E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(6): 372-376

www.fisheriesjournal.com
Received: 21-09-2018
Accepted: 24-10-2018

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Length-weight relationships of 18 fish species in grand-lahou lagoon, south-west Côte d'Ivoire

Coulibaly Bakari, Bamba Mamadou, Tah Leonard, Kouamélan Essetchi Paul and Koné Tidiani

Abstract
Length-Weight relationships (LWR) of 18 fish species belonging to 12 families from the Grand-Lahou lagoon system in the south–west of Ivory Coast were studied. Samples were collected monthly from November 2013 through October 2014, using set of gill nets, bamboo traps, hooks, cast nets and completed with fish from artisanal landings. All length-weight regressions were highly significant, with the coefficient of determination (r^2) ranging from 0.722 (*Ethmalosa fimbriata*) to 0.974 (*Epinephelus aeneus*). The growth parameter (b) of LWR ranged from 2.262 (*Polydactylus quadrifilis*) to 3.942 (*Lutjanus goreensis*) and species exhibited both allometric (b<3, b>3) and isometric (b = 3) growth types. This study provides useful tool for more effective management of these fisheries. In addition, new data were recorded for the first time in Côte d'Ivoire for three species and West Africa for *Lutjanus dentatus*.

Keywords: growth parameter, grand-lahou lagoon, *Lutjanus dentatus*, Côte d'Ivoire

1. Introduction
Lagoon systems, together with other coastal ecosystems, contribute a large part of the ecological richness of the biosphere (Costanza *et al*., 1997) [1]. However, they are sensitive to climatic and human impacts (Dumay *et al*., 2004) [2]. In West Africa, estuaries and lagoons are sites of an important fishing industry for mollusks, crustaceans and fishes (N'Goran, 1998) [3]. In Côte d'Ivoire, the estuarine and coastal environments are subject to heavy human pressure. However, among the country different lagoon systems, Grand-Lahou lagoon seems to be one of the less stressed. Studies performed in Ebrie lagoon (Côte d'Ivoire) showed that fishing pressure could induce important changes on the fish community (Albaret and Laë, 2003) [4]. In other hand, the length-weight relationship (LWR) are widely presented by authors as useful tools frequently used in fish biology (Haimovici and Velasco, 2000 [5]; Da Costa and Araàjo, 2003 [6]; Ferreira *et al.,* 2008 [7]) with several purposes such as predict weight from length measured in yield assessment (Ecoutin and Albaret, 2003) [8], calculate the standing stock biomass (Martin-Smith, 1996) [9], evaluate condition indices (Safran, 1992) [10], estimate growth rates, age structure (Kohler *et al*., 1995) [11], make morphometric comparisons between species and populations (King, 1996; Gonçalves *et al.*, 1997) [12, 13], and several other aspects of fish population dynamics (Morato *et al*., 2001) [14]. These data raised LWR as an importante management tools for a sustainable use of fisheries resources. However, in Côte d'Ivoire, the few information available on LWR for lagoon or estuary system are those of Koffi *et al*. (2014) [15] on Aby lagoon system in the South East and Ecoutin and Albaret (2003) [8] on LWRs of 52 fish species from some West African lagoons and estuaries. Even if it is possible to use the already established relations for the same species in other sites or country (Gonzales *et al.,* 2000) [16], it is better to use local data for quantitative assessments given that these parameters have spatial disparities (Sparre *et al.,* 1989) [17]. In addition, the value of the allometric coefficient b estimated for a species can vary between stocks and even between areas (Andrade and Campos, 2002) [18]. Therefore the study of LWR parameters of fish species exploited in Grand-Lahou lagoon system which supports important fishery activities and seems to be one of the less stressed lagoon in Côte d'Ivoire is justified and aims to provide for the first time LWR information for 18 species of this lagoon.

2. Materials and methods

2.1 Study area

The Grand-Lahou lagoon system is located in south west of the Ivorian lagoons system (5° 08'-5° 03'N; 4° 51'-5° 25'W) (Fig. 1). It covers an area of 190 km² and stretches to about 50 km, from east to west with a maximum width of 14 km and a mean depth of 3 m (Laë, 1982) [19]. Water from the Atlantic Ocean enters the lagoon through the channel of Lahou-Kpanda in the eastern part and receives freshwater discharges from three connecting rivers: Bandama, Boubo and Gô (Laë, 1997) [20] (Figure 1). The mean annual water temperature in the region fluctuates from 25 °C to 28 °C (Konan *et al*., 2008) [21] and the climate of the area is an equatorial. The Grand-Lahou lagoon is characterized by a large area of swamps with a vegetation dominated by mangrove raphia palm (*Raphia sudanica*), African oil palm (*Elaeis guineensis*), and the coconut palm (*Cocos nucifera*) culture.

The study was focused on three stations which are the main landing site of the lagoon and also easily accessible at any season. The station one is an area located in the Tadio lagoon including the fisher's village of Tadjovalekro (Figure 1). The station two is closest to the city of Grand – Lahou in the Tagba lagoon in an area comprising the village of Agoudam and is influenced by marine waters and freshwater coming from Bandama and Gô rivers. The third station located at the connection of sea, the Tagba lagoon and the Bandama Rivers near a fishing ground called Passagri.

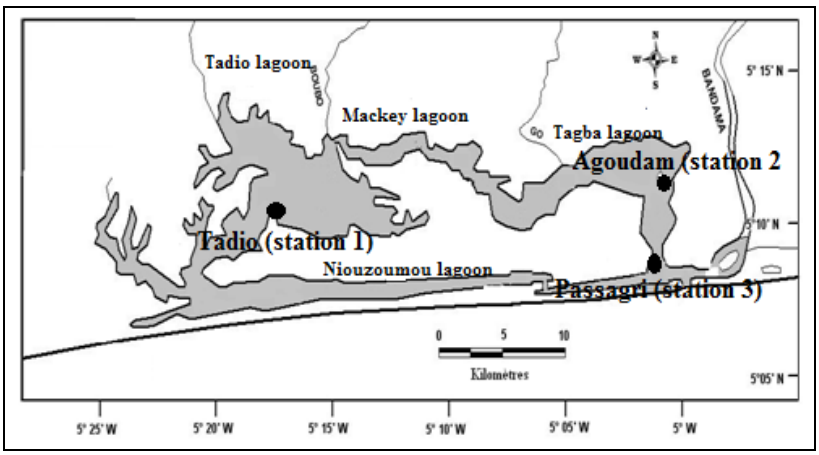

Fig 1: Map of Grand-Lahou lagoon showing sampling stations (●).

2.2 Data collection and analysis

Species were collected monthly over four days per site during the second part of the month from November 2013 through October 2014, using two set of 11 gill nets (10 to 60 mm stretched mesh), bamboo traps, hooks, cast nets and completed with fish randomly collected from artisanal landings at the same time. Captured fishes were identified following Paugy *et al*. (2003) [22]. Data on Standard Length (SL) in mm and total weight (W) in g were recorded for each fish. Only the species presenting a sample size higher than 10 individuals were taken into account. The relationship between the length and weight of a fish is usually expressed by Le Cren (1951) [23] fitting exponential curve equation, $W=aL^{b.}$ Where W is body weight (g), L is the standard length (mm), a is a coefficient related to body form and b (growth parameter) is an exponent coefficient indicating the growth type (Beverton and Holt, 1996) [24]. After logarithmic transformation of this relation (log10 W=log10 a+ b log10 L), parameters (a) and (b) were estimated by the least-square linear regression with a and b respectively the intercept and the slope of the linear regression (Zar, 1999) [25]. For each species, the data collected were validated by the analysis of the graph corresponding to length-weight relationships (Andrade and Campos, 2002; Ecoutin and Albaret, 2003) [8]. The degree of association between the variables was assessed by the determination coefficient (r^2). In order to verify if calculated b was significantly different from three, the Students t-test was used as expressed by the equation according to Sokal and Rohlf (1987) [26]: ts = (b-3)/SE where ts is the t-test value, SE the standard error of the slope b. The type of growth was determined using the ts value: If ts > 1,96 this implies that b≠3 so an allometric growth (negative allometric if b<3 and positive allometric if b>3) and if ts < 1,96 the implication is b=3 so an isometric growth.

3. Results

The LWR results of each species with several descriptive statistics are summarized in Table 1. A total of 6970 specimens were collected. They belong to 18 species and 12 families. The families with the highest species number were Cichlidae (n = 4). The samples size per species were ranged from 10 specimens [*Clarias anguillaris* Linnaeus, 1758] to 2025 [*Ethmalosa fimbriata* (Bowdich, 1825)]. Six species out of 18 [*C. anguillaris*, *Epinephelus aeneus (*Geoffroy Saint-Hilaire, 1817*), Lutjanus dentatus* (Duméril, 1861) and *Lutjanus goreensis* (Valenciennes, 1830)] were found with less than 30 specimens.

Fish sizes variations were ranged from 50 mm SL (4 g body weight) in *E. fimbriata* to 890 mm SL (1568 g body weight) in *Polydactylus quadrifilis* (Cuvier, 1829). Among the 18 collected species, four species, *C. anguillaris*, *L. dentatus*, *L. goreensis* and *Pelmatolapia mariae* (Boulenger, 1899) were described with size-class intervals lower than 100 mm.

All length-weight regressions were highly significant, with the coefficient of determination (r^2) ranging from 0.722 for *E. fimbriata* to 0.974 for *E. aeneus* figure 2. More than eighty eight percent (88.88%) of the LWRs had r^2 values higher than 0.80, while only 11.11% had r^2 lower than 0.80. The growth parameter (b) of LWR varied between 2.262 (in *P. quadrifilis*) and 3.942 (in *L. goreensis*). Species exhibited both allometric (b<3, b>3) and isometric (b = 3) growth types. Student's t-test: showed that the slope b was not significantly different from three for

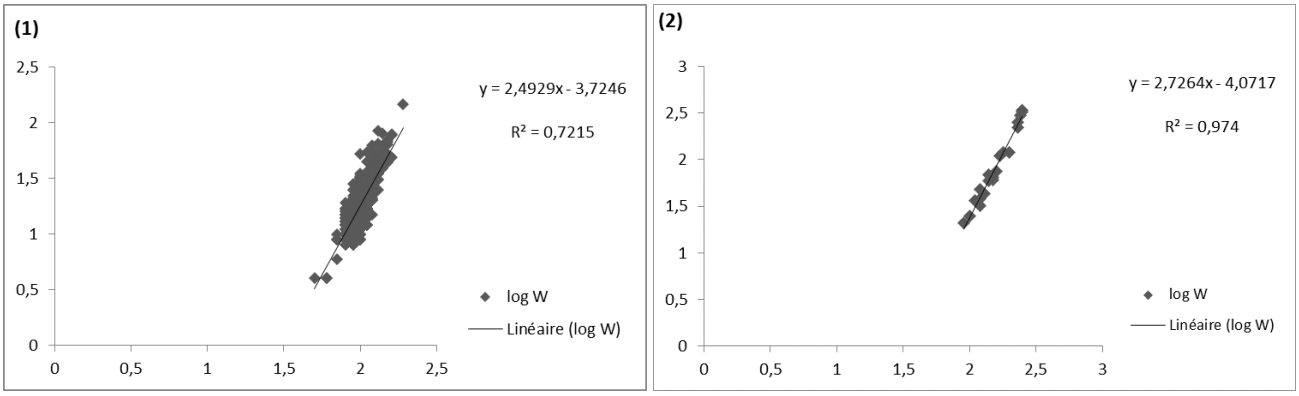

Fig 2. Log transformed Length-weight regression of *Ethmalosa fimbriata* (1), specie with the lowest r² and *Epinephelus* aeneus (2) specie with the highest r² among the 18 studied species in Grand-Lahou lagoon.

Arius latiscutatus, *C. anguillaris*, *L. dentatus* and *Trachinotus teraia* Cuvier, 1832 indicating an isometric growth for these species. The b value was significantly higher than the theoretical value of three for four species [*Elops lacerta* Valenciennes, 1847, *Liza facipinnis* (Valenciennes, 1836), *Mugil bananensis* (Pellegrin, 1927) and *L. goreensis*] indicating positive allometric (Table 1). The Student t-test showed significant lower values for the other ten species indicating negative allometric growth.

Table 1: Descriptive statistics and LWR parameters for 18 selected fish species of the Grand Lahou lagoon; * N: sample size; min: minimum; max: maximum; S.E.: standard error; b: slope; a: intercept; r^2: coefficient of determination; G: growth type; I: isometric; –A: negative allometrie; +A: positive allometrie.

		Length (mm)			Weigth (g)			Parameters of relationship					
Family / species	**N**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**a**	**b**	**SE (b)**	**r^2**	**ts**	**G**
ELOPIDAE													
E. lacerta	1530	187.3	100	320	79.2	9	337	0.006	3.055	0.010	0.876	5.681	+A
CLUPEIDAE													
E. fimbriata	2025	98.0	50	190	18.2	4	147	0.024	2.493	0.003	0.722	185.975	-A
CLAROTEIDAE													
C. nigrodigitatus	904	146.2	70	560	73.3	7	2643	0.018	2.643	0.029	0.906	12.312	-A
CLARIDAE													
C. anguillaris	10	199.0	150	230	86.6	39	122	0.009	2.880	0.092	0.900	1.305	I
ARIIDAE													
A. latiscutatus	81	362.8	110	640	1163.5	19	4939	0.007	3.114	0.135	0.963	0.845	I
SERRANIDAE													
E. aeneus	20	164.0	90	250	117.6	21	340	0.017	2.726	0.099	0.974	2.760	-A
CARANGIDAE													
C. hippos	193	113.9	60	310	56.8	9	970	0.012	2.908	0.027	0.935	3.477	-A
T. teraia	197	278.9	70	500	815.6	9	3950	0.011	2.992	0.107	0.971	0.072	I
LUTJANIDAE													
L. dentatus	26	158.8	120	190	94.9	45	170	0.010	2.955	0.048	0.827	0.953	I
L. goreensis	15	158.7	140	190	85.3	44	162	0.001	3.942	0.067	0.939	14.013	+A
HAEMULIDAE													
P. jubelini	150	155.6	70	230	99.2	9	283	0.014	2.826	0.015	0.908	11.408	-A
CICHLIDAE													
S. melanotheron	116	167.8	90	520	184.2	9	2579	0.047	2.335	0.051	0.805	13.146	-A
T. guineensis	484	141.6	90	370	120.3	9	850	0.034	2.513	0.020	0.831	24.191	-A
P. mariae	30	156.3	130	190	143.3	78	236	0.032	2.543	0.038	0.785	11.999	-A
T. jentinki	212	109.2	60	170	50.0	7	136	0.024	2.640	0.020	0.893	17.730	-A
MUGILIDAE													
L. facipinnis	737	176.9	110	380	105.0	23	942	0.008	3.032	0.015	0.875	2.068	+A
M. bananensis	179	182.5	120	360	117.0	29	942	0.005	3.211	0.028	0.932	7.501	+A
POLYNEMIDAE													
P. quadrifilis	61	232.5	110	890	243.7	24	1568	0.047	2.262	0.085	0.908	8.675	-A

4. Discussion

The range of b values (2.262-3.942) in our study were within the expected limits of (2-4) reported by Tesch (1971) [27] and Bagenal and Tesch (1978) [28] for most fish species. Similar b values were recorded by Koffi *et al*. (2014) [15] (2.229-3.911) for 30 Fish species in Aby Lagoon, Southeastern Côte d'Ivoire, Tah *et al*. (2012) [29] (2.173-3.472) for 36 freshwater species from two tropical reservoirs in Côte d'Ivoire, Konan *et al*. (2007) [30] (2.213-3.729) for 57 fish species in the coastal rivers of Southeastern Cote d'Ivoire and Ecoutin & Albaret (2003) [8] (2.458-3.473) for 52 species of West African lagoons and estuaries. The average of the coefficient of allometry of the 18 species in this work was established to 2,837 with a standard deviation of 0.387. This value is not significantly different from 3 (t-test: t = -1.783; df = 17; p > 0.05) as observed by Ecoutin & Albaret (2003) [8] for 52

species of West Africa lagoon and estuary. So the «cube law» can be applied to most of the species in the Grand Lahou lagoon contrary to Konan *et al.* (2007) [30] and Muto *et al.* (2000) [31] observation in their work respectively on Côte d'Ivoire southeastern rivers and São Sebastião System in Southeastern Brazil. The difference between these results could be related to the types of prospected habitats. Indeed both authors worked respectively on fresh water (rivers) and marine fish, while our work and those of Ecoutin & Albaret (2003) [8], were focused on brackish water (estuary and lagoon).

Thirteen species were present both in this study and those of Ecoutin & Albaret (2003) [8]. The slope b was often lower in our founding except for *L. bananensis* (3.211 *vs* 3.097) *L. goreensis* (3.942 vs 2.883) and *A. latiscutatus* (3.114 vs 2.994 and 3.028). In addition the growth types of a given species vary sometime, considering the studies area as point out in the followings comparison. On the 10 species common to the present study and those of Koffi *et al.* (2014) [15] in the Aby lagoon Côte d'Ivoire, two species show different growth type: *L. falcipinis* (positive allometric vs negative allometric) and *E. fimbriata* (negative allometric vs positive allometric). In comparison of Konan *et al.* (2007) [30], only *S. melanotheron* have a same growth type (negative allometric) on the six common species to both studies. The observed difference in slope and growth types could be due to sampling procedure (sample size and length range) (Morato *et al.*, 2001 [14]; Ecoutin & Albaret, 2003) [8] sexual dimorphism (Artigues *et al.*, 2003) [32], water quality or food availability on fish growth (Henderson, 2005) [33] and other differences in environmental or habitat factors (Morato *et al.*, 2001) [14].

No LWR data from Côte d'Ivoire were known for *A. latiscutatus*, *L. goreensis* and *L. dentatus.* However, except the last specie, LWRs data were reported from other region by Ecoutin & Albaret (2003) [8] for *A. latiscutatus* and *L. goreensis* by *Lalèyè* (2006) [34]. This study provides then, the first data on *Lutjanus dentatus* LWR.

Fishery statistics in Côte d'Ivoire consist mostly on rough estimates of total catch for all species, exploitation indices (e.g., number of canoes, fishermen) and, at best, average length or weight for some species of commercial importance (Tah *et al.*, 2012) [29]. Therefore, the present length-weight key for 18 fish species could be useful tool for more effective management of these fisheries and help biologists to derive weight estimates for un-weighed but measured fish, and estimated the biomass of captured fish species.

5. Conclusion

The first data base of the length-weight relationships parameters including first recorded data for *Arius latiscutatus* and *Lutjanus goreensis* in Côte d'Ivoire, *Lutjanus dentatus* in West Africa, are available for exploited fish species in Grand-Lahou lagoon system. The species growth type are as well positive, negative allometric and isometric. This study provides useful tool for more effective management of Grand-Lahou lagoon system which supports important fishery activities.

6. Acknowledgements

We would like to thank all the fishermen of Tadio, Agoudam and Lahou Kpanda for their support and their participation in the fishing activities. The present work was fully supported by laboratory of Hydrobiology (Université Felix Houphouet-Boigny, Abidjan) and the Oceanological Research Center of Abidjan (Côte d'Ivoire).

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