E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2017; 5(3): 514-519

www.fisheriesjournal.com
Received: 07-03-2017
Accepted: 08-04-2017

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Length-weight relationships of 30 species of fish of the river Sô in Benin (West Africa)

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Abstract
The weight- length relationships of 30 fish species belonging to 16 families from the Sô River in southern Benin were studied. The fish were collected from both experimental and artisanal fisheries. The values of the allometric coefficient b resulting from the weight-length relationships ranged from 2,046 to 4, 09 with an average of 3,034. The correlation coefficients are very high and range from 0.626 for *Brycinus leuciscus* to 0.996 for *Oreochromis niloticus*. These data constitute an important basis for the management of the fish fauna of the Sô River and a reference for future studies.

Keywords: Weight lengths, fish, management, Fauna ichthyological, Sô River

1. Introduction
Growth in the broad sense encompasses all physiological processes that determine the variation in size and biomass of individuals over a specified period of time [1]. It is the result of a general metabolic system involving biotic and abiotic factors [2, 3].
There is a close relationship between weight and length of fish [4]. This relationship is of crucial importance in the management of fish stocks. The data of the length-weight relationships allow estimation of the biomass from the lengths; the definition of the type of growth [5]; the estimation of the welfare condition of fish populations in a given environment [6, 7, 8]. Finally, the parameters of the relationship constitute an essential tool for comparing different populations of the same species living in similar or different ecosystems [9, 10, 11, 12, 13, 14, 15].
In Benin, the relationships between fish weight and length were studied in the Ouémé river [16] and in the Hlan lake [12], but no data exist on the fishes of the Sô River. This river is under threat from several entropic pressures: destruction of habitats, pollution, exploitation of river sand and overfishing by the use of prohibited fishing gear that has a negative impact on fisheries resources. A good knowledge of population dynamics makes it possible to assess the impact of entropic pressures on fisheries resources and to define strategies for their rational management and conservation.
This study describes the length-weight relationships of the 30 most frequent fish species in the Sô River in Benin.

2. Materials and Methods
2.1. Study area
The river Sô (6° 34.97 N; 2° 23.75 E), 84.5 km long, is a river in southern Benin that originates in Hlan Lake. It crosses the town of Adjohoun in the department of Ouémé and that of Sô-Ava in the department of the Atlantic where it flows down into Lake Nokoué the largest estuarine system of Benin. This region is located in the sub equatorial zone characterized by two raining seasons (March to July and September to October) and two dry seasons (November to March and August to September). The highest flows observed during the floods are due to rainfall in the north of the country where the river Sô communicates with the river Ouémé, the largest river in Benin.

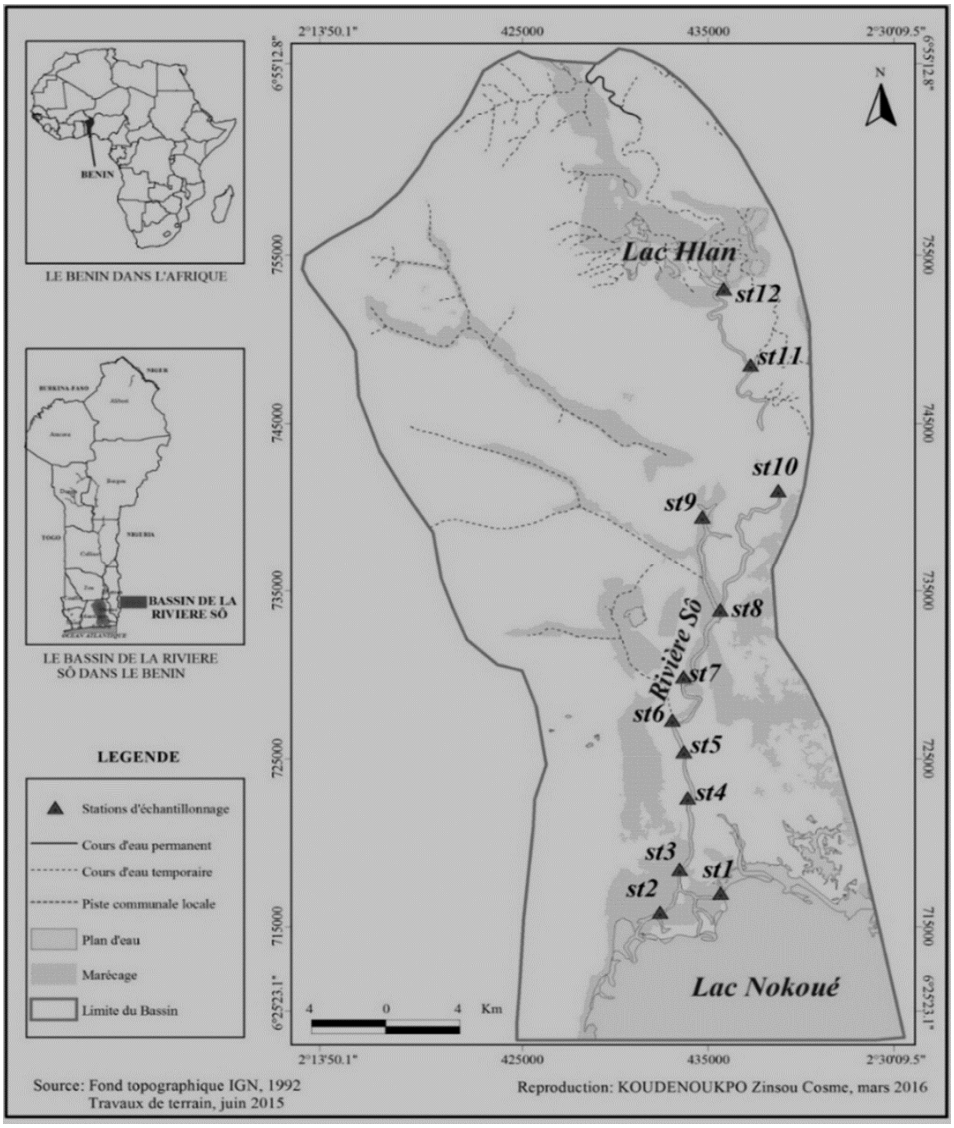

Fig 1: Carte du bassin de la rivière Sô avec les sites d'échantillonnages.

2.2. Data collection and analysis

Data collection was conducted monthly over a one-year period from November 2015 to October 2016 at several stations following the upstream to the downstream gradient of the river. Fish were collected by experimental fishing using a bacterium of nine gillnets mesh between 8 and 60 mm mesh and artisanal fishing using a whole range of fishing gear such as acadjas, hawk nets, Harpoon, gill nets, traps, nets nets.

The fish were identified with the key of [17, 18]. The total weight (W) of each fish was measured in g using a scale; the total length (Lt) and the standard length (Ls) measured in mm using a ichthyometer.

The length-weight relationship was determined in fish of the Sô River by adjusting the exponential function [19] of the type:

$W = a\ Lt^b$

W = total weight of fish in g; Lt = Total length of fish in mm; a and b are the characteristic factors respectively of the medium and the species.

By logarithmic transformation, we have a linear type relation:

$LogW = Loga + bLogLt$ [35]

With a = the ordinate at zero, b = the slope.

Growth is isometric when b is equal to 3; a value of b less than 3 indicates negative allometric growth; Inversely if b is greater than 3 the growth is said to be positive allometric.

The linear correlation between these two variables (weight and length) is expressed by a coefficient (R^2). The Student test at the significance level of 5% was performed to check whether the value of b deduced from the regression curves was different from 3.

The regression parameters were calculated and analyzed using the Satview software (version 5.0.1.0).

3. Results

The parameters a and b of the relationship weight length of 30 fish species grouped into 16 families most frequent river Sô are summarized in Table 1 with their standard errors and Sb correlation coefficient R^2. A total of 6265 fish were measured for this analysis. The number of sampled fish varies from 07 specimens for *Liza falcipinus* to 2081 for *Sarotherodon melanotheron*. Fish size was as small as 3.2 cm for *Tilapia guineensis* and as large as 59.2 cm for *Heterotis niloticus*. The weight varies from 0.7 g for *Brycinus leuciscus* to 1572 g for *H. niloticus*. Values of a ranged from 0.0005 for Gobionellus occidentalis to 0.119 for Clarias ebriensis; The Shapiro-Wilk

normality test (N = 30, W = 0.59, p = 0.0000) shows that a does not follow a normal distribution.

The coefficients of correlation R^2 range from 0.626 for *B. leuciscus* to 0.996 for *Oreochromis niloticus*. The allometric coefficients b vary from 2.046 to 4.09 with an average of 3.034 ± 0.4 and the Shapiro-Wilk normality test (N = 30, W = 0.95, p = 0.24) shows that b has a normal distribution (Figure 2).

Isometric growth was observed in our study in 03 species *Polypterus senegalus; Sarotherodon galileaeus; Heterotis niloticus.*

A negative allometric growth was observed in *Brycinus leuciscus, Brycinus longipinnis, Eleotris vittata, Hemichromis bimaculatus, Oreochromis niloticus, Pellonula leoneensis, Sarotherodon melanotheron, Tilapia guineensis, Tarpon atlanticus, Clarias gariepinus, Clarias ebriensis, Synodontis nigrita, Parachanna africana*.

A positive allometric growth was observed in *Brienomyrus Niger, Chrysichthys auratus, Chromidotilapia guntheri, Dormitator lebrotonis, Ethmalosa fimbriatta, Gobionellus occidentalis, Hemichromis fasciatus, Hepsetus odoe, Liza falcipinnis, Monodactylus sebae, Parachanna obscura, Porogobius schelgelii, Tilapia marries, Tilapia zilli*.

Table 1: Parameters of the relationship length-weight and growth type of thirty species of fish from the Sô River, Benin (N: Number of specimens; Lt : total length (minimum and maximum) in Cm ; W : total weight (minimum and maximum) in g ; a and b : parameters of the length-weight relationship; S.E : Standard Errors of b ; R^2 : Coefficient correlation ; A+ : positive allométric ; A- : négative allométric ; I : isométric)

Espèces	N	Lt		W			Growth			
		Min	Max	Min	Max	a	b	S.E. (b)	r^2	
Characidae										
Brycinus leuciscus	77	4,2	6,2	0,7	2,2	0,021	2,55	0,227	0,626	A-
Brycinus longipinnis	23	5,5	8,1	2	6	0,0176	2,781	0,143	0,957	A-
Mormyridae										
Brienomyrus. niger	24	10,8	13,9	10	24,4	0,001	3,632	0,185	0,945	A+
Clupeidae										
Ethmalosa fimbriatta	16	6	13,5	2	25	0,0077	3,094	0,063	0,99	A+
Pellonula leoneensis	21	5,3	20,6	2	43	0,063	2,156	0,034	0,995	A-
Mugilidae										
Liza falcipinnis	27	18,9	22,1	48	87	0,0056	3,096	0,352	0,917	A+
Eleotridae										
Eleotris vittata	408	6,2	33,1	2	306	0,01	2,98	0,06	0,95	A-
Dormitator lebrotonis	171	5	11,1	5,9	13,9	0,004	3,455	0,098	0,881	A+
Gobiidae										
Gobionellus occidentalis	17	9,5	13,6	5	23	0,0005	4,09	0,088	0,993	A+
Porogobius schlegelii	29	8,4	15,4	5	39	0,003	3,466	0,081	0,985	A+
Hepsetidae										
Hepsetus odoe	88	11,8	34,2	10	282	0,0022	3,352	0,033	0,991	A+
Monodactylidae										
Monodactylus Sebae	51	5	12,7	2	56	0,017	3,208	0,053	0,986	A+
Channidae										
Parachanna obscura	38	11,9	32,2	16	306	0,0065	3,388	0,098	0,97	A+
Parachanna africana	10	8,9	30,9	7,77	339	0,0163	2,85	0,352	0,901	A-
Polypteridae										
Polypterus senegalus	14	19,7	24,3	36	72	0,0046	3,002	0,301	0,892	I
Osteoglossidae										
Heterotis niloticus	32	36,2	59,2	354	1572	0,007	2,999	0,106	0,993	I
Megalopidae										
Tarpon atlanticus	9	30	41	220	529	0,015	2,813	0,347	0,956	A-
Clariidae										
Clarias gariepinus	86	26,8	48	132	677	0,012	2,831	0,107	0,944	A-
Clarias ebriensis	20	11,5	21,1	23	77	0,119	2,046	0,346	0,66	A-
Claroteidae										
Chrysichthys auratus	140	14,6	36,5	22,2	372	0,004	3,202	0,059	0,954	A+
Mochokidae										
Synodontis nigrita	48	6,5	24,3	3,66	91,6	0,0377	2,499	0,112	0,959	A-
Cichlidae										
Hemichromis bimaculatus	157	5	15,1	2	59	0,022	2,878	0,091	0,868	A-
Hemichromis fasciatus	311	4,5	19,1	1	130	0,0084	3,258	0,043	0,949	A+
Oreochromis niloticus	31	6,7	32,9	6	681	0,019	2,986	0,034	0,996	A-
Tilapia guineensis	1889	3,2	25,5	2	192	0,0224	2,917	0,015	0,95	A-
Sarotherodon melanotheron	2081	5,2	25	2,01	254	0,0193	2,979	0,016	0,943	A-
Chromidotilapia guntheri	77	6,4	13,3	4	43,5	0,0097	3,235	0,052	0,98	A+
Tilapia marie	236	5,1	16,2	2	93,1	0,0153	3,125	0,045	0,953	A+
Tilapia zilli	116	8,1	24,5	9,1	221	0,0119	3,139	0,004	0,985	A+
Sarotherodon galileaeus	18	6,5	23	6	246	0,02	3,001	0,036	0,99	I

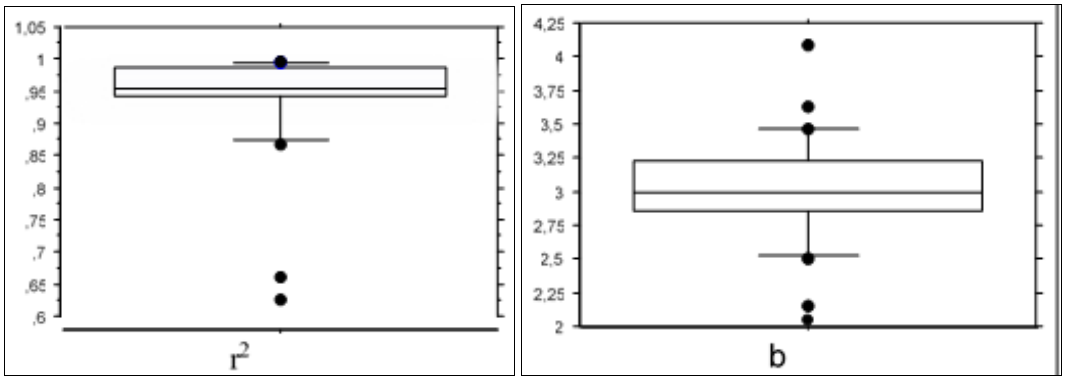

Fig 2: Variation in values of r², b of thirty fish species from the Sô River

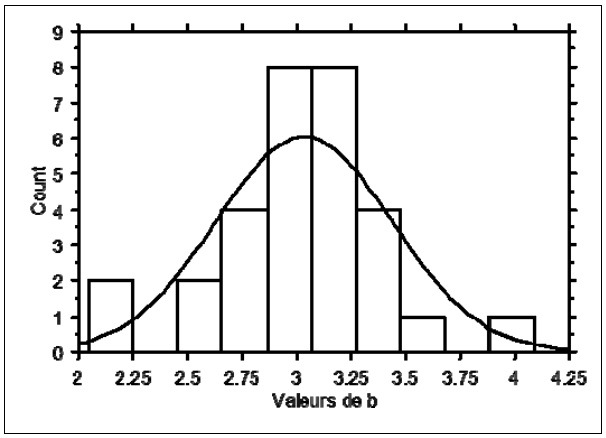

Fig 3: Distribution of b values in thirty species of fish from the Sô River

4. Discussion

The correlation coefficients (R^2) are positive and very high with an average of 0.94 ± 0.05; Indicating that the size increase follows that by weight in the fish of the Sô River. These results are consistent with those obtained in other rivers [16, 11, 4, 20, 21]. The allometric coefficients b range from 2.046 *Clarias ebriensis* to 4.09 for *Gobionellus occidentalis*; these values are in the ranges [2-4] recommended for fish [22]. [23] Says that the exponent b should normally be between 2.5 and 3.5; in our study, two species have aberrant values of b: *C. ebriensis* (2.046); *G. occidentalis* (4.09). The average of the allometry coefficient b is 3.034±0.4 and follows a normal distribution. This mean value of b obtained in our study is similar to that obtained: in the Pendjari river (average value of b = 3.04) [20]; in the Tai River Basin in Ivory Coast (mean value of b = 3.01) [15]; in the Nwaniba River in Nigeria (mean value of b = 3.07) [34] but is less than 3.218 obtained in Hlan Lake [12]; and is higher than the mean value b = 2.89 obtained in the coastal rivers of Côte d'Ivoire [11] to the mean value of b = 0.95 obtained in the Sangana River in Niger [36].

The range of b values (2.046-4.09) obtained in our study are similar to those obtained (2,68- 3,69) in the Nhamundá river in Brazil for 10 species of fish [37]; (2.7-4.03) for 11 species in Hlan Lake [12]; (2.7-3.15) obtained for four species of fish in the Sourou River in Burkina Faso [4]; (2.21-3.72) obtained for 57 species of fish in the coastal rivers of Ivory Coast [11]; (2.79-3.47) obtained for 05 species in the Epe Lagoon in Nigeria [24]; (2.53-2.35) obtained for 35 fish species from Badagry Creek [32]; (2.17-3.47) obtained for 36 species of fish in the Ayamé dam in Ivory Coast [21]; (2.458-3.473) obtained for 52 species of West African estuaries and lagoons [25]; (2.78-3.20) obtained from 06 species of poisons in the Nwaniba river [34].

The b values obtained in this study do not conform to (1.23-5.20) obtained for 11 fish in an Ogudu reservoir in Nigeria [26] and those obtained (1.89-4.437) in the Taï basin in Ivory Coast [15]; à (0.78-1.08) Obtained in the Sangana River in Niger [36].

In the Ouémé river, *Heterotis niloticus*, *Parachanna obscura*, *Tilapia mariae* and *Sarotherodon galilaeus* show isometric growth and *Chrysichthys auratus* shows positive allometric growth [16], which is similar to our results. In the Pendjarie River, *Hemichromis fasciatus*, *Sarotherodon galilaeus* show positive allometric growth and *Oreochromis niloticus* and *Tilapia zili* show isometric growth [20]; in the Taï basin, *Brycinus longipinnis*, *Chromidotilapia guntheri*, *Hepsetus odoe*, *Hemichromis fasciatus* and *Tilapia zillii* showed positive allometric growth [15], which is consistent with our results.

In the Nwaniba River, *Chromidotilapia guntheri* and *Hemichromis fasciatus* show positive allometric growth [34]; which is consistent with the results obtained in this study. *T. guineensis* and *C. gariepinus* exhibit negative allometric growth in the Ero reservoir in Nigeria, which is subject to high levels of fish overexploitation [38], which is consistent with our results.

In the Sô River, b (2.94) of *Heterotis niloticus* [29] is lower than that obtained (b = 2.999) in our study. In Toho Lake, *Oreochromis niloticus* showed isometric growth [27], which is not the case in this study. In the Ado Ekiti reservoir in Nigeria, *Hepsetus odoe* showed a positive allometric growth (b = 3.61) [28], which is higher than the value (b = 3.35) obtained in this species in our study. In Hlan Lake, *Sarotherodon galilaeus* and *Heterotis niloticus* show negative allometric growth [12], which is inconsistent with our findings; but in the Togbadji lake, *S. galilaeus* présent the isométric growth [30] which is consistent to our results. In Lake Naivasha in Kenya, *C. gariepinus* shows positive allometric growth with b = 3.22 [33], which is greater than b = 2.83 obtained in the species in our results. The values of b = 2.91 in *T. guineensis* and b = 2.97 in *S. melanotheron* obtained in our study are close to b = 2.97 and b = 2.85 obtained respectively in *T. guineensis* and *S. melanotheron* in lake Nokoué [6].

The parameters of the length-weight relationships are affected by several factors such as the number of individuals in the sample, habitat, food availability, gonad maturity, fishing pressures [22, 31].

On the river Sô, several acadjas (parks with branches) are installed near the banks; These acadjas are artificial habitats

which allow the grouping of a large number of fish which are constituted in large numbers by Cichlidae such as *T. guineensis*, *S. melanotheron*, *H. fasciatus* and catfish such as *C. auratus*, *C. gariepinus*, *C. ebriensis*; and provided them with good living conditions such as breeding, feeding, protection against predators which is the basis of the good growth observed in several species of fish of this river.

The negative allometric growth observed in *S. melanotheron* and *T. guineensis*, *C. gariepinus* is indicative of an overexploitation of fishery resources caused by the use of tight mesh nets used in the exploitation of the acadjas, and the Zowla nets, there by capturing of very small fish.

5. Conclusion

This study is a contribution to the knowledge of the lengthy relationships of 30 fish species of the Sô River; and will be useful for the development of the fishery resources of this river. A thorough study of the diversity of fish fauna and trophic dynamics is required for the conservation of the fishery resources of this river.

6. Acknowledgment

Our thanks go to the authorities of the CARDER Sô - Ava and the fishermen of the Sô River for facilitating the data collection in the field. We would like to thank the students MAMOUDOU BEIDO Abdoul Aziz, SOUDE Espoir, OSSE Judicaël who participated in the data collection.

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