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Length-Weight Relationships and Condition Factors of 15 Fish Species from the Loémé River Basin (Mayombe, Republic of Congo)

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Abstract

Length-weight relationships and condition factors are among the commonly used parameters to link the length of a fish to its weight. The present study was initiated to find out the growth patterns and overweight status of 15 fish species in the Loémé basin in Mayombe, Republic of Congo. In the period from February 2020 to September 2021, sampling was carried out in eight stations, following a standardised capture method using four gillnets of 10, 12, 15, and 25 mm mesh size and a hawk net of 1.90 m radius with 10 mm mesh size. Length-weight relationships were calculated according to $P = aLS^b$ and the condition factor, using $K = (P/LS^b)* 100$. A total of 1153 specimens representing 15 species, 10 genera and 6 families were recorded. The number of specimens ranged from 10 to 214 for *Chrysichthys auratus* and *Enteromius camptacanthus*, respectively. The allometry coefficient b minimum of 2.697 for *Chromidotilapiamelaniae* and maximum of 3.589 for *Garraornata*, with a mean of 3.03 ± 0.2 is significantly not different from 3 at the 0.05 probability threshold and indicates isometric growth for almost all species, except for *E. camptacanthus* where $b = 2.858$ was statistically different from 3 at the same threshold. The positive and high values of the coefficients of determination $r^2 = 0.787 - 0.989$ of the species, obtained during this study, suggest that weight increases with size in the fish of the Loémé basin. The average condition factor varies from 0.524 ± 0.064 for *G. ornata* to 4.917 ± 0.440 for *C. melaniae*.

Keywords

Fish, Growth, Overweight, Loémé River Basin, Lower Guinea

1. Introduction

Continental aquatic environments are increasingly impacted by the development of human activities (construction of dams for irrigation and electricity, gold mining, over-exploitation of fisheries resources) leading to habitat degradation or disappearance, pollution of various origins, and the reduction and extinction of resources. The consequences of these activities, exacerbated by the ongoing human population growth and the increasing demand for natural resources, are globally endangering aquatic fauna in general and fish fauna in particular. Africa, which was spared for a long time, is in turn suffering from these impacts, even if pollution, for example, is still relatively limited in space [1] [2]. The Republic of Congo is one of the Central African countries where the freshwater fish fauna is poorly documented. The available data on this ichthyofauna are patchy and mostly old [3] [4]. To overcome this deficit, various studies have been carried out for several years on the diversity of fish in Congolese continental waters, with the aim of documenting the species richness, ecology and assessing the impact of human activities on the composition of fish communities [5]-[13]. Work carried out in the Loémé basin [4] [14] only reports a systematic assessment of its ichthyofauna, as is the case for the majority of the fresh and brackish waters of the Republic of Congo. The other aspects such as biology and ecology are not or only very slightly addressed in this basin [15] [16].

The length-weight relationship (LWR) is an important tool in fish biology, physiology, ecology and stock assessment [17]. Indeed, this relationship is a widely used approach in fisheries management, as it provides information on the status of fish stocks in an aquatic ecosystem [18] [19]. In addition, LWR is often used by researchers and nature managers to predict the weight of a fish, knowing its length, when assessing fisheries yields [20] [21]. The condition factor provides information on the overweight status of a fish [22]. It is an instrument often used to compare the overall physiological state of populations over a seasonal cycle or between ponds with similar or different ecological conditions [23] [24]. Largely influenced by environmental parameters (biotic and abiotic), the condition factor can be used as an index to assess the level of disturbance of an aquatic ecosystem [25]. Biological, physiological and ecological studies based on length-weight and condition coefficients of fishes in the Lower Guinea fish province have so far rarely been undertaken [26]. The Loémé River basin, flowing almost entirely in the Republic of Congo, is part of this ichthyological province. It is in this context that the present study reports data on Length-Weight relationships and condition factors of fifteen fish species from the upper Loémé Basin. The main aim of the study is to learn about the growth patterns and overweight status of these fish. It represents an important approach, widely applied in the management of fish populations, as it provides information on the status of stocks [18] [19] [23] [27] [28], for which sustainable management requires a good knowledge of growth parameters [29].

2. Material and Methods

2.1. Environment and Sampled Stations

The area of the Loémé basin concerned by this study is located in the Mayombe, Department of Kouilou and extends from the locality of Mvoungouti to that of Bilinga along the railway line of the Congo-Ocean Railway (CFCO). The Loémé basin, located to the south of the Kouilou basin, has a total surface area of about 3250 km^2. The Congolese Mayombe lies between latitude 3˚30' and 4˚50' South and longitude 11˚30' and 13˚12' East. It is located between 40 and 80 km from the Atlantic Ocean over a width of 50 to 80 km. It is an orogeographic and floristic entity, part of which in Congo Brazzaville became the Dimonika Biosphere Reserve in March 1988 [30]. For this study, eight sampling sites, including tributaries, were surveyed in the upper Loémé basin. These sites were selected because of their accessibility from various CFCO stations. The sampling campaigns were spread over two years, with two campaigns per year, one in the dry season and one in the rainy season.

For each season, fish samples were collected in each site using a standardised method with four gillnets of 10, 12, 15, and 25 mm mesh size, 30 m in length and 1.5 m in width, and a cast net of 1.90 m radius with 10 mm mesh size. At each site, 20 cast net shots were taken for 30 minutes before setting the gillnets overnight (from 5 pm to 7 am) following [6]. Collected specimens were weighed in the field to the gram using a 2500 g capacity KERN PCB scale with an accuracy of 0.01 g and their standard lengths were measured using a calliper with an accuracy of 0.01 millimetres. The lengths obtained were converted into centimetres. All specimens were identified in the field and the number of individuals per species was counted. Fish whose identifications were uncertain in the field were preserved in 10% formalin for further examination at the ichthyological laboratory of the "Institut National de Recherche en Sciences exactes et Naturelles (IRSEN)". The classification of the families follows [31], with genera and species in alphabetical order (**Figure 1**).

2.2. Data Analysis

The length-weight relationship of the species was carried out following the equation of [23]: $P = aLS^b$ where LS is the standard length of the fish in cm, P the weight in grams, a and b representing respectively the intercept and the allometric coefficient were deduced by logarithmic linearization of the type $\log P = \log a + b\log LS$ [32]. The Length-Weight relationship shows isometric growth when b is equal to 3 and allometric growth when it is different from 3. This allometric growth can be either positive, when b is greater than 3; or negative, when b is

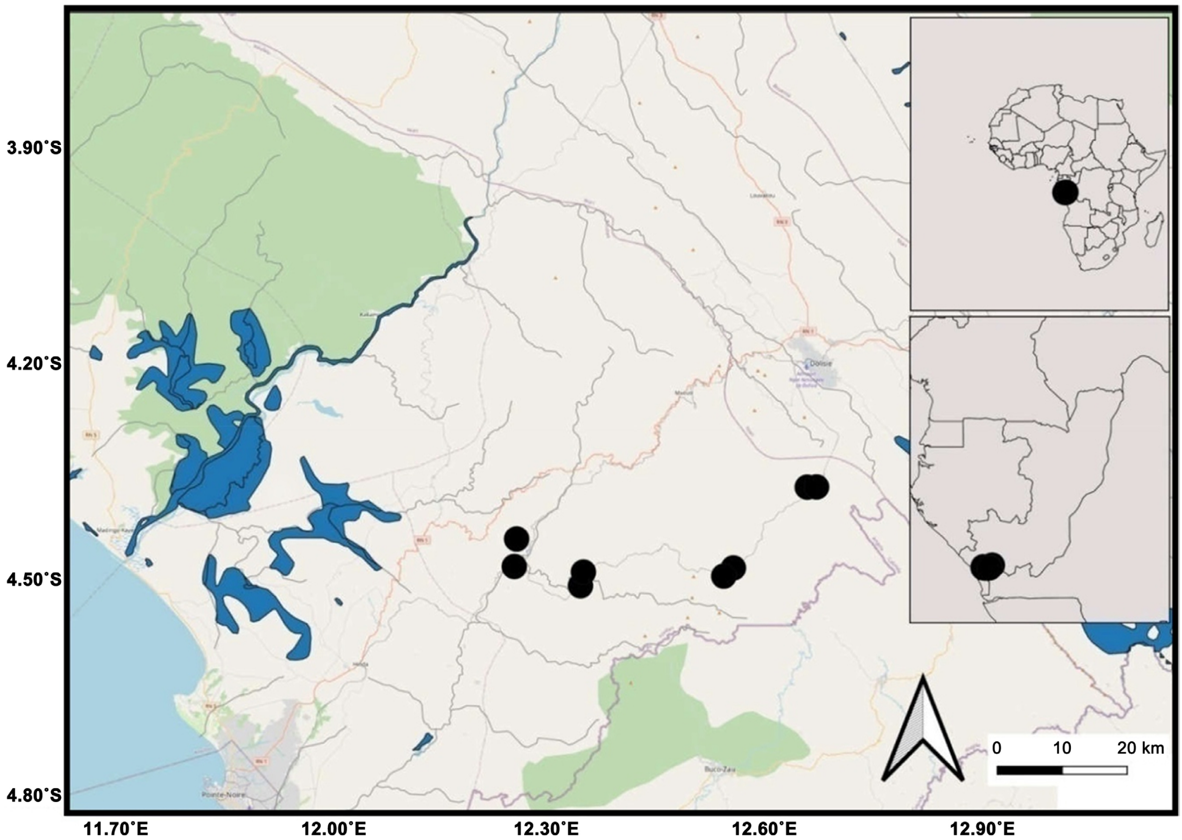

Figure 1. Study area and sampling stations.

less than 3 [33]. The determination of the 95% confidence interval of *a* and *b* was done using the software Statview version 1992-98 (SAS Institute INC). The statistical difference between the value of *b* for each species and the isometric threshold ($b = 3$) was obtained using the Student's t-test performed according to [34] at the 5% significance level such that $ts = (b - 3)/ESb$, where *ts* is the value of Student's test, *b* is the slope of the regression line and ES*b* is the standard error of *b*. Only species with a sample size of at least 10 specimens were considered [26] [35] [36] [37] [38] [39].

The Fulton Condition Factor (K) was determined in order to assess the overweight status of the fish, following the formula: $K = (P/LS^b) * 100$ [18].

3. Results

One thousand one hundred and fifty-three fish specimens representing 15 species, 10 genera and 6 families were counted. The family Cyprinidae is the most represented with seven species, Alestidae, Claroteidae and Cichlidae were represented by two species each whereas Mormyridae and Distichodontidae were only represented by one species each. The minimum number of specimens is 10, *i.e. Chrysichthys auratus* and the maximum is 214, *i.e. Enteromius camptacanthus* (**Table 1**). **Table 2** shows the minimum, maximum, mean and standard deviation of the standard length, weight and condition coefficient for each species.

Table 1. Number of specimens N and estimated parameters of length-weight relationships for the 15 fish species in the Loémé basin. *a*: growth coefficient; *b*: slope of the regression line; CI: confidence interval; SE: standard error; r^2: coefficient of determination; I: isometry; NA: negative allometry.

Family and species	Code	N	*a*	CI of *a* at 95%	*b*	CI of *b* at 95%	ES of *b*	r^2	Type of growth
Mormyridae									
Paramormyrops kingsleyae (Günther, 1896)	*Paki*	80	0.012	0.008 - 0.020	2.969	2.776 - 3.163	0.097	0.922	I
Cyprinidae									
Enteromius camptacanthus (Bleeker, 1863)	*Enca*	214	0.036	0.031 - 0.044	2.858	2.771 - 2.946	0.044	0.951	AN
Enteromius holotaenia (Boulenger, 1904)	*Enho*	48	0.017	0.012 - 0.025	3.251	3.065 - 3.439	0.093	0.963	I
Enteromius martorelli (Roman, 1971)	*Enma*	141	0.027	0.02 - 0.037	2.959	2.795 - 3.125	0.083	0.9	I
Garra ornata (Nichols & Griscom, 1917)	*Gaor*	20	0.005	0.001 - 0.037	3.589	2.666 - 4.513	0.439	0.787	I
Labeo lukulae Boulenger, 1902	*Lalu*	37	0.022	0.017 - 0.031	2.988	2.878 - 3.099	0.054	0.988	I
Labeobarbus compiniei (Sauvage, 1879)	*Laco*	69	0.029	0.023 - 0.037	2.901	2.794 - 3.009	0.054	0.977	I
Labeobarbus sandersi (Boulenger, 1912)	*Lasa*	125	0.024	0.021 - 0.027	3.007	2.953 - 3.062	0.028	0.989	
Distichodontidae									
Distichodus notospilus Günther, 1867	*Dino*	76	0.021	0.019 - 0.025	3.102	3.033 - 3.171	0.035	0.99	I
Alestidae									
Brycinus kingsleyae (Günther, 1896)	*Brki*	95	0.021	0.018 - 0.024	3.042	2.973 - 3.111	0.035	0.987	I
*Brycinus macrolepidotus*Valenciennes, 1850	*Brma*	31	0.016	0.013 - 0.023	3.094	2.969 - 3.220	0.061	0.988	I
Claroteidae									
Chrysichthys auratus (Geoffroy Saint-Hilaire, 1809)	*Chau*	10	0.015	0.004 - 0.059	3.036	2.451 - 3.622	0.254	0.947	I
Parauchenoglanis balayi (Sauvage, 1879)	*Paba*	36	0.017	0.010 - 0.030	3.051	2.811 - 3.292	0.118	0.951	I
Cichlidae									
Chromidotilapia melaniae Lamboj, 2003	*Chme*	20	0.049	0.017 - 0.144	2.697	2.125 - 3.269	0.272	0.845	I
Chromidotilapia mamonekenei Lamboj, 1999	*Chki*	151	0.034	0.029 - 0.041	2.912	2.818 - 3.007	0.048	0.961	I

The minimum standard length of 3.79 cm was measured for *E. camptacanthus* and the maximum standard length of 21.98 cm for *Labeo lukulae*, both members of the family Cyprinidae. Similarly, the minimum weight of 1.58 g and maximum weight of 216.13 g were measured for *E. camptacanthus* and *Labeo lukulae*, respectively. The minimum and maximum condition factors K of 0.410 and 5.977 were calculated for *Garra ornata* and *Chromidotilapia melaniae* respectively.

Table 1 shows that the coefficient of determination r^2 has a minimum value of 0.787 observed for *Garra ornata* and 0.990 for *Distichodus notospilus*. The minimum and maximum value of the intercept *a* are respectively 0.005 with a confidence interval of 0.001 - 0.037, for *G. ornata* and 0.049 with a confidence interval of 0.017 to 0.144 for *C. melaniae*. The allometry coefficient *b* minimum of 2.697 with a confidence interval of 2.125 - 3.269 for *C. melaniae* and maximum of 3.589

Table 2. Maximum, minimum, mean and standard deviation of length, weight and condition coefficient of species. (Min: minimum; Max: maximum; SD: standard deviation)

Family and species	Length (cm)		Weight (g)		K	
	Min-max	Mean ± SD	Min-max	Mean ± SD	Min-max	Mean ± SD
Mormyridae						
Paramormyrops kingsleyae (Günther, 1896)	6.24 - 18.05	10.56 ± 1.80	3.39 - 86.45	15.24 ± 10.45	0.835 - 1.632	1.268 ± 0.177
Cyprinidae						
Enteromius camptacanthus (Bleeker, 1863)	3.79 - 10.16	7.27 ± 1.01	1.58 - 25.62	11.25 ± 4.62	2.287 - 4.729	3.685 ± 0.331
Enteromius holotaenia (Boulenger, 1904)	5.09 - 8.99	7.17 ± 0.90	3.46 - 20.65	11.29 ± 4.39	1.507 - 2.134	1.768 ± 0.148
Enteromius martorelli (Roman, 1971)	4.48 - 8.08	6.69 ± 0.69	2.31 - 13.96	7.78 ± 2.40	1.802 - 3.556	2.730 ± 0.283
Garra ornata (Nichols & Griscom, 1917)	7.54 - 0.08	8.46 ± 0.57	7.78 - 19.72	11.37 ± 3.28	0.410 - 0.636	0.524 ± 0.064
Labeo lukulae Boulenger, 1902	9.26 - 21.98	15.57 ± 3.50	18.76 - 216.13	94.68 ± 54.94	1.884 - 2.617	2.273 ± 0.176
Labeobarbus compiniei (Sauvage, 1879)	5.19 - 19.09	9.56 ± 3.59	3.69 157.47	29.58 ± 34.39	1.316 - 4.082	2.970 ± 0.398
Labeobarbus sandersi (Boulenger, 1912)	5.53 19.34	9.69 ± 3.23	4.11 - 184.59	31.02 ± 36.60	1.704 - 3.027	2.433 ± 0.220
Distichodontidae						
Distichodus notospilus Günther, 1867	4.43 - 12.63	8.57 ± 2.11	2.18 - 58.96	20.35 ± 14.52	1.789 - 2.696	2.163 ± 0.168
Alestidae						
Brycinus kingsleyae (Günther, 1896)	5.43 - 13.60	8.05 ± 1.47	3.58 - 71.55	13.35 ± 8.63	1.869 - 2.561	2.112 ± 0.132
Brycinus macrolepidotus Valenciennes, 1850	7.30 - 16.34	10.74 ± 2.40	7.90 - 07.25	30.86 ± 24.01	1.447 - 2.019	1.697 ± 0.124
Claroteidae						
Chrysichthys auratus (Geoffroy Saint-Hilaire, 1808)	6.72 - 11.76	10.06 ± 1.50	4.66 - 30.32	18.34 ± 7.36	1.306 - 1.744	1.557 ± 0.146
Parauchenoglanis balayi (Sauvage, 1879)	7.18 - 13.17	10.65 ± 1.45	6.02 - 49.85	24.61 ± 10.22	1.357 - 1.974	1.709 ± 0.167
Cichlidae						
Chromidotilapia mamonekenei Lamboj, 1999	5.14 - 8.60	6.59 ± 0.81	3.77 - 18.19	8.80 ± 3.37	2.725 - 4.062	3.481 ± 0.243
Chromidotilapia melaniae Lamboj, 2003	5.83 - 7.91	6.62 ± 0.51	5.88 - 15.78	8.16 ± 2.18	4.400 - 5.977	4.917 ± 0.440

with a confidence interval of 2.666 - 4.513 for *G. ornata*. The standard error of b was 0.028 for *Labeobarbus sandersi* and 0.439 for *G. ornata*. All these values were determined at the 5% probability level. The growth pattern is isometric in all species, except for *E. camptacanthus* where the growth is allometric and negative.

4. Discussion

Length-weight relationships are particularly used for growth-oriented studies, from which growth patterns are inferred [35] [37] [38]. These relationships have been widely used in fish stock assessments to estimate biomass by size and to manage fish populations [23] [38] [40].

Linear regressions were significant for all studied species, at the 0.05 probability threshold, with coefficients of determination greater than 0.78. The species *Garra ornata* and *Chromidotilapia melaniae* with respective coefficients of determination of 0.787 and 0.845 (*i.e.* $r = 0.887$ and 0.919), present a doubtful correlation probably due to the sample size (20 specimens each). Intriguingly, *Chrysichthys auratus* with a lower sample size (10 specimens) shows a nice regression line with $r^2 = 0.947$. The positive and high values of the coefficients of species determination obtained in this study indicate that weight increases with size in fishes of the Loémé basin. The average of the allometry coefficient b for all species is 3.03 with a minimum of 2.69 for *Chromidotilapia melaniae* and a maximum of 3.58 for *Garra ornata*. All b values obtained in this study are in line with typical values of 2.5 to 3.5 [20] [41]. They are not significant at the 0.05 probability level, which corresponds to an isometric type of growth, thus showing that the cubic relationship is applicable for these species in this basin [26] [42]. Except for *Enteromius camptacanthus* where $b = 2.858$ is significantly different at the same threshold. According to [43], the allometry coefficient is related to the quality of the aquatic environment. Thus, it can be inferred that the values of the allometry coefficient observed here could be due to the stability of the environment studied. Only 33.33% of the species in this study have their length-weight relationship contained in the fishbase database. In addition, 66.66% of the species constitute a first in the study of these relationships. The b-allometry coefficients of 60% of these fishbase species are included in the confidence intervals obtained in this work.

The condition coefficient K ranges from 0.41 to 5.977 with a minimum mean of 0.524 ± 0.064 and maximum of 4.917 ± 0.44 for *Garra ornata* and *Chromidotilapia melaniae* respectively. The K values between (2.9 and 4.8) are characteristic of freshwater species [18]. Twenty percent of species (*Enteromius camptacanthus*, *Labeobarbus compiniei* and *Chromidotilapia mamonekenei*) fit this theory, 66.66% of species have mean K values below 2.9 and 6.66% of species have such values above 4.8. These results could be explained by the fact that a given individual may have a higher or lower weight depending on many factors such as the individual's own morphology, fattening state, gonadal sexual stage, proper density, state of replenishment of the digestive tract [19] [44] and environmental conditions [25] which were not considered in this study.

5. Conclusion

This study based on the length-weight relationship and condition factor of fifteen fish species in the upper Loémé basin provides the first basic information on these parameters in this basin. It provided information on the overweight status and growth patterns of the species concerned. The good correlations between size and weight indicated good growth for almost all species. This work, which is one of the first on the scale of the Loémé, can therefore serve as a guide for researchers and decision-makers in conservation measures and sustainable management of environments.

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Conflicts of Interest

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

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