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Full Length Research Paper

Length-weight relationships for 13 fish species from the Gulf of Gabes (Southern Tunisia, Central Mediterranean)

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Length-weight relationships (LWR) were estimated for 13 fish species which are of economic relevance in the commercial fisheries of the Gulf of Gabes (southern Tunisia). A total of 2403 fish specimens were sampled with several fishing gears from October 2008 to September 2009. The sample size ranged from 65 individuals for *Coryphaena hippurus* to 346 for *Euthynnus alletteratus*. The *b* values in the LWR, $W = aL^b$ ranged from 2.807 to 3.284, with a mean of 3.015 ± 0.102 and intercepts between 0.0011 and 0.0432 with a mean of 0.0139. The condition factor (c.f.) values significantly ($p < 0.05$) ranged from 0.64 to 1.55.

Key words: Gulf of Gabes, length-weight, fish species, condition factor.

INTRODUCTION

The relationship between body length and weight (LWR) is of great importance in fishery biology (Sparre et al., 1989; Gulland, 1983). Such data are essential for a wide number of studies, for example, estimating growth rates, age structure and other aspects of fish population dynamics (Kolher et al., 1995). Length-weight regressions have been extensively used to estimate weight from length because of technical difficulties and the amount of time required to record weight in the field. Furthermore, standing crop biomass can be estimated (Morey et al., 2003) and seasonal variations in fish growth can be tracked this way (Richter et al., 2000). However, the length-weight parameters of the same spe-cies may be different in the population because of feeding, reproduction activities and fishing etc. Therefore, data on functional LWR of fish species is important for fish stock assessment and parameters *a* and *b* can be used for length-weight conversion.

The Gulf of Gabes is located in the south eastern part of Tunisia, it extends from Ras Kapoudia, at the parallel 35°N, to the Tunisian-Libyan borders. The gulf of Gabes particularly represents a large nursery for several fish species in the Mediterranean and is regarded as an extremely vital fishing zone. This area is considered as one of the most important areas for fishing in Tunisia (Bradai et al., 1995). Length-weight relationships data in the Gulf of Gabes for several fish species are limited including most of the commercially important species. Moreover, after a large effect of the fishing pressure on the resource and the rejection of industrial area in the Gulf of Gabes, there is an urgent need to manage and regulate the important fishery in the region, and this requires basic population dynamics information for the target species. The study conducted for this purpose established length-weight relationships of thirteen commercial species in the Gulf of Gabes between October 2008 and September 2009.

MATERIALS AND METHODS

Length-weight relationship study was carried out in 2403 specimens of 13 species (Table 1) exploited in the gulf of Gabes (Figure 1). Fish samples were obtained in landing ports of the Gulf of Gabes between October 2008 and September 2009 with various fishing gears (trammel nets, gill nets, bottom trawls, purse seine and beach

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Table 1. Descriptive statistics and estimated parameters of the length-weight relationship for 13 fish species from the Gulf of Gabes.

				Length characteristics (cm)				Relationship parameters					
Family	**Species**	**Sex**	**N**	**type**	**min**	**max**	**mean (±SD)**	**a**	**b**	**SE of b**	**R^2**	**t-test**	**c.f (±SD)**
Scombridae	*Euthynnus alletteratus* (Rafinesque, 1810)	Males	127	Fl	34	97.8	54.65±7.14	0.0282	2.848	0.123	0.99	5.312s	1.52±0.23
		Females	187	Fl	35.5	90.5	50.38±6.12	0.0211	2.919	0.312	0.97	2.205s	1.55±0.33
		Both	346	Fl	19.2	97.8	49.5±7.23	0.0194	2.941	0.223	0.99	3.611s	1.54±0.58
	Scomber scombrus (Linnaeus,1758)	Males	36	Tl	18	33.4	21.56±1.54	0.0020	3.283	0.023	0.99	4.223s	0.87±0.45
		females	43	Tl	18.9	33	22.01±1.42	0.0021	3.156	0.033	0.99	5.421s	0.93±0.65
		Both	85	Tl	18	33.4	22.77±1.63	0.0032	3.245	0.020	0.98	3.455s	0.92±0.24
Carangidae	*Trachurus mediterraneus* (Steindachner, 1863)	Males	89	Tl	14.2	30.4	19.11±0.65	0.0131	2.807	0.162	0.93	2.311s	0.78±0.18
		Females	123	Tl	14	29.3	19.67±0.74	0.0086	2.933	0.154	0.93	0.943	0.77±0.21
		Both	272	Tl	8.8	30.4	17.97±0.66	0.0079	2.969	0.123	0.96	0.879	0.77±0.15
	Caranx crysos (Mitchill, 1815)	Males	87	Tl	14.6	34.9	23.11±1.05	0.0123	3.037	0.114	0.99	1.205	0.78±0.31
		Females	61	Tl	15.3	34.7	23.19±1.21	0.0120	3.042	0.080	0.99	1.116	0.75±0.41
		Both	189	Tl	11.4	34.9	21.73±1.32	0.0128	3.023	0.092	0.99	1.223	0.76±0.15
Sparidae	*Lithognathus mormyrus* (Linnaeus. 1758)	Males	98	Tl	15.5	24	19.4±0.75	0.0070	2.968	0.041	0.96	1.122	1.00±0.42
		Females	48	Tl	15	24	18.78±0.65	0.0084	2.998	0.010	0.97	0.203	1.20±0.48
		Both	161	Tl	15.5	24	18.1±0.84	0.0071	2.931	0.091	0.96	1.560	0.95±0.33
	Boops boops (Linnaeus, 1758)	Males	103	Tl	13	21.8	15.87±0.71	0.0087	3.091	0.055	0.95	1.273	0.95±0.12
		Females	244	Tl	13	22.6	15.89±1.1	0.0102	3.032	0.062	0.95	0.747	0.98±0.24
		Both	346	Tl	12.6	22.6	15.86±0.84	0.0102	3.034	0.023	0.95	0.934	0.91±0.33
	Diplodus annularis (Linnaeus, 1758)	Males	56	Tl	9.8	15	12.6±2.42	0.0321	2.995	0.045	0.94	0.231	0.89±0.36
		Females	78	Tl	10	16	12.9±2.23	0.0244	2.962	0.023	0.96	0.621	0.88±0.45
		Both	161	Tl	9.8	16	13.1±2.54	0.0253	3.012	0.031	0.95	1.111	0.81±0.45
	Pagellus erythrinus (Linnaeus, 1758)	Males	49	Tl	14.6	23.2	18.78±3.11	0.0120	3.004	0.029	0.90	0.027	1.12±0.42
		Females	80	Tl	14.1	22.6	17.46±2.45	0.0141	2.932	0.465	0.88	0.560	1.10±0.35
		Both	129	Tl	14.1	23.2	17.96±3.12	0.0109	3.030	0.053	0.90	0.336	0.99±0.42
Clupeidae	*Sardinella aurita* (Valenciennes, 1847)	Males	112	Tl	12.5	23.2	18.86±2.22	0.0053	3.144	0.013	0.95	2.141s	0.74±0.23
		Females	138	Tl	12.4	24	18.77±2.12	0.0032	3.284	0.022	0.96	4.702s	0.84±0.37
		Both	328	Tl	7.8	24	17.12±2.31	0.0074	3.009	0.025	0.96	0.276	0.77±0.21
Mugilidae	*Liza aurata* (Risso, 1810)	Males	33	Tl	18.8	30.5	21.5±4.12	0.0011	2.976	0.056	0.93	1.230	1.15±0.62
		Females	37	Tl	19.1	31.2	22±3.56	0.0015	2.966	0.042	0.94	2.133s	1.24±0.29
		Both	70	Tl	18.8	31.5	21.7±3.45	0.0014	2.965	0.038	0.92	1.450	1.10±0.44
	Liza saliens (Risso, 1810)	males	55	Tl	18.3	29.5	19.6±2.41	0.0432	2.956	0.041	0.95	3.114s	0.88±0.55
		Females	71	Tl	18	29.4	19.5±1.86	0.0356	2.963	0.034	0.95	2.276s	0.80±0.23
		Both	136	Tl	15.4	29.5	18.4±1.87	0.0321	2.975	0.028	0.94	1.310	0.74±0.21
Belonidae	*Belone belone* (Linnaeus. 1761)	males	47	Tl	24.8	52.4	40.56±4.41	0.0253	3.095	0.101	0.97	0.450	0.64±0.31
		Females	68	Tl	26	52	41.86±4.32	0.0158	3.102	0.076	0.98	2.061s	0.72±0.19
		Both	115	Tl	24.8	52.4	40.12±4.85	0.0102	3.132	0.086	0.97	2.635s	0.66±0.23
Coryphaenidae	*Coryphaena hippurus* (Linnaeus, 1758)	Males	24	Tl	44.9	88.2	61.6±6.77	0.0214	2.941	0.096	0.95	4.365s	0.75±0.18
		Females	41	Tl	44.2	87.5	60.2±6.23	0.0124	2.963	0.064	0.95	2.227s	0.83±0.21
		Both	65	Tl	44.2	88.2	61.3±6.44	0.0133	2.954	0.088	0.96	3.081s	0.77±0.52

Number higher than the sum of males and females because sex identification was not amenable for all individuals; s: $p < 0.05$.

seine). Total or fork length of each fish were measured to the nearest 0.1 cm, using a measuring board, and indivi-duals were weighed on a digital balance with a precision of 0.1 g; sex was recorded when possible for all the fish species of the sample collected. The LWR was estimated by using the equation (Ricker, 1973)

$W = aL^b$

Where, W is body weight (g), L is total or fork length (cm), a is the intercept and b is slope (Tesch, 1971). The para-meters a and b of the length-weight regression of the 13 species were estimated using the Log-transformed equation:

Log (W) = Log (a) + b Log (L)

Where, log L is the independent and log W dependent variables.

The association degree between length weight variables was calculated by the determination coefficient (R^2). LWR are originally used to provide information on the condition of fish, and may help determine whether somatic growth is isometric; b = 3 or negative allometric: b < 3 or positive allometric: b > 3 (Ricker, 1973; Spiegel, 1991). Confidence limits (95%) of the parameters b were estimated (Santos et al., 2002). Student's t-test was used to determine whether the coefficient b was significantly different from 3 (Teissier, 1948). Normality of the b distribution was also tested through symmetry and kurtosis analyses (Zar, 1996).The condition factor (c.f.) was calculated by using the formula (Pauly, 1983)

$c.f. = 100\ W/L^3$

Where, W= weight in grams; L= total or fork length (cm).

RESULTS AND DISCUSSION

A total of 2403 individual fish length and weight observations were recorded for the 13 species, belonging to 7 families, analyzed in this study. With the exception of *Liza aurata* (Fehri-Bedoui et al., 2002), *Belone belone* (Fehri-Bedoui and Gharbi, 2004), *Pagellus erythrinus* (Ghorbel and Bouain, 1990) and *Diplodus annularis* (Bradai et al., 2001), our results constitute the first information for 9 of the 13 species regarding populations of the Gulf of Gabes. Sample descriptive statistics and estimated parameters of the length-weight relationships are given in Table 1.

The high statistical significance of the deter-mination coefficient (R^2), which varied in the range of 0.9 – 0.99 (P < 0.05), attested to the existence of a strong correlation between length and weight.

The sample size ranged from 65 individuals for *Coryphaena hippurus* to 346 for *Euthynnus alletteratus.* Values of *b* ranged from 2.807, for males of *Trachurus mediterraneus* to 3.284 for females of *Sardinella aurita* with an average of 3.015 ± 0.102 at 95% confidence level. The estimated figures are in agreement with Pauly et al. (1997). In this sense, *b* varied in the range of 2.5 - 3.5, suggesting that the result of this study is valid. In the present study, isometric growth (p > 0.05) was observed for 9 species (*T. mediter-raneus*, *Caranx crysos*, *Lithognathus mormyrus*, *Boops boops*, *D. annularis*, *P. erythrinus*, *S. aurita*, *L. aurata* and *Liza saliens*), negative allometic growth (P < 0.05) was observed for *E. alletteratus* and *Coryphaena hippurus* and positive allometric growth (P < 0.05) was observed for *Scomber scombrus* and *Belone belone*. Similar results were obtained for *B. Boops* (Cherif et al., 2008), *T. mediterraneus* (Cherif et al., 2008). *S. scombrus* (Rodriguez-Roda, 1966; Cherif et al., 2008; Hajjej et al., 2009) and *P. erythrinus* (Abdallah, 2002). Statistical significance in the length-weight relationship between sexes was observed for *T. mediterraneus* (t = 5.12; P < 0.05), *L. aurata* (t =3.31; P < 0.05) and *B. belone* (t = 6.42; P < 0.05). The significant differences in slope of length-weight relationship between females and males could be due to the difference between length and weight in sexes. For the other species, there are no significant differences bet-ween sexes. Cherif et al. (2008) presented length-weight relationships for 11 fish species from the Gulf of Tunis (Northern Tunisia), including 6 also examined in this study, these species are *B. boops* (b = 3.06; R^2 = 0.96), *T. mediterraneus* (b = 3.01; R^2 = 0.98), *S. scombrus* (b = 3.37; R^2 = 0.98), *L. mormyrus* (b = 2.84; R^2 = 0.96), *D. annularis* (b = 2.9; R^2 = 0.86) and *P. erythrinus* (b = 2.85; R^2 = 0.96). Such differences in b values can be attributed to the combination of one or more of the following factors: Differences in the number of specimen examined and area/season effect and differences in the observed length ranges of the specimen caught. It is recognized that a number of factors are known to influence the length-weight relationship in fish, including growth phase, sex, seasons, food (quantity, quality and size), stage of maturity and health and general fish condition (Tesch, 1971; Ricker, 1973; Hossain et al., 2006). These factors were not accounted for in the present study. The distribution of the LWR exponents (b) of the 13 species exhibited asymmetric distribution (g_1 = 1.57) and normality in the leptokurtic curve (g_2 = 1.85). Indeed, the existence of fish species with differential growth patterns in the study area implied that some species of the populations in this area had hetero-geneous groups with body weights varying differently with the cube of total length. The condition factor is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fishes. It shows the population's welfare during the various stages of the life cycle (Angelescu et al., 1958). From calculated c.f. values of between 0.64 ± 0.31 and 1.55 ± 0.33, only the mean value of c.f. of *L. aurata* and *E. alletteratus* is >1.0, while for the remaining species, it is <1.0. Gayanilo and Pauly (1997) reported that certain factors often affect the well-being of a fish. These include: data pulling, sorting into classes, sex, stages of maturity and state of the stomach. The values obtained from the study showed that all species studied have c.f. less than those values obtained in other studies (Hajjej et al., 2009; Hattour, 2000; Fehri-Bedoui et al., 2002). This suggests that the condition of the Gulf of Gabes seem to be unfavourable in comparison with subsequent studies in the same area. This aspect does warrant further study.

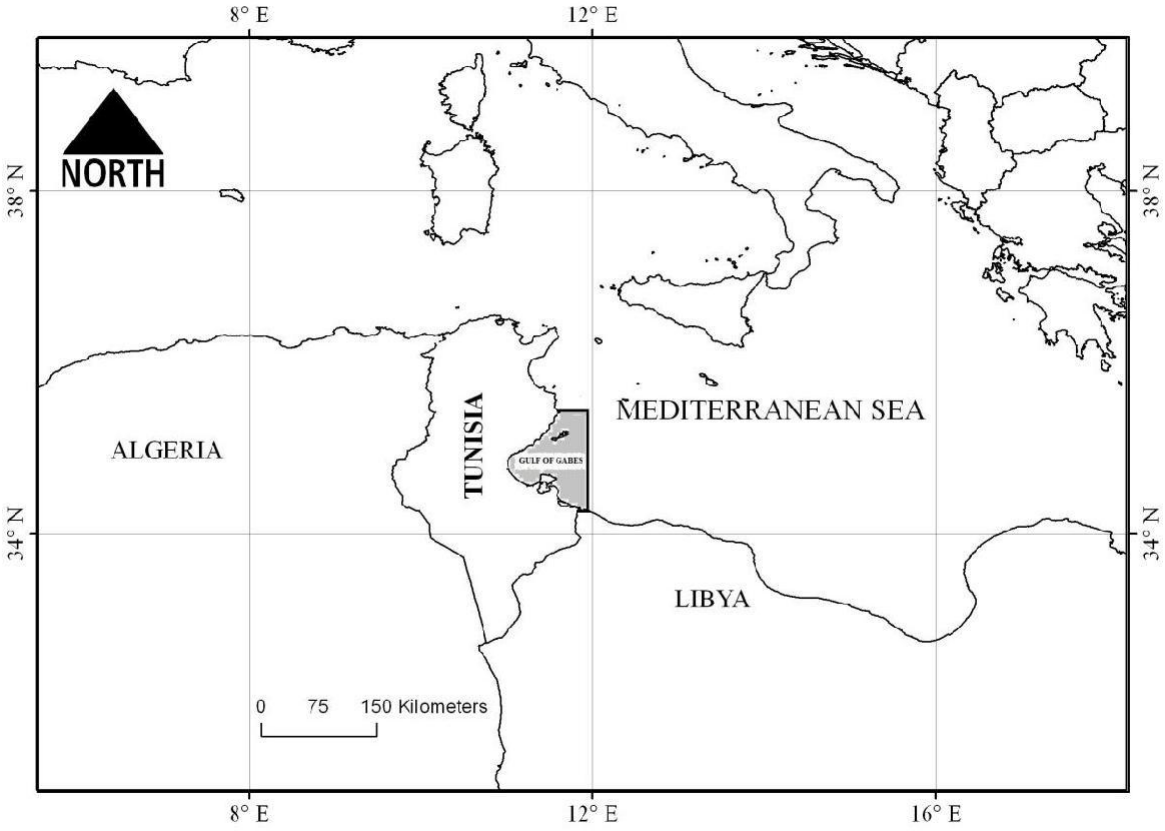

Figure 1. Geographic situation of study area.

In conclusion, this study updates length-weight parameters for many species collected from the Gulf of Gabes. Most of the individual fish presented in this study exhibited a trend of isometric growth, depicting dimensional equality. This implies that the "cube law" can be applied to most of the species in the Gulf of Gabes. The parameters as shown in this study can be used in studying growth and population dynamics for any of the 13 species of fish exploited from this region.

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