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RESEARCH ARTICLE

GROWTH PARAMETERS AND CONDITION COEFFICIENTS FOR THREE FISH SPECIES IN THE LOULALI RIVER

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ABSTRACT

The study focused on the weight-length relationship and condition factor of three species of fish in this river's collection. The biometric characterisation of three species (*Enteromius holotaenia*, *Doumea typica* and *Chiloglanis cameronensis*) from the river loulali was carried out. The standard length of *E. holotaenia* varied between 22.02 and 98.75 mm, with a mean of 61.46 ± 15.62 mm. The correlation coefficient r = 0.99, showing a strong correlation between the two parameters studied. The coefficient b equal to 3.21 indicates that this species has a major allometric growth. The standard length of *Doumea typica* specimens ranged from 64.57 mm to 171 mm, with an average of 106.28 ± 29.80 mm. The correlation coefficient r = 0.99, showing a very strong correlation between the two parameters studied. The b coefficient was 3.08, indicating isometric growth. The standard length of *Chiloglanis cameronensis* varies between 22.48mm and 101.07mm, the correlation coefficient r is equal to 0.99, the correlation between weight and standard length is strong. The b coefficient is equal to 3.26, proof of allometric growth, and the size structure is unimodal.

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INTRODUCTION

Very little is known about Loulali river ecosystem. Existing data are simply an extrapolation referring to the greater basin. The present study is one of the first to be carried out on this fish-rich river. Morphological, physiological, behavioural and biochemical variations are used to identify and classify the fish. However, in practice, it is more common to use morphometric data (i.e. body length, body depth, head length, eye diameter, jaw length) and meristical data (Kémal, 2009). It should also be noted that the study of metric and meristic characteristics is important for identifying fish species, their habitat-related characteristics and the ecological criteria of this habitat (Lalèyè, 2006); this study focuses on growth parameters and the condition coefficient of three species in the Loulali River. In the long term, this will enable the weight of catches to be estimated, populations of species living in different environmental conditions to be compared (Minoungou *et al*., 2020) and oscillations in the metabolic balance to be monitored through the overweight of individuals (Freon, 1976). Knowledge of biometric parameters such as fish size and weight is very important for estimating fish growth (Abba *et al*. 2012).

MATERIAL AND METHODS

Presentation of the study environment: The Congo's hydrographic network is dense enough to resemble a spider's web. It is organised around two main basins, the Congo and the Kouilou-Niari, to which should be added the coastal basins. The Kouilou-Niari basin is the 550th ecoregion in the world, as defined by Robin *et al* (2008) and validated by Skelton and Swartz (2011). It covers the south-western part of the country and extends over an area of 55,340 km2. It is called the Ndouo in its upper reaches and the Niari in its middle reaches, where it receives two of its largest tributaries, firstly the Bouenza river in the Bouenza department, then the Louessé in the Niari department, and finally it becomes the Kouilou river. The Louessé's main tributaries are the Loulali, Lékoumou and Mpoukou rivers, most of which flow into the Lékoumou Department (Vennetier, 2001). The Loulali River (Figure 1) rises in the Bouenza Department and is fed by numerous tributaries, including the Loho towards Mapati and the Lékoumou towards Komono, before flowing into the Louessé Vennetier, 1977. It is a clear-water river that winds through the valleys of the Chaillu massif and becomes more incised downstream, forming waterfalls and rapids. Its

network shows an alignment of almost 84 km in a south-east/north-west direction, perhaps corresponding to certain Precambrian tectonic trends (Vennetier, 1966).

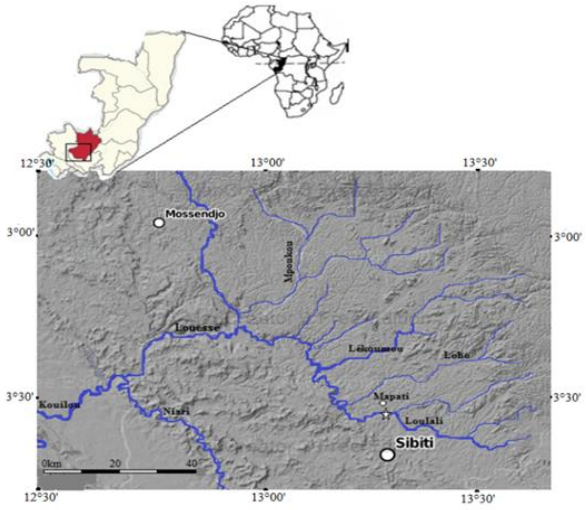

Figure 1. Location of the study site (Maps Creator 3)

Study area : The ichthyofauna of the Loulali River were sampled at several fishing points on either side of the bridge on the Sibiti - Mapati road. Three fishing points were explored, one upstream of the bridge, which is very calm and rich in surrounding vegetation, and the other two, respectively near the bridge in an area with fast-flowing water and downstream of the bridge in a limnetic area. The geographical coordinates of the area were recorded using a Holux-GM-132 GPS and are : 3°33'28.5‘’S and 13°21'32.1‘’E.

Capture, conservation and identification of specimens : The fish were caught using hawk nets and gillnets during two fishing sessions per day (morning and evening) from 14 to 16 August 2014 and from 23 to 24 June 2016. The specimens caught were fixed in a 10% dilute formalin solution and preserved in 5% ? formalin for subsequent identification. The species captured were identified using the various keys available (Mamonékéné and Teugels, 1993 ; Mbega and Teugels, 2003; Stiassny *et al*., 2007).

Weighing, measurements and size structure: Specimens were weighed using an AHOS electronic balance, with a capacity of 2kg and an accuracy of 0.001g. The main measurements were made to the nearest hundredth of a millimetre using an Amig digital calliper. The morphometric characterisation of the species to be studied enabled a size class distribution of the different specimens to be made, by applying the Sturges rule (Scherrer, 1984) which enables the number of size classes (NC) to be calculated: NC = 1 + (3.3 log10Ni) ; where Ni represents the total number of specimens examined.

From the number of classes, it is possible to determine the class interval (CI) using the following formula: CI = (LSmax-LSmin)/NC ; LSmax represents the maximum standard length and LSmin the minimum standard length.

Weight-length relationship: Measurements taken on specimens of Enteromius holotaenia, Doumea typica and Chiloglanis cameronensis, together with the corresponding weights, have made it possible to establish weight-length relationships according to LeCren (1951): Pt = a LS b; where, Pt is the total weight; LS corresponds to the standard length; a is the average condition factor and b the allometry coefficient. This equation becomes LogP = Loga + bLogLS, when compounded by the logarithm. The type of growth is determined by the value of the growth coefficient b. If b is equal to 3, growth is isometric, i.e. body shape and density do not vary with age (Sanogo, 1999; Ricker, 1980). On the other hand, if b is greater than 3, there is better growth in weight than in length, and growth is said to be allometric-majorative. When b is less than 3, growth is said to be allometric minoring, with growth in length much better than in weight (Ibala Zamba *et al*., 2019; Attal and Arab, 2013; Sanogo, 1999 and Micha, 1973). Depending on the species, b values range from 2.5 to 4.0 (Freon, 1976). In the general case where the lengths and weights of a mixture of individuals of different sizes are used, whatever their age and, the bias is always negligible because the size intervals are never very large (Freon, 1976). The Student's t-test at the 95% probability threshold is applied to check whether the value of b deduced from the regression curve is different from the reference value (b=3). It is also interesting to compare the a values obtained for the same species in different areas or at different seasons, when the b slopes are not significantly different. This can be done by an analysis of co-variance, and can highlight biometric differences (Mayrat, 1959 ; Snedecor, 1957).

Condition factor: The condition factor (K) provides information on the well-being of the population during the different stages of the life cycle (N'Guessan *et al*., 2017). It is an indicator of the physiological state of the fish in relation to its overweight (Tabassum *et al*., 2013). It also reflects the interaction between biotic and abiotic factors and the physiological state of the fish. The value of the condition factor for each specimen is given by the following algebraic expressions : K=(P/Lsb) *100 (Bagenal and Tesch, 1978) or K = (P/LS3) x10^5 with K : Fulton's condition factor ; P : weight of specimen (g) ; Ls: standard length (mm) and b : allometry coefficient. The compliance of individual condition factor values for each specimen is determined using Student's t-test: ts = (k - 3)/ES_k, where ts is the Student's t-test value, k is the individual condition coefficient and ESk is the standard error of k. The Fulton condition factor (K) corresponding to the Fulton (1911) individual condition coefficient which differs from the Postel composite condition factor (Ki), whose value takes into account both the condition of the fish and the species-specific allometry coefficient (Postel, 1973).

RESULTS AND DISCUSSION

Biometric characterisation of *Enteromius holotaenia* (Boulenger, 1904) :

Figure 2 . Specimen of *Enteromius holotaenia*

Measurements, size structure and weight and weight-length relationship: A study of the metric and meristic characteristics of 100 specimens of E. holotaenia showed that the size (standard length) of the individuals sampled ranged

Tableau 1. Growth parameters and condition coefficient in *E. holotaenia*

	$P=aLS^b$; Log P= b Log LS + a						$K=(P/LS^3)*100$			
N	a	b	IC de b à 95%	ES de b	r^2	Type of growth	Min.	Maxi.	Moy.	ET
100	0,024	3,211	3,132-3,289	0,04	0,985	Isometry	2,475	4,671	3,471	0,421

Table 2. Growth parameters and condition coefficient in *E. holotaenia* (Ngot *et al.*, 2023)

	P= aLsb ; Log P= b Log LS + a							K=(P/LS³)*100		
N	a	CI de a, à 95%	b	CI de b à 95%	ES de b	r^2	Type of growth	Min.	Max.	Moy.	ET
48	0,017	0,012 - 0,025	3,251	0,065 - 3,439	0,093	0,963	Isometry	1.507	2.134	1.768	0.148

from 21.020 to 98.750 mm, with an average of 61.166 ± 15.770 mm. The sizes most frequently encountered belong to class 5 (modal class), out of the 8 classes obtained (Figure 3). The Student's t-test, applied at the 95% probability threshold for a confidence interval of 58.084 - 64.4, gives a value of t=25.278, with p calculated as 1.0024E-44. This implies a significant difference between the standard lengths of the different specimens.

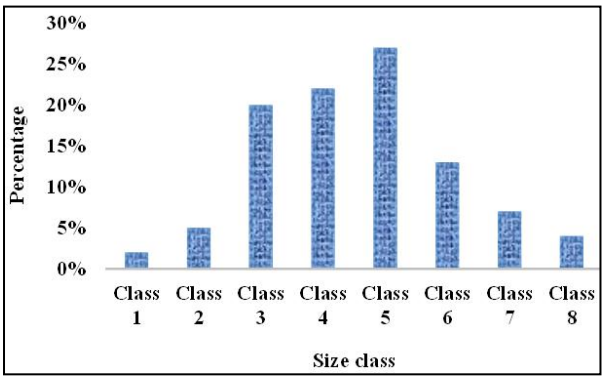

Figure 3. Size structure of *E. holotaenia*

Weight characteristics : For all individuals caught, fresh weights varied between 36.802 and 0.251g, giving an average weight of 9.871±7.761g. However, there was no significant difference between specimens in terms of the range of weights for a 95% probability threshold and a confidence interval varying between 8.3806 and 11.483. The Student's t test gives t=-3.1018E-05 with p=0.99998. The standard length of specimens from the Loulali is less than that of specimens obtained by Mutambue (1996) in the Luki basin in the Democratic Republic of Congo (22.5 - 142.5 mm) but greater than those obtained by Mamonékéné and Teugels (1993) in the same Kouilou-Niari basin, for the Dimonika Biosphere Reserve (61.1 - 75.1 mm). However, the specimens from the Loulali river are larger and longer than those obtained by Ngot *et al* (2023) in the Congo basin, with 48 individuals with an average size of 7.17 ± 0.90 and an average weight of 11.29 ± 4.39.

Weight-length relationship : The results in Figure 4 show the weight-length relationship for *E. holotaenia*. The regression equation linking these two parameters is Pt = 0.0067Ls3.2108, giving a coefficient of determination R^2 equal to 0.98. The correlation coefficient r was 0.99, indicating a strong correlation between the two parameters. The allometry coefficient b is equal to 3.210. A linearisation of the parametric equation for Pt gives P= 3.210 Log Ls+1.622, i.e. a=1.622 and b=3 ES of b=0.084. This value of b is not significantly different from 3 and Student's t-test for $p < 0.05$ indicates growth isometry.

Fulton condition coefficient: The Fulton condition coefficient shows little significant difference for this species, at the 95% probability threshold, for a confidence interval of between 0.0034 and 0.0036 we have t= -3.1018E-05 and p=1.123E-16 < 0.05. The break in the LogPt-LogLs slope is equal to 0.0005≠ 0, which implies that the allometry of the species varies very little during its growth. An analysis of the co-variance of the values of a for the two basins (Kouilou-Niari for the present study and Ngot *et al.*, 2023 for the Louemé coastal basin) gives a much better comparison, from which it emerges that the individuals in the Loulali River are in better condition. The absence of data on conditions and weight-length parameters does not allow any comparison with the results of Moutambue (1996) and Mamonékéné and Teugels (1993).

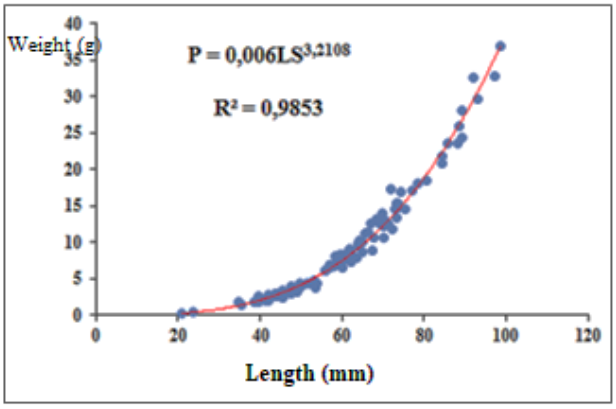

Figure 4. Length-weight relationship in *E. holotaenia*

Biometric characteristics of *Doumea typica* Sauvage, 1878

Figure 5 : Specimen of *Doumea typica*

Measurements and size structure: The main metric characters measured on 60 specimens of *Doumea typica* reveal that the standard length of Doumea typica varies between 64.57 and 171mm with an average of 106.716± 29.953mm. Specimens were divided into 6 size classes with an interval of 17.73mm (Figure 6).

Two groups of individuals can be formed around the two modal classes (1 and 4): group 1 is made up of individuals in classes 1, 2 and 3; group 2, which we will assume to be made up of adult individuals, is formed by classes 4, 5 and 6. Variations in size between individuals of this species are insignificant at 95% for a confidence interval of 98.113-

Tableau 3. Growth parameters and condition coefficient in *D. typica*

	$P=aLS^b$; Log P= b Log LS + a						$K=(P/LS^3)*10^5$		
N	a	b	IC de b à 95%	ES de b	r^2	Type of growth	Max	Min	Moy±ET
49	0,007	3,082	2,996-3,169	0,043	0,99	Isometry	1,123	0,701	0,908±0,079

Tableau 4. Growth parameters and condition coefficient in *C. C cameronensis*

	$P=aLs^b$						$K=(P/Ls^3)*100$		
N	a	b	IC de b à 95%	ES de b	r^2	Type of growth	Min.	Max	Moyenne
40	0,019	3,270	3,164-3,376	0,052	0,99	Isometry	1,8210	3,4844	2,9113±0,5125

115.32, i.e. t=7.6309E-05 where p=0.999. The specimens in the Mamonékéné and Teugels collection are between 38.6 and 140 mm in size, smaller than those in the Loulali River. It therefore appears that the range of size intervals is nowgreater.

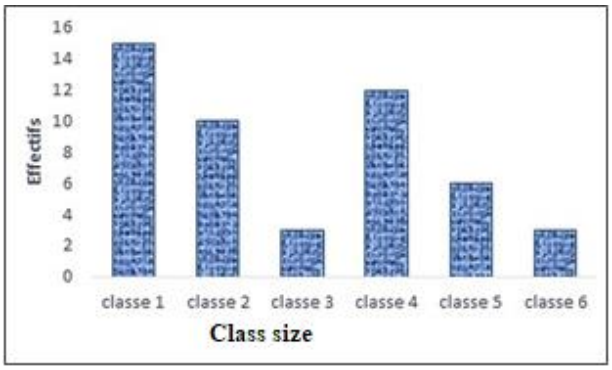

Figure 6. Size structure of *D. typical*

Weight data: Weight ranged from 48.785 to 2.243g, with an average of 13.943±11.514g. At the 95% probability threshold for a confidence interval of between 10.943 and 17.251, the Student's t-test gives a calculated t-value of 0.00022, i.e. p=0.999; the difference is unlikely to be due to chance. The standard error is very small, which means that the weight result obtained is more significant.

Weight-length relationship: The weight-length relationship of *D. typica* specimens shows a power curve (Figure 7), the coefficient of determination $R^2$is equal to 0.99 and the correlation coefficient r is 0.99, indicating a very strong correlation between weight and standard length, the value of the growth coefficient b is equal to 3.08, demonstrating that the growth of *D. typica* is isometric, Student's T test shows no significant difference between the value of the allometry coefficient observed and the standard value (b=3), in *D. typica*, in other words, *D. typica* individuals grow as much as they put on weight.

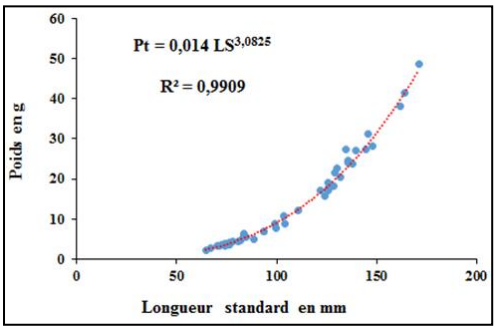

Figure 7. Length-weight relationship for *D. typical*

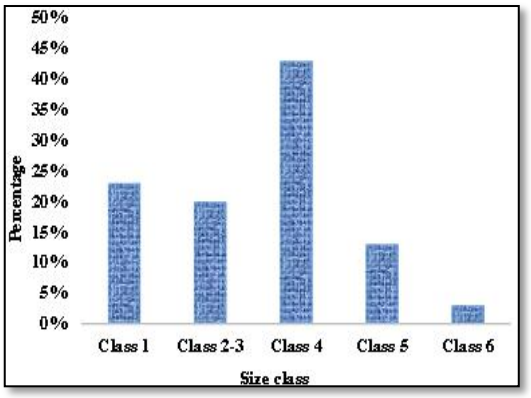

Figure 8. Size structure of *C. cameronensis*

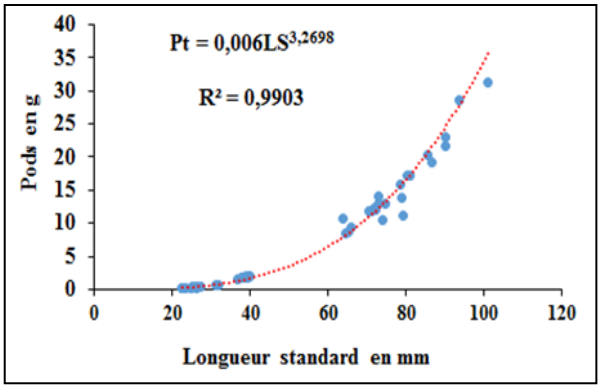

Figure 9. Length-weight relationship in *C. cameronensis*

Condition coefficient : The results of the condition coefficient for the species *D. typica* are given in Table 3.

By considering the Fulton coefficient in the sense of Fulton (1911) where K = (P / LS3) x105 we obtain two groups of individuals: those in the first group, with conditions K<0.9 and those in the second group who have a much better condition (K≥0.9). The Student's t-test applied to these two groups at the 95% probability threshold shows no significant difference (p=0.42; t=0.87) with a confidence interval of between 0.020 and 0.040. The low condition factor values for all specimens and for both size groups combined could be linked to the availability of food in the environment.

Biometric characteristics of *Chiloglanis cameronensis* (Boulenger, 1904)

Measurements and size structure: Measurements of *C. cameronensis* specimens show that the standard length of *Chiloglanis cameronensis* varies between 22.48 and 101.07

Figure 10. Specimen of *Chiloglanis cameronensis*

mm, with an average of 58.28 ± 24.29 mm. The distribution of *C. cameronensis* specimens yielded 6 size classes (Figure 8). The size structure distribution is unimodal, with class 4 accounting for the majority of specimens (43%). The measurements of *C. cameronensis* from the Loulali River are superior to those obtained by Mamonékéné and Teugels (1993) who gave standard lengths of between 22.5 and 34mm because, unlike their study, they characterised a greater number of specimens of varying size.

Weight data: The minimum weight of specimens caught in the Loulali was 0.2360 g and the maximum was 31.1880 g for an average of 9.1803±8.7226g. At the 95% confidence level in the range 6.8949 to 11.884. The Student's t-test gives a value of t=0.16882 (p=0.8667). There was therefore no significant difference in the weight of the specimens.

Weight-length relationship: The relationship between weight and length in *C. cameronensis*, illustrated by the power curve (Figure 9), shows a very strong correlation (r = 0.99). The value of the allometric coefficient b is 3.26, indicating a major allometric growth. The value of b for this species is within the limits declared (2-4) by Tesch (1971) and Bagenal and Tesch (1978) as for most fish and indicates isometric growth. This range of b values is similar to the work of Tah *et al*. (2012) for 36 species from two tropical reservoirs in Côte d'Ivoire.

Condition coefficient: Individuals of this species, although showing an allometry roughly equal to 3, as shown in Table 4; have a variable condition depending on the individual. Student's t-test ($p < 0.05$) applied to the condition factors gives t=-5.2479 and p=3.4486E-6, synonymous with a significant difference in the individual condition factors. The condition factor is said to vary from one individual to another. This result can be explained by the fact that the Loulali River certainly offers the species better living conditions and a wide range of food.

CONCLUSION

The biometric characterisation of three species from the Loulali River (*Enteromius holotaenia*, *Doumea typica* and *Chiloglanis cameronensis*) was undertaken. The results obtained during this study constitute a database on the morphometry and growth of the three most abundant species in this river. Two of these three species show isometric growth:*E. holotaenia* and *Chiloglanis cameronesis*. Differences were observed compared with the results of previous studies. The standard length of *B. holotaenia* from the Loulali river varies between 22.02 and 98.75 mm. Its growth is allometric-majorant and its size structure unimodal. The standard length of *D. typica* varies between 64.57 and 171 mm, and its size structure is bimodal. The standard length of *C. cameronensis* varies between 22.4 and 101.07 mm, its growth is allometric and its size structure is bimodal. All these differences are probably due to environmental variability. In view of the b values obtained for these three species, it seems that this ecosystem is not yet degraded and the fish resource not yet overexploited.

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