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Full Length Research Paper

Length-weight relationships, condition factors and relative weight of five fish species of Bushehr waters, Northern Persian Gulf

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The aim of this study was to record the length-weight relationship parameters and condition factors for some commercially important fish of Bushehr coastal waters of Persian Gulf. The length-weight relationships were calculated for five species caught during fishing surveys using different types of fishing gears (trawls, pots and gill net with different mesh size) during April 2008 to December 2010. The *b* value ranged between 2.733 for *Argyrops spinifer* and 3.03 for *Epinephelus coioides*. The coefficient of determination (r^2) was very significant for all the species. Relative weight had significant differences (Kruskal-Wallis test, P<0.001) with best performance by *E. coioides*. This results show that this range size of specimens in these populations apparently do not reach and surpass 100% of mean weight. In this study, length-weight relationships and condition factors are reported for the first time for *A. spinifer*, *Pomadasys kaakan* and *Lutjanus malabaricus* from the Persian Gulf and for *Lethrinus nebulosus* and *Lutjanus malabaricus ruber* which has not been previously recorded in the Iranian waters.

Key words: Length-weight relationships, condition factor, relative weight, Persian Gulf.

INTRODUCTION

Demersal fishes are important species that landed by industrial and artisanal fleet from the Persian Gulf. Some of these species are protected, listed or endangered (IUCN, 2011). Catch data of fishes indicate 21% decreases in landing from 110,000 tones in 2002 to 87,240 tones in 2003 in the Persian Gulf (Valinassab et al., 2006; Planning and Development Department, 2003). *Argyrops spinifer* (Forsskål, 1775), *Epinephelus coioides* (Hamilton, 1822), *Pomadasys kakaan* (Cuvier, 1830), *Lethrinus nebulosus* (Forsskål, 1775) and *Lutjanus malabaricus* (Bloch and Schneider, 1801) are some of the important species of demersal fishes.

In order to estimate the biomass, it is necessary to know the length-weight relationships of the species studied. Generally, length-weight relationship of fish is used to estimate the condition of fish, its biomass from length observation, the conversion of growth in length equations to growth-in-weight and it is also useful for between-region comparisons of life histories of species (Pauly, 1993; Goncalves et al., 1997; Binohlan and Pauly, 1998).

Fulton's condition factor is widely used in fisheries and fish biology studies. This factor is calculated from the relationship between the weight of a fish and its length, with the intention of describing the "condition" of that individual fish (Froese, 2006). Also, relative condition factor can be use for comparing the observed weight of an individual with the mean weight for that length (Froese, 2006).

Relative weight is considered as management goal by fishery manager for monitoring status of fishes and for

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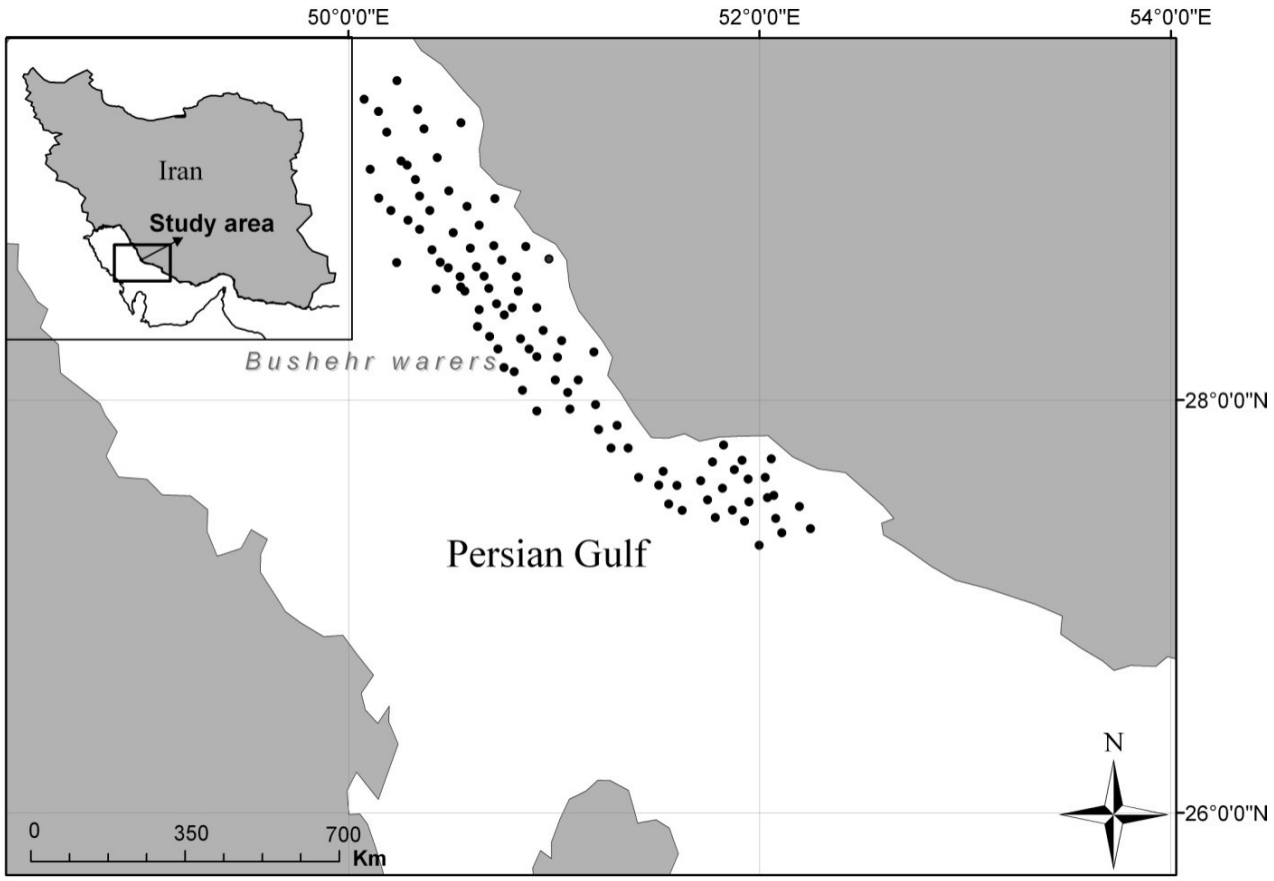

Figure 1. Map of the study area in Persian Gulf. The black points indicate the sampling locations.

comparative growth studies. Relative weight is suitable index for comparing condition across populations and species (Froese, 2006).

Information on the length-weight characteristics of various demersal fishes from Persian Gulf is very dispersed and negligible and to the authors' knowledge for *A. spinifer*, *P. kaakan* and *L. malabaricus* length-weight relationships and condition factors presented herein are reported for the first time from the Persian Gulf and for *L. nebulosus* and *L. malabaricus* has not previously recorded for the Iranian water fishes.

MATERIALS AND METHODS

The data were collected on monthly basis during the April 2008 to December 2010 of fishing research surveys. The study area extends from latitudes 27°15′-30°16′ N and longitudes 49°54′-52°30′E in the Persian Gulf (SW of the Persian Gulf, Figure 1). The specimens were caught by several different types of fishing gear: (i) bottom trawl with mesh size 40 mm (STR) in the cod end; (ii) gill nets with mesh sizes, 80, 90, 100, 130 and 140 mm (STR); (iii) pot nets. Subsequently, the samples collected were considered to represent the spatial and depth range of the study region adequately (Figure 1). Trawl duration ranged from 1 to 3.5 h (mean 2.7±0.2 h) at speeds of about 3.2 knots and were restricted to 30 m depth.

For each specimen, the fork length (FL) was measured to the nearest 0.1 cm, and body weight was measured on a digital scale with 0.1 g accuracy. The length-weight relationships were estimated by using following equation:

$$W = aL^b$$

Where, W is the whole body weight (g) and L is the fork length (cm). The parameters a and b of the length-weight relationships were estimated by the least-squares method based on logarithms:

$$Log\ (W) = log\ (a) + b\ log\ (L)$$

Also the 95% confidence limits of parameters a, b and r^2 (the coefficient of determination) were calculated. A t-test was used to demonstrate significant difference of obtaining b-value in equation from the isometric value 3, expressed by the following equation (Sokal and Rohlf, 1987);

$$t_s = \frac{b - 3}{s_b}$$

Where, t_s is the t-test value; b is the slope and s_b is the standard error of the slope (b). Comparison between obtained values of t-test and the respective tabled critical values give the determination of the b values statistically significant, and their inclusion in the isometric range (b=3) or allometric range (negative allometric; b<3 or positive allometric; b>3). The relative condition factor (K_{rel}) for

Table 1. Descriptive statistics and LWR parameters for five demersal fish species of Persian Gulf (n: sample size, S.E: standard error; Min: minimum, Max: maximum, *a* and *b*: parameters of equation $W = aL^b$, CL 95%: confidence limits, r^2: coefficient of determination).

Family/species	Length (cm)					*WLR* parameters and statistics						
	N	Mean	S.E	Min	Max	*a*	SE(a)	95%CL(a)	*b*	SE(*b*)	95%CL*b*	r^2
Sparidae: *Argyrops spinifer*	545	21.50	0.203	10.2	42.5	0.0504	0.042	0.0440-0.0661	2.733	0.032	2.670-2.796	0.930
Serranidae: *Epinephelus coioides*	199	32.87	0.631	18.8	65.5	0.0120	0.072	0.0090-0.0250	3.030	0.048	2.934-3.125	0.952
Haemulidae: *Pomadasys kaakan*	94	30.77	0.763	18.5	51.4	0.0230	0.083	0.0186-0.0305	2.892	0.062	2.819-2.965	0.985
Lethrinidae: *Lethrinus nebulosus*	150	31.24	0.632	16.5	46.7	0.0380	0.064	0.0280-0.0520	2.780	0.043	2.694-2.867	0.964
Lutjanidae: *Lutjanus malabaricus*	310	26.55	0.559	13.3	58.5	0.0250	0.039	0.0214-0.0306	2.879	0.027	2.824-2.934	0.971

each individual was calculated according to Le Cren equation (1951):

$$K_{rel} = \frac{W}{aL^b}$$

Where, *W* is the body weight (g); *L* is the fork length (cm) and *a* and *b* are the parameters of the *LWR*. Fulton's condition factor *K* was calculated by the formula (Htun-Han, 1978):

$$K = 100\frac{W}{L^3}$$

Where, *W* is the whole body wet weight in grams and *L* is the fork length in grams (Froese, 2006). Using the Froese's equation (2006) the relative weight (W_{rm}) was calculated:

$$W_{rm} = 100\frac{W}{a_m L^b}$$

Where, *W* is the weight of specimen (g); *L* is the fork length of specimen (cm); a_m is the geometric mean *a* and b_m is the mean *b* across all available, non-questionable length-weight estimates for a species as parameters of the mean length–weight relationship that cited in the Fish base (Froese, 2006); *N* is the number of parameter *a* and *b* that is available in the Fish base. Kolmogrov-Smirnow and Levene tests were used to analyze normality of the data and homogeneity of variances, respectively (Zar, 1999). Because the assumptions of parametric statistics could not be met, a non-parametric Kruskal–Wallis test with a 5% level of significance was used whether significant differences in mean W_{rm} between species. All the statistical analyses were considered at a significance level of 5% ($P<0.05$).

RESULTS

In this study, a total of 1298 individuals belonging to 5 different species and five families were collected. In numerical terms, the most important species was *A. spinifer* with 545 individuals. The sample size, the minimum, maximum and mean length (± S.E.), length-weight relationships parameters and statistics are presented in Table 1. The minimum and maximum observed total length (TL) of all specimens captured was 10.2 and 58.5 cm for *A. spinifer* and *L. malabaricus* respectively (Table 1).

All length-weight relationships were highly significant ($P < 0.001$) with coefficient of determination (r^2) values being greater than 0.930. The coefficient *b* values ranged from a minimum of 2.733 for *A. spinifer* to a maximum of 3.030 for *E. coioides*. The growth was negative allometric ($b<3$, $P<0.001$) for *A. spinifer, L. nebulosus* and *L. malabaricus*. *E. coioides* and *Pomadasys kaakan* showed isometric growth ($b =3$, $P > 0.05$) (Table 2).

Relative condition factor (K_{rel}) and Fulton's condition factor (*K*) is shown in Table 3. In this study, the K_n was ranged from 1.022 ± 0.006 (*A. spinifer*) to 1.079 ± 0.014 (*E. coioides*) (Table 3). Relative weight (W_{rm}) differed significantly between species (Kruskal-Wallis test, $P<0.001$) with best performance by *E. coioides* (Table 4; Figure 2).

DISCUSSION

Information on the biological aspects of some demersal fishes from Persian Gulf is dispersed and inappreciable. This was the first comprehensive study of the length-weight relationships and condition factor of the Persian Gulf from Bushehr waters. A large number of specimens were captured by different fishing gears such as trawl, pot net, multidimensional mesh size gill net. Due to non-selective fishing technique such as trawl, specimens captured with different body sizes as far were possible. The differences in fish sizes display that the fish population ranged from immature specimens to fully matured ones (Fifioye and Oluajo, 2006).

Length-weight relationships are not constant over the year and Length-weight relationships parameter may vary significantly due to biological, food availability, temporal and sampling factors,

Table 2. Type of growth for five demersal fish species of the Persian Gulf.

Family/species	n	T (value)	Growth type
Sparidae: *Argyrops spinifer*	545	8.343***	- Allometric
Serranidae: *Epinephelus coioides*	199	0.625	Isometric
Haemulidae: *Pomadasys kaakan*	94	1.741	Isometric
Lethrinidae: *Lethrinus nebulosus*	150	5.116***	- Allometric
Lutjanidae: *Lutjanus malabaricus*	310	4.481***	- Allometric

***; ($P < 0.001$).

Table 3. Relative condition factor (*Kr*) and Fulton's condition factor (*K*) of five demersal fish species from the Persian Gulf, during April 2008 to March 2010.

Family/species	Fulton's condition factor (K)						Relative condition factors (K_{rel})				
	n	Mean	S.E	Minimum	Maximum	95%CL	Mean	S.E	Minimum	Maximum	95%CL
Sparidae: *Argyrops spinifer*	545	2.454	0.017	0.8839	5.088	0.0337	1.022	0.006	0.3842	2.006	0.0117
Serranidae: *Epinephelus coioides*	199	1.436	0.019	0.8904	3.520	0.0381	1.079	0.014	0.6676	2.6633	0.0276
Haemulidae: *Pomadasys kaakan*	94	1.661	0.014	1.2640	2.074	0.0294	1.042	0.008	0.7693	1.2977	0.0174
Lethrinidae: *Lethrinus nebulosus*	150	1.854	0.023	1.3080	3.287	0.0472	1.031	0.011	0.7052	1.0707	0.0218
Lutjanidae: *Lutjanus malabaricus*	310	1.764	0.017	0.7620	3.287	0.0320	1.041	0.009	0.04542	1.9111	0.0177

Table 4. Relative weight (W_{rm}) of five demersal fishes species from the Persian Gulf, during April 2008 to March 2010.

Family/Species	Relative weight (W_{rm})								
	n	a_m	b_m	SE(b_m)	Mean	S.E	Min	Max	95%CL
Sparidae: *Argyrops spinifer*	545	0.1024	2.607	0.048	0.792	0.005	0.3035	1.513	0.0098
Serranidae: *Epinephelus coioides*	199	0.0115	3.060	0.023	1.015	0.014	0.626	2.523	0.0276
Haemulidae: *Pomadasys kaakan*	94	0.0380	2.802	0.089	0.837	0.007	0.6026	1.039	0.0130
Lethrinidae: *Lethrinus nebulosus*	150	0.0318	2.858	0.052	0.944	0.10	0.6536	1.603	0.2370
Lutjanidae: *Lutjanus malabaricus*	310	0.0240	2.907	0.041	0.991	0.009	0.4314	1.8257	0.0177

n: Sample size, a_m: Geometric mean, b_m: Mean *b*, standard error; Min: Minimum, Max: Maximum; CL: Confidence limits

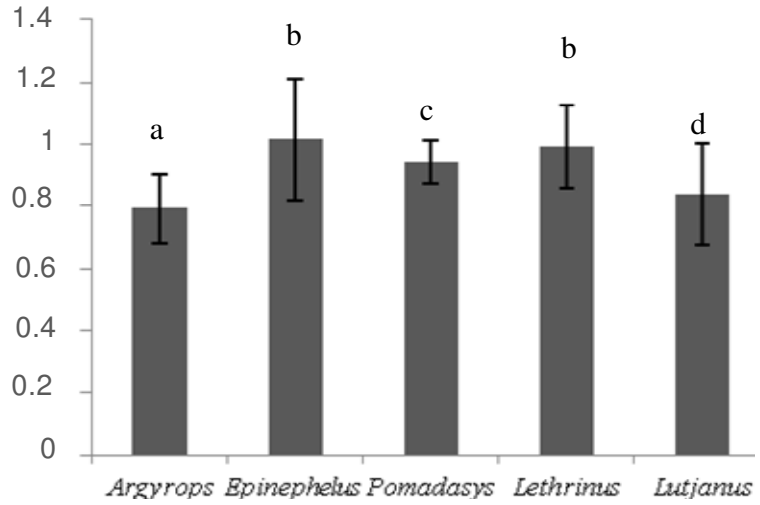

Figure 2. Mean W_{rel} (± S.E) for five demersal fishes species from the Persian Gulf. Means that differed significantly in Kruskal-Wallis test indicated by a,b,c,d.

Table 5. The *a* and *b* parameters of length-weight relationships of selected species obtained from other parts of the world.

Species	Length type	Length	*a*	*b*	Sex	Location
Argyrops spinifer	TL	11.8-55.5	0.2110	2.459	Male	Yemen; Gulf of Aden and Red Sea (Al Sakaff and Esseen, 1999)
	-	-	0.1110	2.540	Mixed	Yemen; Gulf of Aden (Edwards et al., 1985)
	TL	12.1-51.5	0.1120	2.650	Female	Yemen; Gulf of Aden and Red Sea (Al Sakaff and Esseen, 1999)
	FL	-	0.0798	2.657	Mixed	Oman; NW Arabian Sea (Druzhinin, 1976)
Epinephelus coioides	TL	-	0.0144	3.024	Mixed	Kuwait (Mathews and Samuel, 1991)
	TL	6.5-11.1	0.0105	3.084	Mixed	New Caledonia; lagoon (Letourneur et al., 1998)
Pomadasys kaakan	-	-	0.0657	2.713	Mixed	South Africa (van der Elst and Adkin, 1991)
Lutjanus malabaricus	TL	9.0-30.0	0.0313	2.872	Mixed	Australia; N Territory (Willing and Pender, 1989)
	FL		0.0207	2.916	Male	Australia; Pilbara coast (Newman, 2002)
	FL		0.0208	2.919	Female	Australia; Pilbara coast (Newman, 2002)
	FL	27.0-62.0	0.0085	3.137	Mixed	Vanuatu (Pakoa, 1998)
Lethrinus nebulosus	TL	23.0-73.5	0.0950	2.619	Female	Yemen; Gulf of Aden and Red Sea (Al Sakaff and Esseen, 1999)
	TL	22.2-70.5	0.0670	2.708	Male	Yemen; Gulf of Aden and Red Sea (Al Sakaff and Esseen, 1999)
	FL	8.0-69.5	0.0204	2.975	Mixed	New Caledonia; lagoon (Letourneur et al., 1998)
			0.0173	3.010	Mixed	Kuwait (Mathews and Samuel, 1991)

health and sex (Bagenal and Tesch, 1978; Froese, 2006) all of which were not considered for in this study. Since all the specimens were collected over several season, data are not representative of a specific season of the year. The parameters *a* and *b* in this study should only be considered as mean annual values.

These results are suitable for the estimation of length-weight relationship since, the values of *b* are within the range of values of this parameter usually estimated in fishes, which according to Froese (2006) lies between 2.5 and 3.5.

Relative weight in fishery study can be used for comparing condition across different populations and species (Froese, 2006). From the result of relative weights of *A. spinifer*, *P. kaakan, L. nebulosus* and *L. malabaricus* the mean weight calculated for these species were 79.20, 83.77, 0.944 and 99.10% respectively. The results indicate that this range size of specimens in Persian Gulf populations apparently do not reach and surpass 100% of mean weigh.

Table 5 indicates the *a* and *b* parameters of length-weight relationships of selected species obtained from other parts of the world. The difference of *a* and *b* can be affected area, sex, season, degree of stomach fullness, gonad maturity, health, habitat, nutrition (Tesch, 1971). This study also presented the basic information on the length-weight relationships and conditions for this species from Persian Gulf, which would be useful for fishery managers as well as the sustainable management of its numerous resources in the region.

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