A Comparative Ecological Approach of the Length–Weight Relationships and Condition Factor of *Sarotherodon Melanotheron* Rüppell, 1852 and *Tilapia Guineensis* (Bleeker 1862) in Lakes Nokoué and Ahémé (Bénin, West Africa)

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Abstract

This study aimed to estimate the length weight relationships and to characterize the condition factor of Sarotherodon melanotheron and Tilapia guineensis, the most abundant and economically important species in lakes Nokoué and Ahémé (the most important brackish water bodies in South of Benin). Specimens were sampled from September 2004 to August 2005. Results of length-weight analyses did not show any differences between juveniles of S. melanotheron in Lake Nokoué and Ahémé (b = 2.85 and b= 2.87 respectively) and between adults the same species from both lakes (b = 2.88 and b = 2.87 respectively). In T. guineensis juveniles of Lake Nokoué showed allometric growth with b-value of 2.42 whereas adult stage, growth became isometric (b = 2.97). The mean condition factors are 4.66 and 4.45 for S. melanotheron and 4.65 and 4.59 for T. guineensis in Lakes Nokoué and Ahémé respectively. Condition factors values were higher in both lakes during the dry and flooding seasons. Both the abundance of acadjas fisheries (brush-park fisheries) in Lake Nokoué and euryphagic habit of S. melanotheron and T. guineensis could explain the differences in the condition factors recorded in Lakes Nokoué and Ahémé for the two species.

Key words: Cichlid species, condition factor, length-weight relationship, Lakes Nokoué and Ahémé, Bénin.

1. *Introduction*

Length and weight relationships are of great importance in fisheries research because they provide information on population parameters (Krause et al., 1998; Øvredal and Totland 2002; Ecoutin et al., 2005; Samat et al., 2008). The size attained by the individual fish may vary because of variations in food supply, and these in turn may reflect variations in climatic parameters and in the supply of nutrients or in the degree of competition for food. Thus, a change in size through a certain period of time may indicate a change in average age resulting from those factors. Length at weight data can notably provide important clues to climatic and environmental changes, and the change in human subsistence practices (Pauly, 1984; Luff, and Bailey, 2000).

Concerning the condition factor, it is used in fisheries science in order to compare the "condition", "fatness" or wellbeing of fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal, 1978). Condition factor is also a useful index for the monitoring of feeding intensity in fish (Oni *et al*., 1983). It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live (Abowei, 2010). Condition factors of different tropical fish species were investigated and reported notably by Bakare (1970), Saliu (2001), Lizama *et al*. (2002) and similar studies particular to cichlid fish are due to Siddiqui (1977), Welcomme (1979), Fagade (1978, 1983), Dodzie and Wangila (1980), Arawomo (1982) and Oni *et al*. (1983), Abowei, (2010), Lalèyè (1995), Ahouansou et al. (2009).

In spite of their importance in fisheries science, information about length-weight relationships and condition factor are very scarce for fish species of Beninese brackish waters.

This study aimed to estimate the length weight relationship and to characterize the condition factor of *Sarotherodon melanotheron* and *Tilapia guineensis*, the most abundant and economically important species in Lakes Nokoué and Ahémé, which in principle are different in terms of habitat characteristics and fishing practices in use. The essential ecological difference between the two lagoons is based on the brush-park fisheries locally named "acadjas" which are more abundant in Lake Nokoué and scarce because prohibited in Lake Ahémé. Acadjas are artificial systems aimed at enhancing fish production by providing additional substrata for development of plant and animals upon which the fish will feed (Welcomme, 1972).

Also, with surface areas of 150 km² and 80 km² respectively (at low level), Lakes Nokoué and Ahémé are the most important brackish water bodies in South of Bénin. They supply about 60 % of the fish production of all brackish waters of Bénin (Lalèyè & Moreau, 2004; Niyonkuru, 2007). The main objective of this study is carry out an ecological comparative approach based on the determination of length-weight relationships and condition factor of *S. melanotheron* (more than 70% of the total catch in Lake Nokoué) and *T. guineensis* (more than 60 % of the total catch in Lake Ahémé) according to Niyonkuru (2007).

2. *Material and Methods*

2.1. Study area and sampling sites

Lakes Nokoué and Ahémé are located in South of Bénin (Fig 1). Lake Nokoué (6° 25'N, 2° 36' N, Figure 1.) is the largest (approximately 150 km² at low level) and the most productive brackish water body in Bénin (Lalèyè and Moreau, 2004). It is linked eastwards with Porto-Novo lagoon (30 km²) via the 5 km long Totchè channel. In the north lies a vast area of 1,000-9,000 km² according to the season, which is inundated every year by the floodwaters of the Ouémé Delta whereas the south the lake receives seawater through the 4.5 km long Cotonou channel. Because of its location in the most densely populated part of the country, this lake has suffered since the early 1960s from the major disturbances which have radically affected its ecology, notably its hydrology and salinity (Welcomme 1972). With approximately 80 km² at low water level, Lake Ahémé (between 6.20° and 6.40°N and between 1.55° and 2°E, Fig. 1) is the second in surface area after Lake Nokoué (150 km² at low level) and the most productive brackish water body in Benin (Lalèyè & Moreau, 2004). It is linked southward with coastal lagoon via Aho channel. In the north, Lake Ahémé enters in communication with the Couffo River which is responsible of the first rise of water level in the lake, Aho channel and coastal lagoon during July and August just before floodwaters of Mono River.

The Beninese brackish waters experience three "lagoonal" seasons i.e. the dry season (between December and March), the rainy season (between April and July) and the flooding season (between August and November). Water temperatures ranged from 25.7 °C (in January) to 29.2 °C (in March) with an average value of 28 °C.
The depth of Lake varies from 0.4 m to 3.4 m and from 0.77 m to 1.58 m respectively in Lake Nokoué and in Lake Ahémé. Water transparency ranges from 0.2 m to 0.8 m and from 0.23 m to 0.68 m respectively. In Lake Nokoué, the Dissolved Oxygen content is highly variable, ranging from 0.7 mgl^{-1} in very eutrophic waters near large cities to 0.9 mgl^{-1} in clear. In Lake Ahémé, dissolved oxygen ranges from 2.52 mgl^{-1} and 7.04 mgl^{-1}. In the two cases; Maximum Dissolved Oxygen is recorded during the dry season and is associated with the ingress of sea water in the systems. The pH of the two lakes is always slightly alkaline varying between 7 and 9.

The salinity is highly variable, controlled by hydrological patterns that are related to the season and the importance and duration of the connection of sea. Water salinity ranges from 0 to 31 gl^{-1} and 0 to 17.5 gl^{-1} respectively in Lakes Nokoué and Ahémé. The highest values are observed during March in sites close to the channels whereas the lowest in flooding season.

Six sampling sites were chosen during this study according to their location regarding the channels. They are Zogbo, Ganvié and Vêki sites in Lake Nokoué and Dado, Séhômi and Guézin sites in Lake Ahémé (Fig. 1).

2.2. Sample collection and processing of biologic data

Specimens of *S. melanotheron* and *T. guineensis* were sampled monthly from September 2004 to August 2005 in the six stations described above. Fishing was done with multi-meshed nylon gillnets (10-35 mm mesh sizes). The total length (TL) and standard length (SL) of each specimen was measured to the nearest 1 mm on a measuring board.

The individual body weight was measured to the nearest 0.1 mg with an electronic balance.

The length-weight relationship (LWR) was estimated by using the equation: $W= aL^b$ where W= weight (g), L= total length (cm), a = constant, b= growth exponent. The value of *b* gives the information on the kind of growth of fish: the growth is isometric if b = 3 and the growth is allometric if $b\neq3$ (negative if $b<3$ and positive if $b>3$). The 'b' is an exponent b with a value between 2.5 and 3.5 demonstrating normal growth dimensions or interpretation of relative wellbeing (Bagenal, 1978; King, 1996). A logarithmic transformation was used to make the relationship linear

$\log W=\log a + b\log L$.

The length-weight relationships was calculated separately for juveniles and the mature individuals of each species and each lake with main objective for seeing if there is any variation coefficients "a" and "b" according to the age in the two localities. Thus, all individuals with sizes below the size at first sexual maturity were considered as juveniles. According to Niyonkuru (2007), sizes of first sexual maturity for *S. melanotheron* are 7.4 cm, TL for females and 6.5 cm, TL for males in Lake Ahémé and 9.1 cm, TL for male and 8.1 cm, TL in Lake Nokoué. According to same author, sizes of first sexual maturity for *T. guineensis* are 5.9 cm, TL for females and 6.6 cm, TL for males. Then, for *S. melanotheron* of the two lakes, all individuals with sizes below 6.5 cm, TL were considered as juveniles and used to estimate the length-weight relationships for juveniles. For T. guineensis, all sizes below 7.5 cm, TL and 5.5 cm, TL respectively in Lake Nokoué and in Lake Ahémé were used in estimating of the length –weight relationships for juveniles.

Fulton's condition factor was calculated from the expression (Bagenal, 1978):
$K= 100\ W/SL^3$ where W is the whole body weight in grams and SL the standard length in millimeters.

ANOVA was used to compare b to 3 and to test the significance of all regressions. Fisher's PLSD-test in comparison of condition factor of the two lakes. All the analyses were performed using the StatView Software (Version, 1992 SAS Institute INC).

3. Results

3.1. Length- weight relationships

The results of the length-weight analyses are displayed in table 1. Length-weight relationships were significant ($p<0.05$) with r^2 values greater than 0.82. Slopes (b values) of the length weight relationship ranged from 2.42 for juveniles of *T. guineensis* in Lake Nokoué to 2.97 for adults of *T. guineensis* in Lake Nokoué. The regression coefficient (b) of adults *of T. guineensis* was not significantly different from 3. The results of the length-weight analyses did not show any differences between juveniles of *S. melanotheron* in Lake Nokoué and Ahémé (b = 2.85 and b= 2.87 respectively) on one hand and between adults *S. melanotheron* from both lakes on other hand (b = 2.88 and b = 2.87 respectively). Also, b values obtained by combining juveniles and adults of each lakes, are similar in the two lakes (b= 2.86 and b=2.87 respectively in Lakes Nokoué and Ahémé). In other words, *S. melanotheron* had same ecological adaptations during all stages of its life in both lakes. Apparently, the exponent 'b' value obtained lies a little bit far from three. Results exhibited a negative allometric growth, suggesting that they tend to become thinner as they become larger.

Concerning T. *guineensis* juveniles of Lake Nokoué showed allometric growth with b-value of 2.42 (showing that juveniles could had ecological problems) whereas at adult stage, growth became isometric (b = 2.97) . These results were different from those obtained for the same species in Lake Ahémé where both juveniles and adults had apparently the same b-value along of its life (b=2.82 for juveniles and b=2.75 for adults).

3.2. Condition factor

The mean condition factors are 4.66 and 4.45 for *S. melanotheron* and 4.65 and 4.59 for *T. guineensis* in Lakes Nokoué and Ahémé respectively. The results indicated that there was a significant difference between the condition factors of each species according to the lake *(*$p<0.05$). The Student-Newman Keuls test showed that the high condition factor average for each fish species is observed in Lake Nokoué. The average condition factors for immatures, males and females of the two lakes are presented in table 2. There were not significant differences between the condition factors of male and female for the two species in the two lakes ($p>0.05$).

However, the differences between condition factors of immatures and both males and females were highly significant ($p<0.05$) for *S. melanotheron* in two lakes and for *T. guineensis* in Lake Ahémé. The difference of condition factors between immatures and adults of *T. guineensis* in Lake Nokoué were not significant. High condition factors values were recorded for immature individuals for both species in both lakes.

Figure 2 shows the variations in condition factors with standard length. In *S. melanotheron* of both lakes Nokoué and Ahémé (Fig. 2 A and Fig. 2B) and in *T. guineensis* of Lake Ahémé (Fig. 2D), condition factor decreased almost gradually as they grew from juvenile to adult stage. This result suggested that in general, their growth from juvenile to adult stage was probably influenced or affected by extrinsic factors. However, for *T. guineensis* in Lake Nokoué (Fig. 2C), three phases are easily distinguished. In phase I, the condition factor decreased significantly as fish grows until the size of 80 mm, SL. In phase II, the condition remains more or less constant with size between 80 and 130 mm, SL. In the third phase, there was again a decrease of condition factor from 130 mm, SL.

The monthly variations of the condition factors of *S. melanotheron* and *T. guineensis* in Lakes Nokoué and Ahémé are presented in figure 3. The Fisher's PLSD test showed that monthly mean condition factor is most often higher in Lake Nokoué than in Lake Ahémé ($p<0.05$) for both species Condition Factors values were higher in both lakes during the dry season (between December and March) on one hand and the flooding season (between August and November) on other hand showing that fishes were in better condition during these periods than during the rainy season.

4. Discussion

The values of "b" (growth exponent) for the two species examined in two lakes are within the limits (two and four) reported by Tesch (1971) for most fishes. The "b" values obtained for *S. melanotheron* in Lakes Nokoué and Ahémé and for *T. guineensis* in Lake Ahémé are similar meaning that the same length –weight relationships could be apply both for juveniles and adults for these populations. However in Lake Nokoué, *T. guineensis* showed different growth during its life with allometric growth in juvenile stage and isometric growth in its adults stage.
On the whole, "b" values of both juveniles and adults overall taken showed allometric growth for the two tilapias in the two lakes. Ayoade & Ikulala (2007) found in *S. melanotheron* a "b" value of 2.8 very close to the "b" values obtained during this study for the same species These results are different from those found by Laléyé (2006) for the same species in Ouémé River where "b" values were not significantly different to 3. Food and Feeding Habit of *S. melanotheron and T. guineensis* had not been documented in Ouémé River for comparison with this study. Perhaps ecological conditions in Ouémé River could be better than in Lakes Nokoué and Ahémé.
The condition factors are higher for these two species in Lake Nokoué. Indeed, as described in study areas, ecological conditions are different in two lakes in particular the presence of acadjas fisheries in Lake Nokoué and their very scarce presence in Lake Ahémé

Acadjas are functioning as a natural system of enhancing fish production by providing through branches fixed on the bottom, additional substrata for development of plants and animals which will serve as food for fish. Acadjas cover a maximum of 35% of the total area of Lake Nokoué (Lalèye et al. 2007). They are responsible of the phytoplankton biomass and primary production differences observed in two lakes. Indeed, in 1990, the average estimated of the phytoplankton production was 192 $mgC.m^{-2}.days^{-1}$ in Lake Nokoué and only 55 $mgC.m^{-2}.days^{-1}$ in Lake Ahémé (d'Almeida, 1992). The primary production was re-evaluated by Adounvo et al. (2003) between 500-5600 $mgC.m^{-2}.days^{-1}$ in Lake Nokoué and it was the highest of the sub-region.

The condition factors of tilapias should be put in correlation with both these primary production and phytoplankton biomass. Ayoade & Ikulala (2007) reported that plant food organisms constituted the most important food items (82.09 %) of *S. melanotheron* followed by organic detritus (7.41 %), and sand grains (4.76 %). Animal food organisms such as rotifers, insect parts, crustaceans, and copepods, Protozoans, and fish eggs represented only 3.05 % of the total number of food organism. Kone & Teugels (2003) have confirmed that *S. melanotheron* is planktivorous. For *T. guineensis*, Diouf (1996) reported that food items are detritus, plants, zoobenthos and phytoplankton. In Lake Nokoué where dominated acadjas, Gnohossou (2006) reported that food items of both *S. melanotheron* and *T. guineensis* were organic detritus (75%) followed by plant food (20%). Animals rotifers, crustaceans, insects, etc.) represented only 5 %.

According to Ayoade & Ikulala (2007), cichlid fish had a euryphagic feeding habit, a strategy that allows for a switch from one diet to another and also disallows intra- and inter- species competition for food and this single biotic environmental factor might largely be responsible for the differences in the condition factors.

So, both the abundance of acadjas fisheries in Lake Nokoué and euryphagic habit of S. *melanotheron* and *T. guineensis* could explain the differences in the condition factors observed in Lakes Nokoué and Ahémé for the two species

In sub-region, the mean condition factors values founded for *S. melanotheron* were between 4.1 and 5.7 in Lagos lagoon (Fagade, 1979), 3.85 in a West-Africa man-made Lake Ayamé (Koné & Teugels, 1999). Even if available data for the condition factor of *T. guineensis* are very scarce for comparison, on base of comparison of our results with *S. melanotheron* in sub-region, we could confirm that our both tilapias in both lakes Nokoué and Ahémé are in good conditions.

The results of the current study also presented that there were significant variations in condition factors with sizes no difference between condition factors in males and females.. The study was in agreement with the resultants reported by Koné & Teugels (1999) in *S. melanotheron*. Similarly, Anene (2005) did not find significant variations in condition factors with respect to sex and this was in concordance with the values reported for different cichlid fishes in Nigeria (Fagade, 1978, 1983; Dadzie and Wangila, 1980; King, 1994; Junquera *et al.*1999).

About the decrease of condition factor as they grew from juvenile to adult, the results of our study are in agreement with other previous study. Anene (2005) noted that the general trend was that in *Chromidotilapia guntheri, Tilapia cabrae and Tilapia mariae* relatively lower condition factors were recorded for relatively large sizes, while relatively higher condition factors were recorded for rather smaller fish. It could be due to the fact that adults spend a part of their energy in reproduction what probably decrease their condition.

Seasonal variation in the condition factor of fish has been reported, Oni et al. (1983) noted that condition factor is not constant for a species or population over time and might be influenced by both biotic and abiotic factors such as feeding regime and state of gonadal development. As in the present study, Panfili et al. (2004) recorded high condition factor value in dry season for *S. melanotheron* in Sine Saloom Lagoon. Anene (2005) reported that dry season condition factor of *C. guntheri*, and *T. mariae* was higher than wet season values, while for *T. zilli, the* contrary was the case with higher condition values recorded in the wet season. In *T. cabrae,* there was not a significant difference in the condition factor between both seasons.

However, the results of this study do not conform to those published for *T. guineensis* (Fagade, 1978) in which no seasonal changes were observed in condition factor.

This study is the first to show the peak of condition factor during the flooding season. Indeed, in addition to the high primary production in Lake Nokoué, the important decaying organic matter which is seasonally imported buy the Ouémé River during the floods might also enhance the food availability for the two species in Lake Nokoué. This input of organic matter from the upper apart of the drainage basins not so abundant in Lake Ahémé which received only a smaller Couffo River

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Tables

Table 1: Length-weight relationships parameters of *S. melanotheron* and *T. guineensis* in Lakes Nokoué and Ahémé

Species	Lake	Stage	n	a	b	t	r²
S. melanotheron	Nokoué	juveniles	730	0.028	2.85	12.5*	0.95
		adults	1 375	0.026	2.88	18.3*	0.98
		juveniles and adults	2105	0,029	2,86	25,71*	0,98
	Ahémé	juveniles	38	0.028	2.87	3.7*	0.82
		adults	734	0.025	2.87	11.8*	0.97
		juveniles and adults	772	0.029	2,87	12*	0,98
T. guineensis	Nokoué	juveniles	30	0.062	2.42	5.8*	0.91
		adults	400	0.020	2.97	0.57	0.97
		juveniles and adults	430	0.025	2,87	4,48*	0,95
	Ahémé	juveniles	38	0.030	2.82	3.5*	0.97
		adults	1550	0.032	2.75	24*	0.97
		juveniles and adults	1588	0.032	2,76	24*	0,98

*: b significantly different from 3 ($p<0.05$); n = sample size; r^2 = coefficient of determination;
a and b = estimated parameters of the length-weight relationships and t= student test

Table 2: Mean condition factors of immatures, males and females of *S. melanotheron* and *T. guineensis* in Lakes Nokoué and Ahémé

Species	Lake	Immatures	males	females
S. melanotheron	Nokoué	4,89 ± 0,89	4,51 ± 0,60	4,54 ± 0,56
	Ahémé	4,69 ± 0,55	4,40± 0,60	4,43± 0,60
T. guineensis	Nokoué	4,68 ±0,60	4,61 ±0,57	4,71 ± 0,61
	Ahémé	4,68 ±0,56	4,53 ±0,56	4,64 ± 0,56

Figures

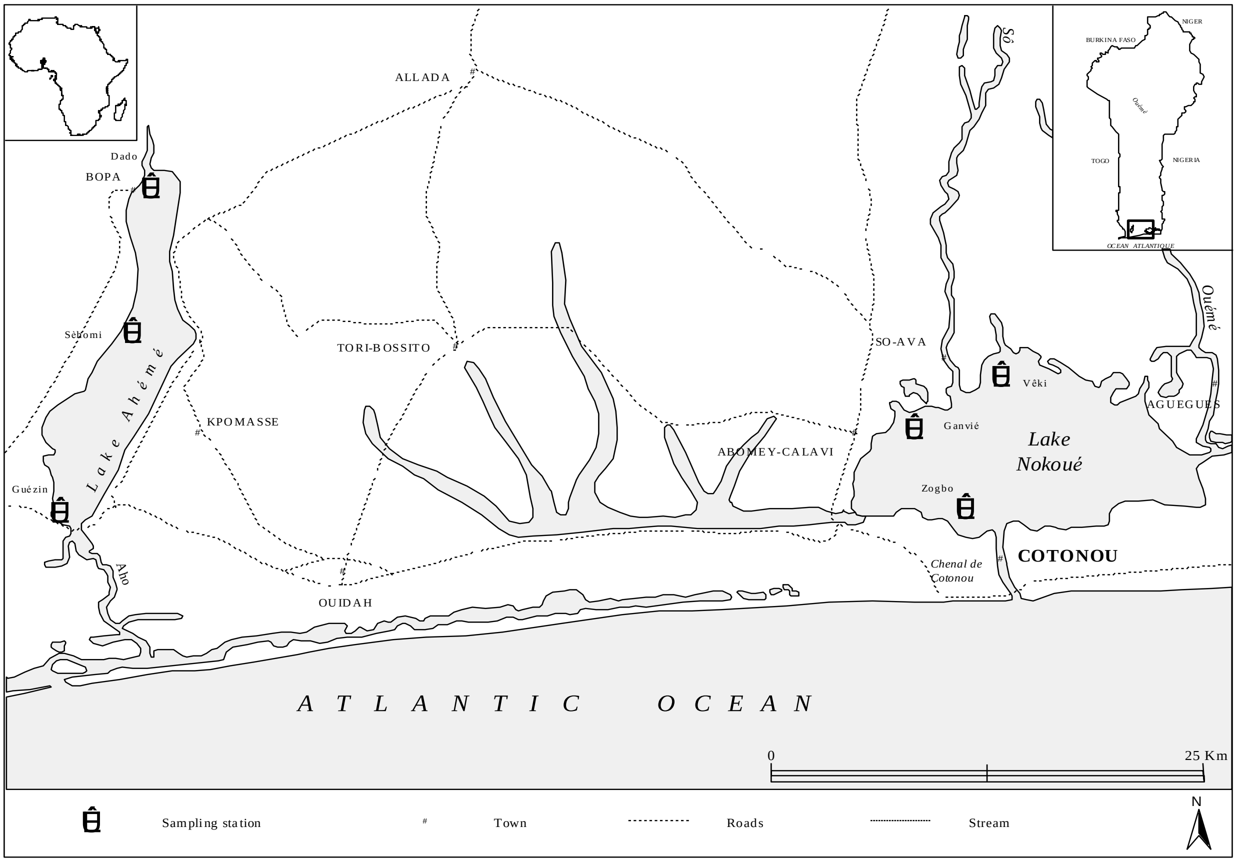

Figure 1: Map showing sampling stations in Lakes Nokoué and Ahémé.

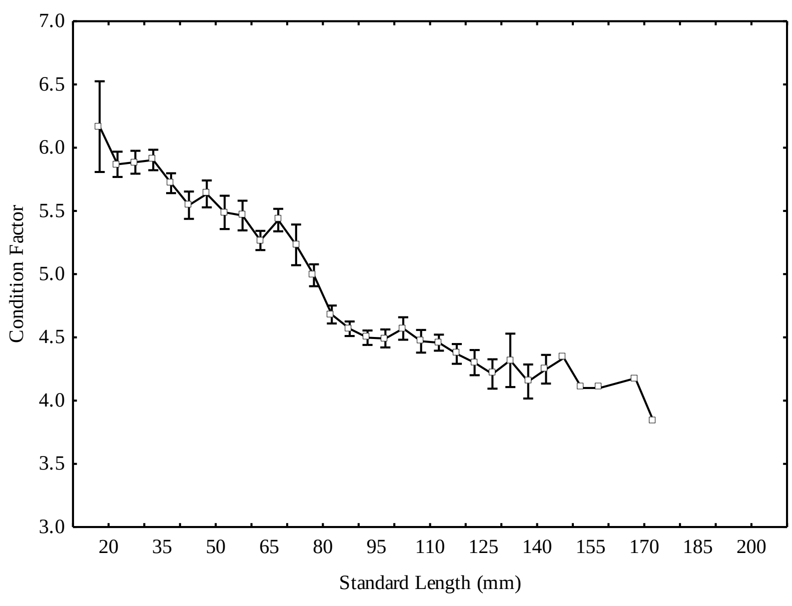

Figure 2.A.

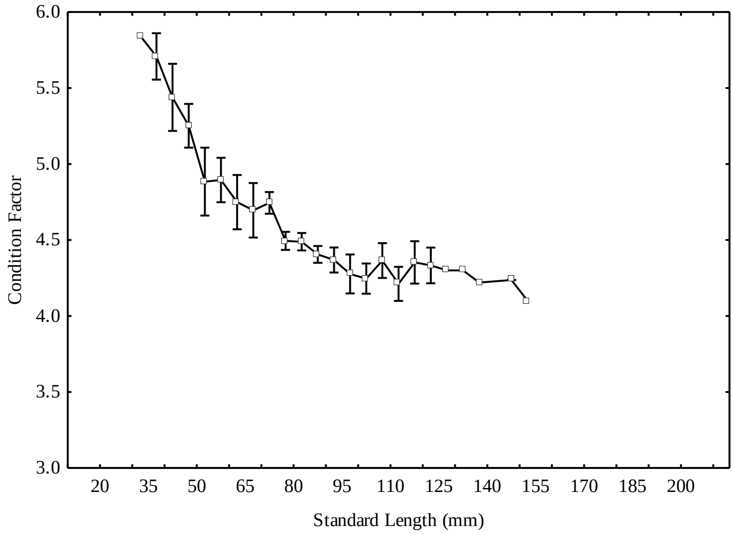

Figure 2B

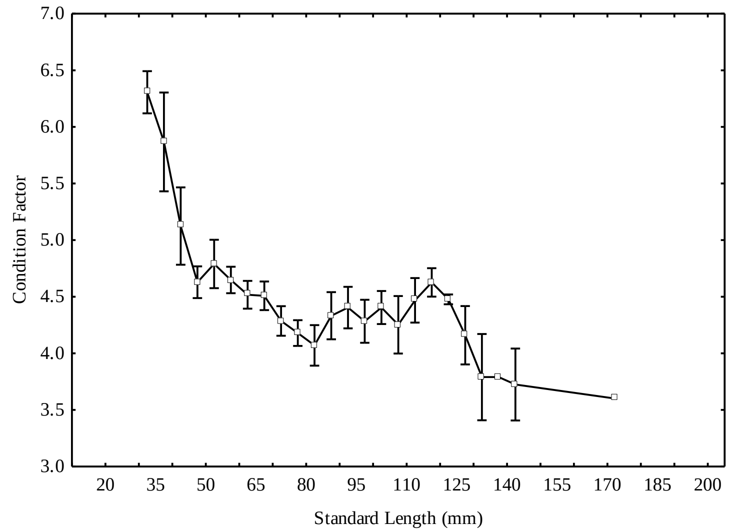

Figure 2C

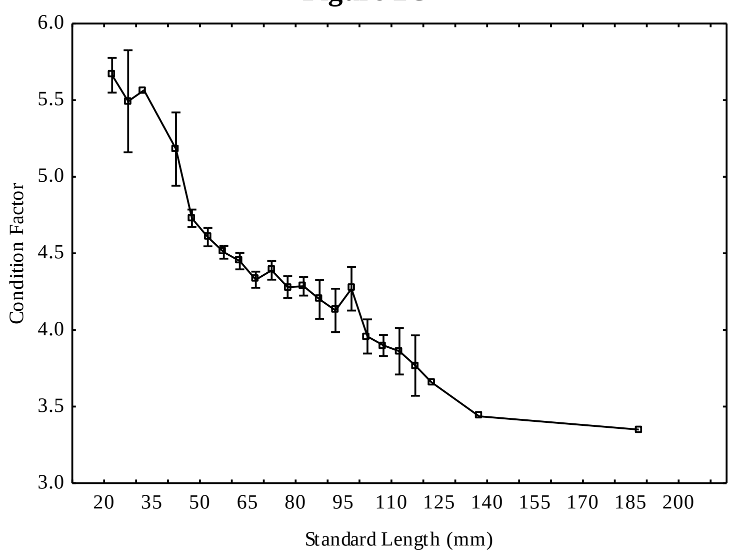

Figure 2D

Figure 2: Variation of condition factor with fish size (Figure 2A: *S. melanotheron* (Lake Nokoué), Figure 2B: *S. melanotheron* (Lake Ahémé); Figure 2C: *T. guineensis*; Lake Nokoué, Figure 2D: *T. guineensis* (Lake Ahémé)).

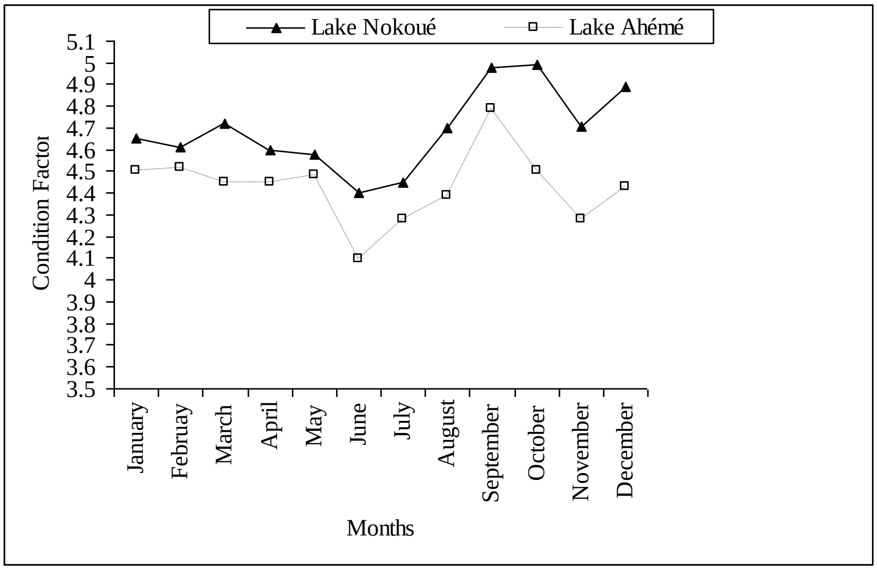

Figure 3 A:

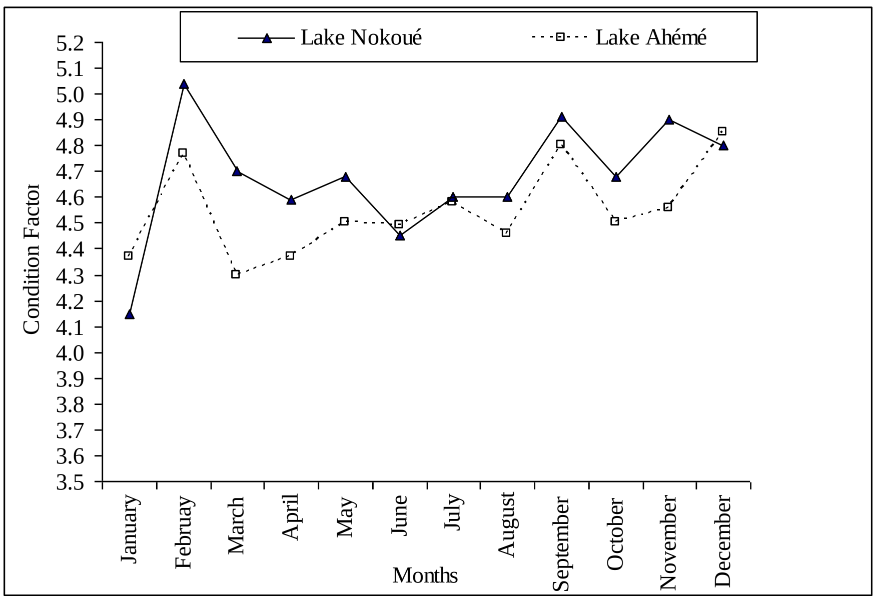

Figure 3B

Figure 3: Monthly variation of K in *S. melanotheron* (B) and T. *guineensis* in Lakes Nokoué and Ahémé