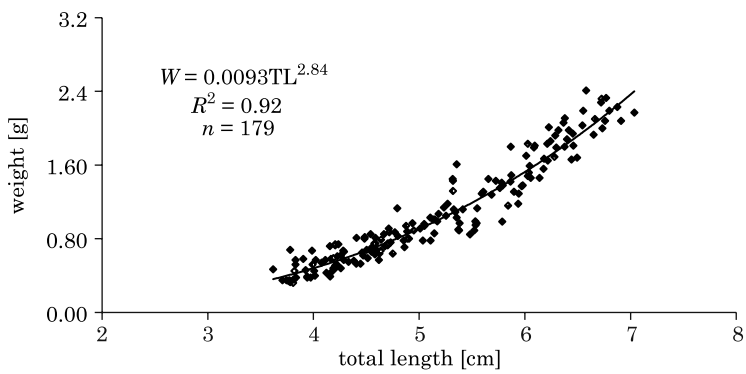


Fig. 4. Length–weight relationship of male *O. bergianus* in Kordan River

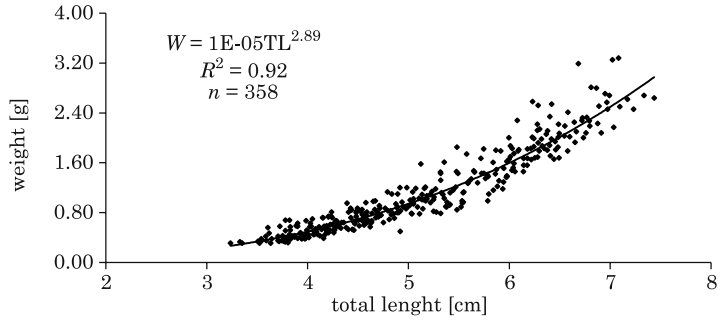


Fig. 5. Length–weight relationship of all specimens *O. bergianus* in Kordan River

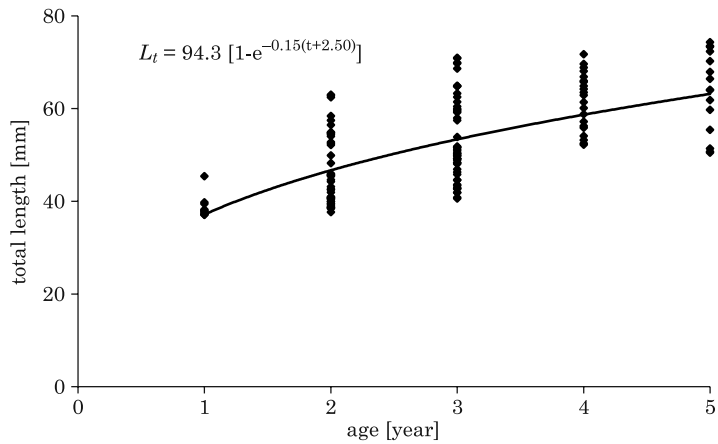


Fig. 6. Age–length relationship of female *O. bergianus* in Kordan River

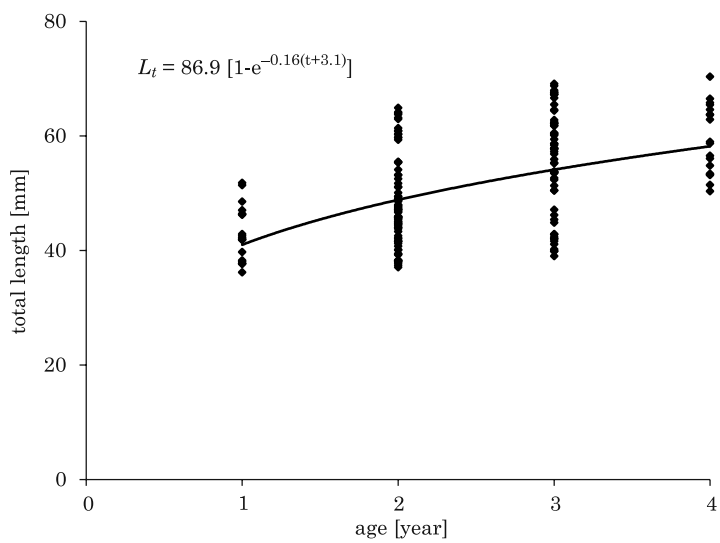


Fig. 7. Age–length relationship of male *O. bergianus* in Kordan River

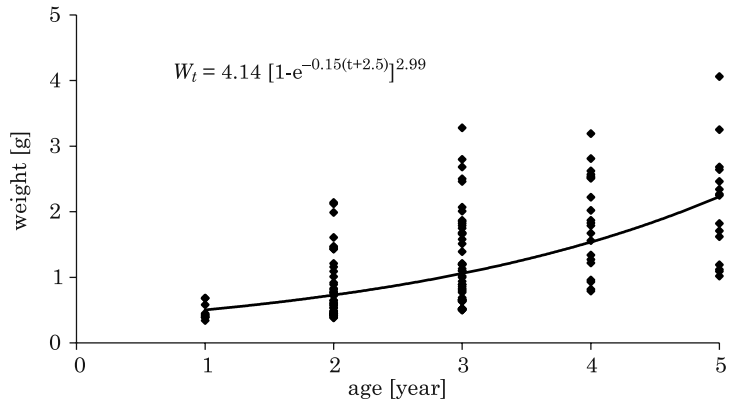


Fig. 8. Age–weight relationship of female *O. bergianus* in Kordan River

The age-length and age-weight relationships in males and females were estimated as $L_t = 8.69[1\text{-}e^{-0.16\ (t+0.3.1)}]$, $W_t = 5.47[1\text{-}e^{-0.16\ (t+3.1)}]^{2.84}$ and $L_t = 9.43[1\text{-}e^{-0.15\ (t+2.5)}]$, $W_t = 4.14[1\text{-}e^{-0.15\ (t+2.5)}]^{2.99}$, respectively (Figs. 6–8). The von Bertalanffy growth parameters for males, females, and all fish are displayed in Figure 3. Based on the growth performance index (Φ›), males showed a higher (3.84) growth rate than females (2.18). Mean total length and weight for different age groups of males and females were estimated (Fig. 9). Age-length and Age-Weight relationships of males and females are plotted in Figure 6 and Figure 7.

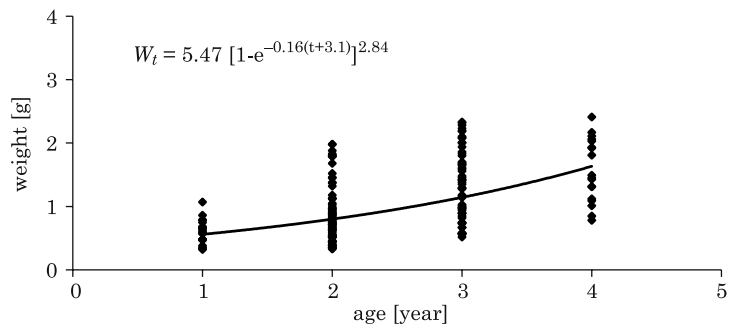


Fig. 9. Age–weight relationship of male *O. bergianus* in Kordan River

The mean condition factor was significantly different in some months. The highest value was in April for males, and in April and May for females (Fig. 10 and Fig. 11). The specific growth rate for males and females is indicated in Table 2. Growth index indicates that females grow faster than males (Table 3). The specific growth rate decreases by age in both males and females. The condition factor did not vary significantly in different ages.

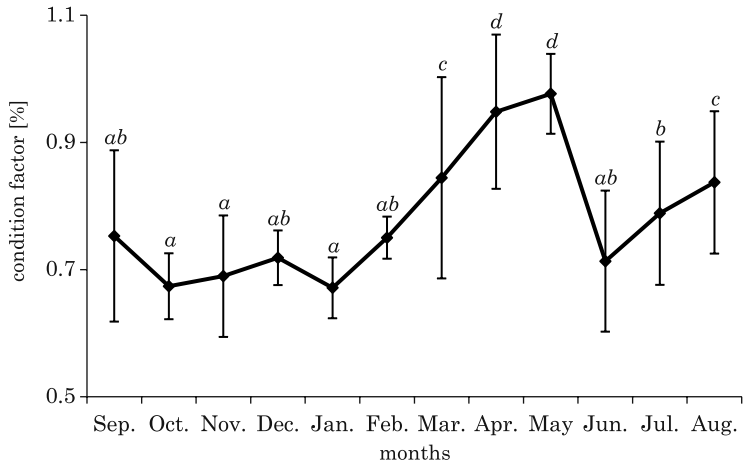


Fig. 10. Condition factor ±Sd of female *O. bergianus* in Kordan River

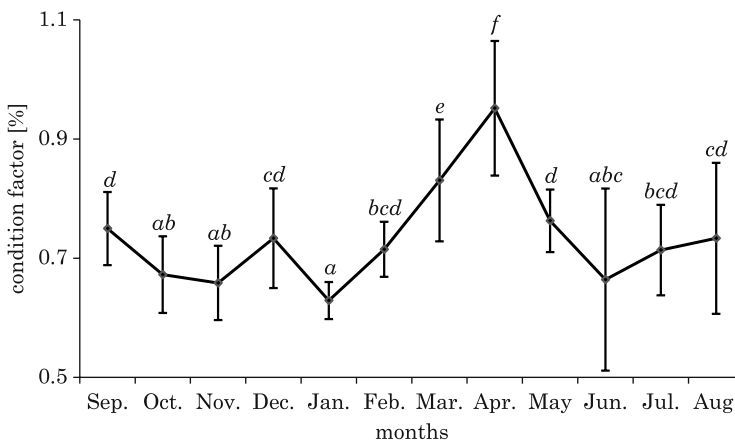


Fig. 11. Condition factor ±Sd of male *O. bergianus* in Kordan River

Table 3

Growth rate of *O. bergianus* in different sexes in Kordan River

| Sex | $L_\infty$ [cm] | $t_0$ | $k$ | $\varphi$ |
|---|---|---|---|---|
| Male | 8.69 | -3.1 | 0.16 | 7.1 |
| Female | 9.43 | -2.5 | 0.15 | 7.2 |

## Discussion and Conclusions

This is the first study on the age and growth of *Oxynoemacheilus bergianus* in Namak basin and also one of the few studies in Iran. The sample size indicates the low frequency of the species in the river, an indication

that the species might be at risk because of ecological threats. Although there are some biological data for some nemacheilid species in Iran, there is none for some others (JAMALI et al. 2015). Like many other species, *O. bergianus* has a small size (total length and weight), not exceeding 90 mm and 6 g (ZAMANI-FARADONBE et al. 2015). Unlike Sefidrud population, females exhibit a much wider range in length and a higher maximum length than males. The total length for some other species of loaches, i.e., *Oxynoemacheilus kiabii*, *O. angora* and *Metaschistura cristata* was reported between 8.2–8.7 mm (ABBASI et al. 2013, HASANKHANI et al. 2014, PATIMAR et al. 2014). Variation in mean size (length and weight) of the population of a species could be explained on the basis of different exploitation patterns and/or ecological conditions. In this sense, while the loach is not subject to commercial exploitation, variation in the environmental conditions of the area seems to be the main factor affecting the loach population.

The maximum age of *O. bergianus* was higher than that observed in Aras River (JAMALI et al. 2015), but less than that observed in *Paracobitis malapterura* and *Paraschistura kessleri* ($4^+$ years for *P. malapterura* in Zarrin-Gol River (now *P. hircanica*) and *P. kessleri* in Zanglanlou River) (PATIMAR et al. 2009, 2010). The age group $2^+$ was dominant in males and $3^+$ in females. In some other species like *T. hafezi* and *B. barbatula* the dominant age classes were $1^+$ and $2^+$ (JAMALI et al. 2014, VINYOLES et al. 2010). In colder waters the age may increase to 8 years as in *B. barbatula* in Siberia (SKRYABIN 1991).

Sex ratio in *O. bergianus* was equal as in Aras population (JAMALI et al. 2015). In *O. kiabi* (ABBASI et al. 2013), this ratio was in favor of females, but in *Paracobitis malapterurus* it was in favor of males (TABIEE and ABDOLI 2005). Sex ratio varies considerably from species to species; but in the majority of species, it is close to one (NIKOLSKY 1963). However, as noted by others (PITCHER and HART 1982, SKRYABIN 1991, FERNANDEZ-DELGADO and ROSSOMANNO 1997), subsequent changes in this ratio may be explained by a number of hypotheses, including differences in habitat preference, season, sampling errors, or selective mortality. Sex ratio was also different from other species of Nemacheilidae, e.g., *Paracobitis malapterura* (PATIMAR et al. 2009), *Barbatula* (VINYOLES et al. 2010), *Paracobitis iranica* (MARMAEI et al. 2014) and *Metaschistura cristata* (Patimar et al. 2011). However, in younger age classes males were dominant and in older age classes females were dominant. In May, females were dominant as seen in *B. barbatula* (VINYOLES et al. 2010). Differing from one population to another of the same species (Table 3), males usually predominate in the younger groups because they mature earlier but live shorter (NIKOLSKY

1963, ASADOLLAH 2011, 2017). Males were longer and heavier in the early stages than females, but in later stages this was reversed.

The *b* value is often about 3 and generally between 2.5 and 3.5. The calculated values of the *b* parameter for other species of *Oxynoemacheilus* loaches ranged from 2.8 to 3.01 (GOLZARIANPOUR et al. 2011, HASANKHANI et al. 2014, JAMALI et al. 2014). Although the growth rate of about 3 indicates the isometric growth that is characteristic for adult fish, that have completed their metamorphosis, the lower *b* value of loaches also indicates a cylindrical body which prevent them from being washed out by currents (ESMAEILI et al. 2014). Even though variation in b values depends primarily on the shape and fatness of the species, the b value in fish varies according to species, sex, age, stage of maturity, season and feeding. In addition, variation in fish shape, physiological conditions, and different amounts of available food, life span or growth increment can all affect the b growth exponent (RICKER 1975, TESCH 1968, SPARRE 1992, BAGENAL and TESCH 1978, KING 1995). 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 regions (HASANKHANI et al. 2013, 2014, KEIVANY et al. 2016b). The growth pattern in fishes is affected by genetics and environmental conditions.

The value of $L_\infty$ for females was higher than that of males which is congruent with findings of other studies (BOROŃ et al. 2008). The reason may be that females grow faster than males, and live longer (WEATHERLEY 1972, ROBOTHAM 1981, KOSTRZEWA et al. 2003, KEIVANY and SOOFIANI 2004, ZANELLA et al. 2003, BOROŃ et al. 2008, KEIVANY et al. 2012). The theoretical maximal length values ($L_\infty$) were close to the size of the largest fish examined and the growth coefficient values indicated a relatively low attainment of maximal size. The differences in growth between regions can be attributed to differences in size of the largest individual sampled in each area and to the differences between populations. On the other hand, it is also possible that the variations in population parameters of the species represent epigenetic responses to different conditions (temperature and food) prevailing in different areas (BRUTON 1990). A possible reason for this difference is the lower maturity age in males compared to females. The $t_0$ was different from other related species (ZANELLA et al. 2003, BOROŃ et al. 2008). The condition factor is an indicator of feeding condition of a fish. Variation in this index is affected by food availability and energy requirements for reproduction (SKRYABIN 1991).

In conclusion, *Oxynoemacheilus bergianus* reaches 7.5 cm in total length, 4.1 g in total weight and a maximum of 6 years in age. The fastest growth rate for this species is in the first and second year of life. This infor-

mation could be used for sustainable propagations of the species in aquaria as a pet fish.

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