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Short Communication

Length-weight relationship and condition factor of female skinnycheek lanternfish, *Benthosema pterotum* (Alcock, 1890), in the Makran Sea (Teleostei: Myctophidae)

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Abstract: Length-weight relationship (*TL-BW*) and condition factors of 654 female skinnycheek lanternfish, *Benthosema pterotum*, were evaluated in the Iranian shelf region of Makran (Oman) Sea from April 2013 through March 2014. Prediction of growth pattern was done using a log-transferred of the power function. Analyzing the coefficient *b*, demonstrated negative allometric growth in juveniles and isometric in adults. The TL-BW relationships obtained were $BW= 0.0173TL^{2.396}$ and $BW=0.0074TL^{2.933}$ for juveniles and adults and $BW=0.0164TL^{2.429}$ for all. The lowest adult condition factor was recorded in summer with an ascending towards spring with the highest value in this season. This value increased from spring to winter in juveniles with the highest value in winter. This trend in juveniles maybe results as better feeding condition in winter, while in adults, it could be affected by the reproductive condition.

Keywords: LWR, Coefficient *b*, Growth Pattern, Juveniles, Adults.

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Introduction

Knowledge of quantitative aspects such as length-weight relationship and condition factor of fishes is an important tool for the study of fishing biology, mainly when the species lies at the base of the higher food web (Lizama & Ambrósio 2002). In fish, the condition factor reflects, through its variations, information on the physiological state of the fish in relation to its welfare (Lloret et al. 2013). From a nutritional point of view, it reflects the accumulation of fat and gonadal development (Le Cren 1951). From a reproductive point of view, the highest condition factor value is an indication of spawning period in some species (Angelescu et al. 1958). The condition factor also gives information when comparing two populations living in certain feeding, density, climate, and other conditions; when determining the period of gonadal maturation; and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source (Weatherly 1979). The study of the condition

factor is thus important for understanding the life cycle of fish species and contributes to adequate management of these species and, therefore, to the maintenance of equilibrium in the ecosystem.

Information on length-weight relationships *(LWRs)* of many fishes is available (see Esmaeili & Ebrahimi 2006; Ghanbarifardi et al. 2014; Hasankhani et al. 2013, 2014; Lawal & Bichi 2014; Keivany et al. 2015; Jafari et al. 2016). Myctophids are among the most abundant fish in micronekton communities in the mesopelagic layer of all oceans, and are an important link in the food chain of marine ecosystems (Gjøsaeter & Kawaguchi 1980). Although Myctophidae is one of the most abundant and varied mesopelagic fish families, biological information of this family is rare. The skinnycheek lanternfish, *Benthosema pterotum* (Alcock, 1890) is the main myctophid species with the highest density throughout the Oman Sea mesopelagic fish resources (Valinassab et al. 2007). Biological studies are restricted to some reports about this commercially important fish (Valinassab et al. 2007; Karuppasamy et al. 2008; Hosseini-Shekarabi et al. 2015). No length-weight records are available for *B. pterotum* and the only one related study is based on a survey in the eastern Arabian Sea (Karuppasamy et al. 2008). This study provides the first published reference on *TL-BW* for this species from the Iranian continental shelf of the Oman Sea.

Materials and Methods

Specimens of *B. pterotum* were sampled on a monthly basis during the study period from April 2013 to March 2014. This study was carried out in the fishing grounds located between 25º37'72"N; 57º13'04"E and 25º32'45"N; 57º23'24"E in the Makran Sea, Iran. Fish were captured from depths between 210 and 265m deploying mid-water trawl nets. Specimens were chosen randomly from the captured fishes and placed in plastic bags over a layer of ice in a cooler and transported to laboratory for further examination. Each individual was measured to the nearest 0.1cm total length (*TL*) with a vernier caliper and weighed to the nearest 0.001g (*BW*) with a digital precision balance.

The power function of total length-body weight relationship, $BW=aTL^b$, was converted into its logarithmic expression:

$$lnBW= lna+blnTL$$

Where *BW* is the whole body weight (g), and *TL* is the total length (cm), and '*a*' and '*b*' are the regression parameters.

A statistical t-test demonstrated the significant differences between obtained *b*-values and isometric values (*b*= 3) with the formula (Zar 2010):

$$t_s=(b-3)/s_b$$

Where t_s is the t-test value; *b* is the slope of curve and s_b is the standard error of the slope. The value of '*b*' from the total length-body weight relationship (Lizama et al. 1999) was employed in calculating the condition factor. Individual values of the condition factor were obtained through the formula:

$$\text{Condition factor}=BW/TL^b.$$

Results

A total of 654 lanterfish specimens were analyzed with lengths of 3.8cm to 5.6cm and weights of 0.381g to 1.230g. Parameters of the *TL-BW* are given in Table 1. As the analyzed specimens were captured randomly by mid-water trawl nets, the results can be considered as representative of the entire population.

Regressions of *TL-BW* is presented in Fig. 1. The overall *TL-BW* of females was $BW=0.0164TL^{2.4289}$. The *TL-BW* in individuals with *TL* up to 4.6cm was $BW=0.0173TL^{2.396}$ whereas for ones with the value larger than 4.6 cm, the relationship was $BW=0.0074TL^{2.933}$.

The estimated regression coefficient *b* of individuals with *TL* up to 4.6cm was 2.396 (2.2182–2.2405, 95% confidence limits, *TL*), which was less than 3.0 ($t_{0.05,421}$=-4.733; $P<0.05$). Whereas, in fish with *TL* larger than 4.6cm, the value of *b* was 2.933 (2.2801–2.3131, 95% confidence limits, *TL*), showing equal value to 3.0 ($t_{0.05,229}$=-0.299; $P>0.05$).

However, the analyzed value in total population is less than 3.0 ($t_{0.05,652}$=-8.292; P<0.05) as the regression coefficient b was 2.429 (2.4241–2.4359, 95% confidence limits, *TL*).

Table 1. Parameters of length–weight regression for lanternfish (*B. pterotum*) caught in the Makran Sea, Iran (April 2013-March 2014).

		Total length (cm)		Total body weight (g)		Regression parameters				
Months	**N**	**Min**	**Max**	**Min**	**Max**	**a**	**95% Cl of a**	**b**	**95% Cl of b**	**r**
April	69	4.0	5.1	0.431	1.002	0.0167	0.0163 - 0.0170	2.4343	2.4204 - 2.4482	0.9217
May	50	3.9	5.4	0.419	1.184	0.0174	0.0167 - 0.0181	2.4608	2.4340 - 2.4877	0.8469
June	57	4.0	5.3	0.408	1.230	0.0153	0.0148 - 0.0159	2.3783	2.3572 - 2.3994	0.8432
July	52	4.1	5.3	0.445	1.066	0.0171	0.0166 - 0.0176	2.4514	2.4310 - 2.4719	0.7913
August	52	4.0	5.6	0.445	1.140	0.0163	0.0158 - 0.0167	2.4193	2.4027 - 2.4358	0.8665
September	56	4.0	5.0	0.425	0.847	0.0156	0.0151 - 0.0161	2.3908	2.3711 - 2.4106	0.6340
October	56	4.1	5.1	0.477	0.914	0.0158	0.0153 - 0.0162	2.3993	2.3805 - 2.4181	0.7034
November	49	4.0	5.2	0.481	1.023	0.0176	0.0171 - 0.0181	2.4701	2.4508 - 2.4894	0.8639
December	50	3.8	5.5	0.381	0.985	0.0160	0.0156 - 0.0163	2.4077	2.3924 - 2.4230	0.8994
January	58	3.9	5.0	0.383	0.918	0.0162	0.0158 - 0.0166	2.4159	2.3990 - 2.4327	0.8787
February	55	3.8	5.1	0.396	0.901	0.0166	0.0161 - 0.0171	2.4319	2.4127 - 2.4511	0.8548
March	50	4.0	5.4	0.520	1.128	0.0184	0.0180 - 0.0187	2.5025	2.4899 - 2.5150	0.8634
All	**654**	**3.8**	**5.6**	**0.381**	**1.230**	**0.0165**	**0.0164 - 0.0167**	**2.4289**	**2.4230 - 2.4348**	**0.8100**

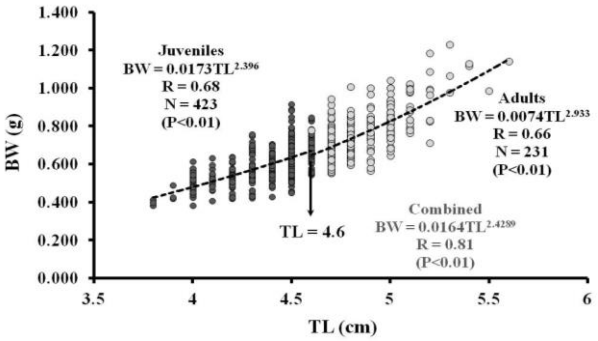

Fig. 1. Scatter plot of empirical points of body weight vs. total length relationship fitted by power function for females of lanternfish (April 2013-March 2014).

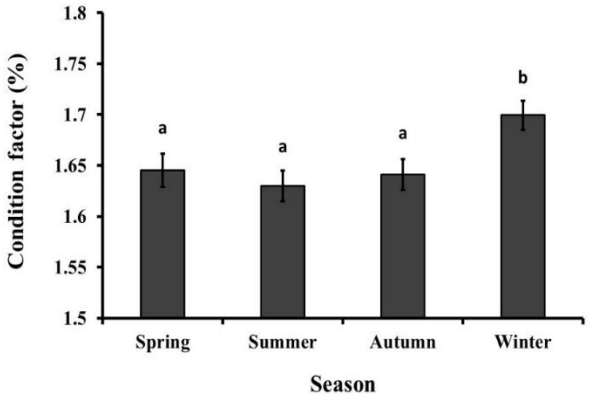

Fig. 2. Seasonal means (bars) and SD (vertical lines) of the condition factor for total females of lanternfish (April 2013-March 2014). Similar letters indicate no statistical difference (P>0.05).

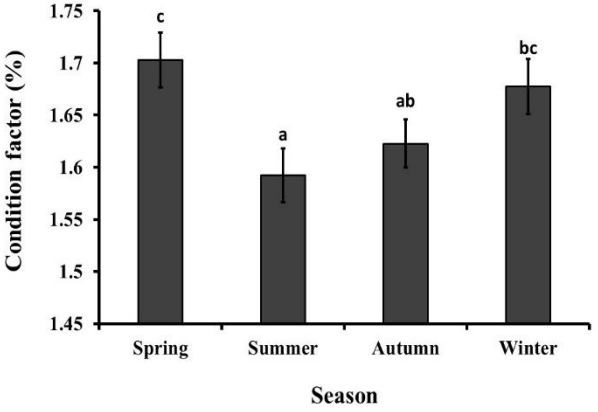

Fig. 3. Seasonal means (bars) and SD (vertical lines) of the condition factor for adult females of lanternfish (April 2013-March 2014).

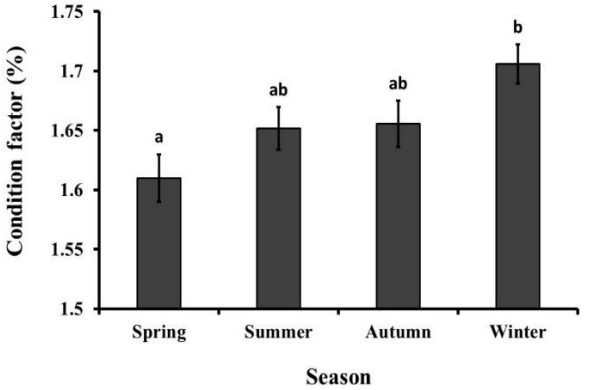

Fig. 4. Seasonal means (bars) and SD (vertical lines) of the condition factor for juvenile females of lanternfish (April 2013-March 2014).

The mean total condition factor of females differed significantly between different seasons (X^2=17.433, N=654, P=0.001) (Fig. 2). This mean is significantly higher in winter (U=11623, N=339, P<0.05) compared to other seasons. In adults, the value of condition factor was significantly higher in spring compared to summer and autumn (U=1340, N=126, P<0.05) (Fig. 3). This factor exhibited less oscillation in juveniles (CV%=11.58) (Fig. 4), with significantly higher value in winter compared to spring (U=4730, N=235, P<0.05). The mean condition factor in adults and juveniles did not significantly differ (t_{652}=0.676, P>0.05).

Discussion

This study provides new records of *TL-BW* for females of *B. pterotum* as compared to FishBase (Froese & Pauly 2017). The best fitted equation for females indicated two different growth patterns for the studied species; a negative allometric growth pattern for juveniles and an isometric growth pattern for adults. In this study, the individuals with total length up to 4.6cm exhibited this pattern. The results may be due to physiological factors such as response to the environmental conditions they come across as a result of their migrations and also of their diurnal changes in growth (Childress et al. 1980). Besides, a groups was considered as juveniles that their gonads did not fully develop and maturity was in progress. Physiological status of maturity and gonadal development can have profound influence on growth rate of individuals (Tabassum et al. 2013). When the total length of fish increases from 4.6cm, the coefficient *b* increases significantly. The higher *b* value may be attributed to relative body plumpness increased more quickly than body length in adults due to different factors, especially to increase gonadal size and sexual maturation (Froese 2006).

There was a certain constancy in the condition factor values in relation to the length of studied specimen during a one-year period. This is in accordance to the results obtained for *Cynoscion jamaicensis* (Muto et al. 2000), however, it was in contrast to *Sardinella aurita* in which higher condition factor was extracted from juveniles (Vazzoler & Vazzoler 1965) rather than adults. Despite the constancy of the index in two different length groups of *B. pterotum*, the condition factor exhibited different patterns in juveniles compared to adults. In the former, the highest condition factor was observed in winter, whereas in the latter was in spring. The condition factor is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fishes (Safi et al. 2014). This value decreases at the onset of the spawning period because of very high metabolic rate needs (Blackwell et al. 2000). There is normally a gradual increase in the condition factor during the reproductive period and reach the basal level immediately afterwards. In adult stage, the condition factor does not only reflect the feeding condition, but includes the condition of gonadal development (Blackwell et al. 2000). The fluctuation of condition factor and the amount of preserved fat follow the reproductive progress. At the start of this process, high values are attributed to conservation of stored energy, increasing size and weight of maturing gonads (Lalrinsanga et al. 2012; Lawal & Bichi 2014); a gradual decrease in condition factor occurs along with a decrease in reserved fat. Afterwards, there is a gradual increase in accumulated fat and condition factor values, suggesting a preparatory span for a new reproductive period.

Different patterns of fluctuation in condition factor of *B. pterotum* juveniles and adults were demonstrated. In the former, the highest condition factor was in winter, whereas in the latter was in spring. This discrepancy maybe due to the gonadal development in adults as reported for *B. pterotum* (Dalpadado 1988) and *B. fibulatum* (Hussain 1992).

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یافته علمی کوتاه

رابطه طول و وزن و ضریب چاقی در جنس ماده فانوس‌ماهی *Benthosema pterotum* (Alock, 1890) در منطقه فلات قاره دریای مکران در آب‌های ایران (ماهیان استخوانی عالی: فانوس ماهیان)

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چکیده: در مطالعه حاضر ارتباط طول و وزن بدن و همچنین ضریب چاقی در جنس ماده ۶۴۵ عدد فانوس ماهی *Benthosema pterotum* (Alock, 1890) در منطقه فلات قاره دریای عمان در آبهای ایران به مدت یک سال از فروردین ۱۳۹۲ تا اسفند ۱۳۹۲ مورد بررسی قرار گرفته است. تخمین الگوی رشد با استفاده از لگاریتم رابطه توانی رشد محاسبه گردید. آنالیز ضریب *b* بیانگر وجود رشد آلومتریک منفی در ماهیان ماده نوجوان و رشد ایزومتریک در نمونه های بالغ بود. ارتباط بین طول و وزن برای نمونه های نوجوان به صورت $BW=۰/۰۱۷۳TL^{۲/۳۹۶}$ و برای نمونه های بالغ به صورت $BW=۰/۰۰۷۴TL^{۲/۹۳۳}$ و برای مجموع نمونه های مطالعه شده به صورت $BW=۰/۰۱۶۴TL^{۲/۴۲۹}$ به دست آمد. کمترین ضریب چاقی ماهیان ماده بالغ در تابستان ثبت شد که روند آن به سمت بهار صعودی با بیشترین مقدار در این فصل بود. ضریب چاقی در نمونه های نوجوان از بهار تا زمستان روند افزایشی داشت به نحوی که بیشترین مقدار ضریب چاقی در زمستان به دست آمد. این روند در ماهیان نوجوان ممکن است بیانگر شرایط تغذیه ای بهتر در زمستان باشد، در حالیکه در ماهیان بالغ، رشد ممکن است تحت تاثیر شرایط تولید مثلی قرار گیرد.

کلیدواژه‌ها: طول کل- وزن بدن، ضریب *b*، الگوی رشد، نوجوان، بالغ.