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# A Statistical Approach on the Length-Weight Relationship and Allometry of *Turbo brunneus*

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**Abstract:** The length-weight and other allometric relationship of *Turbo brunneus* from Tuticorin (Southeast coast of India) coastal waters have not been subjected to through analysis earlier. Totally 778 males and 749 females were collected for the present study. For Length-weight analysis, the males and females of *Turbo brunneus* were fit with linear equation individually. The present study shows that the differences in the growth rate between male and female snails may also leads to the variation. Analysis of covariance revealed significant difference between males and females. The correlation co-efficient values between length and weight in male and female were significant. Changes in the constant allometry of length-weight relationship are associated with an increase in size and sexual maturity. The correlation co-efficient values between length and weight in male and female were significant. From the results obtained through the statistical analysis on various shell characters it is found that the shell of *T. brunneus* also conforms to the equiangular spire model as reported in other snails having turbinate shells.

**Key words:** *Turbo brunneus*, sexual maturity, length-weight relationship, morphology, allometry, statistical approach

## INTRODUCTION

The growth lines on the shells of temperate molluscs are said to the valuable pointers of age, but in tropical waters, on account of lack of distinct seasons, variations in environmental parameters are limited and so, much difference in growth lines is not discernible (Rajagopal, 1982; Shu-Chuan Lee and Shyh-Min Chao, 2003, 2004; Gaur *et al*., 2005). Various factors induce morphometric changes in molluscus, including tidal variations, food availability, seasonal changes and sexual maturation.

The study on length-weight relationship is important.

- To establish a mathematical relationship between the two variables, length and weight.
- To ascertain the variations in length groups, as some organisms are known to change their form or shape during the growth period (Le Cren, 1951).

Since weight of an organism is a linear function of its length, it is observed that the length-weight relationship could be expressed by the hypothetical cub law,

$$W = CL^3 \quad (1)$$

Where:
W = Weight
L = Length
C = Constant

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This formula seems to be fit in cases where density and form remain constant. Martin (1949) has proved the change in form or shape of animals with growth in several cases. Hence, the formula needs to be modified as:

$$W = aL \quad (2)$$

Where:

W = Weight
L = Length
a = A constant equivalent to C
n = Another constant to be calculated empirically from the data.

The insight on length-weight relationship, particularly in molluscs has both pragmatic and intrinsic value. For example, ecological attention is being focused mostly on the biomass and productivity parameters of natural populations and length-weight conversion equations have found considerable utility (Calow, 1975). Moreover, information on the values of proportionality constants obtained in these types of equation may give valuable insight into the underlying nature of shell geometry.

So far, no work was carried out on the length-weight and other allometric relationship of *Turbo brunneus* from Tuticorin coastal waters and hence the present study was undertaken to fill up the gap in molluscan literature on length-weight and other allometric relationship of *T. brunneus.*

## MATERIALS AND METHODS

Specimens of *Turbo brunneus* of different size groups were collected during May 2002-April 2003 from the intertidal areas of Tuticorin coast during low tide and were brought to the laboratory. Totally 778 males and 749 females were collected for the present study. The length of the snails was measured in mm from the curved larger end of the body whorl to the tip of the spiral apex (shell length L) using a vernier caliper corrected to 0.1 mm. The other measurement, such as shell width (B), aperture length (A.L), aperture (A.B) width and opercular diameter (O.D) (Fig. 1) were also taken. The snails were accurately weighted with a single pan electronic digital balance and the readings were then converted into milligrams. In this way totals weight of live animal with shell (Total weight (W)), weight of the flesh without shell (Tissue weight (T.W)) and opercular weight (O.W) were recorded.

The parabolic equation

$$W = aL \quad (3)$$

Can be expressed in the logarithmic form as

$$\text{Log } W + \text{Log } a + n \text{ Log } L \quad (4)$$
$$\text{i.e., } Y = a + bx$$

Where:

a = Log a
b = n
Y = Log w
x = Log L, which is a linear relationship between Y and X.

To find out the differences, if any, between length and weight, the data was subjected to ANOVA.

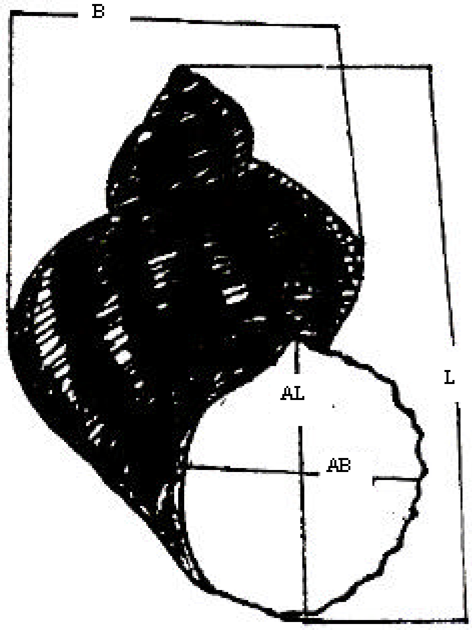


Fig. 1: Calibration of size of *T. brunneus*

The allometric relationship between two characters can be expressed by the general equation Y = bx, where, Y is some measure of a part, x is a measure of the whole body or any part of the body and b the slope of the curve. It can be expressed in logarithmic form in the following way.

$$\text{Log } Y = \text{Log } b + \text{Log } X$$ (Wilbur and Owen, 1964)

Presently, the relationship between the shell length, shell width, aperture length, aperture width, total weight, tissue weight and opercularr weight of *T. brunneus* was studied in all possible combinations using the linear regression techniques and correlation co-efficient.

## RESULTS AND DISCUSSION

**Length-Weight Relationship**

For length-weight analysis, the males and females of *Turbo brunneus* were fit with linear equation individually. The analysis of covariance was applied to find out the difference between males and females, if any. The regression equations derived separately for males and females are as follows:

Male : $\text{Log } W = 0.4447+2.3647 \text{ Log } L$

Female : $\text{Log } W = 0.4361 + 2.9087 \text{ Log } L$

Analysis of covariance revealed significant difference between males and females (Table 1a, b and c). The correlation co-efficient values between length and weight in male ($r = 0.9095$; $p<0.001$) and female ($r = 0.9819$; $p<0.001$) were significant. The scatter diagrams of length-weight for male and female are presented in Fig. 2 a, b. Changes in the constant allometry of length-weight relationship are associated with an increase in size and sexual maturity as observed in some molluscs (Branch, 1981; Shanmugm, 1994, 1997).

Table 1a: Sum of squares and products of length-weight data of males and females of *T. brunneus*

| Sex | No. of samples | $\Sigma_x$ | $\Sigma_y$ | $\Sigma_x^2$ | $\Sigma_y^2$ | $\Sigma_{xy}$ |
|---|---|---|---|---|---|---|
| Male | 778 | 1263.4249 | 3334.0471 | 2055.7676 | 14314.5344 | 5423.1263 |
| Female | 749 | 1211.7849 | 3198.5314 | 1968.1421 | 13721.2444 | 5196.3005 |

$\Sigma_x\Sigma_y$-Sum of x and y., $\Sigma_x^2$, $\Sigma_y^2$, $\Sigma_{xy}$ = Sum of squares and products.

Table 1b: Corrected sum of squares and products of length-weight data, Regression coefficient and deviation from the regression

| | | Sum of squares and products | | | | Errors of estimation | |
|---|---|---|---|---|---|---|---|
| Sex | D.F. | $X^2$ | XY | $Y^2$ | b | D.F | S.S |
| Male | 777 | 6.6758 | 15.7860 | 45.1248 | 2.3647 | 776 | 7.7963 |
| Female | 748 | 5.0102 | 14.5732 | 43.9675 | 2.9087 | 747 | 1.5783 |
| | | 11.6860 | 30.3592 | 89.0923 | | | |

D.F = Degrees of freedom, XY, $X^2$,$Y^2$ = Corrected sum of products and squares , b = Regression co-efficient, S.S = Sum of squares

Table 1c: Analysis of covariance

| Source of variations | Degrees of freedom | Sum of squares | Mean squares | Observed F | 5 (%) F |
|---|---|---|---|---|---|
| Deviation from individual regression with sexes | 1523 | 9.3746 | 0.006155 | 137.6442* | 3.84-3.92 |
| Difference among regressions | 1 | 0.8472 | 0.8472 | | |
| Deviations from average individual regression | 1524 | 10.2218 | | | |

*: Significant

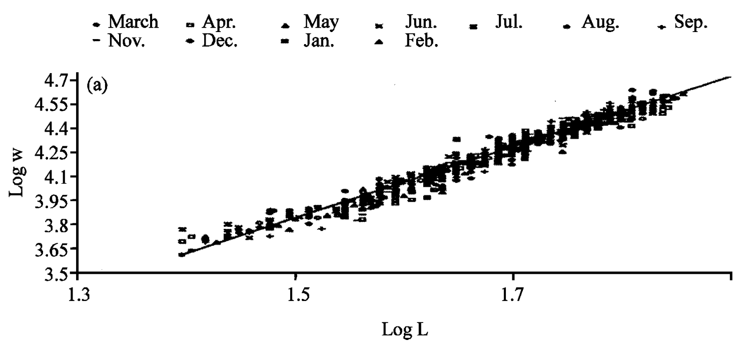


Fig. 2a: Graphical representation of length weight relationship in male *Turbo brunneus*

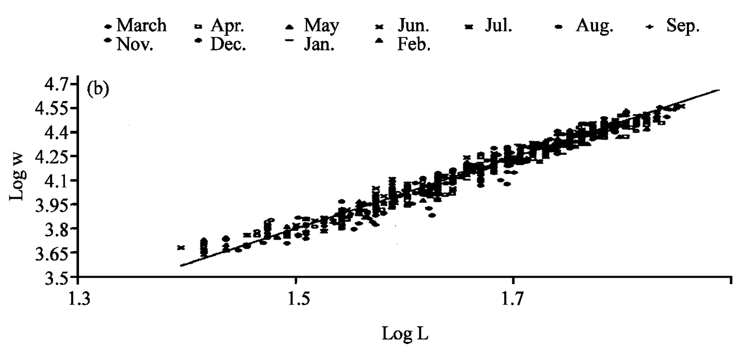


Fig. 2b: Graphical representation of length weight relationship in female *Turbo brunneus*

**Allometric Relationship Between Various Morphological Features**

The linear equation was fitted separately for male and female *T. brunneus.* The logarithmic linear regression and the correlation co-efficient for the various parameters of male and female *T. brunneus* were analysed. From the results, it is evident that the correlation co-efficient values (r) for various combination of body characters as well as shell characters of males and females were found to be significant in Shell length (L) × Shell width (B), Shell length (L) × Aperture length (AL), Shell length (L) × Aperture width (AB), Shell length (L) × Total weight (W), Shell length (L) × Tissue weight

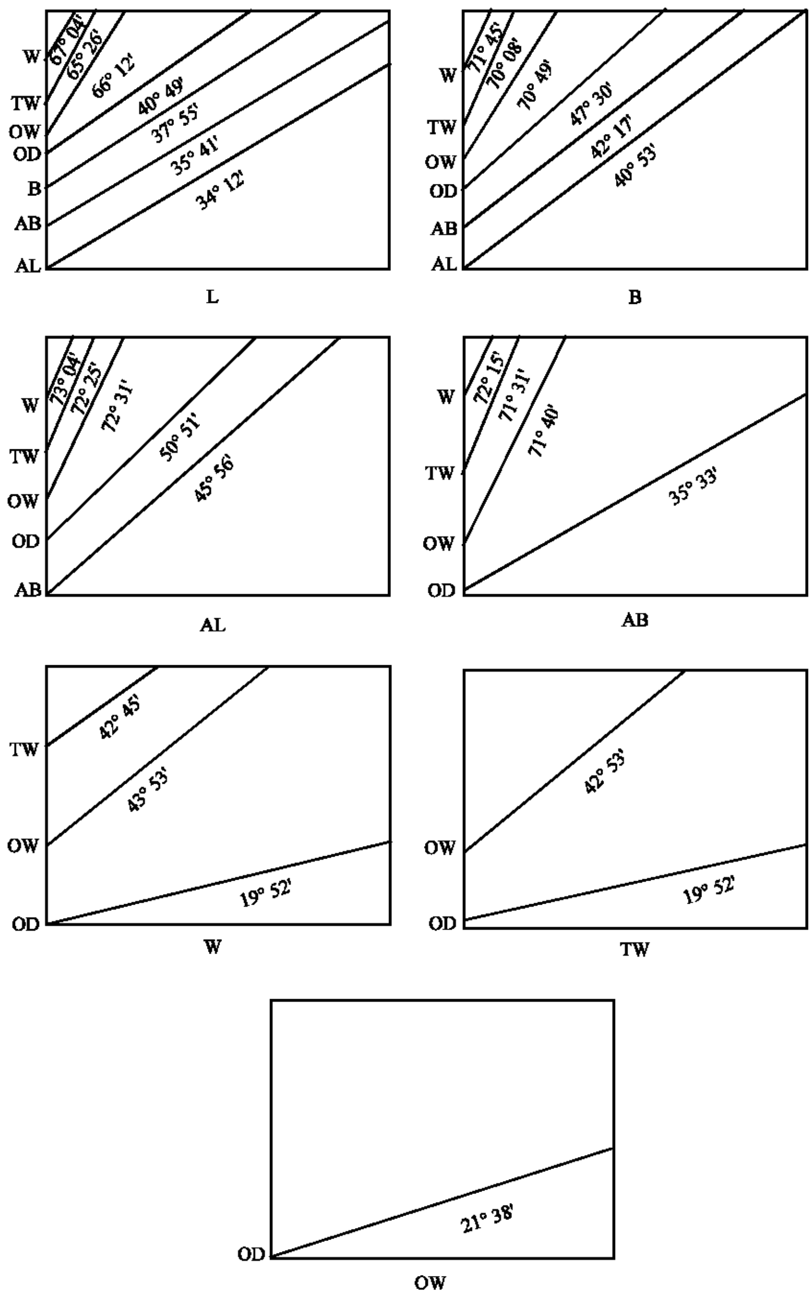


Fig. 3a: Graphical representation with tangent values for allometric relationship in male *Turbo brunneus*

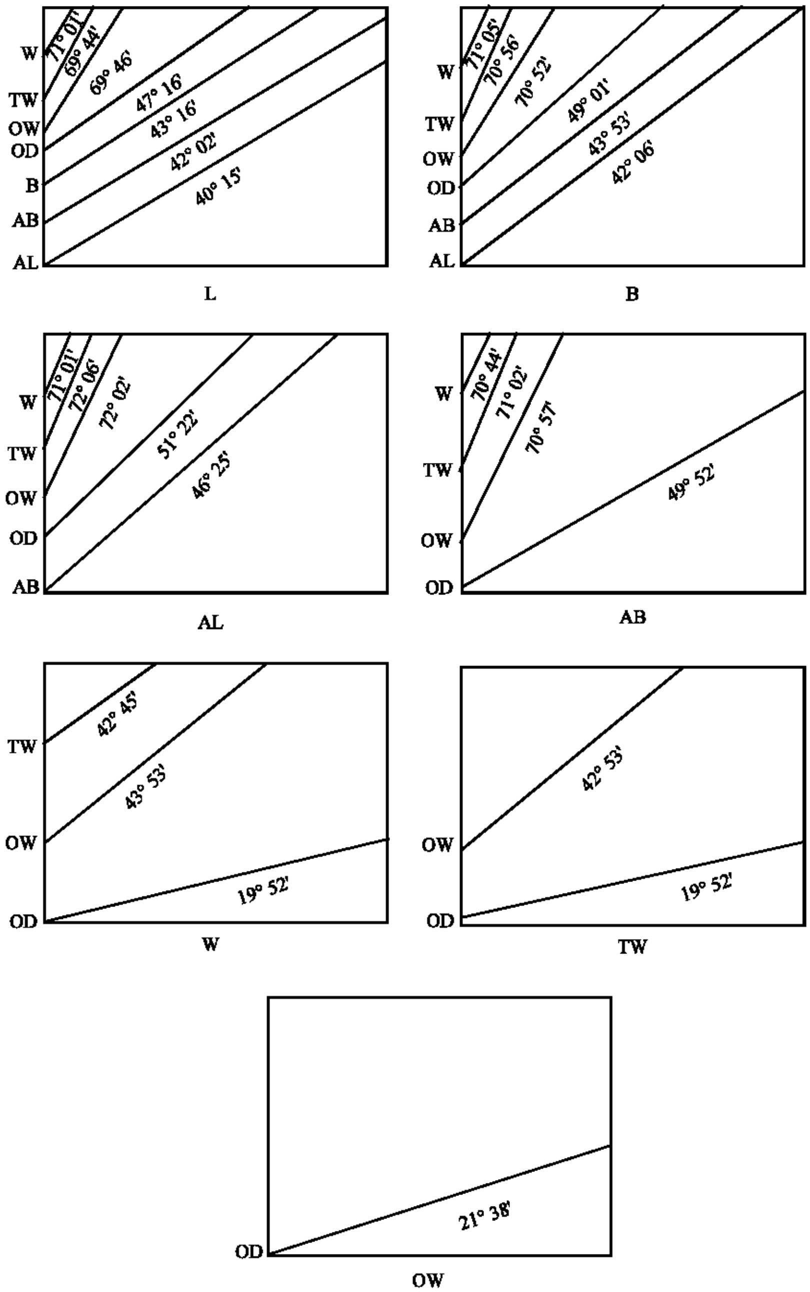


Fig. 3b: Graphical representation with tangent values for allometric relationship in female *Turbo brunneus*

(T.W), Shell length (L) × Opercular diameter (O.D), Shell length (L) × Operacular weight (O.W), Shell width (B) × Aperture length (A.L), Shell width (B) × Aperture width (AB), Shell width (B) × Total weight (W), Total width (B) × Tissue weight (T.W), Shell width (B) × Opercular diameter (O.D), Shell width (B) × Opercular weight (O.W), Aperture length (A.L) × Apeture width (A.B), Aperture length

(A.L) × Total weight (W), Aperture length (A.L) × Tissue weight (T.W), Aperture length (A.L) × Opercular diameter (O.A), Aperture length (A.L) × Opercular weight (O.W), Aperture width (A.B) × Total weight (W), Aperture width (A.B) × Tissue weight (T.W), Aperture width (A.B) × Opercular diameter (O.D), Aperture width (A.B) × Opercular weight (O.W), Total weight (W) × Tissue weight (T.W), Total weight (W) × Opercular diameter (O.D), Total weight (W) × Opercular weight (O.W), Tissue weight (T.W) × Opercular weight (O.W), Tissue weight (T.W) × Opercular diameter (O.D), Opercular weight (O.W) × Opercular diameter (O.D).

The b values were converted into natural tangent values (Fig. 3a, b). The body characters having the tangent values above 45° are said to be positive allometry, while values below 45° are referred to as negative allometry. And values equal to 45° are called isometry and it was observed only in AL × AB (male). However there is a difference in the allometry for some combinations of characters between male -L× W; L × T.W.; L × O.W; B × W; B × T.W; B × O.D; B × O.W; A.L × W; A.L × T.W; A.L × O.D; A.L. × O.W; A.B × W; A.B × T.W and A.B × O.W (Positive allometry); L × B; L × A.L; L × O.D; B × A.L; B × A.B; A.B × O.D; W × T.W; W × O.D; W × O.W; T.W. × O.W; T.W × O.D. and O.W × O.D (Negative allometry) and Female-L × W; L × T.W; L × O.D; L × O.W; B × W; B × T.W; B × O.D ; B × O.W; A.L × A.B; A.L × W; A.L × T.W; A.L × O.D; A.L × O.W; A.B × W; A.B × T.W and A.B × O.D (Positive allometry); L × B; L × A.L; L × A.B; B × A.L; B × A.B; W × T.W; W × O.D; W × O.W; T.W × O.D and O.W × O.D ( Negative allometry). The similarities and difference in shell morphometry can be attributed to the nature of their habitats and the influence of the environmental conditions on their growth and shell properties (Wilbur and Owen, 1964; Saad, 1997; Shu-Chuan Lee and Shyh-Min Chao, 2003, 2004; Gaur *et al*., 2005). The present study shows that the differences in the growth rate between male and female snails may also leads to the variation.

All the length-weight relationships, both in terms of shell and tissue weight were of an allometric form. In *T. brunneus* the results presented in Fig. 2 a, b suggested that the nature of these relationships remains constant from one time of the year to another. From the results obtained through the statistical analysis on various shell characters it is found that the shell of *T. brunneus* also conform to the equiangular spire model as reported in other snails having turbinate shells The b coefficients derived from length-weight regression analysis for male (2.365) and female (2.908) are comparable with the b values derived for *Tegula funebralis* (3.70) (Paine, 1971).

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