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Some reproductive aspects of *Oreochromis niloticus* (LINNAEUS, 1758) at Peele reservoir, Nakanbé River Basin, Burkina Faso

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Abstract
Some reproductive parameters of *Oreochromis niloticus* have been studied from April 2015 to Mars 2017 at Peelé reservoir, Burkina Faso. Specimens of *O. niloticus* were collected monthly from traditional fishing. The overall sex-ratio was 1:0.98. Breeding period occurred from April to July and the spawning of oocytes began at the end of July. The length-weight relationship showed negative allometric growth. Value of condition factor (K) was affected by the measurement unit of length. The size at first maturity was found to be 110.41 mm of standard length (L) and 111.77 mm (L) for females during the first year and the second year; the males one were respectively equal to 145.85 mm and 132.31 mm (L). Absolute fecundity ranged from 174 to 593 oocytes with a mean of 412 ± 28 oocytes while the relative fecundity has been estimated to 6 oocytes per gram of body weight.

Keywords: Breeding period, Cichlidae, fecundity, man-made Lake, length-weight relationship

1. Introduction

Burkina Faso is probably the West African country with the highest density of small water reservoir, due to the constant increasing demand for their creation [1]. The Nakanbé River, which covers approximately 81,932 km^{2,} is an ephemeral river in a semi-arid region of Burkina Faso [2]. It make up a considerable part of the surface water retention of the country with around 400 water reservoirs [2]. Livelihood systems depend heavily on these artificially aquatic ecosystems [1] which permit to fight food insecurity and poverty. They are used for agriculture, farming and fisheries [3]. These water bodies have important fish diversity which is dominates by *Oreochromis niloticus* [4] which has a commercial importance and is a source of quality protein. Indeed, *Oreochromis niloticus* is one of the leading farmed species in the world [5, 6] owing to its benthopelagic diet and has a wide range of tolerance to environmental conditions [7]. In addition, it is a fish that reproduces easily and has a rapid growth [8]. *O. niloticus* is frequent in catches of Peelé reservoir's fishermen and it is appreciates by local population. However, environmental impact of water body construction dam and intensive use may exert severe pressures on aquatics organisms' life, particularly fish one. The construction of a dam on a river can modify, for example, fish laying period [3]. To manage fisheries in each water reservoir, knowledge in their biology and ecology ought to be known. Indeed the knowledge of fish reproduction biology, per example, is essential for a good management of fisheries resources [9]. It's in the sense that some studies has been done, in Nakanbé basin, on fish diet [10], fish parasites and fish ecology [8], but few studies have been done on fish reproduction especially on *O. niloticus* one. In Peelé reservoir, particularly, no study has been carried out in *O. niloticus* reproduction. The aim of the present study was to estimate the reproductive biology of *O. niloticus* in Peelé reservoir, Burkina Faso.

2. Material and methods

2.1 Study area

The present study was carried out in the man-made lake of Peelé, Burkina Faso (Fig. 1). This reservoir was created in 1950 on the Nariale River. Fish were sampled in the downstream part of the reservoir (12°14'53,6"N & 1°11'82,4"W) located in Peelé village. Peelé is a small rural village located at 50 km, at the south-east, of Ouagadougou (Burkina Faso). This village is located in the North Sudanian climatic zone. In that zone, the wet season occurs from June to October and the dry season from November to May. Socio-economic activities are dominated by agriculture, market gardening and fishing.

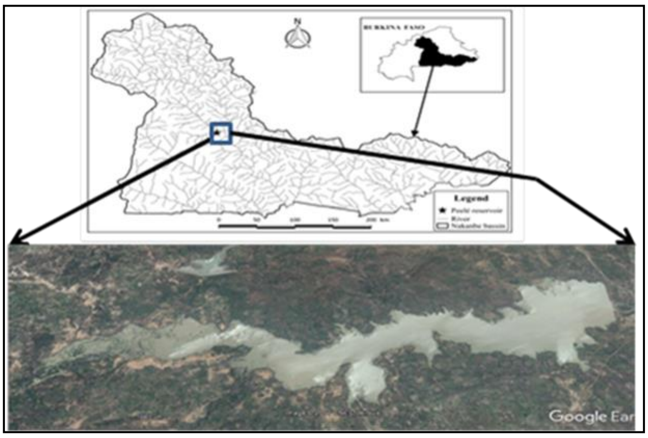

Fig 1: Location of Peelé reservoir in Nakanbé basin (Burkina Faso).

2.2 Fish sampling and analysis

In the zone of Peelé reservoir, the wet season occurs from June to October and the dry season from November to May. Specimens of *O. niloticus* were collected monthly from traditional fishing at Peelé reservoir, from April 2015 to March 2017. After sampling, fish were kept in a cooler with ice and transported to the "Laboratoire de Biologie et Ecologie Animales" (LBEA) of University Ouaga I Pr Joseph KI-ZERBO, Burkina Faso. At LBEA, standard length of specimens was measured to the nearest millimeters using an ichtyometer. The whole body weight and body gutted weight were also measured on a digital balance to the nearest grams.

2.2.1 Sex-ratio

Specimen's sex was determined either by external examination of the genital papilla and has been confirmed after dissection by macroscopic examination of gonads [11]. The sex-ratio is the numerical ratio between males and females.

2.2.2 Maturity stages

After dissection, gonads were removed and weighed to the nearest 0.0001 gram using OHAUS digital balance. Maturities stages were determined by macroscopic observation of gonads (shape, color, volume and number of blood vessels irrigating it, size of oocytes) according to Legendre & Ecoutin [12].

2.2.3 Gonado-somatic index estimation

Gonado-somatic index (GSI), the ratio between gonads weight and body gutted weight, was used to estimate fish sexual activities [13]. GSI was calculated for males and females separately.

2.2.4 Length- weight relationship and condition factor

Length-weight relationship was estimated as $W = a * L^{b}$, where: W= total weight; L= standard length; a= regression intercept and b= slope. a and *b* were calculated by linearizing this relation using the least square method [14]. The value of b was then used to determine the kind of growth: if the value of b is equal to 3, the growth is isometric; if the value of b is different to 3, the growth is allometric negative (b<3) or positive (b>3). Length-weight relationship was estimated for combined specimens (males and females) and separately for males and females. It was also estimated by month, year and seasons.

Condition factor (K) expresses the conditions on fish population and was calculated using the relation [5]: $\mathbf{K} = 100 \times Wg / L^{b}$ where K= condition factor, Wg= body gutted weight, L= standard length and b = slope. Fishes with condition factor values greater than one (≥ 1) were considered as high while those less than one (< 1) were low [15, 14]. It was calculated for all specimens and for males and females separately.

2.2.5 Length at first sexual maturity

Standard length at first sexual maturity (L_{50}) is the standard length at which fifty percent (50%) of the specimens was matures for the first time. It was determined, for each sex, during spawning period and by sampling year according to an equation below generated from logistic regression. In the relation, P is the proportion of mature invidious; L the standard length; α and β are constants. Following a logarithmic transformation L_{50} can be determined using the following equation: $L_{50} = -\alpha/\beta$ [6].

2.2.6 Estimation of fecundities

For fecundity study, only females of stages IV have been considered. Ovary at stages IV were then collected and weighed using a digital balance OHAUS brand (precision 0.0001 g). A portion of ovaries were removed, weighed and it total number of oocytes were counted. Fecundities estimated were absolute fecundity and relative fecundity [16]. Absolute fecundity (Fa), total number of oocytes in the ovaries. Relative fecundity (Fr**)** was determined by doing the ratio between absolute fecundity and specimen's body total weight (W): $Fr = \frac{Fa}{W}$

2.3 Statistical analysis

Data analysis was performed using excel, Statistica and R (from the interface RStudio). All used tests were non-parametric except the Chi-square (χ^2) test used to compare sex-ratio. Mann-Whitney test was used to test the difference between sexes according standard length and body weight. For all the analysis, 0.05 was choosing as probability critical value.

3. Results

3.1 Sampled population structure

Characteristics of the sampled population of *O. niloticus* in Peelé reservoir have been described in Table 1. Of the 491 sampled specimens, 208 (94 males, 99 females and 15 unsexed) were collected the first year and 283(137 males, 137 females and 9 unsexed) the second year. Mann Whitney test showed that males were bigger ($P= 0.000146 < 0.05$) and heavier ($P= 0.0075 < 0.05$) than females.

Table 1: Structure of the population of *Oreochromis niloticus* in Peelé reservoir between April 2015 and March 2017

Sex	Number of specimens	Standard length (mm)			Body total weight (g)		
		Min	Max	mean	Min	max	mean
Females	236	75	151	112.70± 1.04	16	124	55.73± 1.44
Males	231	73	170	121.27± 1.43	16	188	70.93± 2.31
Unsexed	24	71	196	100.74± 2.31	15	73	40.43± 3.96
Total	491	71	196	115.69	15	188	61.63

3.2 Sex-ratio
Sex-ratio has been estimated on 467 specimens constituted by 231 males and 236 females. Overall and annuals values of sex-ratio were described in the Table 2. Seasonal characteristics of the sex ratio were shown in Table 3. Annual and seasonal sex-ratio were not significantly different from theoretical sex-ratio (P>0.05, Chi square test) (Table 2 and Table 3).

Table 2: Inter annual *Oreochromis niloticus'* sex-ratio variation in Peelé reservoir

	Total	Number of males	Number of females	Sex-ratio	χ^2	P-value
April 2015-march 2016	193	94	99	0.95	0.05	0,83
April 2016-march 2017	274	137	137	1	0.03	0,86
Total	467	231	236	0.98	0.08	0,78

Table 3: Seasonal variation of *Oreochromis niloticus*' sex-ratio in Peelé reservoir

Season	Total	Males	Females	Sex-ratio	χ^2	P-value
Dry season I	98	46	52	0,88	0,250	0,62
Dry season II	126	62	64	0,97	0,003	0,95
Wet season I	95	48	47	1,02	0,043	0,84
Wet season II	148	75	73	1,03	0,087	0,77
Total	467	231	236	0,98	0,383	1,00

3.3 Length-Weight relationship and factor condition
Length-weight relationships parameters and factor condition for males, females and overall specimens (males, females and unsexed) are given in Table 4. Length-weight relationships showed a negative allometry's growth in sampled population of *O. niloticus* in Peelé reservoir during the study period.

Table 4: Parameters of length-weight relationship and condition factor of *O. niloticus* in Peelé reservoir.

	All				Males				Females			
	a	b	K (mm)	K (cm)	a	B	K (mm)	K (cm)	A	b	K (mm)	K (cm)
April 2015-march 2016	0.000075	2.85	0.06	11.68	0.000168	2.68	0.06	12.37	0.000064	2.86	0.06	11.27
April 2016-march 2017	0.000938	2.34	0.14	17.27	0.001776	2.21	0.16	19.19	0.000273	2.59	0.13	15.83
Dry season I	0.000098	2.94	0.03	8.25	0.000168	2.68	0.03	8.50	0.000064	2.86	0.02	8.07
Dry season II	0.000115	2.78	0.03	9.62	0.000113	2.78	0.04	11.24	0.000156	2.71	0.03	8.62
Wet season I	0.000343	2.51	0.09	15.16	0.000421	2.41	0.10	15.91	0.000586	2.36	0.09	14.82
Wet season II	0.002677	2.12	0.24	23.99	0.005308	1.98	0.03	26.06	0.000324	2.55	0.23	22.23
Overall period	0.000439	2.48	0.11	14.93	0.000826	2.36	0.09	13.93	0.000162	2.69	0.10	13.81

a, regression intercept; b, slope; K (mm), factor condition when measurement unity of standard length is in millimeter (mm); K(cm), factor condition with centimeter (cm) as measurement unity of standard length.

3.4 Breeding period
The frequency of maturity stages (Fig. 2 and 3) and gonado-somatic index (Fig. 4) were used to indicate gonads development. Females breeding period occurred from April to July, with an important frequency of mature specimens (stage IV and V) in June and July. Maximum percentages of mature males were observed in March, May, June, July and August.

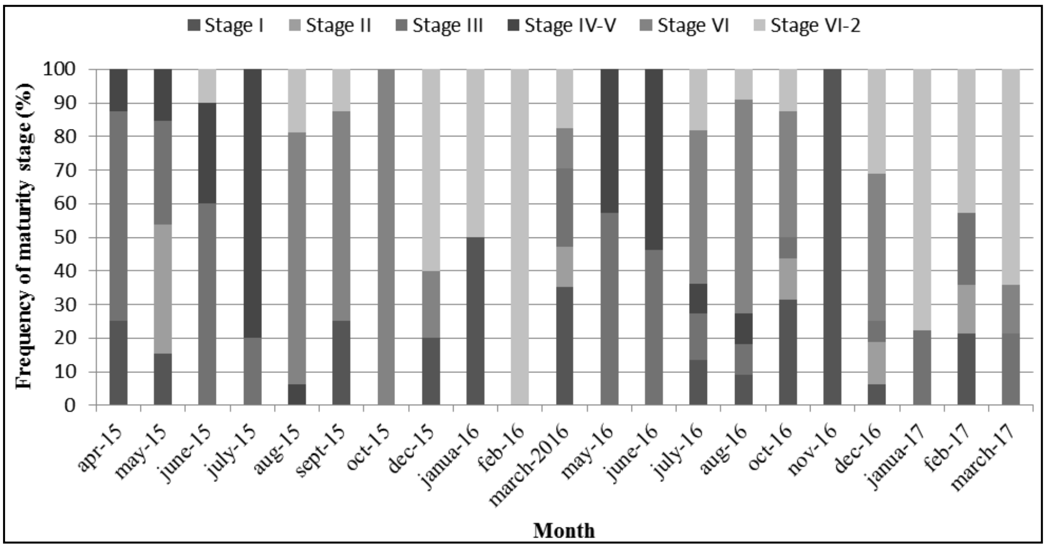

Fig 2: Monthly variation of stages of maturity of *O. niloticus*' females in Peelé reservoir from April 2015 to March 2017

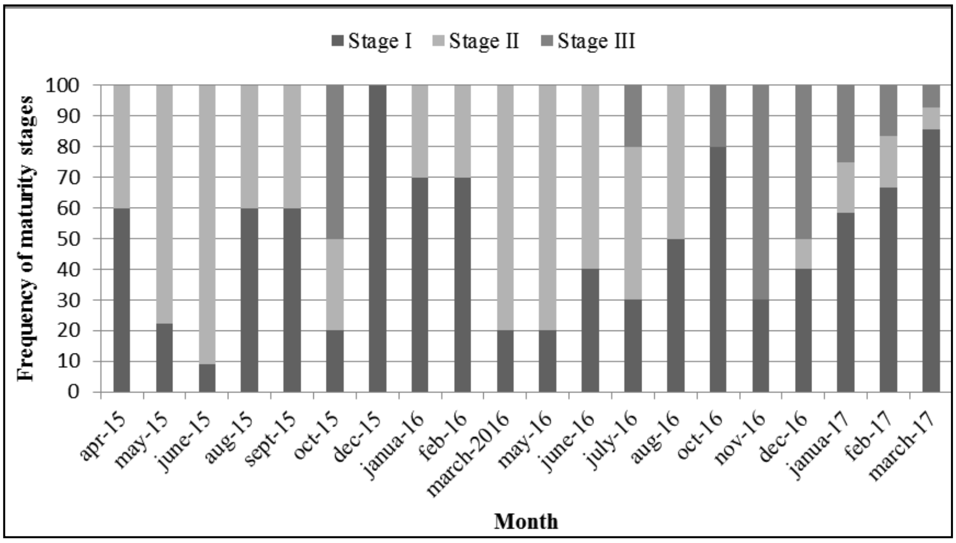

Fig 3: Monthly variation of stages of maturity of *O. niloticus*' males in Peelé reservoir from April 2015 to March 2017

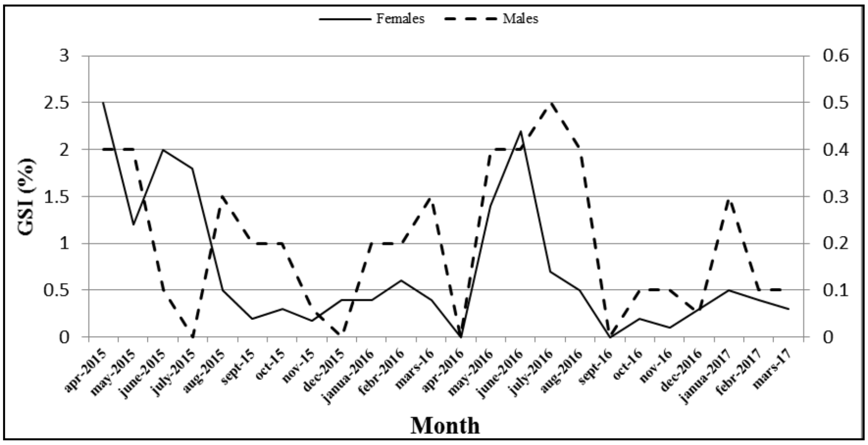

Fig 4: Monthly evolution of Gonado-somatic index (GSI) of *O. niloticus* (males and females) in Peelé reservoir from April 2015 to March 2017.

3.5 Standard length at first maturity

In the first year of our study, the standard length at first maturity of the females of *O. niloticus* was 110.41 mm (Fig. 5 A) while those of the males was 145.85 mm (Fig. 5 C). In the second year, the standard length at the first maturity was estimated to 111.77 mm for females (Fig. 5 B) and 132.30 mm for males (Fig. 5 D). The smallest mature females and males specimens had respectively 97 mm L and 89 mm.

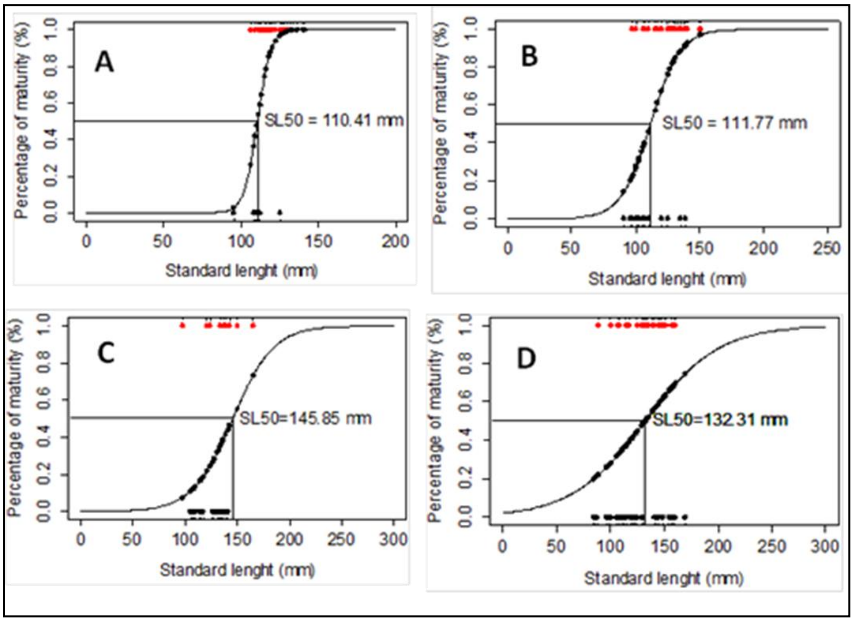

Fig 5: Standard length at first maturity (SL_{50}) of females and males of *Oreochromis niloticus* at Peelé reservoir from April 2015 to mars 2017: *A = SL_{50} females during the first year of the study (April 2015-march 2016); B = SL_{50} during the second year of the study; C = SL_{50} males during the second years study and D = SL_{50} males during the second year of study.*

3.6 Fecundities
Twenty three female's specimens of stage IV were used to estimate absolute and relative fecundities. The average absolute fecundity was 412 and ranged from 174 to 593. Relative fecundity ranged from 3 to 9 oocytes per gram of body weight, with a mean of 6 oocytes/g.

4. Discussion
4.1 Sampled population structure and sex-ratio
In the current study, there was no statistical difference between number of males and females of *O. niloticus* in Peelé reservoir. Similar results were observed in the same species at Coatetelco Lake, Mexico [17], in Opa reservoir, Nigeria [18]. Contrary to the current study, Njiru *et al.* [19], Montcho and Lalèyé [6] were found to *O. niloticus* a sex-ratio in favor of males respectively in Lake Victoria (Kenya) and Lake Toho (Bénin). Thereby, Marconato *et al.* [20] reported that in freshwater, sex-ratio of fish's natural population is generally close to one but could be very altered according season of the year or locally. It is generally reported by many authors that during breeding season, males of Teleost are more numerous in the catches than females. This is usually due to their breeding strategy and the large size of the males. Indeed in *O. niloticus*, females make mouth incubation and they possibly go toward submerged vegetation and rocky to avoid predators even fishermen [17]. However, in this study, males and females were approximately equal in number. This could be due to the sampling technic and a possibility of forming monogamous pairs. Indeed, specimens used for this study were caught by commercial fishing during which spawning grounds could be exploited. In addition, Lévêque and Paugy [3] reported that, in most cases, Cichlid species are monogamous.

4.2 Length-weight relationship and condition factor
Length-weight relationship has a great interest in the determination of fish's well-being and the slope (b) could be affected by the movements of fish. So, according to Muchlisin *et al.* [21], active swimming fish may show lower b value compare to passive swimming fish. As Peelé reservoir is not surrounded by a lot of trees and grasses, *O. niloticus* could hence migrate permanently in food searching and that could be explained why it was showed a negative allometric growth pattern in the current study. Similar results were obtained in Sô river (Bénin) [22] and River Brass (Niger) [23] in *O. niloticus*. Contrary to this study, Alhassan *et al.* [14] found an isometric growth pattern to the same species in Golinga river (Ghana). Length weight relationships could be also affected by many factors like habitat, gonads ripeness and stomach fullness [24, 25]. The values of b of *Oreochromis niloticus* in this study were within the range of normal values 2.5 to 3.5 [25] but were lower than the Bayesian confidence limits in Fish Base [26]. Condition factor is generally used to determine the health and well-being of fish in it habitat. However it is not expressed following the same standards according to many authors who would not gave importance to the use of the unit of measure of length. Indeed, for estimating condition factor, some authors (Ndiaye *et al.* [15], Vianny *et al.* [27]; Aryani *et al.* [28]; Muchlisin *et al.* [21]; Adam and Khalid [29]) used millimeters as unit of measure of length and others authors (Gesto *et al.* [30]; Seiyaboh *et al.* [23]; Ouédraogo *et al.* [4]; Alhassan *et al.* [14]; Baijot *et al.* [31]) were used centimeters. In this study, (using the same formula) condition factor was calculated with a standard length expressed in millimeters and centimeters. Obtained results showed that condition factor was highly influenced by length's measurement unit. So, when millimeters were used as unit, *O. niloticus* was showed a bad condition. Therefore, it was in good condition when standard length was expressed in centimeters. As in the current study, Imam *et al.* [32] (centimeters were used as length unit) found to *O. niloticus* from Wasai reservoir (Nigeria) a factor condition higher than one (K=2.44). However, Adam and Khalid [29] (millimeters have been used as length measurement unit) reported that *O. niloticus*' factor condition was higher than one in the southern part of Jebel Aulia Dam (Sudan). This is contrary to what found in the present study. It's for that reason, we thing that condition factor would not very suitable for determining the health and well-being of fish in their habitat. It would therefore be necessary to measure environmental parameters to know environmental conditions in which fish is found.

4.3 Breeding period
O. niloticus in peelé reservoir, during the current study, was showed a single breeding period occuring from April to July. This period was synchronized with wet saison of the zone. Indeed, according to Lévêque and Paugy [3], for many species, eggs laying coincides with the flood and can take place from the beginning of the flood to its maximum but more rarely during the recession. In addition, Baijot *et al.* [31], was noted that during the period of July, most of Burkina Faso's reservoirs was filled up, at least partially, and this would favors the survival of the offspring. Lowe-McConnel [33] was also repported that breeding period of *O. niloticus* is continuous throughout the year in equatorial lakes while in regions distant from the equator there is single breeding season. Thus, some smalls reservoirs of Burkina Faso (Baijot *et al.*) [31], Lake Toho (Montcho and Laléyé) [6], a single breeding period was also found. While in Lake Ayamé (Côte d'ivoire), an equatorial lake, females of *O. niloticus* was brood practically all the year, Duponchelle and Legendre [34].

4.4 Length at first maturity
Length at first maturity has a great importance in the determination of optimum mesh size and so important to the management of fishery resources [9, 35]. In this study, length at first maturity was higher in males than in females. That could be probably due by the fact that in Cichlids species, males are generally larger than females. Indeed, according to Lowe-Macconnel [33], in natural environment, as soon as the fish reach maturity, males grow faster than females and are consequently larger. Similar findings to those of the current study have been done on *O. niloticus* in Tapoa reservoir (Burkina Faso), Lake Toho (Bénin) and Abu-Zaba Lake (Egypt) respectively by Baijot *et al.* [31], Montcho and Lalèyé [6], and Shalloof and Salama [36]. However in Coatetelco lake, Mexico [17] length at first maturity of females was higher than that of males. Lengths at first maturity (177 mm for males and 157 mm for females) of *O. niloticus* found twenty years ago (since1994) by Baijot *et al.* [31] in Tapoa reservoir were higher than those reported in this study. At this period, environment's conditions of Tapoa's reservoir could be better than those found at Peelé reservoir during study period. Because, with climate change and population's pressure on environment (urbanization, agriculture) aquatic's ecosystems are degrading more and more and this would influenced fish's ecology and biology such as length at first maturity. That could be explained the difference between theirs results and those found in this study. In fact, for Duponchelle and Panfili

[37], in Tilapias, size at first sexual maturity depends on the environment conditions in which the fish grows. So when conditions are unfavorable the size of first maturity decreases while it increases when conditions are favorable.

4.5 Fecundities
Absolute fecundity of *O. niloticus* in this study has been obtained by sub-sampled method. The portion of the ovary was removed before being stored in formalin and this had to influence the results. Indeed, during the taking of the piece of ovary, some oocytes could be destroyed; this would have affected the weight of the ovary portion and consequently influenced absolute fecundity as well as relative fecundity. Thus for future fertility studies (at Peelé reservoir), using sub-sampled method, we suggest to remove some oocytes after digesting the ovaries in Gilson or formalin. Moreover, the success of this method would imply that the oocytes have the same weight and are uniformly distributed in the ovaries. Obtained Absolute fecundity in this study was higher than that found by Komolafe and Arawomo [18] (39-241 oocytes) and lower than that found by Njiru *et al.* [19] (905-7619 oocytes). The first authors were counted total oocytes' number on mouth while the seconds were counted all oocytes found in the ovaries. The limits of these two methods could be at the level of the losses of eggs during the sampling or examination of the specimen or the errors of inattention during oocytes counting. In addition to these methods, we can have photographic, multisub-sampled methods to estimate fecundity. But the best method is to count the number total of oocytes in ovary with oocytes counter machine [38].

5. Conclusion
It appears from this study that *O. niloticus* in Peelé reservoir has single breeding period occurring from April to July and has an allometry's negative growth pattern. In addition length at first maturity of males was higher than females one and average absolute fecundity was equal to 412 oocytes. Knowledge of reproductive parameters of *O. niloticus* in Peelé could permit to managers to manage very well it fishery. It also appears from this study that value of Fulton's condition factor is very influenced by unit of measurement of length. Therefore a reflection should be then done by ichthyologists on the estimation of the condition factor in order to find standards as to the choice of length's measurement unit.

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