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Original Article

Length-weight and length-length relationships, condition factors and optimal length of some fish species from the Persian Gulf and Oman Sea

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Abstract: Length-weight relationships (LWRs), relative condition factor (K_{rel}), relative weight (W_r) and optimal length (L_{opt}) were calculated for five important commercial fishes from Iranian waters of the Persian Gulf and Oman Sea. Samples were collected from 2011 and December 2012 in 11 stations in three Iranian provinces (Hormuzgan, Khozestan and Sistan and baluchestan) using trawl and gillnets. Also, length-length relationships (LLRs) for *Pampus argenteus* and *Scomberomorus commerson* were computed. The values of the exponent b in the length-weight relationship ranged from 2.593 for *S. commerson* to 2.995 for *P. argenteus*. K_{rel} varied between 1.01 ± 0.08 for *Parastromateus niger* and 1.06 ± 0.41 for *P. argenteus*. Also, W_r ranged from 59.12 ± 47.74% for *S. commerson* to 107.78 ± 107.29% for *Eleutheronema tetradactylum*. The L_{opt} were calculated for all five species. A negative allometric growth was found in *S. commerson*, while other four species (*E. tetradactylum*, *Otolithes ruber*, *P. niger* and *P. argenteus*) had isometric growth. The length-weight and length-length relationships presented here are for the first time in the Iranian coastal waters of the Persian Gulf and Oman Sea, which can provide a basis for fisheries management.

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Introduction

The Persian Gulf is lying in sub-tropical climate and located between latitudes 24° 30' N and longitudes 49° 61' E (Kampf and Sadrinasab, 2006; Valinassab et al., 2006). At the end of eastern side of the Persian Gulf, the Hormuz Strait restricts the water exchange between the Persian Gulf and the Northwestern Indian Ocean. A wide variety of marine biota are found in the Persian Gulf, including sea turtles, marine birds, dugongs, whales, dolphins and many (over 500) fish species. Many of the fishes are endemic and heavily dependent on the Gulf environment (UNEP, 1999).

In the last decade, fish landing has been decreased from 110,000 tonnes to 87,240 tonnes in the Persian Gulf (Valinassab et al., 2006; Planning and Development Department, 2003). There are few studies on fishing management and biological information on fish resources in the region (Hosseini, 2002; Shokri et al., 2005; Raeisi et al., 2011; Daliri et al., 2012).

Length-weight relationships (LWRs) are often used to estimate biomass of the standing stock (Martin, 1996), condition indices, ontogenetic changes (Sarafan, 1992) and growth studies (Garcia et al., 1989; Haimovici and Velasco, 2000; Moutopoulos and Stergion, 2002). A LWRs study for a species can provides important insights into the ecology of the species (Froes, 2006).

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Length-length relationships (LLRs) are useful for standardization of length type when data are summarized (Froes, 1998) and also functional for comparative growth studies (Moutopoulos and Stergiou, 2002).

This study reports LWRs, LLRs, condition factors and optimum size (L_{opt}) of *Eleutheronema tetradactylum* (Shaw, 1804), *Otolithes ruber* (Bloch and Schneider, 1801), *Parastromateus niger* (Bloch, 1795), *Pampus argenteus* (Euphrasen, 1788) and *Scomberomorus commerson* (Lacepede, 1800) from the Persian Gulf and Oman Sea. LWRs and LLRs data are available for most fishes of the world, while these data are unavailable in tropical fish species. All these species are of the most commercial importance in the area and this study is the first report of its type on these species from the Persian Gulf (Froes and Pauly, 2012).

Material and method

Sampling was carried out from May 2011 to June 2012 in 11 stations (10 stations using gillnet and 1 by trawl) in the Iranian coastal waters of the Persian Gulf and Oman Sea (Fig. 1).

Nominal mesh sizes of gillnets for *Pampus argenteus*, *Scomberomorus commerson* and *Parastromateus niger*, were 135 mm and 95 mm for *Otolithes ruber* and *Eleutheronema tetradactylum*. A shrimp trawl net with 25 mm and 40 mm nominal mesh size of cod-end and panel, respectively, was used for *Pampus argenteus* and *Scomberomorus commerson*, where we measured length-length relationships data. After each catch operation subsamples were collected from 5-10% of the total catch and fork length (FL) or total length (TL) were measured to the nearest 0.1 cm using a measuring board. Total weight was measured to the nearest 0.1 g using an electronic balance.

The relationship between FL or TL (L) and total weight (W) usually expressed by the equation $W= a L^b$, which W is weight in gram and L is length in centimeters (Ricker, 1975). LWR parameters (a and b) have been calculated from the logarithmic equivalent as Log W= log a + b log L (Zar, 1984). LLRs were determined by the same method: FL = a TL where FL = fork length and TL = total length. The 95% confidence limits of b-value were calculated using the equation $95\%\ cl = b \pm t_{0.05,\ n-2}.S_b$, where n is the number of specimens and S_b is the standard error of the slope (b). A t-test was used to compare the b-values, which obtained in the linear regression, with isometric values for each species (Sokal and Rohlf, 1987): $T_s = (b-3)/S_b$, where T_s is the t test value, b is the LWR parameter and S_b the standard error of the b-value.

The relative weight (W_r) and relative condition factor (K_{rel}) were computed using the equations, $W_r = 100\ (W/W_s)$, where W_r is the relative weight, W is the total weight of a specimens and W_s is a standard weight (75 percentile of observed weights at that length; Wege and Anderson, 1978), $K_{rel} = W/(a\ L^b)$, where W is the body weight in g, L is total length in cm, a and b are LWR parameters (Le cren, 1951).

The optimal length (L_{opt}) was computed by the following equations (Froese and Binohlan, 2000; Froese 2006); $L_{opt} = 10^{1.0421}$ log L_{inf} - 0.2742, $L_{inf} = 10^{0.044\ +\ 0.9841}$ log L_{max}, where L_{inf} is the asymptotic length and L_{max} is the mean length of the three largest specimens caught in last 20 years (from data in this study; Carpenter et al., 1997; Asadi et al., 1996).

Results

A total of 3089 specimens of five important commercial fish species of the Persian Gulf belonging to five families were collected from 11 stations. Length and weight characteristics and parameters of LWRs of all species, confidence limit of b, standard error of a, r^2 and correlation coefficient (r) are presented in Table 1.

The r^2 for all five species were over 0.847 and all regressions (LWRs) are significantly different from 0 ($P<0.05$). The estimates of the parameter b ranged from 2.593 for *Scomberomorus commerson* to 2.995 for *Pampus argenteus*. The length-length relationship parameters for *Pampus argenteus* and

Table 1. The length and weight data and parameters of length-weight relationship (LWR) of five commercial fish species in the Persian Gulf (May 2011 to June 2012).

Family	Species	Length ratio (TL/FL) characteristic						Weight characteristic				LWR parameters					
		N	TL/FL	Mean	SD	Min	Max	Mean	SD	Min	Max	a	SE	b	Cl	r^2	r
Stromateidae	*Pampus argenteus*	1089	FL	18.92	5.28	6.5	37.5	210.5	233.09	10	1500	0.023	0.003	2.995	0.6037	0.847	0.92
Scombridae	*Scomberomorus commerson*	582	FL	89.72	33.27	12	148	6728.43	5433.27	110	24100	0.044	0.013	2.593	0.2454	0.986	0.99
Carangidae	*Parastromateus niger*	858	FL	36.23	4.74	26	49	1242.64	486.99	500	2700	0.033	0.002	2.919	0.1299	0.959	0.98
Sciaenidae	*Otolithes ruber*	398	TL	35.96	7.08	22.5	58	584.02	354.67	103	2105	0.032	0.006	2.706	0.3512	0.861	0.93
Polynemidae	*Eleutheronema tetradactylum*	162	FL	39.61	11.93	19	76	1144.72	1139.47	109	6157	0.016	0.003	2.961	0.3707	0.941	0.97

N: the number of samples, SD: standard deviation, S.E: standard error and Cl: 95% confidence limits, FL: fork length (cm), TL: total length (cm), total weight is in g.

Table 1. The length data and length-length relationship (LLR) of two marine fish species in the Persian Gulf. Data are taken from trawl station.

Species	TL characteristics					FL characteristics				LLR parameters				
	N	Mean	SD	Min	Max	Mean	SD	Min	Max	a	SE	b	Cl	r^2
Pampus argenteus	390	18.53	3.89	9.5	29	15.46	5.32	6.5	24.5	0.476	0.012	1.186	0.06251	0.98
Scomberomorus commerson	76	33.42	5.74	15.5	43	29.55	5.51	12	39	0.611	0.029	1.105	0.03788	0.989

N: the number of samples, SD: standard deviation, S.E: standard error and CL: 95% Confidence limits, FL: fork length (cm), TL: total length (cm).

Table 3. Table 3. Relative weight (Wr) of five fish species of Persian Gulf during May 2011 to June 2012.

Species	W_s	W_r				
		Mean	SD	Min	Max	95% Cl
Pampus argenteus	235	89.57	99.18	4.25	638.29	4.94
Scomberomorus commerson	11380	59.12	47.74	0.96	211.77	3.25
Parastromateus niger	1500	82.84	32.46	33.33	180	1.82
Otolithes ruber	785	74.39	45.11	13.12	168.15	3.73
Eleutheronema tetradactylum	1062	107.78	107.29	10.26	579.75	13.95

Table 4. The optimum length (Lopt in cm) of five different fish species in Persian Gulf.

	Pampus argenteus	*Scomberomorus commerson*	*Parastromateus niger*	*Otolithes ruber*	*Eleutheronema tetradactylum*
L_{opt}	34.33	109.45	34.66	54.64	88.38

Table 5. The parameters of the length-weight relationship (LWR) of selected species in the region and other location of the world.

Species	Location	Length	sex	a	b	Authors
Eleutheronema tetradactylum	Chilka lake	20-840 TL	unsexed	1.57×10^{-6}	3.0405	Patnalk (1969)
	Bushehr (Northwest of Persian gulf)	13.5-43 FL	unsexed	0.0342	2.9477	Daliri et al. (2012)
Parastromateus niger	Bangladesh, bay of Bangal	FL	unsexed	0.0211	3.012	Mustafa (1999)
	Indonesia, western region	5-38 TL	unsexed	0.0073	3.319	Pauly et al. (1996)
	Bangladesh, bay of Bangal	SL	unsexed	0.0138	2.5411	Pati (1981)
Otolithes ruber	Kuwait	14.2-45.5 SL	unsexed	0.0203	2.916	Hussain and Abdullah (1971)
	Bangladesh, bay of Bangal	SL	male	0.0134	2.5307	Pati (1981)
	Bangladesh, bay of Bangal	SL	female	0.009523	2.692	Pati (1981)
Pampus argenteus	Korea Rep, East China and southern Korean waters	FL	unsexed	0.0345	3.000	Lee et al. (1992)
	Persian gulf, coastal waters of Iran	FL	male	0.0187	2.91	Sadeghi et al. (2009)
Scomberomorus commerson	Persian gulf, coastal waters of Iran	FL	female	0.0194	2.89	Sadeghi et al. (2009)
	Queens land, east coast stock	47-155 FL	unsexed	0.0099	2.95	McPherson (1992)

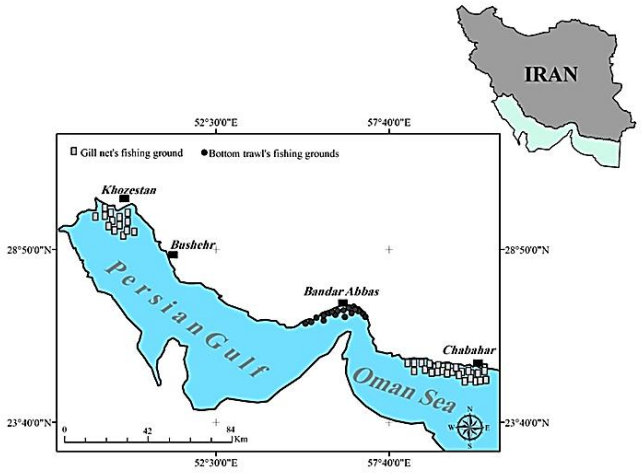

Figure 1. The map of the study area with trawl (■) and gillnet sampling points (●).

Scomberomorus commerson are shown in Table 2. The r^2 values for both species were greater than 0.98. The t-test for LWRs showed that *Eleutheronema tetradactylum* (ts = 0.174), *Otolithes ruber* (ts = 1.38), *Parastromateus niger* (ts = 1.02) and *Pampus argenteus* (ts = 0.013) were isometric in growth while, *Scomberomorus commerson* (ts = 2.731) showed negative allometric growth (all computations were considered at $\alpha = 5\%$).

The mean relative condition factors (K_{rel}) was 1.0299 (± 0.021) and it ranged from 1.01 (± 0.08) for *Parastromateus niger* to 1.06 (± 0.41) for *Pampus argenteus* (Fig. 2).

Relative weight (W_r) of all species are tabulated in Table 3. Values were ranged between 59.12 ± 47.74% for *Scomberomorus commerson* to 107.78 ± 107.29% for *Eleutheronema tetradactylum*. The optimal length (L_{opt}) of all species are presented in Table 4.

Discussion

The length-weight relationship is a very important tool in fisheries assessment (Garcia et al., 1989; Haimovidici and Velasco, 2000; Arslan et al., 2004) and also standing crop biomass can be estimated based on this value (Morey et al., 2003). Froese (2006) expressed that the exponent b should normally lies between 2.5 to 3.5. The b-value ranged from 2.593 (for *scomberomorus commerson*) to 2.995 (for *pampus argenteus*) in this study, so the

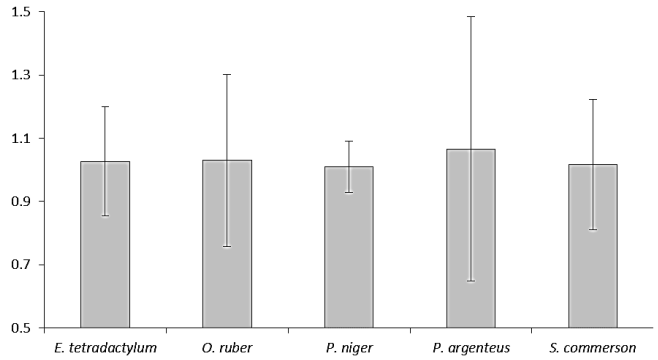

Figure 2. T Relative condition factor (K_{rel}) (± SD) of five fish species from Iranian waters of the Persian Gulf.

parameters can be used safely within the indicated length ranges.

Previous studies on the parameters of the LWR of selected species in Persian Gulf and other location of the world presented in Table5. In general, the variations in parameters (Table 5) may occur according to sex, gonad maturity, season, habitat type, health, food availability, environmental condition (such as temperature and salinity), degree of stomach fullness, differences in the length range of the caught specimens, sampling procedure and fishing gear (Bagenal and Tesch, 1978; Avşar, 1988; Wootton, 1992; Froese, 2006). Also, field measurement can be fluctuating according to differences in fish surface wetness; boat movements and other adverse environmental condition (Gutreuter and Krzoslen, 1994).

Isometric growth (b = 3) for *Eleutheronema tetradactylum*, *Otolithes ruber*, *Parastromateus niger* and *Pampus argenteus* indicated that length increases with body weight (Gayanilo and Pauly, 1997) and small specimens have the same form and condition of large specimens (Froese, 2006). However, *Scomberomorus commerson* shows negative allometric growth (b < 3), the condition decreases with increase of age or elongation of form and increase of length (Hile, 1936).

Condition factors are used to compare the condition, fatness, or well-being (Tesch, 1968) of fishes, based on the assumption that heavier fish of a given length are in better condition (Froese, 2006). Lecren (1951) provided an equation for calculating relative

condition factor (K_{rel}) which compares the observed weight of an individual with the mean weight of the same length. The relative weight (W_r) that indicates the percentage of the weight of an individual fish in comparison to the standard weight at the same length (Wege and Anderson, 1978), which can be used as a management tool for fisheries managers. In this study, *Eleutheronema tetradactylum* (W_r = 107.7 ± 107.29%) had the largest relative weight showing the best performance, whereas *Scomberomorus commerson* (Wr = 59.1 ± 47.74%) was not a proper representative of the environmental condition.

Froese and Binohlan (2000) represented the equation of the optimal length (L_{opt}) which indicates the fit size of fish species for catch. "For most iteroparous fishes (L_{opt}) lies between the first and second spawning, thus, making overfishing is theoretically impossible" (Mayers and Mertz, 1998; Froese, 2006), so these data can be useful for fisheries management in the region. Here, the sex of specimens and seasonal variations were not determined, so it can be considerable for future studies.

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