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THE LENGTH-WEIGHT RELATIONSHIP AND CONDITION OF TRICHIURUS SAVALA GUV. AND VAL.

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The method of analysing the length weight relationship of fish is reviewed. The total length--weight relationship of *Trichiurus savala* Guv. and Val. is expressed by $\log W = .00331 + .0935099 \log L$ for male and $\log W = -1.95865 + 2.19460 \log L$ for female subgroups. The regression of body weight on total length are calculated to be $Y = -15.68 + 1.3\ X$ and $+ = 33.8 = + .191\ Y$. The values of coefficient correlation, r is found to be 0.498.

The mean values of condition, K and relative condition factor, Kn in the length--weight relationship of *Ts.avala* are 0.052 and 0.1203 for male and 0.055 and 0.66 for female subgroups.

Trichiurus savala, commonly known as ribbon-fish, is one of the important demersal fishes of the Bay of Bengal. It is popularly known as 'Talwar' in Karachi, Sind and Makran[9] and 'Churee mach' in Chittagong and Cox's Bazar. *T. savala* is abundant in the inshore waters of the Indian seas and the Bay of Bengal.[2,3] The fishing centres in the Bay of Bengal are the waters surrounding Sonadia, Moiskals, Kutubdia, St. Martin's, Dubla islands, and the coast of Teknaf, Cox's Bazar and Chittagong. *T. savala* and *T. haumela* constitute the ribbon-fish fishery in the Bay of Bengal. The ribbon-fish is very delicious eaten fresh but never reaches beyond the local consumers. Most of the fishes are sun-dried and exported to the neighbouring countries. Not much work has been done in Pakistan on *T. savala*, although it is an economically important fish. The present paper is a part of the studies on the biology of *T. savala*.

There is a particular relationship between the length and weight of fish if there is no significant change in form and specific gravity of the species. For an ideal fish, $n=3$ in $W=aL^n$ and this has been observed by Allen[1] and Ricker.[10] The cube relationship is hardly expected as most of the species do change their shape. The authors[4,6,7] found $n>3$ which is indicative that the fish weight increases as the cube of the length. It is assumed in the present investigation that $n<3$ as it appears from the peculiar ribbon-like shape of *T. savala*, where weight increases very little with considerable increase in length.

Individual variations from the general length–weight relationship have been frequently studied under the term 'condition'.[4,6,12,13] The changes in condition have usually been analysed by means of a 'condition factor' or 'coefficient of condition'. This is calculated as a ratio between the observed weight and that expected from observed length.

Materials and Methods

Materials.—*Trichiurus savala* were collected bi-monthly from fisherman's catch at the fish landing terminals at Cox's Bazar during the period June 1967 to April 1968. The fishes were preserved in 5% Formalin and then shipped to the Fishreies Laboratory, Department of Zoology, Dacca University.

Length was measured in mm and the body weight in g.

Methods.—The body of the fish is continually changing in its proportions during its life time and the simple cube law expression ($K=W/L^3$ where W=weight and L=length) does not hold throughout the life of the fish. It has been found that the length–weight relationship of most fish can adequately be described by a formula,[11]

$$W = c^{L^n} \qquad (1)$$

where c is a constant and n an exponent. This formula has been followed in these studies.

The exponential form of relationship in formula (1) can be expressed in the logarithmic form, as

$$\log W = \log c + n \log L \qquad (2)$$

The values of c and n have been calculated for total length-body weight relationship using the log–log relationship in formula (2). The values of log c and n in formula (2) were calculated by using the mathematical relationship.[11] This relationship has been used simply by plotting the log of the weight against the log of the length for both male and female fish.

The calculated weight for the corresponding observed mean length were obtained by using the formula (2).

In calculating the coefficient of regression for Y on x and for x on Y the formulae are:

$$Y=a+bX \tag{3}$$

and $$X=c+dY \tag{4}$$

respectively. The calculation of coefficient of correlation, r, is as follows:

$$r=\frac{\varepsilon XY-\frac{\varepsilon X\,\varepsilon Y}{N}}{\left[\left\{\varepsilon X^2-\frac{(\varepsilon X)^2}{N}\right\}\left\{\varepsilon X^2-\frac{\varepsilon(Y)^2}{N}\right\}\right]} \tag{5}$$

The condition factor is calculated with the help of the formula: $W=KL^3$ or $K=W/L^3$ where W= weight in g, L=Length in mm and K is the factor of proportion. In the present work, the value of K will be known as the condition factor. The value of K is generally determined from the formula:

$$K=\frac{W\times 10^5}{L^3}$$ which may be written as:

$$K=\log W+\log 10^5-3\log L \tag{6}$$

Results

Length–Weight Relationship.—The total length–weight relationship was calculated from Tables 1 and 2.

Male Subgroup.—The values of log c and n for this subgroup was found to be .0031 and .93509 respectively. The logarithmic form of equation for total length and weight relationship is:

$$\text{Log } W=.00331+.93509\ \text{Log } L$$

TABLE 1.—LOG VALUES OF MEAN TOTAL LENGTH AND OF CORRESPONDING MEAN BODY WEIGHT OF 29 MALE *Trichiurus savala*.

Mean total length L (in cm)	Mean body weight W (in g)	Log L	Log W	(Log L)^2	Log L. Log W
37·4 (1)	36	1.57287	1.5563	2.47133	2.43808
40.8 (1)	39	1.61066	1.59106	2.5924	2.56168
33·46(5)	22.04	1.52453	1.34319	2.31182	2.0467
38.3 (4)	33.25	1.5832	1.52179	2.50656	2.40825
45.2 (3)	29.166	1.65514	1.46486	2.7245	2.41607
38.38(5)	20.38	1.5841	1.30767	2.498	2.05593
40.16(5)	27.5	1.60378	1.43933	2.56967	2.29437
42.4 (5)	55.4	1.62737	1.7356	2.62756	2.80525
		ε12.76165	11.9598	20.30184	19.02633

TABLE 2.—LOG VALUES OF MEAN TOTAL LENGTH AND OF CORRESPONDING MEAN BODY WEIGHT OF 95 FEMALE *Trichiurus savala*.

Mean total length L (in cm)	Mean body weight W (in g)	Log L	Log W	(Log L)^2	Log L. Log W
41.509(11)	41.136	1.61815	1.61421	2.61841	2.61203
39.866(15)	40.666	1.60061	1.60923	2.56195	2.57575
37.68 (10)	32.15	1.57612	1.50717	2.48415	2.37548
44.362 (8)	38.875	1.64701	1.58968	2.71264	2.61822
41 (8)	39.375	1.61278	1.59522	2.60106	2.57274
39.125 (4)	37.125	1.59246	1.56966	2.53593	2.49962
41.19 (11)	40.109	1.61479	1.69324	2.60755	2.58889
46.1857(7)	67.2142	1.66449	1.82746	2.77053	3.04179
41.95 (11)	30.91	1.62274	1.4911	2.63328	2.41967
42.89 (10)	33	1.63236	1.51851	2.6646	2.47875
		ε16.18151	15.92548	26.1901	25.78294

Female Subgroup.—The values of log c and n was found to be -1.95865 and 2.19460. The values when put in the equation for total length and weight relationship:

$$\log W = -1.95865 + 2.19460 \log L$$

On putting the values of log c and n in equation (2) several corresponding values of Log W for any values of log L were obtained for both male and female subgroups separately. A straight line was obtained for male subgroup and a slightly curved line for female subgroup when these values were plotted in a log–log paper (Fig. 1).

The calculated values of F at 5% and 1% level of significance with 9 and 114 df for total length and body weight were found out to be 3.23 and 11.35 respectively.

The mean observed body weights and calculated body weights were plotted against mean total length for both male and female subgroups (Table 3 and Fig. 2a,b). A highly fluctuating curve was obtained for observed weights in both male and female subgroups. The line for calculated weights were almost straight as expected. These lines for calculated weight were positive in both male and female subgroups.

Correlation between observed mean weight and calculated weight was generally normal, although in certain cases significant differences were found between the observed length (L) and the observed weight (W). These differences may be due to heavy feeding or fewer number of fishes in those cases.

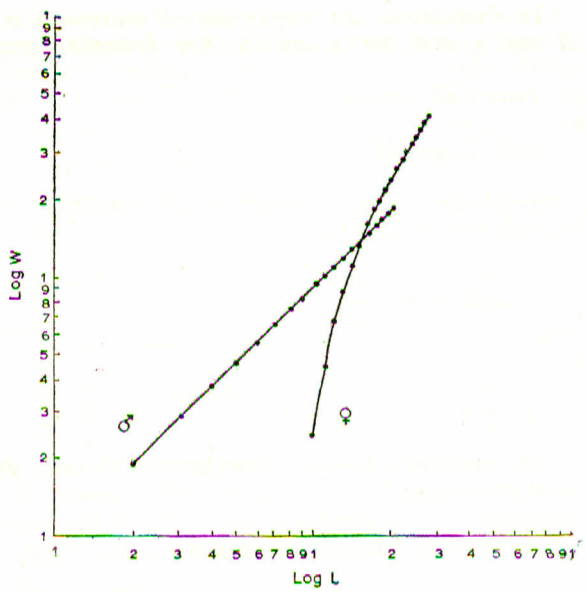

Fig. 1.—Relationship between Log of total length and that of body weight.

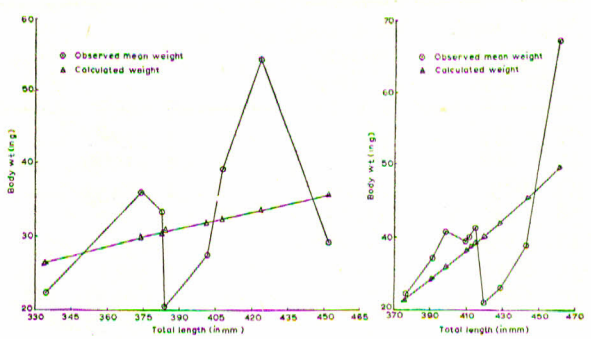

Fig. 2(a,b).—Relationship between total length and body weight.

TABLE 3.—CALCULATED VALUES OF OBSERVED MEAN BODY WEIGHT FOR CORRESPONDING MEAN OBSERVED TOTAL LENGTH OF 29 MALE AND 95 FEMALE *Trichiurus savala*.

Observed length L (in cm)		Observed weight W (in g)		Calculated weight Log W		Calculated weight W (in g)	
Male	Female	Male	Female	Male	Female	Male	Female
37.4	41.509	36.0	41.136	1.474085	1.59254	29.79084	39.1326
40.8	39.866	36.0	40.666	1.50942	1.55404	32.3155	35.8133
33.46	37.68	22.04	32.15	1.42888	1.5003	26.8459	31.645
38.3	44.362	33.25	38.875	1.48374	1.65588	30.4608	45.2773
45.2	41	29.166	39.375	1.551014	1.58076	35.57133	38.0863
38.38	39.125	20.38	37.125	1.48458	1.53616	30.5196	34.4407
40.16	41.19	27.5	40.109	1.50289	1.58517	31.8346	38.5552
42.4	46.1857	54.4	67.2142	1.52505	1.69424	33.5009	49.4586
	41.95		30.91		1.60261		40.059
	42.89		33		1.62373		42.0469

In the equation for the regression of body weight on total length, the values of a, b, c, d, and r were calculated by using the formulae 3 and 4. Putting the values in equations 3 and 4 which can be set as follows:

$Y = -15.68 + 1.3X$ and $X = 33.8 + .191\ Y$

The two regression lines A and B (Fig. 3) cut at a point where the mean values of X (total length) and Y (body weight) lie. Plotting the respective values of X and Y individually in this figure a scatter diagram was obtained. The scatter diagram shows a less perfect correlation. The gradual increase of line A shows the regression of Y on X to be positive as is the correlation. The line B increases much rapidly and shows a positive correlation. The less strong clustering of points around the straight lines shows the correlation to be weak.

The coefficent of correlation, r was calculated by using the formula (5). The value of r was found to be 0.498 with $N=124$. The standard error (S) S_x and S_y were 4.355 and 11.37 respectively.

Condition.—Using the formula (6) the value of K was calculated for total length L and observed weight W of both male and female subgroups (Tables 4 and 5). On plotting the values of K against the mean length, highly fluctuating curves were obtained (Fig. 4 a and b). Plotting the calculated values of K against the mean total length a nearly straight line was obtained. These plotted lines (b and b') gradually decreases almost diagonally from the top left. This indicates that the value of K gradually decreases with increase of body length.

TABLE 4.—OBSERVED AND CALCULATED VALUES OF K FOR CORRESPONDING TOTAL MEAN LENGTH ALONG WITH RELATIVE CONDITION FACTOR (Male subgroup).

Mean total length L (in mm)	Mean observed body weight W (in g)	Calculated weight W	Observed value of K	Calculated value of K	Relative condition factor Kn
374.0 (1)	36.0	257.09	0.069	0.491	0.14
408.0 (1)	39.0	278.27	0.057	0.409	0.14
334.6 (5)	22.0	231.19	0.059	0.617	0.095
383.0 (4)	33.2	262.32	0.059	0.467	0.127
452.0 (3)	29.2	303.94	0.031	0.329	0.096
383.8 (5)	20.4	262.82	0.028	0.465	0.077
401.6 (5)	27.5	274.21	0.042	0.423	0.01
424.0 (5)	54.4	289.12	0.071	0.379	0.188

TABLE 5.—OBSERVED AND CALCULATED VALUES OF K FOR CORRESPONDING TOTAL MEAN LENGTH ALONG WITH RELATIVE CONDITION FACTOR (Female subgroup).

Mean total length L (in mm)	Mean observed weight (in g)	Calculated weight W	Observed value of K	Calculated value of K	Relative condition factor Kn
415.09 (11)	41.14	6125.46	0.057	8.55	0.007
398.66 (15)	40.67	5605.56	0.064	8.83	0.007
376.80 (10)	32.15	4944.59	0.059	9.25	0.006
443.62 (8)	38.87	7086.22	0.044	8.12	0.005
410.00 (8)	39.37	5961.39	0.057	8.65	0.006
391.25 (4)	37.12	5379.60	0.062	8.98	0.009
411.90 (11)	40.11	6022.12	0.057	8.62	0.007
461.86 (7)	67.21	7728.58	0.068	7.86	0.009
419.50 (11)	30.91	6269.14	0.042	8.47	0.005
428.90 (10)	33.00	6581.40	0.042	8.34	0.005

Relative Condition Factor.—For eliminating the effects of length and correlated factors the relative condition factor *Kn* was calculated. The *Kn* values (Tables 4 and 5) were obtained by dividing the observed weight by the respective calculated weight. The *Kn* values in the Tables also show slight variations similar to *K* values for observed weight.

The mean values of observed *K* and *Kn* in length-weight relationship are 0.052 and 0.1203 for male subgroup and 0.055 and 0.66 for female subgroup.

Discussion

The value of *n* will be exactly 3.0 when the growth is isometric in the length–weight relationship of fish.[10] In reviewing the literature it was observed that not too many fish are 'ideal', the values are either lower or higher than 3.0. In *Trichiurus savala*, the value of *n* is less than 1.0 in male subgroups and 2.19 in female subgroups. This result does not agree with the cube law. The low *n* value in both male and female subgroups may be due to their peculiar body shape which increases considerably in length with little increase in body weight. The mean total length of adult fish is 406.5 mm long of which thin attenuated tail covers more than 2/3 of the body. This is why weight does not increase proportionately with the length of the body. The heavier weight of ovary and stomach contents in female fish might have caused the higher *n* value.

Le Cren[6] reported different *n* values for different stages of perch, 3.59 for larvae; 3.01 for 0 and one-year old fish; 3.20 for immature female of 2 years or more; 3.28 for matured male and 3.40 for matured female. The value may lie between 2.5 and 4.0.[5]

The highly fluctuating curves in Fig. 2 (a and b) were obtained for observed weight which may be due to changes in weight effected by stomach contents and stages of good development. Sometimes marked differences are found between different population of the same species or between the same population of different age groups.

The length–weight relationship of *T. savala* may have some error due to the effect of Formalin. Hile[5] reported shrinkage of 1–2% in length and 15–17% loss in weight. Van Oosten[14] reported 4% loss in weight. Parker[8] pointed out that fish shrank 96% of live length after 30–40 days and lost weight in decelerating rate.

The scatter diagram (Fig. 3) for regression shows a less perfect correlation. The absence of strong clustering of points around the straight lines show the correlation to be weak.

A fluctuating curve was found in Fig. 4 when observed *K* value plotted against the total length

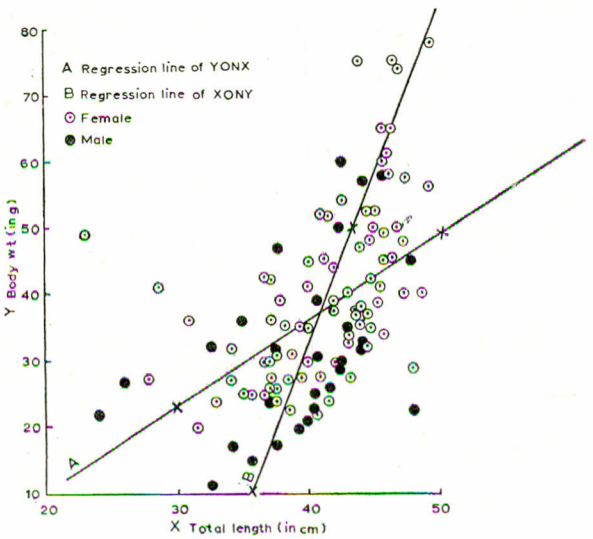

Fig. 3.—Regression line of body weight on total length and vice-versa.

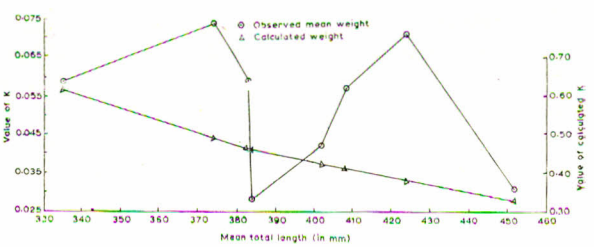

Fig. 4(a).

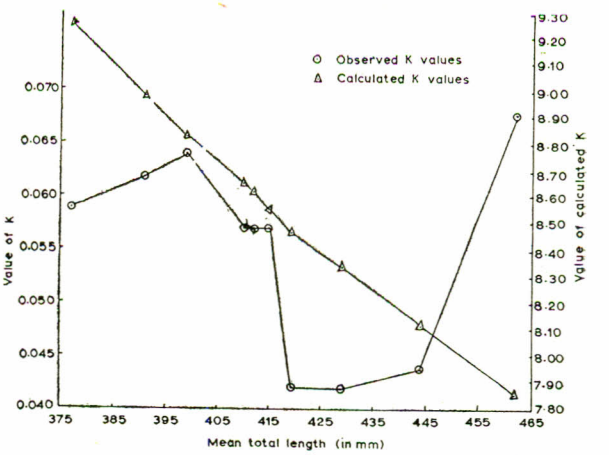

Fig. 4(b).—Relationship between mean length and *K* values.

for both male and female. The condition factor is not constant in great majority of fishes. In Nature it has been found to vary in an individual, a species or a population. It fluctuates periodically with seasons of the year which may be due to spawning and rebuilding of reproductive system. If the fish sheds eggs heavily, the value of the factor will fall.[4] The calculated K value of female fish is higher than the male group. The heavier body weight with matured ovary in female fish may be responsible for higher K values.

In Fig. 4, calculated K value gradually decreases with increase in length whereas Doha and Dewan[4] observed a gradual increase of K value in *Tilapia mossambica*. In *Tilapia*, weight increases when length increases. But in *T. savala*, length increases with little gain in weight. Due to its abnormal body shape and growth pattern the K value of *T. savala* decreases gradually. The fluctuation at certain points may be due to heavy feeding, paucity of data and effect of Formalin which needs further studies.

The relative condition factor *Kn* in Tables 4 and 5 show variations as did in K values for observed weights. The variations may be due to smaller sample size, or different stages of maturity or fractional spawning or difference in the weight of food contents in stomach.

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