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Length-weight relationship and condition factor of *Micralestes eburneensis* populations from the Cavally River in Côte d'Ivoire

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Abstract

This study aims to show the effect of anthropogenic pressures on populations of *Micralestes eburneensis* caught in the River Cavally in Côte d'Ivoire. Sampling took place from April 2015 to May 2017. The fish caught came from experimental and artisanal fisheries. The length-weight relationship and condition factor were determined using the equations P = aLSb and K = 100*P/LS, respectively. A total of 349 individuals with a standard length of between 48 mm and 82 mm and a mass ranging from 3 g to 10 g were caught. The coefficient of determination (r^2) values recorded ranged from 0.66 to 0.88. The estimated allometry coefficients for *M. eburneensis* were 2.81, 2.55 and 2.42 upstream, in the mining zone and downstream respectively. The condition factors of *M. eburneensis* individuals sampled in the Cavally river fluctuated between 0.66 and 1.39 with a median value of 1.05. The lowest values (K = 0.66 - 0.88) were recorded during the dry season. The size range in the three best-represented sampling areas is between 66 and 74 mm (standard length). This study contributes to our knowledge of the biology of *M. eburneensis* and provides a specific database on the length-weight relationship and condition factor of the species *M. eburneensis* from the Cavally River.

Keywords: *Micralestes eburneensis*; Biology; Allometry; Growth parameter; Cavally River; Ivory Coast.

1. Introduction

A watercourse can be influenced both naturally by the geology, vegetation and physiography of its valley and artificially by human activities that profoundly alter the nature of the soil and hydrological pathways [1]. These human activities mainly include industrial deforestation, the construction of dams for electricity and irrigation, overexploitation due to fishing and various forms of pollution [2,3]. In addition to these activities, in Côte d'Ivoire the phenomenon of illegal gold panning leaves no body of water untouched by this disturbance, which poses a serious threat to biodiversity by accelerating the extinction of plants and animals [4]. Indeed, the authorities counted 185 illegal gold panning sites as at 31 December 2016, following the closure of 429 illegal sites in the country [5,6]. In addition to the Tongon and Bonikro gold mines and the Ity gold mine, which are operational in Côte d'Ivoire. A fourth gold mine has been inaugurated in the south-west of the country. The aim of this mine is to increase national gold production from 13 to 16 tonnes a year [7]. Several watercourses are affected by this activity, including the Cavally river (Zouan-hounien), the Bia river (Bianoua), the Bandama river (Bouaflé) and the Bagoe river (Tengrela). In these areas, aquatic biodiversity is threatened by agriculture and mining, which have intensified in recent years, particularly in the Cavally basin and especially in the Ivorian part of its headwaters near Ity [8,9]. Among aquatic resources, fish are highly vulnerable to the chemicals used in gold mining [10]. However, these profound changes to aquatic ecosystems are compromising the life cycle of many economically and ecologically important fish species [3]. This situation requires monitoring. To do this, tool models usually require knowledge of the length-weight relationship, the prey ingested and the feeding habits of different fish

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populations. The length-weight relationship (LWR) is an important tool in fish biology, physiology, ecology and stock assessment. It is often used by researchers and nature managers to predict the weight of a fish, given its length, when assessing fishing yields [11]. The condition factor is strongly influenced by biotic and abiotic environmental conditions and can therefore be used to assess the state of aquatic ecosystems [12]. It also provides information on how overweight a fish is [3]. However, the Cavally is one of the rivers whose fish population has been least studied in Côte d'Ivoire [13,14,15]. Furthermore, although a great deal of research has been carried out on the impact of agricultural and industrial activities [16,17,18,19,20,21] on fish populations in Côte d'Ivoire, very little has been done on the impact of mining activities on this body of water. The objective of the present study is to determine the impact of mining activities in the upper reaches of the Cavally River in Côte d'Ivoire on populations of *Micralestes eburneensis*, the endemic species most commonly exploited by local populations in the study area.

2. Materials and methods

2.1. Study environment

Three sectors were considered in Cavally River taking as reference the intense mining activities area in the locality of Ity. In order to obtain a more comprehensive view of water quality in the study area, the sampling sites were selected on the upper and middle reaches of the Cavally River on the basis of the intensity of anthropogenic pressures, habitat diversity, hydrological regime and canopy. The accessibility of the sites to the teams and sampling equipment was also taken into account. The accessibility of the sectors to the sampling teams and equipment was also taken into account. Fourteen (14) stations were selected in our study area on the Cavally River (Figure 1).

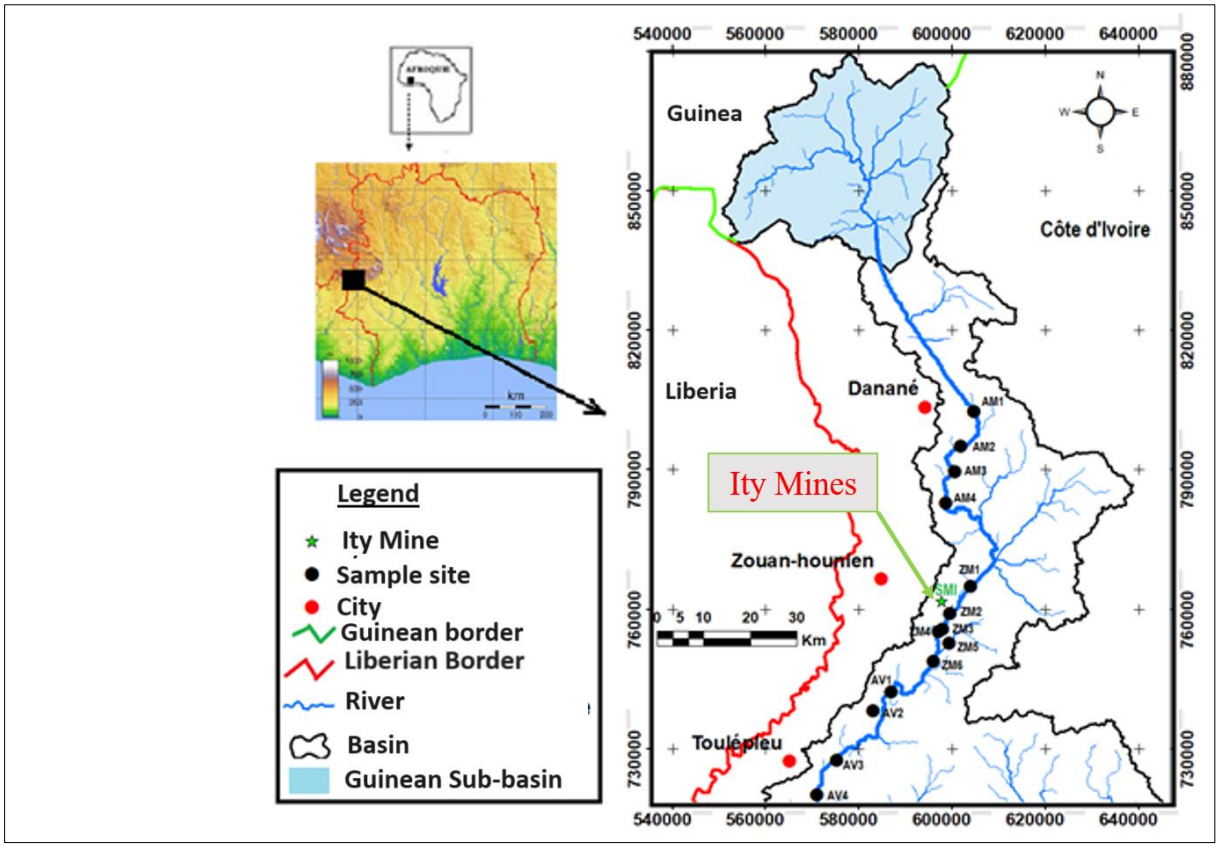


Figure 1 Location of the study area and sampling stations on the Cavally River (Côte d'Ivoire)

The first sampling sector is located upstream of the Ity mining area and comprises the stations of Téapleu-Cavally (AM1), Zan-Hounien (AM2), Liépleu 1 (AM3) and Liépleu 2 (AM4) (Figure 1). The average width and depth are 80.20 m and 4.4 m respectively. This area is characterised by a total absence of mining activity (gold panning). The river is bordered by cocoa plantations and a gallery forest with an average canopy estimated at 50%. The second sampling sector is located in the Ity mining area, with stations at Walter (ZM1), Dahapleu (ZM2), Glaï (ZM3), Sokloaleu (ZM4), Kampiépleu (ZM5) and Floleu premier bord (ZM6) (Figure 1). The average width and depth are 72.69 m and 4.39 m

respectively. This zone lies within the perimeter of the Ity gold mine, with a strong presence of illegal gold panning in the riverbed and on its banks.

The third sampling sector is located downstream of the Ity mining area. It comprises the stations at Gueiossepleu (AV1), Glareu (AV2), Goulaleu (AV3) and Toulepleu-Cavally (AV4) (Figure 1). The river is bordered by cocoa and rubber plantations and a gallery forest. The average width and depth are 68.95 m and 4.06 m respectively

2.2. Fish sampling

The fish caught came from both experimental and artisanal fishing. A set of 9 multi-filament nets with mesh sizes of 10, 15, 20, 25, 30, 35, 40, 45 and 50 mm was used for experimental fishing. Each net is 30 m long with a drop height of 2 to 3 m. The nets are fitted with floats on the upper headline and sinkers on the lower headline. Net fishing was also carried out at each of the stations studied. For artisanal fishing, the gear used during this study consisted of: monofilament gillnets (with empty meshes varying from 15 to 40 mm), creels (made of plant fibres, multifilament netting and wire mesh), dip nets and hawks.

On each specimen of *Micralestes eburneensis* sampled, the standard length was measured using an ichthyometer to the nearest millimetre. An EKS Electronic balance with a capacity of 5 kg and accuracy of 1 g was used to determine their mass.

2.3. Data analysis

2.3.1. Determining the length-weight relationship

Knowledge of the relationship between the standard length (SL) of fish and their total weight (TL) has applications in fisheries biology and fish stock assessment [22,23]. It also allows average weights to be deduced from length data that is more readily available in the field [24]. This relationship is generally of the exponential type. The length-weight relationship is established by the following formula [24]: $P = a \times Lsb$; where P = fish weight (g); Ls = standard length (mm); a = constant; b = allometry coefficient.

The parameters a and b were estimated after the logarithmic transformation of the previous function: $Log(P) = Log(a) + b \times Log(Ls)$.

The allometry coefficient b, which is generally between 2 and 4, represents the ratio of specific growth rates for weight and length. According to Morey et al [25], when b is equal to 3 or is not significantly different from 3, growth is said to be isometric (the specific density of the animal does not change) and when it is significantly different from 3, growth is said to be allometric. If b is significantly greater than 3, the allometry is said to be majorant, which means that the growth is better in weight than in length. If b is significantly less than 3, the allometry is said to be minorizing, meaning that the growth is better in length than in weight.

2.3.2. Determination of the condition factor

The condition factor was used to assess the relative corpulence of *Micralestes eburneensis* individuals sampled in the various fishing zones identified in the River Cavally. Reflecting the corpulence of the fish, the condition coefficient depends mainly on the value of the trophic resources available and the quality of the ecological factors in the environment. Postel's composite condition coefficient [26], which accounts for the net corpulence resulting from environmental or physiological conditions, was used in the present study. The formula applied is as follows: $Kc = (P / Ls3) \times 105$; where P = fish weight (g); Ls = standard fish length (mm).

3. Results

3.1. Length-weight relationships

The length-weight relationship parameters for the *Micralestes eburneensis* population caught in the River Cavally are shown in Figures 2 and 3. The equations of the regression lines between weight and standard length and their coefficients of determination for each population examined are shown in Figures 2 and 3. The values of the coefficient of determination (r^2) range from 0.66 to 0.88. All regressions are highly significant ($0.81 < r < 0.94$). Spatially, the estimated values of the allometry coefficient b were 2.81, 2.55 and 2.42 in the upstream, mining and downstream zones respectively. These values were significantly lower than the threshold of 3 (Student's t test ; $p < 0.05$).

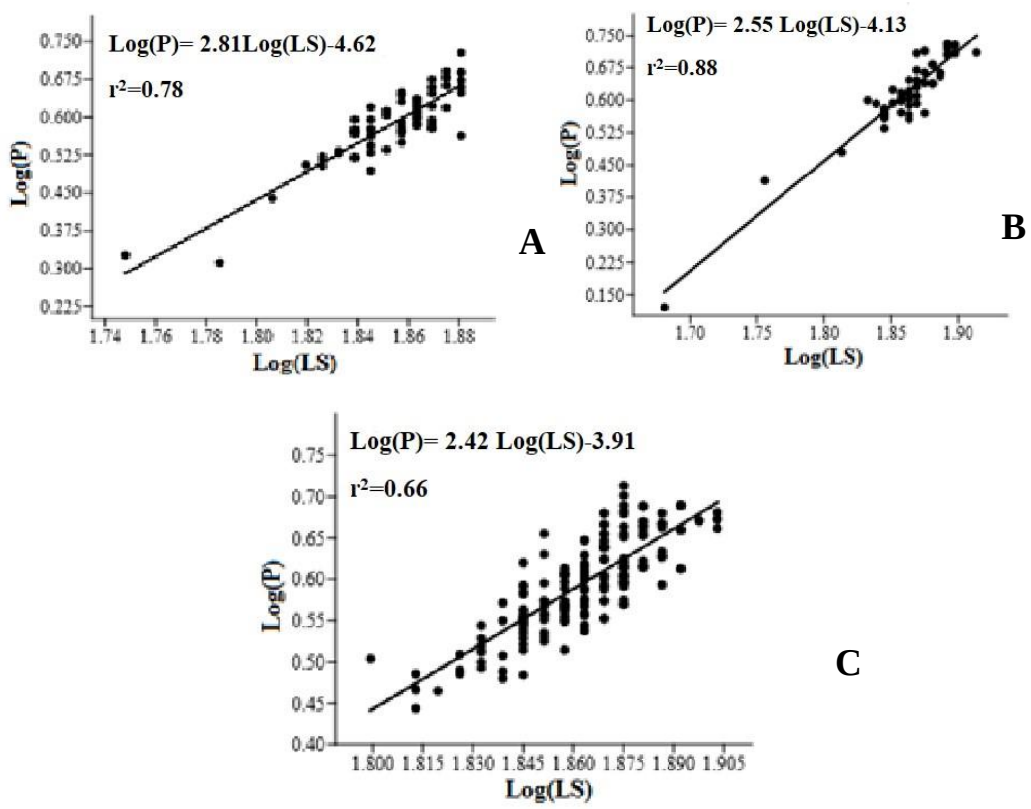


Figure 2 Regression curves of weight versus standard length of *Micralestes eburneensis* caught from April 2015 to May 2017 in the River Cavally (Côte d'Ivoire). A: Upstream; B: Mining area; C: Downstream

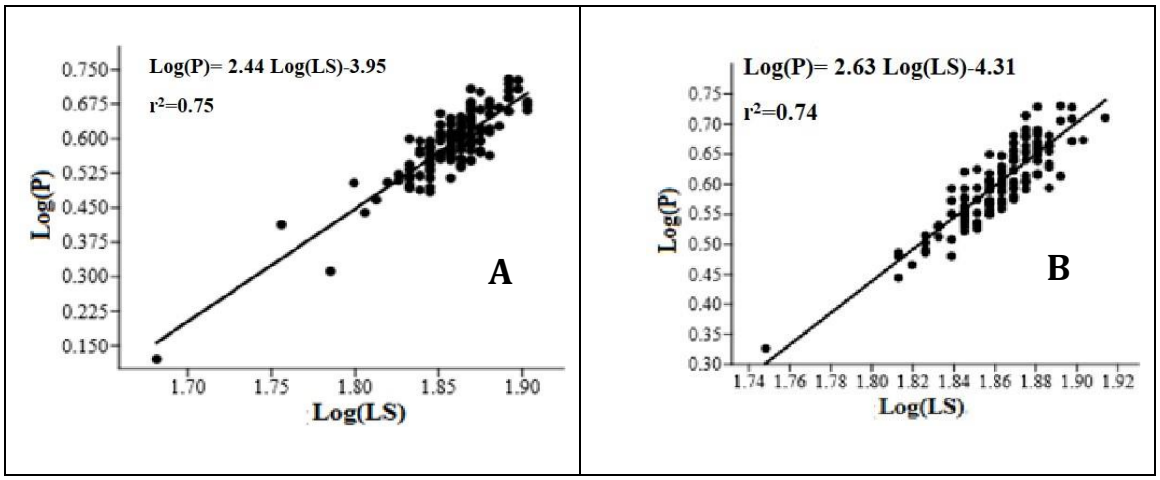


Figure 3 Logarithmic regression curves of weight versus standard length of *Micralestes eburneensis* caught from April 2015 to May 2017 in the River Cavally (Côte d'Ivoire). A: Rainy season; B: Dry season

In terms of temporal variation, the allometry coefficients in the rainy season (b = 2.44) and in the dry season (b = 2.63) were also below the threshold of 3 (Student's t-test ; $p < 0.05$).

M. eburneensis therefore shows negative allometric growth both spatially and temporally.

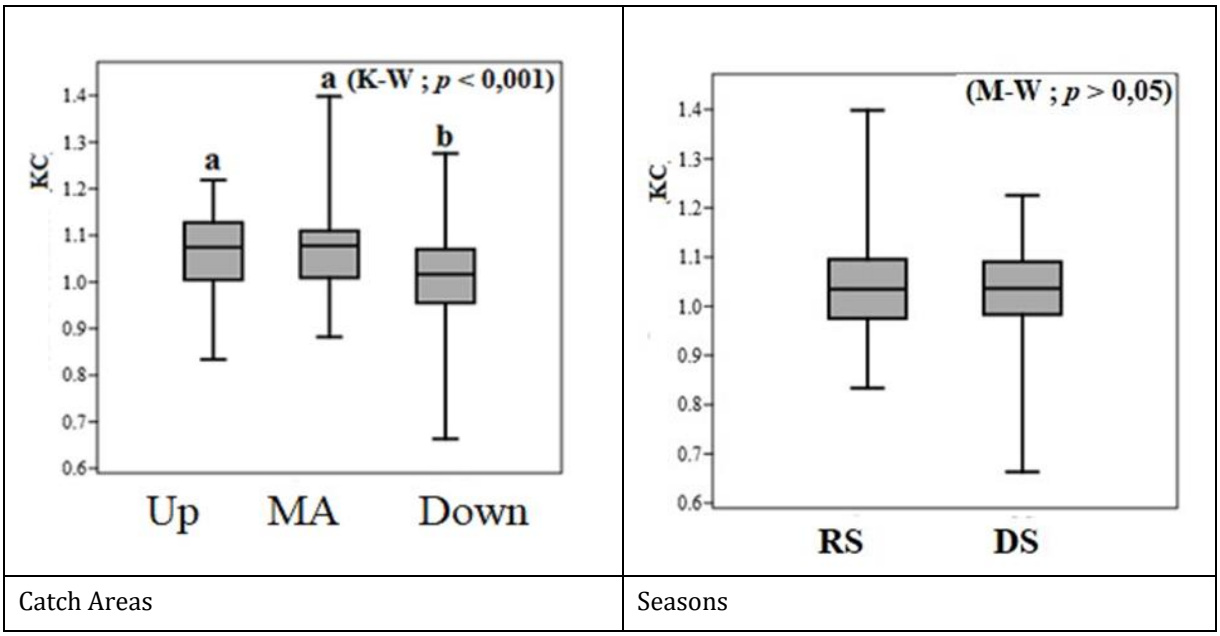
3.2. Condition factor

The condition factor of *Micralestes eburneensis* sampled in the Cavally River fluctuated from 0.66 to 1.39 with a median value of 1.05. The highest median condition factor was recorded in the mining area (1.07) and upstream (1.07). The highest median condition factor was recorded in the mining area (1.07) and upstream (1.07). The lowest median value

for this variable was recorded in the downstream zone (1.01) (Figure 4). Comparison of variations between zones showed a significant difference between upstream, the mining zone and downstream (Kruskall-Wallis ; $p < 0.001$). For this parameter, no significant difference was observed between upstream and the mining zone (Mann-Whitney ; $p > 0.05$) but a significant difference was noted between these two zones and the mining zone (Mann-Whitney ; $p < 0.05$).

The calculated condition factor values for *M. eburneensis* ranged from 0.83 to 1.39 in the wet season and from 0.66 to 1.22 in the dry season (Figure 4). The seasonal differences observed were not significant (Mann-Whitney ; $p > 0.05$) at the scale of the study area.

Table I shows the seasonal values of the *M. eburneensis* condition factor obtained at the different sampling zones. In the downstream zone, the condition factor varied significantly from one season to the next (Mann-Whitney ; $p < 0.05$). On the other hand, no significant difference was observed upstream and in the mining zone between seasons (Mann-Whitney ; $p > 0.05$). However, no significant difference was observed upstream and in the mining zone between seasons (Mann-Whitney ; $p > 0.05$). The highest values (KC = 1.21 - 1.39) were obtained in the rainy season in all zones. The lowest values were recorded during the dry season (0.66 - 0.88).



KC : condition factor ; Up : Upstream ; MA : mining area ; Down : downstream ; RS : rain season ; DS : dry season

Figure 4 Variation in *Micralestes eburneensis* condition factor as a function of catch areas and seasons from April 2015 to May 2017 in the River Cavally (Côte d'Ivoire)

Table I Seasonal variations in the condition factor of *Micralestes eburneensis* according to catch areas from April 2015 to May 2017 in the River Cavally (Côte d'Ivoire)

Capture areas	**Seasons**	**K**	***p-value***
Upstream	RS	1.05 ± 0.08	> 0.05^{ns}
	DS	1.07 ± 0.08	
Mining area	RS	1.08 ± 0.1	> 0.05^{ns}
	DS	1.07 ± 0.01	
Downstream	RS	1.02 ± 0.08	< 0.05*
	DS	0.99 ± 0.08	

*: significant Mann-Whitney test; ns: non-significant Mann-Whitney test; RS: rainy season; DS: dry season, K : condition factor

4. Discussion

The maximum size of *Micralestes eburneensis* (LS = 82 mm) in the present study is smaller than that (LS = 89 mm) reported by Ibala and Vreven [27] in the same river at Flampleu. This difference could be explained by the poor environmental conditions in which the species is found in our study area.

In terms of size structure, the fish samples in the present study have a unimodal distribution. Individuals larger than or equal to 66 mm and smaller than 75 mm were the most abundant. This group could correspond to juveniles and adults respectively. In this study, all the regressions between weight and standard length were highly significant 0. 66 < r^2 < 0.88. This means that an increase in length induces an increase in weight. Thus, fish grow in both length and weight [28,29].

The preponderance of the growth rate of length in relation to weight or weight in relation to length in fish is evaluated by the b coefficient, the value of which varies between 2 and 4 according to [30]. In this study, the values of the allometry coefficient b of the length-weight relationship *M. eburneensis* (2.42 - 2.81) fall within this range. Analysis of the b coefficient revealed negative allometric growth for *M. eburneensis*. Thus weight gain is slower than length growth for this species in our study area.

Spatial analysis of the condition factor revealed significant differences between the mining area and the other two areas. These differences are thought to be related to environmental conditions and the physiological state of the fish. Indeed, several studies have shown that the condition factor can be influenced by a number of factors such as stress, sex, age, gonad maturity stage, season, food availability and other water quality parameters [31, 32, 33,34]. The low values of the condition factor were recorded during the dry season in all three sectors. This period coincides with the river's low-water season. The low values observed are thought to be due to the availability of feed and other water quality parameters. On the other hand, the high values of the condition factor were recorded during the rainy season. This observation could be explained by the greater availability of food resources during the rainy season.

5. Conclusion

The present study, which provides information on the length-weight and condition factor of the populations of *Micralestes eburneensis* in the Cavally river, the species most heavily exploited by the local population, is one of the few studies to examine the biology of fish in this area of very heavy mining exploitation. This study shows that the growth pattern of *M. eburneensis* populations in the Cavally river is affected by mining activities. This study therefore provides an important database for researchers and nature managers in developing management and conservation measures for fish populations in the study area.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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