

Original Research Paper

Length-weight relationship and condition factor (K) of six populations of *Clarias jaensis* (Boulenger, 1909) from Cameroon Rivers

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Abstract:

The metric and weight growth performance of fish in the wild is often difficult to assess. However, there are some formulae, especially length-weight relationship and condition factor that can be used to assess the morphological aspects of these fish with environmental conditions. The study of length-weight relationship and condition factor of *Clarias jaensis* was conducted in six rivers in Cameroon from December 2022 to March 2023. A total of 269 individuals, including 139 males and 130 females, were sampled from 6 rivers in Cameroon. For each fish, the total length (TL) and standard length (SL) were measured with an ichthyometer after sexing, while the total weight (TW) in grams was measured to the nearest 0.5 g using an electronic scale with a capacity of 10 kg. Length-weight relationships were calculated using the equation $TW = a TL^b$ and their condition factors using the equation $K = 100 (TW / TL^3)$; with weight in gram and length in centimeter. The main results show that the different physico-chemical parameters of the water (temperature, pH, total hardness and transparency) varied significantly ($p < 0.05$) among the different Rivers. Largest fish (39.91 ± 4.68 cm) were found in the Nyong River and smallest fish in the Magam River (38.86 ± 4.54 cm). The coefficient b varied from 0.91 to 2.54, indicating negative allometric growth ($b < 3$). The condition factor varied significantly ($p < 0.05$) according to sex with an average of 0.85 ± 0.26 . It was highest ($K = 1.03 \pm 0.18$) in individuals from the Mfourri River and lowest ($K = 0.77 \pm 0.23$) in those from the Nyong River. This factor remained comparable according to sex ($p > 0.05$).

Keywords: Growth, condition factor, *Clarias jaensis*, Cameroon.

Introduction

Catfish of the Clariidae family are of undeniable nutritional and economic interest in Africa. According to Teugels (1996), the greatest diversity of this family is found in Africa, with 14 genera and over 90 species. The use of species from this family in fish farming is justified by their growth rate and high economic value (Offem *et al.*, 2010). According to FAO (2019), African production of these fishes is estimated at more than 230 000 tonnes, making them the second most produced species after Cichlidae. This rich diversity of Clariidae includes *Clarias jaensis*, an endemic species of Cameroon. It is a fish that is highly appreciated in traditional dishes and wedding celebrations, as well as in other customary celebrations. It is easy to handle and highly prized by the local population; it is a potential candidate for fish farming because of its hardiness and its fleshy meat (Pouomogne, 2008). Despite the undeniable economic and nutritional importance of this species, it is still traditionally exploited, so efforts need to be made to manage this resource efficiently. In Cameroon, some studies have been carried out on the

growth, genetics and determination of the protein and energy requirements of this species. A preliminary study of growth in a natural environment has been carried out in the Mbo'o floodplain (Tchouante *et al.*, 2019). It is therefore necessary to extend this study to other river basins for better management of *Clarias jaensis*. Growth in fish, particular length-weight relationships and condition factor are very important in fisheries science. Length-weight relationships provide useful data for assessing stocks and studying population dynamics (Hossain *et al.*, 2012; Kolher *et al.*, 1995). They also allow scientists to compare the morphological aspects of different populations in different environments (Goncalves *et al.*, 1997). Condition factor is a characteristic that gives an idea of overweight of fish (Paugy & Leveque, 2017). This variable provides data on the population structure of the fish species, and is of great importance for the management and conservation of natural populations (Muchlisin *et al.*, 2010; Sarkar *et al.*, 2009). This study was carried out with a view to contributing to a better understanding of the structure of the different populations in order to provide more information necessary for identification of strains that can be exploited for aquaculture. More specifically, the aim was to determine the physicochemical parameters of the water of the different fishing sites and to evaluate the length-weight relationships and the condition factor of *Clarias jaensis* from to the different fishing sites.

Materials and Methods

Study sites

Fish were collected from 6 rivers in Cameroon. Namely: Sanaga, Nyong, Nkam, Menoua, Mfourri and Magam Rivers (Figure 1). The study sites were selected based on their accessibility and the presence of this species.

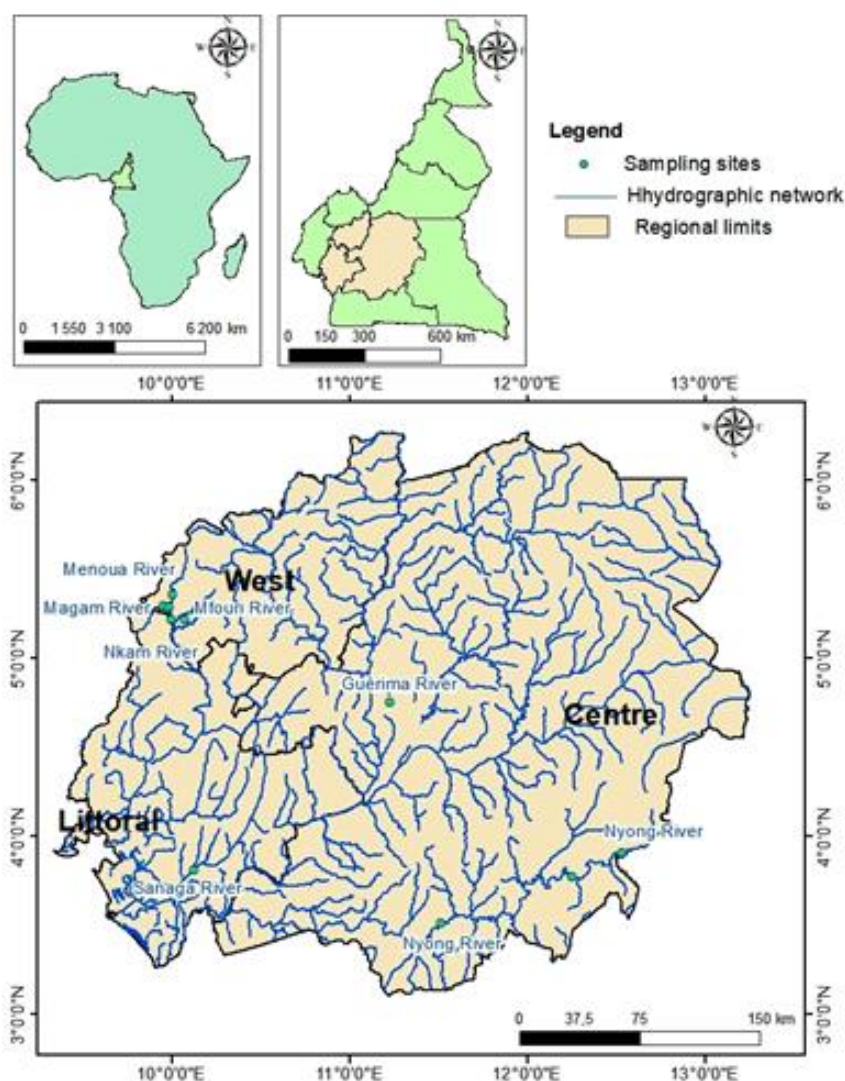


Figure 1. Sampling sites of *Clarias jaensis*

Table 1 shows the geographic coordinates of the different fishing sites

Table 1. Location of capture sites

Rivers	Sites	GPS location
Menoua River	Nteingué	N5°21'9.68472'' E10°0'14.14956''
	Madagascar/Santchou	N5°16'50.8746'' E9°58'50.36628''
Nyong River	Akonolinga	N3°46'10.78968'' E12°14'46.46292''
	Ayos	N3°54'11.11428'' E12°31'35.81688''
	Mbalmayo	N3°30'39.0474'' E11°30'25.73784''
	Fongwang	N5°16'11.45748'' E9°58'30.85248''
Nkam River	Lélem	N5°12'55.63872'' E9°59'437.41144''
	Edéa	N3°48'24.82524'' E10°7'12.62784''
Sanaga River	Edéa	N3°48'24.82524'' E10°7'12.62784''
Magam River	Nden-efoungwo	N5°17'12.45228'' E9°56'52.65744''
Mfourri River	Bamengui	N5°12'51.66432'' E10°4'23.64852''

Data collection

Determination of physicochemical water parameters

To study the habitat of *Clarias jaensis* collected in the different rivers and its probable influence on the characteristics to be highlighted in the different populations, some physicochemical parameters of the water were measured. These were: temperature, pH, transparency, and total hardness. These water parameters were recorded every week at 6 am and 6 pm in all the rivers studied.

pH was measured using a pH meter (Calibreur®), temperature using a thermometer (Traveable®), total hardness using an appropriate kit (Up D-618) and water transparency (water turbidity) measured using the Secchi disc.

Fish sampling

Fish were collected over four months (December 2022 to March 2023), a period of intense fishing activity. The fish were collected by local fishermen using sparrowhawk type gillnets and hooks. A total of 269 specimens of *C. jaensis* were collected, including 139 males and 130 females. Total length (TL) was measured to the nearest 1 cm for each individual after sexing, using an ichthyometer. The total length (TL) of each fish was measured from the tip of the snout to the posterior end of the caudal fin. The total weight (TW) of each individual was then measured in grams to the nearest 0.5 g using an electronic scale with a capacity of 10 kg.

Studied characteristics

Condition factor (K)

Condition factor was calculated using the following relationship $K = 100 (TW / TL^3)$, where, K = condition factor, TW = total fish weight (g), TL = total length (cm) and 100 is a factor to approximate the value of K to unity.

Weight-length relationship

The equation: $TW = a TL^b$ where TW = fish weight (in g), TL = total length (in cm), a = proportionality constant (intercept) and b = regression coefficient (slope) was used to establish the relationships between weight and length (Le Cren, 1951). The degree of association between TL and TW was calculated using the coefficient of determination (R^2). The value of the exponent b gives information about the growth of the fish. If b = 3, the increase in weight is isometric, otherwise it is allometric (positive allometric if $b > 3$, negative allometric if $b < 3$).

Statistical analysis

Descriptive statistics (calculating mean, standard deviation, coefficient of variation) were calculated using the 'summary' function in R software. One way analysis of variance (ANOVA) was used to compare the means of the physicochemical parameters of the water, and Tukey's test was used to separate the means when the differences were significant at the 5% threshold. Student's t-test was used to test the effect of sex on condition factor. All analyses were performed using R version 4.3.0 and Excel 2013.

Results

Physicochemical characteristics

The values of the physicochemical characteristics of the water examined (Table 1) varied significantly from one river to another ($p < 0.05$). Temperature was highest in the Sanaga River and lowest in the Menoua River, while pH was highest in the Menoua River. Water transparency was highest in the Nyong River and lowest in the Magam River. Total hardness was highest in the Magam River and lowest in the Nkam River.

Distribution of fish specimens by size class

The size structure of *C. jaensis* specimens by river (Figure 2) shows that almost all specimens caught were large (39.43 ± 4.67 cm). In general, largest specimens were found in the Nyong and Nkam Rivers, while smallest specimens were found in the Magam and Mfourri Rivers.

Growth and condition factor

Length-weight relationship

Table 2 shows the equations and coefficients of determination for the relationships between total weight and total length for *Clarias jaensis* according to rivers and sexes. The results of this table show that the highest coefficient of determination was observed for males from the Nkam River, while the lowest was observed for males from the Menoua River. Overall, the regression coefficient (b) remained positive and less than 3 in all rivers, regardless of the sex of the specimens. However, the highest regression coefficient was observed for males from the Nkam River, while the lowest was observed for males from the Menoua River.

Condition factor (K)

The condition factor of *C. jaensis* as a function of sexes and rivers is summarised in Tables 4 and 5. These tables show that site had a significant effect on this parameter ($p < 0.05$). Considering the rivers for both sexes, it was highest and lowest for fish from the Mfourri and Nyong rivers respectively. The condition factor remained comparable between the sexes ($p > 0.05$).

Table 2. Mean values of physicochemical parameters by rivers

Rivers	Parameters			
	Temperature (°C)	pH	Total hardness (ppm)	Turbidity (cm)
Sanaga River	29.42±0.98 ^d	7.50±0.06 ^{ac}	62.30±9.74 ^d	66.67±5.16 ^{cd}
Nkam River	25.10±1.51 ^{bc}	7.53±0.04 ^{ac}	51.91±9.16 ^d	58.33±4.08 ^{bc}
Nyong River	26.94±1.47 ^a	7.54±0.05 ^c	64.27±12.42 ^d	68.88±8.32 ^d
Menoua River	23.60 ±1.28 ^c	7.61±0.04 ^b	134.98±20.71 ^c	55.00±5.22 ^b
Magam River	24.25±0.90 ^{bc}	7.56±0.05 ^{bc}	216.56±13.39 ^b	50.00±6.32 ^{ab}
Mfouri River	24.98±0.88 ^{ac}	7.50±0.06 ^{ac}	133.50±18.67 ^c	54.16±5.14 ^b
River average	25.72±2.13	7.54±0.06	106.26±58.24	58.63±10.05

a, b, c, d: Means in the same column that bear different letters are significantly different (p<5%).

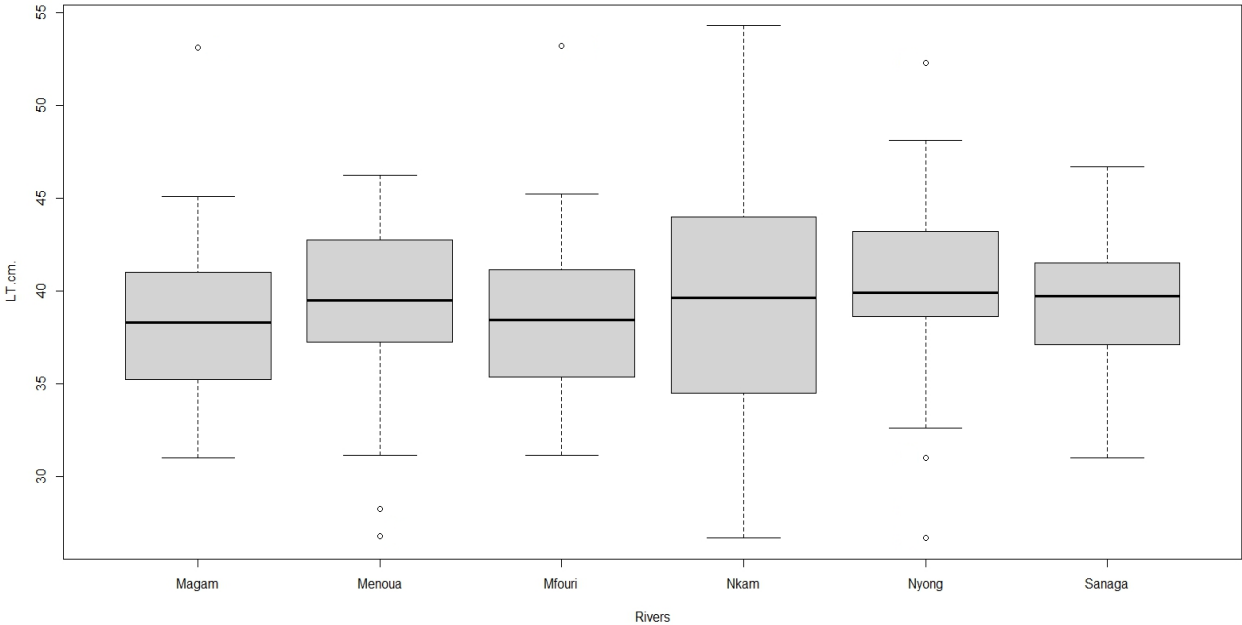


Figure 2. Distribution of specimens by size and river

Table 3. Equations and coefficients of determination for length-weight relationship of *Clarias jaensis* by rivers and sex.

Rivers	Features	Sex		♂♀
		♂	♀	
Sanaga River	Equation	$y = 4.97x^{1.25}$	$y = 2.96x^{1.38}$	$y = 3.10x^{1.37}$
	R ²	0.57	0.38	0.52
Nkam River	Equation	$y = 0.04x^{2.54}$	$y = 7.68x^{1.10}$	$y = 0.97x^{1.68}$
	R ²	0.89	0.61	0.74
Nyong River	Equation	$y = 0.40x^{1.92}$	$y = 10.46x^{1.01}$	$y = 1.18x^{1.62}$
	R ²	0.71	0.42	0.61
Menoua River	Equation	$y = 19.50x^{0.91}$	$y = 4.16x^{1.30}$	$y = 4.82x^{1.28}$
	R ²	0.30	0.34	0.40
Magam River	Equation	$y = 0.26x^{2.09}$	$y = 0.29x^{1.99}$	$y = 0.06x^{2.46}$
	R ²	0.52	0.74	0.62
Mfouri River	Equation	$y = 2.25x^{1.54}$	$y = 2.76x^{1.45}$	$y = 1.11x^{1.78}$
	R ²	0.80	0.71	0.74
River average	Equation	$y = 1.08x^{1.68}$	$y = 5.96x^{1.18}$	$y = 1.26x^{1.63}$
	R ²	0.52	0.38	0.53

R²: Coefficient of determination, ♂: male, ♀: female, ♂♀: combined sex.

Table 4. Condition factor (k) of *C. jaensis* according to rivers

Rivers	Condition Factor (K)		ANOVA
	n	X±S	
Sanaga River	30	0.81±0.19 ^{bc}	***
Nkam River	56	0.80±0.25 ^{bc}	
Nyong River	63	0.77±0.23 ^c	
Menoua River	60	0.90±0.30 ^{ab}	
Magam River	30	0.86±0.25 ^{ac}	
Mfouri River	30	1.03±0.18 ^a	
River average	279	0.85±0.26	

***:<0.001, n: number.

Table 5. Condition factor (k) of *C. jaensis* according to sex

Rivers	♂	♀	T-test
	X±S	X±S	
Sanaga River	0.80±0.28	0.82±0.13	NS
Nkam River	0.70±0.09	0.87±0.30	
Nyong River	0.76±0.18	0.79±0.28	
Menoua River	0.88±0.28	0.93±0.33	
Magam River	0.91±0.32	0.77±0.08	
Mfouri River	0.91±0.21	1.03±0.13	
River average	0.83±0.24	0.86±0.27	

NS: Not significant, ♂: male, ♀: female.

Discussion

A study of the quality of 6 rivers in Cameroon, based on measured physico-chemical characteristics, shows that the descriptors considered vary significantly from one river to another. Temperature was highest in the Sanaga River. Overall, the average water temperature was 25.72 ± 2.13°C. This result is

comparable to that of Kitio *et al.* (2022) (25.61 to 26.29°C) in Lake Assom. The pH was highest in Menoua River when compared to Mfourri River and Sanaga River. Overall, the average pH value was 7.54 ± 0.06 . This result is still relatively lower than that of Kitio *et al.* (2022) (8.08 ± 0.18) in Lake Assom. The geological composition of the soil and surrounding rocks, as well as anthropogenic activities, which differ from environment to another, could explain this difference. Water was more transparent in the Nyong River and less in the Magam River. The low transparency recorded in the Magam River may be due to anthropization caused by agricultural and pastoral activities practiced near this river. Overall, the water transparency ranged from 48.58 to 68.68 cm. This result is lower than that of Kitio *et al.* (2022) (115.00 ± 0.09). Water hardness was higher in the Magam River and lower in the Nkam River.

The size structure of *Clarias jaensis* among rivers showed that, practically all fish caught were large. This can be explained by the fishing techniques used and the fishing pressure. In fact, some fishing gear, such as sparrow nets or hook lines, may be selective for large fish. Such gear may have mesh sizes or hooks of an appropriate size to capture large fish, which may result in selection in favour of these individuals. Individuals from the Nyong Rivers were relatively larger compared to individuals from the Magam River. This result may be explained by greater fishing pressure in the latter.

In fish, growth is indicated by changes in length and weight, and there is a close relationship between these two variables (Le Cren, 1951). The length-weight relationship has been used to test the growth of fish populations (Konan *et al.*, 2021; Diop *et al.*, 2019). When b is equal to 3, the isometric growth pattern is observed, but when b is not equal to 3, the allometric growth pattern is observed, which can be positive when $b > 3$ or negative when $b < 3$ (Le Cren, 1951). The relative growth coefficients (b) of the length-total weight relationships of *Clarias jaensis* in this study varied from 0.91 to 2.54 independent of sex. The values of $b < 3$ for males and females of *Clarias jaensis* in this study indicate negative allometric growth and thus showed that the species grows more in length than in weight. These results are similar to those reported by Lalèyè (2006) for *Clarias gariepinus* and *Clarias ebrimensis*, where the value of b were 2.97 and 2.82 respectively. Contrary results were reported in Burkina Faso for *Clarias gariepinus* ($b=3.14$) (Coulibaly, 2008); in Senegal for *Clarias salae* ($b=3.05$) (Nomwine *et al.*, 2023) and in Burkina Faso for *Clarias anguillaris* ($b=3.33$) (Nomwine *et al.*, 2018). The differences observed are thought to be linked to food availability; habitat and species morphology. The regression coefficient (b) remained positive in all rivers and for both sexes. However, the highest regression coefficients was observed in males from the Nkam River, while the lowest were observed in males from the Menoua River. The results obtained contradict the observations of Tiéma *et al.* (2012) for *Clarias anguillaris*, which showed isometric growth in females ($b \sim 3$) and positive allometric growth in males ($b > 3$). This difference may be due to the sampling period, the degree of sexual maturity and the species morphology.

Condition factor (K) is used to characterise the physiological and nutritional condition of fish (Le Cren, 1951). It can also be used to assess the biological condition and overweight/underweight of fish. According to Fulton (1902), $K \geq 1$ expresses the 'well-being' of a population at different stages of its life cycle, while $K < 1$ means that the fish is underweight in its biotope. The results of this study showed that the condition factor varied significantly from one river to another. It was highest and lowest in fish from the Mfourri and Nyong rivers respectively. The difference between these results may be due to differences in ecological conditions (conductivity, pH, temperature, etc.) or food availability. In fact, the environment naturally varied; from one site to another, and these variations could have impact on resource availability. In general, condition factors were below 1, indicating that fish in rivers were in poorer than average condition. The K values observed in this study are comparable to those reported by Norwine *et al.* (2018) and Chikou *et al.* (2008) for *Clarias anguillaris* and *Clarias gariepinus*, respectively. However, these results differ from those observed by Tchouante *et al.* (2019) for *Clarias jaensis* in the rivers of the Mbô floodplain, where K ranged from 1.05 to 1.17. The differences in K observed between these studies may be related to the availability of food resources, gear selectivity, overfishing and species morphology. Condition remained comparable between the sexes in this study.

Conclusion

This study provides information on the habitat, length-weight relationships and condition factor of *Clarias jaensis* from different rivers in Cameroon. The study of the physicochemical parameters of the different rivers showed variation. The length-weight relationship of *C. jaensis* showed negative

allometric growth in all the rivers independently of sex. The condition factor of *Clarias jaensis* varied significantly from one river to another. It was highest in fish from the Mfourri River and lowest in fish from the Nyong River. This study provides the information needed to understand the strains intended for domestication.

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Author's Contributions

All authors contributed to the writing of the document. Djouatsa Tonfack J collected and analysed the data.

Ethics

The authors declare that no ethical issues could arise after the publication of this manuscript.

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