INTERRELATIONSHIPS OF FRESH BODY WEIGHT AND TOTAL BODY LENGTH AND CONDITION FACTOR IN ADULT *POMADASYS STRIDENS* (FORSSKÄL, 1775) (FAMILY POMADASYIDAE) FROM KARACHI, PAKISTAN

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Abstract

The length-weight relationship (LWR) and condition factor of adult *Pomadasys stridens (Forsskäl, 1775)* samples (N = 192) collected during 2013 and 2014 from Karachi Coast was determined. The largest fish was 20.8 cm long and the heaviest fish was 69.0g in weight. The relationship between length and weight of adult *P. stridens* within the size range of length: 13.8 -20.8 cm was best given by a simple linear equation, W (g) = -2.000 + 3.3621L (cm) ± 1.0194 (r = 0.9788; r^2 =0.9580; Adj. r^2 =0.9578; F = 43337.80 (p < 0.0001). The power equation W (g) = 2.8403.L (cm) $^{1.0467}$ ± 0.01888 (r = 0.9779; r^2 = 0.9562; Adj. r^2 = 0.9560; F = 4151.086 (p < 0.0001) was not better than the linear equation in explanatory power. The LW relationship didn't follow the cube law and indicated a negative allometry between length and weight. The relative condition factor (Kn) averaged to 1.104 ± 0.003 varying from 0.9254 to 1.044 i.e. around 1.7% only). Like, Weight / Length ratio, it was significantly higher in pre-monsoon season. Kn positively associated closely with Weight /Length ratio of the fish.

Introduction

Length-weight relationships (LWRs) have extensively been studied the world over in numerous fishes. A number of such instances have been described by Ahmad *et al.* (2014). Such studies are very useful with a view to estimate fish weight from fish length because of technical difficulties and the amount of time required to record weight in the field (Sinovacic *et al.*, 2004). LWR is the most commonly used analysis in fisheries data (Mendes *et al.,* 2004*).* Furthermore, standing crop biomass can be estimated more easily through regression equations (Morey *et al.*, 2003). The seasonal variations in fish growth can also be easily tracked this way (Richter *et al.*, 2000). LWR in fishes is important for fish stock assessment as regression parameters 'a' and 'b' can be employed for length-weight conversion. The publications (Mutto *et al.*, 2000; Lawson *et al.*,2013; Mutanda Aura *et al*., 2011; Mendes *et al.* , 2004); Ferreira *et al.*,2008; Maci *et al*., 2014;; Ismen *et al.*, 2009; Abdurahiman *et al.*, 2004; and Wigley *et al.*, 2003) are some of the very well known in this connection. Recently Safi *et al.* (2014) have published LW relationship of *stripped piggy fish*, *Pomadasys stridens*, from Karachi coast. The present study of LWR and condition factor of adult *Pomadasys stridens* from the Karachi coast, Pakistan is undertaken in view of the fact that the length-weight parameters of a fish may vary in different populations due to the variation in environmental conditions. It is excellent food fish and widely distributed in the Indo-Pacific region. It inhabits in rocky tide pools and shallow waters. It is carnivorous fish (Safi *et al.*, 2013).

Material and Methods

Samples of adult *Pomadasys stridens* (Forsskäl, 1775) were collected seasonally (pre-monsoon, monsoon and post-monsoon) from Karachi coast, Fish Harbour West Wharf Karachi. In 2013 and 2014. In toto, 96 samples were collected in 2013 and 96 in 2014. Total length (cm) of each fish was measured from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board. Body weight (fresh) was recorded to the nearest gram using a top loading Metler balance. The length (L) and weight (W) relationships (LWRs) were determined statistically for various models (Zar, 1984; Ricker, 1973) with untransformed and logarithmically transformed length and weight data. The values of constant 'a' and 'b' were estimated from the log transformed values of length and weight for equation, log W = log a + b log L. or power model, $W = a.L^b$, to test the cube model of fish growth (Hile, 1936, Le Cren, 1951). The deviation of regression coefficient b from 3 was tested by calculating t value, $t = (b-3) / S_b$, where Sb was given as:

$S_b = \sqrt{[(SW / SL) - b^2] / n - 2}$, where SW is the variance of the body weight, SL, the variance of the total length and n the sample (Lawson *et al.,* 2013).

As Le Cren (1951) had proposed relative condition factor (Kn) in preference to condition factor (K) on the basis some computational and interpretation reasons, we calculated Kn as Wo / Wc (Hile, 1936, Le Cren, 1951), where Wo is the observed fresh weight of the fish and Wc is the calculated fresh weight of the fish according to the significant linear regression equation.

Results and Discussion

A Total of 192 samples of *Pomadasys stridens* were collected from Karachi Fish Harbour during 2013 and 2014. The mean length of the fish was 17.13 ± 0.23, 17.81 ± 0.25, 16.59 ± 0.27 cm in pre-monsoon, monsoon and post monsoon seasons of 2013, respectively. The length was comparable to this statistics in 2014. The length of fish collected varied by 7.51 to 9.34 % in 2013 and 6.45 to 8.73 % during 2014 (Table 1). The overall length during two years averaged to 17.31 ± 0.10 cm (13.8-20.8 cm; CV: 8.35%).

Table. 1. Location and dispersion of length and fresh weight data.

Parameters	N	Minimum	Maximum	Mean	SE	CV (%)
Fish Length (cm)						
Pre-Monsoon (2013)	32	14.50	19.00	17.13	0.23	7.51
Monsoon (2013)	32	16.00	20.80	17.81	0.25	8.07
Post Monsoon (2013)	32	14.00	19.50	16.59	0.27	9.34
Pre-Monsoon (2014)	32	15.00	20.20	17.53	0.25	8.04
Monsoon (2014)	32	16.20	19.80	17.81	0.20	6.45
Post Monsoon (2014)	32	13.80	20.50	16.97	0.26	8.73
Over all Mean	192	13.8	20.8	17.31	0.10	8.35
Fish Fresh weight (g)						
Pre-Monsoon (2013)	32	46.00	61.00	54.69	0.74	7.70
Monsoon (2013)	32	52.00	69.00	58.51	0.88	8.50
Post Monsoon (2013)	32	44.00	63.00	53.31	0.91	9.65
Pre-Monsoon (2014)	32	50.00	66.00	57.22	0.66	6.49
Monsoon (2014)	32	53.00	64.00	58.19	0.59	5.75
Post Monsoon (2014)	32	41.00	66.00	55.22	1.05	10.77
Over all mean	192	41.0	69.0	56.19	0.35	8.89

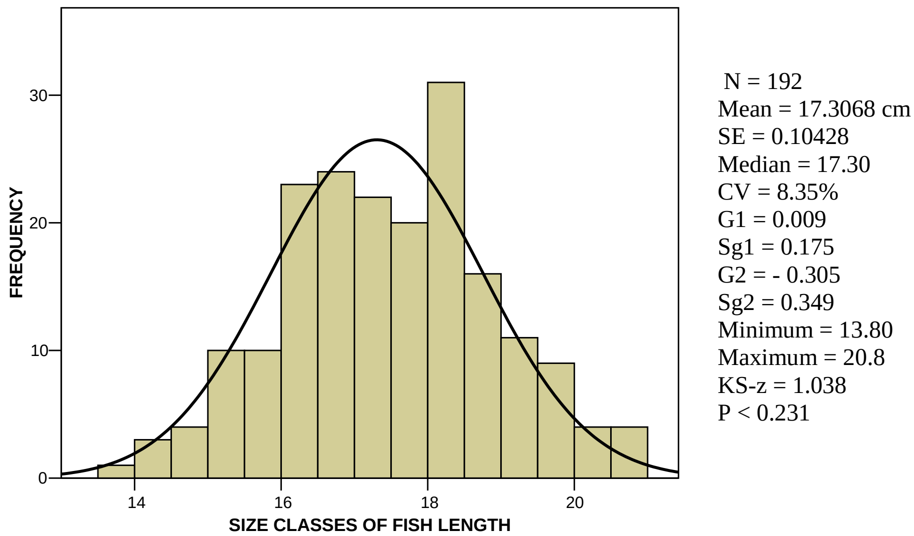


Fig. 1. Frequency distribution of length (cm) of *P.* stridens.

The mean weight of the fish was 54.51± 0.74, 58.51 ± 0.88, 53.31 ± 0.91g in pre-monsoon, monsoon and post monsoon seasons of 2013, respectively. The weight was comparable to this weight statistics in 2014. The weight of fish collected varied by 7.70 to 9.65 % in 2013 and 5.75 to 9.65 % during 2014 (Table 1). The overall weight during 2013 and 2014 averaged to 56.19 ± 0.35g (41.0-69.0g; CV: 8.89%). The variability in length and weight was relatively higher in post monsoon season of 2013 as well as 2014. Both, the length and weight tended to follow normal distribution as indicated by the insignificant Kolmogorov-Smirnov-z test (Fig. 1 and 2).

The weight / length ratio in the study period varied through seasons and the year of study. It was generally little higher than 3 as varied between 2.971 to 3.375 (CV = 1.19%). It averaged to 3.2466 ± 0.00448 and marginally followed normal distribution (Fig. 3). Around 65.6% of the W / L data concentrated between 3.2 and 3.3. This parameter was comparatively lower in pre- and post- monsoon seasons of 2013 and almost comparable in three seasons of 2014 (Fig. 4).

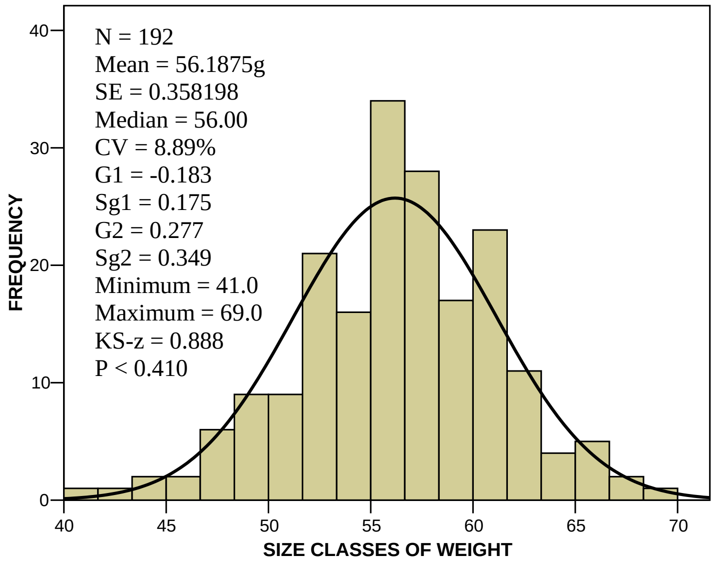


Fig. 2. Frequency distribution of fresh weight (g) of *Pomadasys* stridens.

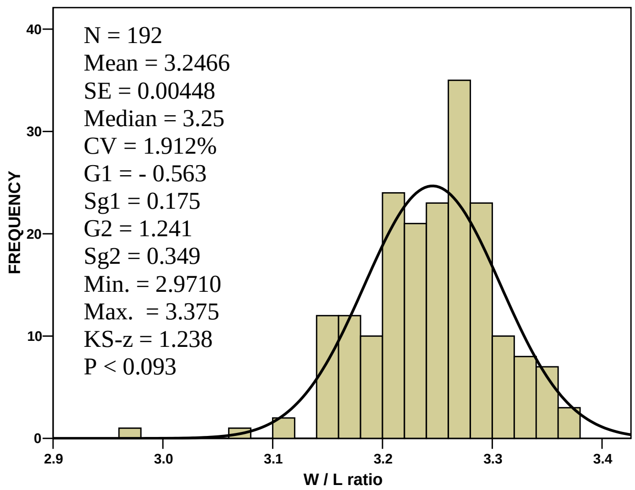


Fig.3. Frequency distribution of W/ L ratio.

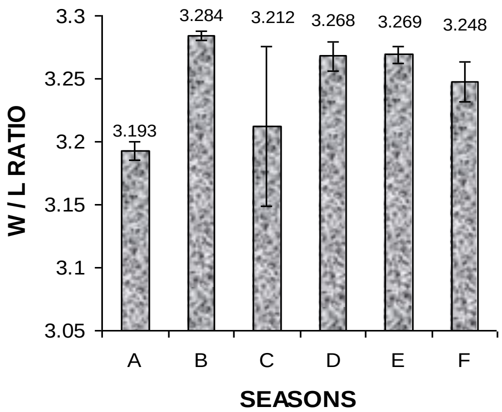


Fig. 4. Weight / Length ratio of the fish for various seasons. A, Pre monsoon, 2013; B, Monsoon, 2013; C, post monsoon, 2013; D, Pre monsoon, 2014; E, Monsoon, 2014 and F, post monsoon, 2014.

The length–weight relationship as per linear model for the years 2013 and 2014 was highly significant (r = 0.974; F = 3540.16, $p < 0.0001$) and 0.972 (F = 1570.30, $p < 0.0001$), respectively. According to the LWRs determined as per power model, *P. stridens* exhibited negative allometric growth for both years of study because b values (b = 1.0648 and 1.014, respectively were smaller than 3. The length-weight scatter diagram for the pooled data (N =192) is presented in Fig. 5 and correlation and regression analyses for the untransformed and transformed data appears in form of regression equations below (Eq. 1-3) for linear model with untransformed. data (Eq.1), for double logarithmic linear models (Eq. 2) and power model (Eq. 3). Within the size range of length: 13.8 -20.8 cm and fresh weight: 41.0-69.0g, the adult *P. stridens* appeared not to follow the cube law (b

=1.04677; Eq. 3). The value of b = 1.0467 was significantly lesser than 3 (t = 79.6, p < 0.0001). The weight of the fish within this size range was somewhat better given (0.18%) by linear model (r = 0.9788, F = 43337.8, p < 0.0001) than power model (r = 0.9779, F = 4151.09, p < 0.0001) if viewed on the basis of Eq, 1 and 3.

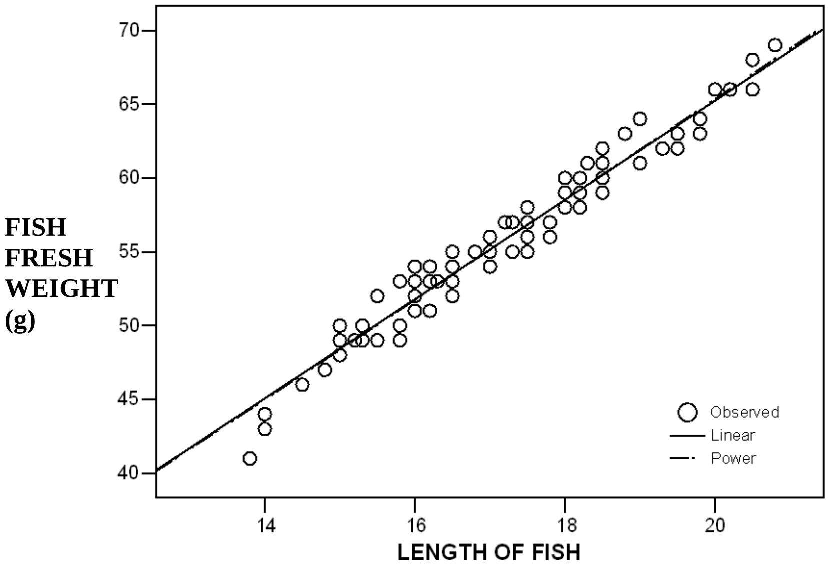


Fig. 5. LW (cm-g) relationship in *Pomadasys stridens* (pooled data)

SIMPLE LINEAR MODEL (Untransformed) EQUATION

Weight (g) = -2.000 + 3.3621L (cm) ± 1.0194
t_a = -2.256(p < 0.0252; t_b = 65.3862 (p < 0.0001)
r = 0.9788; r^2 =0.9580; Adj. r^2 =0.9578; F = 43337.80 (p < 0.0001) …… Eq. 1

DOUBLE LOGARITHMIC MODEL EQUATION

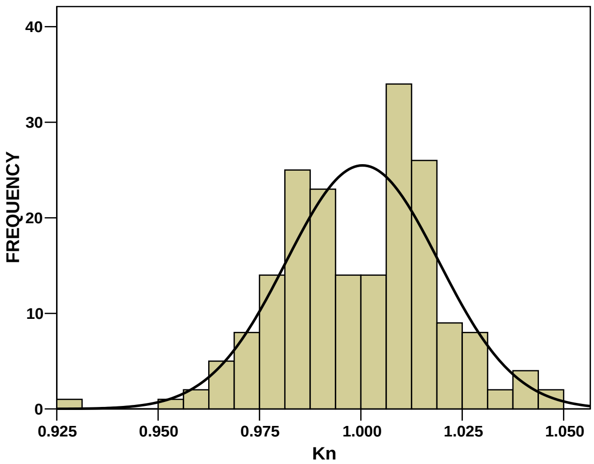
Log_e Weight (g) = 1.04393 + 1.04677 Log_e L ± 0.01888
t_a = 22.557 (p < 0.00001; t_b = 64.435 (p < 0.0001)
r =0.9779; r^2 =0.9562; Adj. r^2 = 0.9560; F = 4151.86 (p < 0.0001)………Eq.. 2

POWER MODEL EQUATION

Weight (g) = 2.8403.L $(cm)^{1.0467}$ ± 0.01888
t_a = 21.61 (p < 0.00001; t_b = 64.435 (p < 0.0001)
r =0.9779; r^2 = 0.9562; Adj. r^2 = 0.9560; F = 4151.086 (p < 0.0001)……..Eq. 3

It is obvious that *P. stridens* within the given range of size do not follow Cube law. LWR in the given range is best given by the simple linear equation. Our results are in contradiction to Safi *et al.* (2014). Within a similar length range of 15.6 – 19.8 cm (155 male) and 9.9-21.0 (236 female), they reported that LWR in male, female and combined sexes of this species follow the cube law. As regard to the cube law application in LWR of fishes, there are contradictory reports. For a size range of 16-59 cm, *Scomberomorus maculatus* (combined sexes, N = 159), has been reported to follow cube law of growth (b = 3.0242; r^2 = 0.9848) in continental shelf region from cape Hatteras, N. Carolina to Nova Scotia (Wigley *et al.*, 2003). Khan *et al.* (2013) also reported *Pomadasys maculatus* to follow cube law in the coastal water of Karachi, Pakistan and grow symmetrically and isometrically. LW relationship in most fish can be adequately described by $W = a.L^b$, where b is exponent usually falling between 2.5 and 3.5 (Carlander, 1969) or 2.5 to 4.0 (Hile, 1936). If value of b is 3, the fish grows isometrically, and if b is greater than 3, the fish exhibits positive allometry and if b is lesser than 3, the fish exhibits negative allometry (Tesch, 1968). For an ideal fish which maintains the same shape, b = 3, and this occasionally been observed (Allen, 1938). In the vast majority of instances where LWRs have been calculated, however, it has been found that the cube law is not obeyed and $b \neq 3$. Most of the fishes change their shape as they grow (Martin, 1949) and so cube law relationship could hardly be expected. It may be assumed that in probable $b \neq 3$. It has been found that while b may be different for fish from different location, different sexes or for larval, immature and mature fish (Le Cren, 1951). For instance, *Acanthopagrus berda* male (N = 233) and female (N = 280) samples from Karachi Coast of Pakistan have been shown to bear negative allometry (b = 2.638 and 2.636, respectively) but the pooled sample of male + female + unsexed individuals (N = 1074) followed cube law in LWR (Hameed *et al*., 2013). Adult *Scomberomorus guttatus* is also shown to exhibit negative allometry by Ahmad *et al* (2014), The magnitude of b may change with metamorphosis and or on onset of maturity (Frost, 1945). In 57 fish species of São Sebastião system of Brazil, Mutto *et al*. (2000) found the value of ranging from 2.746 to 3.617 (mean = 3.136). Of the 57 species, only 13 (26%) had b equal to 3. The rest of the 44 species (74%) had b ≠ 3 i.e. they didn't follow the cube law. The distribution of b of 57 species exhibited symmetry (g_1 = - 0.7497, p < 0.803) and normality in the mesokurtic curve (g_2 = 0.013, p < 0.67). It was concluded by them that the cube law cannot be applied in most of the fishes of São Sebastião system. In theory one might expect b =3, because volume is a 3-dimensional object roughly proportional to the cube of length for regular shaped solid. In fishes that have thin elongated bodies will tend to have value of b lower than 3 while fishes that have thicker bodies tend to have values of b that are greater than 3 (Brodziak, 2012). In 51 species studied, the value of b ranged between 1.94 (*Loligo duranceli*) and 3.62 (*Portunus pelagicus*). The mean value of b was 2.80 ± 0.32 (SD) and median 2.85. For male and female samples pooled (N=200) of *S. guttatus* admeasuring 32 to 51 cm in length, the value of a = 0.023 and b = 2.752 was reported for equation, $W = a.L^b$, by Abdurahiman *et al.* (2004) from Karnataka, India. Male individuals of *Schizopyge isocinus* are reported to exhibit negative allometry in Jhelum River water of Kashmir, India (Dar *et al.*, 2012). In *Schizopyge curvifrons*, there also exists negative allometry throughout the year except in March and October in Jhelum River water of India (Mir *et al.*, 2012).

It has been pointed out that calculation of condition factor (K) is based on comparison of a fish with an ideal fish in which $Wt \propto L^3$ and there may be several instances when organisms don't follow the cube law (Hile, 1936; Le Cren, 1951). The differences in magnitude of K may be interpreted on various characteristics such as fatness of fish, suitability to the environment or gonadal development, etc. K may be influenced with fish length, age, sex and maturity, parasitization, food and feeding, growth rates, the sampling methods used and the presence or absence of the swim bladder and consequently the specific gravity of the fish (Tester, 1940; Le Cren, 1951, Kesteven, 1947). Since *P. stridens*, in our studies exhibited negative allometry and deviated significantly from the cube law, K if calculated by the formula, $K = Wo \times 10^5 / L^3$, may be expected to give some erroneous results. In this view, in the present studies, relative condition factor (Kn) was computed as Wo / Wc (variations of observed weight of the individuals from the expected weight derived from the LWR). Le Cren (1951) has proposed Kn in preference to K under such conditions.



N = 192
Mean = 1.1040
SE = 0.003281
Median = 1.003281
CV = 1.70%
G1 - 0.262
Sg1 = 0.175
G2 = - 0.512
Sg2 = 0.349
Minimum = 0.9254
Maximum = 1.0439
KS-z = 1.466
P < 0.027

Fig. 6. Relative condition factor (Kn) of total *P. stridens* individuals. Negatively skewed and Leptokurtic.

Fig. 6 presents relative condition factor (Kn) for the pooled data of *P. stridens* for 2013 and 2014. Kn averaged to 1.104 ± 0.00328 and exhibited negative skewness. It varied from 0.925 to 1.044. The concentration of Kn around 1 may be due to very close relationship of Wo to Wc (r = 0.979, p < 0.0001; Wc = 1.802 + 0.968 Wo ± 1.0106; F, 4312.7, p < 0.0001). The variation in magnitude of Kn was merely 1.17 % which indicated that it may be associated to an extent with physiological activities of fat building and consumption. Like W/L ratio, Kn varied insignificantly during 2014. However, it was significantly higher in pre-monsoon season of 2013 and quite lower in post monsoon season of 2013 (Fig. 7) and as evident from paired t-test analysis (Table 2). The maturation of gonads in *P. stridens* is from February to April (Safi *et al.*, 2014). Fish consume fat during spawning (Dar *et al.*, 2012). Therefore, the general condition of P. *stridens* should not be good after or during spawning in monsoon or post-monsoon season.

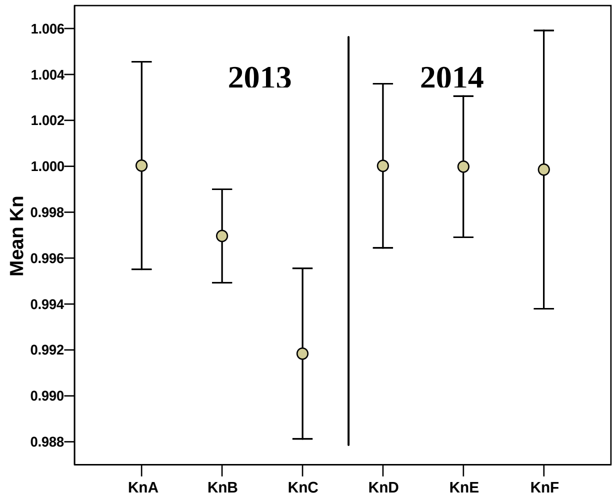
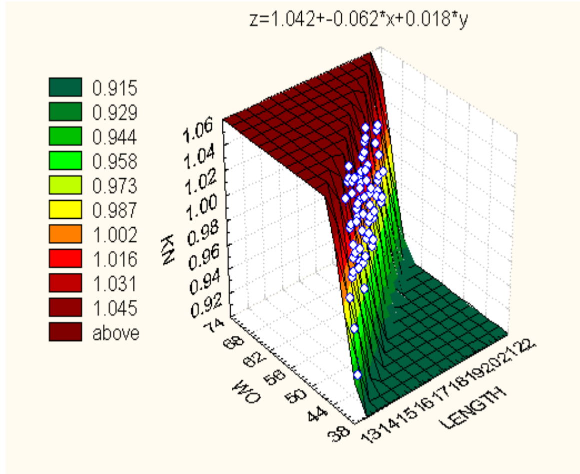


Fig. 7. Average Kn values for various seasons of fish collection.
KnA, pre-monsoon (2013);
KnB, Monsoon (2013);
KnC, Post monsoon (2013;
KnD, Pre-monsoon 2014;
KnE, Monsoon (2014);
KnF, post monsoon (2014)



Linear Multiple regression

Kn = 1.042 – 0.062 L + 0.18W ± 0.019566
t = 604.1 t = -129.19 t = 131.96
$p < 0.0001$ $p < 0.0001$ $p < 0.0001$
R = 0.995; R^2 = 0.989; Adj R^2 = 0.989;
F = 8709.47 ($p < 0.00001$)

		L	W
Partial Correlation	=	- 0.994	0.995
Zero Order Correlation	=	- 0.019	0.185

Fig. 8. Surface plot of linear relationship of Kn with weight and length.

Table 2. Pair comparison t-test for relative condition factor (Kn) for pre-monsoon, monsoon and post-monsoon seasons.

Pairs of parameters		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	KnA - KnB	.0030656	0.0155388	0.002747	- 0.002537	.0086680	1.116	31	0.273
Pair 2	KnA - KnC	.0081917	0.0197460	0.003491	0.001073	.0153109	2.347	31	0.026
Pair 3	KnB - KnC	.0051260	0.0090388	0.001598	0.001867	.0083849	3.208	31	0.003
Pair 4	KnD - KnE	.0000336	0.0151967	0.002686	- 0.005445	.0055126	.012	31	0.990
Pair 5	KnD - KnF	.0001643	0.0227780	0.004027	- 0.008048	.0083766	.041	31	0.968
Pair 6	KnE - KnF	.0001307	0.0175769	0.003107	- 0.006206	.0064679	.042	31	0.967

Acronyms: as in Fig.7.

Kn, as indicated by the surface plot of Kn against weight and length of the fish, it related more closely with length (negatively) than weight of the fish (positively) (Fig. 8). Kn related closely with W / L ratio in direct fashion (r = 0.9790) i.e. in adult *P. stridens,* Kn may closely be mimicked by W / L (Fig. 9). This simple parameter, W / L, may be useful in representing the fish conditioning in situations when LWR is found not following the cube law.

Further research on the subject is, however, needed to elucidate the LWR and conditioning in *P. stridens*. It may be mentioned that relationship of gonadostomatic index (GS) should be evaluated as condition factor of fish. There should be some relationship between gonadostomatic index and Kn and other environmental and physiological factors (Dar *et al.*, 2012).

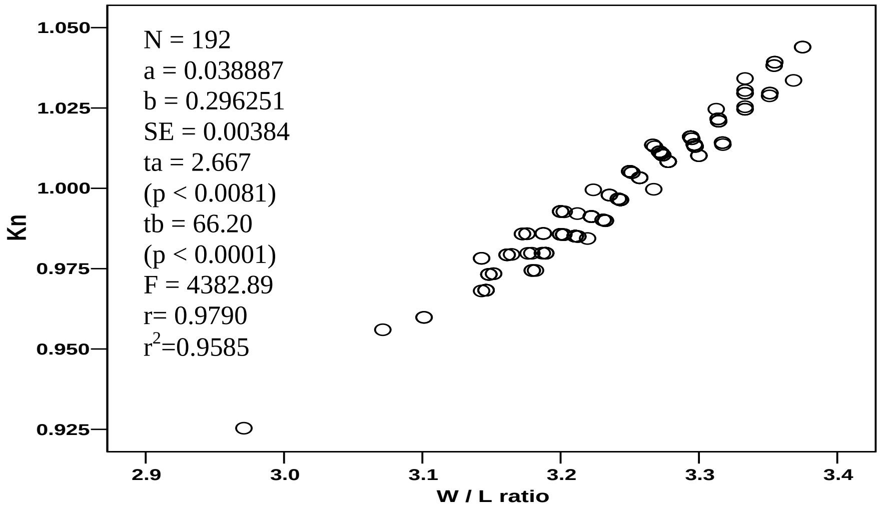


Fig. 9. Relationship of Kn with W/L Ratio as given by linear correlation and regression.

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