AGE AND GROWTH OF THE FISH *LUCIOBARBUS CALLENSIS* (CYPRINIDAE) IN THE OULDJET MELLEGUE DAM (ALGERIA, TEBESSA)

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Abstract. The present study focuses on the growth of the species *Luciobarbus callensis*, which is a freshwater fish, more specifically in Algerian rivers and dams. A total of 211 specimens of *L. callensis* were collected from the Ouldjet Mellegue dam in Tébessa during a period from February 2022 to May 2023. The direct scalimetric method was used to determine age. This method showed six age groups for females and five age groups for males. Size frequency distributions and growth parameters were analysed using the von Bertalanffy method. According to the parameters of this method, female barbels (L∞=62.10, K=1.41, Φ'=3.73) show faster growth than males (L∞=51.05, K=0.57, Φ'= 3.17). The allometric coefficients of the size-eviscerated weight relationship indicate an isometric allometry for the whole population.
Keywords: *Algerian barbel, Cyprinidea, lenght-weight relationship, Von Bertalanffy method, Eastern Algeria*

Introduction

Freshwater fish are widely distributed in Algeria. They extend throughout the north, centre and south of the country, thus occupying different environments. Continental waters offer an extraordinary diversity of fish, to date there are approximately 67 species were identified belonging to 45 genera and 27 families (Lounaci, 2012).

The family Cyprinidae contains the largest number of freshwater fish species. The Algerian barbel, *Luciobarbus sp*, is an endemic species distributed in the Maghreb ecoregions (Saadi and Sebaa, 2022). *Luciobarbus callensis* (Valenciennes, 1842) is a characteristic species of North Africa, where it is very well represented in Algeria, Morocco and Tunisia (Djemali, 2005). This native species lives in dams and rivers in harmony with other allochthonous cyprins represented by: *Cyprinus carpio* (Linnaeus, 1758), *Carassius carassius* (Linnaeus, 1758), *Carassius auratus* (Linnaeus, 1758) and *Abramis brama* (Linnaeus, 1758).

Compared with sea fishing, the exploitation of freshwater fishery resources in Algeria is still relatively recent. The barbel is very abundant in Algerian dams and rivers and constitutes a very important fish mass. As a result, it favors the citizen to do tourist or commercial fishing. However, the Algerian government created an executive decree n° 04-86 of 26 Moharrem 1425 corresponding to March 18, 2004 setting minimum commercial sizes of biological resources. These minimum sizes correspond to the dimensions of the fish measured from the tip of the snout to the end of the caudal fin of

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the dorsal part. The minimum fishing size of *Barbus* is 30 cm and that of *L. callensis* is 15 cm (Mimeche, 2014).

According to Cooke et al. (2012), the study of biological traits is an important element in the general description of a species, this information is essential for the assessment of the role of biodiversity in the functioning of ecosystems.

Knowledge of growth is essential to conduct a study on fish stocks evolution, as well as on the organic production of an environment. This aspect are most often the ultimate aim of work carried out on African continental aquatic environments (De Merona and Ecoutin, 1979).

The study of growth requires a good knowledge of fish and of biotic and abiotic parameters. In fish, growth is continuous. There is therefore a relationship between length and age, and it varies according to the environment. Growth parameters can be excellent indicators of a fish's state of health and the quality of the environment in which it lives. Various methods are available to estimate growth (Alem and Amarouche, 2020).

Von Bertalanffy's (1938) model remains the most widely used (Hilborn and Walters, 1992). This model uses adjustment parameters that can be determined by different statistical methods (Walford, 1946; Gulland and Holt, 1959) or from computer programs (Saila et al., 1988).

Thus, it has the advantage of describing growth well in the interval of observed data and is easily incorporated into production models (Gaamour, 1999). This model has been so used in growth studies of different that it has become a standard model for comparing growth between populations and species (Dall et al., 1990; Wahle and Fogarty, 2006).

Despite the importance of *Luciobarbus callensis* (*L. callensis*), and its wide distribution in Algeria, studies on this endemic species remain limited and are relatively recent, relating to its biology, parasito-fauna, reproduction, growth (Djoudad et al., 2014; Morsi et al., 2015; Allalgua et al., 2015; Boucenna et al., 2015, 2018; Tolba et al., 2018; Berrouk et al., 2020).

It is this lack of knowledge of the growth biology of *L. callensis* at Ouldjet Mellegue dam (Eastern Algeria) that forms the basis of this work, and we will also address the relationship between the size of individuals and their weight, which is also necessary for analytical dynamics studies.

Materials and methods

Study area

The Ouldjet Mellegue dam is located 12 km upstream of the town of Ouenza, less than 75 km from the town of Tébessa and less than 100 km from the Mediterranean coast, in a region with low rainfall (around 350 mm per year). The dam site is located at the Ouldjet outlet through the Djebel Krorza of the Oued Mellegue (*Fig. 1*). The dam was built in 1954, and its initial retention capacity is estimated at 182.3 million m³ (Sayadi and Bekaddour, 2020).

Study method

Our sampling is random during the period from February 2022 to May 2023, we sampled 211 fish, including 124 males and 87 females. Fish were taken using gillnets (different mesh sizes: 20, 25, 30, 35, 40 and 45 mm), each net measuring 100 m of length for a drop of 3.5 m. The fish are collected early in the morning. The most fish caught were

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brought back alive to the laboratory, where they were identified according to criteria established by Fischer et al. (1987) measured (*Fig. 2*), dissected and euthanized by spinal sever ance. The care and use of experimental fish complied with national authorities for animal welfare laws, guidelines and policies as approved by Schedule 1 of the Animals (Scientific Procedures) Act 1986.

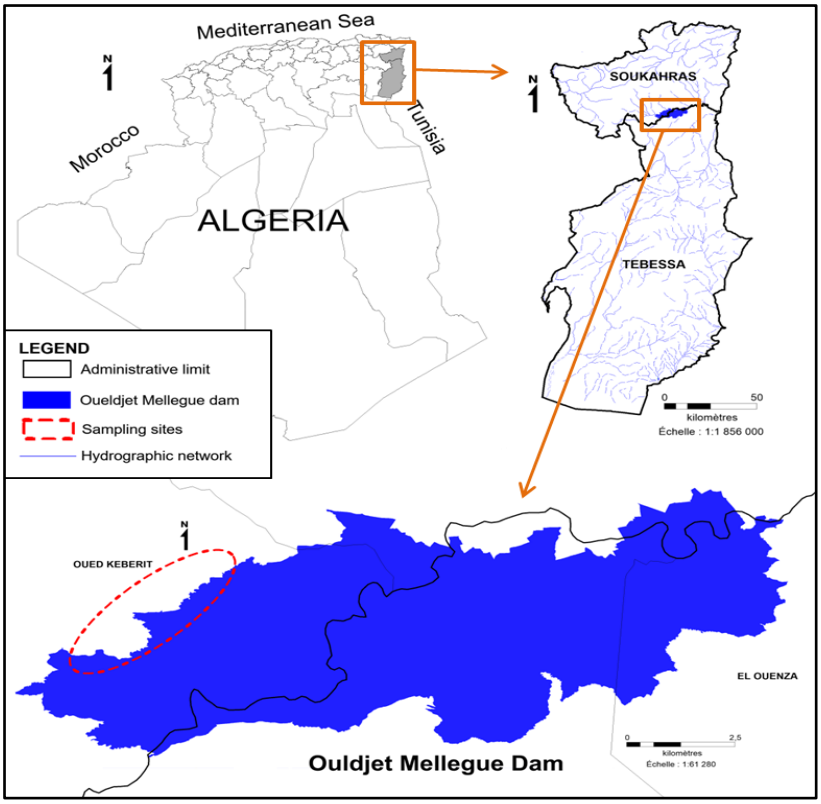

Figure 1. *Location of the Ouldjet Mellegue dam*

Figure 2. *The species Luciobarbus callensis (photos taken during the present study)*

The fish's sex was determined by observing the development of its gonads. Males have milky testes that are whitish in colour without any vascularization, while females have ovaries full of vascularized ovules with a more or less granular appearance.

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The age of the fish was determined by the direct method of studying the scales (scalimetry), where the age of the fish is estimated by counting the growth marks (growth arrest rings) (Meunier et al., 1979).

Statistical data processing

Sex-ratio and age

The sex ratio is defined as the proportion of males or females to the total population and is expressed as: Masculinity rate = M/ (F+M)*100; Femininity rate = F/ (F+M)*100 with: F: number of females; M: number of males.

The chi-square test ($\chi 2$) was used to assess the variation in observed sex-ratio values.

Age was determined using the scalimetric method, as our species has a body covered in scales.

Growth modelling

Absolute linear growth

Von Bertalanffy's (1938) mathematical model of individual growth established absolute linear growth. This is best suited to expressing individual growth in length and mass. Generally, the mathematical equation used to model growth is of the form *Eq.1*:

$$L_t = L_\infty(1 - e^{-k(t-t_0)} \quad \text{(Eq.1)}$$

with:
K: Growth coefficient determining the rate at which the fish reaches its maximum size; calculated using Fulton's formula (*Eq.2*):

$$K = W / L_t^b \quad \text{(Eq.2)}$$

where,
L_t: Length at time t; L_∞: Maximum or asymptotic length, is done by the method of Pauly (1985), it is based on the maximum length (Lmax), observed in a species, its formula is expressed as follows (*Eq.3*):

$$L_\infty = L_{max}/0{,}95 \quad \text{(Eq.3)}$$

and t_0: theoretical age at which size and weight are zero. According to Pauly (1979), this is determined using the following empirical equation (*Eq.4*):

$$Log10\,(-t0) = -0.3922 - 0.2752 \times Log10\,L\infty - 1.038 \times Log10\,K \quad \text{(Eq.4)}$$

Growth performance index Φ'

The growth performance index (Φ') was calculated by the empirical equation (*Eq.5*) of Munro and Pauly (1983):

$$\Phi' = log\,K + 2log\,L\infty \quad \text{(Eq.5)}$$

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Length -weight relationship (relative growth)

The expression of the relationship between length and weight of a fish results in the following equation (*Eq.6*) (Ricker, 1975):

$$W = a \, . \, L_t^b \quad \text{(Eq.6)}$$

By logarithmic transformation, this equation can be made linear in the form (*Eq.7*):

$$Log\ W = b\ log\ Lt + Log\ a \quad \text{(Eq.7)}$$

with:

W: Weights (g); Lt: Total length (cm); a: proportionality constant; b: allometry coefficient.

The adjustment of this linear model to the observed size-weight data is obtained by the method of least rectangles. Statistically, the coefficient value b is compared to $b_0 = 3$ at the threshold $\alpha = 0.05$ using the Student t-test (*Eq.8*) (Dagnelie, 1975):

$$t_{cal} = \frac{|b^2 - b_0^2|\sqrt{n-2}}{2b_0 * b\sqrt{1-r^2}} \quad \text{(Eq.8)}$$

When b = 3, the growth is said to be isometric. If b <3: allometry is minorant. When b >3, allometry is majorante.

The significance of the Pearson correlation was verified using Student's t test and the difference in lenght-weight relationship between the two sexes was tested by ANCOVA (Dagnelie, 1975).

Weight growth

Von Bertalanffy's (1938) descriptive model of weight growth is written as follows (*Eq.9*):

$$W_t = W_\infty (1 - e^{-k(t-t_0)})^b \quad \text{(Eq.9)}$$

with:

Wt: total weight in grams at t time; W_∞: asymptotic weight corresponding to L_∞; b: allometry coefficient; k et t_0: parameters of the Von Bertalanffy equation.

Data analysis

In the calculations of the present work, we retained the eviscerated weight (We) to eliminate variations due to the state of stomach contents and the degree of weight evolution of the gonads, using R 4.3.3 (R Development Core Team, 2022). The normality of the results was tested by the Shapiro Wilk test. All graphs were performed using package "ggplot2" for Aesthetics Data Visualization (Wickham, 2016).

The statistical significance of the difference in lenght-weight relationship between the two sexes was verified with an analysis of covariance (ANCOVA) using "tidyverse", "ggpubr", "rstatix" and "broom" packages (Wickham et al., 2019; Kassambara, 2023a,b).

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Results

Sex-ratio

The population, represented by a sample of 211 *L. callensis* individuals, is structured as follows: 124 are males (M = 58.76 %), 87 females (F = 41.23 %) (*Table 1*). The overall sex ratio (SR) determined during our sampling was 70.16%. It was consistently in favour of males throughout the sampling period ($\chi 2$=46.06; $p<0.001$).

Table 1. *Percentage of sexes of L. callensis in Ouldjet Mellegue dam*

Sex	Workforce	Percentage	Sex-ratio
♀	87	41.23 %	70.16%
♂	124	58.76 %	

Size structure

Examination of 211 specimens of *L. callensis* shows that the total lengths of combined sexes ranged from 20 cm to 59 cm. We note that the lowest size was recorded in males and the highest in females (*Fig. 3*).

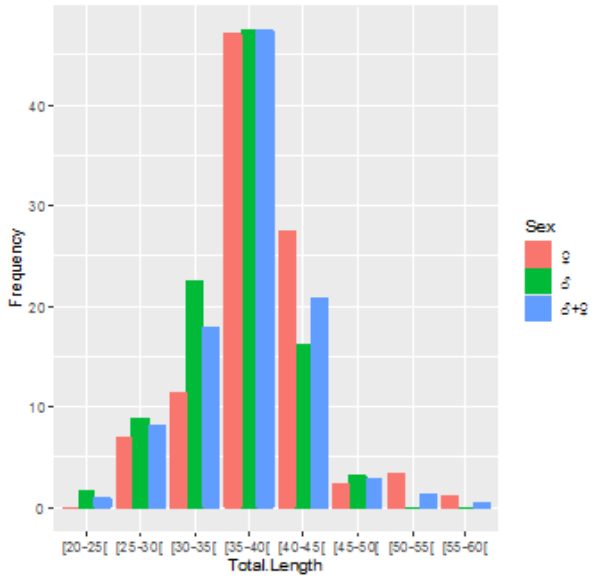

Figure 3. *Size structure of Luciobarbus callensis from Ouldjet Mellegue dam*

The size class [35-40[which presents the highest frequency (F = 47.39%). However, the lowest frequency value (F =0.47%; 0.95%) is recorded by the size classes of [55-60[and [20-25[respectively. In Owr stady, we note the absence of large male specimens and small female specimens (F = 0%).

Age structure

The scalimetry method allowed us to decompose all the specimens of *L. callensis* in six age classes (from 1 to 6 years), Age class 3 was found to have the highest frequency for the total population (F = 37.91%), males (F = 37.90%) and females (F = 37.93%). However, males show only five age groups (1+ to 5+ years) (*Fig. 4*).

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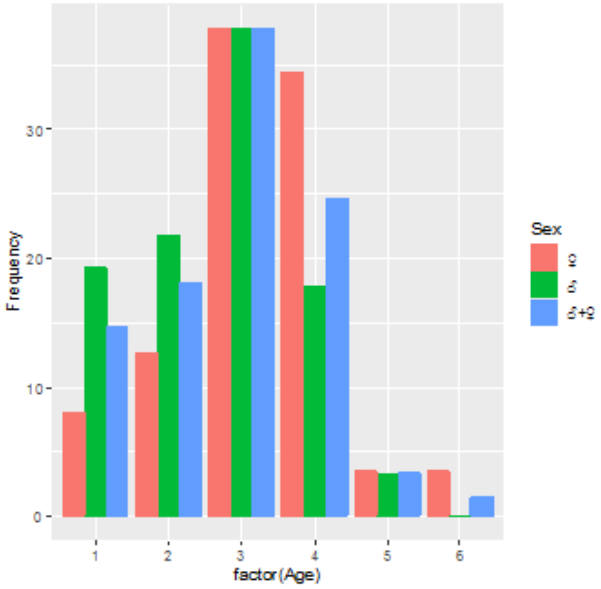

Figure 4. *Age composition of Luciobarbus callensis from Ouldjet Mellegue dam*

Absolute linear growth

The asymptotic sizes (L∞) obtained for the total population (62.10 cm), females (62.10 cm) and males (51.05 cm) are larger than the observed maximum sizes (59 cm, 59 cm and 48.50 cm respectively). Thus, the asymptotic size (L∞) of females is larger than that of males with a difference of 11.05 cm. In contrast, the growth constant (K) for females (1.41) was greater than that for the total population (0.87) and males (0.57) (*Table 2*). The growth index of Munro and Pauly (1983) is 3.73 for females, 3.52 for males and 3.17 for the combined sexes.

Table 2. *Parameters of the Von Bertalanffy linear growth equation of both sexes and the combined sex of L. callensis*

Sex	L∞	K	T_0	Φ'	L min	L max	Equation
♂	51.05	0.57	-0.25	3.17	20	48.5	$L_T=51.05\ (1-e^{-0.57\ (t+0.25)})$
♀	62.10	1.41	-0.09	3.73	27	59	$L_T=62.10\ (1-e^{-1.41(t+0.09)})$
♂+♀	62.10	0.87	-0.15	3.52	20	59	$L_T=62.10\ (1-e^{-0.87(t+0.15)})$

Length-weight relationship (relative growth)

Figure 5 represent regression lines linking eviscerated weight and total length for each sex as well as the combined sex of *L. callensis*.

The results show a highly significant correlation between the total length of the fish and its eviscerated weight for the total population ($t=47.05$; $p<0.001$), males ($t=35.83$; $p<0.001$), and females ($t=29.50$; $p<0.001$).

The results obtained by the weight-size equations are recorded in *Table 3*. These equations show positive correlations of all *L. callensis* individuals. The slopes or b-values of the size-weight relationship, differ statistically between the two sexes (ANCOVA covariance analysis size/weight relationship ($F=5.50$ and $p<0.05$).

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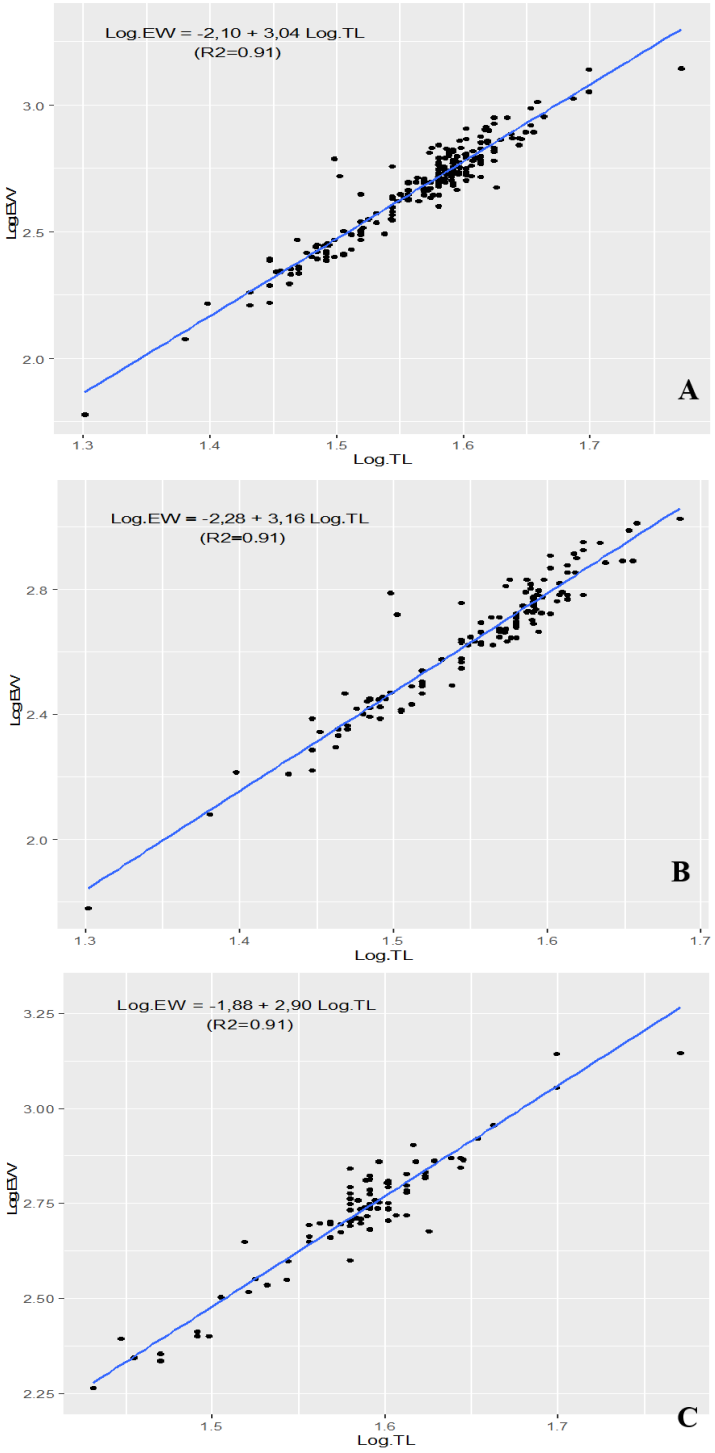

Figure 5. *Length-weight relationships for combined and separed sexes of Luciobarbus callensis. A: combined sexes; B: males; C: females*

For the total population (males, females and sex combined), the estimated values of b (regression slopes) are statistically equal to the theoretical slope $b_0 = 3$ (*Table 3*), this would indicate that the latter are characterized by isometric growth for eviscerated weight and height.

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Table 3. *Size-weight relationship parameters for both sexes and the combined sex of L. callensis*

Sex	N	a	b	R^2	t_{cal}	Allometry	Equation
♂	124	0.0053	3.16	0.9132	1.95(=)	Isometry	$W_E = 0.0053L_T^{3.16}$
♀	87	0.013	2.90	0.9110	1.04(=)	Isometry	$W_E = 0.013L_T^{2.90}$
♂+♀	211	0.0079	3.04	0.9137	0.65(=)	Isometry	$W_E = 0.0079L_T^{3.04}$

N: simple size; a: intercept; b: slope; R^2: coefficient of determination; t_{cal}: t-test calculated

Absolute weight growth

The adjustment parameters (L∞, k and t_0) of the Bertalanffy mathematical equation and the allometry coefficient (b) give us the model of absolute weight growth presented in *Table 4*.

Table 4. *Parameters of the Von Bertalanffy weight growth equation for both sexes and the combined sex of L. callensis*

Sex	Equation
♂	$P_T=1322.95\ (1-e^{-0.57\ (t+0.25)})^{3.16}$
♀	$L_T=2065.98\ (1-e^{-1.41(t+0.09)})^{2.9}$
♂+♀	$L_T=2238.21\ (1-e^{-0.87(t+0.15)})^{3.04}$

Total asymptotic weights W in males, females and sexes combined (1322.95 g; 2065.98 g and 2238.21 g, respectively) were greater than the maximum total weights sampled (1251.2 g, 1753.3 g and 1276 g, respectively).

Figure 6 shows that there is no remarkable difference in weight growth between females and males. At 5 years, we note that weight growth in females (mean Wt = 1189.63 g) is slightly greater than that of males (mean Wt = 1127.85 g).

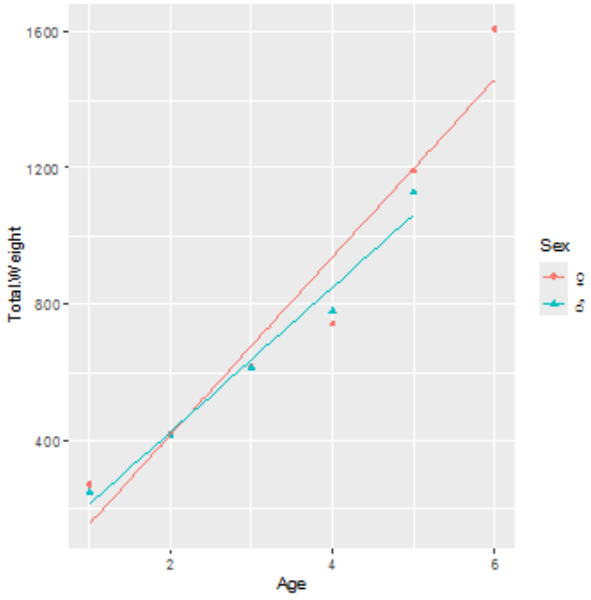

Figure 6. *Theoretical weight growth curve of Luciobarbus callensis*

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Discussion

The linear growth of the Algerian barbel (*Luciobarbus callensis*) from Ouldjet Mellegue dam (Tébessa) was studied according to the model of Von Bertalanffy (1938), and was applied for the separate sex and for both sexes combined.

The size distribution of the population shows a dominance of sizes between 35 cm and 40 cm. In *L. callensis*, age was determined by reading the hyaline lines *(annulu*) on the scales (scalimetric method) (Kraiem, 1994; Bouhbouh, 2002; Morsi et al., 2015). This direct method has given very satisfactory results (Arrignon, 1976; Meunier, 1988).

Six age groups have been isolated in the *L. callensis* population. According to Nikolskii (1969), this age range is accepted as an indicator of sufficient food availability.

The maximum age determined does not exceed 5 years for males and 6 years for females and the total population. These structures shown in Ouldjet Mellegue dam are close to those observed in the population studied in Oued El-Harrach (Algeria) by Morsi et al. (2015), which shows a population reaching up to 6+ years of age. Similarly, Mouaissia (2018) reported a maximum age of 8 years for the barbel of the Béni Haroun dam (Mila, Algeria).

On the other hand, the age structure of the specimens of *L. callensis* from our study dam was different from that observed in other regions of the Maghreb namely the K'sob dam where the life of the population living in this dam was long, with at least 12 age groups observed (Mimeche et al., 2013; Mimeche, 2014) and the Allal El Fassi dam in Morocco (Bouhbouh, 2002). So Kraiem (1994) confirmed that the species *L. callensis* has a maximum longevity of 14 years in Tunisian reservoirs.

The maximum lengths observed in our study (Lt) were 59 cm for 6-year-old females, compared with 48.5 cm for a 5-year-old male. Our results are similar to those obtained in Beni Haroun dam (Mila) (Mouaissia, 2018) and in Hamiz dam lake (Algeria) (Oueld Rouis et al., 2012), where the maximum lengths detected were 44.50 cm (with an age of 8+ years) and 46 cm respectively.

The maximum size of the fish captured in Sidi Salem dam and Joumine dam in Tunisia (Kraiem, 1996), as well as Oued El Harrach (Morsi et al., 2015) in Algeria are too small (not exceeding 30 cm) than that of the fish captured in our study.

Indeed, the age structure of our specimen study from Ouldjet Mellegue dam differs markedly from that of previously studied populations. Bianco (1998), reports that the maximum size of the genus *Luciobarbus* reaches 120 cm.

The adjustment of the growth of *L. callensis* by the Von Bertalanffy model gives: $L\infty$ = 62.10 cm, K = 0.87 year^{-1} and t_0 = - 0.15 years for the total population, $L\infty$ = 51.05 cm, K = 0.57 year^{-1} and t_0 = - 0.25 years for males and $L\infty$ = 62.10 cm, K = 1.41 year^{-1} and t_0 = - 0.09 years for females.

This model shows that the asymptotic size values for females are higher than for males. According to some authors, females have faster growth than males (Pourriot and Meybeck, 1995).

As has been shown in *L. callensis* from other regions, but also in many fish species, there is a difference in growth between males and females.

Females grow faster than males and reach a larger asymptotic size. Mouaissia (2018) also noted this at the Beni Haroun dam in Mila, Algeria. These authors mention that the asymptotic length can reach 56.69 cm in females of *L. callensis* and 43.09 cm in males. Similarly, the study by Boubouh (2002) in the Allal El Fassi reservoir in Morocco showed that females reached an asymptotic length of 32.73 cm, while males reached only 29.55 cm.

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On the other hand, lower asymptotic values are noted: In Algeria, in the Oued El Harrach, Morsi et al. (2015) show that males ($L\infty = 26.25$ cm) reach a greater asymptotic length than females ($L\infty = 23.16$ cm).

In terms of growth rate (K) for barbel, our results are slightly higher for females than for males and both sexes combined. Our data are similar to those reported in Algeria, by Allalgua (2017) in the Foum EL Khanga dam ($K = 1.05$ years^{-1} in parasitized males and 2.39 in non-parasitized males), and by Brahmia et al. (2016) in Lake Oubeira ($K = 0$, 78 years^{-1}).

According to Vazirzadeh and Yelghi (2015), these differences in growth rates are related to climatic conditions and genetic variations. The difference in growth between the two sexes allows females to reach larger sizes than males at the same age (Godinho, 2001).

However, our results are higher than those recorded in Algeria by Mouaissia (2018) ($K = 0$, 32 years^{-1}), and by Boubouh (2002) in the Allal El Fassi reservoir in Morocco ($K = 0.105$ years^{-1} in female barbel).

In explaining these differences in growth parameters (L and K), Kapoor and Khanna (2004) indicate that environmental factors such as water temperature, food, low water quality, fish biology and hormones are the major factors that influence growth. Geographically different fish populations can influence individual growth (Wootton, 1990).

Estimates of the Φ' performance index provide an indicator of the reliability of the results, as they suggest that the values are similar for the same species and genera. The value of the growth performance index obtained in this study in the Ouldjet Mellegue dam is between 3.17 and 3.73, indicating good sampling and uniform selection of *L. callensis* specimens. Indeed, according to Baijot et al. (1994), the results of the population study are reliable only if the values of the growth performance index are between 2.65 and 3.32.

The value obtained from (Φ') in the *L. callensis* population of the Ouldjet Mellegue dam (Tébessa, Algeria) (Φ'= 3.52), is close to that obtained in Algeria by Allalgua (2017) in the Foum El-Khanga dam at Souk-Ahras (Φ'= 3.04), but it is higher than those obtained in Algeria (Mila) by Mouiaissia (2018) in the Beni Haroun dam lake (Φ'= 2.80).

Regarding the relative growth or size-weight relationship in *L. callensis* of the Ouldjet Mellegue dam (Tébessa, Algeria) is isometric in females, males and both sexes combined ($b = 2.90$; $b = 3.16$ and $b = 3.04$ respectively), indicating that length and weight increase proportionally. Our results are consistent with those of Penczak and Molinski (1984) in Oued Sebaou, Brahmia et al. (2016) in the lake Obeira and Mouaissia (2018), who found an isometry of growth in males, but a majoring allometry in females of *L. callensis*.

In the study in Oued El-Harrach by Morsi et al. (2015), "b" values show an isometry between length and weight in both sexes (b=3.021). However, Mimeche et al. (2013) showed in the K'sob reservoir a b-value of less than 2.53 and $r^2 = 93\%$. The origin of the samples and the living conditions of the different media could explain this difference in the allometric coefficient.

This relationship (size-weight) is variable over time under the influence of several biotic and abiotic factors, including habitat, sector/season effect, stomach vacuity, gonad maturity, sex, overweight and ontogenic development of caught specimens (Tesch, 1971; Wootton, 1998).

The study of the size-weight relationship generally meets two objectives in fisheries: the determination of the weight of individuals whose size we know or vice versa and the

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description of forms, overweight and its variations during growth. These parameters are of practical interest in the problems of rational exploitation of animal populations where, in order to maximum yield, it is important to know how to translate size into weight or weight into size and to have an easy-to-calculate parameter that characterizes the overweight of the specimens and its evolution over the year or their life (Belhoucine, 2012).

Variations in environmental factors such as water, temperature, quantity and abundance of food are likely to explain the variation in growth parameters between different regions (Mert and Bulut, 2014).

Conclusion

This study shows that:

For all individuals (n = 211) of Algerian barbel (124 males and 87 males), the total length varies between 27 cm and 59 cm in females and between 20 cm and 48.5 cm in males. The scalimetric method shows the existence of six age classes for barbels from the Ouldjet Mellegue dam in Tébessa.

Von Bertalanffy's (1938) growth parameters differ between the sexes, namely the asymptotic length (L∞), the growth coefficient (K) and the performance index (Φ). For the size/eviscerated weight relationship, the population of L. callensis is characterized by an isometric allometry (weight evolves proportionally with the cube of size) in males, females and sexes combined.

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