Chapter 4

LENGTH WEIGHT RELATIONSHIP AND CONDITION FACTOR

Contents

4.1 Introduction

The studies on length weight relationship are very important for fishery biology and stock assessment of fishery resources. Generally, growth of fish is the most suitable feature to establish the population analysis, typically indicated by variations in length and weight (Mansor et al., 2010). Investigations on the length weight relationship and condition factor enables to compare the population of same species from different localities. The relationship also gives an idea on the condition of fish associated with maturity and breeding. The length-weight relation equation provides a mathematical relationship among the two variables, length and weight, so that the unknown variable can be easily calculated from known variable. It is also used to find out the expected weight from length and weight and is used as an indication of fatness. These expressions are helpful for creating yield equation and estimation of the strength of population. The precise relationship between length and weight differs among species of fish according to their innate body shape, and within species according to the condition of individual fish (James et al., 2000). The length weight relationship may vary over time with some internal and external factors. The factors influencing the variation of length weight relationship and condition of fishes may be due to food availability, sex, maturation, spawning seasons and water conditions. Moreover, LWR provide information on the condition and growth patterns of fish (Keri et al., 2011). Length weight relationship are often used as an indication of gonad development of fish and are used for knowing life history traits of different species (Wooton, 1990; Ayoade and Ikulala, 2007).

The growth of fishes can be categorised into three i.e., isometric growth, negative allometric growth and positive allometric growth. Whereas the fish showing isometric growth pattern there is no change in body shape and weight according to the increase in length. A fish is in good condition exhibit isometric growth. While the lean fishes show negative isometric growth. Insufficient availability of food and environmental changes are the major reason for negative allometry in fish. When a fish is showing positive allometric growth they increase in weight at faster rate in relation to its increase in length. Fat fishes exhibit positive allometric growth. Increase in the ovary during breeding season increases the total body weight of a fish. Hence the length weight relationship is an indication of gonad development in fishes.

Based on the Fulton's (1904) cube law, Froese (2006) stated that, in younger stages of fishes their growth rate is faster in length than width or any other directions. Thus their length- weight ratio changes as the fish grows in length. According to the general cube law, weight of the fish would vary as the cube of length. Deviations from cube laws are measured by condition factor (Shabir et al., 2012). Condition factor is also called as ponderal index or K factor. Where as in relative condition factor (Kn) is a measure of deviation from the length or weight of a fish. It is the ratio between observed weight and calculated weight.

Condition indices have been used by fish culturists as indicators of the general "well-being or fitness'' of the population under consideration (Fafioye and Oluajo, 2005). According to Tesch (1968) condition factor used for estimating the condition, robustness or degree of wellbeing of fish, based on this he stated that heavier fishes are in better condition than lean ones. Moreover the lean fishes are considered to be at risk of harsh environmental conditions. (Jones et al., 1999). Fagade (1979) states that feeding intensity influences condition factor and it is used as an index of growth.

4.2 Review of literature

A large number of studies reported earlier on the aspects of length weight relationship and condition factor (Le Cren, 1951; De and Dutta, 1990; Simon and Mazlan, 2008; Okendro et al., 2009; Sani et al., 2010; Biswas, 2011; Karna et al., 2012; Achakzai et al., 2013; Parida et al., 2013; Nan Zhang, 2016 and Xiong et al., 2016). Oribhabor et al. (2009) pointed out the importance of length weight relationship in population assessments such as standing stock biomass, calculating condition indices etc. while studying the length weight relationship of *Saratherodon melantheron* and *Tilapia guineensis* in a mangrove creek in Nigeria.

Achakzai et al. (2013) worked on length weight relationship and condition factor on *Oreochromis mossambicus* from Sindh River in Pakistan. Some of the other recent works on length weight relationships and condition factors are made by Subba and Adhikaree (2011) on *Neolissochilus hexagonolepis*, Parida et al. (2013) on *Liza macrolepis*, Anika and Bhatia (2014) on *Cirrhinus mrigala*. Srivastava et al. (2013) described length – weight relationship of the Asian striped catfish, *Mystus vittatus* from non drainable perennial ponds from Lucknow. They suggested some proper management measures for sustainable fishery management in the non – drainable ponds of India.

Ratnakala et al. (2013); Nandikeswari et al. (2014); Pathak and Mohd (2015), etc also gave contributions of information on length weight relationship of different species of fishes from Indian sub continent. Ratnakala et al. (2013) pointed out the significance of length weight relationship in taxonomic differences of the species while studying on *Lates calcarifer* of two river systems in Andhra Pradesh. Nandikeswari et al. (2014) investigated length weight relationship of *Terapon jarbua* from Puduchery waters of East coast of India. He further explained correlation between L-W relationship and some biological parameters. Pathak and Mohd (2015) worked on the lesser spiny eel *Macrognathus aculeatus* from various river basins of India. Mortuza and Al-Misned (2015) estimated length weight relationship of twelve fishes of River Padma of Bangladesh and suggested some management measures for the conservation of species.

Soomro et al. (2007) studied length weight relationship of a freshwater catfish *Eutropiichthyes vacha* from Indus River. Tripathi et al. (2010) worked on the fresh water catfish, *Mystus vittatus* in river Ghaghra, Eastern U.P. and suggests some management measures on catfish resources. A comparative study on the length weight relationship and condition factor of two ariid catfish species were carried out by Sawant et al. (2013). Other notable works on the length weight relationship of catfishes are that of Sawant and Raje (2009) on *Arius caelatus* and *Arius thalassinus*, Davies et al. (2013) on *Clarias gariepinus*, Balamurugan et al. (2013) on *Arius arius.* James et al. (2015) studied length weight relationship and condition factor of *Clarias gariepinus* from a lake in Kenya known as Naivasha.

The study sought to provide base line information on Length weight relationship, condition factor and relative condition factor of *Arius subrostratus* from Cochin estuary.

4.3 Materials and methods

A total of 1205 specimens of *Arius subrostratus* (628 males and 577 females) ranging in size from 12.5 to 34.5 cm in total length (TL) and 16 to 410 g in weight were used for the length weight analysis. The relationship between various parameters was determined by the least square method (Le Cren, 1951). Total length (cm) of each fish was taken from the tip of snout (mouth closed) to the extended tip of caudal fin using a measuring board. Body weight was measured to the nearest gram using a digital balance after removing adhered water and other particles from the surface of the body. The fishes were sexed by observing the gonads after dissecting abdomen.

Length weight relationship

The relationship between length and weight of a fish is usually expressed by the equation, $W = a L^b$. Where 'w' is body weight (g), L is total length (cm), 'a' is a coefficient related to body form and 'b' is an exponent indicating isometric growth when equal to 3 (Beverton and Holt, 1996). A logarithmic transformation was used to make the relationship linear Log W= Log a + b Log L. Values of the exponent b provide information on fish growth. When b=3, increase in weight is isometric. When value of b is other than 3, weight increase is allometric. (positive allometric if $b > 3$, negative allometric if $b < 3$) (Levent et al., 2007).Significance between regression coefficients of the sexes was tested by ANOVA (Snedecor and Cohran, 1967; Ostertagova and Ostertag, 2013; Neill, 2010).

Condition factor

Variations from length – weight relationship or cube law are depicted by condition factor or K – factor (Le Cren, 1951). The general well being of fish (condition factor, K) was determined by the formula by Hile (1936).

$$K = W^* 100/ L^3$$

Where,

W = Weight of the fish in (g)

L = Total length of fish in cm

Relative condition factor

The relative condition factor (Kn) is described as the ratio between actual weight (observed weight) and the calculated weight based on the length weight equation. Le Cren (1951) said that the condition factors measures all variations associated with physical condition of water, season, food availability and maturity stages.

The relative condition factor (Kn) can be computed using the formula:

$$Kn = W / a L^n \text{ (Le Cren , 1951)}$$

Where, aL^b = computed weight for observed length.

This can be expressed as

Kn = W/W', Where W is observed weight and W' the calculated weight as determined from the length – weight equations. The data used for length – weight relationship were also utilized for calculating the relative condition factor.

Ponderal index (Kn) was observed separately for males and females of different length groups of 3 cm length interval. Le Cren (1951) modified formula, $Kn = W/ aL^n$ was used for calculation of the relative condition factor.

4.4 Results

Length- weight equations were calculated separately for males, females and sexes combined. When empirical values of length were plotted against their relative weight on an arithmetic scale, smooth curves were obtained (Fig. 4.1).

The regression coefficients calculated using the method of least square for male and female of *A. subrostratus* in the size range 12.5 to 34.5cm gave the following equations:

Male: $W = 0.0057 L^{3.0544}$

Log $W = -2.2441 + 3.0544 \log L$ $r^2 = 0.961$

Female: $W = 0.0010 L^{3.6075}$

Log $W = -2.2441 + 3.0544 \log L$ $r^2 = 0.952$

Pooled: $W = 0.0026 L^{3.3049}$

Log $W = -2.585 + 3.3049 \log L$ $r^2 = 0.944$

The length weight relationship was calculated during different seasons to observe if there are differences in the relationship due to sex and season. In all cases, the relationship was found to be linear in the logarithmic form confirming to the general formula expressing relationship between the length and weight of fishes (Tables 4.1 and 4.3).

Table 4.1. Length and weight of *A. subrostratus* from Cochin estuary during April 2011 to March 2013

Length group (cm)	No of fishes Combined	Mean length (cm)	Mean weight (g)	No of males	Mean length (cm)	Mean weight (g)	No of Females	Mean length (cm)	Mean weight (g)
12-15	14	13.84	15.87	10	13.67	16.7	4	13.98	15.25
15-18	66	16.38	27.22	41	16.4	27.57	25	16.35	26.79
18-21	253	19.58	49.15	133	19.49	46.94	120	19.7	51.97
21-24	458	22.4	78.76	228	22.43	78.67	230	22.37	78.85
24-27	133	25.14	111.2	69	25.23	111.72	64	25.04	110.65
27-30	22	27.86	139.89	8	27.99	142.5	14	27.76	137.85
30-33	7	30.96	204.86	5	31.02	195	2	30.8	229.5
33-36	5	33.8	323.75	3	33.55	283	2	34.05	364.5

Table 4.2. K and Kn values of *A. subrostratus* for different length groups during April 2011 to March 2013

Length (cm)	Male K	Kn	Length (cm)	Female		Length (cm)	Sexes combined	
				K	Kn		K	Kn
13.67	0.6111	1.0206	13.98	0.5601	1.1409	13.84	0.5965	1.0575
16.4	0.6168	0.93	16.35	0.6269	1.1114	16.38	0.6207	1.0063
19.49	0.6594	0.9467	19.7	0.6784	1.1166	19.58	0.6684	1.0198
22.43	0.6901	1.0357	22.37	0.7058	1.0698	22.4	0.698	1.0498
25.23	0.6922	1.0304	25.04	0.6972	1.0041	25.14	0.6946	1.0165
27.99	0.6476	0.9549	27.76	0.649	0.8539	27.86	0.6485	0.9045
31.02	0.6564	0.9614	30.8	0.789	0.9923	30.96	0.6943	0.9467
33.55	0.8476	1.0935	34.05	0.921	1.0879	33.8	0.877	1.1078

Table 4.3. Regression equation of Length-Weight relationship and condition factor of *A. subrostratus* from 2011 to 2012 period

Season	sex	Regression	r2	K
Pre monsoon	Male	Log W= 0.0054+3.1117log L	0.902	0.7384
	Female	Log W= 0.0050+3.1448log L	0.93	0.7741
	Pooled	Log W = 0.0047+3.1592log L	0.942	0.7514
monsoon	Male	Log W = 0.0038 +3.1939log L	0.915	0.679
	Female	Log W = 0.0042+3.1734log L	0.898	0.7029
	Pooled	Log W = 0.0039+3.1876log L	0.921	0.6872
Post monsoon	Male	Log W = 0.0045+3.1175log L	0.896	0.6059
	Female	Log W = 0.0044+3.1232log L	0.886	0.6437
	Pooled	Log W = 0.0038+3.1604log L	0.913	0.6399

Table 4.4. Regression equation of Length-Weight relationship and condition factor of *A. subrostratus* from 2012 to 2013 period

Season	sex	Regression	r2	K
Pre monsoon	Male	Log W = 0.0064+2.9832log L	0.932	0.6112
	Female	Log W=0.0070+2.9683log L	0.8996	0.6306
	Pooled	Log W=0.0072+2.9532log L	0.924	0.6247
monsoon	Male	Log W=0.0018+3.4422log L	0.906	0.7247
	Female	Log W=0.0017+3.4802log L	0.968	0.7464
	Pooled	Log W=0.0017+3.4705log L	0.944	0.7349
Post monsoon	Male	Log W+0.0759+2.2469log L	0.0706	0.741
	Female	Log W=0.0044+3.1909log L	0.929	0.7788
	Pooled	Log W=0.0231+2.6434log L	0.775	0.7592
Pre monsoon	Male	Log W=0.0072+3.0162log L	0.95	0.7447
	Female	Log W=0.0027+3.3265log L	0.89	0.7451
	Pooled	Log W=0.0065+3.051log L	0.936	0.7449

The Analysis of variance (ANOVA) result indicated that length weight relationships between sexes were highly significant at 1% level. As may be seen from the equations, the exponential values for males, females and sexes combined were practically identical. The coefficient of correlation, 'r^2' for males, females and sexes combined for the regression of total length and body weight were estimated as 0.961, 0.952 and 0.944 respectively which is highly significant at 1% level. In the present study, the value of 'b' in *A. subrostratus* was found to range between 3.0544 to 3.6075. The exponential value of Length-weight relationship 'b' obtained in the present study was slightly greater than '3' there by indicating isometric growth of fish. The value of 'r' and results of't' test indicated high degree of correlation between length and weight ($p > 0.01$).

The relative condition factor (Kn) for all fish samples were determined from the average lengths and weights of 3 cm interval of total length (Table.4.2). The values of Kn showed fluctuation in all size groups of both males, females and sexes combined. The monthly Kn values were calculated for various length groups. Values of Kn for different size groups ranged from 0.93 to 1.0935 in males, 0.8539 to 1.1409 in females and 0.9045 to 1.1078 in sexes combined (Table. 4.2 and figures. 4.1.1, 4.1.2, 4.1.3). In the present study, sex-wise analysis of Kn values in females (1.047) was higher than that of males (0.997). In sexes combined the mean value was 1.014.

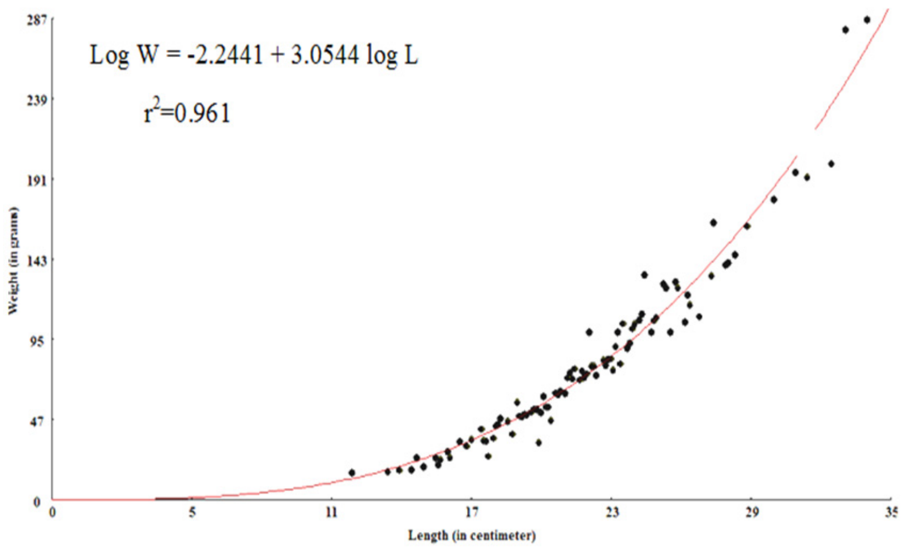

Fig. 4.1.1. Regression curve of length weight relationship of *Arius subrostratus* (Male)

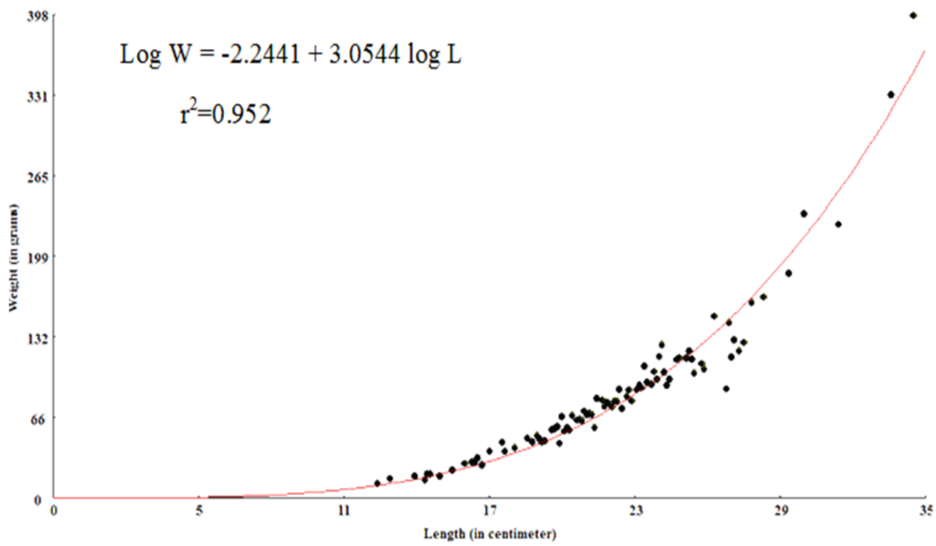

Fig. 4.1.2. Regression curve of length weight relationship of *Arius subrostratus* (Female)

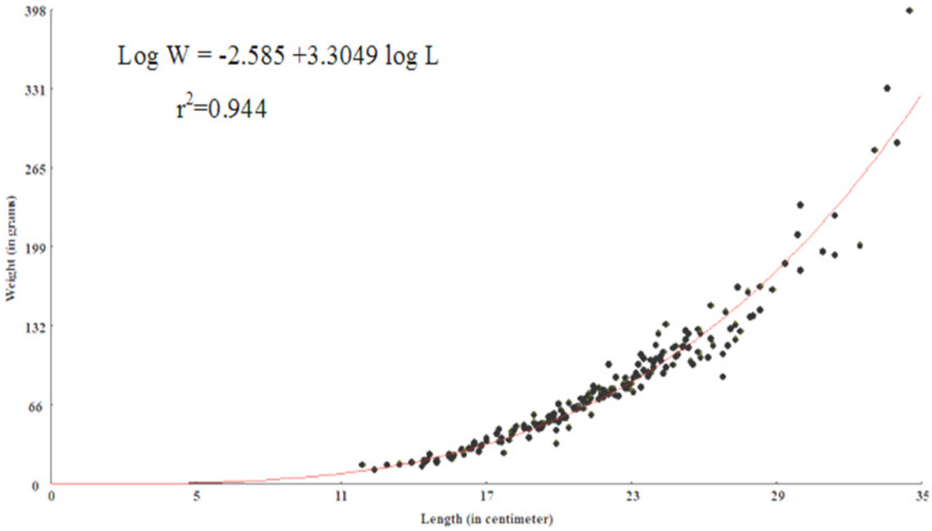

Fig. 4.1.3. Regression curve of length weight relationship of *Arius subrostratus* (pooled)

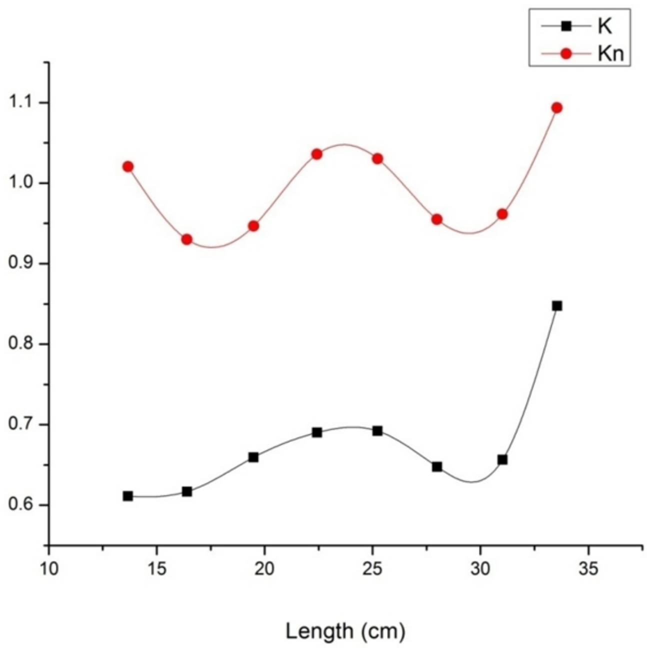

Fig. 4.2.1. K and Kn values of *A. subrostratus* related to length group of males

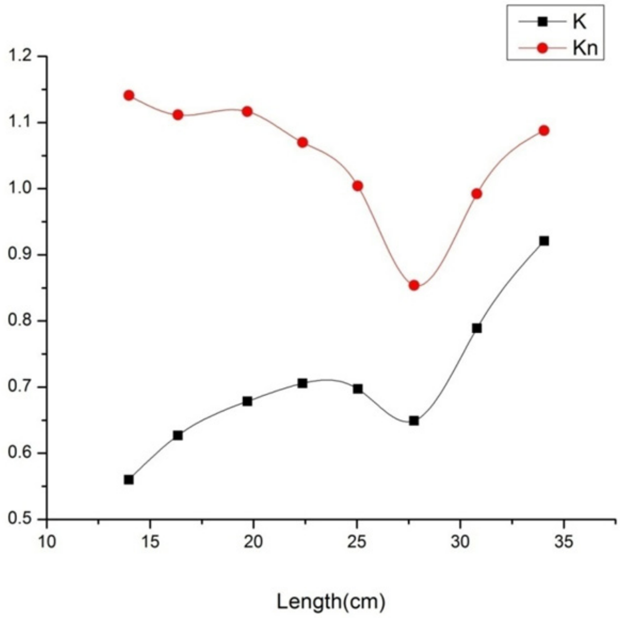

Fig. 4.2.2. K and Kn values of *A. subrostratus* related to length group of females

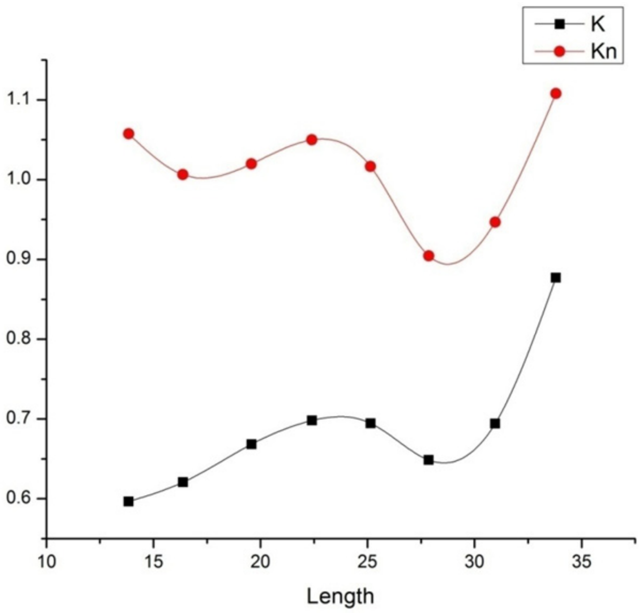

Fig. 4.2.3. K and Kn values of *A. subrostratus* related to length group of combined sexes

4.5 Discussion

Length and weight data provide statistics that are cornerstones in the foundation of fishery research and management (Anderson and Neumann, 1996). Cone (1989) indicated that the relationship between fish weight and length is frequently used to compare the effect of biotic and abiotic factors on the health or well-being of a fish population. It is universal that growth of all living organisms including plants and animals increases with the increase in body length. As a consequence it can be said that length and growth are inter related. Length weight relationship can be expressed by the cube formula $W = aL^3$ by earlier workers (Brody, 1945; Lagler, 1952; Brown, 1957). For an ideal fish, which exhibits isometric growth, the value of regression coefficient should not be different from 3 and fishes departing from isometric growth are rare (Beverton and Holt, 1957).

Froese (2006) suggested that the frequencies of b values around 3.0 and below 2.3 and above 3.7 were higher than predicted by a normal distribution. The values of the exponent 'b' for males, females and combined sexes were significantly higher than 3.0 exhibiting a positive allometric growth for some fishes (Mourad et al., 2008). The highest b value was arrived in females followed by combined sexes and then in male fishes. This indicates that females are in better condition when compared to males and sexes combined. The exponential value of 3.6075 implies that female gain weight at a faster rate in relation to the length than males (3.0544) and sexes combined (3.3049). Le Cren (1951) reported that females are heavier than the males of the same lengths probably because of the difference in fatness and gonadal development. Similar observations were reported in *Schizothorax niger* by Shaheena and Yousuf (2012). Awasthi et al. (2015) estimated length weight relationship of *Trichogaster lalius* from different pond ecosystems of eastern and central regions of India. The study indicated negative allometric (b < 3) growth and did not follow the cube law. On the other hand study of Kunjwal and Anju (2016) on *Schizothorax richardsonii* exhibited positive allometric growth (b > 3).

Isometric growth pattern has been reported in *Mastacembelus armatus* (Narejo et al., 2003); *Nandus nandus* (Somagoswami and Dasgupta, 2004); *Cynoglossus macrostomus* (Rekha, 2007); *Amblypharyngodon mola* (Suresh et al., 2007); *Priacanthus hamrur* (Johnson et al., 2007); *Otolithes cuvieri* (Prasanth et al., 2007) and *Thunnus albacares* (Prathibha Rohit et al., 2008).

All the earlier reports (Laghari et al., 2009 and Begum et al., 2010) are in compliance with the present findings on the length weight relationship in *A. subrostratus* in which the b values were very close to the isometric value of 3. A study on length weight relationship of a cold water fish a river in Nepal by Subba and Adhikaree (2011) showed isometric growth pattern, where the estimated 'b' value was near to 3. Deviation from cube law were recorded in many fish species by many authors (Anand and Reddy, 2012; Ahmad et al., 2012; Nehemia Alex et al., 2012). Mortuza and Fahad (2015) stated that the abundance of juveniles may be the reason for the elevated 'b' value while evaluating L - W relationships of some fishes from River Padma.

Masud and Singh (2015) investigated the length weight relationship and condition factor of *Salmophasia bacaila* from river Yamuna. They observed the allometric growth in which b value were different from 3. Nandikaswari et al. (2014) worked on length weight relationship and condition factor of *Terapon jarbua* and reported the high b value which was greater than 3. Positive allometry exhibited by the female fishes is usually an indication of its spawning season.

Abujam and Biswas (2016) observed fluctuations in ‘b’ value according to different season in a spiny eel *Macrognathus pancalus* from Assam. While Ali et al. (2016) reported monthly fluctuations in ‘b’ value in *Liza ramada* from Libya. They mentioned availability of food is the major reason for the instability that occurred in ‘b’ value.

The negative allomerty shown by some species may be due to the gonad development activities as the inner or stored energy of the fishes were utilized for the gonad development. This will slow down the process of body building of tissues (Mazlan et al., 2008). Whereas, Nan Zhang (2016) pointed out several physical and biological factors for the reason behind the negative allometry while worked on Golden Pompano *Trachinotus ovatus.* They may be sex, maturity stages, geographical variation and condition of the fish.

However some species exhibited positive allometric growth such as in *Alburnus mossulensis* (Radkhah, 2016) from Iran; *Lates calcarifer* (Ratnakala et al., 2013) from Andhra Pradesh, India; *Pseudotolithus* *senegalensis* (Olapade and Tarawallie, 2014) from Sierra Leone; *Clarias gariepinus* (Davies et al., 2013) from Nigeria.

Condition assessment is usually practiced by fisheries personnel as one tool for evaluating fish populations and communities (Brian et al*.,* 2000). According to Le Cren (1951), Kn value greater than 1 indicates good general condition of the fish. According to Bhattacharya (2012), the value of condition factor in *Ompok pabo* was nearer or greater than 1, which indicates good general well-being of fish. In the present study the highest values of condition factor in female fishes indicated that females have better condition compared to males. In females Kn values showing high values up to the length group 24 – 26 cm and 27 – 30 cm values showed major fluctuations which may be attributed to the spawning activity of the species. In males Kn value showed fluctuations and comparatively lower in size group of 15 – 20 but suddenly rose in length group of 21 – 26 cm that indicates attainment of maturity in this group. In *Decapterus russelli* from Mangaluru Region, both sexes showed increase in condition factor with increasing length (Ashwini et al., 2016). Ali et al. (2016) reported month wise and sex wise variation in condition factor of *Liza ramada* from eastern coast of Libya. Nair et al. (2015) studied Length – weight relationship of *Stolephorus Commersonii* from Kerala coast, and the study showed monthly fluctuations in condition factor.

Examination of K values indicated that larger fishes exhibited healthy and robust condition showing good compatibility with the environment. Masud and Singh (2015) made a statement that, higher

K value is an indication of heavy weight of the fish, while the K value becoming lower there would be low body weight. Some authors have summarised about the variations of condition factor in accordance with the changes in environmental conditions (Ratnakala et al., 2013; Sarkar et al., 2013). According to them, a change in condition factor of a fish also indicates climate change. Paswan et al. (2012) made an assessment on season wise condition factor of two species of *Trichogaster* from Brahmaputra Basin of Assam in which winter season showed the highest condition factor in both fishes. While, Bolarinwa (2016) observed high K value during the monsoon season on both *Oreochromis niloticus* and *Chrysichthys nigrodigitatus* from a lagoon in Nigeria. These findings pointed out the seasonal fluctuations in the temperature of water affects the condition of fish. Occurrence of high K value during monsoon season in female *Macrognathus pancalus* is an indication of breeding season (Abujam and Biswas, 2016). Whereas study of Ali et al. (2016) presented higher K value during the summer season. Srivastava et al. (2013) studied on striped catfish, *Mystus vittatus* and revealed there is no monthly variation in the value of condition factor. Kalita et al. (2016) studied length weight relationship of two species of *Trichogaster* (*Trichogaster fasciata and Trichogaster lalius*) and observed fluctuation in condition factor with increasing length and weight. Nandikeswari et al. (2014) reported that the change in length weight relationship and condition is based on the habitat and feeding habit of the species. Jan and Ahmed (2016) and Aryani et al. (2016) opined fluctuation in K value as an indication of spawning season and gonadal development.

During the present study *A. subrostratus* showed relative condition factor (Kn) ranging from 0.8539 to 1.1409 with a mean value of 1.014. This indicated healthy condition of *A. subrostratus* is satisfactory. There was no notable seasonal variation in condition factor during the entire study period.

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