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Research Article

Length-weight Relationships of 30 Fish Species in Aby Lagoon, Southeastern Côte d' Ivoire

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Abstract: Most West African lagoons are very productive ecosystems that support important fishery activities. However, increases in human populations put heavy pressure on their resources. This raised the importance of sustainable management tools for these ecosystems. Length-Weight Relationships (LWRs) which is an important fish stock assessment tool was investigated in the Aby lagoon, southeastern Côte d'Ivoire. Fishes were caught monthly from February 2012 through March 2013 using gillnets. Fishes captured were identified, weighted to the nearest gram and standard length was measured to the nearest millimeter. The 30 fish species selected for this study belong to 18 families. The highest species number (n = 7) was recorded for Cichlidae family. All length-weight regressions were significant with a coefficient of determination (r^2) varying from 0.462 (*Parailia pellucida*) to 0.984 (*Elops lacerta*). Growth coefficient, b of the LWR ranged from 2.229 (*P. pellucida*) to 3.811 (*Eleotris vittata*). Nineteen species exhibited negative allometric growth pattern while 11 had positive allometric growth. These results are useful references for West African coastal lagoon management and particularly for that of the Aby lagoon system.

Keywords: Fish, growth parameters, lagoon, West Africa

INTRODUCTION

Worldwide, lagoon systems represent 13% of the coastline (Knoppers, 1994) and together with other coastal ecosystems contribute a large part of the ecological richness of the biosphere (Costanza *et al*., 1997). Due to their location between the continent and the sea and their shallow depths, lagoons are among the most productive ecosystems (Knoppers, 1994) but also very sensitive to both climatic and human impacts (Dumay *et al*., 2004). Lagoons can be high in productivity and serve as important nursery habitats that provide food and shelter for juvenile stages of many economically valuable fishes (Parrish, 1989).

In West Africa, estuaries and lagoons are sites of an important fishing industry for mollusks, crustaceans and fishes (Albaret, 1994; N'Goran, 1998). In this region the estuarine and coastal environments are also subject to heavy human pressure, with an annual population growth rate of 4-7 and 60% of industries located in coastal cities (Charles-Dominique, 1994; UNEP, 1999; Baran, 2000). Studies performed in Ebrie lagoon (Côte d'Ivoire) showed that fishing pressure could induced important changes on the fish community (Albaret and Laë, 2003): the main changes included lowering of fish diversity in catches, fish biomass, average catch length and trophic level of catches. These data raised the importance of management tools for a sustainable use of fisheries resources in these lagoons. Moreover, there is an urgent need to manage and regulate the small-scale coastal fishery in the region (Albaret and Laë, 2003; Njifonjou *et al*., 2006) and this requires basic population dynamics information for the target species.

Data on the functional Length-Weight Relationship (LWR) is important for fish stock assessment (Muto *et al*., 2000). Length and weight data are essential for estimating growth rates, age structure (Kohler *et al*., 1995), calculate the standing stocks biomass (Martin-Smith, 1996), condition indices (Safran, 1992) and several other aspects of fish population dynamics (Morato *et al*., 2001).

The present study describes the length-weight relationships for 30 coastal fish species in the Aby lagoon system which supports important fishery activities in south east Côte d'Ivoire.

MATERIALS AND METHODS

Study area: The Aby lagoon system is located in south east Côte d'Ivoire (2°51'-3°21'W and 5°01'-5°22' N) (Fig. 1). It covers an area of 424 km² and stretches for 24.5 km north to south and 56 km east to west with a

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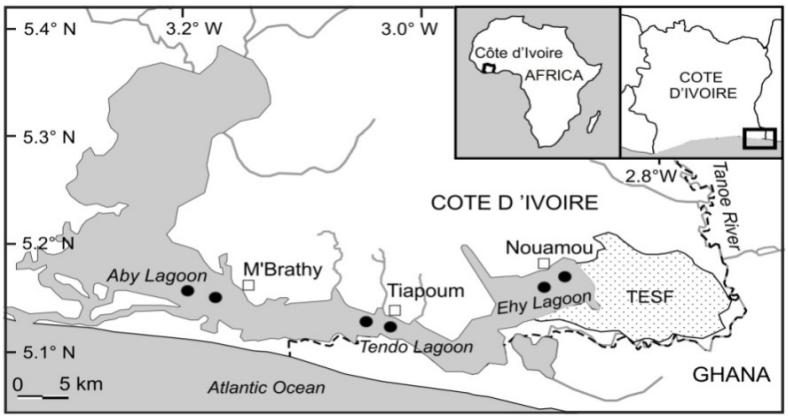

Fig. 1: Sampling sites (●) in the Aby lagoon system (Côte d'Ivoire). TESF = Tanoe Ehy Swamp Forest

maximum width of 15.5 km and maximum depth of 17 m (Avit *et al*., 1996; Kouadio *et al*., 2008). This lagoon receives freshwater discharge from the Tanoe and Bia rivers and the Tanoe-Ehy Swamp Forest (Seu-Anoï *et al*., 2011; Konan *et al*., 2013).

Data collection and analysis: Fish samples were collected monthly from February 2012 through March 2013 using two batteries of gillnet (06 to 60 mm stretched mesh). Fishes captured were identified following Paugy *et al*. (2003a, b) and Decru *et al*. (2012).

Data on Standard Length (SL) in mm and total weight (W) in g were recorded for each fish. Length-weight relationships of 30 species were estimated by fitting an exponential curve (Le Cren, 1951):

$$W = a \times SL^b$$

Parameters *a* and *b* were then estimated by the linear regression analysis from log-transformed data:

$$LogW = Loga + b \times LogSL$$

where,
a = The intercept
b = The slope (Tesh, 1971)

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). 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 3, the Students t-test was employed ($p<0.05$) (Sokal and Rohlf, 1987).

RESULTS

Summary of length-weight relationships for 30 fish species was presented in Table 1.

Species studied belong to 18 families. The families with the highest species number were Cichlidae (n = 7), Schilbeidae (n = 3), Clupeidae, Cyprinidae, Claroteidae and Carangidae (n = 2).

A total of 4466 individuals were collected and samples size ranged from 11 individuals for *Clarias buettikoferi* to 621 for *Pellonula leonensis*. Fish size was as small as 28.9 mm SL (28.6 g body weight) in *Chrysichthys nigrodigitatus* and as large as 400 mm (1145 g body weight) in *C. nigrodigitatus*.

All length-weight regressions were highly significant, with the coefficient of determination (r^2) ranging from 0.462 in *Parailia pellucida* to 0.984 in *Elops lacerta*. Eighty percent of the LWRs had r^2 values higher than 0.90, while 13.33% had r^2 values between 0.80-0.90. Only 6.66% had r^2 lower than 0.80.

Table 1: Number of specimens (n), standard length (minimum and maximum), total weight (minimum and maximum) and parameters of the length-weight relationship of fish species caught in Aby lagoon system, southeastern Côte d'Ivoire

		Length (mm)		Weight (g)		Length-weight relationship				
Family/Species	n	Min	Max	Min	Max	a	b	S.E. (b)	r^2	Growth
Elopidae										
Elops lacerta	38	105	220	12.6	144.5	0.004	3.202	0.143	0.984	A+
Clupeidae										
Ethmalosa fimbriata	21	87	135	13	56	0.004	3.438	0.310	0.952	A+
Pellonula leonensis	621	39	103	0.69	12.81	0.011	2.783	0.153	0.725	A-
Notopteridae										
Papyrocranus afer	13	230	390	73.05	400	0.005	3.046	0.033	0.972	A+
Mormyridae										
Marcusenius senegalensis	24	150	200	52.8	131	0.007	3.069	0.049	0.818	A+

Table 1: Continue

		Length (mm)		Weight (g)		Length-weight relationship				
Family/Species	n	Min	Max	Min	Max	a	b	S.E. (b)	r²	Growth
Hepsetidae										
Hepsetus akawo	50	81	255	5.75	300	0.005	3.245	0.173	0.982	A+
Cyprinidae										
Labeo coubie	122	85	280	16.25	513	0.011	2.980	0.014	0.947	A-
Barbus snoeksi	40	47	75	2.5	7.4	0.034	2.291	0.501	0.853	A-
Claroteidae										
Chrysichthys maurus	65	90	208	16.5	216	0.014	2.812	0.133	0.946	A-
Chrysichthys nigrodigitatus	541	28.9	400	3.25	1145	0.026	2.505	0.350	0.814	A-
Schilbeidae										
Parailia pellucida	386	53	95	1.39	7.2	0.026	2.229	0.545	0.462	A-
Schilbe intermedius	22	80	170	5.5	68.1	0.005	3.220	0.156	0.949	A+
Schilbe mandibularis	330	60	175	2.2	121.96	0.004	3.303	0.214	0.939	A+
Clariidae										
Clarias buettikoferi	11	150	222	31.44	96.51	0.018	2.557	0.313	0.916	A-
Monodactylidae										
Monodactylus sebae	84	35	135	4.2	204.1	0.020	2.849	0.107	0.964	A-
Carangidae										
Hemicaranx bicolor	34	85	115	19.1	51.4	0.013	2.934	0.047	0.916	A-
Caranx hippos	46	35	135	1.19	61.12	0.013	2.881	0.084	0.961	A-
Gerreidae										
Eucinostomus melanopterus	60	42	92	1.9	22.55	0.008	3.103	0.073	0.967	A+
Haemulidae										
Pomadasys jubelini	22	80	150	11.66	84.64	0.014	2.860	0.099	0.964	A-
Cichlidae										
Chromidotilapia guntheri	171	34	140	1.52	11081	0.013le	2.994	0.004	0.961	A-
Hemichromis fasciatus	149	43	152	2.5	150	0.008	3.164	0.116	0.973	A+
Sarotherodon melanotheron	326	44	175	3.4	220.7	0.014	2.933	0.047	0.947	A-
Tylochromis jentinki	242	40	180	1.9	195	0.012	2.960	0.028	0.962	A-
Tilapia guineensis	221	35	125	2.11	101.89	0.013	2.982	0.013	0.952	A-
Tilapia mariae	34	61	185	14.76	339	0.018	2.869	0.093	0.964	A-
Tilapia zillii	359	30	150	1.67	150	0.014	2.931	0.049	0.958	A-
Mugilidae										
Liza falcipinnis	184	70	200	5.78	164.6	0.009	2.971	0.021	0.968	A-
Gobiidae										
Porogobius schlegelii	80	45	95	1.7	19.25	0.011	2.879	0.086	0.927	A-
Eleotridae										
Eleotris vittata	38	75	169	5.61	157.69	0.002	3.811	0.573	0.952	A+
Paralichthyidae										
Citharichthys stampflii	132	74	160	6.95	91.52	0.004	3.430	0.304	0.891	A+

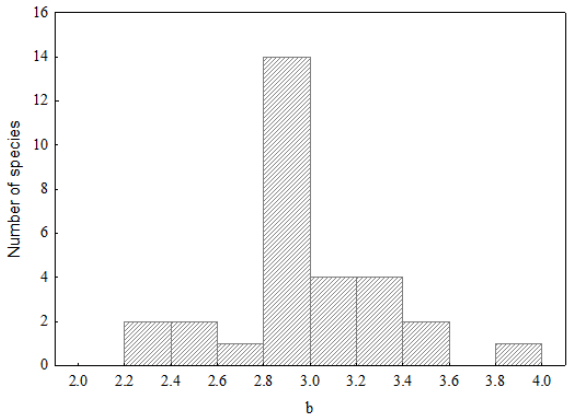

Fig. 2: Distribution of the value b of length-weight relationships for 30 fish species caught in Aby lagoon (Côte d'Ivoire)

The growth parameter (b) of LWR varied between 2.229 (in *P. pellucida*) and 3.811 (in *Eleotris vittata*), with a mean value of 2.974 (SD = 0.323). The median values of b was 2.965 (Fig. 2).

Species exhibited both allometric (b<3, b>3) and isometric (b = 3) growth types. The Student's t-test showed that the b (b = 2.994-2.229; SD = 0.232; t-test: t = -3.763; df = 18; $p<0.05$) was significantly lower than the theoretical value of 3 indicating negative allometric growth for 19 species (Table 1), while for 11 species the Student t-test showed significant higher values (b = 3.811-3.046; SD = 0.220; t-test: t = 4.150; df = 10; $p<0.05$) indicating positive allometric growth.

DISCUSSION

Fish species studied in the Aby lagoon varied in size between 28.9 mm SL (28.6 g BW) in *C. nigrodigitatus* and 400 mm SL (1145 g BW) in *C. nigrodigitatus*. Typical classical estuaries are distinguished by a higher proportion of juvenile sizes which utilize this habitat as nursery and feeding grounds. Therefore the absence of fish below 28.9 mm SL may be associated with fishing gear selectivity rather than implying the absence of small sized individuals.

Except for *P. pellucida* the correlation coefficient (r^2) for the length-weight relationship of the fishes (ranging from 0.725 in *P. leonensis* to 0.984 for *E. lacerta*) is high which indicate increase in length with increase in weight. This agreed with earlier studies involving fish species from different water bodies (Fagade, 1983; Lalèyé, 2006; Ayoada and Ikulala, 2007).

The values of b (growth exponent) for all the species were within the limits (2-4) reported by Tesch (1971) and Bagenal and Tesch (1978) for most fishes: b value of *Marcusenius senegalensis*, *Papyrocranus afer*, *Schilbe intermedius*, *S. mandibularis*, *Citharichthys stampflii*, *Eleotris vittata*, *Elops lacerta*, *Ethmalosa fimbriata*, *Eucinostomus melanopterus*, *Hemichromis fasciatus* and *Hepsetus akawo* (b>3.0) indicated positive allometry; while other species (b<3.0) had negative allometric growth. This b value range was comparable to those obtained by Tah *et al*. (2012) (2.173-3.472 for 36 freshwater species from two tropical reservoirs in Côte d'Ivoire), Konan *et al*. (2007) (2.213-3.729 for 57 species of small coastal rivers in south east Côte d'Ivoire) and Ecoutin and Albaret (2003) (2.458-3.473 for 52 species of West African lagoons and estuaries). These values usually ranged from 2.5 to 4.0 for many fish species and mostly remained within the expected range of 2.5-3.5 (Martin, 1949). When b = 3, the fish grows isometrically resulting in ideal shape of fish. When it is less than 3.0, the fish experiences a negative allometric growth like in *Labeo coubie*, *Liza falcipinnis*, *Monodactylus sebae*, *P. pellucida*, *P. leonensis*, *Pomadasys jubelini*, *Porogobius schlegelii*, *Sarotherodon melanotheron*, *Tilapia guineensis*, *T. mariae*, *T. zillii*, *Tylochromis jentinki*, *Barbus snoeksi*, *Caranx hippos*, *Chromidotilapia guntheri*, *Chrysichthys maurus*, *C. nigrodigitatus*, *Hemicaranx* bicolor and *Clarias buettikoferi* of present study. When the value of b is more than 3.0, the fish grow following the positive allometric pattern.

The study of Konan *et al*. (2007) was performed in a geographically closer site with present study. Twenty one species were found common between this study which was undertaken in some Ivorian coastal rivers (Bia, Soumié, Eholié, Ehania and Noé) (Konan *et al*., 2007) and Aby lagoon (present study). Among these species, 13 (*Elops lacerta*, *Pellonula leonensis*, *Papyrocranus afer*, *Marcusenius senegalensis*, *Labeo coubie*, *Chrysichthys nigrodigitatus*, *Pomadasys jubelini*, *Chromidotilapia guntheri*, *Eucinostomus melanopterus*, *Tylochromis jentinki*, *Tilapia guineensis*, *Tilapia mariae* and *Liza falcipinnis*) showed isometric growth patternes in the coastal rivers (Konan *et al*., 2007) while they exhibited allometric growth (b>3 in *Elops lacerta*, *P. afer*, *M. senegalensis* and *E. melanopterus*; b<3 in *P. leonensis*, *L. coubie*, C. *nigrodigitatus*, *P. jubelini, C. guntheri, T. jentinki, T. guineensis*, *T. mariae* and *L. falcipinnis*) in the Aby lagoon. *Hepsetus akawo*, *Chrysichthys maurus*, *Schilbe intermedius, Schilbe mandibularis*, *Sarotherodon melanotheron* and *Tilapia zillii* presented the same growth characteristics between these two habitats while *Parailia pellucida* and Hemichromis *fasciatus* showed diffferent allometric growth patterns (b>3 *versus* b<3) between coastal rivers studied by Konan *et al*. (2007) and the Aby lagoon. Furthermore some b data from many freshwater species appeared different between Ayame 1 and Buyo reservoirs (Côte d'Ivoire) (Tah *et al*., 2012) and the Aby lagoon. For instance *L. coubie* and *C. nigrodigitatus* presented isometric growth patterns in Buyo reservoir, while they showed allometric growth characteristics in Aby lagoon. Some species (*Chrysichthys maurus*, *C. guntheri* and *S. melanotheron*) had the same growth patterns between these reservoirs and the Aby lagoon, but others (Schilbe intermedius, *Schilbe mandibularis* and *T. zillii*) presented different (b>3 *versus* b>3) allometric growth between these revervoirs and the Aby lagoon.

Several authors have reported both isometric and allometric growth for different species from various water bodies (King, 1991; Oribhabor *et al*., 2009). Parameters of length weight relationships are affected by several factors such as season, sample size, habitat, gonad maturity, sex, diet and stomach fullness, health, fish activities, seasonal growth rates and preservation techniques (Bagenal and Tesch, 1978; Mizuno and Furtado, 1982; Lowe-McConnell, 1987). Other factors such as temperature, trophic level and food availability in the community are also important (Mizuno and Furtado, 1982; Lowe-McConnell, 1987). All of these effects were not considered in the present study. Our results could be considered as mean annual values for the species since the fish samples were collected during different seasons throughout the sampling period and the data do not represent a particular season or time of the year. The regional differences of estimated b values may present spatial variations resulting from the influence of water quality or food availability on fish growth (Sparre *et al*., 1989; Mommsen, 1998).

In the current study maximum fishes showed deviations from the ideal value (b = 3). Similar observations were made for other West African fish population: in two reservoirs (Tah *et al*., 2012) and in some small coastal rivers of Côte d'Ivoire (Konan *et al*., 2007). Overall, it is recognized that only a fair number of species seems to approach the ideal growth pattern with b value equal to 3 (Anbalagan *et al*., 2009; Oribhabor *et al*., 2011).

This study provided the basic information on the length-weight relationships of 30 fish species from the Aby lagoon system that will be useful for the management of fishery resources.

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