ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 10, pp. 20528-20530, October, 2017

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

LENGTH–WEIGHT RELATIONSHIPS AND CONDITION FACTORS OF 16 FISH SPECIES FROM NORTHERN TUNISIAN COASTS, MEDITERRANEAN SEA

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DOI: http://dx.doi.org/10.24327/ijrsr.2017.0810.0909

ARTICLE INFO

Article History:

Received 17th July, 2017
Received in revised form 21st August, 2017
Accepted 05th September, 2017
Published online 28th October, 2017

Key Words:

Length–weight relationships, Fulton, Elasmobranchii, Teleostei, Tunisia, Mediterranean Sea.

ABSTRACT

The aim of this study was to investigate the length–weight relationships of 16 commercial fish species from Northern Tunisian coasts. A total number of 1853 fish specimens were collected between March 2015 and December 2016. Fulton's condition factor (K) and the length-weight parameters were estimated. There was correlation between the fish total length and weight (R^2 range: 0.56 to 0.98). The K values ranged between 0.2±0.03 and 2.6±0.3. The values of b parameter ranged from 2.37 and 3.43 and intercepts (a) between 0.001 and 0.056.

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INTRODUCTION

The length-weight relationship parameters of fishes are essential in fisheries management and description of some biological aspects (Froese, 2006). They have been appliedto assess fish stocks (Ricker, 1968). Fish weight and length are also used to estimate Fulton's condition factor (K), informing about the individual fish's health. Condition factor values vary according to the state of sexual maturity, food availability and environmental conditions (Ndiaye *et al*., 2015). Length-weight relationship parameters varied between species and within stocks in relation to region, sex, season and age group (Mahe *et al*., 2016). In Tunisia, some studies have been carried out on the length-weight relationship of marine fishes (Cherif *et al*., 2008; Hajjej *et al*., 2010; Benmessaoud *et al*., 2015).

The aim of the present study was to investigate the weight-length relationships for two elasmobranch and fourteen teleost species collected from Northern Tunisian coasts.

MATERIALS AND METHODS

Fish sampling

A total number of 1853 fish belonging to 16 species were sampled collected from March 2015 to December 2016 from port of Bizerte (Northern Tunisia, Mediterranean Sea). European eels (*Anguilla anguilla*) and Dover sole (*Solea solea*) were only collected from Ghar El Melh lagoon (37°8'0"N; 10°11'30"E) (Northeastern Tunisia) (Table 1).

For each fish, total length (in cm) and total weight (in g) were measured. The sex of each smooth-hound (*Mustelus mustelus*) and small-spotted catshark (*Scyliorhinus canicula*) was determined visually by examining the presence of claspers. Teleost fish species were sexed by macroscopic examination and/or histological observation of gonads.

Length-weight relationships parameters

The length-weight relationships were expressed as follows:
$Wt = a\ Lt^b$

Where Wt: total body weight in grams; Lt: total body length in centimetres; a: regression intercept; b: slope of regression line. Growth type either isometric (b=3) or allometric, in this case, it can be negative allometric (b < 3) or positive allometric (b >3) (Froese, 2006).

The values of the constantsa and b were calculated by the logarithmic transformation of the above equation:
$\log W = \log a + b \log L$

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Fulton's condition factor was determined using the following formula:

$K= (W/L^3) \times 100$

Where, W: total body weight in grams, L: total body length in centimetres.

Histology

In order to determine the gender of the studied fishes, representative sections from the middle parts of the gonads were sliced and fixed in 10% formaline solution. Gonad sections were stained with hematoxylin-eosin (H.E.) and examined under microscope at 100x and 400x magnifications.

Statistical analysis

Statistical analysis was performed using SAS software 9.1. The association between length and weight variables was investigated by linear regression and the determination coefficient (R^2) was calculated. A t-test (H0: b=3) with a confidence level of ±95% (α=0.05) was calculated as follow (Sokal and Rohlf, 1987):

$ts = (b-3)/sb$

Where, ts= t-test value, b: the slope of the regression line and sb: the standard error of the slope (b).

RESULTS

A total of 1853 fish specimens consisting of 376 Elasmobranch and 1477 Teleost fishes were collected from Northern Tunisian coasts. The length, weight, mean Fulton's condition factor and length-weight relationships parameters are represented in Table 1. The sample size varied between 20 specimens for Atlantic mackerel *Scomber scombrus* and European hake *Merluccius merluccius* and 410 for the horse mackerel *Trachurus trachurus*. There was a positive correlation between total length and weight, the R^2varied between 0.56 and 0.98for red mullet (*Mullus barbatus*) and dusky grouper (*E. marginatus*), respectively. For nine species, the R^2 values were higher than 0.9 indicating a strong correlation between the two parameters ($p<0.0001$).

The K values ranged from 0.2±0.03 for European eel (*Anguilla anguilla*) to 2.6±0.3 for white seabream (*Diplodus sargus*). For six species (*D. sargus*, *E. marginatus*, *M. barbatus*, *M. surmuletus*, *P. erythrinus* and *S. umbra*), the mean condition factor values were higher than1.

The values of parameter b ranged between 2.37 for *Scyliorhinus canicula* and 3.43 for *Scomber japonicas* (Table 1)

Table 1 Length-weight relationship parameters of 16 Tunisian coasts' fish species

Species	Sex	N	TL (cm)	Weight (g)	Mean K ±SE	Parameters of LWR					
			Min-Max (Mean±SE)	Min-Max (Mean±SE)		a	b	SE (b)	95% CI (b)	R^2	t-test
Anguilla anguilla	C	240	23.8-70.5 (44.6±11.3)	21.8-775.7 (187.1±155.3)	0.2±0.03	0.001	3.2	0.037	3.13-3.27	0.97	4.68
	M	7	24-34 (29.1±3.9)	370-1040 (654.3±240.4)	2.6±0.3	0.111	2.56	0.304	1.59-3.353	0.93	-1.43
Diplodus sargus	F	26	21-35 (28.9±4.6)	250-1430 (665.2±310.1)	2.6±0.3	0.05	2.8	0.136	2.55-3.05	0.95	-1.45
	C	33	21-35 (28.9±4.4)	250-1430 (662.9±293.3)	2.6±0.3	0.056	2.77	0.121	2.52-3.02	0.94	-1.91
	M	6	87-103.5 (97.1±7.3)	14000-22500 (19156.7±3899.9)	2.1±0.05	0.041	2.85	0.16	2.16-3.54	0.99	-0.95
Epinephelus marginatus	F	24	38.5-102 (69.2±15.7)	900-17000 (7142.7±4483.6)	1.9±0.2	0.022	2.97	0.105	2.75-3.19	0.97	-0.3
	C	30	38.5-103.5 (74.8±18.3)	900-22500 (9545.5±6515.8)	1.9±0.2	0.016	3.05	0.08	2.89-3.21	0.98	0.62
Merluccius merluccius	C	20	22.5-27.5 (25.2±1.2)	84-143 (103.4±17.1)	0.65±0.06	0.029	2.53	0.456	1.56-3.5	0.63	-1.02
Mullus barbatus	C	70	13-17 (14.9±1)	15-55 (36±8.8)	1.1±0.2	0.019	2.79	0.302	2.19-3.39	0.56	-0.71
	M	26	15-21 (17.6±1.2)	40-120 (85±21.2)	1.53±0.22	0.005	3.4	0.461	2.44-4.36	0.69	0.87
Mullus surmuletus	F	93	15.5-22 (18±1.1)	50-160 (89.5±20)	1.53±0.21	0.027	2.8	0.244	2.32-3.28	0.59	-0.81
	C	119	15-22 (17.9±1.1)	40-160 (88.5±20.2)	1.5±0.2	0.017	2.95	0.213	2.53-3.37	0.62	-0.22
	M	66	39-71 (53.2±6.3)	217-1056 (440.5±170.7)	0.3±0.03	0.003	2.97	0.1	2.77-3.17	0.93	-0.31
Mustelus mustelus	F	48	43-66 (52±5.8)	241-900.7 (430.2±149.9)	0.3±0.02	0.005	2.89	0.097	2.69-3.09	0.95	-1.15
	C	114	39-71 (52.7±6.1)	217-1056 (436.2±161.7)	0.29±0.03	0.004	2.9	0.073	2.76-3.04	0.93	-1.12
Pagellus erythrinus	C	53	12.8-22.5 (16.9±2.8)	30.5-137 (68.9±33.2)	1.35±0.17	0.028	2.74	0.092	2.56-2.92	0.95	-2.81
Sardinella aurita	C	68	14.4-24.5 (19.8±2)	19-114 (57±17.2)	0.72±0.12	0.018	2.69	0.174	2.34-3.04	0.78	-1.78
	M	50	13.3-28.7 (18.5±3.7)	34.6-321.2 (91.4±68.8)	1.27±0.09	0.011	3.05	0.061	2.93-3.17	0.98	0.83
Sciaena umbra	F	21	15.4-31.2 (22±4.7)	50.4-360.3 (156.5±101.2)	1.28±0.12	0.01	3.04	0.097	2.84-3.24	0.98	0.76
	C	89	13.3-31.2 (19.5±4.3)	34.6-360.3 (109.9±87.4)	1.27±0.1	0.0096	3.09	0.041	3.01-3.17	0.98	2.27
	M	31	20.3-29 (24.2±2.1)	68.9-280 (137.7±49.1)	0.93±0.15	0.0017	3.54	0.33	2.86-4.22	0.8	1.62
Scomber japonicus	F	35	19-28 (24.1±2)	57.4-240 (130.8±45.1)	0.92±0.22	0.031	2.6	0.52	1.54-3.66	0.43	-0.76
	C	187	17.5-29 (22.7±2.2)	34-280 (108.3±40)	0.89±0.15	0.0023	3.43	0.12	3.19-3.67	0.82	3.59
Scomber scombrus	C	20	27-39.5 (32.2±4.6)	184.4-519 (281.1±111.2)	0.82±0.08	0.042	2.52	0.15	2.2-2.84	0.94	-3.16
	M	134	35.5-50.7 (43±3.4)	133.8-421.2 (257.2±59.1)	0.32±0.06	0.02	2.51	0.145	2.22-2.8	0.69	-3.35
Scyliorhinus canicula	F	128	34.2-49.2 (41.8±3)	140.8-384.3 (257.1±54)	0.35±0.06	0.032	2.4	0.168	2.07-2.73	0.62	-3.56
	C	262	34.2-50.7 (42.4±3.3)	133.8-421.2 (257±56.5)	0.33±0.06	0.035	2.37	0.111	2.15-2.59	0.64	-5.64
	M	47	15.8-26 (20.3±2.4)	37.7-135.6 (72.6±24.3)	0.84±0.09	0.025	2.64	0.126	2.39-2.89	0.91	-2.84
Solea solea	F	58	14.6-32.5 (21.5±4.1)	21.6-224.7 (90.4±44.7)	0.86±0.12	0.03	2.58	0.089	2.4-2.76	0.94	-4.69
	C	105	14.6-32.5 (21±3.4)	21.6-224.7 (82.4±37.9)	0.9±0.11	0.027	2.61	0.07	2.47-2.75	0.93	-5.46
Trachurus mediterraneus	C	33	19.7-38.5 (24.9±4.2)	61-269 (128.9±64.5)	0.78±0.1	0.018	2.73	0.171	2.38-3.08	0.89	-1.56
	M	155	13-33.5 (19.2±3.2)	19-201.2 (59±36.9)	0.75±0.08	0.007	3.04	0.066	2.96-3.12	0.93	0.56
Trachurus trachurus	F	132	12-28 (20±3.3)	14-191.1 (66.6±39.9)	1.01±0.87	0.004	3.19	0.049	3.09-3.29	0.97	3.89
	C	410	12-33.5 (19.4±3)	14-201.2 (60.5±33.8)	0.76±0.08	0.007	3.02	0.038	2.95-3.09	0.94	0.45

N: sample size; Min: minimum; Max: maximum; K: Fulton's condition factor; CI: confidence interval; R^2: coefficient of determination; SE: standard error; a: regression intercept; b: slope of regression line; M: males; F: females; C: combined sexes;

DISCUSSION

Fulton's condition factor (K), an expression of relative fatness of fish, indicates the interaction between several factors (biotic and abiotic) and the fish condition. For all 16 species. The K values ranged from 0.2±0.03 to 2.6±0.3. The condition factor (k) estimated for round sardinella (*Sardinella aurita*), Atlantic mackerel (*Scomber scombrus*) and Mediterranean horse mackerel (*Trachurus mediterraneus*) are similar to those reported by Hajjej *et al*. (2010) in Gulf of Gabes (South Tunisia) (K= 0.77; 0.92 and 0.77 respectively). Nevertheless, K value estimated in common pandora (*Pagellus erythrinus*) (1.35±0.17) was higher than the K estimated by Hajjej *et al*. (2010) (K: 0.99±0.42).The condition factor of European eel (*Anguilla anguilla*) from Ghar El Melh lagoon (K: 0.2±0.03) is higher than in Dutch lakes (K range: 0.16-0.18) (Simon, 2007) and Italian coastal waters (K range: 0.13-0.18) (Quadroni *et al*., 2013). In the present study, Dover sole (*Solea solea*) showed a k value (0.9±0.11) less than those obtained by Jebali *et al*. (2013) in three sites in the east coast of Tunisia: Khniss (1.41±0.11), Sayada (1.58±0.16) and Teboulba (1.26±0.07).

The estimated allometric coefficients (b) were within the range (2.5-3.5) defined by Froese (2006), with the exception of *Scyliorhinus canicula*. The length-weight relation showed in the present study have more or less similar growth patterns with those obtained in others regions. The variation of b value depends mainly on the shape and fatness of the species (Simon *et al*., 2009). Within the same species, the parameter b may show seasonal and regional variation (Demirel and Dalkara, 2012). Thus, the length-weight relation in fish depends on several factors including sex, gonad maturity, food availability, stomach fullness, health status and environmental conditions. The differences in b values may be attributed also to the number of specimens examined and the observed length ranges of the species (Moutopoulos and Stergiou, 2002).

In conclusion, the data obtained in the present study provided and update of the length-weight relationships and condition factors of 16 commercial fish species from Northern Tunisian coasts. Those results can be used to the fisheries management and can facilitate fish biologists to assist in estimating the biomass of captured fish species. The estimated parameters should be applied to the species within the specific length ranges analyzed.

Acknowledgements

The authors would like to thank Drs.DhiaeddineTarhouni and Mohamed Oussama El Hafi, Direction Générale des Services Vétérinaires, Tunisia for their help in collecting samples. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The author certifies that there is no conflict of interest.

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