Reproduction, age and growth of *Tilapia zillii* (Cichlidae) in Oued Righ wetland (southeast Algeria)

by

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Abstract. – The aim of this study is to contribute to a better understanding of *Tilapia zillii* (Cichlidae) biology in the Saharan wetland of Oued Righ (south-eastern Algeria). Eight seasonal sampling campaigns have been conducted between October 2011 and September 2012 for a total of 813 specimens, including 230 males, 329 females and 254 individuals of indeterminate sex. Reproduction of *T. zillii* was investigated by considering the reproductive cycle, sex distribution and length at first maturity. Seasonal sex distribution was in favour of females during all seasons. The values of the gonadosomatic (GSI) and hepatosomatic (HSI) indexes of females and males indicated a single reproduction period from April to July. The length at first maturity (Lm50) was 9.9 cm for females and 9.7 cm for males. The condition factor K indicated a good condition of the individuals that is reflected by an accumulation of reserves. The age was determined by two methods: the Bhattacharya's indirect method (1967) and a direct method, which was based on scale reading on 155 individuals with size from 6.4 to 19.9 cm. Monitoring scale marginal elongation over a year identified the formation period of the stop growth ring, which occurs in winter. These data allowed to determine the spawning period and to estimate the ages of *T. zillii*.

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Résumé. – Reproduction, âge et croissance de *Tilapia zillii* (Cichlidae) dans la région de l'oued Righ (sud-est algérien).

Le présent travail a pour objectif de contribuer à une meilleure connaissance de l'écobiologie de *Tilapia zillii* (Pisces, Cichlidae) dans la zone humide saharienne de l'oued Righ (sud-est algérien). Huit campagnes saisonnières d'échantillonnage ont été menées entre octobre 2011 et septembre 2012 pour un total de 813 spécimens dont 230 mâles, 329 femelles et 254 individus de sexe indéterminé. La reproduction a été étudiée en considérant le cycle sexuel, la distribution des sexes et la taille de première maturité sexuelle. La distribution des sexes est en faveur des femelles. Les valeurs des rapports gonadosomatique (RGS) et hépatosomatique (RHS) des femelles et des mâles indiquent une seule période de reproduction qui s'étale du mois d'avril au mois de juillet. La taille de première maturité sexuelle (Lm50) est de 9,9 cm pour les femelles et 9,7 cm pour les mâles. Le facteur de condition K reflète la bonne condition des individus qui se manifeste par une accumulation des réserves indispensables pour la gamétogenèse printanière. L'âge a été déterminé par deux méthodes : la méthode directe par lecture des écailles de 155 individus de taille comprise entre 6,4 et 19,9 cm, et la méthode indirecte de Bhattacharya (1967) qui a permis de décomposer les deux échantillons mâle et femelle respectivement en quatre et trois cohortes. Le suivi de l'allongement marginal de l'écaille au cours d'une année a permis de déterminer la période de formation de l'anneau d'arrêt de croissance qui se situe en hiver. Connaissant la période de ponte, cette donnée nous a permis d'estimer les âges de *T. zillii* à la formation des anneaux d'arrêt de croissance. L'étude des croissances linéaire et pondérale, établie à partir de la clé âge-longueur, a permis d'obtenir les équations de von Bertalanffy.

Key words
Cichlidae
Tilapia zillii
Algeria
Sahara
Reproduction
Age
Growth

The Maghreb ichthyofaunal province (Roberts 1975) is mainly characterized by a low diversity in freshwater fish (Doadrio, 1994; Lévêque *et al*., 2008). The synthesis of data performed by Kara (2012), along with the large investigation covering the North part of Algeria and some Saharan regions, allows us to conclude that the freshwater fish fauna is composed of 48 species (belonging to 15 families), of which 21 are autochthonous and 27 are introduced. The autochthonous species are mostly cichlids (23.8%), followed by cyprinids (19%) where the genus *Barbus* is the most represented.

The wide distribution of cichlids marks a tolerance to salinity variability. The tilapia subfamily consists of a hundred species, which are well known in Africa for centuries. *Tilapia zillii* (Gervais, 1848) is distinguished by its ability to adapt in freshwater, brackish, and hyaline conditions (Zyadah, 1999). In Algeria, the first description of *T. zillii*

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was made by Gervais (1848), who discovered the species in the waters of Touggourt artesian wells, and called it *Acerina zillii*. Many data are available regarding to growth and physiology of this species (Polat, 1998; Dikel *et al*. 2002; Yildirim *et al*. 2009; Mahomoud et *al*. 2011; Yildirim and Guroy, 2015), but studies in Algeria are scarce (Zouakh *et al*., 2005). Therefore, as part of our research, it seems essential to study thoroughly its reproduction, age, and growth in order to identify the major biological aspects and population dynamics of this native species.

MATERIALS AND METHODS

Fish samplings

We revealed the presence of *T. zillii* in Djemaa city (southeastern Algeria) (Fig. 1), in a river belonging to the wetland of Oued Righ (latitude: 33°31'40.36"N; longitude: 6°01'10.01'"E). The area under study belongs to the Saharan bioclimatic region, which is characterized by a mild winter and ranked as Ramsar site (MADR, 2004). Fish sampling was performed methodically every one month and a half, *i.e.* two samples per season during an annual cycle. So, eight seasonal sampling campaigns have been conducted from October 2011 to September 2012. During this period, a total of 813 specimens were collected (230 males, 329 females, and 254 individuals of indeterminate sex). In the sampled streams, specimens of *T. zillii* were caught using a seine net with 1 cm mesh size. For each specimen caught, in order to study reproduction, age and growth, we measured: total length (TL), fork length (FL), standard length (SL) in millimetre with accuracy of 1 mm, total weight (Wt), eviscerated weight (We), gonad weight (Wg), and liver weight (Wl) in gram (g) with an accuracy of 0.01 g.

Reproduction

Reproduction of *T. zillii* was investigated by considering the reproductive cycle, the sex distribution, and the length at first maturity. Sex and maturity stages of gonads were determined by using the scale of Mahomoud *et al*. (2011).

Stage 1 (*immature or virgin and resting adult)*: thin, translucent and pale in colour testicles. Small and thin ovaries occupying a small part of the body cavity; invisible oocytes. Both gonads are invisible to the naked eye.

Stage 2 *(early maturing)*: testes enlarged, flat, increased in weight and volume, and creamy white in colour. Ovaries

Figure 1. – Location of the study area (●).

slightly larger and increased in weight. Whitish oocytes, occupying approximately half of the body cavity.

Stage 3 *(developing)*: testes more vascularized, thicker in size. Ovaries distended occupying about 2/3 of abdominal cavity with large pale yellow eggs.

Stage 4 *(pre-spawning)*: soft testicles, swollen, milky white, increased in weight and volume, occupying entire body cavity. More enlarged ovaries occupying the entire abdominal cavity with large number of big, turgid, spherical, translucent, swollen green ripe ova.

Stage 5 (*spawning)*: white testicles. A simple compression brings out the sperm. Mature oocytes visible through the ovarian wall and some ripped eggs present in the oviduct.

Stage 6 *(spent)*: empty testes with evidence of hemorrhage. Flaccid, sac-like and reduced in volume ovaries.

The numerical proportions of the sexes (Kartas and Quignard, 1984) were determined each season as follow: sex distribution of males = M / (M + F) × 100, sex distribution of females = F ∕ (F + M) × 100, where F is the number of females and M is the number of males. Temporal changes in gonadosomatic index (GSI) and hepatosomatic index (GSI) were followed to describe the sexual cycle and to determine the spawning period:

$$GSI = Wg / We \times 100, HSI = Wl / We \times 100.$$

The Fulton composite coefficient (Postel, 1973) was used to express the condition of the specimen, depending on the season and sex. This condition factor (K) was calculated using the formula:

$$K = W_e / TL^b \times 100,$$

where b, the allometric coefficient, is defined for each sex in the study of relative growth (Perez and Pereiro, 1985).

Length at first maturity

Length at first maturity (Lm50) is the length at which 50% of the individuals have reached maturity. In order to accurately estimate Lm50, sampling should focus only on individuals caught during the spawning period.

Age and growth

The study of age was carried out by two methods. The first method, the indirect one, is the method of Bhattacharya (1967). This method, whose application protocol is slightly modified by Gayanilo *et al*. (2005), is based on the analysis of frequency distributions of measured sizes (TL). The age-length data pairs, obtained by Bhattacharya's method and direct reading scale method, were introduced in the FISAT II (1.2.0) for the calculation of von Bertalanffy growth equation parameters. The calculated growth parameters L_∞, *k* and t_0, along with the corresponding equations for *T. zillii*, are grouped by gender. The parameters used for estimating the weight growth of *T. zillii* are those obtained by the analysis of the age-length key of the Bhattacharya's method for separate sexes and for combined sexes. This choice is justified by the fact that the asymptotic lengths (L_∞), calculated by the analysis of the scale reading age structures, are less than the maximum lengths observed. The second method, the direct one, is the scale reading. In this method, 3 to 8 scales per specimen were always collected under the left pectoral fin. The scales, cleaned with water, were mounted between two blades and observed under a binocular microscope at constant magnification. On each scale, using an ocular micrometer, the total radius of the scale (R) and the radii R_1, R_2, R_3, …, R_n of growth-stop rings were identified, following the line segment enclosing the nucleus to the anterior-medial end of the fish scale. Additionally, in order to determine the period of onset of growth arrest rings, we analyzed the seasonal variation of marginal elongation (ME) with the formula (Man-Wai and Quignard, 1984):

$$ME = R - R_n / R_n - R_{n-1},$$

where R is the total radius of the fish scale; R_n is the last ring radius; and R_{n-1} is the before last ring radius. The relationship within scale size and the biometric relationships between the different lengths of the individuals are of the type Y = aX + b. Additionally, Lee's formula (Lee, 1920), slightly modified by Francis (1990) was selected to carry out the retrospective calculation of the fish size at the time of the ring formation:

$$TL_i = (bR_n + a) / (bR + a)L_c,$$

where TL_i represents the fish length at the time of the ring formation *i*; L_c is the total length of the fish at catch; R_n is the radius of the scale at n^{th} ring; R is the total scale radius; a is the length fish to the scale formation; b is the slope of the relationship as a function of TL.

The length-weight relationship is of type:

$$W = a\,TL^b,$$

where W is fish weight in g; TL is fish total length in cm; a is the scaling constant and b is the allometric coefficient/ growth parameter. The equation is written as follows:

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

Where L_t is the fish length at time t; L_∞ is the theoretical asymptotic length if the individual increases indefinitely; *k* is the growth coefficient or growth rate; t_0 is the theoretical age for which fish length is zero.

The combination of linear growth equation with the length-weight relationship leads to the growth equation by weight of von Bertalanffy:

$$W_t = W_\infty(1 - e^{-k(t - t_0)})^b,$$

where W_∞ is the asymptotic weight in g; *b* is the coefficient of relative growth between weight and length.

To compare the curve of the theoretical weight gain of males to that of females, we calculated the medium growth rate (ø') (Pauly and Munro, 1984). The formula is as follows:

$$ø' = Log(k) + 2LogL_\infty,$$

where *k* is the growth coefficient and L_∞ is the asymptotic length.

Table I. – Seasonal sex distribution of *T. zillii*.

Season	Males		Females		Total	ε
	N	%	N	%		(α = 5%)
Autumn	38	39.18 ± 9.71	59	60.82 ± 9.71	97	2.13
Winter	15	30.61 ± 12.90	34	69.39 ± 12.90	49	2.71
Spring	140	43.75 ± 5.44	180	56.25 ± 5.44	320	2.24
Summer	37	39.78 ± 9.95	56	60.22 ± 9.95	93	1.97
Total	230	41.14 ± 4.08	329	58.86 ± 4.08	559	4.19

The age-length key obtained by back calculation indicates that the columns represent the average lengths, calculated from the brute values for each age considered. While the underlined values indicate reverse calculated mean sizes, corresponding to slower growth rings in each age group.

Statistical analyses of sex-distribution, monthly means of GSI, HSI and K were performed by using *ε*-test based on the comparison of two observed values (mean, percentage or slopes).

RESULTS

Sex distribution

Sex distribution by season (Tab. I) reveals a clear dominance of females during autumn, winter and spring (ε > 1.96; α = 5%), with a maximum value in winter. Summer (spawning period) presents a well-balanced sex distribution (ε ≈ 1.96; α = 5%). In general, the numerical proportion of females, which is around 59%, is significantly different from that of males; the latter oscillates around 41% (ε > 1.96; α = 5%).

Gonadosomatic index (GSI)

For the GSI, figure 2A shows that for both females and males, maturation of genital products starts in March. The average GSI is more important than in January with 0.52 for males and 1.39 for females. In April, the index reaches 0.64 and 2.14, respectively. Consequently, gonads are then at their maximum weight mass. Beginning of spawning and emissions causes a decrease of average GSI in June and July. From September, the GSI is low, indicating the spread of sexual rest until the following March, for the acquisition of another annual cycle.

Hepatosomatic index (HSI)

For both sexes, the HSI peaks in March, before the sexual maturation of gonads (2.67 for males and 3.14 for females). The minimum values are found in September, at the end of the spawning period (1.01 for males and 1.23 for females) (Fig. 2B).

Condition factor (K)

Considering the seasonal mean, the condition factor K varies significantly for both sexes: firstly, between autumn and winter (ε = 4.86; α = 5 % for males; ε = 4.92; α = 5 % for females); secondly, between winter and spring (ε = 4.92; α = 5 % for males; ε = 4.5; α = 5 % for females). It peaks in winter with average values of 2.21 for males and 2.89 for females. In spring, K significantly decreases slowly to 2 for males and 2.65 for females (Fig. 3).

Length at first maturity

According to figure 4, the length at first maturity (Lm50) is approximately 9.7 cm for males, 9.9 cm for females and about 10 cm for both sexes.

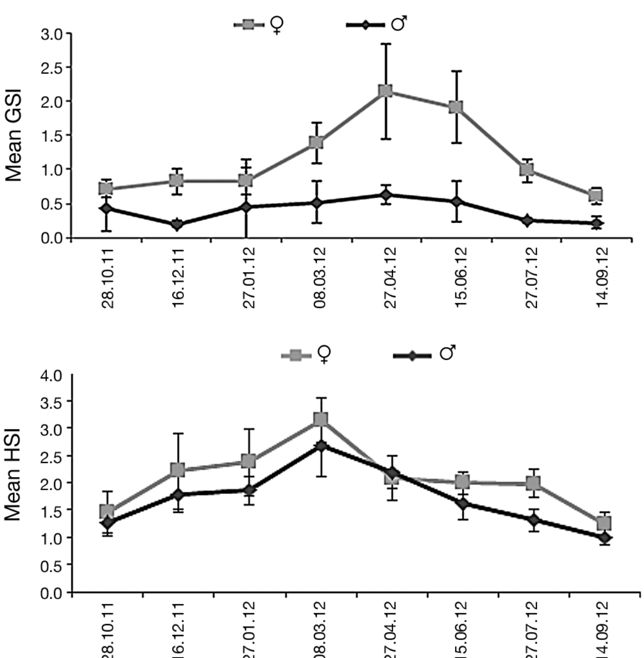

Figure 2. – Mean gonadosomatic index (GSI) and mean hepatosomatic index (HSI) in *T. zillii* males and females of Oued Righ wetland, from October 2011 to September 2012. Vertical bars indicate SEM.

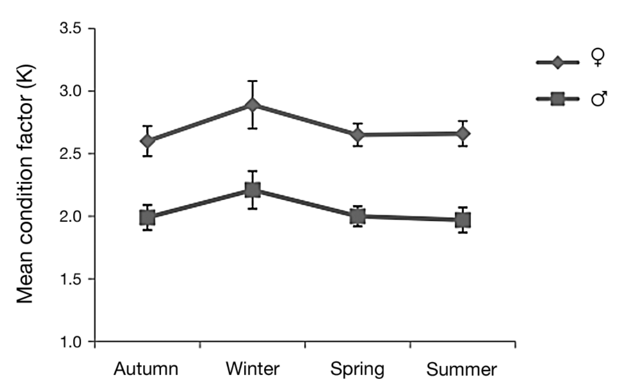

Figure 3. – Mean condition factor K according to sex and season of *T. zillii*. Male: ε = 4.92; α = 5 %; female: ε = 4.5; α = 5 %).

Age group (yr.)		I	II	III	IV	
♂	TL obs.	9.67 ± 1.5	14.05 ± 0.52	15.05 ± 0.95	17.5 ± 0.52	TL cal.
	TL_1	8.06	9.32	8.6	7.95	8.77 ± 0.45
	TL_2		11.99	11.36	10.54	11.64 ± 0.44
	TL_3			13.45	13.14	13.42 ± 0.7
	TL_4				15.46	15.46 ± 0.62
	N	13	28	23	3	
♀	TL obs.	9.96 ± 1	12.24 ± 0.39	13.6 ± 0.55	13.83 ± 0.49	TL cal.
	TL_1	8.19	8.84	8.94	7.96	8.65 ± 0.37
	TL_2		10.71	10.98	10.04	10.8 ± 0.34
	TL_3			12.43	11.36	12.27 ± 0.5
	TL_4				12.62	12.62 ± 0.58
	N	22	21	34	6	
♂ + ♀	TL obs.	9.64 ± 0.75	13.28 ± 0.42	14.19 ± 0.53		TL cal.
	TL_1	7.53	9.1	8.74	7.85	8.49 ± 0.32
	TL_2		11.44	11.09	10.14	11.17 ± 0.29
	TL_3			12.82	11.91	12.7 ± 0.43
	TL_4				13.55	13.55 ± 1.04
	N	40	49	57	9	

Table II. – Size (TL in cm) observed and calculated retrospectively for males, females and combined sexes of *T. zillii* in Oued Righ wetland. N: Number of individuals; Obs: observed, cal: calculated, yr: year, TL1: total length for age group I, TL2: total length for age group II, TL3: total length for age group III, TL4: total length for age group IV.

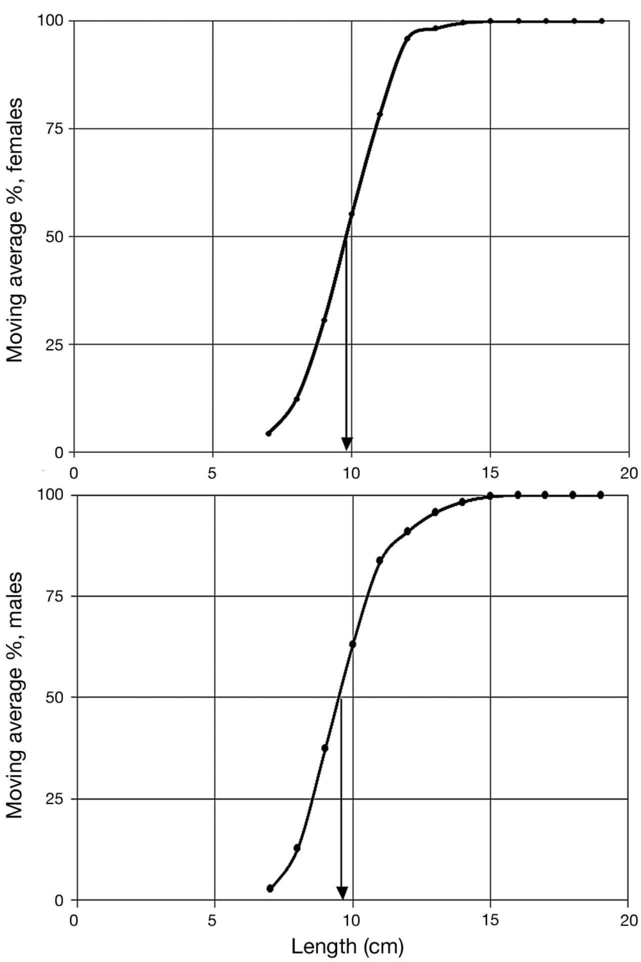

Figure 4. – Length at first sexual maturity of *T. zillii* in females and males.

Age and growth

Bhattacharya's method (1967) allows us to break down the male and female samples into four and three cohorts, respectively, which cluster around lengths of 8.66 ± 0.34, 13.72 ± 0.21, 16.83 ± 0.18, 19.56 ± 0.32 cm for males and 8.38 ± 0.42, 12.79 ± 0.16, 17.18 ± 0.24 cm for females.

Marginal elongation

Values considered are those of seasonal mean. A minimum of scale growth appears during the winter (0.33 ± 0.16 mm, $\alpha = 5\%$), while the maximum is observed in autumn (0.9 ± 0.12 mm, $\alpha = 5\%$) (Fig. 5). Thus, the slower growth ring appears in winter. The spawning period of *T. zillii* lasts three months from May to July and, assuming that spawning takes place in May and the growth rings on the scales are formed in January, the approximate of maximal determined age is four years.

Age-length relationship

By all the obtained results for males, females and both sexes combined, a regression was conducted to know the mathematical relationship between age and size. This analysis highlights a logarithmic regression. The regressions obtained for males, females and both sexes, have allowed to find high coefficients of determination (r^2), 0.846, 0.828 and 0.883, respectively.

Linear growth equations can be written as follows: $L_t = 23.22(1 - e^{-0.45t})$ for males, $L_t = 20.99\ (1 - e^{-0.49t})$ for females and $L_t = 24.87\ (1 - e^{-0.40t})$ for both sexes.

The established sex relationships are shown in Table III. The values of the parameter b are remaining close to 3, regardless of the gender. The ε-test, based on the comparison

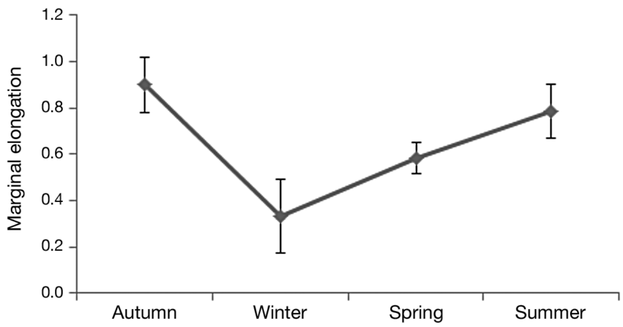

Figure 5. – Seasonal variation of marginal elongation.

Table III. – Equations of length-weight relationships in females, males and both sexes of *T. zillii*.

	Allometry relation	N	r^2	$\lvert t \rvert_{cal.}(\alpha = 5\%)$
Male	$W_t = 0.022TL^{2.893}$	230	0.98	0.05
Female	$W_t = 0.031\ TL^{2.772}$	329	0.98	0.104
Both sexes	$W_t = 0.021\ TL^{2.917}$	813	0.99	0.041

Table IV. – Equations of biometric relations of *T. zillii*. TL: total length, SL: standard length, FL: fork length

	Relations	r^2	$\lvert t \rvert_{cal.}(\alpha = 5\%)$
Male	TL = 1.43SL – 2.05	0.980	7.91
	TL = 1.01FL + 0.07	0.996	0.55
Female	TL = 1.25SL + 0.19	0.994	4.24
	TL = 1.03FL – 0.06	0.994	1.11
Combined sexes	TL = 1.23SL + 0.33	0.994	2.11
	TL = 1.02FL + 0.05	0.996	0.62

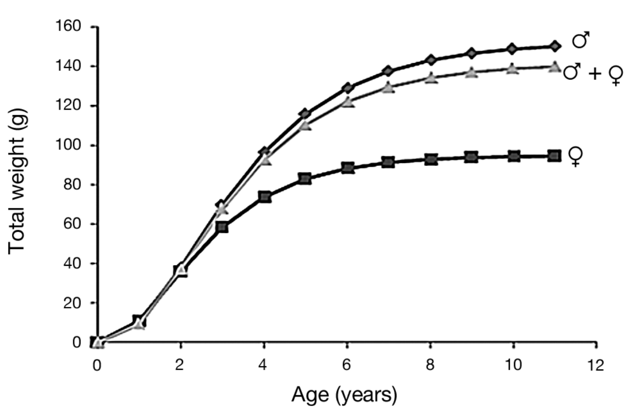

Figure 6. – Weight growth curves of *T. zillii* according to von Bertalanffy equation.

of two slopes, provides values below 1.96 for $\alpha = 5\%$. Table IV summarizes the equations relating the total length to the other dimensions of the individual. Regarding the relationship between the total length and the fork length, the calculation of the ε-test provides values below 1.96 for $\alpha = 5\%$, indicating an isometry between the total length and the fork length for separated and mixed sexes. On the opposite, regardless of the sex and both sexes, the relationship calculated between the total and the standard length show strong evidence of an upper bound allometry (slope always greater than 1).

According to von Bertalanffy method of growth, equations derived in weight are the following: $W_t = 196.73(1 - e^{-0.45t})$ for males, $W_t = 143.21\ (1 - e^{-0.49t})$ for females, and $W_t = 247.40\ (1 - e^{-0.40t})$ for both sexes.

Figure 6 shows the theoretical weight growth curves. The study of weight gains of both sexes of *T. zillii* has determined 141.6 g as a theoretical maximum weight. From 2 years old, males show a slight faster growth in weight than that of females (ø' males = 2.38; ø' females = 2.33).

DISCUSSION

The results of the overall sex distribution of *T. zillii* of the wetland Saharan region of Oued Righ show that it is in favour of females during all seasons. This means that the stock contains more females than males. In contrast, results from other studies (Phillip and Ruwet, 1982; El-Shazly, 1993; Negassa and Getahun, 2003; El-Sawy, 2006; Akel and Moharram, 2007; Negassa and Prabu, 2008; Mahomoud et *al.*, 2011) showed that sex distribution was always in favour of males. These differences could be explained either by the number of individuals considered, which have a direct impact on the value, or by the environmental conditions in the study area, such as water temperature (27°C seasonal average) and water salinity that varies between 7.8 and 10.2 psu (practical salinity unit). The study of the seasonal evolution of GSI allowed to determine the spawning period of *T. zillii*, which runs from March to August. Maximal values of GSI for both male and female are reached in spring (Fig. 2A). Indeed, the maturation of genital products begins in winter and is completed in spring. The first issuances of gametes take place in spring. The gonads are then emptied of their gametes in summer. In fact, we noticed that, in July, the majority of females were in stage VI (post-spawning). The spawning period for cichlids, especially for *T. zillii*, has already been determined by several authors (Tab. V). The results obtained in different African regions are broadly consistent with ours. For instance, in Abu Qir Bay Lake (Egypt), according to Akel and Moharram (2007), spawning of the species was observed between June and September. For Siddiqui (1979) in Naivasha Lake (Kenya), spawning takes place slightly later and would last from June to January; this may be due to hydrological conditions.

Seasonal variations of the hepatosomatic index (HSI) in both sexes of *T. zillii* show hepatic synthesis and hepatic lipid consumption phases. This index peaks before the sexual maturation of gonads, which means that the average weight of the liver begins to grow from autumn to winter.

However, the minimum values are noticed at the end of the spawning period. Due to the significant variations in the HSI, this species would draw its energy from lipid reserves of the liver and, thus, could belong to the category of fish called 'lean' that store their lipid reserves in the liver. However, this remains to be confirmed by the study of the mesenteric reserve index (MRI) and the extra-visceral reserve index (EVRI) to check if the liver plays a more important role than the mesenteric fat and muscle in the phenomenon of genital product maturation.

The condition factor K indicates the good condition of the individuals of *T. zilli* that is reflected by an accumulation of reserves essential to spring gametogenesis. The variations in this factor are low. However, it should be noted that, at the spawning period, fish overweight is at its minimum, probably due to the maturation of sexual products and their issuance, which requires relatively high energy expenditure.

In our case, the length at first maturity (Lm50) of males and females of *T. zillii* in natural environment are substantially similar. However, in a confined environment (Dadzie and Wangilia, 1980) or in farming conditions (Macintosch and Little, 1995), sexual maturation of *T. zillii* happens earlier. These differences in length at first sexual maturity may be attributed to differences in genetical and environmental conditions such as food supply, population density and changes in temperature and salinity (Bardackci and Tanyoloc, 1990; Ünlü and Balci, 1993). Lowe-McConnell (1982) reports that in crowded environments, male tilapias grow faster than females.

The age-length relationship obtained by the scale direct reading shows that four age groups are found in both sexes and for all studied individuals. On the whole, the mean sizes of males and females is relatively the same in the first three age groups, and is different in the last one. On the other side, longevity is the same, indicating a non-similar linear growth for both sexes of *T. zillii*. In Oued Righ wetland, *T. zillii* reaches a maximum age of four years. The latter are higher than the lengths calculated for the four age groups. The back calculation tends to underestimate the age-length relationship for males, females and both sexes combined. This confrontation has set our choice on the results of the key obtained by scale direct reading for the determination of growth parameters. The size is 2.49 for males, 2.85 for females and 2.38 mm for both sexes combined.

The results of the mean sizes obtained by back calculation are closer to those of Ibrahim *et al*. (2008) in Abu-Zabal Lake (Egypt) and of Hatem and Marwa (2008) in the Nile River (Egypt) (Tab. II). A difference is noted with those of Hadi (2008) in Umhfein Lake (Libya) and Mehanna (2004) in Wadi El-Raiyan Lake (Egypt). This is probably due to the interpretation of the scales and the quality of the sampling, as shown by Chauvet (1988). The regressions obtained for males, females and both sexes have allowed to get high coefficients of determination (r^2), 0.846, 0.828 and 0.883, respectively. These two variables are well inter-correlated, allowing thus to determine the size of the fish since the appearance of the fish scale. The size is 2.49, 2.85 and 2.38 mm, respectively, for males, females and both sexes combined. According to table VI, these lengths are close to the values found by

Table V. – Spawning period of *T. zillii* in different regions according to literature data.

Authors	Study area	Spawning period
Mahomoud *et al*. (2011)	Timsah Lake (Egypt)	April-August
Ishikawa and Tachihara (2008)	Okinawa-jima (Japan)	April-August
Akel and Moharram (2007)	Abu Qir Bay Lake (Egypt)	June-September
MacLaren (1981)	Manzalah Lake (Egypt)	April-September
Negassaand Prabu (2008)	Zwai Lake (Ethiopia)	April-September
Siddiqui (1979)	Naivasha Lake (Kenya)	June-January
Present study	Oued Righ wetland (Algeria)	April-July

Table VI. – Age-length keys of *T. zillii* in different regions according to literature data.

			Age-length key			
Authors	Study area	Sex	I	II	III	IV
Ibrahim *et al*. (2008)	Abu-Zabal Lake (Egypt)	M + F	9.03	11.36	13.34	15.29
Hatem and Marwa (2008)	Nile River (Egypt)	M + F	7.00	10.50	12.60	14.20
Hadi (2008)	Umhfein Lake (Libya)	M + F	11.69	15.33	18.01	20.35
Mehanna (2004)	Wadi El-Raiyan Lake (Egypt)	M + F	14.75	22.18	26.69	29.38
Present study	Oued Righ wetland (Algeria)	M + F	8.39	11.38	13.45	15.95

Table VII. - L_∞ and *k* parameters of *T. zillii* (combined sexes) in different regions according to literature data.

Authors	Study area	L_∞ (cm)	*k* /yr
Jensen (1957)	Noussa Hydrodrome (Egypt)	23.10	0.33
El Bolock and Koura (1961)	Beteha Lake (Syria)	20.90	0.39
Payne and Collinson (1983)	Qarun Lake (Egypt)	21.98	0.66
Khallaf *et al*. (1986)	Bahr Shebeen (Egypt)	19.50	0.49
El-Sehamy (1993)	Bahr Shebeen (Egypt)	21.56	0.27
Faltas (1995)	Qarun Lake (Egypt)	20.96	0.35
Mehanna (2004)	Wadi El-Raiyan Lake (Egypt)	33.50	0.49
Hadi (2008)	Umhfein Lake (Libya)	28.81	0.24
Present study	Oued Righ wetland (Algeria)	20.54	0.50

Hatem and Marwa (2008) in the Nile River (Egypt) and by Mehanna (2004) in Wadi El-Raiyan Lake (Egypt).

The values of the asymptotic length L_∞ are broadly similar to those of maximal sizes in females and males. It is the case for all individuals. Table VII summarizes some results of the growth parameters L_∞ obtained for *T. zillii* in different regions. Geographic variations are probably due to the quality of the sampling methods used, as well as the fluctuations of the physicochemical parameters of the environment (Ibrahim *et al*., 2008). We notice that the values of the parameter b of allometry relation (Tab. III) remain around 3 regardless of the gender. The coefficients of determination (r^2) obtained are close to 1, thus showing a good dependency between the total weight (Wt) and the total length (TL). The ε-test, based on the comparison of two slopes, provides values below 1.96 for $\alpha = 5\%$. This result allows to conclude that *T. zillii*, fished in Oued Righ wetland, is characterized by an isometry between the total weight and the cube of the total length, and this for both separated and combined sexes.

The length-weight relationship established for *T. zillii* by Lalèyè (2006) on Ouémé River (Benin) and the present work shows an isometry (b = 2.972, b = 2.917, respectively), but the studies of Béarez (2003) on Hippopotamus Pond (Burkina Faso), Coulibaly (2003) on Volta River (Burkina Faso) and Konan *et al*. (2007) on Bia River (Côte d'Ivoire), show a decreasing allometry (b = 2.743, b = 2.810, b = 2.837, respectively). Britton and Harper (2006) on Naivasha Lake (Kenya), Bongonyinge (1984) on New Calabar River (Nigeria) and Entsua-Mensah (1995) on Volta River (Ghana) describe a majorant allometry (b = 3.156, b = 3.210, b = 3.176, respectively).

The divergence between these results may be closely related to the richness of nutrients and good hydroclimatic conditions that are the source of the abundance of plankton, essential for *T. zillii* diet. In addition, the sampling period, compared to the spawning period during which the condition factor (K) reaches its minimum, could result in a bad condition of individuals during spawning. After the spawning period, the fish quickly gain weight, which would increase the K factor.

The study of weight gains indicates that at the same age (in particular from 2 years old), weight gain of males is faster than females.

Ultimately, in order to complete the reproduction study, it would be interesting to estimate fertility. In addition, the age determination by the otolithometry method is recommended to confirm the results obtained through the fish ageing.

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