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Age structure and growth of Algerian barbel *Luciobarbus callensis* (Valenciennes, 1842) (Cyprinidae) in El-Harrach River (North of Algeria)

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Abstract. The age and growth of Algerian barbel, *Luciobarbus callensis* (Valenciennes, 1842), in El-Harrach River (North of Algeria) were studied in samples taken from catches of local fishermen obtained between June 2013 and May 2014. The maximum length was 25.5 cm (TL - total length) in females and 23.5 cm in males. Among 1000 specimens representing 7 age classes (from 0+ to 6+), fishes of 2+ and 4+ was dominant (79.8 %). The population of *L. callensis* consists of 834 individuals matures (357 females and 477 males). The calculated overall sex ratio is 1:0.74 (Chi² X^2 = 58.59, P<0.01). Length–weight relations were calculated for females, males, immature and all specimens. Isometric growth was observed for the both sex and immature with slopes (b values) of the length–weight relationships ranged from 3.021±0.027 (males) to 3.070±0.055 (immature). The Von Bertalanffy equation for the theoretical growth in length was: $Lt = 26.249[1-e^{-0.23(t-0.281)}]$ for males and $Lt = 23.158[1-e^{-0.31(t-0.213)}]$ for females.
Key Words: Algerian barbel, life-history styles, stream ecosystems, length–weight relationship, Von Bertalanffy model, gonad-somatic index.

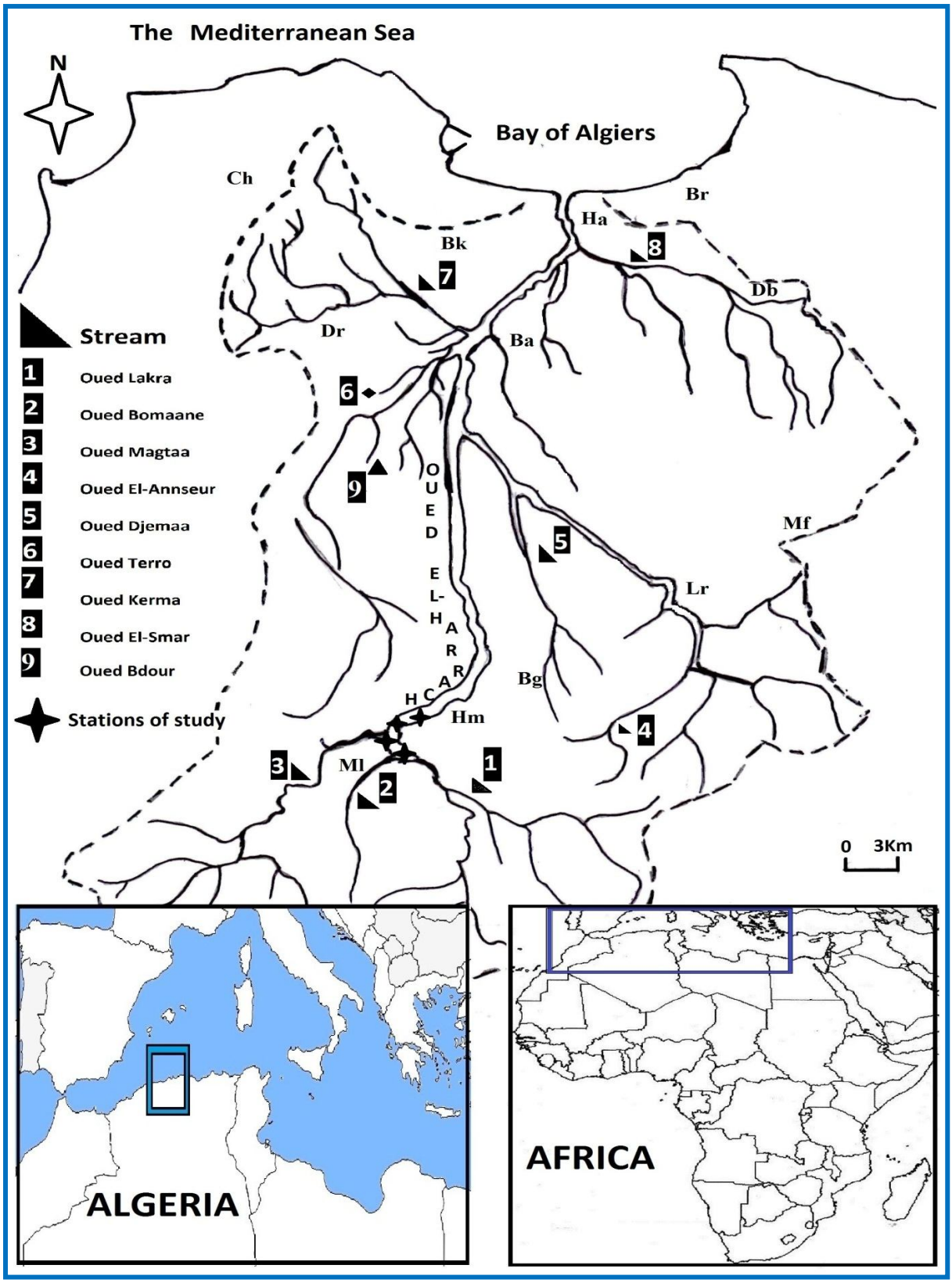
Introduction. The Algerian barbel, *Luciobarbus callensis* Valenciennes, is an endemic fish distributed to the northeast of the Maghreb ecoregion (Berrebi et al 1995; Kraiem & Pattee 1988; Azeroual et al 2000; Kara 2012; Mimeche et al 2013).

The information is absent in North Africa, and it is very difficult to apreciate the status of a species and to make appropriate management and conservation. The Algerian ichthyofaunal region is mostly characterized by a low diversity in freshwater. The Cyprinidae family includes the greatest number of species (Mimeche et al 2013), as it shows a wide distribution around the world (Szlachciak & Strakowska 2010).

In this study we will offer the information on population dynamics of Algerian barbel *L. callensis* distributed in rivers of central Algeria. In the North of Algeria the river as seasonal regime is typical of the Mediterranean climate.

The objectives of the study were to provide information on the ecology of this species, to analyze the age, growth, condition factor and the gonad-somatic. There is a limited of studies on the biology and ecology of the Algerian barbel (Penczak & Molinski 1984; Ould Rouis et al 2012; Mimeche et al 2013). *L. callensis* (Valenciennes) is a synonymy of *Barbus callensis* (Kottelat & Freyhof 2007; Gante 2011; Mimeche et al 2013).

Material and Method. El-Harrach River is one of the major rivers which cross the plain of Mitidja. It locates in the north central of Algeria. It originates in the Blida Atlas (36° 28'7.44 "N, 3° 0'50.53" E). This river empties into the Bay of Algiers (36° 44'29.89 "N, 3° 7'54.06" E), after a course of 67 km. Its tributaries are: Lakra stream, Boumâan stream, Magtaa stream, Djemâa stream and others stream (Figure 1).



(Ha - El-Harrch city, Br - Borj El-Kiffan, Db - Dar El-Baida, Ba - Baraki, Mf - Meftah, Lr - Larbaa, Bg - Bougara, Hm - Hammam melouane, Ml - Magtaa Lazrag Village, Dr - Duira, Bk - Bir Khadem, Ch - Chéraga).

Figure 1. Map of study area showing geographical position of El-Harrach River, fishing sites, in north center of Algeria.

The catchments area of El Harrach River belongs to the large coastal watershed of Algiers. It covers an area of 1,236.28 km^2, extends from north to south about 51 km and from east to west about 31 km.

The upper watershed is characterized by a vegetation cover of 40 to 50%, with shrubs (less than 7 m) of the peaks which are composed of cypress tree (*Cupressus simpervirens*), Aleppo pine (*Pinus halepensis*) and carob tree (*Ceratonia siliqua*) and mastic tree (*Pistacia lentiscus)*. On the lower slopes, the main vegetation is encountered Reed (*Phragmites communis*), Oleander (*Nerium oleander*) and Olive (*Olea europea*) (Bouchelouche 2010). Thermal analysis of the water of El-Harrach River shows the existence of two periods: the first period from April until October when the maximum temperature is marked in July and August (25.5°C). And the second period is from November to March with a minimum value of (9°C) in March. During the study period, the pH of the water of El Harrach River varies between 7.46 and 8.38, respectively, in August and October. This variation of pH depends of the nature of the land which is traversed, as verified by the pH of sediment analysis of various stations of study. El Harrach River is characterized by basic sediment. The monthly values of conductivity fluctuate between 697 and 1456 µS/cm. The maximum was recorded in autumn period (October) and the minimum was recorded in the winter period (January). According to normal values, the maximum of salinity was recorded during the autumn (October) and the minimum was recorded during the winter period (January) and respectively for these two periods: 0.73 ‰ and 0.34 ‰. The highest saturation is marked in December (11.26 mg/L) and the lowest value was in April (7.53 mg/L). This may be due to oxygen consumption by aerobic bacteria.

A total of 1000 barbel specimens (38-255 mm total length and 0.345-162.1 g total weight) were collected monthly in June 2013 to May 2014 at 4 different sites from the upstream to the downstream of El-Harrach River (Figure 1), with use of a gasoline-powered-electrofishing gear, sampling was conducted from inside the river for 60 minutes period in each site. Fresh fish is immediately transported to the laboratory where once measured and weighted.

The total length (TL; ±0.1 mm), fork length (FL; ±0.1 mm) and the standard length (SL; ±0.1 mm) was measured by an ichtyo-meter. The weight was evaluated by an electronic balance accuracy of 1 g by considering the total weight (TW). All specimens were dissected to obtain eviscerated weight (EW). Sexes was determined macroscopically, the male gonads (testes) which are whitish and smooth and female gonads (ovaries) are grainy and color ranging from pale yellow to orange were assessed as gonad weight (Gw).

Age was estimated by interpreting growth rings on 1000 scales from 477 male (TL: 66.87-235 mm; TW: 3.5-136.1 g), female (TL: 62.21-255 mm; TW: 2.6-255 g), Immature (TL: 38-147 mm; TW: 0.345-34.12 g), and length frequency distribution. Scales (8-10) below the first radius of the dorsal fin and above the lateral line were removed from each specimen, these scales were cleaned using 8% NaOH and used for age determination, the length frequency distribution of the samples was studied over separate short periods of time (monthly and seasonally) to reduce the effects of seasonal growth. Generally in fish, the sex ratio is expressed by 1:1 (M:F) and uses the Chi-squared test.

The relationship between the TL and TW (logarithmic transformation) were calculated for all samples, immature and for males and females separately (Froese 2006). The existence of significant differences between relationships was verified by analysis of covariance (ANCOVA):

$$\log TW = a + b \log TL$$

Where: TW = total weight; TL = total length;
a = the intercept; b = the regression slope.
Parameters a and b were calculated by least-squares regression, as was the coefficient of determination (r^2). Significant difference of b values from 3, which represent isometric growth (Pauly 1993).

Growth was estimated by fitting the size-at-age data to the Von Bertalanffy growth function (VBGF) (Ricker 1975):

$$L_t = L_\infty[1-e^{-k\,(t-t_0)}]$$

Where L_t is the total length at age t, L_∞ is the asymptotic length, k ($year^{-1}$) is a coefficient describing the rate at which the growth curve approaches the asymptote and t_0 represent the theoretical age at which predicted mean standard length is zero.
Total fish wet weight was used to determine condition of the fish by the commonly used condition factor, K:

$$K = (TW / TL^3) \times 100$$

Where TW is the total weight (in g) and TL is the total length (in mm), were calculated for males and females seasonally (Froese 2006).

The level of reproductive activity was estimated using the gonad-somatic index (GSI) was estimated as the ratio of gonad weight to the eviscerate weight of the body, which can encrypt the growth of gonads during the reproductive cycle (Roche et al 2003).

Ovaries were collected and the GSI determined from 357 female Barbel and from 477 male. The mean calculated GSI in each state per month were used to describe changes in gonad sizes through time.

$$GSI = (Gw / Ew) \times 100$$

Where Gw is the gonad weight (g) and Ew is eviscerated weight. The data were statistically analyzed using test of comparison of means of the two sexes. The statistical significance of the differences was verified with analysis of covariance between sexes (ANCOVA). The statistical analyses were performed by the SPSS (SPSS, Chicago, Il, USA) software package.

Results and Discussion. The number of suitable specimens for age class determination was 1000. Age determination by scales showed 7 age-groups (0+ to 6+ years) in females and males (Table 1). The age structure of *L. callensis* specimens caught in El-Harrach River was different from that observed in others area from Algeria *i.e.* Oued Sebaou (Penczak & Molinski 1984) and K'sob reservoir (Mimeche et al 2013; Mimeche 2014), while the maximum lengths detected in El-Harrach River is 25.5 cm in TL and 23.1 cm in FL. However, these structures showed in El-Harrach River is similar from those observed in the studied populations from streams in Maghreb (Table 2).

The maximum individual lengths observed were a 25.5 cm TL in females (October 2013) and a 23.5 cm TL in males (February 2014). Females were significantly longer two-way ANOVA, $F(1, 832) = 68.2$, $P<0.001$) than males (mean in females, FL = 13.01 cm; mean in males, FL = 11.63 cm). The fork length shown in immature fish is FL = 8.55 cm.

The population structure observed into EL–Harrach River was characterized by the dominance of the age classes between 2+ and 4+ (79.8% of the overall individuals). Moreover, both sexes showed low occurrence of 5+ and 6+ in all season (Figure 2, Table 1). This result similar to Kraiem et al (1986) in Béja stream (N Tunisia) (Table 2). The immature 0+ and 1+ present an important portion in spring and summer. Seasonally approach of the length frequency distributions along the study period showed a continuous presence of males with a length between 10.5 cm and 15.5 cm FL (Figure 3, Table 1). The size range of females during the studied period was shorter than of males. The number of immatures is reduced than in the both sexes (higher presence in spring).

The population of *L. callensis* consisted in 834 matures individuals, including 357 females and 477 males. The value of the sex ratio is in favor of males with 57.2% toward females with 42.8%. The calculated overall sex ratio is 1:0.74 (Chi² $X^2 = 58.59$, $P<0.01$).

Table 1

Length and weight of *Luciobarbus callensis* from Oued El-Harrach River

Sexes		*Parameter*	*Age group*						
			0+	*1+*	*2+*	*3+*	*4+*	*5+*	*6+*
Population	Total number		31	92	246	330	222	63	16
	TL (cm)	Range	3.8-9.5	6.73-12.5	7.8-15.2	10-17.7	13.25-19.6	15.4-21	17.8-25.5
		mean±SE	6.36±1.55	9.26±1.26	10.84±1.3	13.02±1.09	15.4±1.12	17.55±1.33	21.82±1.63
	TW (g)	Range	0.345-8.4	3.12-20.8	4.2-29	8.17-70.5	20.19-99.6	33.14-108.4	65.5-162.1
		mean±SE	3.02±2.04	8.46±3.59	13.72±5.33	23.25±6.97	39.26±10.64	59.03±16.35	117.73±20.19
Male	Total number		4	36	120	183	111	21	2
	TL (cm)	Range	6.68-9.5	7.5-12.1	7.8-15.2	10-16.6	13.5-18	15.4-18	23-23.5
		mean±SE	8.4±1.3	9.77±1.17	10.93±1.28	12.94±1.1	15.35±0.98	16.7±0.84	23.25±0.35
	TW (g)	Range	3.5-8.4	4.7-17	5-31.7	10.1-44.7	20.19-62.2	37.8-62.3	111.1-136.1
		mean±SE	6.07±2.23	9.51±3.26	13.84±4.86	22.57±6.09	37.89±8.44	48.62±9.05	123.6±17.67
Female	Total number		1	9	62	121	108	42	14
	TL (cm)	Range	6.22-6.22	8.3-12.5	8.3-14.7	10.6-17.7	13.5-19.6	15-21	17.8-25.5
		mean±SE	6.221±0	10.4±1.28	11.51±1.2	13.21±1.07	15.5±1.26	17.97±1.32	21.62±1.64
	TW (g)	Range	2.6-2.6	7.8-20.8	5.9-35.8	13.6-70.5	24.7-99.6	33.4-108.4	65.8-162.1
		mean±SE	2.6±0	13.51±3.98	17.17±5.72	25.11±8	40.9±12.42	65.6±16.32	116.89±21.31
Immature	Total number		26	47	64	26	3	0	0
	TL (cm)	Range	3.8-7.542	6.73-10.5	8-12.1	10.4-15	14.2-14.7	-	-
		mean±SE	6.05±1.38	8.65±0.09	10.04±1	12.63±1.05	14.5±0.26	-	-
	TW (g)	Range	0.345-4.8	3.12-13.41	5-16.89	8.17-27.57	29.58-34.12	-	-
		mean±SE	2.57±1.64	6.67±2.38	10.17±3.11	19.4±5.16	31.7±2.28	-	-

TL - Total length, TW - total Weight, SE - standard error.

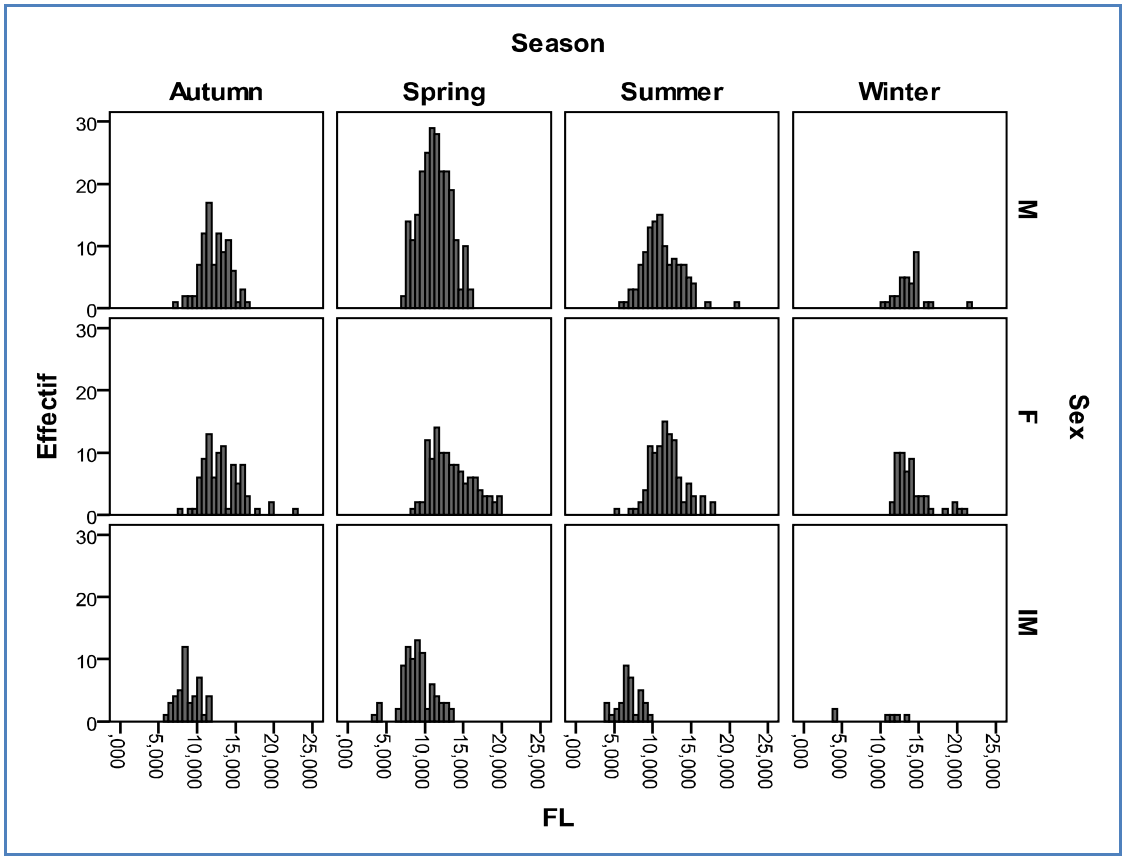


Figure 2. Length-frequency distributions of males (M), females (F) and immature (IM) of the specimens caught in each season in El-Harrach River during the study period. (FL - fork length).

Table 2
Maximum total length and age class observed in studies of *Luciobarbus callensis* by other authors

Locality (Area)	*Length (cm)*	*Age class*	*Reference*
Oued El-Harrach River	25.5 (f) 25.3 (m)	6+ 6+	This study
K'sob reservoir (NE Algeria)	36 (m) 34.2 (f)	13+ 12+	Mimeche et al (2013)
Hamiz reservoir (N Algeria)	46 (m)	-	Ould Rouis et al (2012)
Ghezzala stream (N Tunisia)	32	-	M'Hadhbi & Boumaiza (2008)
Allal El Fassi reservoir (N Morocco)	22.5(m)*, 26.7 (f)*	10+ 12+	Bouhbouh (2002)
Joumine reservoir (N Tunisia)	30	-	Kraiem et al (1986)
Béja stream (N Tunisia)	26	5+	Kraiem et al (1986)
Sidi Salem reservoir (N Tunisia)	25	4+	Kraiem et al (1986)
Sebaou stream (NE Algeria)	16.2	3+	Penzak & Molinski (1984)

* data in fork length; *m* and *f* indicate males and females, respectively.

Length–weight relationships were calculated for females, males, immature and all specimens (Table 3). Isometric growth was observed with slopes (*b* values) of the length–weight relationships ranged from 3.021±0.027 for males to 3.070±0.055 for immature, with r^2 values being greater than 0.95. However, there were no significant differences in length–weight between females, males and immature (P>0.05). Penczak & Molinski (1984) in Oued Sebaou revealed a value *b* = 3.207 and r^2 = 0.996. Mimeche et al (2013)

showed in K'sob reservoir a lower value b = 2.53±0.11 and r^2 = 0.93. In this study, the values of "b" are nearly isometric relationship between length and weight. This result reflects the good environment and habitat for *L. callensis* in El Harrach River.

Table 3

Length–weight relationship (LWR) parameters and values (a and b) of Algerian barbel

Species	*N*	*a*	*SE (a)*	*CI 95% (a)*	*b*	*SE (b)*	*CI 95% (b)*	r^2
Population	1000	-2.107	0,018	(-2,14)-(-2,07)	3.108	0.017	3.07-3.14	0,972
Immature	166	-2.083	0.053	(-2,19)-(-1.98)	3.070	0.055	2.96-3.18	0.950
Male	477	-2.016	0.03	(-2,07)-(-1.96)	3.021	0.027	2.97-3.07	0.965
Female	357	-2.006	0.037	(-2,08)-(-1.93)	3.033	0.032	2.97-3.10	0.961

N- effective, SE- the standard error of the slope (a, b), CI-confidence interval, r^2- the coefficient of determination.

The Von Bertalanffy equation for the theoretical growth of Algerian Barble in length was: $L_t = 26.249[1-e^{-0.23(t-0.281)}]$ for males and $L_t = 23.158[1-e^{-0.31(t-0.213)}]$ for females. The results for the von Bertalanffy growth equations for male and female were, for the L∞ values, 26.249 cm and 23.158 cm, respectively. These values have been observed as 29.55 cm for male and 32.73 cm for female by Bouhbouh (2002) in Allal El Fassi reservoir in Morocco.

The mean condition factor for females, males and immature are similar, but the differences between sexes were not significant (P>0.05). The factor K showed a similar pattern in both sexes (Figure 3), with a maximum in August for the both sexes, October and May for the females and another maximum for males in February, just before spawning. Concerning the minimum, females present in June the low values of K, the males present their low values in June 2013 and May 2014, and this period coincide with the end of reproduction. The important value in August with condition factor coincides with the raw fall precipitation in the study area and that promote the abundance of benthic insects entering the basic fish diet. The temporal variation in somatic condition (factor K) reflected the effects of both environmental seasonality and the reproductive cycle of the species (Mimeche et al 2013).

The determination of the spawning season for *L. callensis* population in El-Harrach River was based on the gonadosomatic index values (Figure 4). There was a marked individual variation in the pattern of monthly GSI values. According to these average values, the highest GSI values were observed in the samples of May in both sexes. The mean GSI values decreased in August for females and in December for males. The spawning started in April in this river, this result is similar to the population of Barbel in Hamiz reservoir (Algeria) (Ould Rouis et al 2012) and founded between April and May in Allal El Fassi reservoir (Morocco) (Bouhbouh 2002). The development of gonad-somatic index of female is important, because the ovarian tissue contained much more energy than testis (Encina & Granado-Lorencio 1997).

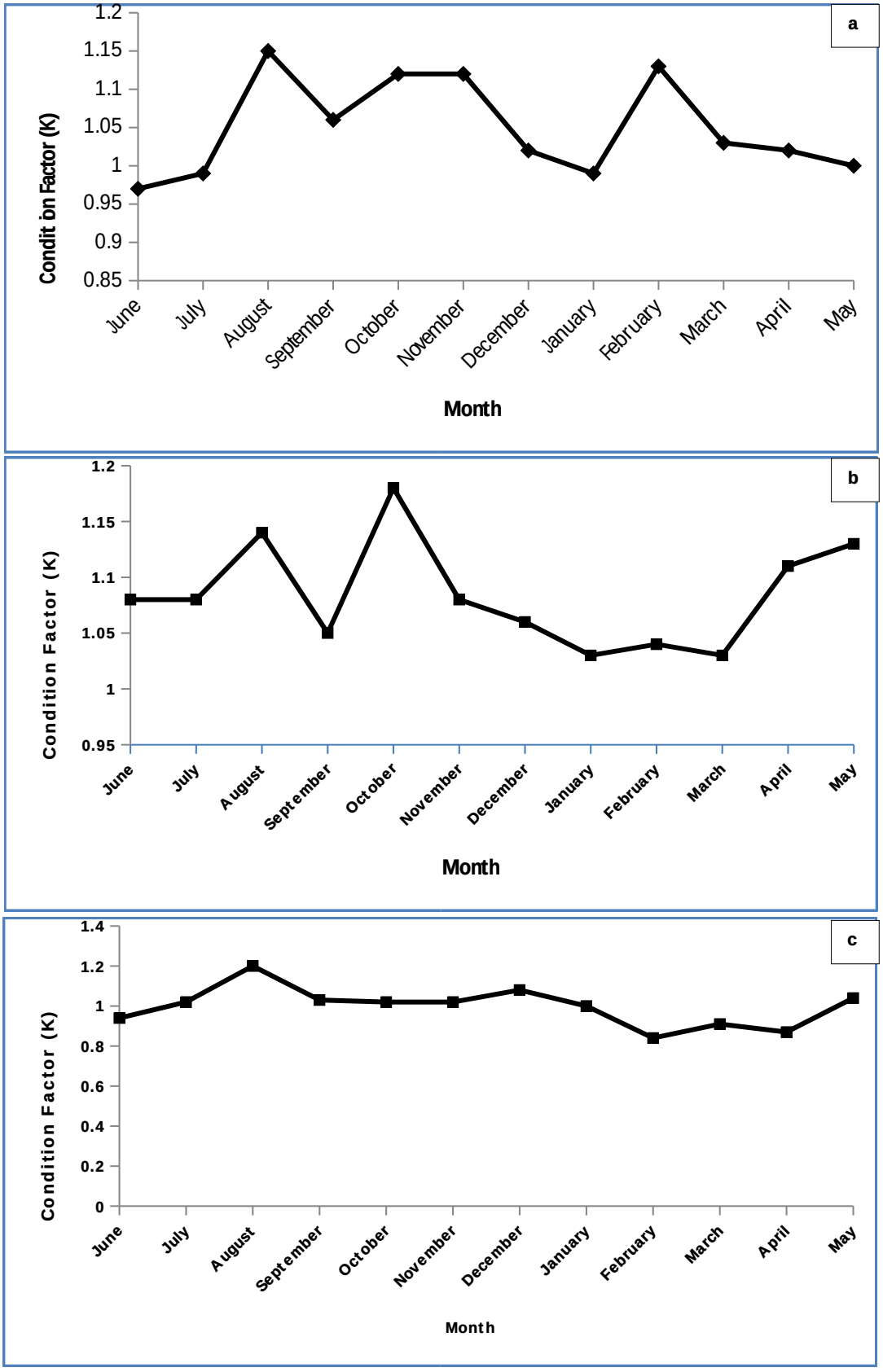


Figure 3. Condition Factor (K) of males (a), females (b) and immature (c) of the specimens caught in El-Harrach River during the study period.

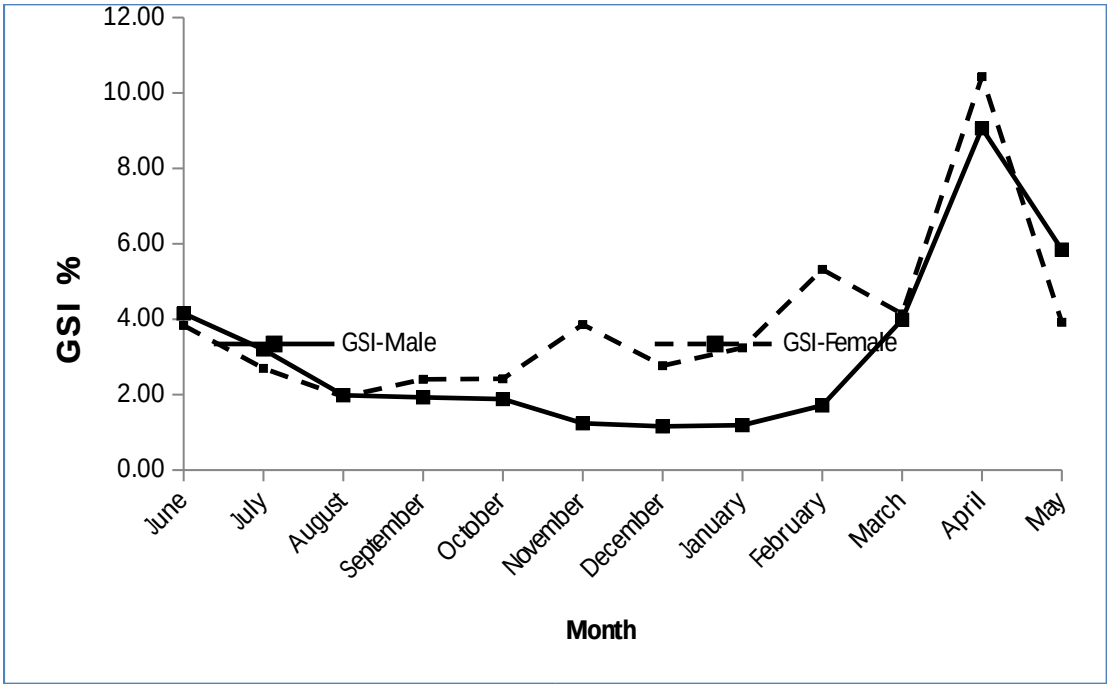


Figure 4. Gonad-Somatic Index (GSI) of females and males of the *Luciobarbus callensis* specimens caught in El-Harrach River during the study period.

Conclusions. The population of the Algerian barbel *L. callensis* lives in a native fluvial hydrosystem. This study provides some important information on the age, growth, condition factor and the gonad-somatic index of this species. These results give many alternatives with contribution to ichthyofauna conservation and protection in its native area of distribution.

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