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Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon

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ABSTRACT

Length-weight relationships (LWRs) and relative condition factor are of great importance in fishery assessment studies since it provide information about the growth of the fish, its general wellbeing, and fitness in a marine habitat. LWRs for 9 fish species collected from the marine area of Tripoli-El Mina, North Lebanon, were established, and their growth condition was evaluated. The results indicated that almost all captured species exhibited a negative allometric growth and tended to be thinner. A significant difference was observed between *b* values during the warm and cold periods for *Liza ramada*, *Oblada melanura* and *Epinephelus costae*. In terms of seasonal variation, *Liza ramada* exhibited a positive allometric growth only in winter, while *Oblada melanura* had a positive allometric growth during the summer. The relative condition factor (K_n) fluctuated between 0.99 and 1.00, indicating a state of wellbeing for these fish species. The current study provided the first baseline data about LWRs and relative condition factor of fish species from the Eastern Mediterranean city of Tripoli. Such data is valuable for establishing a monitoring and management system of these fish species.

Introduction

Fish is an essential dietary component because of its high protein content. Unfortunately, fish stocks are plummeting worldwide notably in Mediterranean Sea, the study area, mainly because of two factors: the overexploitation of certain fish species and the environmental degradation caused, among other things, by pollution (Zhou et al., 2010; Coll et al., 2010). Fish stocks are usually monitored through fisheries that are a vital economical component of maritime nations. However, fisheries are still collapsing in some areas of the world despite efforts to sustain a healthy marine environment and preserve both fish biodiversity and biomass (Tsikliras et al., 2015).

Fisheries management addresses, among others, the economic, social and biological factors affecting fish stock in order to adopt a strategy that fulfills the feeding requirements of societies without exploiting fish stocks (FAO, 2003). Keystone tool for investigation and management include the biometric studies that deliver information on fish species for an estimated assessment of their biomass (Zargar et al., 2012). In biometric studies, it is imperative to determine the growth characteristics related to the weight and length of the fish (Morato et al., 2001), in addition to the condition of wellbeing of the species influenced by different biological and environmental factors. The importance of determining length-weight relationships (LWRs) in fish has been emphasized by many studies. It provides information about the growth pattern, general health, habitat conditions, life history, fish fatness and condition, as well as morphological characteristics of the fish (Schneider et al., 2000; Froese, 2006).

LWRs are expressed in a formula, which allows the estimation of the fish weight (W) using a particular length (L), and can be applied to studies on gonadal development, feeding rate and maturity condition (Beyer, 1987). It must be noted, however, that LWRs differ among fish species depending on the inherited body shape and the physiological factors such as maturity and spawning (Schneider et al., 2000). This relationship might change over seasons or even days (De Giosa et al., 2014). It is argued that *b* may change during different time periods illustrating the fullness of

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stomach, general condition of appetite and gonads stages (Zaher et al., 2015). In addition, the growth process can differ in the same species dwelling diverse locations, influenced by numerous biotic and abiotic factors. An additional important biometric tool is the relative condition factor (K_n) that was derived from the LWRs (Le Cren, 1951). K_n measures the deviation of an organism from the average weight in a given sample in order to assess suitability of a specific water environment for growth of fish (Yilmaz et al., 2012; Mensah, 2015). An overall fitness for fish species is assumed when K_n values are equal or close to 1.

Although numeric biometric studies were conducted around the Mediterranean Sea, very few of these studies occurred in Lebanon (Eastern Mediterranean). Literature survey revealed only three studies addressing biometrics of fish in Lebanon: Lelli et al., (2017) on dermersal fish species, Lteif et al., (2016) on sharks and batoids, and Bariche et al., (2006) on small pelagic fishes. None of the species studied in this paper has already been studied in these previous articles. Hence, the aim of this study was to 1) estimate LWRs for 9 fish species (including, respectively, three and two species of Diplodus and Epinephelus genus), 2) assess K_n to evaluate the fitness of the water body for fish growth, and 3) consider seasonal variations on LWRs for 3 species for which a sufficient number of samples was available for the four seasons. This information will enhance management and conservation, and allow future comparisons between populations of the same species.

Materials and methods

Fish were collected over four seasons in 2015–2016 from the marine area of Tripoli El-Mina, north of Lebanon (Latitude: 34° 25′ 59.99″ N, Longitude: 35° 50′ 59.99″ E). Fish were caught randomly using a mid-water trawl using fishing cages. Following the recommendations set by the U.S. EPA (Bigler, 2000), fish were collected, kept alive and intact for direct biometric measurements. Fishing was done during the day over four seasons in 2015–2016 in two sites. In the first site (port), fish were sampled from the closest point to the land while fish from the second site were collected at three distances from a major sewage outlet: 10 m, 500 m, and 1000 m. Fish were photographed individually to scale and identified down to the species by the scientists of the National Center for Marine Research (NCMS-NCSR)-Lebanon. Biometric measurements of each fish were taken as follows: Length measurements were recorded as total length (TL in cm) from the mouth to the end of the caudal fin measured to the nearest 0.1 cm by using a regular ruler validated against a Vernier caliper. Weight was measured using a digital balance with an accuracy of 0.01 g.

Length-weight relationships

The log transformation formula of Le Cren was used to establish LWRs (Le Cren, 1951). The length-weight equation $W = a\ L^b$ was used to estimate the relationship between the weight (g) of the fish and its total length (cm). Using the linear regression of the log-transformed equation: $\log(W) = \log(a) + b \log(L)$, the parameters a and b were calculated with 'a' representing the intercept and 'b' the slope of the relationship. In order to establish LWRs with respect to periodic variations that can affect b (Zargar et al., 2012), fish were grouped according to the period when they were caught (Warm period: spring and summer; Cold period: fall and winter). If no effect was detected at the larger period classification, then b was assessed and interpreted by individual season. When applying this formula on sampled fish, b may deviate from the "ideal value" of 3 that represents an isometric growth (Ricker and Carter, 1958) because of certain environmental circumstances or the condition of the fish themselves. When b is less than 3, fish become slimmer with increasing length, and growth will be negatively allometric. When b is greater than 3.0, fish become heavier showing a positive allometric growth and reflecting optimum conditions for growth.

Relative condition factor (K_n)

K_n was established to assess the condition of different fish species under study. K_n is defined as W_o/W_c, where W_o is the observed weight, and W_c is the calculated weight (Le Cren, 1951). Good growth condition of the fish is deduced when $K_n \geq 1$, while the organism is in poor growth condition compared to an average individual with the same length when $K_n < 1$. K_n was also assessed within different periods (warm for spring and summer; cold for fall and winter). It should be noted that the stomachs of fish were not emptied before weighing.

Statistical analysis

All data was analyzed using IBM SPSS statistics 21. To investigate the LWRs data, ANOVA was used to evaluate the statistical significance of the regression model detected when $P < 0.05$ (Gökçe et al., 2010). To verify if b for each species is statistically significantly different from the predictions assigned for isometric growth ($b = 3$), student t-test comparison was performed. While a statistically significant difference of b from 3 implies an allometric growth either positive or negative ($P < 0.05$), an isometric growth is assigned when b is not statistically different from 3 ($P > 0.05$) (Yilmaz et al., 2012). Statistical differences in b value between periods and among seasons were tested using a one-way ANOVA with P significant at <0.05. Data was normally distributed after being evaluated using Shapiro-Wilks test (Zar, 1999) with homoscedasticity assumed via Levene's test (Sokal and Rohlf, 1995). Student-Newman-Keuls (SNK) test was used to detect differences among seasons for some species (Abdi and Williams 2010). Differences between K_n values of collected fish species in warm and cold periods were tested using the student's t-test (Yilmaz et al., 2012). The coefficient of determination (r^2) is a measure of the quality of a linear regression's prediction (a value close to 1 means a better model).

Results and discussion

100 specimens comprising 9 fish species were caught from the marine area of Tripoli, Northern Lebanon. The studied fish species corresponds to landings from local fishermen fishing vessels. Artisanal fishing in the region represents a primary economic activity for coastal communities. The collected species are valued table fish with high commercial value in this area and constitute a significant fishery resource along the coastal area of Tripoli. The narrow size range for the various species is likely related to the used fishing technology. In fact, local fishermen have been using fishing cages that favor fish species within these size ranges. Consequently, LWRs reported in the current study for these fish species should be applied within the observed length ranges.

Fish were first evaluated for their International Union for Conservation of Nature (IUCN) status (Table 1). While other species were listed under the "Least Concern" category, the commercially important fish *Epinephelus marginatus* exhibited an "Endangered" status (Cornish and Harmelin-Vivien, 2004), thus suggesting that this fish should be subject to conservation measures through continuous monitoring of the species condition in the Mediterranean region. Furthermore, the numbers of *Diplodus cervinus*, which has a "Least Concern" IUCN status, are decreasing and therefore should be subject to continuous monitoring as well (Russell, 2014).

Table 1
LWR for the 9 species collected throughout the whole year based on the equation log (W) = log *a* + *b* log(L) (*a*: intercept and *b*: slope of the equation). N (sample size), Length (L) in cm- weight (W) in g. Minimum: (Min) and Maximum (Max) of L & W; SE is Standard error; CI (*b*): confidence intervals of *b*; r^2: coefficient of determination, *P* is significance of regression with *P* significant at <0.05; relative condition factors (K_n) of the selected fish species with its range (Min-Max) and SE. *t*-test significance was conducted to verify if *b* is significantly different from the consensus *b* = 3; The growth behavior was deduced based on *b*.

Species/genus	*Diplodus (Genus)*	*Diplodus cervinus*	*Diplodus puntazzo*	*Diplodus Sargus*	*Epinephelus (Genus)*	*Epinephelus costae*	*Epinephelus Marginatus*	*Pagrus caeruleostictus*	*Liza ramada*	*Oblada melanura*	*Mycteroperca rubra*
N	24	7	12	5	28*	13	13	3	24	14	9
$L_{min-max}$ (cm)	21.0–27.5	22.0–26.0	21.0–27.0	23.0–27.5	24.0–37.5	24.0–33.0	24.0–37.5	21.0–26.0	24.0–37.0	22.0–30.0	24.0–34.0
$W_{min-max}$ (g)	169.00–368.20	169.00–334.00	184.50–302.00	182.95–368.20	183.50–758.70	183.50–427.20	212.45–758.70	153.00–232.60	155.00–474.00	160.00–341.00	171.70–368.90
a	0.53951	0.01577	0.44157	18.1134	0.03221	0.07516	0.01923	0.626614	0.15101	0.08472	0.05345
b	1.916	3.016	1.985	0.823	2.733	2.462	2.906	1.811	2.165	2.424	2.537
SE (b)	0.438	0.808	0.392	2.042	0.236	0.25	0.298	0.706	0.18	0.373	0.361
CI (b)	1.009–2.823	0.940–5.093	1.112–2.859	−5.676–7.322	2.248–3.217	1.913–3.012	2.251–3.561	−7.16–10.783	1.791–2.540	1.612–3.237	1.683–3.390
r^2	0.466	0.736	0.719	0.051	0.838	0.898	0.897	0.868	0.867	0.779	0.876
P	0.000	0.014	0.000	0.714	0.000	0.000	0.000	0.237	0.000	0.000	0.000
t-test sig	0.000	0.23	0.000	–	0.000	0.000	0.000	–	0.000	0.000	0.000
Growth behavior	Negative allometry	Isometry	Negative allometry	–	Negative allometry	Negative allometry	Negative allometry	–	Negative allometry	Negative allometry	Negative allometry
K_n	0.997	0.994	0.995	–	1.002	1.002	0.995	–	0.998	0.994	0.992
Min-Max	0.978–1.019	0.9689–1.024	0.977–1.011	–	0.973–1.029	0.973–1.029	0.960–1.021	–	0.970–1.028	0.970–1.022	0.965–1.039
SE	0.002635	0.00864	0.003491	–	0.004938	0.004938	0.004986	–	0.003303	0.00428	0.007675
IUCN status**		LC	LC	LC		DD	En	LC	LC	LC	LC

*The genus Epinephelus (28 individuals) also include the *Epinephelus haifensis* but no regression was performed for this species since only two samples were only collected.
**The IUCN status of the nine fish species caught: En: endangered; LC: least concern; DD: data deficient.

Length-weight relationships over the whole year

Next, the nine fish species were assessed for the relationship between the body length and weight. The examined specimens exhibited total length and weights varying between 21.0 and 37.5 cm (Mean = 27.1 ± 3.2) and 153.00–758.70 g (Mean = 259.35 ± 90.18), respectively, over the whole year. The sample size as well as the length and weight characteristics are presented in Table 1. It should be noted that estimated LWRs were considered only as mean annual values for most of these species since the data was collected over an extensive period of time and is not representative of a particular season. With an adequate number of caught fish available, the LWRs were established for two genera (*Diplodus* and *Epinephelus*) as well as for species within these two genera and four other species. While the sample size within each genus/species ranged from 1 to 24 fish, linearity was assessed only when there was a minimum of three specimens. The coefficient of determination r^2 values varied between 0.898 (*Epinephelus costae*) and 0.719 (*Dipoldus puntazzo*) (Table 1).

These high coefficient of determination values obtained in the assessment of LWRs over the whole year means a good quality of the prediction of a linear regression for the analyzed fish species, and suggested that extrapolation in future catches can be done in that geographical spot for this size range. Significant correlation ($P < 0.05$) was observed for all tested species except for *Diplodus sargus* and *Pagrus caeruleostictus* ($P > 0.05$). The non-significant regression found for the latter species is perhaps due to the low number of specimens (5 and 3, respectively). The negative allometric growth deduced for nearly all analyzed fish ($b < 3$, *t*-test, $P < 0.05$) suggested that these species have a relatively slow growth rate and tend to be thinner (Table 1). However, the *Diplodus cervinus* exhibited an isometric growth ($b = 3$, *t*-test, $P > 0.05$) which may be related to its specific phenotype or to the environmental conditions of its habitat (Tsoumani et al., 2006). With *b* (for all species) fluctuating between 1.985 and 3.016 (Mean value of 2.499 ± 0.369), no positive allometry was detected for any of the sampled fish.

While some of our results are in agreement with other regional and international findings on biometrics of fish studied, others are not (Table 2). In terms of agreement for instance, Bouchereau et al. (1999) reported a negative allometric growth for *Epinephelus marginatus* from Lavezzi islands ($b = 2.60$) while Akyol et al. (2007) reported a negative allometry for *Epinephelus costae* from Aegean Sea in Turkey ($b = 2.736$). The findings of Morey et al. (2003) were similar to our finding for the *Epinephelus costae* collected from the west Mediterranean ($b = 2.967$). Furthermore, the negative allometric growth ($b = 2.165$) reported for *Liza ramada* in our study is in conformity with the findings of Mohammed et al. (Mohammed et al., 2016) for the same fish in Eastern Libya ($b = 2.847$). The LWRs for *Oblada melanura* reported by Mahmoud et al. (Mahmoud, 2010) corroborate the negative allometric growth reported in our study (Species from Egypt $b = 2.934$; Species from our study $b = 2.424$). On the other hand, the isometric growth ($b = 3.016$) observed for *Diplodus cervinus* harvested from Tripoli El-Mina in the current study was not in conformity with the positive allometric growth ($b = 3.762$) reported by Wassef (1985) for fish collected from Egyptian Mediterranean. In addition, while an allometric negative growth with a *b* value of 1.985 was calculated for *Diplodus puntazzo* collected from Tripoli El-Mina, an isometric growth with *b* value of 3.001 was reported for fish harvested from the Adriatic sea (Kraljević et al., 2007). *Epinephelus marginatus* collected from southwestern Atlantic displayed a positive allometric growth with *b* value of 3.094 (Condini et al., 2014) whereas it exhibited a negative allometric growth in our study ($b = 2.906$). Furthermore, Aronov and Goren (2008) recorded *b* value of 3.135 for *Mycteroperca rubra* collected from the eastern Mediterranean, thus suggesting a positive allometric growth which is in contrary to the negative allometric growth obtained in our study ($b = 2.537$). While we cannot conclusively explain the agreements and disagreements with published literature, it might be due to the condition of the species itself, its phenotype and its specific geographic location and hence its environment as several researchers have observed (Tsoumani et al., 2006). Phenotypic factors, especially in the case of *Liza ramada*, can play a role in affecting the allometric growth data. With its distinctive elongated body, *Liza ramada* increases more in length than in weight, thus, the body form and shape strongly affect the LWRs (Karachle & Stergiou, 2012). The variation in the obtained *b* values might be correlated

Table 2
Literature reports describing allometric growth of fish compared to the findings in the current study. N: Sample size; *b* is slope of the equation log (W) = log *a* + *b* log(L).

	Species	Location in current study	N	*b*	Location (Literature)	N	*b*	Literature
Reports in agreement with the findings in this study	*Epinephilus marginatus*	Tripoli-Lebanon	13	2.906	Lavezzi island	24	2.60	Bouchereau et al., 1999
	Epinephilus costae	Tripoli-Lebanon	13	2.462	Aegean Sea Turkey	59	2.736	Akyol et al., 2007
	Epinephilus costae	Tripoli-Lebanon	13	2.462	West Mediterranean	16	2.967	Morey et al., 2003
	Liza ramada	Tripoli-Lebanon	24	2.165	Eastern Libya	45	2.847	Mohammed et al., 2016
	Oblada melanura	Tripoli-Lebanon	14	2.424	Egypt	477	2.934	Mahmoud, 2010
Reports not in agreement with the findings in this study	*Diplodus puntazzo*	Tripoli-Lebanon	12	1.985	Adriatic sea	598	3.001	Kraljević et al., 2007
	Epinephilus marginatus	Tripoli-Lebanon	13	2.906	Southwestern Atlantic	211	3.094	Condini et al., 2014
	Mycteroperca rubra	Tripoli-Lebanon	9	2.537	Eastern Mediterranean	205	3.135	Aronov & Goren, 2008
	Diplodus cervinus	Tripoli-Lebanon	7	3.016	Egyptian Mediterranean	85	3.762	Wassef, 1985

with many factors such as food availability, season and sex (Yilmaz et al., 2012; Ali et al., 2016).

Length-weight relationships by periods (warm vs cold)

Effects of seasons, periods, and food availability on the variation of *b* were explored in our study. Only three species, namely *Liza ramada*, *Oblada melanura* and *Epinephelus costae*, were caught throughout the seasons and/or periods and for which *b* parameter can be used for comparison (Table 3). We first present our data per period followed by per season. For the three species *Liza Ramada*, *Oblada melanura* and *Epinephelus costae*, there was a significant difference between *b* values during the two periods (warm and cold) ($P < 0.05$). *b* ranged from 2.175 (cold period) to 2.282 (warm period) for *Liza ramada*, 2.030 (cold period) to 2.925 (warm period) for *Oblada melanura*, and 2.356 (cold period) to 2.503 (warm period) for *Epinephelus costae* (Table 3). The higher values of *b* (Table 3) obtained in warm vs lower ones in cold periods ($P < 0.05$) for the three species, *Liza ramada, Oblada melanua,* and *Epinephelus costae* might be linked to the effect of temperature during each period. The improved growth of fish during warm periods can be rationalized by the fact that

Table 3
Period/Season, Count (N sample size), Length (L) in cm- weight (W) in g relationship for the 3 species found across seasons, presented here during the warm period (Spring and Summer) and the cold period (Fall and winter) based on log (W) = log *a* + *b* log(L) (*a*: intercept and *b*: slope of the equation). Minimum: (min) and Maximum (Max) of L & W, CI (*b*): confidence intervals of *b*; r^2: correlation coefficient of the regression; *P1* is significance of regression with all *P* being significant at <0.05; *P2* is significance of difference in mean *b* values between warm and cold period for the same species; *P3* is significance of difference in mean *b* values among seasons; *t*-test significance is conducted to verify if *b* is significantly different from consensus *b* = 3). (–) indicate that the regression is not significant, and therefore growth behavior cannot be deduced, or sample size was not adequate for regression analysis.

Species	Periods/ seasons	N	$L_{min-max}$ (cm)	$W_{min-max}$ (g)	*a*	*b*	CI (*b*)	r^2	*P1* of regression	*P2* of periods	*P3* of seasons	*t*-test sig	Growth behavior
Liza ramada	Warm	10	26.0–36.0	156.00–368.70	0.09977	2.282	1.684–2.881	0.906	0.000	0.000	0.000	0.000	Negative allometry
	Spring	6	26.5–36.0	189.30–368.70	0.22182	2.059	1.521–2.597	0.966	0.000			0.000	Negative allometry
	Summer	4	26.0–29.0	156.00–188.80	1.233105	1.500	1.098–4.098	0.755	0.131			–	–
	Cold	14	24.0–37.0	155.00–474.00	0.148594	2.175	1.566–2.78	0.835	0.000			0.000	Negative allometry
	Fall	6	24.0–27.0	155.00–190.00	5.61048	1.064	0.835–2.964	0.377	0.195			–	–
	Winter	8	27.0–37.0	169.00–474.00	0.005848	3.115	2.291–3.940	0.934	0.000			0.000	Positive allometry
Oblada melanura	Warm	9	23.0–29.0	165.60–341.00	0.016672	2.925	1.407–4.443	0.748	0.003	0.000	0.000	0.001	Negative allometry
	Spring	2	26.0–27.0	212.50–297.00	–	–	–	–	–			–	–
	Summer	7	23.0–29.0	165.50–341.00	0.009616	3.091	2.267–3.915	0.949	0.000			0.000	Positive allometry
	Cold	5	22.0–30.0	160.00–317.00	0.302691	2.030	1.017–3.043	0.931	0.008			0.000	Negative allometry
	Fall	2	26.0–28.0	236.00–237.00	–	–	–	–	–			–	–
	Winter	3	22.0–30.0	160.00–317.00	0.176198	2.203	1.744–2.662	1	0.01			0.000	Negative allometry
Epinephelus costae	Warm	7	24.0–33.0	187.70–427.20	0.065615	2.503	1.856–3.150	0.952	0.000	0.000	–	0.000	Negative allometry
	Cold	6	24.0–30.0	183.50–353.00	0.10666	2.356	0.598–4.115	0.776	0.02			0.000	Negative allometry

higher temperatures will lead to an increase in the metabolic rates of fish and hence the digestion processes are sped up leading to faster growth (Clarke and Fraser, 2004). All three species exhibited a negative allometric growth during both warm and cold periods ($P < 0.05$, $b < 3$, *t*-test) despite the significant growth increase observed during the warm period (Table 3).

Length-weight relationships by seasons

Next, we explored the behavior of *b* during individual seasons for the two fish species that were collected during all four seasons. There was a significant difference in *b* values between seasons for *Liza ramada* and *Oblada melanura* ($P < 0.05$ for both) (Table 3). For *Liza ramada*, the SNK test revealed a significant difference between spring and summer and between fall and winter, with the latter being the highest in growth ($b = 3.115$). While *Liza ramada* exhibited a negative allometric growth in spring, positive allometric growth ($P < 0.05$, $b > 3$, *t*-test) was attained only during winter. On the other hand, *Oblada melanura* exhibited negative allometric growth in winter and positive allometric growth in the summer ($b = 3.091$, $P < 0.05$ in summer vs $b = 2.203$ in winter) (Table 3). Our results summarizing the effect of seasonal variations on the growth of *Liza ramada* (Table 3) were in agreement with the report of Ali et al. (Ali et al., 2016) who also found a negative allometric growth in spring vs a positive allometric growth during winter for *Liza ramada* caught from the Eastern coast of Libya (*b* ranging from 2.973 to 3.321) with no plausible explanation except that it might be related to stomach fullness. However, the growth of *Oblada melanura* showed opposite trends between summer and winter. In fact, the outcome observed for the growth of *Oblada melanura* in our study, summarized by negative allometric growth in winter vs a positive allometric growth in the summer (Table 3), is in agreement with the finding of Arslan et al. (2004) who revealed negative allometric growth of fish during winter due to insufficient feeding at low water temperatures.

It is noteworthy mentioning that the caught fish were not sexed, which could influence LWRs reported in the current study (Pardoe et al., 2008). Sex is an important factor to consider because some species are monandric protogynous hermaphrodite, changing from female to male with increase in size (such as of *Epinephelus marginatus*), and others are hermaphrodite exhibiting partial protandry (such as *Diplodus sargus* spp sargus) (Mouine et al., 2007). Thus, future LWRs studies should consider the sex factor to depict a comprehensive analysis of the data. Another factor that might influence LWRs is the maturity stage of the analyzed fish. While *Liza ramada*, *Oblada melanura* and *Diplodus sargus* caught in the current study were all sexually mature organisms, *Mycteroperca rubra* and *Epinephelus marginatus* were all immature fish (Table 4). *Diplodus puntazzo*, *Diplodus cervinus* and *Epinephelus costae* in our harvest included both mature (83%, 57%, 31% respectively) and immature individuals.

Table 4
Maturity of fish collected in the current study.

Species	Length at first maturity (reference)	% Mature fish	% Immature fish
Diplodus cervinus	25 (Derbal and Kara, 2013)	57	43
Diplodus puntazzo	22 (Kraljević et al., 2007)	83	17
Diplodus sargus	21 (Mouine et al., 2007)	100	0
Epinephelus costae	30 (Gothel, 1992)	31	69
Epinephelus marginatus	>38.6 (Renones et al., 2007)	0	100
Liza ramada	22–24 (El-Halfawy et al., 2007)	100	0
Mycteroperca rubra	>38 (Aronov and Goren, 2008)	0	100
Oblada melanura	>17 (Cetinić et al., 2002)	100	0

The relative condition factor (K_n)

K_n values of the nine evaluated species in the current study fluctuated between 0.99 and 1.00 as shown in Table 1. These values suggest a state of wellbeing for the species tested. Many factors affect the growth condition of fish including reproductive cycles, availability of food, as well as habitat and environmental factors (Morato et al., 2001). The deviation of K_n from 1 reveals information concerning the differences in food availability and consequence of physicochemical features on the life cycle of fish species (Le Cren, 1951). Table 5 shows K_n values for the three selected fish species when partitioned according to warm and cold periods. The effect of temperature variation on K_n values was not illustrated in the case of *Oblada melanura* and *Epinephelus costae* since there was no significant difference in mean K_n between periods ($P > 0.05$, *t*-test) for these fish species. This was not the case for *Liza ramada* where the mean K_n value showed a significant difference between warm ($K_n = 1.00$) and cold periods ($K_n = 0.99$) ($P < 0.05$, *t*-test) suggesting a better fitness for this species during the warm period ($K_n = 1$) (Table 4). High K_n values during warm period may be related to the increase in the feeding intensity of these fish. Indeed, increased K_n could be related to larger food availability or to a higher feeding activity during warmer periods when temperature is optimum (De Giosa et al., 2014). Furthermore, it is known that fish usually decrease their feeding activity and use their lipid reserves during spawning which results in a decrease in condition (Lizama and Ambrósio, 2002). As spawning of *Liza ramada* generally occurs at the beginning of cold period, the drop in feeding activity might also explain the lower K_n values observed during this period. It should be noted that the gut fullness was not investigated prior to analysis since it was documented in literature that the fullness status was not likely to be linked to the condition factor (Hanjavanit et al., 2013). In fact, when the fish gets enough food for its growth, K_n will be greater than one corresponding to optimum growth condition. The fish might have an empty stomach at collection even though it is consuming sufficient food for its growth and survival in the marine habitat.

Table 5
Relative condition factors (K_n) of the 3 selected fish species in 2 periods: Warm (Spring, summer) and cold (Fall, winter). N: sample size of captured fish; Wo: observed weight (g); Wc: calculated weight (g), Mean deviation of the individual observed weight from the calculated weight ((Wo-Wc)/Wc); The *t*-test significance: the statistical significance of the *t*-test ($P < 0.05$) performed to deduce if there is significant difference between mean K_n in warm and cold periods.

Species	Periods	N	Mean Wo	Mean Wc	K_n	Mean deviation	*t*-test sig
Liza ramada	Warm	10	213.63	213.24	1.002	0.00180	0.026
	Cold	14	213.00	213.67	0.997	−0.00315	
Oblada melanura	Warm	9	237.54	240.08	0.990	−0.01059	0.566
	Cold	5	235.55	235.63	1.000	−0.00035	
Epinephelus costae	Warm	7	308.42	306.78	1.005	0.00536	0.891
	Cold	6	270.01	270.69	0.997	−0.00250	

Conclusion

This study provided the first data on LWRs and K_n for some fish species collected from the marine area of Tripoli, North of Lebanon. Almost all LWRs showed a negative allometric growth of fish which might be attributed to environmental conditions or linked to morphological characteristics specific to each species. K_n was generally close to 1 showing an overall state of wellbeing of tested species. Specifically, *Liza ramada* had a better fitness in warm periods compared to cold ones which might be due to the increase in feeding activity and food availability when temperatures are higher. This study fulfilled the aims set for it, and the data presented might constitute a valuable guideline for establishing future biometric studies for fish collected through the Lebanese coastal line.

Conflict of interests

The authors declare that they have no competing interests.

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