Length-Weight and Tail Length-Total Length Relationships in *Panulirus homarus* Linnaeus of the South-West Coast of India

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Length-weight relationships of *Panulirus homarus* caught from the Kanniyakumari coast was found to be $W = 0.000566\ L^{2.50}$. The relationship between tail length and total length was also investigated and compared with that of *Panulirus polyphagus*. Same relationship did not hold good for the two sexes as in the case of *P. polyphagus*. For a given tail length, the head length, the total length and the weight appear to be relatively larger for females of small sizes of *P. homarus*.

Spiny lobsters are important marine products exported from India, generating sizeable foreign exchange. During 1982, 724 tonnes of frozen lobster tails and cooked whole lobsters valued at Rs. 59.5 million were exported from India (Anon 1983). Among the six commercially important species of spiny lobsters (Genus: *Panulirus)* recorded from Indian waters, *P. homarus* is the most important commercial species particularly on the south-west coast (George 1967). A detailed study of the length-weight and tail length - total length relationships of *P. homarus* is reported in this paper.

Materials and Methods

The materials for the present study were collected from Enayam (77° 11′E and 8° 13′N), and Kadiapatnam (77° 18′E and 8° 8′N) of Kanniyakumari District during 1982-'83. Eight hundred nine lobsters ranging from 80 to 335 mm in length and 30 to 1150 g in weight were used in this study. Each lobster was measured and weighed to the nearest 0.5 mm and 5 g respectively. The total length and tail length were measured as shown in Fig. 1. Length and weight measurements were plotted (weight on the ordinate and length on the abscissa), seperately for males, females and berried females (female lobster carrying egg mass on the ventral side of the abdomen) for each centre. The plot suggested the well known relationship $W = aL^b$ where W is the weight, L, the length and a and b are constants. In the logarithmic scale, this relationship transforms to the linear equation;

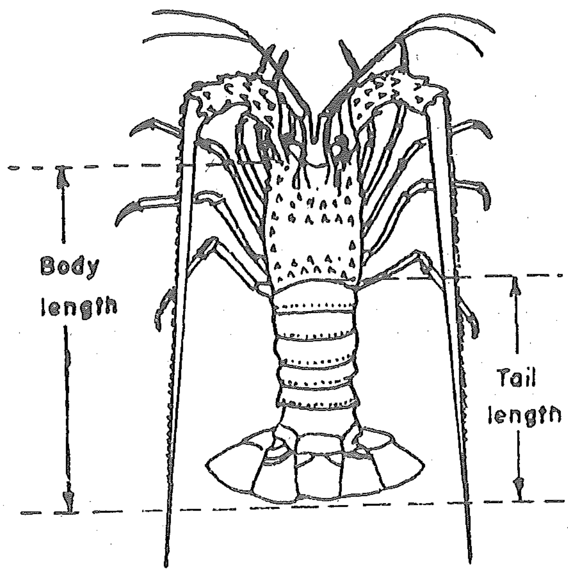

Fig. 1. Principal measurements used.

$Y = A + BX$ where $Y = \log W$, $X = \log L$, $A = \log a$ and $B = b$. A and B were estimated by the method of least squares. Similarly the total length and tail length measurements also were plotted (total length on the ordinate and tail length on the abscissa) and the relationship between these two body parts was found to be linear. The equality if any of each relationship for the sexes was investigated by analysis of covariance (Snedecor & Cochran, 1967).

Results and Discussion

For the length-weight relationship, the correlation coefficients were found highly significant ranging from 0.851 to 0.936 for the different place-sex combinations showing that about 72 to 88% of the variations in logarithm of weight is explained by variations in the logarithm of length. The standard errors of the regression coefficients were within 2 to 5% of the regression coefficient for all the place/sex categories except in berried lobsters which were 7 and 9%. This increase in standard errors may be attributed to the difference in weight due to difference in the number of eggs carried in the berry. The length-weight relationship in the original scale for all the categories is presented in Table 1.

Table 1. *Length-weight relationship in the original scale*

Place/sex category	Length-weight relationship
Kadiapatnam ♂	$W = 0.000522\ L^{2.50}$
Kadiapatnam ♀	$W = 0.000401\ L^{2.56}$
Kadiapatnam $♀_B$	$W = 0.018400\ L^{1.85}$
Enayam ♂	$W = 0.001830\ L^{2.28}$
Enayam ♀	$W = 0.001550\ L^{2.30}$
Enayam $♀_B$	$W = 0.083300\ L^{1.59}$

Sub-population from a single stock may have the same length-weight relationship. Indeed specimens of adjacent places separated only by a distance of 15 km as in this case, have the same relationship. But whether sexes cause difference in the length-weight relationship is to be examined. Application of Bartlett's test (Snedecor & Cochran, 1968) to test homogeneity of residual variances gave a chi-square value of 160.26 with 5 degrees of freedom which is highly significant ($P < 0.005$) showing that the residual variances are heterogeneous. The residual variances for males and non-berried females at Enayam are larger than the corresponding ones for Kadiapatnam. When males and non-berried females of this place were excluded, the residual variances were found to be homogeneous (chi-square for Bartlett's test being 1.53 for 3 df which is not significant). A plausible explanation for the heterogeneity in variance may be the difference in fishing techniques employed at the two places. At Kadiapatnam both gill-nets and traps are used to catch lobsters, whereas at Enayam there is a self imposed ban amongst the fishermen on fishing with gill-nets. Trap fishing is seasonal and restricted from October to March whereas gill-nets are operated almost throughout the year. This indiscriminate use of gill-nets results in the catch of large quantities of undersized juveniles before the fishing season. At Enayam, trap fishing commences by October only and by that time the stock attains marketable size. The residual variances of berried females for the two places did not show appreciable difference because the size of the berried females fall within a specified length group at any place. Variances of weight and length also indicated this. The variabilities for a given sex were found to be different for the two places, while they were not found to differ much for the berried.

As the difference if any, in length-weight relationshp for males and females will be revealed by a difference in the respective regression equations, the equality of the regression lines was tested by the analysis of covariance (Snedecor & Cochran, 1968). It can be seen that there is no difference in the slopes ($F=0.23$ with 1 and 396 degrees of freedom) and elevations of the regression lines ($F=0.49$ with 1 and 397 degrees of freedom) for males and non-berried females). Thus a common relationship, namely, $Y = -3.25 + 2.50\ X$ appears to hold good for *P. homarus* with a standard error 0.0323 of the regression coefficient (percentage error being 1.3%). In terms of length and weight this would be:

$$W=0.000566\ L^{2.50}$$

95% confidence interval for the regression coefficient was found to be 2.43 to 2.56. The curve along with the plotted points is presented in Fig.2. The regression coefficient, that is, the index to which L is raised lies close to 2.5 and not to 3. Thus for *P. homarus* the cubic law does not appear to hold good.

If the length-weight relationship is used to predict the expected mean weight for a given length, 95% confidence interval for the expected mean weight (Mendenhall & Reinmuth, 1978) may be given as:

$$\hat{y} \pm t_{(\propto/2)}\ s\sqrt{1/n + (X_p - X)^2/\lesssim x^2}$$

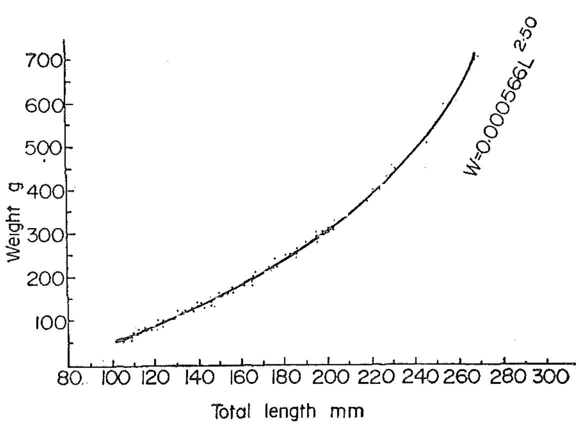

Fig. 2. Total length-weight relationship

where $\hat{y}$ is the expected mean weight in terms of logarithms, t $(\propto/2)$ is the t-value corresponding to $(\propto/2)$% significance level, s is square root of the residual variance, X_p is the length (in terms of logarithm) for which the weight is to be predicted, $\bar{x}$ is the mean length in terms of logarithms and $\lesssim x^2$ is the corrected sum of squares for X. The predicted mean weights along with the confidence limits for three typical length measurements at the two extremities and the middle of the length ranges are as given below.

Length	100	154	250
Prdicted weight	56.2	165.5	555.8
95% confidence limit	(54.5-58.0)	163–168)	(537–575)

It can be seen that at the extremities the error is about ±3% of the predicted weight while n the middle of the length range it is only ±1.5%.

As the berried females have a comparatively higher weight for a given length because of its berry, a relationship was worked out excluding the berried for a more precise conversion from length to weight. This worked out to

$$Y = -3.16 + 2.45X$$

which, in terms of length and weight would be

$$W = 0.000689\ L^{2\cdot45}$$

(The standard error 0.0358, of the regression coeffieient is only 1.5% of the same).

Relationship between tail length and total length:

The relationship between these two was found to be linear from the plot. Residual variances were found to be lacking in homogeneity, the chi-square for Bartlett's test being 420.99**, which is highly significant for 5 df. Variances of total length and tail length were also found to be heterogeneous for the place/sex categories. As in the case of length-weight relationship, the difference in the type of gear operated at the two places may be responsible for this heterogeneity. The residual variances for males and females (non-berried) of Kadiapatnam was seen to be homogeneous. Therefore, whether the same relationship holds good for males and females was tested by means of analysis of covariance using data from Kadiapatnam. The F-test for comparison of slopes was not found to be significant (F = 2.90 with 1 and 396 degrees of freedom) showing that there was no difference in the slopes of the two regression lines. But the difference in elevations was found to be significant (F - 4.61* with 1 and 397 degrees of freedom). Because of these, for a given tail length, the total length is expected to be larger for females than that for males as can be seen from the elevations of the two lines:

Males: Total length = 5.24 + 1.52 × (tail length), standard error of the regression coefficient = 0.0262, which is only 1.7% of the regression coefficient.

Females: Total length = 9.45 + 1.47 × (tail length), standard error of the regression coefficient = 0.0223 which is only 1.5% of the regression coefficient.

(It may be noted that the slopes of the two lines are to be considered equal). Since for a given tail length, total length is relatively more for females, it follows that for a given tail length, head length is expected to be relatively more for females, as the total length is head + tail length. Also, as the length-weight relationship for males and females has been found to be the same, it follows that for a given tail length, the head length, the total length and the weight of the lobster, all appear to be relatively larger for females of this species. This applies to the small sized lobsters. (The berried females have been excluded from the relationship which formed the basis for the above conclusion).

The average tail length of males and females at Kadiapatnam were 84.9 mm and 90.4 mm while these were 118 mm and 106 mm for males and females respectively at Enayam. Thus a predominance of larger lobsters in the catch at Enayam owing to the difference in the gear operated is evident. When the specimens of the two places were combined the tail length-total length relationships worked out to:

Males: Total length = 9.83 + 1.47 × (tail length) with 0.0208 as the standard error of the regression coefficient.

Females: Total length = 9.93 + 1.47 × (tail length) with 0.0105 as the standard error of the regression coefficient.

The elevations of these two lines do not appear to be different. This may be due to the landings of large sized lobsters at Enayam. Thus the difference in total length for a given tail length appears to be pronounced only for small sized lobsters.

Mathai & Nair (1979) have worked out the regression of total length on tail length for *P. polyphagus* at Goa. They observed that a common relationship did not hold good for males and females.

From a comparison of elevations of the regression lines for males and females, for this species also, the females appeared to be slightly larger in total length than the males at the early stages.

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References

Anon (1983) *Marine Products Export Review,* Marine Products Export Development Authority, Cochin, India, 28 p.

George, M.J. (1967) *The Indian Spiny Lobster.* p. 82 Souvenir, 20th Anniversary, Central Marine Fisheries Research Institute

Mathai, T.J. & Nair, A.K.K. (1979) *Fish. Technol..* **16**, 83

Mendenhall, W. & Reinmuth, J.E. (1978) *Statistics for Management and Economics,* p. 789. Duxbury Press, North Scituate, Massachusetts

Snedecor, G.W. & Cochran, W.G. (1968) *Statistical Methods,* p. 593, Indian Edition, Oxford & IBH Publishing Co., New Delhi