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Length-Weight relationship and condition factor for 22 freshwater fish species from Solomougou Dam Lake (Korhogo, Côte d'Ivoire)

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Abstract

Fishery biologists use models that incorporate allometric growth coefficient of Length-Weight relationship. Also, Fulton's condition factor gives information about overweight's status of fish in their habitat. These parameters have been studied for 22 fish species from Solomougou Dam Lake. Samplings were conducted from October 2018 to September 2019. Standard length (cm) and weight (g) have been recorded in situ on each specimen from commercial catches. The equation $W=aLs^b$ was used. Allometric growth coefficients b and theoretical value 3 were compared using Student's t -test. The equation $K=W.100/Ls^b$ allowed calculating Fulton's condition factor. Results indicated that allometric growth coefficients b obtained varied between 2.104 and 3.046. Six species out of the twenty-two ones studied showed isometric growth: *Brycinus imberi*, *Clarias gariepinus*, *Hemichromis fasciatus*, *Labeo coubie*, *Labeo parvus* and *Marcusenius furcidens*. However, Only *Heterobranchus longifilis* had positive allometric growth. At the opposite, all the others species showed negative allometric growth: *Chrysichthys maurus*, *Chrysichthys nigrodigitatus*, *Chromidotilapia guntheri*, *Heterotis niloticus*, *Marcusenius ussheri*, *Mormyrus rume*, *Oreochromis niloticus*, *Petrocephalus bovei*, *Sarotherodon galilaeus*, *Sarotherodon melanotheron*, *Schilbe intermedius*, *Synodontis schall*, *Tilapia guineensis*, *Tilapia mariae* and *Tilapia zillii*. Fulton's condition factors ranged from 0.884 ± 0.085 to 8.968 ± 1.818 . These values, higher than 2.9 for 59.09% of the species, indicate a good adaptation of the majority of them in this Lake.

Keywords: Allometry, Fulton's condition factor, Fish, Lake Solomougou, Côte d'Ivoire

Introduction

Stock assessment involves using mathematical models for best management in fisheries studies. Many of these models incorporate growth parameters including allometric growth coefficient of Length-Weight relationship. According to Britton and Davies (2007) ^[1], this last parameter can be used to evaluate natural populations. It also helps to understand the growth pattern, allowing estimating the average weight at a given length and vice versa. The advantage is that direct weight measurements can take a lot of time (Sinovcic *et al.*, 2004) ^[2].

Another parameter, Fulton's condition factor, provides information on the state of overweight of fish species in their environment (Paugy and Lévêque, 2017) ^[3]. It is largely influenced by biotic and abiotic parameters, so evaluating the level of disturbance in an aquatic ecosystem (Baby *et al.*, 2011) ^[4].

Allometric growth coefficients of Length-Weight relationship and Fulton's condition factor data for fish species living in northern hydrosystems in Côte d'Ivoire are rare. In this part of the country, fishing, source of fish proteins for local populations, is mainly practised in Dam Lakes (Da Costa *et al.*, 2004) ^[5]. Today, this activity, more than a subsistence one, becomes commercial and therefore deserves to be better managed. This involves studies of biology, ecology and evaluation of exploitation levels of fish stocks. So, this work focuses on the study of these parameters for the main species caught in the Solomougou Dam Lake. This reservoir is the fifth largest Dam Lake in the north of the country (Traoré, 1996) ^[6]. The results obtained will therefore constitute an important basis for any policy management of this fishery.

Materials and Methods

Study area

This study was conducted on the Solomougou Dam Lake. It is located in northern Côte d'Ivoire, precisely in the department of Korhogo. Its watershed is located between the meridians 5°30' and 6°W and the parallels 9° and 9°30'N (Anonyme, 1962) [7]. It was built in 1973 by Rice Development Society (SODERIZ) and covers a maximum area of 500 hectares of water (Traoré, 1996) [6].

Data collection

This study was conducted from October 2018 to September 2019 with weekly sampling at the beginning of each month. Fish have been caught by six fishing gears types including gillnets, hawk nets, traps, bamboo traps, longlines and seines. Samples from commercial catches were collected in situ randomly. Then, fish were grouped according to species and their identification was made using Stiassny *et al.*' keys (2008) [8]. Then, each specimen has been measured taking standard length (Ls) to the nearest millimeter and weighted to the nearest gram.

Data processing

Only species with sample size more than 10 specimens were studied (Lalève, 2006) [9]. Length-Weight relationship was established using equation $W=aLs^b$ (Le Cren, 1951) [10] where W is total weight of the fish in grams (g), Ls standard length in centimeters (cm), a is a constant and b the allometric growth coefficient. Parameters a and b were calculated after logarithmic transformation of the equation into $\log W=\log a+b\log Ls$. The allometric growth coefficient b, slope of the linear regression, expresses relation between weight gain and growth in length. Thus, Length-Weight relationship reflects isometric growth when $b=3$, allometric growth in favour of weight when $b>3$ and allometric growth in favour of body length when $b<3$ (Froese, 2006) [11]. Student's t-test was used to test the differences between b values and the theoretical value 3 using equation $t_s=(b-3)/ES$, where t_s is Student's t-test value, b the slope of the linear regression and ES the standard error of the slope b (Sokal and Rohlf, 1987) [12]. The 95% confidence limits for b (CL95%) were computed using the equation $CL=b\pm(1.96\times SE)$ with SE=Standard error of b.

As for Fulton's condition factor K, it was calculated from the equation $K=W.100/Ls^3$ (Pauly, 1993) [13] where W is total weight of fish in grams (g), Ls standard length in centimeters (cm) and b allometric growth coefficient of Length-Weight relationship.

Results

Composition of the samples

Catch composition analysis allowed studying Length-Weight relationship for twenty-two (22) species belonging to nine (09) families. A total of 4518 specimens were analyzed for this purpose (Table 1).

Allometric growth coefficient of Length-Weight Relationship

Sample sizes of species studied vary between 19 specimens (*Heterotis niloticus*) and 798 (*Brycinus imberi*). According to standard lengths, the minimum recorded was 5.5cm for *Hemichromis fasciatus* and the maximum 70cm for *Clarias gariepinus*. As for the intervals of length classes, the lowest observed was 3.3cm for *Petrocephalus bovei* and the largest for *Clarias gariepinus* (57.4cm). Correlation coefficients r^2 vary between 0.828 (*Mormyrus rume*) and 0.992 (*Heterobronchus longifilis*). In addition, 18.18% of the calculated correlation coefficients are between 0.80 and 0.90 compared to 81.82% between 0.90 and 1. Finally, allometric growth coefficients of Length-Weight relationship vary between 2.104 (*Mormyrus rume*) and 3.046 (*Hemichromis fasciatus*).

General analysis of Table 1 indicates that after comparing allometric growth coefficients of Length-Weight relationship values obtained to theoretical value 3 with student's t-test, only six (06) species out of the twenty-two (22) ones studied show isometric growth. Those are *Brycinus imberi*, *Clarias gariepinus*, *Hemichromis fasciatus*, *Labeo coubie*, *Labeo parvus* and *Marcusenius furcidens*. Also, *Heterobronchus longifilis* is the only species with positive allometric growth. All the others species show negative allometric growth.

Fulton's condition factor

Analysis of Table 1 indicates that Fulton's condition factor K calculated vary from 0.884 ± 0.085 to 8.968 ± 1.818 . However, the lowest value, less than 1, was recorded for *Heterobronchus longifilis*, followed by *Clarias gariepinus* and *Marcusenius ussheri* which had respective k values of 1.241 ± 0.554 and 1.875 ± 0.220 . On the other hand, the highest values of this parameter were noted for *Heterotis niloticus* ($k=8.968\pm 1.818$), *Mormyrus rume* ($k=7.1855\pm 1.1566$) and *Tilapia guineensis* ($k=6.991\pm 0.352$), followed by *Sarotherodon galilaeus*, *Tilapia zillii*, *Sarotodon melanotheron* and *Tilapia mariae* with condition factor values between 5 and 6.

Table 1: Allometric growth coefficients and Fulton's condition factor values for the 22 fish species studied. N, number of specimens; Min., minimum; Max., maximum; a, constant; b, allometric growth coefficient; SE(b), standard error of b; r2, determination coefficient; CL, confidence limits; t, Student's t test; A, allometry; A-, negative allometric growth; A+, positive allometric growth; I, isometric growth; K, Fulton's condition factor.

Family/Espèces	N	Length (cm)		Weight (g)		a	b	SE(b)	r ²	95%CL of b	t	A	K
		Min.	Max.	Min.	Max.								
Alestiidae													
<i>Brycinus imberi</i>	798	5.8	15.5	4	92	0.022	3.027	0.018	0.907	2.991 - 3.063	0.1953	I	2.172 ± 0.278
Cichlidae													
<i>Chromidotilapia guntheri</i>	88	6	15.5	5	120	0.039	2.860	0.038	0.876	2.786 - 2.935	5.3610	A-	3.902 ± 0.441
<i>Hemichromis fasciatus</i>	219	5.6	17.3	5	168	0.025	3.046	0.060	0.977	2.927 - 3.164	0.1362	I	2.540 ± 0.286
<i>Oreochromis niloticus</i>	560	6.5	25.4	9	548	0.048	2.878	0.023	0.965	2.833 - 2.923	3.2046	A-	4.781 ± 0.490
<i>Sarotherodon galilaeus</i>	475	6.5	19.6	11	233	0.060	2.790	0.028	0.970	2.734 - 2.845	2.2156	A-	5.991 ± 0.642
<i>Sarotherodon melanotheron</i>	18	7.1	18.4	14	191	0.057	2.782	0.179	0.987	2.431 - 3.133	6.7790	A-	5.757 ± 0.445
<i>Tilapia guineensis</i>	21	7.6	11.5	17	52	0.070	2.727	0.082	0.981	2.566 - 2.887	2.1953	A-	6.991 ± 0.352
<i>Tilapia mariae</i>	228	6.8	15.8	11	160	0.051	2.814	0.036	0.861	2.744 - 2.884	7.2980	A-	5.188 ± 0.988

<i>Tilapia zillii</i>	344	7	18.8	12	198	0.059	2.781	0.030	0.958	2.722 - 2.840	3.3364	A-	5.908 ± 0.707
Clariidae													
<i>Clarias gariepinus</i>	141	12.6	70	17	2661	0.012	2.934	0.140	0.940	2.661 - 3.208	0.7530	I	1.241 ± 0.554
<i>Heterobronchus longifilis</i>	36	13.2	47.8	23	1164	0.009	3.040	0.295	0.992	2.463 - 3.617	2.8661	A+	0.884 ± 0.085
Claroteidae													
<i>Chrysichthys maurus</i>	183	6.8	18.7	6	127	0.034	2.789	0.039	0.943	2.711 - 2.866	3.4681	A-	3.431 ± 0.368
<i>Chrysichthys nigrodigitatus</i>	89	8.2	27.5	9	490	0.020	2.986	0.070	0.947	2.850 - 3.123	3.6807	A-	2.024 ± 0.225
Cyprinidae													
<i>Labeo coubie</i>	161	11.5	36	34	1080	0.030	2.903	0.046	0.970	2.813 - 2.993	0.3620	I	2.985 ± 0.264
<i>Labeo parvus</i>	68	8.7	31.5	14	664	0.025	2.956	0.123	0.986	2.715 - 3.196	1.9014	I	2.561 ± 0.276
Mochokidae													
<i>Synodontis schall</i>	573	6.2	16.4	6	104	0.031	2.855	0.028	0.927	2.800 - 2.909	5.2179	A-	3.171 ± 0.513
Mormyridae													
<i>Marcusenius furcidens</i>	115	10.6	23	16	155	0.020	2.860	0.073	0.930	2.716 - 3.004	1.5756	I	2.002 ± 0.381
<i>Marcusenius ussheri</i>	91	11	28	17	245	0.019	2.872	0.081	0.954	2.713 - 3.031	20.4795	A-	1.875 ± 0.220
<i>Mormyrus rume</i>	103	10.3	36.2	24	356	0.157	2.104	0.044	0.828	2.018 - 2.190	5.2909	A-	7.186 ± 1.157
<i>Petrocephalus bovei</i>	70	6.2	9.5	5	18	0.027	2.830	0.053	0.899	2.727 - 2.934	7.4280	A-	2.714 ± 0.321
Osteoglossidae													
<i>Heterotis niloticus</i>	19	8.7	36	20	599	0.088	2.426	0.200	0.955	2.034 - 2.819	2.1223	A-	8.968 ± 1.818
Schilbeidae													
<i>Schilbe intermedius</i>	118	9.1	24.5	11	138	0.032	2.608	0.058	0.949	2.495 - 2.721	5.2331	A-	3.248 ± 0.372

Discussion

Allometric growth coefficients of Length-Weight Relationship calculated for twenty-two (22) species from Solomougou Dam Lake vary between 2.104 and 3.046. These values are within the required interval, usually between 2 and 4 in fish, according to Bagenal and Tesch (1978) ^[14]. The limits of our values are also close to those obtained by Tah *et al.* (2012) ^[15], between 2.173 and 3.472, for 36 freshwater fish species in Ayamé I and Buyo Lakes in Côte d'Ivoire.

Three growth models have been noted according to b values. Six species, represented by *Brycinus imberi*, *Clarias gariepinus*, *Hemichromis fasciatus*, *Labeo coubie*, *Labeo parvus* and *Marcusenius furcidens* showed isometric growth. This means that for them, weight gain increases proportionally to growth in length. *Heterobronchus longifilis* is the only species with positive allometric growth, indicating relative weight growth faster than growth in length. In contrast, for all other species that showed negative allometric growth, their growth in length is faster than weight gain during their growth.

Tah *et al.* (2012) ^[15] calculated allometric growth coefficients of Length-Weight Relationship for 36 species in two Ivorian inland waters. However, only eleven (11) of our species showed growth patterns similar to theirs: *Chrysichthys nigrodigitatus*, *Chromidotilapia guntheri*, *Chrysichthys maurus*, *Heterotis niloticus*, *Labeo coubie*, *Marcusenius ussheri*, *Mormyrus rume*, *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Sarotherodon melanotheron* and *Schilbe intermedius*. At the opposite, seven (07) other species represented by *Brycinus imberi*, *Hemichromis fasciatus*, *Labeo parvus*, *Marcusenius furcidens*, *Petrocephalus bovei*, *Synodontis schall* and *Tilapia zillii*, showed different allometric growth coefficients values. For example, *Brycinus imberi*, *Hemichromis fasciatus*, *Labeo parvus* and *Marcusenius furcidens* have isometric growth in the Solomougou Dam Lake, while Tah *et al.* (2012) ^[15] reported allometric growth for these species. For *Petrocephalus bovei* and *Tilapia zillii*, our results indicate negative allometric growth against positive allometric growth noted by Tah *et al.* (2012) ^[15].

Four of our species have not been studied by Tah *et al.* (2012) ^[15]. These are *Clarias gariepinus*, *Heterobronchus longifilis*, *Tilapia guineensis* and *Tilapia mariae*. A negative allometry was noted by Ecoutin and Albaret (2003) ^[16] for *Tilapia*

guineensis in Ébrie lagoon in Côte d'Ivoire (b=2,847), also in this study (b=2,727). As for *Clarias gariepinus*, Coulibaly (2008) ^[17] and King (1996) ^[18] reported a positive allometry in the Sourou River in Burkina Faso (b=3.14) and in Nigeria (b=3.14) respectively, in contrast to isometric growth for this species in our study (b=2.934). For *Tilapia mariae*, King (1996) ^[18] reports two different allometric growth coefficients (b=2.852 and b=3.169) in two inland waters in Nigeria, while our results indicate negative allometric growth (b = 2.832). It is generally accepted that differences in allometric growth coefficients of the Length-Weight relationship for a same species in different areas are attributable to factors such as sampling procedure (size and length of the sample) (Ecoutin and Albaret, 2003) ^[16], sexual dimorphism (Artigues *et al.*, 2003) ^[19], water quality or food availability (Henderson, 2005) ^[20].

Fulton's condition factor (K) allowed evaluating physiological status of fish, based on the principle that specimen of a given length with a higher mass are in better condition. Bagenal and Tesch (1978) ^[14] reported K values between 2.9 and 4.8 for freshwater fish. On this basis, only 27.27% of species sampled in Solomougou Dame Lake have mean values of K while 31.82% and 40.91% are respectively above and below this interval. Thus, 59.09% of species, with K values greater than 2.9, is an indication of good adaptation for the majority of them to the conditions of life in the Solomougou Dam Lake.

Conclusion

The present study allowed calculating allometric growth coefficients of Length-Weight Relationship for the twenty-two (22) representative fish species in the Solomougou Dam Lake catches. The results indicated isometric growth in six of them, positive allometric growth for one species and negative allometric growth for fifteen others. These data could be used for models for any management program in this fishery.

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