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Research Paper

Length-weight relationship of a native fish in different freshwater systems in Algeria

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ABSTRACT

The objective of the present study was to identify the differences between the population structure and the biometric relationships of the cyprinid *Barbus callensis* Valenciennes, 1842, living in different freshwater systems: El Harrach wadi located about 12 km east of Algiers and Hamiz dam situated 35 km from Algiers. We conducted sampling monthly from March to June 2013. In both freshwater systems, we collected two hundred and thirty-one individuals of *B. callensis*. For each individual, the total standard lengths and the total weight were measured using an electronic scale. The results showed isometric growth for both barbels living in the wild and living in an artificial environment. Here, we provide new finding regarding maximum size recorded in *B. callensis*: in our sampling, the heaviest fish caught in the dam was a female weighing 904 g corresponding to a total length of 43.5 cm. This recorded size exceeds that published (30.0 cm) by Fishbase. This comparative growth of *B. callensis* in different hydrosystems is new in Algeria and interesting information about this species is given: males, females and juveniles are present in the river as well as in the dam. Furthermore, we point out that barbels have isometric growth in natural and artificial environment.

Key words: Invasive species, El Harrach wadi, North Africa, condition factor, juveniles, vulnerable habitats, Hamiz dam.

INTRODUCTION

The fish *Barbus callensis* is an endemic species of Northern Africa (Pellegrin, 1939; Almaça, 1972). This species is synonymous of *Barbus setivimensis* Valenciennes, 1842 (Lévêque and Daget, 1984). It lives in freshwater ecosystems, which are particularly vulnerable habitats with high biodiversity. Absolutely, more than twelve thousand fish species live in these biotopes (Berra, 2008) where fauna is dominated by Cyprinidae: family which includes *B. callensis* Valenciennes, 1842. In Algeria, despite its wide distribution in rivers, the information concerning it in literature is lacking or fragmentary. This species is now attracting increasingly the curiosity of many researchers, whose most recent works can be cited (Bacha and Amara 2007; AberkaneandIguer-Ouada, 2011; Kara, 2012; Mimeche et al., 2013; Ould Rouis et al., 2016; Fergani and Arab, 2017; Aberkane et al., 2018). In addition, we cite published data of some authors who have highlighted reproductive traits and various ecological characteristics related to this species (Doadrio, 1994; Berrebi et al., 1995; Kraiem, 1996, 1997; Ould Rouis et al., 2012).

Our findings aim to describe biometric parameters such as length-weight relationship, condition factor (K) and here, for the first time, we compare the growth allometry of this native fish living in freshwater ecosystems as 'El Harrach' a natural lotic river and 'Hamiz' lake, an artificial lentic dam. Such comparative studies on the growth of this species in two completely different environments are very rare or absent in the literature. It is therefore a contribution to knowledge the biology and growth parameters of this originally fluvial fish, which is currently locked up in dam lakes, built across watercourses in order to retain water.

Finally, the present study could be useful for better fish

management of our water bodies and, in particular, for the sustainable development and conservation of this species subjected not only to several types of pollution but also, to a continuous stocking which is carried out without prior studies.

MATERIALS AND METHODS

Study site

The study was undertaken in two different ecosystemsof Algeria(Figure 1): El Harrach river (hereafter called wadi), one of the largest streams that crosses the Mitidja plain (minor width of the bed from 7 to 16 m). The wadi originates in the Blida Atlas Mountains near Hammam Melouane. It is 67 km long and flows into the Mediterranean, right in the middle of the bay of Algiers. It has an average flow of 4 to 5 m^3 s^{-1} but this can rise to 3000 m^3 s^{-1} in times of flood (Aroua and Berezowska-Azzag, 2009). The dry period extends from mid-May to the end of September, so there is an irregularity of the hydraulic regime, leading to an almost total drying in summer.

The sampling station located at an altitude of 273 m (Figure 1A) is far from any source of pollution (36° 27' 46 N, 03° 01' 46 E). A vegetative cover of approximately 50% characterizes the watershed where, we can recognize generally *Pinus halepensis*, *Pistachia lentiscus*, *Olea europea*, *Nerium oleander* and *Ceratonia siliqua.* In El Harrach wadi, the barbel: *B. callensis* cohabits with the European eel: *Anguilla anguilla* (Linnaeus, 1758) which is considered as a vulnerable species, threatened with extinction (Loucif et al., 2009). Next to these fish live other animal species such as the green frog: *Hyla arborea* (Linnaeus, 1758), the common toad: *Bufo bufo* (Linnaeus, 1758), the freshwater snake: *Coronella* sp., freshwater crabs and insect larvae such as Odonata (Hafiane et al., 2016).

The second, El Hamiz dam (hereafter called Hamiz), is one of the oldest Algerian dams located 35 km southeast of Algiers city, at 158 m altitude and 25 km from the sea. The Khemis El Khechna region has a Mediterranean climate. The dry period also spreads over 5 to 6 months and a longer wet one from October to April (7 months). The Hamiz, a relatively regular basin, built on wadi Arbatache is oriented from northeast to southwest extending over an area of 128 ha and has a maximum depth of 45 m. Precipitation, air and water temperatures are extremely variable. Water salinity does not exceed 0.3%, has slight alkaline pH, and well-mineralized (1042 m*S* cm^{-1}) with 0.015 mg/ml of dissolved oxygen. On the lake, we chose a sampling station (Figure 1B) (roughly 20 m depth) near the dike (36º 35' 59'' N, 3º 20' 50'' E). Moreover, the water level in the reservoir depends on rainfall, evaporation and the use of water for irrigation and for drinking.

Several fish species live in community with *B. callensis* in the Hamiz: the invasive common carp: *Cyprinus carpio*, Linnaeus, 1758; the silver carp: *Hypophthalmichthys molitrix* (Valenciennes, 1844) and the bighead carp: *Hypophthalmichthys nobilis* (Richardson, 1845). These invasive carps were introduced into the lake without any prior study (Ould Rouis et al., 2016), simply because they are good indicators of water oxygenation and for their protein supply to the inhabitants living around the dam.

Sampling methods

In the dam (the lentic environment), fish were collected monthly using trammel nets which were dropped near the dike and remain immersed in the water for one night. Next day, we removed them from water and then fish were collected and sacrificed.

In the wadi (the lotic environment), where water is permanent in nature and the speed of the current is variable, fish sampling was made by electric fishing. At the end of sampling, we immediately transported the fish in coolers to the laboratory and examined it in the same day. The sexes were identified by macroscopic observation of the gonads after dissection of the fish.

Statistical analyses

All values of parameters were kept and analyzed. The relationship between the total weight (Wt± 0.1 g) and the total length (Lt ± 0.1 cm) was established by the Le Cren's (1951) equation: $W = aL^b$, where a is the regression intercept and b expresses the growth rate. The ratio of sexes was expressed as: Rs = (Nf / Nm) * 100, where, Nf: number of females and Nm: number of males. The condition factor (K) was calculated using Fulton's (1904) formula: $K = 100WL^{-3}$.

The intensity of the relationship between the two variables (length/weight) is given by Pearson's "r" (Borsali, 2010).

RESULTS

Features of fish population

One hundred and twelve specimens of *B. callensis* were collected in Hamiz. The observation of the gonads showed twenty-one males and eighty-eight females. Immature fish (2.7 %) were not considered in this study.

On the other hand, one hundred and nineteen individuals of the same species were captured in the wadi. Of these, sixty-six were males, forty-nine were females and again, we set aside 3.4% immature fish.

Among the fish caught, there was a clear difference in size between those who live in El Harrach wadi and those of Hamiz dam. Absolutely, 50% of the fish caught in the wadi

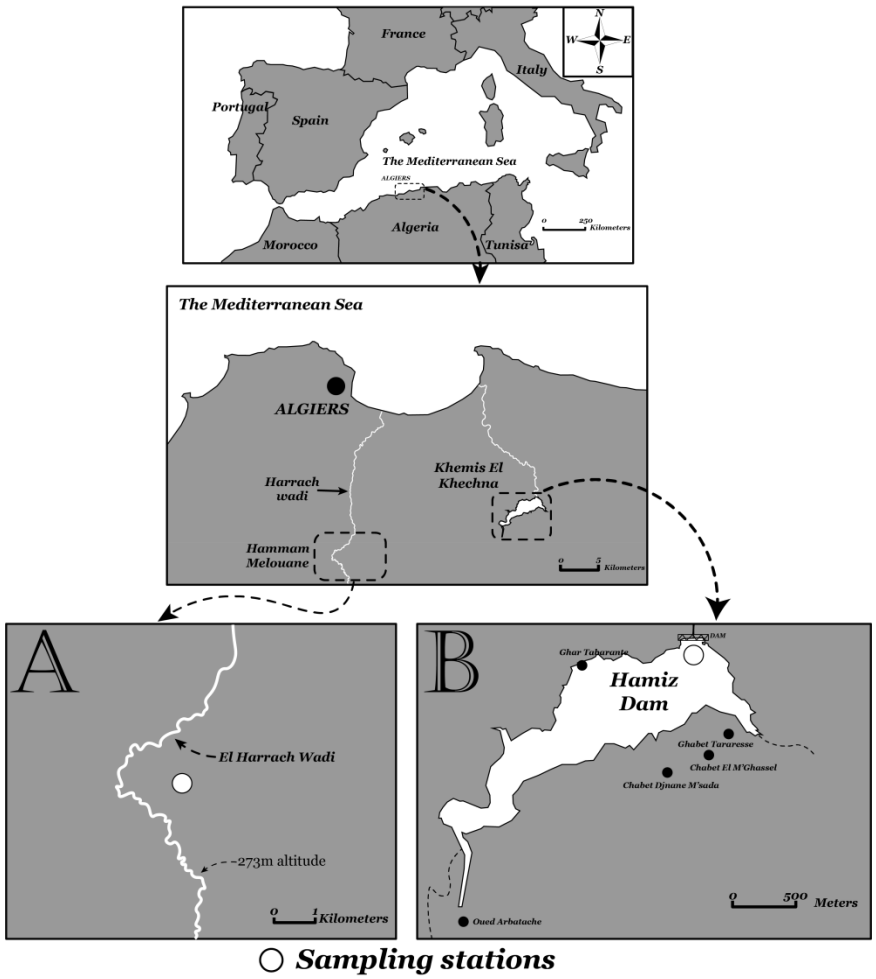

Figure 1: Location of the sampling stations on both El Harrach wadi (A) and Hamiz dam (B).

were small (6.9 cm ≤ Lt < 12.8 cm). While, 50% of the fish caught in the dam were larger in size (19.3 cm ≤ LT < 32.7 cm). Furthermore, most of the individuals caught in Hamiz were females. However, fish of the wadi were mostly represented by males. In the dam, half of the females had average sizes (19.3 cm ≤Lt < 33.95 cm) while, the size of all females captured in the wadi are less or equal 21 cm. A comparative study of males size in the two water bodies showed that the total length of individuals living in the wadi does not exceed 17.4 cm, while the size of half males fish caught in the dam varies from 25.1 to 29.2 cm.

Sex ratio

In the wadi, the sex ratio is in favor of males (χ^2 = 24.70, p = 0.0059) and in the dam, it is significantly different from the theoretical 1:1 sex ratio (χ^2 = 62.89, p < 0.05)(Table 1). In the dam, it appears that females are of large size (Lt ≥ 31.40 cm) unlike in the wadi, fish of size less than 13.95 cm are mainly males and individuals greater than or equal to this value are mainly females.

The size frequency distribution (Figure 2) shows a similar evolution where, two cohorts could be identified: in the wadi, there were more young barbels (40) than in the lake (25). Moreover, in the first biotope, the size of young fish ranged between 11.78 cm ≤ Lt < 14.22 cm, while in the second, it varied between 31.30 and 33.74 cm.

Length-weight relationship and condition factor

The determination coefficient (R^2) between length and weight variables was high, indicating a strong Pearson correlation coefficient (0.93 ≤ r ≤ 0.99) (Table 2). In addition, the average condition values (K) of fish (all sexes mixed) in both ecosystems were approximately equal (Table 2). This condition value was relatively low probably due to the influence of external (environmental) or internal (physiological) factors.

Table 1: Variations in the sex ratio (females/males) according to size classes in *B. callensis*

Biotopes	Size classes (cm)	Frequencies	χ^2
El Harrach Wadi	[0-6.90]	1	1.00
	[6.90-8.31]	5	1.80
	[8.31-9.72]	16	2.25
	[9.72-11.13]	15	3.77
	[11.13-12.54]	21	4.26
	[12.54-13.95]	23	1.09
	[13.95-15.36]	8	4.50
	[15.36-16.77]	7	0.14
	[16.77-18.18]	18	0.89
	[18.18-19.59]	4	4.00
	≥ 19.59	1	1.00
Hamiz Dam	< 24.14	4	2.00
	[24.14-26.56]	6	0.20
	[26.56-28.98]	11	0.82
	[28.98-31.40]	25	1.00
	[31.40-33.82]	20	16.20
	[33.82-36.24]	17	17.00
	[36.24-38.66]	13	13.00
	[38.66-41.08]	6	2.67
	≥41.08	10	10.00

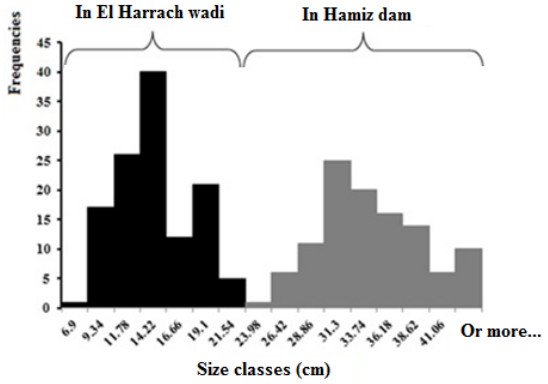

Figure 2: Size frequency distribution in barbels of El Harrach wadi and Hamiz dam.

Table 2: Biometric parameters of length-weight relationship and condition factor of *B. callensis*.

Biotopes	N	L_T min – L_T max (cm)	W_T min – W_T max (g)	a	b	R^2	r	K ± CI
El Harrach wadi	**119**	6.9 - 21.0	3.28 - 81.16	0.0079	3.1	0.97	0.99	1.02 ± 0.02
	♂	6.9 - 17.4	3.28 - 63.11	0.0090	3.0	0.97	0.99	1.00 ± 0.03
	♀	8.0 - 21.0	5.22 - 81.16	0.0071	3.1	0.97	0.98	1.04 ± 0.04
Hamiz dam	**112**	19.3 - 46.5	60.00 - 904.00	0.0054	3.2	0.95	0.98	1.03 ± 0.02
	♂	25.1- 39.1	110.00 - 628.00	0.0046	3.2	0.87	0.93	1.04 ± 0.05
	♀	19.3 - 43.5	60.00 - 904.00	0.0087	3.1	0.95	0.97	1.04 ± 0.02

K: condition factor; **CI:** confidence interval.

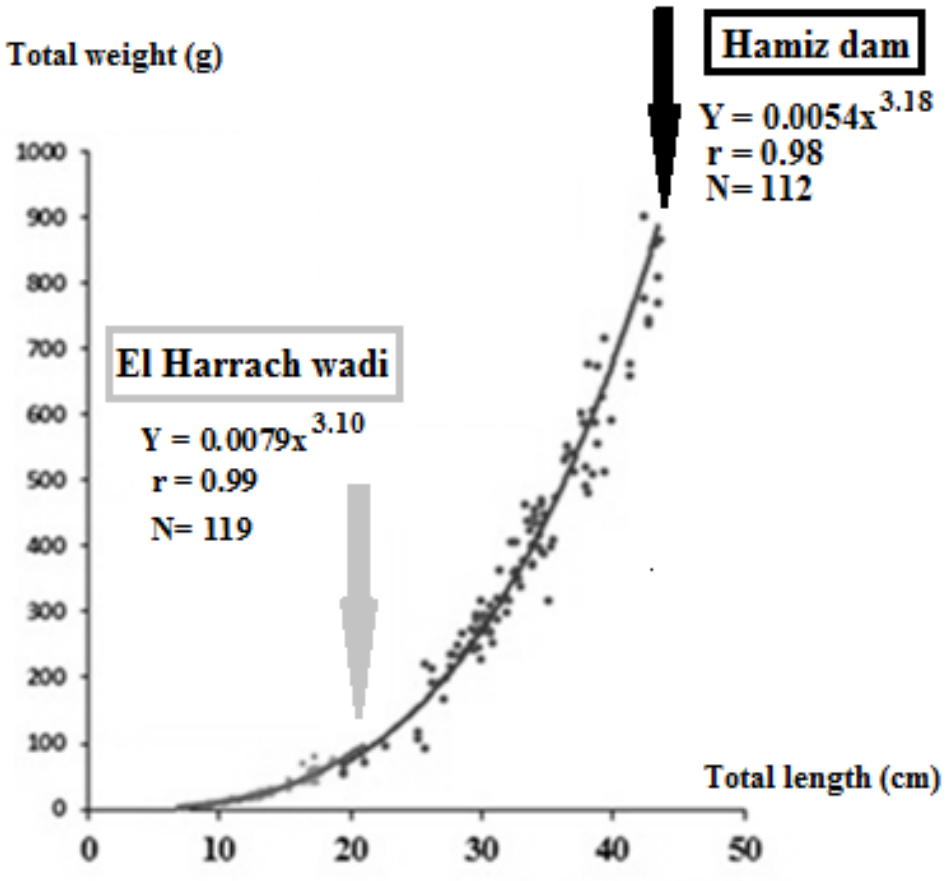

Figure 3: Length-weight relationship of *B. callensis* in El Harrach wadi (grey curve) and in Hamiz dam (black curve).

Figure 3 shows the type of growth allometry of *B. callensis* (all sexes mixed) sampled in both freshwater systems. The growth rate (b) did not deviate too far from 3 ($3.10 \leq b \leq 3.18$). Comparison of the residual variances of the two samples showed an $F = 1.059$ with $p = 0.379$. The Student "t" for the slope test was 0.996 with $p = 0.320$, while the Y-intercept test showed a $t = 1.349$ with $p = 0.178$.

DISCUSSION

Algeria's freshwater fish fauna is composed of forty-eight species belonging to fifteen families. Twenty-one species have been considered indigenous, of which 19% are Cyprinidae especially, represented by the genus *Barbus* (Kara, 2012). Our fishing efforts in both hydrosystems show the existence of a population of *B. callensis*. However, this species is naturally rheophilic and fluvial like its close species *B. barbus* and *B. meridionalis* (Bruslé and Guignard, 2001). It is also naturally present in gueltas (Froese and Pauly, 2018) and in natural lakes in Tunisia (Chaouachi and Ben Hassine, 1998). The two populations sampled appear to include more males in the wadi, more females in the dam and juveniles. Our spring sampling synchronizes with the laying period, which corresponds to the rising water temperature. Absolutely, in Cyprinids, temperature remains the most important factor in determining the laying period (Poncin et al., 1987). In the dam, *B. callensis* spawns between April and June when the temperature of the water reaches 18°C (Ould Rouis et al., 2012). This large number (50%) of mature females that congregate in the deep waters of the lake demonstrates once again that reproduction takes place in this artificial environment to which our species has adapted. The low value of the condition coefficient of *B. callensis* in both wadi and dam is probably due to the use of energy reserves for reproduction. The high values of the correlation coefficient (r) reflect a strong link between the growth of the two length/weight variables, both in barbels of the wadi and the dam. The growth of the two populations is isometric and there is no significant difference, as the residual variances of the two samples are not significantly different from each other. The slopes of the two regression lines are identical as well as intercepts, which confirms that the barbels grow in the same way in both the wadi and the dam. As a result, fish of the wadi have a slim appearance. However, fish caught in the lake have a slightly higher allometric growth as compared with those caught in the wadi; individuals caught

in the lake showed a slight tendency to gain weight as compared with their growth in size (Ould Rouis, S., pers. comm.). The same result has been shown for barbels living in Ichkeul lagoon in Tunisia (Chaouachi and Ben Hassine, 1998). Knowledge of growth is therefore a fundamental aspect of studying fish dynamics (Panfili et al., 2002). This growth seems to be influenced by many factors characterizing the type of environment, such as calm waters of the lake (fish do not need to fight against the speed of the current), environmental conditions (food availability) and temperature distribution in the water column, which would allow fish to perform their life cycle well (Poncin et al., 1987). The use of statistical tests allowed us to describe the nature of the barbels' growth;
the growth rate values obtained did not show any significant difference in growth between the barbels of the wadi and those of the lake. It seems that our species generally develops isometrically, but as it grows, individuals living in Hamiz tend to be heavier. In addition, it appears that the condition of this species (all sexes combined) decreases significantly during the laying period after using energy reserves for reproduction. However, it is important to note that fish seem to be in good condition in the reservoir during our sampling period. At the same time, we observe that the population living in the large grain size system, subjected to a high current speed, is mainly represented by young males. In contrast, in the deep lake where waters are calm, we observed a dominance of old females larger than 41 cm in *B. callensis* population.

CONCLUSION

It can be concluded that our species has adapted to a multitude of habitats, which seem to offer favorable trophic conditions for fish populations. In addition, our results specify for the first time the growth parameters of this native fish, which could be a good biological indicator of the state of fish populations and should make it possible to diagnose both the state of these populations and the freshwater ecosystems in which they live. Taken together, our data would seem useful for the management and conservation of this native species in different freshwater bodies.

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