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Condition factor and seasonal variation in Length-weight relationship of *Acanthopagrus arabicus* from Karachi Coast, Pakistan

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Abstract
The present research was undertaken to study the condition factor and seasonal variation in the length-weight relationship of *Acanthopagrus arabicus* from Karachi coast, Pakistan. This work provides a first detailed study on length-weight relationship along with condition factor of *Acanthopagrus arabicus* from this region. The coefficient of correlation were ranged $r^2 = 0.878 – 0.954$ for male and $r^2 = 0.851 – 0.917$ for female (Year 2011), $r^2 = 0.867 – 0.952$ for male and $r^2 = 0.890 – 0.977$ for female (Year 2012) and $r^2 = 0.867 – 0.933$ for male and $r^2 = 0.851 – 0.958$ for female (year 2013). *Acanthopagrus arabicus* showed negative allometric growth ($b < 3$) in all seasons with the exceptions of positive allometry noticed only in Autumn 2012 and 2013 (male) and isometry in Spring 2011 (male) and 2012 (male and female). Condition factor K showed fluctuations along length groups but no significant relationship was observed between 'K' and gender of the species. While calculated values of 'Kn' showed a significant increase with the increase in length groups of both sexes.

Keywords: Condition factor, seasonal variation, length-weight relationship, *Acanthopagrus arabicus*

1. Introduction
Arabian yellow-finned seabream '*Acanthopagrus arabicus*' locally termed as 'Dhandya' is currently known only from Middle Eastern waters (The Gulf) from Duqum (J. Randall's collection), southern Oman to Qatar (type locality), and off the coasts of Kuwait (including Iran and Pakistan), to Trivandrum, south-western India [1]. Later on further studies confirmed the presence of *Acanthopagrus arabicus* in Pakistan [2].
To study fish biology, length-weight relationship (LWR) and condition factor (K and Kn) are basic parameters but they play an important role in aquaculture practices, growth proportions, assessment in fisheries stock and length and age constructions [3]. Therefore a number of studies have been done by different authors to provide data on LWR, condition factor and relative condition factor (K and Kn) [4-10].
The present study was design for detailed observations of three years on condition factor, relative condition factor and seasonal variation in the length-weight relationship of *Acanthopagrus arabicus,* which will provide useful data for fisheries management, as there is no such data or information on this commercially valuable species from Pakistan.

2. Material and Methods
Sampling Procedure: The present work comprises of three years data including four different seasons in each year. A total of 1400 specimens collected from landings at Karachi Fish Harbor at monthly basis from January 2011 to December 2013. The collection contained 701 females and 699 males.

2.1 Measurements: Specimens were measure for Total Length (TL) from snout to tip of the caudal fin and Body Weight (B. Wt) to nearest 0.1mm and 0.01g respectively. The digital balance was used to measure body weight.

2.2 Data analysis/statistical analysis: LWR calculated by using= $a L^b$ (Le Cren, 1951) [11] Where, W = Body Weight (g), a = Regression intercept (constant), L = Total Length (mm), b = Regression slope (constant). For the better understanding log, transformed data was used.

Relative condition factor calculated by Kn = W/w (Le Cren, 1951). Where,
W = Observed Body weight (g), w = calculated body weight resulting from LWR.
Condition factor calculated by $K = 100aL^{b-3}$ (Clark, 1928) [12], which was derived from Fulton's condition factor equation by replacing W in $K = 100\ W/L^3$ with aL^b because $W = aL^b$as mentioned above. Where W = a = Regression intercept (constant), b = Regression slope (constant) and L = Total length (mm). Statistical analysis was done by using SPSS (IBM) version 22. Standard error and coefficient of correlation were also calculated.
* Note: Only functional males and functional females were considered for this study, as *Acanthopagrus arabicus* is a protandrous hermaphrodite.

3. Results

3.1 Length-weight relationship: Values of minimum, maximum, and standard deviation for total length (mm) and body weight (g) of male and female in each season of three different years are provided in Table 1, 2 and 3. Presented data for Length-weight relationship in male and female specimens showed variation in different seasons showing isometric, negative and positive allometric growth. Overall, negative allometric growth was observed within a season in both sexes. Positive allometry noticed only in autumn 2012 and 2013 (male) and isometry in spring 2011 (male) and 2012 (male and female). The variation observed during this study may be due to feeding intensity in that particular season or gonadal cycle of the species. There was no significant difference noted in the value of 'b' between male and female of the same season with a few exceptions. Length-weight relationship showed a significant relationship ($P<0.05$, Table 4, 5 and 6). Regression line plot for male and female in different seasons presented in Fig 1 (a, b, c, d), Fig 2 (a, b, c, d), Fig 3 (a, b, c, d), Fig 4 (a, b, c, d), Fig 5 (a, b, c, d) and Fig 6 (a, b, c, d).

3.2 Condition factor (K and Kn): The current work results suggested no significant relationship between condition factor (K) and the gender of the species, the value of 'K' for male and female was more than 1. A slight variation noticed in the value of 'K' in different length groups. While relative condition factor (Kn) significantly increased with increase in the length of both genders of the species. (Fig 7 a, b, c, d)

Table 1: Descriptive statistics and measurements for length and weight of *Acanthopagrus arabicus* in different seasons of year 2011.

Year 2011										
Season	Gender	N	TL (mm)				B.Wt (g)			
			Min	Max	Mean	SD	Min	Max	Mean	SD
Autumn	Male	45	2.236	2.548	2.384	0.069	2.000	2.919	2.439	0.209
	Female	40	2.301	2.458	2.380	0.048	2.190	2.623	2.422	0.140
Winter	Male	71	2.217	2.486	2.341	0.074	1.954	2.713	2.357	0.203
	Female	62	2.217	2.505	2.341	0.066	1.954	2.803	2.343	0.175
Spring	Male	46	2.241	2.531	2.352	0.054	1.978	2.912	2.365	0.166
	Female	56	2.267	2.544	2.386	0.071	2.121	3.010	2.483	0.213
Summer	Male	55	2.267	2.439	2.337	0.045	2.079	2.593	2.341	0.141
	Female	72	2.290	2.465	2.354	0.039	2.146	2.628	2.371	0.117

¶ Autumn (October, November), Winter (December, January, February), Spring (March, April, May), Summer (June, July, August, September), N = number of specimen, TL = total length, B.Wt = body weight, SD = standard deviation

Table 2: Descriptive statistics and measurements for length and weight of *Acanthopagrus arabicus* in different seasons of year 2012.

Year 2012										
Season	Gender	N	TL (mm)				B.Wt (g)			
			Min	Max	Mean	SD	Min	Max	Mean	SD
Autumn	Male	29	2.301	2.547	2.427	0.071	2.176	2.926	2.591	0.242
	Female	31	2.279	2.538	2.382	0.054	2.097	2.908	2.432	0.163
Winter	Male	56	2.236	2.498	2.368	0.063	1.954	2.900	2.406	0.196
	Female	61	2.238	2.512	2.382	0.061	2.121	2.806	2.443	0.171
Spring	Male	46	2.241	2.531	2.352	0.054	1.978	2.912	2.365	0.166
	Female	57	2.265	2.549	2.387	0.067	2.121	2.996	2.475	0.203
Summer	Male	55	2.267	2.439	2.337	0.045	2.079	2.593	2.341	0.141
	Female	62	2.241	2.537	2.369	0.074	2.061	3.000	2.423	0.223

Table 3: Descriptive statistics and measurements for length and weight of *Acanthopagrus arabicus* in different seasons of year 2013.

Year 2013										
Season	Gender	N	TL (mm)				B.Wt (g)			
			Min	Max	Mean	SD	Min	Max	Mean	SD
Autumn	Male	41	2.305	2.549	2.418	0.065	2.228	2.932	2.548	0.211
	Female	40	2.301	2.458	2.380	0.048	2.190	2.623	2.422	0.140
Winter	Male	69	2.217	2.496	2.352	0.073	1.978	2.895	2.377	0.208
	Female	73	2.223	2.517	2.363	0.070	2.000	2.789	2.383	0.181
Spring	Male	61	2.230	2.526	2.344	0.059	2.021	2.898	2.366	0.172
	Female	73	2.258	2.549	2.386	0.066	2.161	2.978	2.475	0.188
Summer	Male	86	2.265	2.545	2.330	0.050	2.061	2.883	2.332	0.144
	Female	72	2.290	2.465	2.354	0.039	2.146	2.628	2.371	0.117

Table 4: Regression parameters of log length-weight relationship along with't' test for *Acanthopagrus arabicus* in different seasons of year 2011.

Year 2011										
Season	**Gender**	**N**	**Regression**		**SE**		**r²**	**t-test**		**P**
			(a)	**(b)**	**(a)**	**(b)**		**(a)**	**(b)**	
Autumn	Male	45	-4.615	2.959	0.236	0.099	0.954	-19.566	29.921	0.000
	Female	40	-4.158	2.765	0.321	0.135	0.917	-12.969	20.529	0.000
Winter	Male	71	-3.649	2.566	0.269	0.115	0.878	-13.547	22.306	0.000
	Female	62	-3.591	2.535	0.223	0.095	0.922	-16.072	26.569	0.000
Spring	Male	46	-4.710	3.008	0.264	0.112	0.942	-17.807	26.755	0.000
	Female	56	-4.509	2.931	0.223	0.093	0.948	-20.262	31.435	0.000
Summer	Male	55	-4.659	2.995	0.307	0.131	0.908	-15.196	22.834	0.000
	Female	72	-4.084	2.742	0.323	0.137	0.851	-12.643	19.987	0.000

Table 5: Regression parameters of log length-weight relationship along with't' test for *Acanthopagrus arabicus* in different seasons of year 2012.

Year 2012										
Season	Gender	N	Regression		SE		r²	t-test		P
			(a)	(b)	(a)	(b)		(a)	(b)	
Autumn	Male	29	-5.434	3.307	0.349	0.144	0.952	-15.590	23.034	0.000
	Female	31	-4.660	2.977	0.203	0.085	0.977	-22.901	34.862	0.000
Winter	Male	56	-4.453	2.896	0.365	0.154	0.867	-12.193	18.788	0.000
	Female	61	-3.921	2.672	0.292	0.122	0.890	-13.450	21.837	0.000
Spring	Male	46	-4.710	3.008	0.264	0.112	0.942	-17.807	26.755	0.000
	Female	57	-4.696	3.004	0.156	0.066	0.975	-30.019	45.858	0.000
Summer	Male	55	-4.659	2.995	0.307	0.131	0.908	-15.196	22.834	0.000
	Female	62	-4.555	2.945	0.210	0.089	0.948	-21.662	33.201	0.000

Table 6: Regression parameters of log length-weight relationship along with't' test for *Acanthopagrus arabicus* in different seasons of year 2013.

Year 2013										
Season	**Gender**	**N**	**Regression**		**SE**		**r²**	**t-test**		**P**
			(a)	**(b)**	**(a)**	**(b)**		**(a)**	**(b)**	
Autumn	Male	41	-5.086	3.158	0.327	0.135	0.933	-15.562	23.368	0.000
	Female	40	-4.158	2.765	0.321	0.135	0.917	-12.969	20.529	0.000
Winter	Male	69	-3.836	2.641	0.297	0.126	0.867	-12.913	20.924	0.000
	Female	73	-3.491	2.485	0.211	0.089	0.916	-16.583	27.914	0.000
Spring	Male	61	-4.211	2.806	0.237	0.101	0.929	-17.775	27.769	0.000
	Female	73	-4.154	2.779	0.165	0.069	0.958	-25.131	40.117	0.000
Summer	Male	86	-4.046	2.737	0.247	0.106	0.888	-16.372	25.814	0.000
	Female	72	-4.084	2.742	0.323	0.137	0.851	-12.643	19.987	0.000

¶ SE = standard error, (P<0.05)

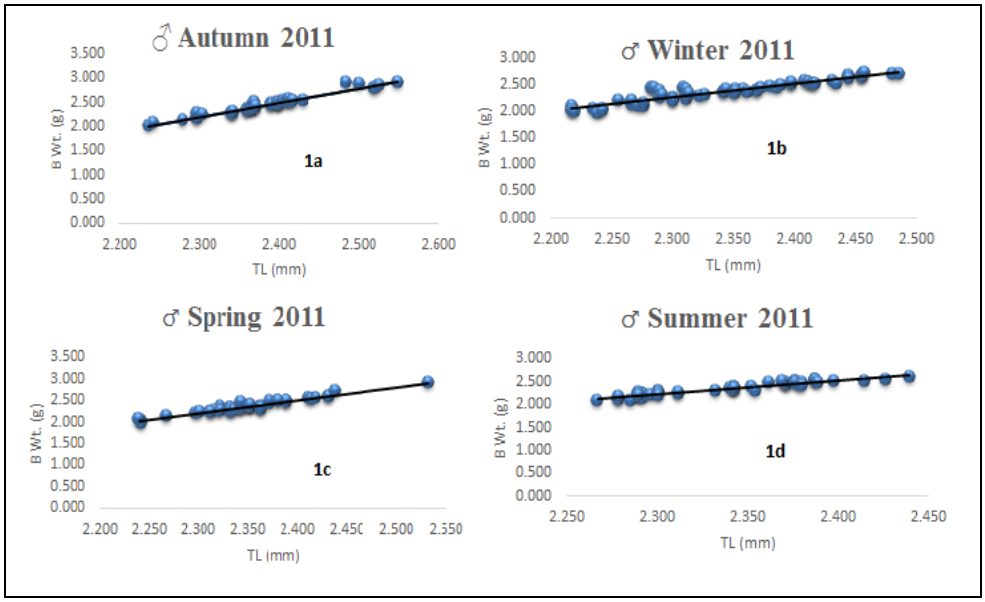

Fig 1a, b, c, d: Length-weight relationship linear plot for male (♂) in different seasons of year 2011.

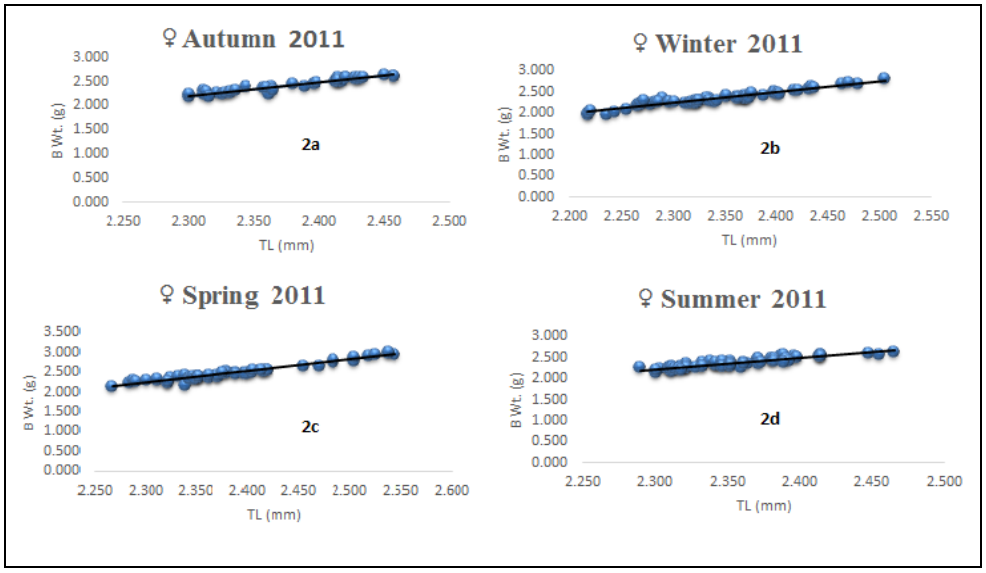

Fig 2a, b, c, d: Length-weight relationship linear plot for female (♀) in different seasons of year 2011.

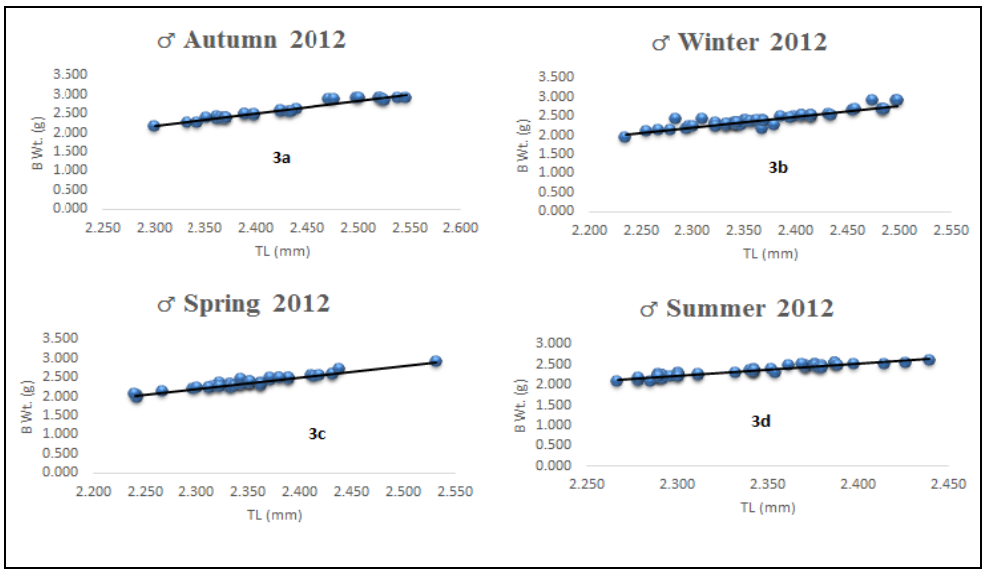

Fig 3a, b, c, d: Length-weight relationship linear plot for male (♂) in different seasons of year 2012.

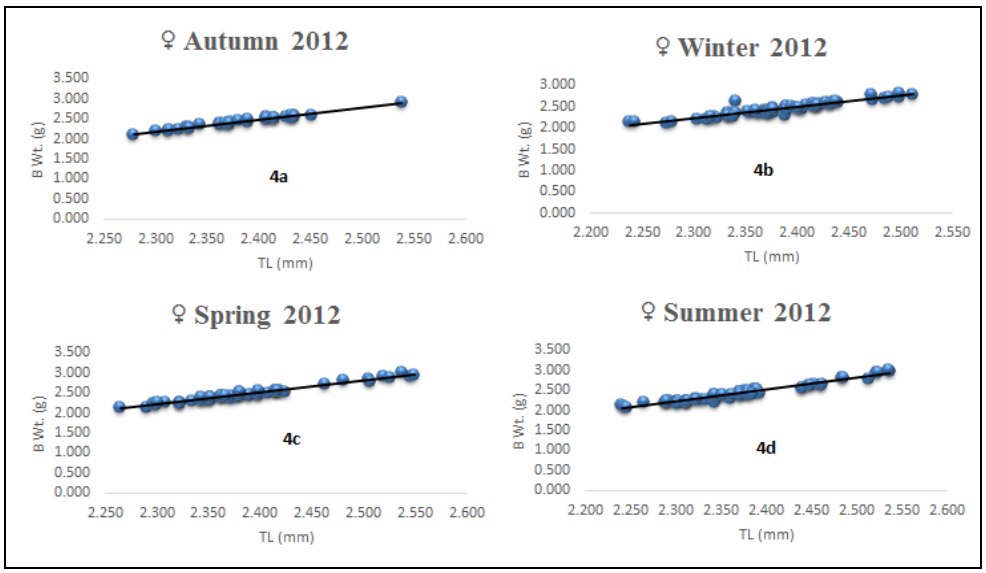

Fig 4a, b, c, d: Length-weight relationship linear plot for female (♀) in different seasons of year 2012.

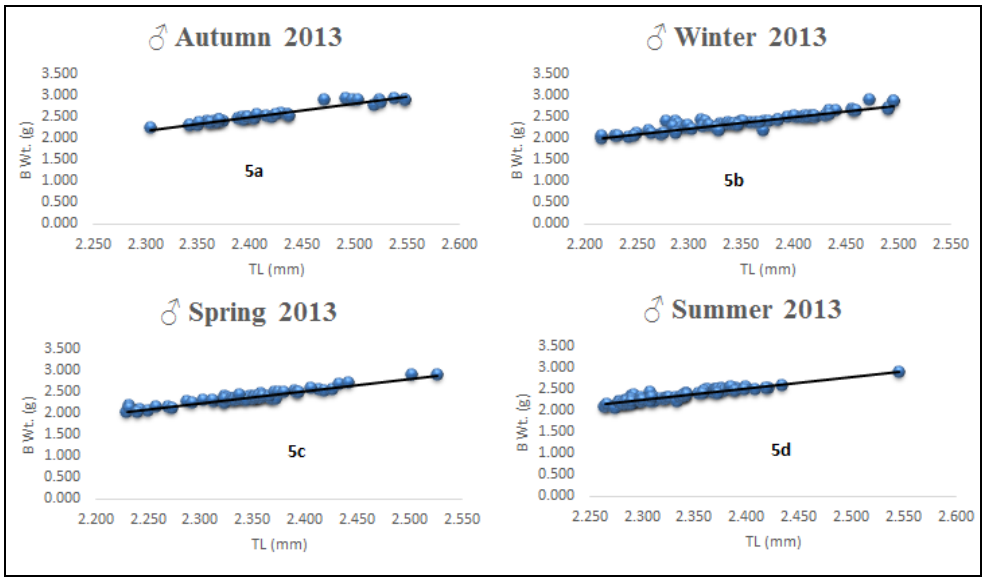

Fig 5a, b, c, d: Length-weight relationship linear plot for male (♂) in different seasons of year 2013.

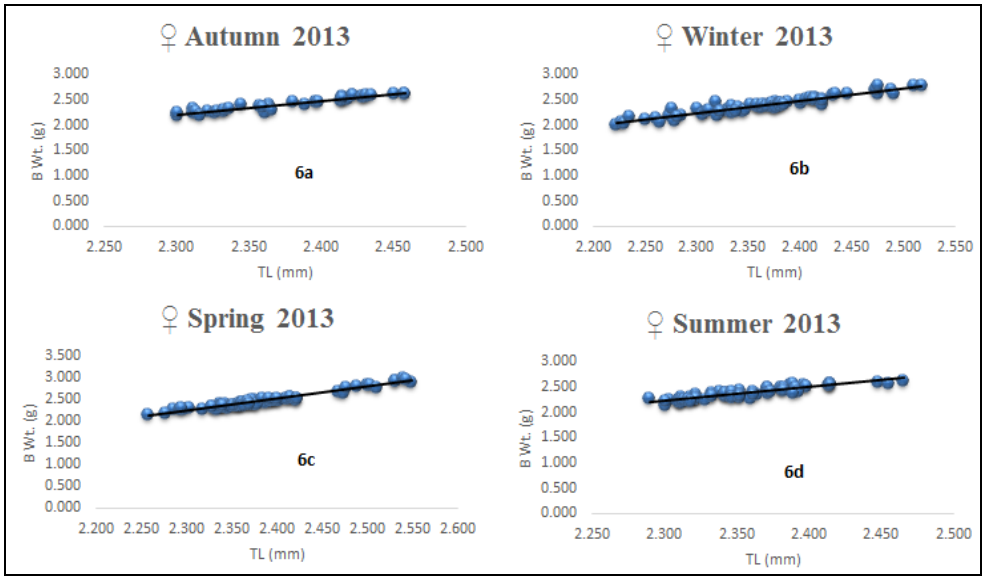

Fig 6a, b, c, d: Length-weight relationship linear plot for female (♀) in different seasons of year 2013.

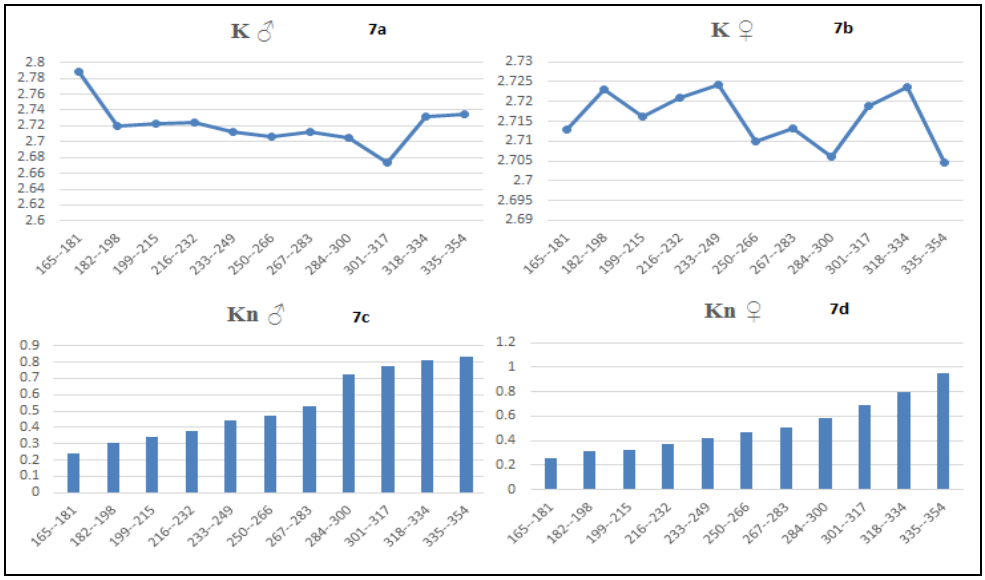

Fig 7a, b, c, d: Condition factor (K) and relative condition factor (Kn) in male and female with different length groups.

4. Discussion

4.1 Length-weight relationship

Hussain *et al*. [13] presented length-weight relationship for two specie of the same family from Karachi coast. Results indicated isometric growth for *Acanthopagrus latus* (b = 3.015) and *Acanthopagrus berda* (b = 3.092). On contrary Hameed *et al*. [14] observed negative allometric growth patterns in *Acanthopagrus berda* from Karachi coast. Similarly, current work also showed over all negative allometric growth pattern in *Acanthopagrus arabicus* from Karachi coast with few exceptions that may be because of environmental conditions or fish body conditions.

Seasonal variation in value of 'b' and negative allometric growth from this region observed by different authors [15-21]

4.2 Condition factor (K and Kn)

Froese [22] provided details on condition factor 'K' and relative condition factor 'Kn' and his work also deals with the difference between both, which can be noticed in present work as well. Safi *et al*., [21] also suggested no significant relationship in 'K' and 'Kn' and genders as well as seasons from this region. Abbas [23] discussed condition factor in Anchovy suggesting similar results with the current study, including higher values of condition factor in females than in males (female = 0.95 and male = 0.83). Like most of the studies on condition factor suggesting that if, value of condition factor is around or equals to 1 it indicates wellness or good condition of the species, present study also obtained similar observations on condition factor 'K' and relative condition factor 'Kn' in *Acanthopagrus arabicus* from Karachi coast.

5. Conclusion

The present work suggested that length-weight relationship in *Acanthopagrus arabicus* showed variation in different seasons of three years data. Overall, negative allometry has been observed while isometric growth pattern was also noticed in few seasons. Differences were observed in condition factor and relative condition factor for *Acanthopagrus arabicus*. This study is providing necessary data on growth pattern in different seasons as well as condition of the fish, which could be useful in fisheries management in this region.

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