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Length-Weight Relationship and Condition Factor of *Coptodon walteri* (Thys Van den Audaerne, 1986)

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Abstract

For the conservation of endemic species, it is essential to obtain basic biological data. In this framework, the growth parameters of the fish *Coptodon walteri* from the Cavally River, an area under the effect of the Ity gold mine in the southwestern part of Côte d'Ivoire, were analyzed. A total of 128 specimens were sampled between May and July 2021, including 72 from the Cavally SMI Hill South sector (CSH), located in the Ity mining area and 56 from the Bakatouo Camp sector (BC), outside the Ity mining area. Specimens were sampled using the standardized fishing method with monofilament gill nets (10, 12, 15, 20 and 30 mm) mesh size. The equations $P = aLS^b$ and $K = \frac{100P}{LS^b}$ were used to determine the length-weight relationship and the condition coefficient. The allometric coefficient b of the length-weight relationship varied from 3.01 in the Cavally Colline Sud sector to 3.2 in the Bakatouo sector. Specimens from the Cavally Colline Sud sector exhibited isometric growth, while those from the Bakatouo sector displayed positive allometric growth. The average condition factor varied from 1.46 ± 0.24 for the Bakatouo sector and 2.06 ± 0.28 for the Cavally Colline Sud sector. The results obtained provide information on the living conditions of *Coptodon walteri* sampled at the two sites of the Cavally River. These results show the consequences of gold panning on the growth parameters of *C. walteri* living in this part of the river.

Keywords

Coptodon walteri, Mining, Cavally River, Length-Weight, Condition

Coefficient, South-West Ivory Coast

1. Introduction

Fish provides 15% of animal protein intake for more than four billion people around the world. Additionally, fishing supports the livelihoods of over 12% of the global population, either directly or indirectly (FAO, 2012). In the global South, and particularly in Africa, the stakes are considerable. This region is characterized by rich yet fragile biodiversity, with many communities relying heavily on natural resources and ecosystem services linked to this biodiversity. The West Africa not only serves as the primary source of protein but also represents a vital source of foreign exchange (Horemans, 1998; Ticheler, 2000).

Côte d'Ivoire boasts rich biological diversity spread across its territory. However, this biodiversity is under severe threat due to the rapid degradation of its natural resources and the significant loss of genetic diversity, highlighted by the disappearance of species and genes (Avit et al., 1999). The severe damage to natural ecosystems and the destruction of species result from various anthropogenic activities. Habitat destruction caused by human activities (fishing, dam construction, overfishing, illegal gold panning, etc.) represents one of the most critical threats to biological diversity (Avit et al., 1999). These anthropogenic activities are becoming increasingly detrimental to fish populations (Yao, 2006). In Côte d'Ivoire, clandestine gold panning activities impact nearly every region of the country. The nation's aquatic ecosystems are not spared, with the Cavally River being particularly affected. For several years, the Cavally River has experienced escalating and persistent pollution driven by deforestation, the expansion of agricultural activities, and, most critically, clandestine gold panning near localities surrounding the Ity gold mine (Toto, 2018). Certain sections of the Cavally River experience significant anthropogenic pressure, primarily due to gold mining activities (Doffou et al., 2019). The intensive mining operations, which involve motorized machinery within the riverbed and the use of chemicals, have resulted in severe environmental consequences. These include water pollution, bank destabilization, destruction of the forest gallery, disruption of ecosystem functions, alteration of the substrate, and elevated concentrations of suspended matter (Doffou et al., 2019).

An updating of data on the fishery resources of the Cavally River is therefore crucial, as this river harbors endemic species with restricted distributions that are increasingly threatened by significant disturbances, particularly mining activities in its main bed (Konan et al., 2015).

Among these endemic species is *Coptodon walteri,* a species commonly found in artisanal fisheries along the Cavally River in Danané, Zouan-Hounien, and Bin-Houyé in western Côte d'Ivoire (Doffou, 2014; Konan, 2015; Konan et al., 2015). Thus, the present study aims to contribute to the establishment of biological data on endemic species of the Cavally River.

Specifically, this involves identifying the type of growth (isometric and allometric) of *Coptodon walteri* and determining the condition factors of this species. Notably, this research represents the first investigation into the growth parameters on the species *C. walteri*.

Following this introduction, which outlines the study's framework, the material and methods used will be detailed. The results will then be presented and discussed, culminating in the conclusion.

2. Materials and Methods

2.1. Study Environment and Sampling Sites

The study was carried out on the Cavally River, 700 km long. This river is shared by three countries: Ivory Coast, Guinea and Liberia. The Cavally has a lot of meanders. The Cavally watershed is characterized by dense forest vegetation and a very tight hydrographic network (Vo, 1969). Agriculture is the main activity in the region, illegal gold panning is also one of the important economic activities (Zénobe, 2010).

In total, two sectors were sampled on the Cavally River (**Figure 1**). The sampling campaigns took place over three (3) months, from May to July 2021 following a standardized capture method using monofilament gillnets of 10, 12, 15, 20 and 30 mm mesh side. For each station sampled, the nets were set at 5 p.m. and collected the next day at 8 a.m. A total, 128 specimens of *Coptodon walteri* including 72 in Cavally SMI Colline Sud (SCS) and 56 in the Bakatouo camp sector (BC) were used as part of this study. In the field, for each specimen, the total length and weight were determined respectively using an ichthyometer graduated to the millimeter and an electronic balance.

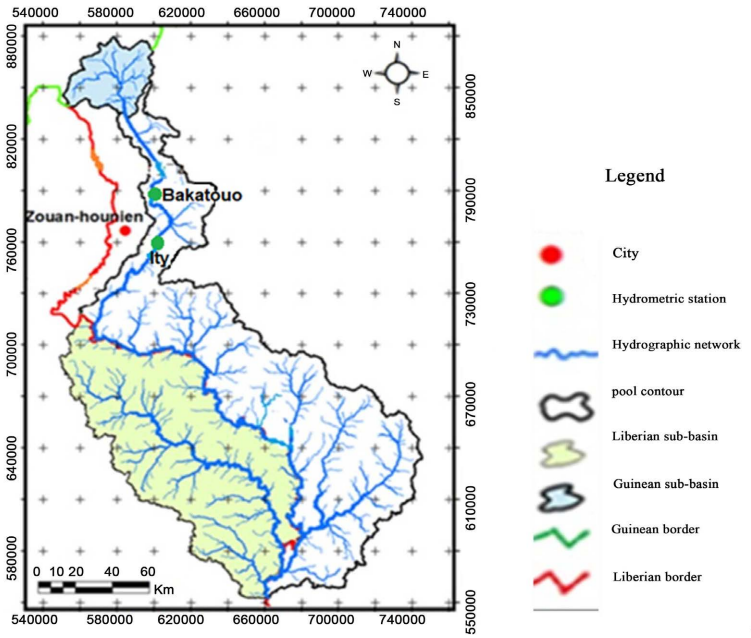

Figure 1. Hydrography of Cavally River (Brou et al., 2017).

2.2. Characteristics of the Sampled Sites

The Cavally SMI Colline Sud (CSH) site is located in Floleu in the Ity mining area with a strong presence of clandestine gold panning activity in the river bed. As for the Bakatouo site, it is located outside the perimeter of the Ity mine, bordered by cocoa and rubber plantations and a gallery forest.

2.3. Experimental Investigation or Procedure

Generally speaking, knowledge of the relationship between the standard length (*LS*) which is the distance separating the tip of the fish's snout from the base of the fish's caudal fin and their total weight (*PT*) finds applications in biology fisheries and in the assessment of fish stocks (Coulibaly, 2003). The regression curves of the equation

$$P = aLS^b \tag{1}$$

are obtained from the length-weight, where P represents the weight of the individual (g), LS the standard length (cm), a is the initial growth coefficient and b the slope of the regression line. After transforming Equation (1) into its logarithmic form

$$\log(a) = \log(a) + b \times \log(Ls), \tag{2}$$

the parameters a and b for each of the equations of the Length-Weight relationship were estimated by linear regression analysis (Zar, 1999).

The Length-Weight relationship reflects isometric growth when $b = 3$ and allometric growth when $b \neq 3$. However, positive allometric growth is observed when $b > 3$ and negative allometric growth when $b < 3$ (Morey et al., 2003). The statistical difference between the value of b for each species and the isometric value ($b = 3$) was obtained using the Student's t test. All tests are significant at the 5% level ($p < 0.05$). To evaluate the body condition of the fish in the Cavally River, the individual value of the condition factor for each sector was calculated using the formula of Koné & Teugels (2003):

$$K = \frac{100P}{LS^b} \tag{3}$$

where P represents the weight of the individual (g) and LS, the standard length (cm).

3. Results and Discussion

3.1. Results

3.1.1. Pruning Frequency

Figure 2 and Figure 3 illustrate the size frequency distribution of *Coptodon walteri* studied in each of the two surveyed sites. The species *C. walteri* presents a distribution which includes a modal class at the two stations. In the BC site, the modal class is 8.59 to 9.88 cm (SL). Most specimens collected in this environment have a size between 7.5 and 14.7 cm (SL) and specimens with a size between 8.7 and 9.8 cm (SL) are the most numerous. For the CSH station, the recorded modal

class is 4.5 to 5.9 cm (*LS*). The dominant size range is between 4.5 and 14.5 cm. Fish that are between 4.5 cm and 6 cm (*LS*) are the most numerous.

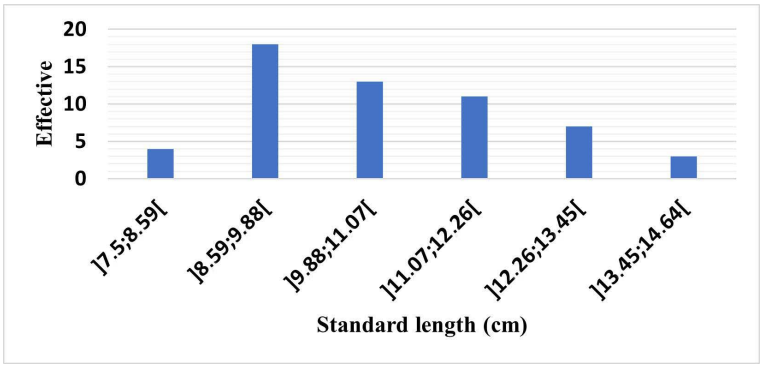

Figure 2. Size distributions of *Coptodon walteri* specimens from the BC site in the Cavally River.

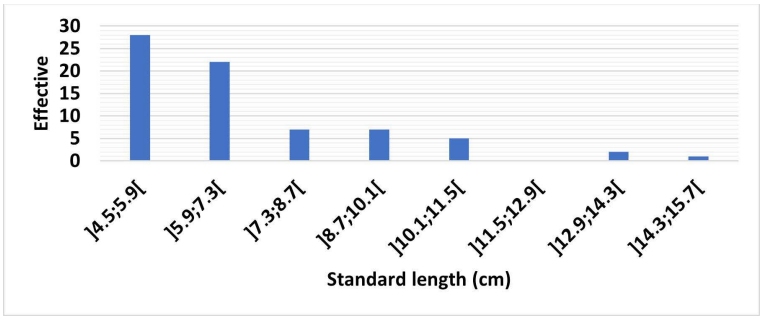

Figure 3. Size distributions of *Coptodon walteri* specimens from the CSH site in the Cavally River.

3.1.2. The Length-Weight Relationship

The weight of *Coptodon walteri* varies from 21.08 g to 177.78 g with an average of 65.14 g for the BC sector. In the CSH sector, the weight of this species oscillates between 3.5 g and 136.5 g with an average of 20.63 g. The average weight of *C. walteri* varies significantly from one sector to another (Fisher F test, $p < 0.005$).

The parameters of the population length-weight relationships between standard length and weight of *C. walteri* individuals sampled in the Cavally River and their coefficients of determination are presented in **Table 1**. The linear regressions were highly significant ($p < 0.05$) for the two sectors studied, with the determination coefficients r^2 of 0.95 (CSH) and 0.96 (CB). *C. walteri* specimens at the Cavally River sampling stations have an allometry coefficient b of 3.01 (CSH) and 3.2 (BC). These values are statistically equal to 3 for the CSH sector and greater than 3 for the BC sector (Student's t-test; $p < 0.05$). Thus, the growth of *C. walteri* is of the isometric type for the CSH sector and of the positive allometric type for the BC sector.

3.1.3. Condition Factor

The condition factor of *Coptodon walteri* sampled in the Cavally River fluctuated

Table 1. Length-weight relationship parameters and growth type of *Coptodon walteri*.

		length		Weight (g)		Allometry		
Site	N	Min - max	Moy	Min - max	Moy	r^2	*b*	Growth type
BC	56	7.5 - 14.7	10.6	21.08 - 177.78	65.1	1	3.2	PA
CSH	72	4.5 - 14.5	7.09	3.5 - 136.5	20.6	1	3.01	I

BC = Bakatouo camp; CSH = Cavally SMI hill South; N = number of individuals; r^2 = correlation; PA = positive allometry; I = Isometry.

from 0.02 to 3.7 with a median value of 1.79. The highest median condition factor was recorded in the CSH site (2.06) and the lowest median value of this variable was recorded in the BC site (1.46) (Table 2). Comparison of variables between zones showed a significant difference between the two study sites (student's t test; $p < 0.05$). The calculated *C. walteri* condition factor values vary from 1.6 to 3.7 in the CSH sector and from 0.02 to 1.94 for the BC sector Table 2.

Table 2. Condition factor K of *Coptodon walteri* in the Cavally River.

		K	
Site	N	Min - max	Moy ± DS
BC	56	0.02 - 1.93	1.46 ± 0.24
CSH	72	1.59 - 3.79	2.06 ± 0.28

3.2. Discussion

This study was based on the analysis of the growth and body condition of sympatric *Coptodon walteri* from two sites in the Cavally River (Côte d'Ivoire.) The results showed through the size frequency distribution that the standard length for CSH specimens is between 4.5 cm and 14.5 cm and for BC individuals, the frequency is 7.5 and 14.7 cm. The average sizes of *C. walteri* specimens from these two sites in the Cavally River are 7.09 cm (CSH) and 10.64 cm (BC) for the standard length. This standard-length range obtained is lower than that observed by Konan et al. (2015), who obtained a standard length in this species that varied from 4.7 cm to 27 cm, respectively. This could be related to gold mining activity and agricultural inputs. Indeed, according to the work of Konan et al., 2020, artisanal gold panning contributes to the modification of water quality parameters. This observation, based on the processing of LandSat satellite images from 1986, 2011 and 2018 using remote sensing software and geographic information systems (GIS), showed that the area most affected by this artisanal gold panning activity is located between the operating perimeter of Ity Mining Company and the village of Floleu. Their study also revealed that the deterioration in the water quality of the Cavally River is mainly due to organic and oxidizable matter (alteration indices between 12.56 and 19.80), suspended particles, phosphorus matter (indices varying from 84.80 to 97.60), trace metal elements, acidification of the water and changes in temperature. The value of the allometry coefficient b of the length-

weight relationships in this study is respectively 3.01 for CSH and 3.2 for the BC sector. These values are included in the range of values (2 to 4) indicated by Offem et al., (2009). The obtained allometry coefficient b of 3.01 (CSH) and 3.2 (BC) in these two sites of Cavally, shows that the allometry coefficient of CSH (3.01) is statistically equal to 3 (Student t-test; $p < 0.05$). In this environment the species has an isometric growth, that is to say that the body shape and density do not vary with age. As for sector BC, the allometric coefficient b is 3.2, greater than 3 (Student t-test; $p < 0.05$), so the growth of the species in this sector is of positive allometric type, that is to say that the growth is better in weight than in length. These values corroborate with those of Froese et al., 2013 who estimated that the coefficient b of the species *C. walteri* is 3.03 (2.81 - 3.25). This difference in growth observed in these two sites, according to Yakubu et al., 2016 is due to the quality of the aquatic environment. Thus, we can deduce that the low value of the allometry coefficient (3.01) of *Coptodon walteri* in the CSH sector could be due to the advanced state of degradation of the river in the CSH sector due to the Ity mine, clandestine exploitation or overexploitation of aquatic resources. The size frequency distribution shows two classes of specimens: those whose size is less than 7.3 cm and those which are greater than 7.3 cm. These two groups could correspond respectively to juveniles and adult individuals according to the observations of Doffou, 2019, whose individuals sampled in the Cavally River had a size greater than or equal to 6.6 cm were the most abundant. Thus, for the species *C. walteri*, we find more individuals which have a size between 4.5 and 7.3 cm (SL) in the CSH environment. These results show that there is a higher proportion of young individuals for this species in this environment than adults. As for the individuals collected in the BC sector, they all have a size greater than 7.3 cm SL. This difference in size at the two sites could be due to the consequence of the ecological conditions and the poor environmental conditions in which the species is found in our study area (Doffou, 2019). In addition, in *C. walteri*, the maximum size recorded in this study is 14.7 cm SL (BC). This value is higher than that reported in the literature which is 3.3 cm SL. Lévêque & Daget (1984); Noakes & Balon (1982) and Boussou (2013) noted that due to spatial disparities, for taxa inhabiting different hydrosystems, growth and maximum size observed may be different. The study of the condition factor reveals a significant difference between the CSH site and the BC site. This difference would be related to environmental conditions and the physiological state of the fish. Indeed, several studies have shown that the condition coefficient can be influenced by a number of factors such as stress, diet and sexual maturity of individuals as well as other water quality parameters (Anibaze, (2000); Lizama & Ambrósio (2002); Aliko et al. (2010)). The low values of the condition factor were recorded in the BC sector. These low values observed would be due to water quality parameters or inputs from plantations and gold mining. On the other hand, high values of the condition factor were recorded in the CSH site. Our results are consistent with those of Amara et al. (2007), who observed a significant difference between two sites with different levels of degradation.

4. Conclusion

The growth results of *Coptodon walteri* from the two sampled sites on the Cavally River provide important preliminary data for researchers and managers that can inform the development of management and conservation measures for this species.

This study determined the allometry and condition factor of *C. walteri*. Analysis of the size frequency distribution shows that specimens from the CSH site have a maximum size of 14.5 cm and those from the BC site, 14.7 cm. Furthermore, specimens from the BC control site (75 mm SL) appear to be significantly larger than those from the CSC site (45 mm SL). The study of standard length-weight relationships showed that *C. walteri* exhibits positive allometric growth (control: b = 3.2), which reflects greater growth in weight than in size during its growth in this environment, while those caught on Cavally Hill exhibit isometric growth (b = 3.01).

Regarding the condition coefficient K, the values obtained at the CSC level are higher. This spatial variation in body size would be the consequence of the disruption of the ecological conditions of the Ity Gold company's exploitation sites. For the moment, this is the first published study on this endemic species, *C. walteri*. To be more confident in our conclusion, previous studies on growth must be considered along the entire length of the Cavally River by addressing other parameters. Thus, a thesis is currently underway on this species, focusing on the dosage of heavy metals as well as the genetic diversity of this species in four sites. Regarding its diet, an article is being written by a group of researchers, but no study has yet been carried out on the sex ratio.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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