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Weight-length and total length-standard length factor relationships, and condition factor of the main fish species in Lake Maabo, Chad (Central Africa)

Abba Amba BRAHIM[1,2], Pierre K. HOUNDONOGBO[2], Imaculé Schadrac BAGLO[2], Antoine CHIKOU[2] and Philippe A. LALEYE[2]

[1]*Université de Sarh, Faculté des Sciences Agronomiques et de l'Environnement, Département de Pêche et Aquaculture, BP 105 Sarh, Chad*
[2]*Université d'Abomey-Calavi, Faculté des Sciences Agronomiques, Laboratoire d'Hydrobiologie et d'Aquaculture, 01 BP 526 Cotonou, Bénin*
* *Email: Brahim Abba amba <brahim.amba@gmail.com>*

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ABSTRACT

The fish communities of Lake Maabo are little studied despite the increasing fishing effort on this ecosystem. The present study aims to establish weight-length (Pt = a Lt b) and total length-standard length (LT = p + q LS) relationships, and to determine the condition factor of the main species of Lake Maabo. To this end, morphometric data were collected monthly between January 2016 and December 2019 from artisanal fisheries. A total of 4,891 specimens belonging to 25 commercial fish species were caught using various fishing gears and techniques. The regression coefficient b ranged from 1.17 (*Hydrocynus forskali)* to 4.69 in (*Ctenopoma kingsleyae)*. Two species showed positive allometric growth, 2 with isometric growth and 21 species with negative allometric growth. The total length-standard length relationship was positive and significant for all species (r^2 between 0.666 and 0.999). Only *Tetraodon lineatus* had a condition factor within the range recommended for mature tropical freshwater fish. The condition factor ranged from 0.536±0.182 to 3.810±0.850, with an overall mean of 1.804±0.833. These results showed that fish in Lake Maabo are under increasing anthropogenic pressure. They show the need to study the population dynamics of the most exploited species in that Lake.

Keywords: Logone Basin, growth, exploitation, actinopterygian.

INTRODUCTION

Lake Maabo, one of the small lakes of the Greater Chad Basin, is supplied by the Chari-Logone complex and is located in the Logone sub-basin. This sub-basin (Logone) is subject to high anthropogenic activities and Lake Maabo is under pressure (Brahim et al., 2023). The latter is subject to high fishing pressure and is threatened by silting due to the degradation of plant cover and the agricultural activities in the basin (FAO, 2019, Brahim et al., 2023). Considering these threats, it is of the utmost importance to establish a database on the habitat, biodiversity, and ecology of the organisms that live in that ecosystem for sustainable management. Among the

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organisms colonizing the sub-basin, fish are particularly concerned, as they are the primary target of fishing activities (Brahim et al., 2023). Recent studies have reported 45 fish species in the lake (Thiaw, 2011; Brahim et al., 2023), a relatively high diversity for the lake's 15 Km^2 surface area. Like the other small ecosystems in the greater Chad Basin Lake Maabo is one of the refuge and breeding grounds for overexploited fish species in the greater Chari-Logone complex (Paugy et al., 2006a and b; Thiaw, 2011; Brahim et al., 2023; Brahim et al., In press). The preservation of this ecosystem is therefore a matter of urgency in view of its ecological importance. The data available on Lake Maabo concerns only the diversity and structure of ichthyological populations (Brahim et al., 2023) and the physicochemical quality of the water (Brahim et al., In press).

There is a lack of data on the biology of the organisms living there, particularly fish. Among the parameters used in fisheries biology, the study of weight-length relationships and the condition factor plays a very important role (Moutopoulos and Stergiou, 2002, Lederoun et al., 2016, 2022). Weight-length relationships make it possible to determine the weight of fish by knowing their length, or vice versa, and to evaluate the overweight of fish in order to assess their growth, and the fishing pressure in the environment (Sidibé, 2003; Lalèyè, 2006, Lederoun et al., 2022). In fisheries management, weight-length relationships can be used to monitor the growth of organisms (overweight) and, consequently, to formulate recommendations for responsible exploitation of the stock. For example, overexploitation of fish causes permanent stress, resulting in a reduction in fish size, stock dominance by small fish, a reduction in catches by fishermen, and so on. Similarly, calculating the condition factor makes it possible to assess the health status or well-being of the fish (Froese, 2006, Lederoun et al., 2016), but also to evaluate the ecological status of the ecosystem in which the fish live (Anene, 2005; Lederoun et al., 2022). The present work was therefore initiated to monitor the fish stock in Lake Maaba by studying the most heavily fished commercial species, which are therefore the most exposed to fishing pressure. It provides an initial database on weight-length, total length-standard length relationships, and condition factor values for the most abundant fish in artisanal catches from Lake Maabo.

MATERIALS AND METHODS

Study area

The study is carried out in Lake Maabo, located in the Logone basin in Chad (Central Africa). It lies between 8°22'31.28" N latitude and 15°53'1.60" E longitude with a surface area of 15 Km^2 and is supplied in water mainly by the Logone and Chari rivers (more than 90% of inflows) via its two arms, Rôh and Ngonka bidri (Thiaw, 2011; FAO, 2019, Brahim et al., 2023a, b). For this study, fish samples were collected from artisanal fishermen using several fishing gears in Guiro, Maabo and Bemela. These three stations are areas where fishing activity is intense and permanent. (Figure 1).

Data collection methods

Data were collected monthly between January 2016 and December 2019. The stations, namely Guiro, Maabo and Bémalla were surveyed monthly. Fish samples were collected from traditional fishermen who use creels, gillnets, longlines and beach nets for the fishing activities. Fish specimen sorted and pre-identified were individually weighed (total weight) using a 0.1 g precision scale, and the total and standard lengths were taken to the nearest centimeter using an ichthyometer (0.1 cm precision). A representative number of each pre-identified species was fixed in 10% formalin and then preserved in 70% alcohol for the confirmation of identity of the species at Hydrobiology and Aquaculture Laboratory, Faculty of Agronomic Sciences, University of Abomey-Calavi (Benin). Only species with some individuals equal to or greater than 10 were included in the present study following the recommendation of Lederoun et al. (2022). Identification was carried out using the fish identification keys of Paugy et al. (2003 a and b). These keys, which are proposed for use in West African ecosystems, were used in the present study in a Central African ecosystem, as studies in the Chad-Chari-Logone basins (Blache et al., 1964; Lévêque and Paugy, 2006b) and in Lake Maabo in particular (Thiaw, 2011, Brahim et al., 2023) have shown that the fauna of the Lake Maabo and its tributaries is very similar ichthyology of these basins was made up of species known from the Niger basin, i.e. from West Africa.

Data processing and statistical tests

The data collected were used to establish the weight-length relationships according to the formula Pt = a Lt b (Le Cren 1951), with Pt the body weight in grams (g), Lt the total length in centimeters (cm), “a” the y-intercept and “b” the slope or allometry coefficient. Standard deviation and 95% confidence interval were determined using Statview software (v.5.0.1, SAS Institute). Student's t-test was performed to compare the values of b to 3 according to the equation of Sokal and Rohlf (1987):

ts = (b - 3) / SE, with ts the t-test value, b the slope and SE the standard deviation of the slope b. PAST3.exe software was used for that purpose and the test was considered significant at the 5% threshold ($p < 0.05$).

Also, the relationships between total length and standard length were established for each species using simple linear regression: Lt = p + q Ls, where “p” is the intercept and “q”. is the slope.

Finally, the condition factor K was determined according to the formula K = Pt/TLb x 100 (Tesch, 1971), with Pt and TL the data used for the weight-length relationships.

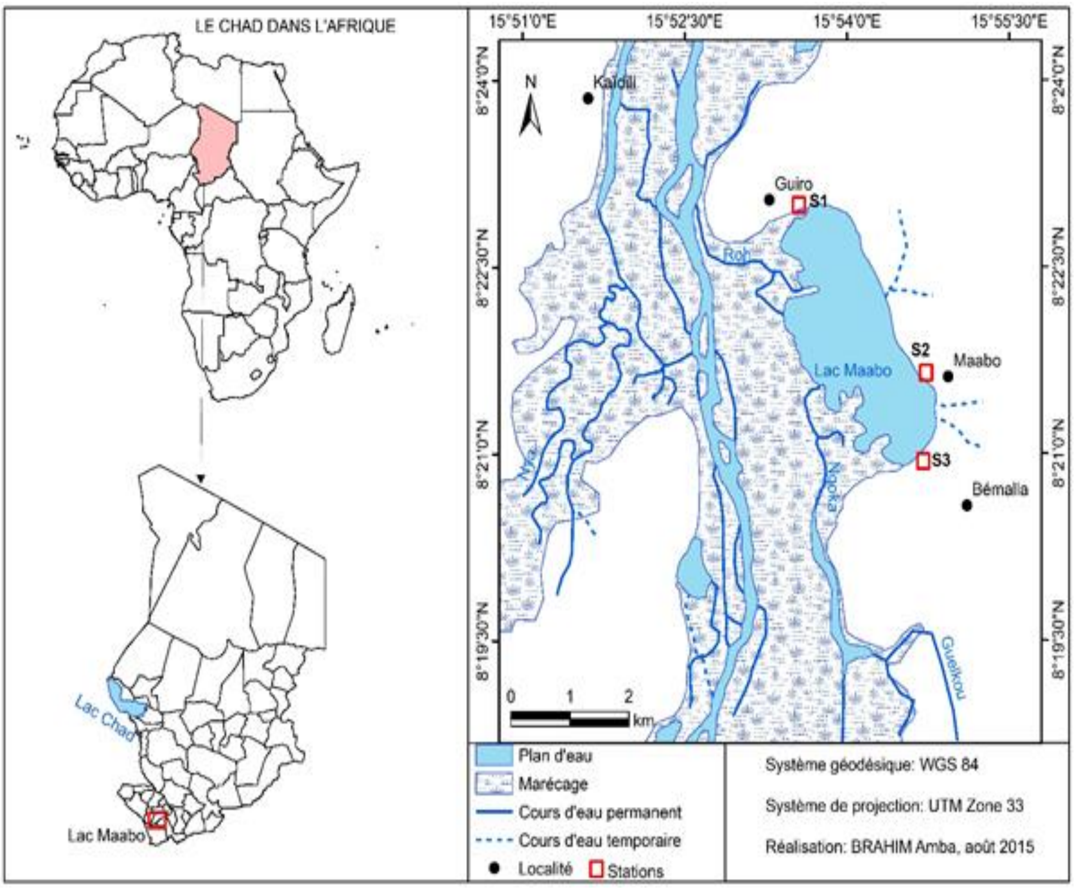

Figure 1: Location of Lake Maabo and sampling stations.

RESULTS

A total of 4.891 fish specimens were used in this study. Sample size per species ranged from 38 individuals for *Lates niloticus* (Linnaeus, 1762) to 1652 individuals for *Oreochromis niloticus* (Linnaeus, 1758) (Tables 1 and 2). The smallest recorded length was 4.9 cm TL in *Synodontis nigrita* (Valenciennes, 1840) and the smallest recorded weight was 2.5 g in *Parailia pellucida* (Boulenger, 1901). In contrast, the greatest length was 69.5 cm TL for *Heterotis niloticus* (Cuvier, 1829) and the greatest weight was 1738.3 g for *Lates niloticus* (Linnaeus, 1762) (Table 1).

Correlation coefficients (r2) were all positive for weight-length relationships and ranged from 0.924 to 0.995 (Table 1). The intercept (a) ranged from 0.001 for *Distichodus rostratus* Günther, 1864 to 3.12 for *Hydrocynus forskali* (Cuvier, 1819), with an average of 0.34±0.64 (Table 1). Two species out of the 25 species sampled presented a positive allometric growth ($b > 3$; $p > 0.05$). These were *Mormyrus rume* Valenciennes, 1846 and "*Ctenopoma" kingsleyae* Günther, 1896. *Synodontis ouemeensis* Musschoot and Lalèyè, 2008 and *Distichodus rostratus* Günther, 1864 show isometric growth ($b = 3$; $p < 0.05$). The b coefficient was significantly lower than 3 ($p < 0.05$) for all remaining species (Table 1). Overall, 21 out of 25 species showed negative allometric growth (Table 1).

The correlation coefficients (r^2) of the total length-standard length relationships ranged from 0.666 to 0.999, meaning that the relationship between total length and standard length was positive and significant for all species (Table 2).

The condition factor ranged from 0.536±0.182 in *Auchenoglanis biscutatus* to 3.810±0.850 in *Tetraodon lineatus*, with an overall mean value of 1.804±0.833 (Table 1).

DISCUSSION

Total weight - total length and total length - standard length relationships are often used in the management of fish stocks and specifically in the evaluation of fishing yields. They enable the weight of a fish to be predicted when its length is known, and vice versa (Écoutin and Albaret 2003; Froese, 2006, Froese et al., 2014; Lederoun et al., 2022). These relationships are therefore of great importance for the management of aquatic ecosystems (Lalèyè, 2006; Lederoun et al., 2022). However, studies on these relationships are still rare or even non-existent in several African ecosystems such as the Logone basin in Chad. Lake Maabo is one of the most important ecosystems in the basin in terms of fish diversity and the fishing pressure it is subject to (Brahim et al., 2023). The present study provided the first data on these growth parameters of fish in Lake Maabo.

Sample size ranged from 38 specimens for *Lates niloticus* to 1652 specimens for *Oreochromis niloticus*, and is within the minimum sample size (n=10) recommended by several authors (Lalèyè, 2006; Lederoun et al. 2016, 2022) for establishing weight-length relationships in fish. Total length ranged from 4.9 cm TL for *Synodontis nigrita* to 69.5 cm TL for *Heterotis niloticus*, stipulating that sampling included both juveniles and adults fish specimens. This could be explained by the fact that the specimens used in this study come from artisanal fisheries using a variety of fishing gears, namely: creels, gillnets, longlines and beach nets. Although this combination of fishing gear provided a representative sample, it also reflects the fishing pressure on fisheries resources in Lake Maabo.

Table 1: Descriptive statistics and estimated values of total weight-total length relationships (PT = a LT b) for the main species in Lake Maabo; A+, Positive allometric growth; A-, Negative allometric growth; CI, Confidence interval; LT, Total length; N, Number of specimens; Min-Max, Minimum-Maximum; PT, Total weight; SE, Standard deviation.

Families/Species	N	LT (cm)	Weight (g)	Parameter regression					Growth
		Min-Max	Min-Max	A	b	SE of b	95% of cc b	r²	
Tetraodontidae									
Tetraodon lineatus Linnaeus, 1758	43	23,6-29	300-426	0,428	2,050	0,132	1,784-2,316	0,925	A-
Mochokidae									
Synodontis batensoda Rüppell, 1832	88	6,4-16	8,1-61,1	0,056	2,549	0,088	2,374-2,724	0,952	A-
Synodontis nigrita Valenciennes, 1840	255	4,9-18,9	6,2-81,1	0,154	2,084	0,054	1,978-2,191	0,924	A-
Synodontis ouemeensis Musschoot & Lalèyè, 2008	223	7,3-25,7	10,1-98	0,181	2,958	0,044	2,871-3,045	0,948	I
Schilbeidae									
Parailia pellucida (Boulenger, 1901)	60	7,5-10,2	2,5-5,5	0,013	2,602	0,106	2,39-2,814	0,955	A-
Schilbe intermedius Rüppell, 1832	116	6,2-23	10,5-98,9	0,654	2,613	0,031	2,552-2,674	0,98	A-
Channidae									
Parachanna obscura (Günther, 1861)	179	17-63,5	60-356	0,978	2,523	0,017	2,489-2,558	0,989	A-
Cichlidae									
Coptodon guineensis (Bleeker in Günther, 1862)	85	6,3-20,8	10-100	0,518	2,755	0,042	2,672-2,838	0,977	A-
Coptodon zillii (Gervais, 1848)	200	5-19,4	10,9-100,1	0,529	2,687	0,04	2,609-2,765	0,949	A-
Oreochromis niloticus (Linnaeus, 1758)	1652	5,8-40	15,3-590	0,052	2,554	0,025	2,504-2,604	0,956	A-
Sarotherodon galilaeus (Linnaeus, 1758)	252	6,1-33	11,9-628,2	0,035	2,785	0,034	2,717-2,852	0,982	A-
Mormyridae									
Marcusenius senegalensis (Steindachner, 1870)	217	8-30,3	3,4-65,9	0,11	2,876	0,027	2,823-2,928	0,979	A-

Families/Species	N	LT (cm)	Weight (g)	Parameter regression					Growth
		Min-Max	Min-Max	A	b	SE of b	95% of cc b	r²	
Mormyrus rume Valenciennes, 1846	276	10,1-31,8	13,6-579,3	0,012	3,141	0,044	3,054-3,227	0,974	A+
Petrocephalus levequei	46	6-7,2	2,1-3,4	0,024	2,542	0,134	2,272-2,811	0,944	A-
Latidae									
Lates niloticus (Linnaeus, 1762)	38	10-58,6	18,7-1738,3	0,056	2,502	0,064	2,372-2,633	0,988	A-
Cyprinidae									
Labeo parvus Boulenger, 1902	58	17-26,7	34-73	0,685	2,398	0,028	2,341-2,454	0,989	A-
Labeo senegalensis Valenciennes, 1842	123	8,7-17,9	8,1-55	0,063	2,32	0,052	2,217-2,422	0,971	A-
Alestidae									
Alestes baremoze (Joannis, 1835)	216	8,7-27,7	6,10-72,30	0,075	2,066	0,034	1,998-2,134	0,972	A-
Hydrocynus forskali (Cuvier, 1819)	60	14-23,6	69,2-129	3,12	2,172	0,024	2,123-2,220	0,988	A-
Osteoglossidae									
Heterotis niloticus (Cuvier, 1829)	176	14,3-69,5	60-610,6	0,452	2,7	0,021	2,658-2,743	0,987	A-
Distichodontidae									
Distichodus rostratus Günther, 1864	116	9,6-24,6	12-295,2	0,001	3,048	0,058	2,934-3,164	0,989	I
Clariidae									
Clarias (Clarias) gariepinus (Burchell, 1822)	90	13,5-66	24,5-2010	0,034	2,574	0,062	2,451-2,698	0,975	A-
Citharinidae									
Citharinus citharus (Geoffroy Saint-Hilaire, 1809)	111	15,8-66	38,5-470	0,253	2,784	0,017	2,751-2,817	0,995	A-
Claroteidae									
Auchenoglanis biscutatus (Geoffroy Saint-Hilaire, 1808)	107	15-19,8	35,8-72,9	0,045	2,479	0,047	2,386-2,572	0,982	A-
Anabantidae									
«Ctenopoma» kingsleyae Günther, 1896	104	6,3-11,7	8,1-88,3	0,001	3,693	0,124	3,448-3,939	0,966	A+

Table 2: Descriptive statistics and estimated values for the total length-standard length relationship (LT = p + q LS) and the condition factor for the main Lake Maabo species. LT, Total length; LS, Standard length; N, Number of specimens; Min-Max, Minimum-Maximum; SE, Standard deviation.

Families/Species	N	LT (cm) Min-Max	LS (cm) Min-Max	Parameter regression LT = p + q LS	SE of p	SE of q	r²	Condition factor Min-Max	Condition factor Mean ± SD
Tetraodontidae									
Tetraodon lineatus Linnaeus, 1758	43	23,6-29	18,5-23,9	LT= 5,1+1LS	0,015	0,001	0,999	2,930-4,230	3,810±0,850
Mochokidae									
Synodontis batensoda Rüppell, 1832	88	6,4-16	4,7-14,6	LT= 2,7+1LS	0,02	0,001	0,999	1,068-3 ,516	2,602±0,745
Synodontis nigrita Valenciennes, 1840	255	4,9-18,9	3-16,7	LT= 1,679+1,024LS	0,022	0,002	0,999	0,903-3,57	1,798±0,951
Synodontis ouemeensis Musschoot & Lalèyè, 2008	223	7,3-25,7	5,7-23,4	LT= 2,278+1,001LS	0,01	0,001	0,999	0,593-3,052	1,177±0,553
Schilbeidae									
Parailia pellucida (Boulenger, 1901)	60	7,5-10,2	6,5-9	LT= 1,325+1,007LS	0,536	0,069	0,786	1,145-1,447	1,293±0,077
Schilbe intermedius Rüppell, 1832	116	6,2-23	5-21,9	LT= 1,803+1,048LS	0,261	0,019	0,964	0,685-2,577	1,361±0,931
Channidae									
Parachanna obscura (Günther, 1861)	179	17-63,5	15-62,3	LT= 2,181+1,002LS	0,175	0,005	0,996	1,486-5,156	3,205±1,107
Cichlidae									
Coptodon guineensis (Bleeker in Günther, 1862)	85	6,3-20,8	4,8-18,6	LT= 2,175+1,002LS	0,025	0,002	0,999	1,319-3,224	2,296±0,519
Coptodon zillii (Gervais, 1848)	200	5-19,4	3-17,3	LT= 1,974+1,003LS	0,036	0,003	0,998	1,330-3,696	2,719±0,378
Oreochromis niloticus (Linnaeus, 1758)	1652	5,8-40	4,4-34,6	LT= 5,272+0,843LS	0,16	0,01	0,879	1,186-3,199	2,356±0,215
Sarotherodon galilaeus (Linnaeus, 1758)	252	6,1-33	5,4-30,4	LT= 3,296+0,987LS	0,271	0,019	0,931	1,601-3,208	2,571±0,788
Mormyridae									
Marcusenius senegalensis (Steindachner, 1870)	217	8-30,3	6,2-28,9	LT= 1,405+1,039LS	0,133	0,008	0,987	0,313-1,820	0,794±0,354
Mormyrus rume Valenciennes, 1846	276	10,1-31,8	8,3-29	LT= 3,141+0,952LS	0,331	0,017	0,922	0,632-2,162	1,200±0,253

Families/Species	N	LT (cm)	LS (cm)	Parameter regression				Condition factor	
		Min-Max	Min-Max	LT = p + q LS	SE of p	SE of q	r^2	Min-Max	Mean ± SD
Petrocephalus levequei	46	6-7,2	4,9-6,2	LT= 1,383+0,94LS	0,448	0,082	0,747	2,184-2,678	2,395±0,110
Latidae									
Lates niloticus (Linnaeus, 1762)	38	10-58,6	8,2-49,1	LT= 0,175+1,224LS	1,854	0,062	0,914	1,557-2,741	1,768±0,401
Cyprinidae									
Labeo parvus Boulenger, 1902	58	17-26,7	13-25,7	LT= 2,567+0,987LS	0,721	0,036	0,932	1,476-3,170	2,160±0,514
Labeo senegalensis Valenciennes, 1842	123	8,7-17,9	6,5-15,6	LT= 3,253+0,942LS	0,382	0,033	0,869	1,115-3,839	2,341±0,554
Alestidae									
Alestes baremoze (Joannis, 1835)	216	8,7-27,7	7-25,1	LT= 2,524+1,004LS	0,223	0,014	0,961	1,303-2,802	1,589±0,137
Hydrocynus forskali (Cuvier, 1819)	60	14-23,6	12-21,4	LT= 1,848+1,015LS	0,315	0,019	0,981	1,447-3,331	1,949±0,902
Osteoglossidae									
Heterotis niloticus (Cuvier, 1829)	176	14,3-69,5	12,6-65,6	LT= 3,595+0,991LS	0,784	0,02	0,933	0,629-2,558	1,325±0,637
Distichodontidae									
Distichodus rostratus Günther, 1864	116	9,6-24,6	7,5-22,8	LT= 7,291+0,665LS	0,505	0,032	0,788	0,779-2,357	1,426±0,376
Clariidae									
Clarias (Clarias) gariepinus (Burchell, 1822)	90	13,5-66	11,9-60	LT= 1,472+1,051LS	0,255	0,011	0,99	0,719-1,101	0,935±0,285
Citharinidae									
Citharinus citharus (Geoffroy Saint-Hilaire, 1809)	111	15,8-66	11-63,5	LT= 3,097+0,977LS	0,755	0,018	0,964	0,368-1,928	0,714±0,292
Claroteidae									
Auchenoglanis biscutatus (Geoffroy Saint-Hilaire, 1808)	107	15-19,8	12-18,2	LT= 5,406+0,798LS	0,589	0,039	0,796	0,451-1,093	0,536±0,182
Anabantidae									
«*Ctenopoma*» *kingsleyae* Günther, 1896	104	6,3-11,7	5,4-10,2	LT= 2,102+1,024LS	0,487	0,072	0,666	0,565-1,167	0,777±0,129

In the weight-length relationship (Pt = a Lt b), the value of b is used to assess fish growth. It varies between 2 and 4, but its normal value is closed to 3. When b = 3, growth is isometric, whereas it is allometric when b is different from 3 (Bagenal and Tesch 1978; Lederoun et al., 2022). When b > 3, growth is said to be positive allometric, while a value of b < 3 indicates negative allometric growth. Out of 25 species recorded in this study, 21 (84%) showed negative allometric growth. The fish are therefore growing in length rather than weight, indicating that they are not overweighting. This may be explained by the increasing fishing pressure, but also by alternating floods and droughts in the Chad Basin (Amba et al., in press). The effects of overfishing and alternating drought and flood on fish growth are well known (Mommsen 1998, Lederoun et al., 2022). Overfishing and extreme variations in climatic parameters (alternating high and low water) create stress in the environment, resulting in reduced growth of organisms and overpopulation of small specimens. Fishing disrupts the ecosystem and primary production, resulting in the unavailability of the food resources needed for organisms to grow (Viaho et al., 2021; Badji et al., 2023). As for climatic variations, a plunging drought leads to a scarcity of food resources and consequently disrupts the growth of organisms (Coulibaly, 2008; Chikou et al., 2011; Kone et al., 2014). These stresses lead organisms to reproduce more rapidly in order to ensure the survival of the species. As a result, energy reserves are used more for reproduction than for growth. As a result, fish are not overweight and show negative allometric growth.

The b values recorded in the present study ranged from 2.050 to 3.693. According to Froese et al. (2014), b values should be between 2.9 and 3.1 for most species, whereas Carlander (1969) had proposed b values between 2.5 and 3.5. Only 4 species (16%) respected the interval proposed by Froese et al. (2014), while 18 species (72%) respected that of Carlander (1969).

To the best of our knowledge, there is no work on weight-length relationships in the Logone basin and surrounding area, which could serve as a reference for the present study. Nevertheless, the b values recorded (2.050 and 3.693) are close to those recorded by certain authors in African ecosystems. This is the case for the values 2.458 to 3.473 recorded by Ecoutin and Albaret (2003) for 52 species in West African lagoons and estuaries, 2.330 to 3.518 recorded by Lalèyè (2006) for 52 species in the Ouémé basin in Benin, 2.213 to 3.729 reported by Konan et al. (2007) for 57 species in the coastal rivers of southeastern Ivory Coast, from 2.173 to 3.472 recorded by Tah et al. (2012) for 36 species from lakes Ayame I and Buyo in Ivory Coast, and from 2.194 to 3.673 recorded by Lederoun et al. (2022) for 40 species in the Mono River in Benin. The overall mean value of b for the 25 species studied was 2.618±0.036 and was significantly different from 3, indicating that overall fish growth in Lake Maabo is negative allometric. Fish therefore, grow in length rather than weight in Lake Maabo. Several factors can influence fish growth in a given ecosystem. These may include biotope quality, trophic level, food availability, sex, maturity stage, diet and health status of the specimens considered (Oribhabor et al., 2009; Koffi et al., 2014; Lederoun et al., 2016, 2022). None of the above parameters were taken into account when sampling the specimens used in this study. However, the functioning of Lake Maabo and the Chari-Logone basin in which it is located may explain the results obtained. Indeed, Lake Maabo is characterized by periodic drying, which disrupts ecosystem functioning and the biology of the organisms living within the ecosystem (Brahim et al., 2023, Brahim et al.,in press). The considerable reduction in lake surface area during droughts leads to a concentration of fish in a pool of water with few food resources. Several authors reported that periodic drying of an ecosystem disrupts fish growth (Mommsen 1998; Lederoun et al., 2016, 2022).

The condition factor (K) is used in fisheries biology to assess the health or well-being of fish. For a given length, the specimen with the highest biomass is in better condition (Froese, 2006; Lederoun et al., 2016). According to other authors, the condition factor can be used as an index to assess the status of the aquatic ecosystem in which lives the studied fish, as it is highly dependent on the environmental parameters (Anene, 2005; Lederoun et al., 2016, 2022).

In this study, condition factor values ranged from 0.536±0.182 to 3.810±0.850, with an overall mean value of 1.804±0.833. According to Bagenal and Tesch (1978), the condition factor should be between 2.9 and 4.8 for most fish. Only 2 species (8%) had their condition factor within this range. Overall, the fish are in poor condition, reflecting the poor ecological health of Lake Maabo. The periodic draining of the lake, fishing pressure and the development of agriculture with the use of fertilizers in the lake's vicinity could explain the results obtained (Brahim. AA et al., 2023a). Several authors have asserted that the health of fish in an ecosystem system could be adversely affected by anthropogenic and climatic disturbances to the ecosystem (Stalnaker et al., 1989, Lederoun et al., 2016, 2022).

Conclusion

This study has provided the first data on the morphometric characteristics of Lake Maabo fish from artisanal catches. The majority of fish studied showed negative allometric growth, indicating poor environmental condition. The condition factor values confirm this poor ecological state, with 92% of the species not being overweight. These data could contribute to fishing statistics in the Logone basin in general and Lake Maabo in particular. It would be interesting to continue this work by assessing the fishing pressure on the ecosystem through a study of the population dynamics of the most exploited species in Lake Maabo.

AUTHORS' CONTRIBUTIONS

AAB is in charge of the study; he collected the data and drafted the first version of the manuscript. PKH and ISB analysed the data and corrected the manuscript to improve its scientific quality. AC read and corrected the manuscript and PAL supervised the entire study.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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