Reproductive biology of *Carassius carassius* (Cyprinidae) in Beni Haroun Dam, Algeria

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Abstract. Aspects of the reproductive biology of *Carassius carassius* were studied from samples collected in Beni Haroun Dam during January and December 2015. A total of 333 specimens were investigated consisting of 227 females and 106 males. The sex ratio was in favor of females while its evolution has shown significant differences by size classes ($\chi 2$, $p<0.05$), the difference was not significant by months. The monitoring of the monthly evolution of the three parameters (GSI, HSI and K), and evaluation of the length weight relationship of the *C. carassius* has shown that it has a single spawning period covering the month of May until July. The correlation coefficient (r^2) for length-weight relationship was found to be 0.65 for males and 0.79 for females. The value of coefficient of allometry for both sexes (b) was observed to be less than 3 indicating a negative allometric growth coefficient of allometry.

Key Words: length-weight relationship, sex ratio, GSI, HSI, K, coefficient of allometry, spawning period.

Introduction. Carassius carps have been a popular freshwater fish from ancient times as a valuable food source and as the basis of sport fisheries. *C. carassius* is an exotic fish species introduced in Algeria in 2006 (Kara 2012). It occurs in shallow ponds, lakes rich in vegetation and slow moving rivers (Vostradovisky 1973). It burrows in mud in the dry season or winter (Allardi & Keith 1991) and tolerates low temperatures, organic pollutants and low oxygen concentration in water (Blazka 1958; Vostradovisky 1973).

Reproductive biology investigation of fish species is vital in order to assessing commercial potentialities of its stock, culture practice and actual management of its fishery (Doha & Hye 1970; Soofiani et al 2006; Dopeikar et al 2015). It has three key components including: sexual maturity, reproductive period and fecundity, which are important demographic characteristics, essential for understanding a species life history (Cortes 2000).

Various methods are used to assess the reproductive condition in fishes, including microscopic gonadal staging, macroscopic gonadal staging, oocyte size–frequency distributions, sexes steroid measurement and gonadal indices (Lowerre-Barbieri et al 2011; West 1990).

The gonadosomatic index expresses the weight of the gonad in relation to the body weight and is expressed as percentage (Bagenal 1967). Monthly variations of the gonadosomatic index (GSI) provide the reasonable indicator of reproductive seasonality for fish. The seasonal timing of reproduction, spawning time is often identified from changes in the gonadosomatic index which determines reproductive season (Arruda et al 1993). The hepatosomatic index is the ratio of liver weight to body weight. The liver is a key organ in fish production of vitellogenin, the yolk precursor (Lucifora et al 2002). Hepatosomatic index is important because it describes the fish's stored energy and is a good indicator of recent feeding activity (Tyler & Dunns 1976). Condition factor (K) is

quantitative parameters of the well-being state of the fish and reflects feeding condition. This factor varies according to influences of physiologic factors, fluctuating according to different stages of the development. Length-weight relationship is considered to be one of the important biological information in order to describe mathematical relationship between variances, length and weight. Because information about length and weight attributes of growth are essential in understanding this relation and length-weight relationship has been used in fish biology (Costa & Araùjo 2003).

Some of the biological studies on *C. carassius* have included information on reproductive biology, especially in terms of spawning period and length at maturity (Tarkan et al 2009; Targonska et al 2012; Vostradovisky 1973; Laurila et al 1987). The available information indicates that *C. carassius* spawns clear to pale yellow eggs on dense vegetation in shallow water (Laurila et al 1987). In many parts of Europe spawning takes place in March-June where ripe females release 10,000-300,000 eggs (Maitland & Campell 1992; Billard 1997; Spratte & Hartmann 1997).

In Algeria nothing is known about the *C. carassius* population in Beni Haroun Dam. Thus, in an attempt to fill this knowledge gap, the present contribution of this paper is to investigate some aspects of the reproductive biology (gonadosomatic index, hepatosomatic index, condition factor and sex ratio breeding season) of the fish in the Dam with the aim of providing preliminary necessary scientific information for proper utilization and management of the stock.

Material and Method

Sampling. Fishes were collected from January 2015 to December 2015 from daily catch of artisanal fishermen and from the Beni Haroun Dam (36°33’18.55”N / 6°16’10.93”E), north east of Algeria. In the laboratory, for each specimen, total length (TL) was measured using an ichtyo-meter and body weight (W) was taken on balance to the nearest 0.01g. Sex determination was done by visual examination of the gonads. The gonads and liver were removed and weighed by digital balance.

Data analysis

Sex ratio. Present the proportion of males and females in the population (Kartas & Quignard 1984).

$$\text{Proportion of females} = (F/F + M) \times 100$$
$$\text{Proportion of males} = (M/F + M) \times 100$$

Three indices were used to investigate the monthly changes in gonads in order to estimating the spawning season of this species:

The gonadosomatic index (GSI): The monthly changes were calculated using the formula given by Roche et al (2003):

$$GSI = (GW/EW) \times 100$$

Where:
GW: gonad weight (g);
EW: eviscerate weight (g).

The hepatosomatic index (HSI): The monthly changes were calculated using the formula given by Bougis (1952):

$$HSI = (HW/EW) \times 100$$

Where:
HW: Hepatic weight (g);
EW: eviscerate weight (g).

The condition factor (K): was estimated according to the following relation (Gomiero & Braga 2005):

$$K = (EW/TL^{b}) \times 100$$

Where:
EW: Eviscerate weight of fish (g);
TL: total length of fish (cm);
b: coefficient of allometry.

The length-weight relationship was calculated using the formula of Le Cren (1951):

$$EW = aTL^b$$

All analyses were performed with Statistica (data analysis software system) version 8.0. The χ^2 test was employed to compare the sex ratio by seasons and size classes ($p<0.05$). ANOVA statistical analysis was employed in order to compare the average GSI and HSI.

Results

Sex ratio. The sampled population is composed of 333 specimens: 106 males (31.73%) and 227 females (67.69%). The average sex-ratio determined during the annual cycle was in favor of females (Table 1). Gender distribution according to the size of the fish shows that females dominate with small and large size classes (χ^2 = 26.46; $p<0.05$), While males dominate with (20-21), (30-31) size classes (Figure 1). In general, sex ratios by season were in favor of females and were no significant difference between males and females by months (χ^2 = 13.41; $p>0.05$) (Figure 2).

Table 1

Characterization of the global sex ratio of *Carassius carassius* samples from the Beni Haroun Dam

Sex	*Effectives*	*Percentage ± IT*
Females	227	67.96±2.74
Males	106	31.73±2.74
Total	334	100

IT: interval of trust.

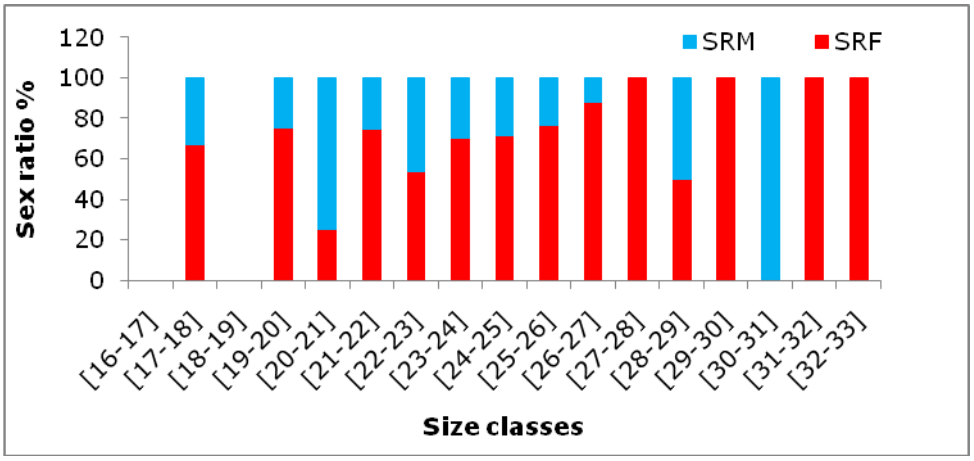

Figure 1. Sexes distribution of *Carassius carassius* depending on the size classes.

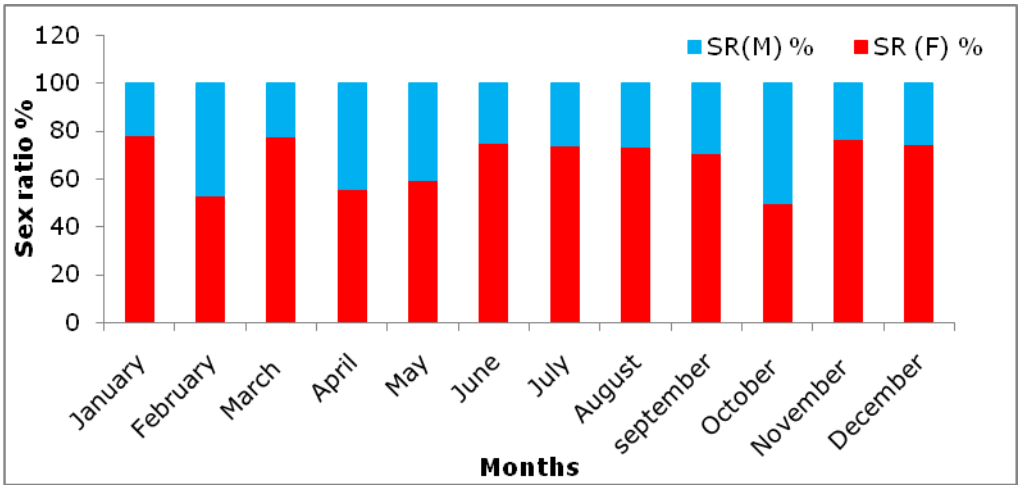

Figure 2. Monthly proportion of males and females of *Carassius carassius.*

Sexual cycle and spawning period

Variation of gonadosomatic index (GSI %). The results revealed that the peaks of GSI are in the month of May, for female (14.74±2.12) and male (12.81±1.41), In June the GSI value decreased, the lowest average value was recorded in September for females (2.45±1.58) and in August for males (2.20±0.63) (Figure 3).
The ANOVA analysis shows a significant difference in GSI of females (F_{obs} = 13.12; P≤0.001) and males (F_{obs} = 3.72; P≤0.001).

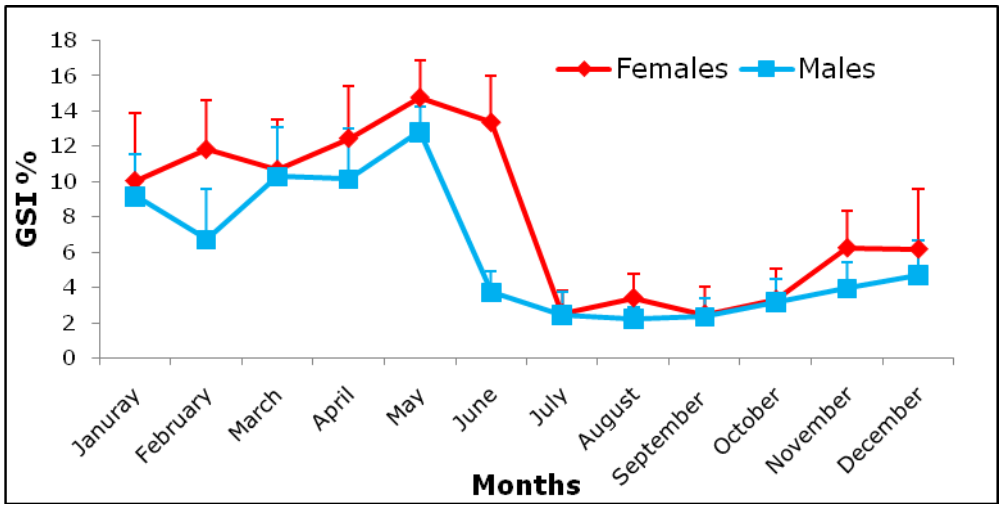

Figure 3. Gonadosomatic index (GSI) values of *Carassius carassius* by sampling months.

Variation of Hepatosomatic index (%). Monthly changes of HSI values for both sexes are shown in (Figure 4). HSI of males evolves in a similar way as females, showing a significant difference in HSI of females (F_{obs} = 4.79; P≤0.001), and males (F_{obs} = 24.78; P≤0.001). The important values are recorded during April for males (8.77±1.08), and females (10.47±1.41). The minimum mean values of HSI were found in May for Females (2.86±1.08) and in June for Males (3.01±1.80).

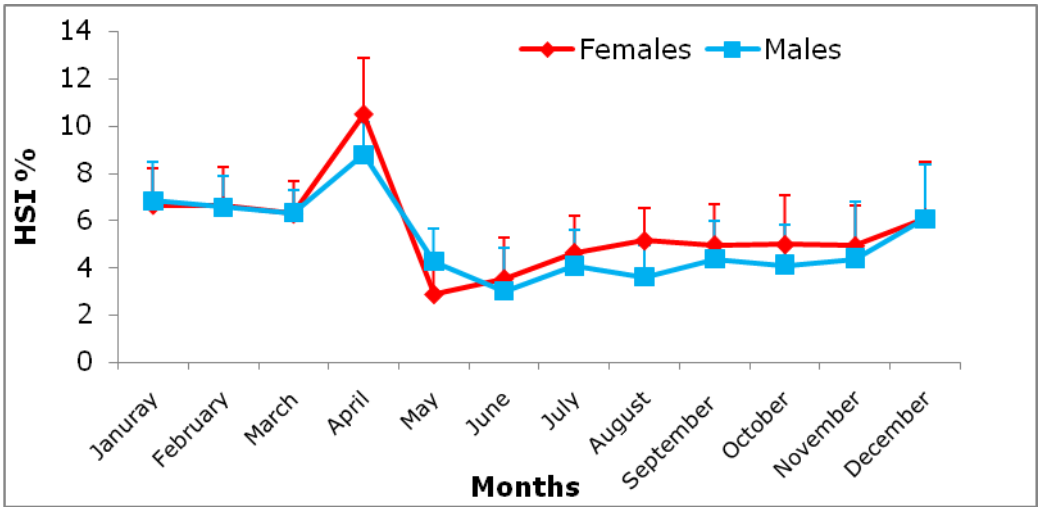

Figure 4. Hepatosomatic Index (HSI) values of *Carassius carassius* by sampling months.

Variations of the length-weight relationship parameters. A highly correlation was observed between total length and eviscerate weight for both sexes (Figure 5) with correlation coefficient r^2 = 0.79 in females and r^2 = 0.65 in males.

The length-weight relationship of *C. carassius* indicated a negative allometric growth for both females and males (b<3).

Table 2

Length-weight relationship parameters of *Carassius carassius*

Sex	*N*	*a*	*b*	r^2	*Total length (cm)*			*Eviscerate weight (g)*		
					Min	*Max*	*Mean±SE*	*Min*	*Max*	*Mean±SE*
Females	227	0.018	2.96	0.79	17.6	32.4	23.9±*1.86*	50	310	*181.70±46.35*
Males	106	0.016	2.82	0.65	17.7	30.2	*23.4±1.66*	78	299	*169.27±36.39*

N: sample number; r^2: correlation coefficient; a and b: Length-weight parameters; SE: standard error.

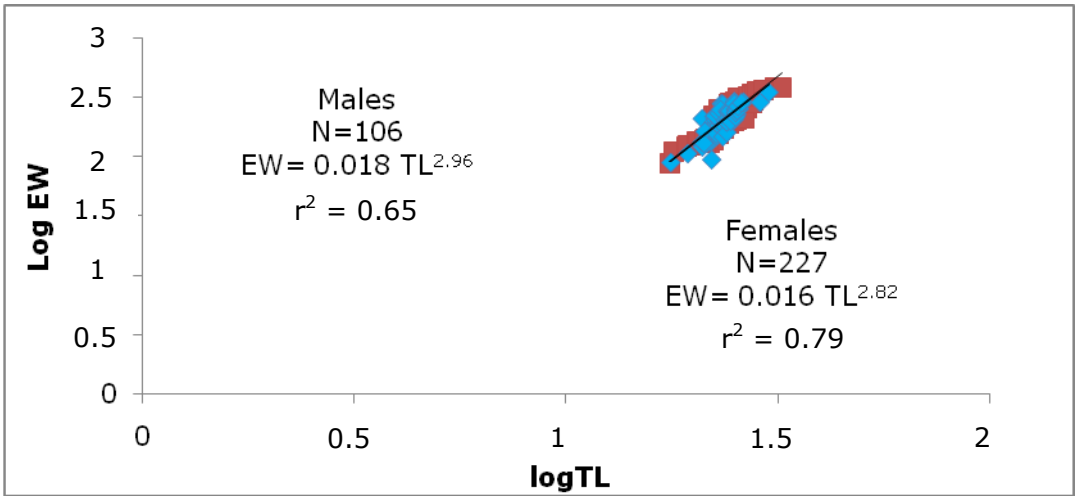

Figure 5. Length weight relationship of *Carassius carassius*.

Condition factor K. The K values for female samples ranged between 1.36 and 1.68 during January to December. Evolution of this factor is generally similar during the year. The lowest value was noticed in June for both sexes (Females K = 1.36; Males K = 1.25) The highest values of condition factor were generally observed in September for females (K = 1.68) and in December for males (K = 1.58) (Figure 6).

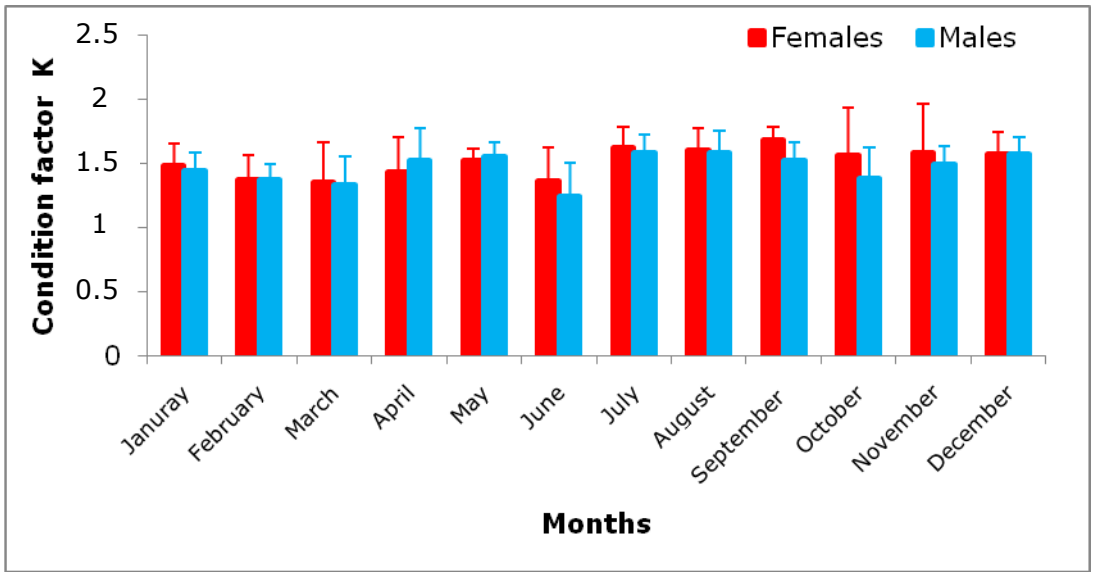

Figure 6. Monthly condition factor K of *Carassius carassius.*

Discussion. In the present study, the global sex ratio of *C. carassius* was in favour of females. Preponderance of females over males had been recorded in the population of the same species by Dadebo & Tugie (2009) and for another species (*Carassius gibelio)* by Balik et al (2004). The authors suggested that sexes disparity could be a result of the differential survival potentials of the species against certain environmental conditions of a water body. Offem et al (2007, 2009) described it as a mechanism for regulations or sex related behaviors in fishes, such as female emigrate between and feeding grounds exposing them to the possibility of better opportunities for better quality and quantity of food.

Generally, the results of sex ratio of different sizes showed that females were the dominant sexes in major length classes. Similar repletion was observed by Dadebo & Tugie (2009) in lake Ziway, Ethiopia. The absence of males above 31 cm could be because of the difference in growth rate of both sexes where females attain larger size than males. Other biological mechanisms such as differential maturity rates, differential mortality rates, or differential migratory patterns between the male and female sexes may also cause unequal sex ratios at different size classes (Sandovy & Shapiro 1987; Matsuyama et al 1988).

The study of sex ratio by seasons shows a dominance of females during autumn and winter, which seems to correspond to a strong and early maturation period of the ovaries. We also observed a clear decrease in the rate of femininity tending to reach a numerical equality with males during April and May coincides with the spawning period of *C. carassius* and can be explained by the migration of males as a reproductive behavior from deep to the area that the samplings were carried out (Aydin 2015). The monthly changes in GSI showed that the reproductive period of *C. Carassius* began in May and ended in July. According to obtained result from gonadosomatic examining, the GSI values increased in March and got its highest value in May, then decreased gradually from May to July. These results agree with Moisander (1991) who reported that the gonadosomatic index of female's *C. carassius* decreases from May to mid-July. Like most European cyprinids, the spawning season for *C. carassius* is from late spring through mid-summer, after water temperatures in the littoral zone warm; water temperatures of 17–20°C are needed for spawning (Hakala 1915; Schäperclaus 1953; Astanin & Podgorny 1968; Seymour 1981).

Based on the GSI values, the reproductive cycle of *C. caassius* can be divided into prespawning period (December to April), with increasing of GSI values (from 6.14 to 12.43), spawning period (from May to July) during which the GSI decreases (2.20), and

the sexual resting phase which lasts from July until November with low GSI values (2.50 to 3.22). Several environmental factors could be responsible for the high breeding activity of *C. carassius* in Beni Haroun Dam during the months of December to April. The beginning of the rainy season, changes in temperature, rise in water level and the subsequent lowering of water conductivity were implicated as the triggering factors for spawning of many tropical fish species (Rinne 1975; Dadzie & Okach 1989; Dadebo 2000; Dadebo et al 2003).

In several species, the gonadosomatic situation and amount of allocated energy for reproduction is predicted by the HSI index (Yagarina & Marshall 2000; Siami et al 2017). Typically, in many fish species, the GSI is in highest value and the HSI increases at the peak of spawning (Galloway & Munkittrick 2006). Based on the obtained results in different months, the lowest value of HSI in *C. carassius* was at the beginning of May, and it was in its highest value in April. Minimal HSI values were obtained during the reproductive period. For both sexes, when the HSI values were at its minimal, the GSI values were highest and this condition suggesting the point that the liver has a weight loss during reproduction which may indicate the mobilization of hepatic reserves for gonads maturation. Same results were reported by Delahunty & Vlaming (1980) for *Carassius auratus*. Gonadal recrudescence in female fishes involves an accumulation of lipid and protein stores within the developing oocytes. These stores may come from visceral organs, body musculature and ingested food if the fish feeds during recrudescence (Delahunty & Vlaming (1980)

In the present study, the coefficient of allometry (b) of length-weight relationship was significantly less than 3 in both sexes. Therefore, it is revealed that both male and female showed negative allometric growth. Changes in weight is relatively greater than changes in length, as a fish grows, due to relationhip between fish length and weight. The value of b may vary with feeding state, maturing, sex (Salam & Davies 1994).

In this work the minimum mean K was in June for males and females. The temporal variation in condition factor (K) reflected the effects of both environmental seasonality and the reproductive cycle of the species (Mimeche et al 2013). Condition factor (K) is one of the most important parameters, which throws light on the physiological state of the fish in relation to indication of the onset of the sexual maturity (Salam & Davies 1994). This condition is the result of mobilization of somatic energy reserves needed for reproductive development and energy in spawned fish, influenced by reduced feeding during this period (Palazon-Fernandez et al 2001).

Conclusions. In Algeria, this is the first study on *C. carassius* fish in Beni Haroun Dam, so it is necessary to know about the culture of this fish in freshwater condition. For this reason, this research is worked done about different reproductive aspects of *C. carassius*. It is concluded that the spawning period of *C. carassius* occurred from May to July. The gonadosomatic index decreased gradually from May to July, additionally, hepatic somatic index (HSI) had a clear inverse seasonal pattern to GSI during this period reflect the poor somatic condition during the spawning season. Breeding season was from May to July with a peak in May.

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