LENGTH-WEIGHT RELATIONSHIP IN *SARDINELLA ALBELLA* (VAL.) AND *S. GIBBOSA* (BLEEK.) *

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ABSTRACT

The length-weight relationships in *S. albella* and *S. gibbosa* were estimated. In *S. albella*, the regression coefficients of the 20-39 mm group, the larger indeterminates of the 40-95 mm group and the sexes were found to be significantly different from one another and from 3. In *S. gibbosa*, the regression coefficients of the 20-39 mm group and the larger fish (indeterminates of the 40-95 mm group and the sexes) were significantly different from one another and from 3. In both species, the regression coefficients of the fishes of the 20-39 mm group were significantly higher than those of the fishes of the larger size-groups.

INTRODUCTION

The study of the length-weight relationship in fishes is of primary importance, among other things, in setting up yield equations (Beverton and Holt, 1957; Ricker, 1958), in estimating the number of fish landed, and in comparing populations in space and time. The general expectation is that the weight of fishes would vary as the cube of length (Brody, 1945; Lagler, 1952; Rounsefell and Everhart, 1953; Brown, 1957). But the actual relationship may depart significantly from this (Le Cren, 1951), as fishes normally do not retain the same shape or body outline throughout their life span and the specific gravity of the tissues may not remain constant. Nevertheless, most workers have been content only to describe the estimated relationship, without proceeding further to test whether the departures from cubic relationship that they had noted are statistically significant or not. This aspect has been taken into consideration in the present account of the length-weight relationship of *Sardinella albella* (Val.) and *S. gibbosa* (Bleek.) of the Mandapam area; this study is also part of an investigation into the biology and fishery of these sardines, results of certain aspects of which have already been published (Sekharan, 1955, 1959).

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Of the nine species of *Sardinella* occurring in the seas around India (Misra, 1952), the length-weight relationship of only *S. longiceps* Val. is known (Dhulkhed, 1963). Ganapati and Rao (1957) have given the values of the condition coefficient of *S. gibbosa* off Waltair.

MATERIAL AND METHODS

All material was collected by the author from Thedai-Pullamadam and other fishing centres of the Mandapam area. Only fresh material was used. Specimens from gill-nets were not included in this study. The standard length of each fish was noted, correct to one mm; and before weighing in a physical balance, the moisture on each fish was removed. Weight was determined correct to 0.01 g in fish of up to about 80 mm in length and 0.1 g in larger fish. As mentioned by previous workers, length-weight relationship of each fish can be expressed by the formula,

$$W = a\ L^n$$

where, W=weight, L=standard length, and a and n are constants.

Logarithmic transformation of the formula gives a straight line relationship of the form,

$$\text{Log}\ W = \text{Log}\ a + n\ \text{Log}\ L$$

where, Log W is the dependent variable (y), log L the independent variable (x), n the regression coefficient or slope (b); and Log a the y — intercept. Log a and the regression coefficient (b) were estimated by the usual method of least squares.

LENGTH-WEIGHT RELATIONSHIP IN *S. ALBELLA*

Estimated regressions—Altogether 229 fish of the length range 20-124 mm were examined. A preliminary plot showed that the same equation would not fit the data for the entire length range and that breaks occurred around the 35-39 and 85-89 mm groups. Separate estimates were therefore made for different groups, as mentioned below:

1. Very small fish (20-39mm): $\text{Log}\ W = \bar{6}.1075 + 3.6391\ \text{Log}\ L$
2. Larger indeterminates (40-89 mm): $\text{Log}\ W = \bar{6}.6782 + 3.2803\ \text{Log}\ L$
3. Females (72-124 mm): $\text{Log}\ W = \bar{6}.8950 + 3.1757\ \text{Log}\ L$
4. Males (77-123 mm): $\text{Log}\ W = \bar{5}.1458 + 3.0518\ \text{Log}\ L$

The significance of the differences between the regression coefficients (b) was tested, as usual, by the method of analysis of covariance. The relevant data are given below:

N	20-39 mm 67	40-89 mm 98	Female 63	Male 68
$\Sigma(x-\bar{x})^2$	0.3544	0.9944	0.2686	0.2276
$\Sigma(y-\bar{y})^2$	4.8656	10.8135	2.7455	2.1868
$\Sigma(x-\bar{x})(y-\bar{y})$	1.2897	3.2619	0.8530	0.6946
$b\Sigma(x-\bar{x})(y-\bar{y})$	4.6933	10.7000	2.7089	2.1198
$\Sigma(y-\hat{y})^2$	0.1723	0.1135	0.0366	0.0670

N=number of observations; $\Sigma(y-\hat{y})^2$= sum of squares of deviation from regression.

The test of heterogeneity of the regressions is given below:

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Deviation from total average regression	291	0.4487		
Deviation from individual regressions within samples	288	0.3894	0.001352	
Difference	3	0.0593	0. 01977	14.62

$F_{1\%}$ =3.86

The differences between the regression coefficients were significant at 1% level.

The test of heterogeneity was again performed for the last three groups (indeterminates of the 40-89 mm group, male and female) as shown below:

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Deviation from average total regression	225	0.2275		
Deviation from individual regressions within sample	223	0.2171	0.0009735	
Difference	2	0.0104	0.0052	5.34

$F_{1\%}$ =4.70

The differences between the three were again found to be significant at 1% level.

But it was found that the difference between female and male regression coefficients was not significant at 1% level ($F=2.32$; d.f.$=1$; 127; $F\,1\%=6.84$). Hence a pooled estimate was made for males and females. The formula was

$$\text{Log } W=\bar{5}.0110+3.1195 \text{ Log } L.$$

For the pooled male and female estimate the sum of squares etc. were as follows: $\Sigma(x\text{-}\bar{x})^2=0.4962$, $\Sigma(y\text{-}\bar{y})^2=4.9336$; $\Sigma(x\text{-}\bar{x})\,(y\text{-}\bar{y})=1.5479$; $b\Sigma(x\text{-}\bar{x})\,(y\text{-}\bar{y})=4.8287$; $\Sigma(y\text{-}\hat{y})^2=0.1049$.

The differences between the regression coefficients of the sexes (male and female pooled) and indeterminates of the 40-89 and 20-39 mm group were again tested; the F values are given below:

	F	$F_{1\%}$	Degrees of freedom
Between the sexes and 40-89 mm group	8.66	6.75	1; 225
Between the sexes and 20-39 mm group	39.86	6.76	1; 194
Between the 40-89 and 20-39 mm groups	18.61	6.80	1; 161

It will be seen that the differences between the regression coefficients of the three groups were significant at 1% level. The three regression lines (for the 20-39 mm group, 40-89 mm group and sexes) are shown in Fig. 1. Among the

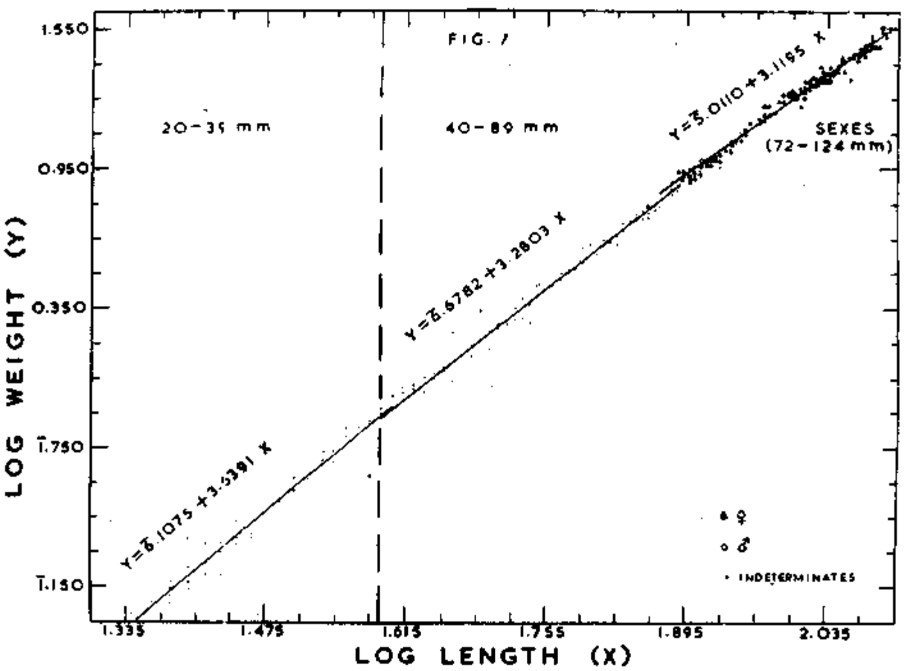

FIG. 1. Length-weight relationship in *S. albella*.

three groups, the smallest fish (20-39 mm group) had the highest regression coefficient (3.64), which shows that they increase in weight at a comparatively higher rate than the larger fish.

Applying the t-test, it was seen that the regression coefficients of the three groups mentioned above were significantly different from 3 at 1% level. The results are given below:

Length-groups (mm)	b-3	t	Degrees of freedom	$t_{1\%}$
20-39	0.6391	7.39	65	2.66
40-89	0.2803	8.13	96	2.63
Sexes	0.1195	2.96	129	2.62

LENGTH-WEIGHT RELATIONSHIP IN *S. GIBBOSA*

Estimated regressions—Altogether 195 fish were examined. A preliminary plot showed that the relationship was different in the 20-39 mm group, compared to the larger fish. Hence, as in *S. albella*, length-weight relationship was estimated for very small fish (20-39 mm), larger indeterminates (40-95 mm), females (90-137 mm) and males (90-134 mm). These are given below:

1. For very small fish (20-39 mm): $\text{Log } W = \bar{7}.6061 + 3.9547 \text{ Log } L$
2. Larger indeterminates (40-95 mm): $\text{Log } W = \bar{6}.8593 + 3.1428 \text{ Log } L$
3. Females (90-137 mm): $\text{Log } W = \bar{5}.0660 + 3.0434 \text{ Log } L$
4. Males (90-134 mm): $\text{Log } W = \bar{6}.9909 + 3.0780 \text{ Log } L$

As before, the difference between the regression coefficients was tested by the method of analysis of covariance. The relevant data are given below:

	20-39 mm	40-95 mm	Female	Male
N	33	112	25	25
$\Sigma(x-\bar{x})^2$	0.2408	1.3203	0.0875	0.0782
$\Sigma(y-\bar{y})^2$	3.9173	13.1878	0.8168	0.7541
$\Sigma(x-\bar{x})(y-\bar{y})$	0.9523	4.1494	0.2663	0.2407
$b\Sigma(x-\bar{x})(y-\bar{y})$	3.7661	13.0407	0.8105	0.7409
$\Sigma(y-\hat{y})^2$	0.1512	0.1471	0.0063	0.0132

N = number of observations; $\Sigma(y-\hat{y})^2$ = sum of squares of deviation from regression.

The test of heterogeneity of the regressions was performed as shown below:

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Deviation from average total regression	190	0.4589		
Deviation from individual regressions within samples	187	0.3178	0.001699	
Difference	3	0.1411	0. 04703	27.68

$F_{1\%}=3.89$

It was found that the difference between the regression coefficients was significant at 1% level.

The differences between the regression coefficients of the last three groups (larger indeterminates, female and male) were again tested as shown below:

Source of variation	Degrees of freedom	Sum of square	Mean square	F
Deviation from average total regression	158	0.1679		
Deviation from individual regression within samples	156	0.1666	0.001068	
Difference	2	0.0013	0. 00065	0.61

Here the mean square for differences between regression coefficients was less than that for individual regression within samples. It could therefore be taken that the differences between regression coefficients of the last three groups were most probably not significant.

A pooled regression estimate was therefore made for the 40-137 mm group (i.e., the indeterminates of the 40-95 mm group and the sexed fish). The estimated regression was

$$\text{Log } W=\bar{6}.8573+3.1444 \text{ Log } L$$

The sum of squares etc. were: $\Sigma(x-\bar{x})^2=3.0400$; $\Sigma(y-\bar{y})^2=30.2246$; $\Sigma(x-\bar{x})(y-\bar{y})=9.5589$; $b\,\Sigma(x-\bar{x})(y-\bar{y})=30.0570$; $\Sigma(y-\hat{y})^2=0.1676$.

The difference between the regression coefficients for 20-39 mm and 40-137 mm groups was again found to be significant at 1% level. ($F=86.06$, d.f.$=1$; 191, $F_{1\%}=6.75$).

The two regression lines are shown in Fig. 2. The test and the figure show that in relation to length, fish of the 20-39 mm group increase in weight at a higher rate than fish of the larger size groups. The most interesting point here is that for the 20-39 mm group, the regression coefficient almost equalled the value of 4, a very high figure compared to the estimate for even the corresponding length-stratum of *S. albella.*

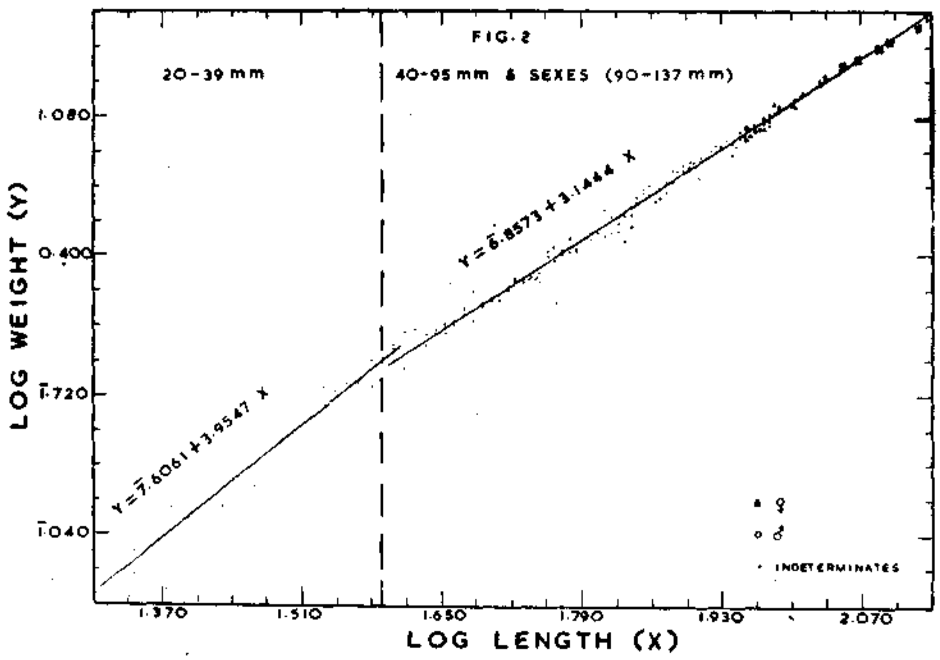

FIG. 2. Length-weight relationship in *S. gibbosa.*

Applying the t-test, it was seen that the regression coefficients of both the groups mentioned above differed significantly at 1% level from 3. The results are given below:

Length groups (mm)	b-3	t	Degrees of freedom	t 1%
20-39	0.9547	6.71	31	2.75
40-137	0.1444	7.78	160	2.58

REMARKS

The results show that in both the sardines, the regression coefficients of the 20-39 mm groups are higher than those of the larger size-groups. A partial explanation for this could be the change in the body outline of these fishes as they increase in length. It has been seen (Sekharan, unpublished) that in both species, body-depth in relation to length increases more rapidly in the 20-34 mm groups than in the larger size-groups and that the differences in the regression coefficients of the body depth-length relationship of the two length-strata are statistically significant.

The t-tests showed that the regression coefficients of the length-weight relationship in both the species differed significantly from 3. An interesting point here is the absolute value of the regression coefficient (b) of the length-weight relationship in the small fishes (20-39 mm). In both species it is more than 3.6; in *S. gibbosa* it approaches the high value of 4. It may be mentioned that Le Cren (1951) recorded a value of 3.59 for the regression coefficient of the length-weight relationship in the larvae of *Perca fluviatilis*.

In the larger individuals of both sardines, however, the regression coefficients are close to the expected value of 3. The main difference between the two species is in regard to the regression coefficients of the fishes above 40 mm in length. In *S. albella*, unlike in *S. gibbosa*, the regression coefficient for the sexes is significantly different from that for the larger indeterminates. The regression coefficient, especially for larger indeterminates, is higher in *S. albella* than in *S. gibbosa*.

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