

Comparison of Length-Weight Relationship in *Liza tade* (Forsk.) from Estuaries of the Southern Karnataka Coast by Multiple Regression Analysis

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Random samples of *Liza tade* were collected from Netravathi-Gurpur, Mulky, Kallyanpura, Mabukala and Gangolli estuaries in the years 2000, 2001 and 2002. Multiple linear regression technique with 1 dummy variable for sex of fish was used to identify the homogeneity or otherwise of 2 length-weight relationships for each estuary and in 3 years after pooling length-weight data accordingly. In addition, isometric growth of 2 sexes was tested by t-test. Trend line graph was used to compare growth conditions in various length-weight relationships. The whole process is a substitute for Analysis of Covariance technique.

Key words: *Liza tade*, multiple linear regression equation, length-weight relationship, trend line graph.

Study of length-weight relationship of the form $w = alb$ (Le Cren, 1951) is a part of biological studies of a species to know the average size of fish at first maturity, spawning season, relative condition factor and asymptotic weight. The fitted length-weight relationship is used in raising the monthly sampled weight of a species to derive the length frequency distribution for the estimated monthly catch for use in stock assessment studies. Reddy (1985) worked on some biological aspects of *L. tade* from Mangalore region. Other than *L. tade*, the important contributions on length-weight relationships are by Rangaswamy (1976) and Das (1977) on *M. cephalus*, Kurup and Samuel (1992) on *L. parsia* from Cochin estuary. Gowda (1985) worked on *V. seheli* from Mangalore waters. Here an attempt is made to study the length-weight relationship of *L. tade* from the estuaries of the southern Karnataka coast as a part of the project on stock assessment of *L. tade*.

Materials and Methods

Monthly samples of specimens of *L. tade* were collected from Netravathi-Gurpur,

Mulky, Kallyanpura, Mabukala and Gangolli estuaries of the Karnataka coast, during the years 2000, 2001 and 2002. A total of 1761 fishes of *L. tade* were sampled in 3 years in the size range of 9 to 31 cm. Total length (in cm) and body weight (in g) of each fish were recorded with identification to sex. Length-weight relationship of the form $w = alb$ was fitted by multiple linear regression analysis using 1 dummy variable for sex of fishes. Thus the multiple linear regression equation of log weight on log length with 1 dummy variable is given by:

$$Y = A_0 + A_1 D + B_0 X + B_1 DX$$

where, Y = log length

X = log weight

$D = 0$, if fish is female

$= 1$, if fish is male

A_0 = difference of 2 obesity values of male and female fishes in log units

B_0 = basic regression coefficient of female fishes

B_1 = difference of 2 regression coefficients of males and females

In the above regression equation the coefficients A_0 , A_1 , B_0 and B_1 were tested by t-test for their significance (departure from zero). If all coefficients are significant, then separate length-weight relationships were derived by putting $D = 0$ and $D = 1$ in the fitted multiple linear regression equation to obtain respective length-weight relationships for females and males as :

$$= A_0 + B_0 X$$

$$Y = (A_0 + A_1) + (B_0 + B_1)X$$

On the other hand, if only A_0 and B_0 are found to be significant by t-test, then combined length-weight relationship was derived as the average of 2 length-weight relationships of females and males:

$$Y = A_0 + A_1/2 + B_0 X + B_1 X/2$$

In otherwords, the homogeneity of 2 length-weight relationships follows from non-significance of B_1 and A_1 coefficients by t-test. Once homogeneity or otherwise of length-weight relationships was identified, isometric growth in females was tested by t-test statistics as:

$$t = (B_0 - 3) / S.E(B_0)$$

Then if both the coefficients B_1 and B_0 are not significantly different from '0' and '3' respectively, there is evidence to say that 2 regression coefficients are equal for males and females with isometric growth in both the sexes. These analysis were done for samples of *L. tade* from 5 estuaries pooled for 3 years and again in 3 years separately for the pooled samples of *L. tade* from 5 estuaries. The detailed results are given in Tables 1 and 2 respectively. The variations in the growth conditions are explained in Fig.1 by the trend line graph. All the statistical analysis were done by MINITAB and EXCEL packages.

Results and Discussion

The fitted multiple linear regression equation for each estuary from the yearly pooled length frequency data of *L. tade* with details on significance of A_0 , A_1 , B_0 and B_1 coefficients hence the indication on the homogeneity or otherwise of 2 length-weight relationships with isometry are shown in Table 1. There was homogeneity in the length-weight relationship of the 2 sexes in Netravathi-Gurpur, Mabukala and Gangolli estuaries. Baburaj (1985) has worked on some aspects of biology of *L. tade* from estuaries of Mangalore region and derived the pooled length-weight relationship for 2 sexes as $\log w = -1.6318 + 2.7085 \log l$. The length-weight relationship of *L. tade* in the present study for Netravathi-Gurpur estuary was very similar to earlier work of Baburaj (1985). Comparing *L. tade* with other important species of Mulletts, Rangaswamy (1976) reported length-weight relationship of *M. cephalus* did not vary from Ennore and Adyar estuaries ($b = 2.7788$). Das (1977) has reported that b values were same for males and females of *M. cephalus* thus supporting the homogeneity of length-weight relationship of 2 sexes in 3 estuaries since *L. tade* belongs to the same group. Gowda *et. al* (1983) has also reported that there was no significant change in the length-weight relationships of 2 sexes of *V. seheli* from Mangalore waters. It was observed by Kurup and Samuel (1992) that in case of *L. parsia* length-weight relationship of females was $\log w = -1.0628 + 2.4465 \log l$ while that of males was $\log w = -1.2117 + 2.4465 \log l$ from Cochin estuary and there was no significant difference in the 2 length-weight relationships showing negative allometric growth in both the species in *L. parsia*. These results give evidence that in the present study the characteristics of length-weight relationship of *L. tade* from the estuaries of the southern Karnataka coast are not deviating much from the results as length-weight relationships of the other species of mullets elsewhere. Further negative allometric growth conditions were observed in *L. tade* in these

Table 1. Multiple linear regression equations and other details in 3 years of *Liza tade* from estuaries of the southern Karnataka coast

Estuaries/ sample size	Multiple linear regression equations and significance	Indications
Netravathi n = 581 females = 267 males = 314	$Y = -1.66 - 0.0345 D + 2.73 X + 0.0237 DX$ (46.04) (0.56) (89.24) (0.45)	Homogeneity in length-weight relationship $Y = -1.66 + 2.73 X$ $B_1 = 0.0237 \Rightarrow$ Growth conditions are same in males and females. $B_0 = 2.73 * \neq 3 \Rightarrow$ No isometric growth in (8.84) males and females.
Mulky n = 378 females = 190 males = 188	$Y = -1.30 - 0.4091 D + 2.42 X + 0.3426 DX$ (15.61) (3.60) (36.14) (3.61)	Separate length-weight relationships Females : $Y = -1.30 + 2.42 X$ Males : $Y = -1.71 + 2.76 X$ $B_1 = 0.3426 * \Rightarrow$ Growth condition are not same in males and females. $B_0 = 2.42 * \neq 3 \Rightarrow$ No isometric growth (8.65) in males and females.
Kallyanapura n = 234 females = 96 males = 138	$Y = -2.13 + 0.4985 D + 3.1079 X - 0.4410 DX$ (19.85) (3.51) (34.41) (3.53)	Separate length-weight relationships Females : $Y = -2.13 + 3.11 X$ Males : $Y = -1.88 + 2.89 X$ $B_1 = 0.4410 * \Rightarrow$ Growth conditions are not same in males and females. $B_0 = 3.11 = 3 \Rightarrow$ Isometric growth in (1.22) females and not in males.
Mabukala n = 259 females = 124 males = 135	$Y = -1.58 - 0.0858 D + 2.66 X + 0.0758 DX$ (30.34) (1.28) (60.71) (1.29)	Homogeneity in length-weight relationships $Y = -1.63 + 2.69 X$ $B_1 = 0.0758 \Rightarrow$ Growth conditions are same in males and females. $B_0 = 2.66 * \neq 3 \Rightarrow$ No isometric growth (7.77) in males and females.
Gangolli n = 319 females = 199 males = 120	$Y = -1.65 + 0.1637 D + 2.7261 X - 0.1455 DX$ (23.69) (1.36) (47.64) (1.42)	Homogeneity in length-weight relationships $Y = -1.57 + 2.6533 X$ $B_1 = 0.1455 \Rightarrow$ Growth conditions are same in males and females. $B_0 = 2.73 * \neq 3 \Rightarrow$ No isometric growth (4.72) in males and females.

() indicate value of 't' statistic for testing significant departure from zero.

Numbers with bold lettering indicate significance at $p = 0.05$ for non-zero values

(()) indicate values of 't' statistic for testing isometric growth in females the fitted regression equation.

* denotes significant departure of female fishes from isometry at $p = 0.05$

3 estuaries in the range of 2.65 – 2.73. There was significant difference in the length-weight relationship of male and female specimens of *L. tade* from Mulky and

Kallyanapura estuaries indicating non-homogeneity of length-weight relationships. Isometric growth ($b = 3.11$) in females was observed only from Kallyanapura estuary

Table 2. Multiple linear regression equations and other details of *Liza tade* from all estuaries of southern Karnataka coast

Year/Sample size	Multiple linear regression equations and significance	Indications
Year 2000 n = 319 males = 128 females = 191	$Y = -1.67 - 0.154 D + 2.73 X + 0.13 DX$ (19.34) (0.99) (38.46) (1.03)	Homogeneity in length-weight relationship $Y = -1.75 + 2.80 X$ $B_1 = 0.13 \Rightarrow$ Growth conditions are same in males and females. $B_0 = 2.73 * \neq 3 \Rightarrow$ No isometric growth in males and females. (3.86)
Year 2001 n = 192 males = 327 females = 407	$Y = -1.64 + 0.0646 D + 2.70 X - 0.0531 DX$ (39.37) (1.15) (77.45) (1.11)	Homogeneity in length-weight relationship $Y = -1.61 + 2.67 X$ $B_1 = 0.0531 \Rightarrow$ Growth conditions are same in males and females. $B_0 = 2.70 * \neq 3 \Rightarrow$ No isometric growth in males and females. (8.60)
Year 2002 n = 770 males = 408 females = 362	$Y = -1.69 + 0.0621 D + 2.75 X - 0.0459 DX$ (47.05) (0.96) (87.83) (0.82)	Homogeneity in length-weight relationship $Y = -1.66 + 2.73 X$ $B_1 = 0.05 \Rightarrow$ Growth conditions are same in males and females. $B_0 = 2.75 * \neq 3 \Rightarrow$ No isometric growth in males and females. (1.80)

() indicate value of 't' statistic for testing significant departure from zero.

Numbers with bold lettering indicate significance at $p = 0.05$ for non-zero values

(()) indicate values of 't' statistic for testing isometric growth in females the fitted regression equation.

* denotes significant departure of females fishes from isometry at $p = 0.05$

since B_1 is significant. It was observed that the growth conditions in *L. tade* were relatively poor in Mulky estuary, probably due to unfavorable conditions in the ecosystems. Inconsistent growth conditions prevailed in these estuaries during the period under study.

Table 2 gives the results of analysis of length-weight data of *L. tade* from the 5 estuaries of southern Karnataka coast in 3 years. It can be seen from Table 2 that there was homogeneity in the length-weight relationship of males and females of *L. tade* in all the 3 years and negative allometric growth was observed in both the sexes. According to Rangaswamy (1976) length-weight relationship of *M. cephalus* did not vary significantly between years and environment which is true in the present study for *L. tade* which belongs to the same family.

The inconsistent growth in males and females of *L. tade* was observed as can be seen from sign of B_1 coefficients of multiple linear regression equation. The negative B_1 coefficients indicate lower growth conditions in males than females while positive B_1 coefficients indicate higher growth conditions in males than females, with magnitude. Thus there was higher differential growth condition in the males and females of *L. tade* from Kallyanapura estuary ($B_1 = -0.4410$) followed by Mulky estuary.

Fig. 1 gives the variation in the b and A values of *L. tade* for Table 1 and 2. This figure gives the clear picture of the average condition of growth in *L. tade* estuarywise and yearwise. According to Le Cren (1951) the variation in ecological conditions of 2 habitats or variation in the physiology of the animals or both are responsible for variation

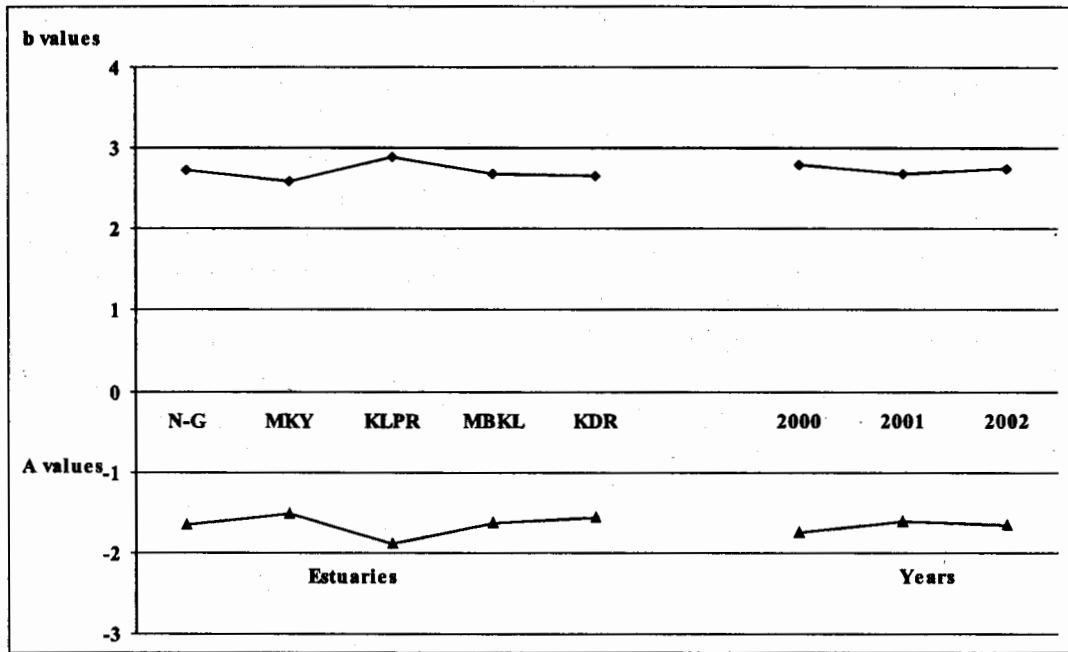


Fig. 1. Trend line graph showing b and A values

in growth rate in the same species from different localities. On the other hand it can be seen that the condition of growth is towards declining trend year after year. Again this gives the evidence that the ecosystem might be the causative factor for poor growth condition in *L. tade* in the estuaries of southern Karnataka coast.

From Fig. 1 it is interesting to note a comparative relationship between condition of growth and obesity values in fishes. In any length-weight relationship b values are directly related to $\frac{1}{2}A\frac{1}{2}$ values. Higher the values of b, higher the $\frac{1}{2}A\frac{1}{2}$ values are. In other words, the growth condition in fishes is inversely related to obesity, since obesity $a = \text{antilog}(A)$ in any length-weight relationship of the form $w = alb$. It has been found that the difference in b and A values are equal for length-weight relationship of males and females in any species. It was also observed that for any 2 length-weight relationships of males and females of a given species the difference of 2 regression coefficients is almost same and opposite to that of the difference of 2 intercept values as can be seen in the present study for *L. tade* also.

The method of multiple linear regression equation analysis with 1 dummy variable is an alternate approach for the Analysis of covariance technique (Snedecor & Cochran, 1968) to test the homogeneity or otherwise of the 2 length-weight relationships and hence derivation of 2 length-weight relationships with indication to isometric growth of males and females. Best comparison of length-weight relationships is possible with the trend line graph of b and A values instead of representing the length-weight relationship of the form $w = alb$ in the non-linear form graphically without any valid inferences.

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References

- Das (1977) Length-weight relationship and relative condition of Grey Mullet, *Mugil cephalus*. *Mahasagar*. 10, pp 145-149.
- Gangadhara Gowda, S.L. Shanbhogue, K.S. Udupa (1987) Length-weight relationship and relative condition of Grey

Mullet, *Valamugil seheli* (Forsk.) from Mangalore waters. *Indian Journal of Fisheries* 34, pp 340-342.

Kurup, B.M. and Samuel, C.T. (1992) Length-weight relationship in the goldspot Mullet *Liza parsia* of Cochin estuary. *J. Mar. Biol. Assoc. India*, 34, pp 110-114.

Le Cren, C.D. (1951) The length-weight relation and seasonal cycle in gonad weights and condition in the perch (*Perca fluviatilis*) *Journal of Animal Ecology* 20, pp 201-219.

Rangaswamy, C.P. (1976) Length-weight relationship in Grey Mullet *Mugil cephalus* Linnaeus, *Matsya*, 2, pp 19-22.

Reddy, S. (1985) *Some aspects of biology of the Mullet, Liza tade (Forsk.) from Mangalore waters*. M.FSc Thesis, University of Agricultural Sciences, Bangalore.

Snedecor, G.W. and Cochran, W.G. (1968) *Statistical methods*. Oxford and IBH Publishing Company, Calcutta, India.