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Original Article

Biometric parameters of the redline torpedo fish *Puntius denisonii* Day 1865, an endemic barb in the Western Ghats Hotspots of Southern India

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Abstract: Studies on the biometric parameters of a species to have an important role in its population or stock management and conservation. Present study investigated the morphometric, meristic, length-weight relation (LWRs), length-length relation (LLRs) and growth status (K and Kn) of the Redline torpedo barb, *Puntius denisonii* collected during August 2012 to July 2013 from river Valapattanam, Kerala. The length-weight relationship was established for monthly to differentiate growth variation and also separately calculated for males, females pooled and indeterminate. Length-length relationship, morphometric and meristic characteristics were also represented by the equation: $Y = a + b^X$. The length-weight relations established for males was: log W = -2.207 + 3.148 log L; for females: log W = -2.360 + 3.316 log L; for indeterminate: log W = -2.176 + 3.171 log L and for pooled was: log W = -2.076 + 3.030 log L. The regression coefficients between pooled, indeterminate, males and females of *P. denisonii* did not show any significant variation from isometric growth ($P<0.05$). All morphological characters were highly correlated with total length and correlation coefficient (r) was highest for standard length (0.9889) and pre anal length (0.9904) and lowest for pelvic fin length (0.6150). Based on the study fin formula can be written as $D_{\text{ii-9}}$, $P_{\text{i-16}}$, $V_{\text{i-8}}$, $A_{\text{i-6}}$ and $C_{22\text{-}24}$.

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Introduction

Biometric parameters have been commonly used to distinguish the species taxonomically, to identify stocks of fish and to separate different morphotypes (Jayaprakash, 1974; Lourie et al., 1999; Doherty and McCarthy, 2004; Tarkeshwar et al., 2012). Length-weight relationship (LWRs) of fishes are used for the estimation of average weight of the fish of a given length group (Beyer, 1987) and also provided useful data for stock assessment and population dynamics studies (Kolher et al., 1995). Apart from this, the length-weight relationship can also be used for deriving comparisons between different stages in life history and between fish populations from regions or habitat groups (Petrakis and Stergiou, 1995; Goncalves et al., 1997) and tracking seasonal variations in fish growth (Richter et al., 2000).

The Western Ghats in peninsular India supports over 48% of the fish biodiversity in India (Ghosh and Ponniah, 2001) and is one of the global biodiversity hotspots (Myers et al., 2000). The Western Ghats are already known to have high levels of endemism (Dahanukar et al., 2011) and this unique ecosystem should receive the highest priority for species conservation (Marcus et al., 2012). *Puntius denisonii* (Day, 1865) an endemic ornamental barb of the Western Ghats of India belongs to the family Cyprinidae and is distributed in twelve rivers of Kerala (Mercy et al., 2009).

A large number of endemic species of the Western Ghats are known to be facing severe population decline due to indiscriminate collections for ornamental fish trade (Raghavan et al., 2009). In order to manage endangered species effectively, it is

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necessary to identify the reason for decline and a thorough knowledge of the ecology of the target species (Leunda et al., 2007). Over the last few decades wild population of *P. denisonii* has been declined due to various reasons and the species was categorized as Endangered (Ali et al., 2010). This work on the biometric measurements of *P. denisonii* was carried out as part of the study of population characteristics of this species from River Valapattanam of the Northern part of Kerala, India.

Materials and methods

Monthly samples were collected during daytime from river Valapattanam (Latitude 11°93' N; Longitude 73°73' E) during the period from August 2012 to July 2013. The fishes were caught by means of the traditional fishing gears veeshu vala (cast net) and koru vala (encircling net). The samples were immediately fixed in10% formalin and transferred to the laboratory.

The length-weight relationships (LWRs) were established separately for male, female, indeterminate and pooled using the formula $W= aL^b$ (Le Cren, 1951) and the relationship was expressed in the logarithmic form as: Log W = log a + b log L. The constants ‘a’ and ‘b’ were estimated using least square method. Length-length relationships (LLRs) between L_T *vs* L_F; L_T vs L_S, L_S vs L_H, L_H vs L_T, L_H *vs* L_F and L_S *vs* L_F were also calculated by linear regressions. The ponderal index (K) was worked out to assess the well-being of the population with the assumption that the growth of fish in ideal condition maintains equilibrium in length and weight (Hile, 1936). The general well-being of the fish (condition factor) was determined by the formula: $K = W*100/L^3$. Where, W = Weight of the fish in (gm); L = Total length of fish (cm). The relative condition factor (Kn) is described as the ratio between the actual weight (observed weight) and the calculated weight based on the length weight equation i.e., Kn = W/W^, (Le Cren, 1951), where, W = Observed weight and W^= Calculated weight. The data used for length-weight relationship were also utilized for calculating the condition factors.

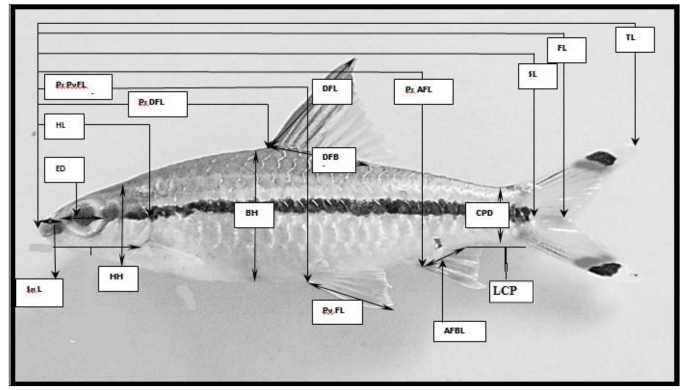

Figure 1. Schematic representation of *Puntius denisonii* indicating morphometric measurements.

Condition index (K and Kn) was calculated separately for, males, females and pooled samples of different length class (1 cm class).

Eighteen morphometric and elven meristic characters as shown in Figure 1 were studied by following the standard procedures described by Dwivedi and Menezes (1974). Length of the specimen was measured with vernier callipers nearest to 0.1 cm and weighed with an electronic balance nearest to 0.1gm (Sartorius GD-303). The length parameters were total length (L_T), standard length (L_S), fork length (L_F), pre dorsal fin length (L_{PrDF}), pre-anal fin length (L_{PrAF}), pre-pelvic fin length (L_{PrPvF}), pre-pectoral fin length (L_{PrPrF}), dorsal fin length (L_{DF}), Pelvic fin length (L_{PvF}), dorsal fin base length (L_{DFB}), anal fin base length (L_{AFB}), head length (L_H), head height (H_H), body depth (D_B), caudal peduncle depth (D_{CP}), caudal peduncle length (L_{CP}) snout length (L_{Sn}) and eye diameter (E_D). All morphometric characters were expressed in percentage of total length (L_T) and head length (L_H). Scatter gram of morphometric characters were plotted and the linear regression equation was fitted using least square method described by Snedecor and Cochran (1967). The relationships were represented by the equation: $Y = a + b^X$, Where, Y: a dependent variable, X= an independent variable, a= a constant (intercept) and b= the regression coefficient (slope). The correlation coefficient (r) is usually calculated to express the degree of linear association or interdependence of two variables.

Table 1. Logarithmic length-weight relationship (LWR) of *Puntius denisonii*.

	Length (cm)		Weight (gm)		a	b	r^2
	Min	max	min	max			
August 2012	4.8	6.8	4.8	6.8	-1.81	2.68	0.75
September 2012	7.6	11.5	4.8	6.8	-1.96	2.91	0.96
October 2012	6.3	14	4.8	6.8	-2.01	3.01	0.91
November 2012	6.6	13	4.8	6.8	-2.09	3.10	0.99
December 2012	7.6	11.8	4.8	6.8	-1.96	2.92	0.94
January 2013	6.4	12.9	4.8	6.8	-2.24	3.19	0.97
February 2013	7.5	11.7	4.8	6.8	-1.96	2.87	0.85
March 2013	3.6	12.9	4.8	6.8	-2.01	2.96	0.99
April 2013	4.3	12.1	4.8	6.8	-1.93	2.95	0.99
May 2013	4.7	12.9	4.8	6.8	-2.01	2.95	0.97
June 2013	4.6	12.5	4.8	6.8	-2.07	3.08	0.99
July 2013	3.3	12.4	4.8	6.8	-2.01	2.99	0.99

The significance of regression was tested by ANOVA. The regression coefficients of the sexes and indeterminate were compared by analysis of covariance (ANACOVA) (Snedecor and Cochran, 1967) to establish the variations in the 'b' values, if any, between them. Bailey's t-test (Snedecor and Cochran, 1967) was employed to find out whether 'b' value significantly deviated from the expected cube value of 3 [$t= (b-3)/S_b$], where b = regression coefficient and S_b = Standard error of 'b'. The coefficient of correlation 'r' was determined in order to know the relationship between the two variables.

Results and discussion

The endemic and endangered status makes, *P. denisonii* an important freshwater species of study and the biometrics information is useful for more effective management of in-situ conservation. A total of 306 specimens comprising 111 males, 97 females and 98 indeterminate were used for the study. The smallest length of captured fish was 3.30 cm and highest was 14.00 cm in T_L (Table 1). When empirical values of lengths were plotted against their respective weight on a logarithmic scale, linear line were obtained (Fig. 2 a, b, c and d). LWRs of males, females, indeterminate and pooled stock of *P. denis*onii were established as follows:

Males: $\log W = -2.207 + 3.148 \log L$

Females: $\log W = -2.360 + 3.316 \log L$

Indeterminate: $\log W = -2.176 + 3.171 \log L$

Pooled : $\log W = -2.076 + 3.030 \log L$

The length-weight relationship for *P. denisonii* of pooled population was calculated as Log W = -2.076 + 3.030 l log L (r^2 = 0.97). The parameter b values of LWRs vary generally between 2.5 to 3.5 are more common (Froese, 2006). Normally, b is close to 3, indicating fish grow isometrically; values significantly different from 3.0 indicate allometric growth (Tesch, 1971). The results of the present study shows that the regression coefficient does not significantly different from 3 (P<0.05) and thus follows the cubic law for isometric growth (Grover and Juliano, 1976). The calculated 'b' varied from a minimum of 2.68 (August) and to a maximum of 3.19 (January). Le Cren (1951) states that the LWRs in fishes may probably be related to the seasonal variations, as fishes do not retain the same shape or body contour throughout the year. All the earlier reports (Brody, 1945; Lagler, 1952; Brown, 1957; Balasunder Reddy, 1981; Narejo et al., 2003; Rekha, 2007; Choudhury et al., 2012) are in compliance with the present findings of the length-weight relationship in *P. denisonii.*

The exponent of length-weight relationship b was higher than 3 (males 3.148; females 3.316, Indeterminate 3.171 and pooled 3.303) and the 95% higher and lower confidence interval values were also above 3 indicating that the growth of *P. denisonii* in river Valapattanam was isometric. The exponential value of 3.316 implies that the female gain weight at a faster rate in relation to the length than males (3.148). Le Cren (1951) reported

Table 2. Logarithmic length-length relationships (LLRs) of *Puntius denisonii*.

L_T *vs* L_F =	y = 0.8671X -0.0563; r² = 0.9771
L_T *vs* L_S =	y = 0.7892X -0.1385; r² = 0.9873
L_S *vs* L_F =	y = 1.0832X +0.1855; r² = 0.9619
L_S *vs* L_H =	y = 0.2199X +0.1947; r² = 0.9746
L_H *vs* L_T =	y = 0.1737X +0.1632, r² = 0.9638
L_H *vs* L_F =	y = 0.1939X +0.2159; r² =0.9239

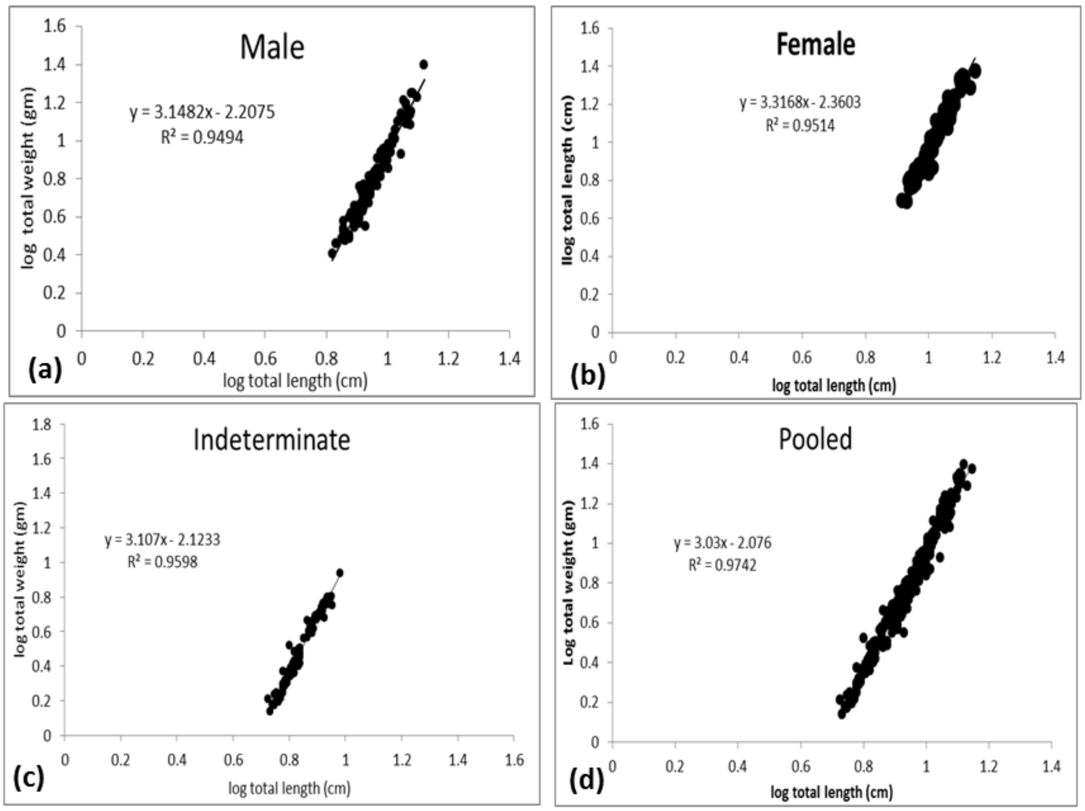

Figure 2. Scatter plot of logarithmic length-weight relationships (LWRs) of *Puntius denisonii*.

that females are heavier than the males of the same lengths probably because of the difference in fatness and gonadal development. In addition, growth increment, differences in age and stage of maturity, food, as well as environmental conditions such as temperature, salinity and seasonality can also affect the value of ‘b’ for the same species (Weatherley and Gill, 1987; Jaiswar and Kulkarni, 2002). Relationships between L_T, L_F, L_H and L_S of *P. denisonii* along with the estimated parameters of the length-length relationship and the coefficient of determination r^2 are presented in Table 2. All LLRs were highly correlated to each other (0.92 to 0.98).

Condition factor can be used as an index to assess the status of the aquatic ecosystem in which fish live (Anene, 2005). The mean values of condition factor (K) and relative condition factor (Kn) worked out separately for male, female and pooled samples (Figs. 3 and 4). In the present study, the condition factor (K) vary between 0.8858 to 1.0483 in the pooled sample, 0.8380 to 1.0865 in the male, 0.8282 to 1.004 in the female. The relative condition factor (Kn) varied between 0.8180 and 1.9187 in the case of pooled, 0.0342 and 1.9638 in the male, 0.3577 and 3.0043 in the female. Kn value of female is higher than that of male in *P. denisonii*, higher Kn values in females may be due to the heavier gonadal development in females (Shinkafi and Ipinjolu, 2010). In *P. denisonii*, Kn values showed gradual increment to higher length groups of males and females, which may be due to better foraging ability and conservation of stored food materials in adult than juveniles as suggested by Ikomi and Sikoki (2003) and Shinkafi and Ipinjolu (2010).

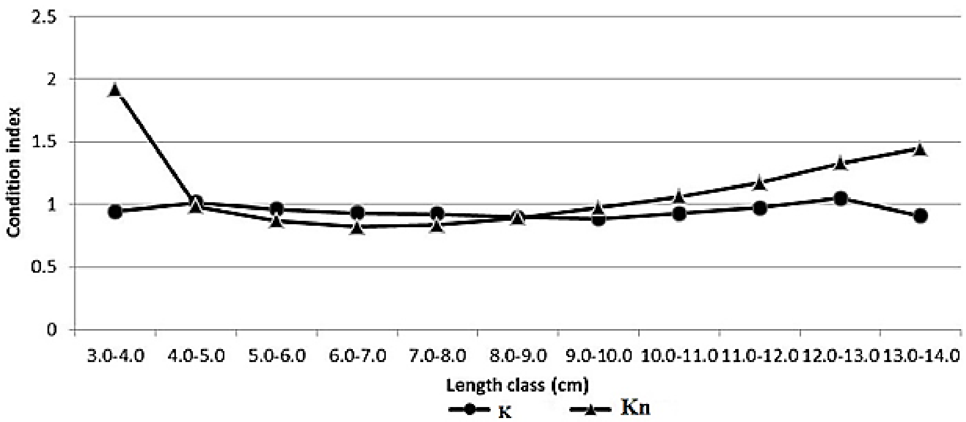

Figure 3. Condition factor (K) and relative condition (Kn) of *Puntius denisonii* (pooled).

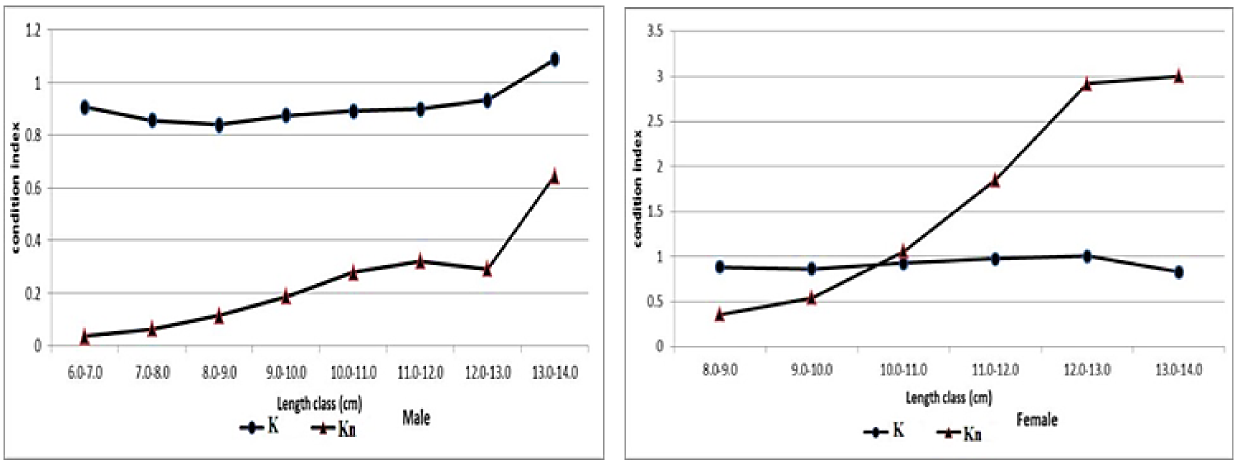

Figure 4. Condition factor (K) and relative condition (Kn) of *Puntius denisonii*.

Table 3. Meristic characters of *Puntius denisonii*.

Character	Number	Character	Number
Single fins:		Gill rakers (upper and lower)	26
Dorsal fin (Spines-Rays)	ii-9	Number of barbel	02
Anal fin (Spines-Rays)	i-6	Number of Lateral line	01
Caudal fin (Rays)	22-24	Scale along lateral line	24-26
Adipose fin	Absent	Scale above lateral line	06
Paired fins:		Scale below lateral line	04
Pectoral fin (Spines-Rays)	1-16	Total Vertebrae	28
Pelvic fin (Spines-Rays)	i-8	Pre anal vertebrae	17

Fluctuations in the condition of different length group may also be in relation to their reproductive cycle, feeding rhythms or physico-chemical factors of environment, age, physiological state of fish or some other unknown factors as suggested by many workers (Le Cren, 1951; Kumar and Kurup, 2010).

Morphometric and meristic features have been commonly used to distinguish the species taxonomically, to identify stocks of fish, and to separate different morphotypes (Jayasankar et al., 2004; Turan, 2004). In the present investigation, specimens ranging from 5.70-10.50 cm L_T were used for the morphometric and meristic characteristics studies. Measurements of various morphometric characters of *P. denisonii*, such as mean, median, standard deviation and coefficient of variation are presented in Table 4 and 5. Regarding proportional values between each character and L_T, body depth (D_B) showed a maximum coefficient of variation (21.42%), while snout length (L_{Sn}) showed minimum variation (10.07%). Body depth (D_B) of fishes mostly depends upon the stage of reproduction

Table 4. Statistical estimate of morphometric characters of *Puntius denisonii*.

L_{T}	5.7	10.5	7.5628	7.1	1.3907	18.3891	
L_{F}	4.9	9.1	6.5028	6.2	1.2212	18.7802	85.9841
L_{S}	4.3	8.1	5.8285	5.5	1.1006	18.8843	77.0683
L_{PrAF}	3.2	6.1	4.4571	4.3	0.8902	19.9732	58.9346
L_{PrPvF}	2.4	4.3	3.1057	2.9	0.5651	18.1966	41.0653
L_{PrDF}	2.1	3.9	2.8257	2.7	0.5287	18.7133	37.3630
L_{H}	1.1	1.9	1.4742	1.4	0.2405	16.3141	19.4937
D_{B}	1.0	2.0	1.4028	1.3	0.3004	21.4188	18.5493
H_{H}	0.7	1.2	0.9228	0.9	0.1456	15.7873	12.2024
L_{CP}	0.7	1.4	0.9057	0.9	0.1607	17.751	11.9758
D_{CP}	0.5	0.9	0.66	0.6	0.1376	20.8525	08.7268
L_{Sn}	0.4	0.5	0.4228	0.4	0.0426	10.0753	05.5912
D_{E}	0.4	0.6	0.4942	0.5	0.0764	15.4722	06.5357
L_{DFB}	0.7	1.3	0.9457	0.9	0.1771	18.7306	12.5047
L_{AFB}	0.4	0.6	0.4571	0.4	0.0777	17.0153	06.0445
L_{PvF}	0.9	1.3	1.1457	1.2	0.1615	14.0964	15.1492
L_{DF}	1.2	1.9	1.5114	1.5	0.2529	16.7357	19.9848
Characters	Min	Max	Mean	Median	S.D	C.V	% L_{H}
L_{H}	1.1	1.9	1.4742	1.4	0.2405	16.3141	
H_{H}	0.7	1.2	0.9228	0.9	0.1456	15.7873	62.5968
L_{Sn}	0.4	0.5	0.4228	0.4	0.0426	10.0753	28.6821
E_{D}	0.4	0.6	0.4942	0.5	0.0764	15.4722	33.5271

Min= minimum, Max= maximum; SD=standard deviation; C.V= coefficient of variation; LT (%) = percentage of total length; LH (%) = percentage of head length

Table 5. Regression analysis of morphometric characters of *Puntius denisonii* as function of total length (L_{T})

Characters	a	b	r	r^2	Y = a +b X
L_{F}	-0.0723	0.8694	0.9900	0.9802	-0.0723+0.8694 TL
L_{S}	-0.1237	0.7870	0.9944	0.9889	-0.1237+0.7870 TL
L_{PrAF}	-0.3608	0.6370	0.9952	0.9904	-0.3608+0.6370 TL
L_{PrPvF}	0.2343	0.3796	0.9343	0.8729	0.2343+0.3796 TL
L_{PrDF}	0.0008	0.3735	0.9823	0.9650	0.0008 +0.3735 TL
D_{B}	-0.1742	0.2085	0.9652	0.9652	-0.1742+0.2085 TL
H_{H}	0.1546	0.1015	0.9695	0.9401	0.1546 +0 .1015 TL
L_{CP}	0.1205	0.1038	0.8980	0.8065	0.1205+0.1038 TL
D_{CP}	-0.0136	0.0890	0.9001	0.8102	-0.0136+0.0890 TL
L_{Sn}	0.2354	0.0247	0.8089	0.6544	0.2354+0.0247 TL
E_{D}	0.1156	0.0500	0.9104	0.8290	0.1156+0.0500 TL
L_{DFB}	0.0234	0.1219	0.9574	0.9166	0.0234+0.1219 TL
L_{AFB}	0.0989	0.0473	0.8467	0.7169	0.0989+0.0473 TL
L_{PvF}	0.4569	0.0910	0.7842	0.6150	0.4569+0.0910 TL
L_{DF}	0.3102	0.1588	0.8732	0.7625	0.3102+0.1588 TL

Table 6. Regression analysis of morphometric characters of *Puntius denisonii* as function of head length (L_{H})

Characters	a	b	r	r^2	Y = a + b X
D_{H}	0.0604	0.5849	0.9657	0.9325	0.0604+ 0.5849 TL
L_{Sn}	0.2050	0.1477	0.8340	0.6955	0.2050+0.1477 TL
E_{D}	0.0708	0.2871	0.9031	0.8157	0.0708+0.2871 TL

(ripe, spawning, or spent) especially in females; it may be resulted by the variation of body height (B_{H}) in related to growth (Gunawickrama, 2008).

The growth of the morphometric characters in relation to the total length was noted to be the least in the snout length (b=0.247) and the highest in the fork length (b=0.869). High degree of correlation of morphometric characters with total length is evident from r-values which ranged from 0.7527 to 0.9841 (Tables 5 and 6). The morphometric characteristic such as L_{F}, L_{S}, D_{B}, L_{PrDF}, L_{PrAF}, L_{AFB}, D_{CP}, L_{H}, H_{H} and E_{D} were highly correlated with total length (r>0.990), as well as H_{H} (0.965), E_{D} (0.903) and L_{Sn} (0.834) were highly correlated with head length (L_{H}) (Fig. 6). The coefficient of correlation of head length (L_{H}) against compared characters ranged from minimum of 0.6955 for snout length to maximum of 0.9325 for head height (Fig. 5). In general, fishes

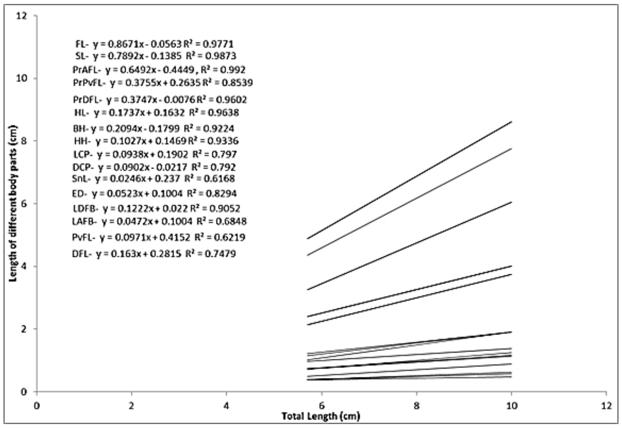

Figure 5. Scatter diagram of morphometric characters in relation to total length (L_T)

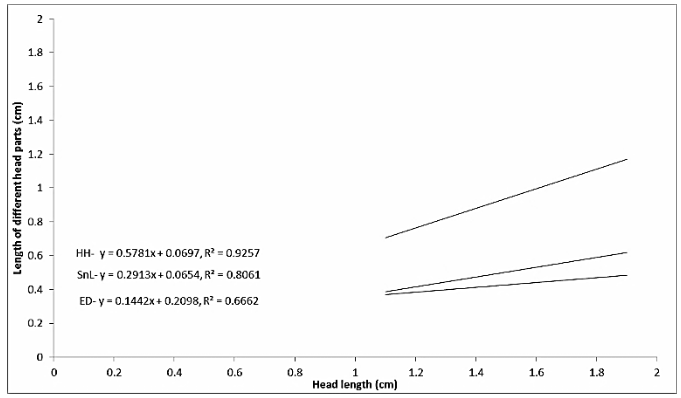

Figure 6. Scatter diagram of morphometric characters in relation to head length (L_H)

demonstrate greater variance in morphological traits both within and between populations, and are more susceptible to environmentally induced morphological variation (Wimberger, 1992; Swain and Foote, 1999), which might reflect different feeding environment, prey types, food availability or other features. The results of various meristic characters were presented in Table 3. Based on the results from the present study, the fin formula for *P. denisonii* from River valapattanam could be written as: D $_{ii\text{-}9}$, P $_{i\text{-}16}$, V $_{i\text{-}8}$, A $_{i\text{-}6}$ and C $_{22\text{-}24}$. These results are in agreement with earlier studies (Ali et al., 2010).

The riverine ecosystem of Valapattanam is affected by pollution, pesticides, habitat destruction and sand mining. Swain and Foote (1999) reported that, biometric characters of fishes may influence by environmental changes. During our study, we observe different types of malformation such as, vertebral deformity, semi-operculum and puff out belly in *P. denisonii* (Day, 1865) from Valapattanam River (unpublished results). Similar reports of skeletal deformities in freshwater fish species in Bhavani River (Raj et al., 2004). These studies show rivers of Kerala facing serious threats by these kinds of illegal and indiscriminate man-made alterations. These findings would give information to fishery biologists about morphometric, meristic characteristics, length-weight relation, length-length relation and condition index of redline torpedo barb, *Puntius denisonii* (Day, 1865) in the river Valapattanam in southern India.

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