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Ecological comparative approach of *Sarotherodon melanotheron* populations of lowlands dradged and costal lagoon at Togbin in Benin: Weight-Length relationship and condition factor

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Abstract

Lowland dredging has been booming in Benin since 2008 following the ban on the exploitation of marine sand due to coastal erosion. Dredging the hydrobiological influence of aquatic ecosystems and it is essential to understand its impact on the ecology of the fish fauna for future policies of development and protection of fisheries. It is in this logic that the present study aims to evaluate, through a comparative approach, the weight-length relationship and the condition factor of the *S. melanotheron* population of the dredged bottomlands and the costal lagoon at Togbin. In this study, 428 specimens (230 for the lagoon and 198 for the shallows) were collected from June to September 2017 on which the total weight and total length were taken followed by monthly measurements of the physicochemical parameters of the water. We obtained that the weight-length relationship is significant ($p < 0.05$, R2> 0.70) and revealed a growth isometry at the two water bodies with the coefficient b which varies between 2.0061 and 2.842 ($b = 3$; < 0.05) respectively for dredged bottomlands and all-sex lagoon. The condition factor K obtained for the dredged bottomlands ($K = 33.88 \pm 12.11$) is significantly higher than that of the lagoon ($K = 3.04 \pm 1.07$) ($p=0.000$). In short, lowland dredging does not damage the ecology of *Sarotherodon melanotheron*. However, control measures for dredging activities are necessary to avoid the destruction of fish habitat.

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Introduction

Fishing in Republic of Benin is one of major economics activities that supports nearly 300,000 people (PSRSA 2011). In addition to the marine environment, fishing grounds consist mainly of rivers, lakes, lagoons, shallows . In Republic of Benin, those grounds are increasingly subject to sand dredging activities what they are manual or industrial. Thus, the Togbin shallows in western Benin are the subject of extensive sand dredging activity. According to Demir *et al.* (2004) and Hakkou *et al.* (2015), the sand dredging activity of aquatics environments modifies the abiotic function and the biotic structure of the habitat.

Changes brought by sand dredging can contribute either to the planning of water bodies and watercourses or to the degradation of the ecological conditions of the biological diversity in which they live (Newell *et al.*, 1998, Grégoire, 2004). The development of water bodies and watercourses seems essential for aquatic production, especially for ecosystems whose process of filling is accelerating. However, very few studies have focused on assessing the ecological conditions of the ichthyenne population that lives in the sand-drenched lowlands. The objective of the present study is to provide information on the ecology of the *Sarotherdon melanotheron* population through a comparative analysis of the weight-length relationship and condition factor of the dredged bottomlands and the coastal lagoon. Togbin.

Materials and methods

Study area

Dredged lowlands and the Togbin coastal lagoon are two aquatic ecosystems side by side in the heart of the west complex of Ramsar 1017 and located between 06 ° 21'13.5 "N and 002 ° 18'25.4" E. Dredged bottoms communicate with the lagoon especially during rainy periods. Togbin area is characterized by vegetation dominated more than 60% by the mangrove (*Rhizophora racemosa* and *Avicennia africana*), followed by *Acrostichum aureus*, *Drepano carpus lunatus*, *Paspalum vaginatum*, *Cyperus articulatus* and *Imperata cylindrica* (Akotossodé, 2016). The ambient temperature varies between 25 ° C and 27.7 ° C (Adité *et al.*, 2013) and can reach 32.6 ° C during the peak period of the dry season (ASECNA, 2014). The climate is subequatorial with two rainy seasons (April to July and September to October) and two dry seasons (December to March and late July to early September). The average rainfall is about 1,307.3 mm (Adité *et al.*, 2016). The economic activities of the populations in the environment are mainly fishing, agriculture, salt production and a spectacular development of the sand dredging companies officially authorized by the Benin Environmental Agency (ABE).

Data collection

The species studied is *Sarotherodon melanotheron* (Rüppell, 1852). This species is the most abundant of the continental aquatic ecosystems of Benin Republic and the most represented in the catches at the Togbin lagoon (Adité *et al.*, 2013). Sampling was done exclusively on the artisanal fishery between June and September 2017 and collected 428 specimens of *S. melanotheron* (all stages combined) with 230 specimens for the lagoon and 198 specimens for the lowlands dredged. Morphometric measurements including total length (cm) and total weight (g) were taken. The physicochemical parameters measured are temperature (°C), pH, dissolved oxygen (mg.l^{-1}), transparency (cm), depth (m) and salinity (‰). Temperature (surface and depth), pH, dissolved oxygen (surface and depth) and salinity are measured in-situ with direct reading by means of measuring devices. Transparency and depth were measured using the Secchi disk graduated to the centimeter. The parameters are measured every month, in the morning between 6am and 9am.

Data analysis

Physicochemical characterization

The physicochemical parameters were analysed by Statistica V6 software 1984-2003. The average of each parameter was calculated and after verification of normality, the Mann-Whitney U-Test was used to test a probably significant difference in physico-chemical parameters between water bodies.

Weight - Length Relationship and Condition Factor: The weight-length relationship is a power-type relation expressed by the formula: $PT = aLT^b$ (Cren, 1951 in Lédéroun, 2015) with PT = Total weight (g); LT = total length (cm); a = coefficient related to the ecological factor and b = coefficient of allometry. This relation determine the type of growth through the value of the coefficient b. For this purpose, if b <3, the growth is negative allometric; b> 3, the growth is positive allometric; b = 3, the growth is isometric. The linearization of this between the total weight and the total length is obtained in the form of log PT = log a + b log LT. This relationship was established using the Stat view 1992-98 SAS software and the Student's T-Test was used to determine the significant difference between the calculated b-factor and the standard 3. The condition factor (K) is determined by the following formula $K = 100 \times PT / (LT^b)$ (TESCH, 1971 in Lédéroun, 2015).

Results

Physico-chemical parameters

Table 1 presents the average values of the physicochemical parameters obtained by body of water throughout the period of the study. The average surface and depth temperatures are respectively 27.13 ± 0.53 ° C and 27.06 ± 0.61 ° C for the lagoon and 27.33 ± 0.46 ° C and 27.5 ± 0.18 ° C for the shallows. These averages do not differ significantly between water bodies ($p > 0.05$).

Table 1. General averages of physicochemical parameters by water body.

	T (surf)	T (depth)	DO (surf)	DO (prof)	pH	Sal	Trp	depth
lagoon	27.13±0.53^a	27.06±0.61^a	1.638±1.1^a	1.625±1.08^a	8.25±0.31^a	5.25±0.89^a	63.75±9.91^a	1.57±0.49^a
lowlands	27.33±0.46^a	27.5±0.18^a	2.73±0.41^a	2.58±0.54^a	8.11±0.21^a	5.63±0.92^a	65.25±10.08^a	6.2±1.21^b
U Test	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05	< 0.0007

T = Temperature; DO = Dissolved oxygen; Sal = salinity; Trp = transparency ; surf = surface.

Averages with the same letters on the vertical do not differ significantly between them, while those with different letters are significantly different from each other at the 5% level.

The same is true for dissolved oxygen where the means obtained respectively at surface and in depth are 1.638 ± 1.1 mg / L and 1.625 ± 1.08 mg / L for the lagoon and 2.73 ± 0.41 mg / L and 2.58 ± 0.54 mg / L for dredged bottomlands. The overall average pH is 8.25 ± 0.31 for the lagoon and 8.11 ± 0.21 for the drilled shallows. Although the average pH at the lagoon appears to be higher than that of dredged shoals, the Man-Whitney U test does not reveal any significant difference between them at the 5% level. As for salinity, the averages obtained do not differ from each other and are respectively 5.25 ± 0.89 ‰ for the lagoon and 5.63 ± 0.92 ‰ for the dredged lowlands.

Table 2. Synthesis of associates constants to weight-length relationships.

Areas	Sex	a	b	R^2	T Test	TG
Lowland dradged	Males	0.5608	1.8126	0.7883	< 0.001	Isométrie
	Females	0.136	2.3151	0.8256	< 0.001	Isométrie
	All Sex	0.3235	2.0061	0.795	< 0.0001	Isométrie
Lagoon	Males	0.0326	2.7936	0.9088	< 0.001	Isométrie
	Females	0.0255	2.9079	0.8452	< 0.001	Isométrie
	All sex	0.029	2.842	0.8785	< 0.0001	Isométrie

TG=Type of growth.

The average transparency obtained for the lagoon is 63.75 ± 9.91 cm and 65.25 ± 10.08 cm for the dredged bottomlands with a non-significant difference at the 5% threshold. The average depth obtained for dredged lowlands (6.2 ± 1.21 m) is significantly greater than that of the lagoon which is 1.57 ± 0.57m ($p < 0.0007$).

Table 3. Average condition factor per body of water by sex.

Sex	Condition Factor		
	Lowlands dradged	Lagoon	p
Males	58.32 ± 17.89^a	3.37 ± 1.25^b	0.000
Females	14.13 ±5.81^b	2.64 ± 0.89^d	0.000
All sex	33.88 ± 12.11^c	3.04 ± 1.07^d	0.000
p	0.000	<0.05	

Averages with the same letter on the horizontal as on the vertical do not differ from each other while those carrying different differ significantly at the threshold of 5%.

Length-weight relationships of S. melanotheron of lowlands and lagoon

Fig. 1 shows the weight-length relationship of *S. melanotheron* populations of dredged bottom-lands and lagoon, respectively, as well as the associated equations, and Table 2 summarizes the coefficients a and b, the determination R^2, the type of growth and the probability associated with the comparison of each value of b with the standard 3.

Analyzes show that, whatever the body of water and sex, the relationship between weight and length of the population of *Sarotherodon melanotheron* is highly significant ($p < 0.001$) with a coefficient of determination (R^2) varying between 0.78 and 0.90 for both bodies of water. Considering the values obtained for the coefficient of allometry b, it should be noted that the coefficients obtained for the individuals of the dredged bottomlands are relatively higher than those of the all-sex lagoon, and the lowest value has been obtained at the level of male individuals from dredged shoals (b = 1.81). However, b is significantly equal to 3 (b = 3, $p < 0.05$) and the growth in this case is of isometric type for both populations during the study period.

The linearization of each of the relationships according to sex and water bodies makes it possible to note that the correlation coefficient (r) is significantly positive for sex and for water bodies ($p = 0.0000$). This correlation (r) varies between 0.9194 and 0.9553 then between 0.8301 and 0.9167 respectively at the level of the population of the lagoon and dredged bottomlands.

Condition factor

The condition factor K for sex by body of water is summarized in Table 3 and its evolution according to size classes is shown in Fig. 2. In the *S. melanotheron* population of dredged shoals, the male individuals have a significantly higher condition factor than females ($p < 0.001$).

It is the same for the population of the lagoon ($p < 0.02$). Comparing the condition factor of the same sex between body of water, it is observed that whatever the sex, the condition factor of the individuals of the dredged bottomlands is significantly higher than that of the individuals of the lagoon ($p < 0.000$). Considering size classes, a downward trend is observed as size increases.

This trend is more pronounced in the dredged bottom population than in the lagoon population.

The condition factor calculated for all genders combined is significantly higher at the lowlands dredged than at the lagoon level with $p = 0.000$.

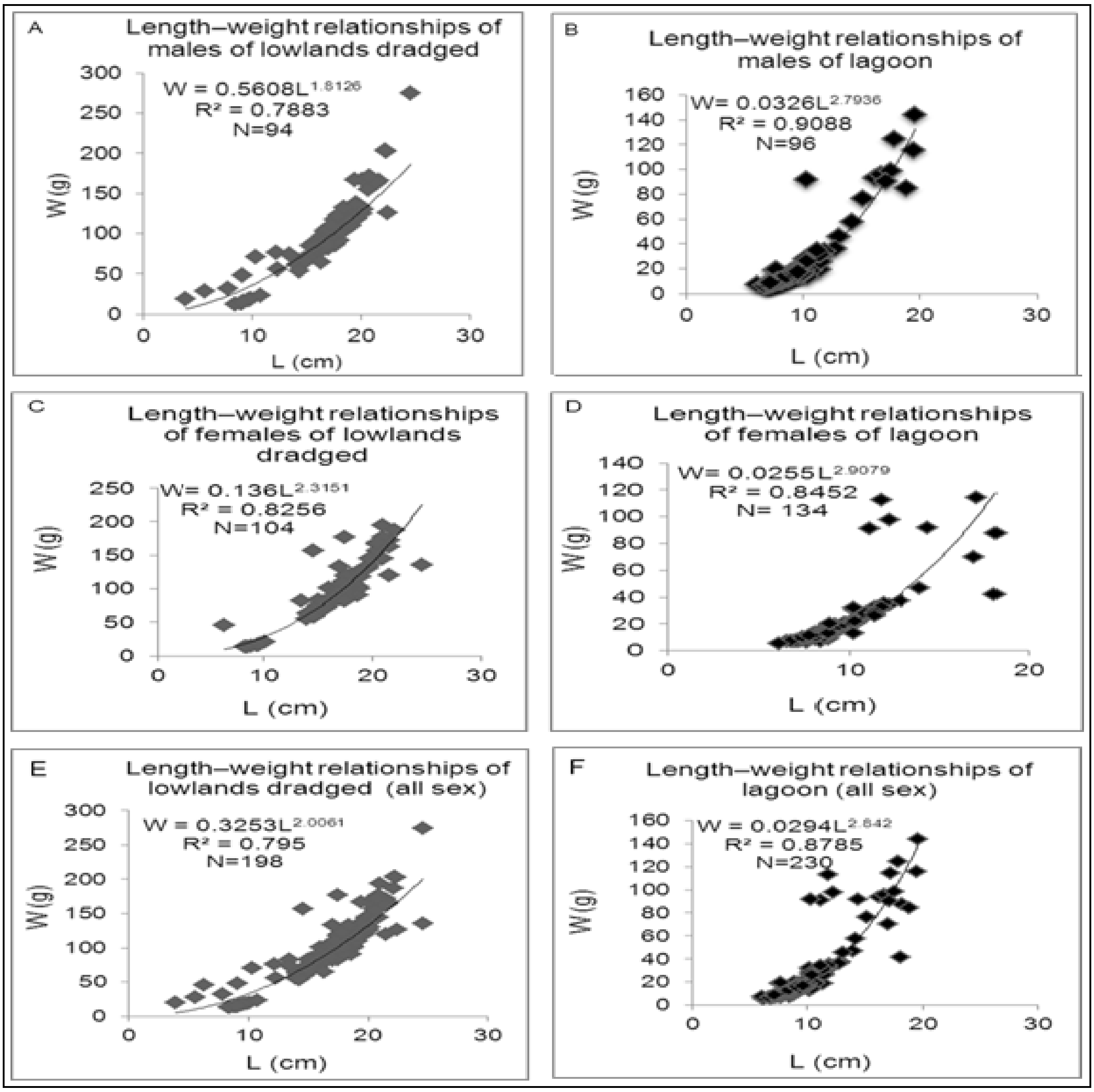

Fig. 1. Weight-Length relationship of *S. melanotheron* population of lowlands-dredged and coastal lagoon at Togbin.

Discussion

The values obtained for the physicochemical parameters do not differ from one water body to another except for the depth which is significantly higher in the dredged bottom-lands than in the lagoon. The averages obtained for the parameters are in line with the ecological requirements reported by Amoussou *et al.* (2016).

Isometric growth indicates equal growth between the total length and weight of individuals in the dredged bottom-lands and the lagoon. These observations are different from those obtained by Niyonkuru and Lalèyè, 2012 and Lédéroun, 2015, which had obtained negative allometric growth for the same species in the Lakes (Nokoué and Ahémé) and in the Mono Valley respectively. Ecoutin and Albaret (2003) reported negative allometric growth in *Sarotherodon melanotheron* from tropical lagoons. At Strabag Lake in Ibadan, Amoo and Komolafe, 2016, observed a negative allometry for a similar species including *Sarotherodon galillaeus.*

The tendency of the condition factor obtained in the present study according to the size classes corroborates the observations of Ahouansou-Montcho *et al.* (2009) for the species *Lates niloticus* in the Pendjari River. This trend is related to the ecological requirement of the youngest (food requirement, dissolved oxygen requirement ...) which is more easily met than those of adults. Young population demand fewer food resources for their growth, while adults demand enough for their growth but also for their reproduction (Amoussou *et al.*, 2016). Oxygen demand for metabolism increases with ingestion capacity and age of individuals (Soletchnik *et al.*, 1997). As a result, smaller specimens find their vital need filled earlier than adults.

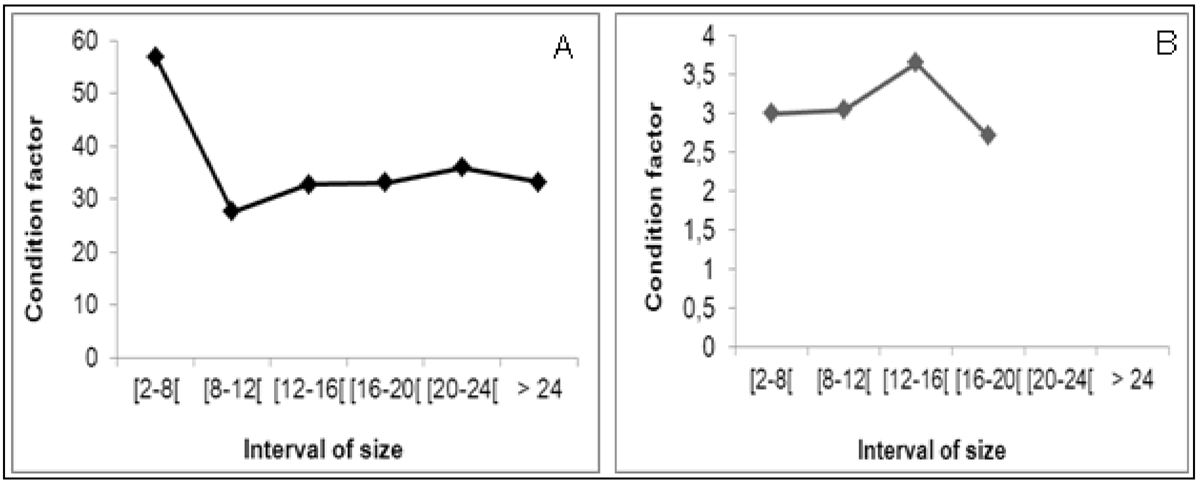

Fig. 2. Trend of condition factor K according to interval of size.

As for the condition factor for sex, the trend is that males have a relatively better condition than females at both water bodies. This tendency is explained by the vigor of the males causing them to grab faster food resources than females in food competition situations. Also, the sex ratio is in favor of females for both bodies of water (especially low-lying dredged) and therefore, males in reproduction have a lower specific richness than females (Achoh, 2017).).

As a result, males enjoy better ecological conditions than females, which are important. Comparing the condition factor of the same sex between body of water, it is noted that the individuals of dredged bottomlands have a condition factor higher than those of the lagoon.

This observation is explained by the depth given to the lowlands which allows to enlarge the living space. It also allows better primary production (guarantee of trophic production) given the low turbidity recorded after dredging.

Conclusion

The sand dredging activity modifies the hydrology of the lowlands. The growth of *S. melanotheron* populations in the dredged lowlands and the lagoon is of isometric type for all sex.

The condition factor is higher in dredged shoals than in those in the lagoon. In short, dredging favors better fish production at the lowland level and as such, could systematically be the solution to consider in order to revive the aquatic ecosystem whose fill-up is accelerating.

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