

Biological parameters of *Luciobarbus callensis* populates Beni-Haroun dam, north-eastern Algeria

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Abstract. Berrouk H, Sahtout F, Boualleg C. 2020. Biological parameters of *Luciobarbus callensis* populates Beni-Haroun dam, north-eastern Algeria. *Biodiversitas* 21: 5691-5697. Fish age and growth data mainly assist many ichthyologists to understand the life history features of species and populations. Growth is a major process of fish biology, and considered as one of the key processes of length-structured models of fishes. Thus, the present study was devoted to studying growth of an autochthonous species (*Luciobarbus callensis*), populating the dam of Beni-Haroun (Mila city, northeast of Algeria), and is known for its socio-economic value and aquaculture interest. The study was conducted on a sample of 257 fish individuals during the period 2015-2016. The age of *L. callensis* was determined by using the scalimetry method, providing easier sampling and reading procedures, and also high precision. Fish sexes were identified via the observation of gonads, by naked eye based on gonad shape and color, where the number of females was higher (165) than males (92). The obtained results revealed a maximum longevity of seven years of *L. callensis*, and the determined growth parameters of the separated and combined fish sexes were found to be as follow: $L_{\infty} = 47,3$ cm; $K = 0,29$; $t_0 = -0,51$; $\phi' = 2,813$ (females); $L_{\infty} = 42,11$ cm; $K = 0,26$; $t_0 = -0,58$; $\phi' = 2,663$ (males); and $L_{\infty} = 47,37$ cm; $K = 0,20$; $t_0 = -0,75$; $\phi' = 2,652$ (combined sex). Moreover, the evolution of the total weight of fishes with respect to their size presents minor allometry ($b < 3$), (with or without sex distinction).

Keywords: Beni-Haroun dam, growth modelization, *Luciobarbus callensis*, Von Bertalanffy model

INTRODUCTION

Luciobarbus callensis is an important Cyprinidae species throughout the aquacultural world due to reasons such as its abundance, and availability at affordable prices (Mimeche et al. 2013). This species characterizes the north of Africa and is widely distributed in Algeria, Morocco, and Tunisia, in addition to the important animal protein sources it provides to rural populations (Mimeche et al. 2013). Whilst, it was firstly found in Calle Lake (E-Taref city, north-eastern Algeria) located at the Algerian part of El-Kebir basin, just on the Algerian-Tunisian border (Berrouk 2019). This autochthonous species inhabits natural river stretches and also dams, together with other non-autochthonous species as evidenced by *Cyprinus carpio*, *Carassius carassius*, and *Abramis brama*. Further, several studies investigating the growth of freshwater fishes, like *L. callensis* have been conducted in Algeria, Hamiz dam (Ould Rouis et al. 2012), K'Sob dam (Mimeche et al. 2013), Oued El-Harrach dam (Morsi et al. 2016), Obeira Lake (Brahmia 2017), and Aures region (Chaibi 2014)). The knowledge of the populations' age structure, size structure, and sex ratios as well as the growth rates of individuals, is crucially important (Quist et al. 2012). Age estimation by indirect methods such as monitoring temporal changes in length-frequency histograms can be highly informative of the population demographic. Direct estimation of age from growth ring, such as scales and otoliths provides more accurate and precise estimates of population age structure and growth

rates compared to length-frequency histograms (Hoxmeier et al. 2001).

Moreover, the characteristics of *L. callensis* age can be determined whether by a direct reading of the anatomic fish sections, like otolith scales (the case of our study), or by the operculum and even the vertebrae, or also by the marking method (Boucenna et al. 2015). Besides, the growth study was performed according to the mathematical model of individual growth elaborated by Von-Bertalanffy (1938), constituting the necessary data for fish biomass estimation. This model is applied in various biological and ecological fields and enables us to estimate the weight from size and age (Khelifi 2018).

MATERIALS AND METHODS

Study zone

The study was conducted in Beni-Haroun dam of Mila City in Mila Province, north-eastern Algeria, located on the Ouedkebir River at about 40 km from the north of Constantine City, and 350 km from the east of Algiers (capital of Algeria). The dam is of great interest in the transfer of mobilized water resources toward six north-eastern cities (Batna, Kenchela, Mila, Oum El Bouaghi, Jijel, and Constantine) (ANBT 2015). Also, it is one of the 85 dams currently in exploitation in Algeria and is the second biggest dam in Africa after Elsad-Elali dam of Egypt. The first impounding of the dam was started in August 2003. The dam is 114 m in height upstream of the

bed, 100 m in width at the base, and a crest length of 710 m, in addition to a water storage capacity of 997.9 million cube meter, and recently has reached a maximum storage capacity of one billion cube meter. The difficult topography of the region imposes the establishment of a complex technical design, including a gigantic pumping station, three control dams, and more than 600 kilometers of transfer and supply pipes. Large urban centers and vast irrigable land (semi-arid highlands) lead to high demand for local resources (Khelifi 2018; Berrouk et al. 2018, 2020) (Figure 1).

Sampling procedures

The capture of 257 individuals of *L. callensis* was carried out during the period 2015-2016. Fish sampling was carried out by local fishermen using gill nets, which are static capture tools composed of a monofilament nylon net mounted between a head-rope, and generally provided with floats and at the foot of lead wire (Chahinez et al. 2012; Berrouk et al. 2020). The fish lengths were measured by using an ichtyometer since the total weight was determined by a precision balance (0.01g). The sex of each individual was determined through direct observation, based on color and shape of gonads (Mimeche 2014).

Sex-ratio

Then, the chi-squared (χ^2) test was used to evaluate the variation of the observed values of the sex-ratio compared to the theoretical proportion of 0.5 by the formula:

$$\chi^2 = (m^2 / F) + (f^2 / F) - n$$

Where, m: number of males; f: number of females; n = m + f; F = n/2. Please note that this test is valid only for number of males or females higher than 5 (Wahiba et al. 2017).

Size-weight relationship

The relationship between the total length and weight of all samples and the two separated sexes was determined according to the following allometric equation: $P = a \times TL^b$, which can be transformed into logarithmic form as $\text{Log } w = \text{Log } a + b \times \text{Log } TL$. Where W is the total weight (g), TL is the total length (cm), a and b are the regression constants. The values a and b were determined through a t-test in accordance with the equation reported by Schwartz (1992). According to b values, the relationship becomes isometric ($b = 3.0$), positively allometric (minor) $b > 3$, and negatively allometric $b < 3$ (major).

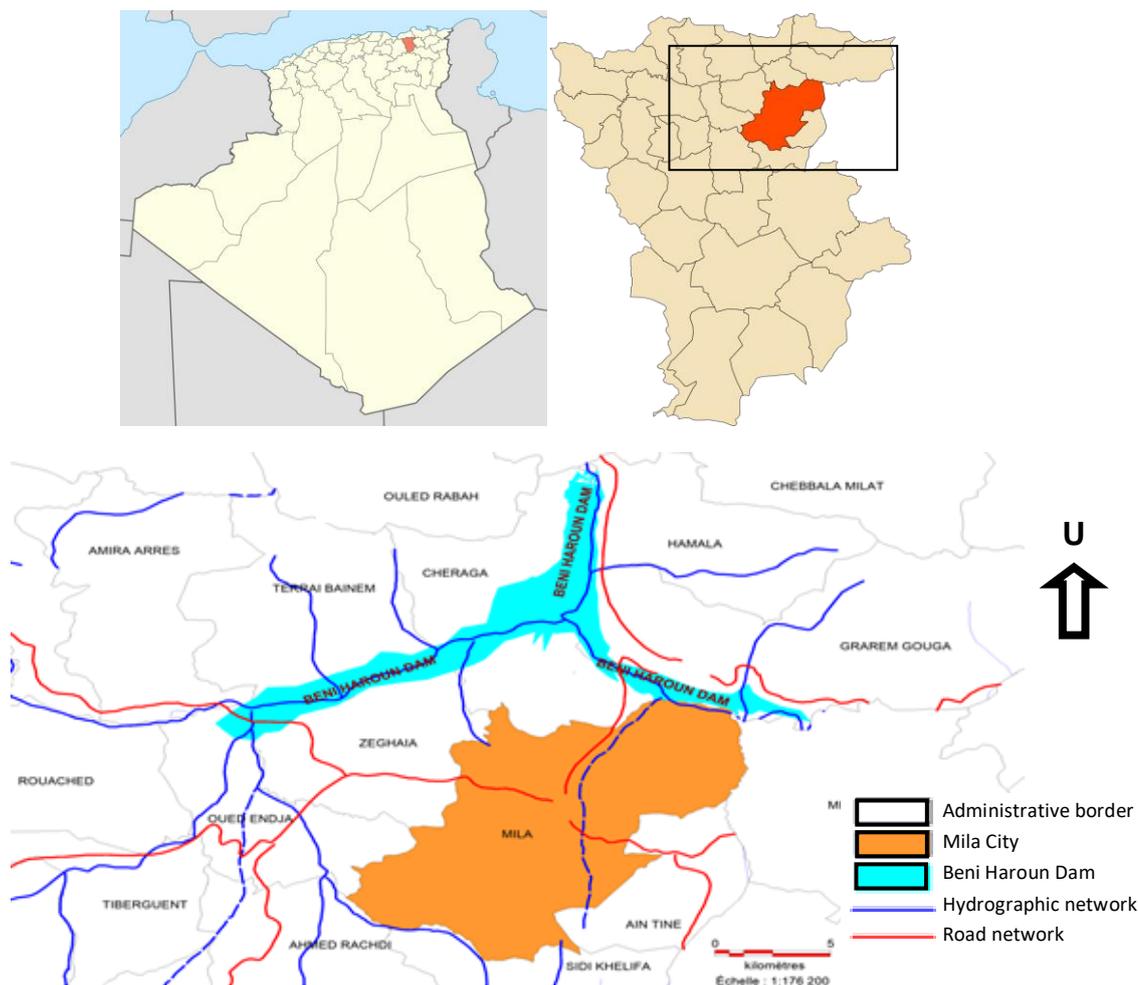


Figure 1. Geographical location of Beni-Haroun dam of Mila, north-eastern Algeria (Berrouk et al. 2019)

Determination of fish age

Fish age was estimated using scalimetry (direct reading of scales). The scales were taken from the lateral dorsal part of the body, where their appearance is the earliest stage scales were afterward cleaned by the running water, and rubbed between the thumb and forefinger to get rid of the tissue fragments and mucus covering them, then sorted under a binocular magnifier (Berrouk 2019). To perform the best possible estimation of fish age and to reduce the possible errors of fish scales analysis, three readings were carried out by three different observations. Hence, the adopted of fish age is that exhibiting a better agreement between the different readings (Khélifi 2018).

Determination of growth parameters

The growth parameters of *L. callensis* were determined via the analysis of size frequencies of 257 specimens allocated into size classes of 2 cm length. The equation of Von Bertalanffy (1938) based on the asymptotic length L_{∞} and the growth coefficient K is the most used equation by researchers, owing to its importance in determining the observed growth of the fish species, as well as it serves as a sub-model in the more complex models describing the dynamics of fish populations (Khélifi 2018).

The mathematical model is described by the following formula:

$$L_t = L_{\infty} (1 - \exp^{-k(t-t_0)})$$

Where, « L » is the length in function of age (or time), which is generally expressed in a year, while the parameters; L_{∞} , K , and t_0 characterize the performed adjustment, but the recent definitions that we can provide are as follow:

« L_t » is the fish length in time t (age), L_{∞} is the average length of the very old, known also as the asymptotic length L when the time (t) tends towards infinity. Of note, it must not be confused with the maximum length reached by the studied species, since it is possible to express the value of the asymptotic length L_{∞} by the empirical relationship of Pauly (1985):

$$L_{\infty} = L_{\max} / 0.95$$

Where K is the growth constant or the curvature parameter, representing the adjustment line slope between the length and the instantaneous increase, and t_0 (the initial condition parameter) is the theoretical fish age at zero length, but this is not the case in reality. The initial time (t_0) can be determined by the following empirical equation:

$$\log_{10}(-t_0) = -0.3922 - 0.2752 \times \log_{10} L_{\infty} - 1.038 \times \log_{10} K$$

Further, the growth parameters of the same species, of the same stock, or different stocks can be compared using Phi prime (Φ') test as designed by the following equation:

$$\Phi' = \log K + 2 \log L_{\infty}$$

The growth parameters of Von Bertalanffy (1938) equation (L_{∞} , K , and t_0) were determined by the method of Ford (1946).

RESULT AND DISCUSSION

Sex-ratio

Of a total of 257 examined individuals, we observed 92 males and 165 females, sex-ratio analysis was performed by studying global sex-ratio (Table 1). Females were generally more abundant than males, a significant difference between males and females throughout the year ($\chi^2 = 20.74$; $P \leq 0.001$) was noticed.

Size-structure of *Luciobarbus callensis* population

The distribution of size frequencies of individuals of *L. callensis* population has been established with two 2 cm-classes. The frequencies of males, females, and males/females (combined sex) were found to be close in the class interval 34-36 cm: (23.91%, 24.85%, 24.51%, respectively). Additionally, a frequency peak of 26.09% was noticed in males of size classes 32-34 cm, but it was absent in the following size classes: 20-22 cm, 42-44 cm, and 44-46 cm (Figure 2).

Determination of fish age

Age composition of 257 fishes of *L. callensis* is shown in Figure 3, and hence the scalimetric method enables us to decompose all the fish individuals into 7 classes of age ranging from 1 to 7 years. As can be seen from Figure 3, the frequencies of total population (combined sex) and females are abundant in the 7 classes, the frequencies of males are absent in the first and the seventh age classes.

Study of the fish growth

The values of asymptotic length for males, females and males/females (combined sex) are, respectively $L_{\infty} = 42.11$ cm, $K = 0.26 \text{ yr}^{-1}$, $t_0 = -0.58 \text{ y}$; $L_{\infty} = 47.37$ cm, $K = 0.29 \text{ yr}^{-1}$, $t_0 = -0.51 \text{ y}$, and $L_{\infty} = 47.37$ cm, $K = 0.20 \text{ yr}^{-1}$, $t_0 = -0.75 \text{ y}$. Moreover, the performance index value was found to be high in females (2.813) and close in males and combined sex (2.663 and 2.652, respectively). The slopes (or b values) of size-weight relationship were statistically different between sexes [Covariance analysis (ANCOVA), $F = 7617.684$, $p < 0.0005$ (Table 2).

The exponent b is significantly less than 3 (t-test, $p < 0.05$) for males, females, and combined sex, showing minor growth allometry of *L. callensis* (Table 3).

Table 1. Proportion of males and females in the population of *Luciobarbus callensis* in Beni-Haroun dam

Sex	Effective	Percentage
Females	92	64.20
Males	165	35.80

As shown in Table 4 and Figure 4, the length-weight relationship of the combined sex is determined following the following equations: $W = 0.115 \times TL^{2.354}$ ($R^2 = 0.88$, $n = 257$) for females, $W = 0.1104 \times TL^{2.370}$ ($R^2 = 0.89$, $n = 165$) and $W = 0.1683 \times TL^{2.237}$ ($R^2 = 0.85$, $n = 92$) for males.

Table 4. Length-weight relationship of *Luciobarbus callensis* in Beni-Haroun Dam, Algeria

	$W = a \times TL^b$	$\text{Log } W = \text{Log } a + b \times \text{Log } TL$
Males	$W = 0.1683 \times TL^{2.237}$	$\text{Log } W = -0.7737 + 2.237 \times \text{Log } TL$
Females	$W = 0.1104 \times TL^{2.370}$	$\text{Log } W = -0.9567 + 2.37 \times \text{Log } TL$
Combined	$W = 0.115 \times TL^{2.354}$	$\text{Log } W = -0.9391 + 2.354 \times \text{Log } TL$



Figure 3. Age composition of *Luciobarbus callensis* in Beni-Haroun Dam, Algeria

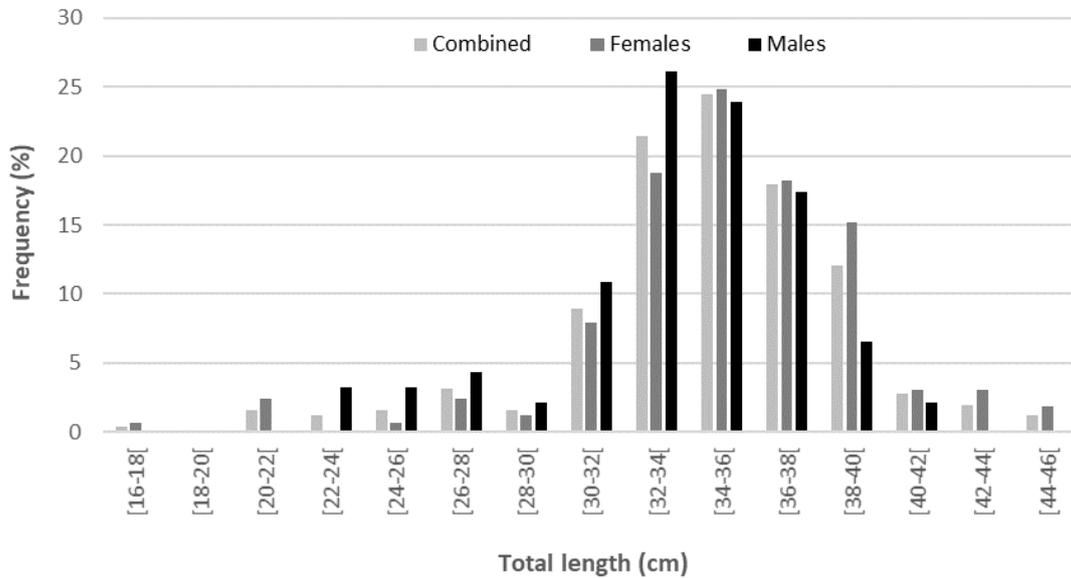


Figure 2. Length frequency distribution of *Luciobarbus callensis* collected from Beni-Haroun Dam, Algeria

Table 2. Parameters of the von Bertalanffy growth equation for males, females and all *Luciobarbus callensis* in Beni-Haroun Dam, Algeria

	n	L_{∞} (cm)	K (year ⁻¹)	t_0 (year)	θ^*	Lmin -Lmax
Males	92	42.11	0.26	-0.58	2.663	21.5-40
Females	165	47.37	0.29	-0.51	2.813	16.5-45
Combined	257	47.37	0.20	-0.75	2.652	16.5-45

Table 3. Length-weight relationship parameters for males, females and combined sex of *Luciobarbus callensis* in Beni-Haroun Dam, Algeria

	n	a	b	R ²	t_{cal}	Significance	Allometry
Males	92	0.1683	2.237	0.85	7.68	+	Minorant
Females	165	0.1104	2.37	0.89	9.64	+	Minorant
Combined	257	0.115	2.354	0.88	11.91	+	Minorant

n: sample size; a: intercept; b: slope; R²: coefficient of determination; t_{cal} : t-test calculated $p < 0.05$ [based on (Pauly 1984)]; GT, growth type (A-, Negative allometric growth)

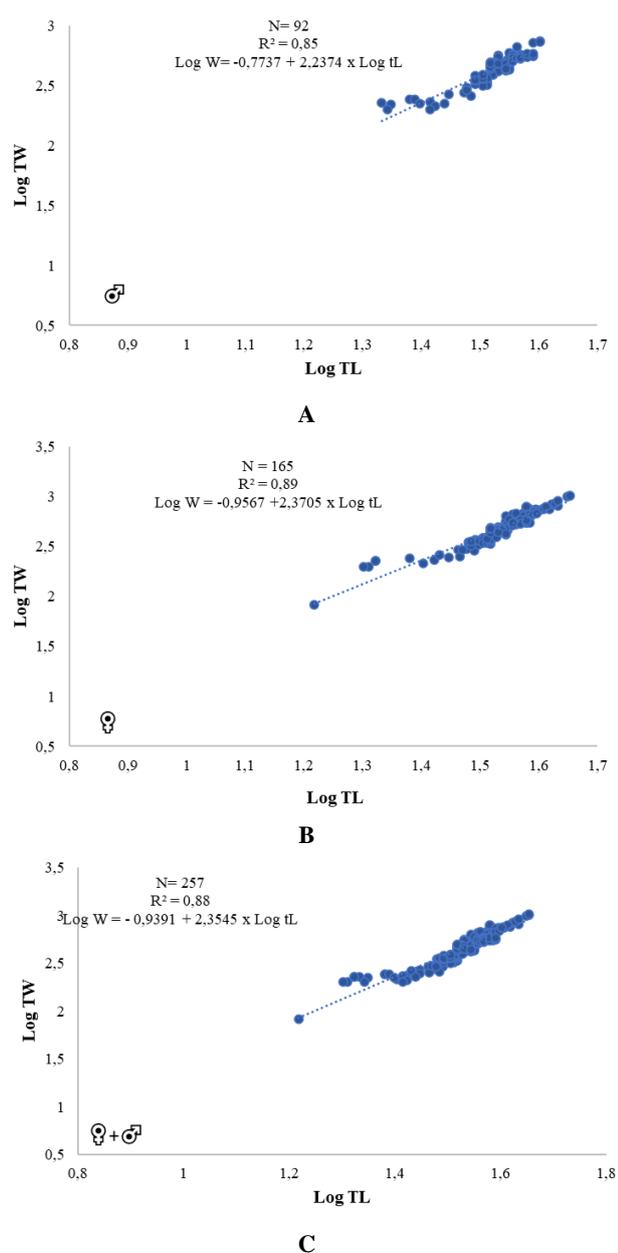


Figure 4. Length-weight relationships for males, females and combined sex of *Luciobarbus callensis*. A. Males; B. Females; C. Combined

Discussion

In the Maghreb, the native fish community is mostly dominated by Cyprinidae, in particular, endemic barbel species (Brahimi 2018). The omnivorous (barbel) fish species present one of the greatest specific diversities of fish classes, whose distribution is very extensive on three continents; Africa, Europe, and Asia (Kraiem 1998). A total of 257 specimens of both sexes (165 Females and 92 males) were examined and the global sex-ratio, shows that Females were generally more abundant than males, meanwhile a significant difference between males and females throughout the year, in this study, the age of *L. callensis* was determined using the scallometric method or

the direct reading of scales (Kraiem 1994; Mimeche 2014). The number of the appropriate specimens to determine the age classes were 257 showing sizes ranging between 16 and 46 cm. Also, the determination of fish age revealed 7 age classes in the combined sex (the total population) and females of *L. callensis*, however, males have shown only 5 age classes. Accordingly, our results are in agreement with the results of Mouaïssia (2018) study conducted on the same dam and the same species. The later exhibits 7 age groups of the total population and females, in addition to 5 age groups of males, along with sizes ranging between 16.5 and 47.5cm, and are also close to those of Morsi (2016) who have found in Wadi El-Harrach river (near Algiers) that *L. callensis* fish population can reach 6 years. Further, Khelifi (2018) has found that all the *Carassius carassius* specimens captured from Beni-Haroun dam can reach also 7 age classes, meanwhile, this same population includes 5 age classes in Ain El-Dalia dam. Richard et al. (2018) have found that *Hybognathus amarus* (Cyprinids) from Rio grande (New-Mexico) can reach also 5 years. In contrast, Mimeche et al. (2013) and Mimeche (2014) have found that *L. callensis* population from K'sob dam of the Maghreb region may reach fish longevity of 12 years, while Kraiem (1994) has proved that *L. callensis* from the Tunisian reservoir has maximum longevity of 14 years.

In this study, the observed maximum lengths were 40 cm for males, and 45cm for females and the combined sex, and these results are a little close to those of Ould Rouis et al. (2012) in Hamiz dam (North Algeria). The authors have reported maximum fish lengths of 44.5 cm for males and 46 cm for females, since the study of Mouaïssia, (2018) conducted on *L. callensis* fish from (Beni-Haroun dam) showed that males and females could reach, respectively the sizes of 39.5 and 47.5cm. Also, Bianco (1998) has indicated that the maximum size of *L. callensis* can reach 120cm. As previously reported (Gerdeaux 1985; Pourriot and Meybeck 1995), females have a more rapid growth than males. In regards to the asymptotic length values of the total population ($L_{\infty} = 47.37\text{cm}$) are a like to those of females ($L_{\infty} = 47.37\text{cm}$), but are higher than those of males ($L_{\infty} = 42.11\text{cm}$), and similarly to the results of Mouaïssia (2018) study performed on the same species and in the same dam, where females and males showed, respectively $L_{\infty} = 56.69\text{cm}$ and 43.09cm . Additionally, Brahmia (2017) has found in Oubeira Lake that the asymptotic length of *L. callensis* population was less significant (37.8cm), while Fatiha et al. (2017) have reported asymptotic length values of *Cyprinus carpio* from Foum Elkonga dam (Souk-Ahras city, northeast of Algeria) ranging between 48.83 cm in males and 58.28 cm in females and combined sex. Furthermore, the catabolism coefficient (K) value, in the present study, was found to be much higher in females (0.29) than that in males (0.26) and combined sex (0.20), and in this regard, Morsi (2016) have found for the same species from Wadi- El Haraach river a much higher K value in females (0.31) than males (0.23). Mouaïssia (2018) has reported a much higher K value in females of *L. callensis* than that of males from Beni-Haroun dam. These differences in K values would be somehow related to the

climatic conditions and genetic variations (Vazirzadeh and Yelghi 2015).

On the other hand, the values of performance growth index (\emptyset') were relatively lower in males (2.66), females (2.81), and combined sex of *L. callensis*. These results are very close to those reported by Mouaïssia (2018) in the same dam and same species (males: 2.71; females: 2.78; Combined sex: 2.80), some authors have reported \emptyset' values ranging from 3.04 to 3.82 in other sectors. These differences in \emptyset' values could be due to the hydrological characteristics differing from zone to others. On top of that, the allometric coefficient value of length-weight relationship indicates negative (minor) allometry in males ($b = 2.37$, $R^2 = 0.89$), females ($b = 2.23$, $R^2 = 0.85$) and combined sex ($b = 2.35$; $R^2 = 0.88$), suggesting thus the less rapid increase of weight compared to the length curve. Our results are in line with those reported from Mimeche et al. (2013) study conducted on K'sob reservoir, and which has shown inferior b value of *L. callensis* population than $b = 2.53$ and $R^2 = 0.93$. Also, our data concord with those of Khelifi (2018) who has found negative (minor) allometry in the growth of *Carassius carassius* (separated and combined sex) from Beni-Haroun dam. Whilst, Mouaïssia (2018) has reported a positive (major) allometry in the growth of females and combined sex of *L. callensis* from the same dam since males of the same species revealed an isometry growth. According to Wootton (1990), the size-weight relationship is variable in time under the influence of several biotic and abiotic factors, especially habitat, sex, season, and maturity of the gonads. Therefore, the study of size-weight relationship responds generally to two main objectives, the first one is to determine the individual weight whose size is known or vice versa, and to be able to convert size into weight or vice versa since the second objective is to describe the individual forms.

In many countries, the situation of freshwater fish is fairly well known with protection and conservation programs are underway. In Algeria, the exploitation of freshwater fishery resources has started to gain some speed only in the last few years. The study of biological traits is an important element in the description of any species of fish. Thus, this study is essential to gain fundamental insight and knowledge into the biodiversity and population structure which in turn should provide us with necessary tools for the management and conservation programs. The ecological research should increasingly support these efforts particularly for species with restricted distribution (Cooke et al. 2012; Mameri et al. 2018).

In summary, the results of this work are related to the contribution to the study of *L. callensis* fish growth in Beni-Haroun dam (Mila city, northeast of Algeria). The highlights of this work are provided below: (i) The scalimetric method showed the existence of seven age classes; (ii) The study of growth parameters of Von Bertalanffy (1938) has shown different values in asymptotic length (L_∞), growth coefficient (K), and performance index (\emptyset') in both sexes; (iii) The size-weight relationship of *L. callensis* population was characterized by negative (minor) allometry, which could be explained by the rapid increase of size compared to weight.

Conclusively, the study needs further research on the following points: (i) Increase the sampling efforts to provide a good insight into the total barbel population of Beni-Haroun dam; (ii) Study the maximum and minimum weights, asymptotic weight (W_∞), and the sex ratio; (iii) Perform supplementary works on the growth and the distribution area of Barbel fishes to provide a good understanding of their environmental dynamic; (vi) Perform similar works on the growth of Cyprinids fishes, like *Carassius carassius* and *Cyprinus carpio*, and study, even their growth parameters under parasite effects; (v) Study the physicochemical parameters on the biology of fishes.

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