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Length–Weight Parameters for 32 Species from the Marchica Lagoon (Mediterranean, Morocco)

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ABSTRACT

Length–weight relationships for 32 coastal fish species from the Mediterranean Marchica coastal lagoon, Nador (north-eastern Morocco) are presented in this study. Field studies were conducted during the period 2015–2016. The sampling gear used was a large seine net, targeting pelagic and demersal fish species. The most abundant families were Gobiidae, Labridae, Engraulidae, Atherinidae, Clupeidae and Sparidae. The fit of the equations ($W=a\ L^b$) with a and b parameters estimated from regular and functional regression (of log-transformed weight and length data) were determined. The exponent b varied between 2.1317 for *Sparus aurata* and 3.4897 for *Pagellus acarne*, whereas all the remaining values of b were higher than 2.91.

INTRODUCTION

The length-weight ratio of marine populations is very important for an effective exploitation and management. These relationships were initially used to provide information on the condition of marine species and decide whether somatic growth was isometric or allometric **(Le Cren, 1951; Ricker, 1975)**.

In fisheries biology, the length-weight relationship is frequently used to transform growth in length equations for the estimations of weight at age and use in stock assessment models **(Pauly & Christensen, 1993)** to evaluate condition indices **(Anderson *et al.*, 1983)**, and for the life histories and morphological comparisons of populations deriving from various areas **(Petrakis & Stergiou, 1995; Ecoutin *et al.*, 2005)**.

Length–weight relationships have been addressed along the Algerian coast **(Ansell *et al.*, 1980; Chaoui *et al.*, 2006)**, Greece **(Petrakis & Stergiou, 1995; Moutopoulos & Stergiou, 2002)**, the eastern Mediterranean Sea, in Turkish waters **(Taskavak & Bilecenoglu, 2001; Can *et al.*, 2002; Ismen, 2003; Yeldan *et al.*, 2003)**, Egypt **(Abdallah, 2002)**, the western Mediterranean Sea in Spain **(Valle *et al.*, 2003)**, Libya **(El Tawil *et al.*, 2004)**, Tunisia **(Cherif *et al.*, 2008)** and Italy **(Battaglia *et al.*, 2010)**.

A study on the length-weight relationship has already been discussed in the Moroccan Atlantic Sea, Merja Zerga **(Kraïem *et al.*, 2001)**, but no information on the length-weight relationships for the species of Marchica (coastal lagoon) has been previously recorded.

In the current research, the length-weight relationships of 32 species collected in the coastal lagoon of Marchica (north-eastern Morocco) were addressed. These species are mostly frequent in shallow waters as well as commercial juvenile fish species that use the coastal lagoon as a nursery habitat.

MATERIALS AND METHODS

1. Study area and sampling

The Marchica lagoon (35° 09′ 36″ N, 2° 50′ 24″ O), also known as the Nador lagoon, with its 115 km^2 (25 km long and 7.5 km wide) constitutes the second largest lagoon in North Africa and the unique coastal lagoon on the Mediterranean coast of Morocco, Fig.1. This lagoon reaches a maximum depth of approximately 8 meters. A long sandbar (Lido) of 25 km separates the lagoon from the Mediterranean Sea, with an artificial opening of about 300 m wide and 6 m deep, which allows water exchange.

In addition to its value, ecologically (Site of Biological and Ecological Interest since 1996; Ramsar Site since 2005) and socio-economically (mainly artisanal fisheries), the lagoon is exposed to a pressure from a complex mix of human-induced stress factors such as urbanization, pollution, overfishing, tourism and sewage, among others.

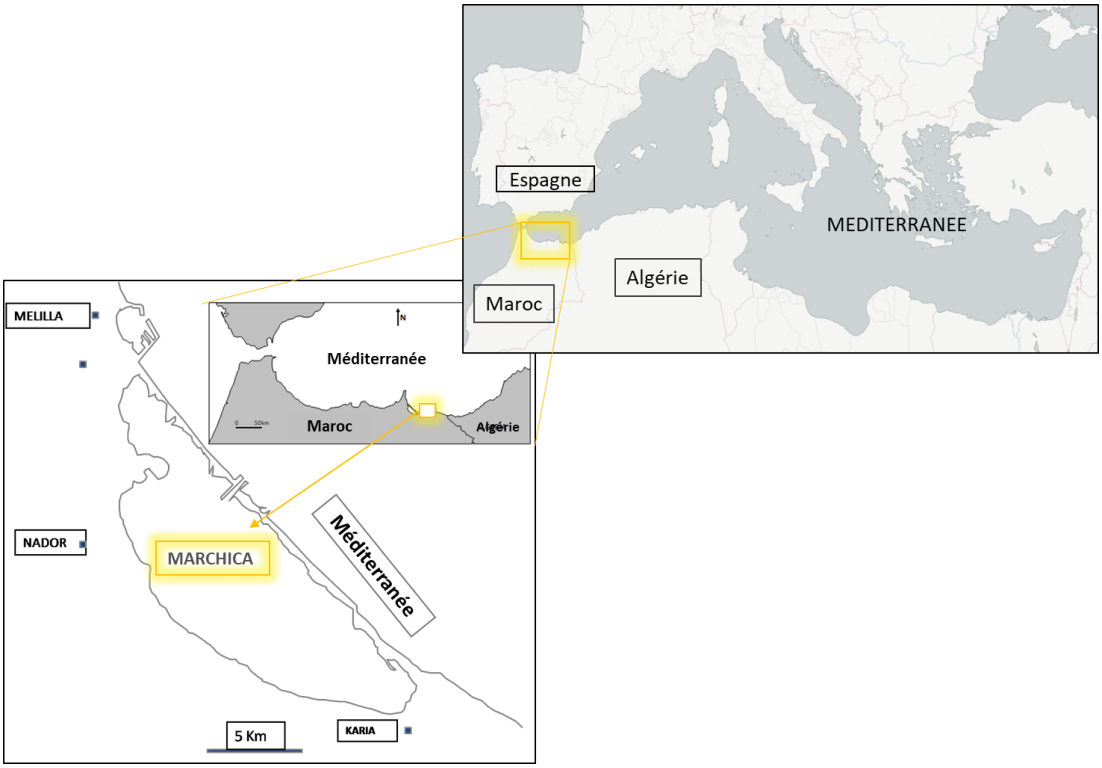

Fig. 1 Localisation of the Marchica lagoon on the Mediterranean coast of Morroco.

2. Biological measurements

Identified specimens were measured for total length (TL) to the nearest 0.1 cm and weighed (total weight, TW) to the nearest 0.01 g.

3. Statistical Analysis

The estimation of a and b parameters of the function $W = a L^b$ and the determination of all the length–weight relationships were obtained by using the least squares fitting method, in which the data of W and L were log transformed, where W is the weight of the specimens in grams; L is the total length in cm; a is a coefficient related to the shape of the body; and b the regression coefficient is an exponent indicating isometric growth when it is equal to 3. The significance of the regression and the b-value for each species tested by t-test were assessed by the Rstudio to verify that it was significantly different from the isometric growth **(Zar, 1996), Table 1**.

RESULTS

In this survey, overall 12766 specimens, belonging to 32 species and 17 different families were weighed and measured. In the course of the survey, the Gobiidae, Labridae, Engraulidae, Atherinidae, Clupeidae and Sparidae were the most abundant families.

Samples of all species were taken throughout the year. These data are therefore

not representative of a specific season and the length-weight parameters estimated must be considered as mean annual values.

Results in **Table 1,** showed length-weight relationships and length characteristics for 32 species. The specimens number is (n), ranges of length (minimum and maximum), the parameters of the length-weight relationship are (a) and (b), the coefficient of determination is (r^2), the significance of the value p, (+) is for $p < 0.05$ and (-) is for $p > 0.05$, all of which were determined by the Rstudio program, and the growth types are indicated.

Table. 1 Parameters Length (L)–weight (W) relationships of 32 species from the Marchica coastal lagoon, Nador (north-eastern Morocco).

Family	Scientific name	n	Min	Max	a	b	r^2	P-Value	Growth type
Anguillidae	*Anguilla anguilla*	44	7	72	0.039	2.805	0.95861	+	allometric (-)
Atherinidae	*Atherina boyeri*	1189	2.5	15	0.0056	3.1007	0.93652	+	allometric (+)
Blenniidae	*Salaria pavo*	165	4.7	14.5	0.0086	3.066	0.96154	+	allometric (+)
Bothidae	*Arnoglossus rueppelli*	12	5	13.1	0.01	3.0057	0.99116	+	allometric (+)
Carangidae	*Trachinotus ovatus*	114	6.7	55	0.0171	2.7243	0.91721	+	allometric (-)
	Trachurus trachurus	86	1.9	21	0.0097	2.9854	0.97944	+	allometric (-)
Clupeidae	*Sardina pilchardus*	1057	1.1	171	0.0081	2.9844	0.84439	+	allometric (-)
Engraulidae	*Engraulis encrasicolus*	1668	2.9	11	0.0051	3.0481	0.95358	+	allometric (+)
Gobiidae	*Gobius cruentatus*	195	4.8	9.2	0.0199	2.7193	0.80555	+	allometric (-)
	Gobius niger	3853	0.7	13.2	0.0182	2.7953	0.85422	+	allometric (-)
	Gobius paganellus	44	5.6	10.5	0.0107	3.1297	0.8145	+	allometric (+)
Hemiramphidae	*Hyporhamphus picarti*	65	12	20	0.0035	2.8022	0.89662	+	allometric (-)
Labridae	*Symphodus cinereus*	1390	4.2	14.4	0.0118	3.1307	0.94413	+	allometric (+)
	Symphodus ocellatus	73	5.2	12.3	0.015	2.9476	0.70772	+	allometric (-)
Moronidae	*Dicentrarchus labrax*	11	9.1	51	0.084	3.0404	0.99095	+	allometric (+)
Mullidae	*Mullus barbatus*	167	5.4	19.2	0.0067	3.2299	0.95562	+	allometric (+)
	Mullus surmuletus	24	5.6	10.2	0.0065	3.3596	0.96584	+	allometric (+)
Scorpaenidae	*Scorpaena maderensis*	139	7	27	0.054	3.1749	0.97222	+	allometric (+)
Sepiidae	*Sepia officinalis*	741	1	17	0.4664	2.4227	0.94165	+	allometric (-)
Sparidae	*Diplodus vulgaris*	578	2	16.5	0.0112	3.1827	0.98949	+	allometric (+)
	Lithognathus mormyrus	14	8.2	22.5	0.0197	2.8497	0.97933	+	allometric (-)
	Pagellus erythrinus	13	4.7	19.1	0.0175	2.9481	0.99326	+	allometric (-)
	Pagellus acarne	142	3.5	14.5	0.0042	3.4897	0.97344	+	allometric (+)
	Sparus aurata	22	11	24.5	0.1303	2.1317	0.72014	+	allometric (-)
	Sparus aurita	92	9.9	24.6	0.0304	2.5418	0.90769	+	allometric (-)
	Spicara smaris	21	7.4	12.9	0.0109	2.9885	0.97789	+	allometric (-)

	Sarpa salpa	48	9.6	21.7	0.014	3.0259	0.98674	+	allometric (+)
	Diplodus annularis	283	2.6	16	0.0122	3.1576	0.90705	+	allometric (+)
	Diplodus sargus	24	6.2	20	0.0155	3.0643	0.99601	+	allometric (+)
	Boops boops	393	3.6	15.4	0.0061	3.2541	0.97522	+	allometric (+)
Sphyraenidae	*Sphyraena sphyraena*	88	16	48	0.0073	2.8318	0.96245	+	allometric (-)
Syngnathidae	*Syngnathus acus*	11	8	11.3	0.0008	2.8075	0.88387	+	allometric (-)

(n) is the sample size; (min) and (max). are minimum and maximum total lengths in (cm); (a) and (b) are the parameters of the length–weight relationship;(r^2) is the coefficient of determination.

The sample size ranged from 3853 specimens for *Gobius niger* to 11 specimens for *Syngnathus acus* and *Dicentrarchus labrax.*

The majority of r^2 values were higher than 0.80, excluding two species: *Sparus aurata* (r^2 = 0.72014, 22 individuals), *Symphodus ocellatus* (r^2 = 0.70772, 73 individuals).

In this study, the exponent b ranged from 2.1317 for *Sparus aurata* and 3.4897 for *Pagellus acarne*, while all other b values were greater than 2.91, **Table 1**.

Concerning the type of growth, all species showed an allometric growth ($b \neq 3$) **Table 1**, whereas 16 species showed negative allometric growth (b<3), and the other 16 species showed positive allometric growth (b>3), with most relationships being highly significant ($P < 0.05$).

DISCUSSION

This study showed differences in b-values between length and weight. The exponent b is often close to 3, varying in value from 2 to 4 **(Tesch, 1971)**. Values of b equal to 3 indicate that fish grow isometrically; values other than 3 indicate allometric growth.

The differences in b values obtained in this study can be attributed to one or more of the following factors: the season and the effects of different areas, temperature and water salinity changes, sex, food availability, differences in the number of specimens examined also differences in the observed length ranges of the species caught **(Weatherly and Gill, 1987; Moutopoulos and Stergiou, 2002)**. **Dulcic and Kraljevic (1996)** reported that the parameters estimated for length-weight relationships can be different depending on the season and year, mainly due to the physico-chemical characteristics of the environment, sex and maturity stage of a given species, which were not considered in this study.

The negative allometric growth (b<3) of the 16 species means that they grow faster in length than in weight and the positive allometric growth (b>3) of the 16 other species means that they grow faster in weight than in length **(Karachle and Stergiou, 2012)**.

This study could serve as a comparison with similar studies on estuaries and coastal lagoons in the Mediterranean Sea and could be useful in situations where fish populations are subject to commercial fishing, restoration programmes or indeed any other management activity.

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