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Abundance, length-weight relationships and Fulton's condition factor of the freshwater cichlid *Sarotherodon galilaeus* (Pisces: Teleostei: Perciformes) from a sand-dragged man-made lake of Southern Benin, West Africa

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Key words: Artificial lake, Condition indices, Establishment, Fisheries, Length-weight model.

Abstract

Condition factors and growth trends indices such as allometry coefficients are decisive fisheries management tools that evaluate the well-being of fishes, their establishment and the quality of their habitat. We investigated the condition factors and length-weight relationships of a freshwater tilapine cichlid, *Sarotherodon galilaeus*, that has naturally colonized the artificial lake of Ahozon (South-Benin). *S. galilaeus* individuals has been sampled every month in the "aquatic vegetation" and in the "open water" habitats with seines, cast nets, gill nets and hooks. This species dominated Lake Ahozon and made about 85.21% of the fish community. Fish sizes showed significant spatial ($F_{1,5548}$=57106.9, p=0.0001) and seasonal ($F_{2,5547}$=82,06, p=0.0001) variations and smaller sizes (18.65±5.76mm-SL) were recorded in the "aquatic vegetation" considered as the spawning ground for *S. galilaeus*. In Lake Ahozon, length-weight regression equations gave slopes *b* ranging between 2.636 and 3.081 indicating that *S. galilaeus* exhibited both allometric and isometric growth. Also, the species exhibited spatial ($F_{1,5548}$=94.510, p=0.0001), seasonal ($F_{2,5547}$=7.163, p=0.001), ontogenetic ($F_{2,5547}$=63.591, p=0.0001) and sexual ($F_{1,3781}$=8.275, p=0.001) variations of condition factors (K) that mostly depend on the availability of food resources. The prominence of the species and its condition factors indicated that *S. galilaeus* is well-establishment in Lake Ahozon. The improvement of growth performance and well-being for a sustainable fisheries/aquaculture in Lake Ahozon require the protection of the foraging and spawning grounds, the prevention against organic and chemical pollution, the introduction of predators to prevent overpopulation of *S. galilaeus*, the fertilization of the lake and a planned harvest of the fish stock.

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Introduction

The freshwater cichlid, *Sarotherodon galilaeus* (Pisces: Teleostei: Perciformes) is a worldwide Sub-Saharan African tilapine species that occurs in the Nile Basin, Niger River, Senegal and Casamance rivers of the Senegal Republic, Gambia River, Geba River in Guinea Bissau, Konkoure River in Guinea Conakry, Oubangui River in Central Africa, Ogun, Cross, Benoue, Logone and Chari rivers in Nigeria (Fryer and Iles, 1972; Lowe-McConnell, 1987; Leveque *et al*., 1992; Leveque, 1997; Snoeks, 2000). Also, this species inhabits lakes Mobutu,Turkana in the Democratic Republic of Congo (RDC), Lake Tchad, and in many water bodies of Benin (Leveque *et al*., 1992). *S. galilaeus* (Linné, 1758) species belongs to the family Cichlidae, Percoidei Sub-order, Perciformes Order, Acanthopterygii Super Order and Actinopterygii Subclass. This species exhibits a grew silvery color on the fins and sides and juveniles show some black vertical lines on the sides (Leveque *et al*., 1992; Leveque, 1997). About body ratio, the head length is 32.5-39.0% the standard length, body height is 43.0-56.5 % the standard length and pectoral length is 36.0-50.0% the standard length.

In Benin, *S. galilaeus* occurs in rivers Mono, Oueme, Niger, Sô and in natural Lakes such as Toho-Todougba, Ahouangan, Toho, Hlan, Azilli, Doukon and the coastal lagoon (Leveque *et al*., 1992; Van Thielen *et al*., 1987; Adite and Van Thielen, 1995; Adite and Winemiller, 1997). Particularly, in Toho-Todougba Lagoon (South- Benin), of the total annual fish catches estimated at 387 metric tons, about 73% (283 metric tons) was *S. galilaeus*, making this species the most valuable commercial fish resources in this water body (Adite and Winemiller, 1997). In addition, *S. galilaeus* has naturally colonized and dominated a sand-dragged artificial freshwater lake of Ahozon Village (Ouidah City, County of Pahou) in Southern Benin where the species is well-established and reproduce actively (Gbaguidi and Adite, in press). Lake Ahozon is an abandoned and neglected artificial water body resulted from a progressive accumulation of running water in an extensive hole, created by sand-dragging activities, and where *S. galilaeus* dominated the fish community (Gbaguidi *et al*., in press). In Lake Ahozon, *S. galilaeus* showed a sex-ratio of (0.60:1) and sizes at sexual maturity (L50) were about 131mm and 106mm, respectively, for males and females. In this man-made water body, *S. galilaeus* spawned all seasons and batch fecundity ranged between 42 oocytes and 1,149 oocytes**.** The species foraged mainly on algae (blue-green algae, green algae, desmids, diatoms), sand particles and detritus (Gbaguidi and Adite, in press; Gbaguidi *et al*., in press).

However, despite the fisheries and commercial importance of this species, and the high numeric abundance in this man-made lake, nothing is known about the length-weight relationships, the growth trends and the condition factors of *S. galilaeus* in this unmanaged artificial lake. Indeed, condition factors and length-weight relationships of fishes are important tools for fishery management and reflect habitat conditions (Abowei, 2010a, 2010b). Also, the growth factors and associated structural indices assess the plumpness or well-being of the species and hence, are response of the physiological conditions of fishes (Tesch, 1971; Abowei, 2009). Consequently, length-weight models and condition factors could be used as indicators to evaluate the productivity and the “ecological health” of aquatic ecosystems (Deekae and Abowei, 2010). More importantly, condition factors consistently affect the spawning cycle and are robust predictors of fecundity, reproduction, growth and mortality in fishes, and have been widely used as a measure of feeding intensity (Abowei, 2009). As a result, length-weight models and condition indices of fishes are valuable community structure tools used for management decision in fisheries and to evaluate the overall establishment of a naturally-colonized or introduced fish species (Schreck and Moyle, 1990).

The present study was carried out to assess the plumpness/well-being and growth trends of the freshwater cichlid, *Sarotherodon galilaeus* (Linné, 1758) in the man-made lake of Ahozon (South-Benin) using the Fulton’s condition factor and the matrixes of length – weight regression equations of the species. Inferences have been made for fisheries management and aquaculture valorization.

Materials and methods

Study area

The man-made lake of Ahozon (South- Benin) is the study habitat, located in Ouidah City, Pahou County (Fig. 1a). The city of Ouidah extended about 364 km² and comprises on its South, the Atlantic Ocean and the mangrove-lined coastal lagoon (Capo-chichi, 2006).

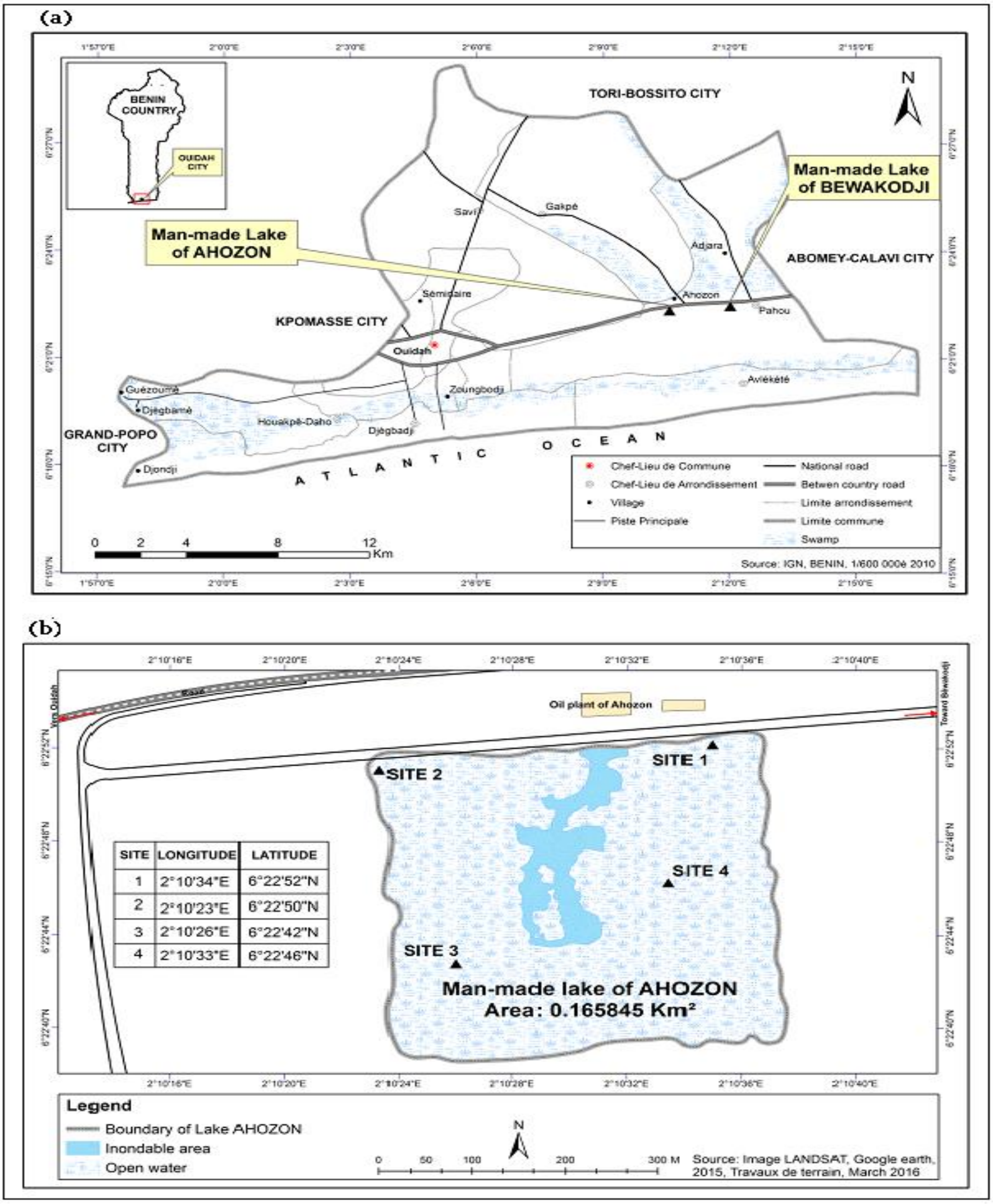

Fig. 1. Map showing: (a) Ouidah City in South-Benin and the study location, the man- made lake of Ahozon, and (b) the sampling sites: Site 1 and Site 2 = aquatic vegetation habitats; Site 3 and Site 4 = Open water habitats.

The climate is sub equatorial with two (2) wet seasons (April to July; mid-September to October) with a peak usually recorded in June, and two (2) dry seasons (December to March; August to mid-September). Yearly mean rainfall was about 1307.3 mm. Ambient temperatures ranged between 25°C and 33.6°C and monthly evaporation varied from 59.2 to 145 mm (Akoegninou *et al.*, 1993). The study area comprises some sandy soils, red ferric soils and a vast swampy soil, located at the coastal zone, and extended from Cotonou city (South-Benin) to Ouidah. Currently, this swamp undergoes sand-dragging activities, considered as an ecological disaster. Plantations such as *Elaeis guineensis* (palm tree) and *Coco nucifera* (coconut tree), producing oil for industries, were common in the study area (Adite and Van Thielen, 1995). Also, intense agriculture dominated by corn, tomatoes, beans, groundnuts etc. occurred in the study region. Likewise multispecies fisheries dominated the environment of Ouidah and took place in the brackish coastal lagoon and in some freshwater lakes such as Toho-Todougba, Ahouangan and Dati. Though not widespread, fish culture was encountered with couple of fish ponds constructed in swampy areas.

In Southern Benin, Lake Ahozon (Fig. 1a and 1b) lies between two water bodies, Lagoon Toho-Todougba (15 km²), a freshwater lake, and the coastal lagoon (60 km²), a brackish water, both about 5 km apart from Lake Ahozon. GPS tracking revealed that Lake Ahozon (06°22'52"N ; 002°10'34"E) covered about 0.165845 km² (Fig. 1b). These kinds of man-made lakes, in general neglected and abandoned by the owners, originated from sand-dragging activities, and the resulting hole receives every wet season, a huge volume of running waters. Evaluation of water quality indicated that Lake Ahozon had depths varying between 16.2 - 240 cm (mean: 80.19 cm) and transparencies ranging from 16.2 to 60.5 cm (mean: 36.63 cm). Water temperatures ranged between 28.2°C and 38.7°C (mean: 33.25°C), pH between 6.7 and 9.7 (mean: 7.51), dissolved oxygen between 0.73 and 11.8 mg/l (mean: 5.43 mg/l), and conductivity between 50 and 560 µ/cm (mean: 240 µ/cm) (Gbaguidi *et al.*, in press). In the man-made lake of Ahozon, the "aquatic vegetation" habitat showed muddy bottoms whereas the "open water" habitat exhibited sandy-muddy bottoms with dominance of sand.

Dominant phytoplankton genera in Lake Ahozon were *Navicula, Peridinium, Scennedesmus, Pinnularia, Spirogyra, Cosmarium, Melosira, Synechocystis, Microcystis, Oscillatoria, Euglena, Phacus, Surirella* and *Lychmophora* and zooplanktons were dominated by *Trichocerca, Keratella, Brachionus* and copepods. Benthic macro invertebrates recorded were chironomid larvae and a Gasteropod mollusk, *Melanoïde tubercularis*. Aquatic vegetation was dominated by *Cyperus crassipes*, *Cyperus rotundus*, *Fuirena umbellata*, *Andropogon gayanus*, *Ludwigia perennis*, *Emilia praetermissa*, *Eleocharis complanata*, *Enydra fluctuans* et *Mariscus ligularis*. The fish community of Lake Ahozon comprised three cichlids, *Sarotherodon galilaeus*, the dominant species, *Oreochromis niloticus* and *Tilapia guineensis*, a claroteid, *Chrysichthys nigrodigitatus*, the African bonytongue, *Heterotis niloticus* (Osteoglossidae), and the African catfish, *Clarias gariepinus* (Clariidae) (Gbaguidi *et al.*, in press). Sporadic subsistence multi species fisheries occurred in the man-made lake of Ahozon and were practiced by a couple of migrant fishermen.

Sampling sites

Fish samplings were done on four (4) sites in Lake Ahozon: two (2) in the "aquatic vegetation" habitat and two (2) in the "open water" habitat (Fig. 1b). The "aquatic vegetation" habitat, the edge of the lake, is shallow and characterized by a low water velocity and a relatively dense vegetation. The "open water" habitat exhibited a relatively high depth and high water velocity, but exempt of vegetation.

Fish collection

The population of *S. galilaeus* was sampled in the "aquatic vegetation" and in the "open water" using appropriate set of fishing gears and techniques so that the species would be well represented and samples reflect the relative abundance of the fish community (Winemiller, 1992a; Adite *et al.*, 2005). At the open water and aquatic vegetation habitats, fishes were sampled twice a month from August 2014 to July 2015 with cast nets (9.80 m-diameter, 4.90 m-height, 40 mm-mesh), seines (4.15 m-length x 1.77 m-width, 3 mm-mesh), hooks (90 m-length) and experimental gill net (40 m x 1.05 m, 40 mm mesh). Cast nets were used in the "open water" with the help of fishermen. The net, once casted covered a defined area, then the cast net was pulled out delicately in the boat and all trapped fishes were then removed by hands. Seine hauls in marginal aquatic vegetation were made by setting the seine stationary, and kicking the vegetation to drive the fish in to the net before lifting it (Winemiller, 1992a). At each sampling site, ten rounds of seining were done. Hooks and gill nets were set in the "open water". Samplings with gill nets were made by attaching the net to the sticks and left it for 12 hours (Adite *et al.*, 2005). Aggregated samples from cast nets, seining, gill nets and hooks were gathered to assess the abundance of *S. galilaeus* population in the man-made lake of Ahozon. Once caught, the fish samples were identified. Species identification was based on references such as Needham (1962), Lopez-Fernandez *et al.* (2003), Leveque *et al.* (1992), Van Thielen *et al.* (1987), and Lowe McConnell (1975, 1987). The sex of each individual was determined: males possess a tinny sexual opening that also serves to as anal orifice whereas females possess two (2) distinct orifices. Fish individuals were then measured, weighted and preserved in 10% formalin in situ and transported to the "Laboratory of Ecology and Management of Aquatic Ecosystems" where samples were preserved in 70% ethanol for further observation (Murphy and Willis, 1996).

Data Analysis

Morphometric data such as total length (TL), standard length (SL), fish individual weight (W) along with sampling site and sampling period, were recorded in SPSS (Morgan *et al.*, 2001) computer software spreadsheet. Abundance, relative abundance (%), means and ranges of standard length (SL) and weight (W) were computed for the whole population, by habitat type (aquatic vegetation, open water) by season (flood, dry, wet), by life stage (juveniles, sub adults, adults) and by sex (male, female). The frequency histograms (sizes structures) of standard length (SL) intervals were constructed for *S. galilaeus*. Length-weight relationships were examined according to the curvilinear model:

$W = aTL^b$ (Le Cren, 1951)

and its log-linear form:

$\text{Log } W = \text{Log } a + b \text{ Log } TL$

where TL is the total length, W is the fish individual weight, *a* is the intercept, and *b*, the slope, is the allometry coefficient (Le Cren, 1951). One-way analysis of variance was used to test significance of the regression. Also, the Fulton's condition factors of *S. galilaeus* have been evaluated following Tesch (1971):

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

where K is the Fulton's condition factor, W, the fish individual weight (g), TL the total length (cm), and *b* the allometry coefficient. The length-weight relationships and the Fulton's condition factors (K) of *S. galilaeus* were examined by habitat type, by season, by life stage, by gender and for the whole population.

Results and discussion

Species abundance and size structure

In the current study, of 6506 individual fishes collected and comprising six (6) species, *S. galilaeus*, dominated numerically the fish community of Lake Ahozon and alone made 85.21% of the total sample. The five species remaining, namely the nile tilapia *Oreochromis niloticus* (Cichlidae), *Tilapia guineensis* (Cichlidae), the silver catfish, *Chrysichthys nigrodigitatus* (Claroteidae), the African bonytongue, *Heterotis niloticus* (Osteoglossidae), and the African catfish, *Clarias gariepinus* made together not more than 14.79%. Furthermore *S. galilaeus* dominated the biomass and alone accounted for about 55.46% of the total biomass. The study revealed seasonal variations of the abundance of *S. galilaeus* with the wet season making alone 45.71% of the total sample (Table 1).

Table 1. Abundance, relative abundance, size range and mean, weight range and mean of *Sarotherodon galilaeus* by habitat, gender, life stage and season from the artificial lake of Ahozon (South-Benin).

Factor	Abundance	Relative abundance (%)	SL mean (mm)	SL range (mm)	Weight mean (g)	Weight range (g)
Habitat						
• ***Aquatic vegetation***	1876	33.80	18.65	8-76	0.43	0.1-17.9
• ***Open water***	3674	66.20	75.93	17-192	21.50	0.4-190
Sex*						
• ***Male***	1412	37.33	61.19	29-192	14.62	1.3-190
• ***Female***	2371	62.67	50.50	28-140	12.95	1.1-128.5
Life stage						
• ***Juvenile***	1862	33.55	18.40	8-39	0.39	0.1-7.8
• ***Sub-adult***	680	12.25	65.10	38-85	14.06	2.6-28.4
• ***Adult***	3008	54.20	78.23	61-192	23.11	6.5-190
Season						
• ***Flood***	1519	27.37	59.79	11-130	16.36	0.1-95.2
• ***Dry***	1494	26.92	62.02	9-192	16.65	0.1-190
• ***Wet***	2537	45.71	51.38	8-140	11.84	0.1-128.5
Total	**5550**	**100**	**56.55**	**8-192**	**14.38**	**0.1-190**

* Genders were undetermined for small individuals (31.84 % of the sample)

Table 2. Linear regression equations (Log TL – Log W) of *Sarotherodon galilaeus* by habitat, gender, life stage and season from the artificial lake of Ahozon (South-Benin).

Regression factors	Abundance	Slope (*b*)	Determination coefficient (r^2)	Correlation coefficient (r*)	Intercept (*a*)
Total sample	5550	2.961	0.98	0.99	-5.44
Habitat					
• *Aquatic vegetation*	1876	2.782	0.81	0.90	-5.27
• *Open water*	3674	2.636	0.82	0.90	-4.35
Sex*					
• *Male*	1412	2.913	0.95	0.98	-3.92
• *Female*	2371	2.780	0.99	0.99	-4.24
Life stage					
• *Juvenile*	1862	2.778	0.80	0.89	-5.27
• *Sub-adult*	680	2.964	0.82	0.90	-5.38
• *Adult*	3008	2.680	0.81	0.90	-4.51
Season					
• *Flood*	1519	3.003	0.99	0.99	-5.57
• *Dry*	1494	3.081	0.97	0.99	-6.64
• *Wet*	2537	2.894	0.99	0.99	-5.27

* Genders were undetermined for small individuals (31.84 % of the sample).

$P<0.001$ for all regression slopes.

Also, the study showed ontogenetic variations in the abundance of *S. galilaeus*. Indeed, of 5550 *S. galilaeus* individuals recorded in the sample, 33.55% were juveniles (TL ≤ 50mm), 12.25% were sub adults (TL between 50mm - 90mm) and 54.20% were adults (TL ≥ 90mm) and thus, dominating the population. With regard to gender, the population was dominated by females with a sex-ratio of (0.60:1) (Table 1).

Spatial and seasonal variations of individual sizes were recorded in the population. In the "open water" habitat, standard length (SL) varied between 17mm-192mm (mean: 75.90 mm) whereas in the "aquatic vegetation", SL ranged between 8mm and 76mm (mean: 18.65mm). Also, standard length (SL) frequency histograms established for both habitats showed unimodal size distributions (Fig. 2 and 3).

Table 3. Spatial variations of condition factor (K) of *Sarotherodon galilaeus* from the artificial lake of Ahozon (South-Benin).

Habitat category	Abundance (Number of individuals)	Mean Condition Factor (K)	Range (K)	± SD*
Aquatic vegetation	1876	2.40	0.07-40.96	1.33
Open water	3674	2.12	0.20-4.97	0.31
Total	5550	2.26	0.07-40.96	0.84

*SD = Standard deviation.

Table 4. Sexual variations of condition factor (K) of *Sarotherodon galilaeus* from the artificial lake of Ahozon (South-Benin).

Genders	Abundance (Number of individuals)	Mean Condition Factor (K)	Range (K)	± SD*
Male	1412	2.83	0.82-40.96	1.44
female	2371	2.25	0.53-25.12	1.19
Total	3783*	2.43	0.53-40.96	1.31

* Genders were undetermined for small individuals (31.84 % of the sample).

*SD = Standard deviation.

Length-weight relationships

Growth trends of *S. galilaeus* were examined by establishing total length - body weight regression equations. Le Cren's (1951) length-weight relationship model (Fig. 4) for the whole population of *S. galilaeus* was as follow:

$W = 0.023TL^{2,961}$; $R^2 = 0.984$; N=5550

and regression equation (Fig. 5) for the population using the log transform data was:

Log W = -5.44 + 2.961 Log TL

where TL is the total length, W is the individual weight, a = -5.44 is the intercept, and b =2.961, the slope, is the allometry coefficient (Le Cren, 1951).

Furthermore, regression equations were established by habitat types (open water; aquatic vegetation), seasons (flood, dry, wet), life stages (juveniles, sub adults, adults), and genders (male, female). The matrix of slopes (b), intercepts (a) and correlation coefficients (r) generated from the regression equations are shown on Table (2). Overall, the slopes b were positive and ranged between 2.636 for the open water sub population and 3.081 for the dry season sub population, with significant ($p \leq 0.001$) "r" ranging between 0.89 and 0.99 (Table 2). Spatially, the "aquatic vegetation" habitat sub population exhibited higher slope b = 2.782. Seasonally, the sub population of dry period showed higher slope b = 3.081 whereas ontogenetically, sub adult sub population exhibited higher slope b = 2.964 compared to juveniles and adults sub population. Sexual variations of allometry coefficient (b) were recorded with males sub population exhibiting higher slope b = 2.913 compared to females.

Table 5. Ontogenetic variations of condition factor (K) of *Sarotherodon galilaeus* from the artificial lake of Ahozon (South-Benin).

Life stage	Abundance (Number of individuals)	Mean Condition Factor (K)	Range (K)	± SD*
Juveniles	1862	2.42	0.07-40.96	1.37
sub adults	680	2.34	0.53-4.97	0.36
adults	3008	2.15	0.20-4.68	0.28
Total	5550	2.26	0.07-40.96	0.84

*SD = Standard deviation.

Table 6. Seasonal variations of condition factor (K) of *Sarotherodon galilaeus* from the artificial lake of Ahozon (South-Benin).

Season	Abundance (Number of individuals)	Mean Condition Factor (K)	Range (K)	± SD*
Flood	1519	2.21	0.82-8.23	0.37
Dry	1494	2.24	0.07-19.85	0.79
Wet	2537	2.30	0.20-40.96	1.04
Total	5550	2.26	0.07-40.96	0.84

*SD = Standard deviation.

Condition factors

Tables (3), (4), (5) and (6) show the computed Fulton's condition factors (K) by habitat type, gender, life stage category, season and for the whole population of *S. galilaeus*. Overall the condition factors (K) ranged between 0.07 and 40.96 (mean = 2.26) and significant variations (P≤0.05) were recorded by habitat type, gender, life stage category and season. Spatially, the "aquatic vegetation" habitat exhibited higher condition indices (2.40 ±1.33), compared to the "open water" habitat. In gender, male sub population exhibited higher mean condition indices (K =2.83 ±1.44). Among life stage categories, the juvenile sub population exhibited higher K (2.42 ±1.37) compared to sub adult and adult sub populations. Seasonally, the mean condition factor K (2.30 ±1.04) of the wet season sub population was higher than those of flood and dry periods.

Because most African natural water bodies are overfished and ichtyofaunal resources threatened, commercial and subsistence fisheries/aquaculture require valorization of existing non conventional medium environments (example: sand-dragged man-made lakes) along with adapted and cultivable fish species. Abundance, growth trends and condition factors are some of the key community structures to evaluate the performance and the establishment of such species in these medium environments (Steingrimsson and Gislason, 2002; Adite, 2007). The current study consistently showed that the cichlid tilapine, *S. galilaeus*, a naturally-colonized species, dominated the fish community of the artificial lake of Ahozon (South-Benin), and numerically made 85.21% of the total sample and 55.46% of the total biomass. The favorable ecological condition namely the water quality characterized by an alkaline pH, a relatively high water level, transparency, dissolved oxygen, conductivity, and within the limit of tolerance of the cultivated species, *S. galilaeus*, accounted for this high abundance. Furthermore, *S. galilaeus*, like most tilapine cichlids, reproduces all seasons and thus, causing permanent recruitment of juveniles that increased relative abundance and the prominence of the species (Laleye *et al.*, 2003; Laleye *et al.*, 2004).

Seasonally, higher abundance (45.71%) of *S. galilaeus* was recorded in the wet season which corresponds to the species' optimal breeding season. Ontogenetically, the higher abundance (54.20%) recorded for adults (TL ≥ 90mm), was due to the permanent accumulation of this underexploited size category in the artificial lake of Ahozon.

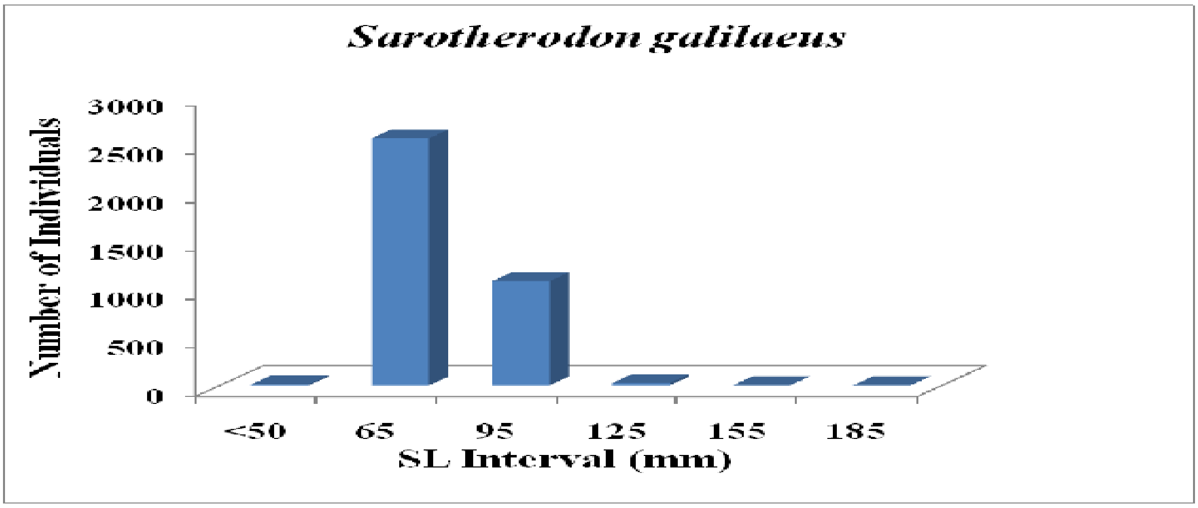

Fig. 2. Size structure of *Sarotherodon galilaeus* (n=3674) from the "open water" habitat of the artificial lake of Ahozon (South-Benin).

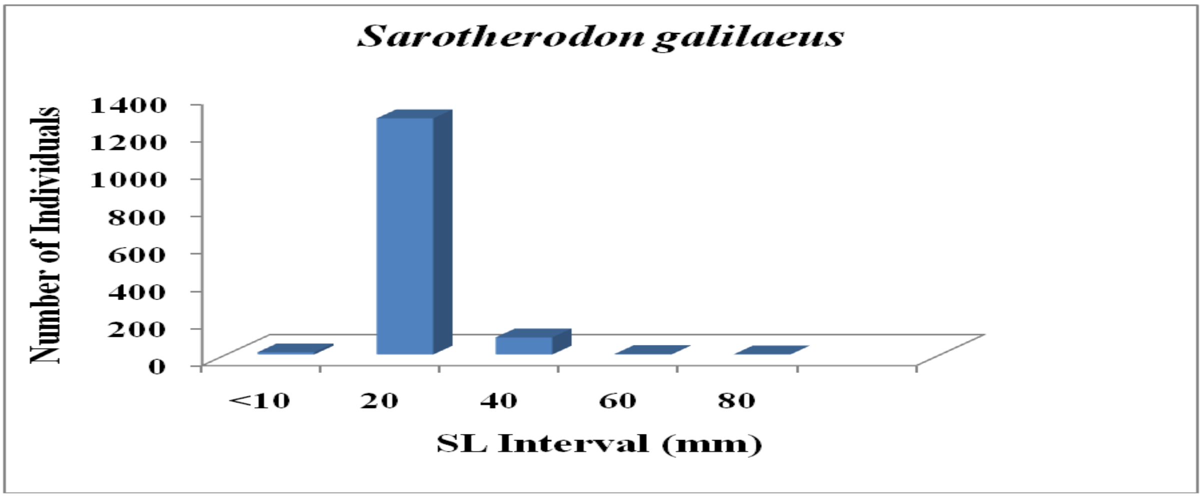

Fig. 3. Size structure of *Sarotherodon galilaeus* (n=1876) from the "aquatic vegetation" habitat of the artificial lake of Ahozon (South-Benin).

In the man-made lake of Ahozon, the study consistently revealed spatial and seasonal variations of individual sizes of *S. galilaeus*. Indeed, one-way analysis of variance on the standard length (SL) across the two habitats ("open water" versus "aquatic vegetation") and across the three seasons (wet, flood, dry) showed significant variations ($p \leq 0.0001$) of SL between habitats and among seasons. The computed *F*-values, along with degrees of freedom and *p*-values were $F_{1,5548} = 57106.9$, $p = 0.0001$ for habitats and $F_{2,5547} = 82{,}06$, $p = 0.0001$ for seasons. Smaller sizes (18.65±5.76mm-SL) were recorded in the "aquatic vegetation" habitat considered as the spawning ground for *S. galilaeus* and even for most fish species, compared to the "open water" habitat that harbored larger sizes of *S. galilaeus* with a mean of 75.90 ±9.52mm-SL. Seasonally, larger sizes (62.01±27.14mm-SL) were recorded during the dry periods compared to the wet and flood seasons, the species' optimal breeding periods, dominated by juveniles.

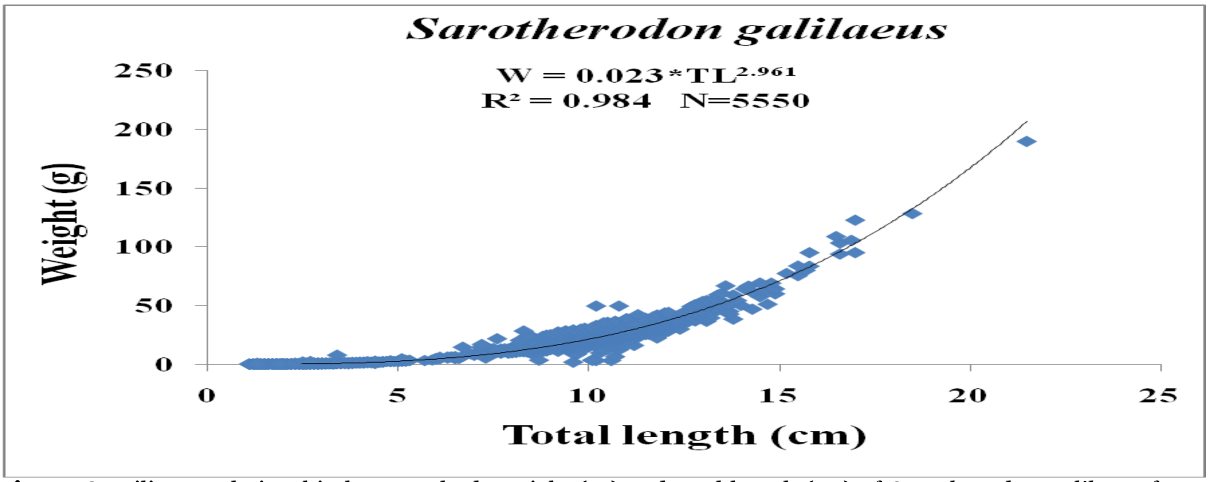

Fig. 4. Curvilinear relationship between body weight (W) and total length (TL) of *Sarotherodon galilaeus* from the artificial lake of Ahozon (South-Benin).

In Lake Ahozon, length-weight regression equations gave slopes *b* ranging between 2.636 and 3.081 indicating that *S. galilaeus* exhibited both allometric and isometric growth patterns (Okpeicha, 2011). Spatially, the higher slope *b* = 2.782 recorded in the "aquatic vegetation" compared to "the open water", was probably due to the high concentration of foods resources in the "aquatic vegetation" habitat. Likewise, during dry period, preys were probably more concentrated and available to *S. galilaeus* sub population that generated a higher slope *b* = 3.081 indicating a majoring allometric growth. Inversely, during wet season, foods resources were probably more diluted and less available for the fish. Consequently, length - weight regression equations generated reduced slopes *b* (Table 2). Nevertheless, in the flood season, the recorded slope *b* = 3.003, nearly equal to 3, indicated an isometric growth pattern, suggesting that the fish became more rotund as total length increased (Deekae and Abowei, 2010). Ontogenetically, the higher slope *b*= 2.964 recorded for the sub adults, and close to isometric growth trends, was probably due to the fact that this life stage mobilized all its metabolic energy to grow. Inversely, adults were permanently involved in the reproduction process and mobilized most of their metabolic energy for gonad maturation, nest construction, egg laying, hatching, and parental care of larvae and hence, exhibited lower slope *b*= 2.680, less than 3, indicating that the fish became less rotund as total length increased. Sexually, the higher slope *b* = 2.913 recorded for males compared to females, was probably due to the fact that during spawning, females mobilized their metabolic energy for ovary maturation, mouth brooding, nest construction, egg laying, hatching, and parental care of offsprings and consequently, showed reduced slope *b*= 2.780.

In general, *S. galilaeus* exhibited spatial, seasonal, ontogenetic and sexual variations of condition factors (K) in the artificial lake of Ahozon. Indeed, one-way analysis of variance on the K across the two habitats (open water; aquatic vegetation), the three seasons (flood; dry; wet), the three life stages (juveniles; sub adults; adults) and the two sexes showed significant ($p \leq 0.001$) variations of K. The computed *F*-values, along with degrees of freedom and *p*-values were $F_{1,5548}$ = 94.510, p = 0.0001 for habitats, $F_{2,5547}$ =

7.163, p = 0.001 for seasons, $F_{2,5547}$ = 63.591, p = 0.0001 for life stages and $F_{1,3781}$ = 8.275, p = 0.001 for genders. Condition indices were higher in the vegetation (mean: 2.41±1.36) where foods are usually more diversified, concentrated and available. Also, the well-being indices for *S. galilaeus* were higher during the wet season (mean: 2.30±1.041) when the intrusion of water in the aquatic vegetation habitat was initiated and thus, making the foods more concentrated and more available for the fishes. Inversely, the lower K (mean: 2.21±0.37) recorded during the flood period was probably due to food dilutions in a higher water volume making the preys less available. In addition, optimal reproduction of most fish occurred during the flood period and hence, led to reduced growth rates and hence to low condition factors. Likewise, the flooding season, though moderate in these artificial lakes, is considered as a stressful period for the fish resources because of the instantaneous changes in water levels and consequently, could generate low indices of condition (Adite *et al.*, 2006). Also, ontogenetic variations in the well-being of *S. galilaeus* were shown by the higher condition indices recorded for juveniles (mean: 2.42±1.37) mostly dwelling the "aquatic vegetation" habitat that harbor high foods resources. In contrast, adults exhibited lower condition indices (mean: 2.15±0.28) because they were mostly involved in spawning and hence, mobilized their metabolic energy for the success of the reproduction and for parental care to increase the early life survivorship (Adite *et al.*, 2006). The lower K=2.25±1.19 recorded for female was probably due to the fact that, during spawning, the energy expenses of females were in general higher than those of males exhibiting higher condition factors (Tesch, 1971).

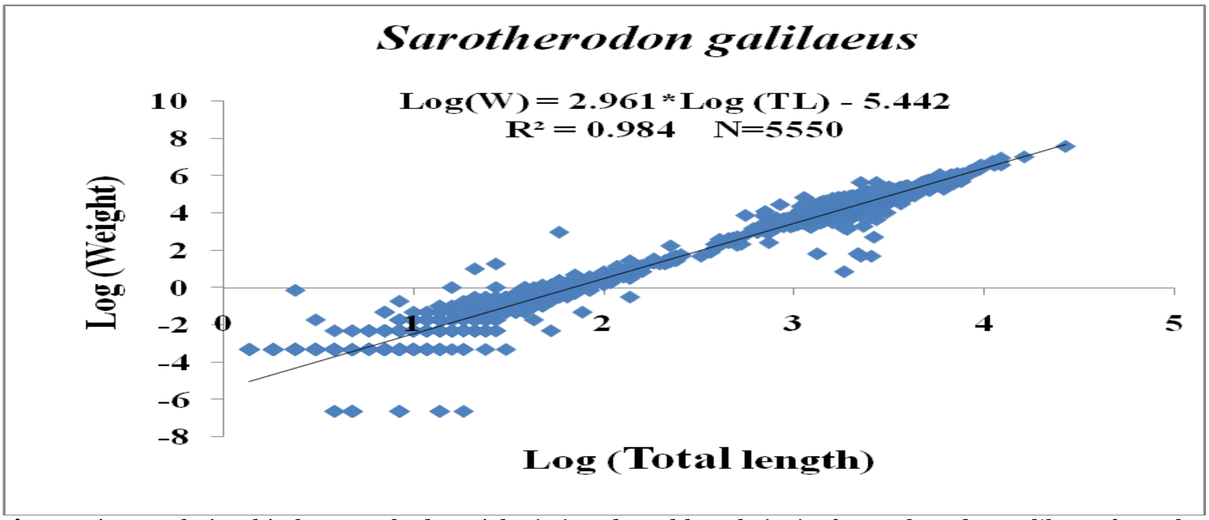

Fig. 5. Linear relationship between body weight (W) and total length (TL) of *Sarotherodon galilaeus* from the artificial lake of Ahozon (South-Benin).

Conclusion

Length – weight relationships and conditions factors are useful instrument for fisheries management and robust predictors of fish fecundity, reproduction, growth and mortality. The results of the present study give valuable information on the plumpness or well-being of *S. galilaeus* in the man-made lake of Ahozon. Overall, the study showed significant spatial, seasonal, ontogenetic and sexual variations of length – weight relationships and conditions factors of *S. galilaeus*. These expected variations were favored by the favorable environmental quality and the ability of this tilapine species to exploit and to utilize a broad spectrum of available food resources to satisfy its nutritional needs leading to the reproduction success, the propagation and the establishment of *S. galilaeus* in this artificial water body. The improvement of growth and condition factors for a more commercially and economically successful fisheries require the protection of spawning and foraging grounds, the prevention against organic and chemical pollution, the introduction of predators to prevent overpopulation of *S. galilaeus*, the fertilization of the lake and a planned harvest of the fish production.

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