World Journal of Dairy & Food Sciences 4 (1): 56-64, 2009
ISSN 1817-308X

Analysis of Age and Growth Rate of *Turbo brunneus*

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Abstract: Studies on age and growth provide an insight into age class, structure of stock, changes in abundance of population, its relation to fishing, longevity and growth rate. Monthly samples of *Turbo brunneus* were collected between May 2007 and April 2008 from Tuticorin, Southeast coast of India. The collections included all the size groups' possible and totally 778 males and 749 females were selected for this study. The growth rate of *T. brunneus* decreases with an increase in age. According to the probability method, the first year group, which showed the maximum growth rate attained the length of 34.3mm in male and 33.54mm in female. The growth rate declined gradually through 10.50, 6.08 and 3.99mm in male and 9.69, 7.60, 5.51mm in female during second, third and fourth years respectively. Hence, size related changes in diet, food availability or other aspects of inter-specific competition might have important consequences for wide scale as well as local growth investigation. There must be some sort of internal control in growth. Genetically determined variation in growth rate has been found even within species.

Key words: *Turbo brunneus* · Age and Growth · Population · Structure of stock

INTRODUCTION

Studies on age and growth provide an insight into age class, structure of stock, changes in abundance of population, its relation to fishing, longevity and growth rate. Since growth is defined as an increase in body size, meat weight or volume, studying these could be the most appropriate method for measuring growth [1]. Among Molluscus, growth is measured in terms of sheel dimensions like length, width, height etc. because the shell is considered as one of the prominent characteristic features of the phylum. The studies on age and growth would help to explain the impact of environmental parameters on growth and would also facilities comparison of growth rates in different water bodies. The appraisal of age and growth helps in fishery management as it expounds the year class composition, growth rate and optimum growth in fishery. In understanding and evaluating different age classes and the rate of growth and variations in the abundance of population inhabiting a particular environment, the study of length weight relationship and size frequency distribution are very important. The growth rate of many species has been studied in molluscs using different techniques such as labeling (Branch, 1981), annual growth rings and distribution of size cohorts [2,3].

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 [4]. Various factors induce morphometric changes in molluscus, including tidal variations, food availability, seasonal changes and sexual maturation.

Recently, theoretical and empirical developments have focused on the importance of size and growth for other aspects of the life of an organism: mortality, fecundity cost of maintenance and fitness. Growth trajectories tend to follow certain characteristic patterns. Often, but not always, growth is rapid at first and then levels off later in life of an animal to approach an apparent asymptote. A number of mathematical models have been proposed as formal descriptions of these patterns. They include the size length frequency method, von Bertalanffy's equation and Ford-Walford graph. The models are empirical in the sense that the values were determined by fitting it with equations.

The present study on the age and growth of T. *brunneus* occurring in Tuticorin coastal waters was carried out by employing various empirical methods to understand the age structure of the stock and the longevity.

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MATERIALS AND METHODS

Random monthly samples of *T. brunneus* were collected between May 2007 and April 2008 from Tuticorin coast, adjacent to the harbour. The collections were made during spring low tide, from the exposed intertidal shore where the snails were found grazing on the algae. The collections included all the size groups possible and totally 778 males and 749 females were selected for this study. Measurement for length was taken from the tip of the spire to the lowest point of the body whorl. The snails were grouped into 19 size groups having 1.8mm intervals and the size frequencies were converted into percentage and represented by histograms for each month throughout the period of study.

Age and growth was determined by various methods *viz.* Length frequency method [5], Probability plot [6], von Bertalanffy's equation [7] and 4. Month mode curve [8 and 9].

Size (Length) Frequency Method: The multimodal length distribution of a population permits statistical classification of I ndividuals into different age groups [5]. Estimation of age and growth by use and modal values in length frequency distribution has been widely employed in fishery science. The principle underlying this method may be summarized as follows:

1) Length of animals, of each age group and of each brood, is approximately normally distributed in a population with restricted spawning season.
2) Growth is such that the modes of length distribution in successive age groups of broods in samples taken from the population are separated along length axis and may be readily distinguished and
3) When the length frequency distribution of a sample containing a number of age group or brood is drawn, a polymodal curve is obtained, the separate mode represents the approximate mean size of the constituent age groups. This method is suitable for the younger groups. But with advance in age, growth slows down which results in overlapping of modes and making it difficult to separate.

If the snails spawn continuously, the length frequency distribution will be a multimodal curve, with several normal components. When a snail spawns only once or twice in the year, the modes will represent the successive year and the half-year classes respectively. By this method the average size of few earlier classes can be traced. However with increase in age, the growth becomes less. This results in overlapping of modes and separation of modes becomes difficult.

Probability Plot Method: This method, described by [6], was used to solve the bimodal or polymodal frequency distribution. Amended this method and used it to estimate growth in a species with prolonged spawning period [10]. This method, found to be successful in getting a high degree of accuracy, helps in sorting out different size groups resulting from the contribution of different broods.

Von Bertalanffy's Growth Equation: The mathematical model derived by von [7] was used to calculate the length of this snail at a given time. The von Bertalanffy growth curve is an equational tool that has been used to describe the growth of organisms in various forms [7, 11 -13].

This mathematical expression is useful in interpolation, extrapolation and also in production computation [14,15]. Since growth is the sum total of anabolism and catabolism, a growth curve in length fits well with the growth rate of many species [16,11]. By this equation, length for different years has been calculated and then plotted along with the observed length of the same period, which shows a general agreement in growth pattern. This equation gives a linear relationship between length 'L' at a time 't' and (t+x) is expressed as:

$$Lt = L\alpha\ [1-e^{-k}\ (t-to)] \qquad (1)$$

Where,

Lt = Length at age 't'
Lα = asymptote of the growth curve in length
e = base of natural logarithm
k = coefficient of catabolism
t = age of animal and
t_o = arbitrary origin of the growth curve.

The above equation can be written as,

$$Lt + 1 = L\ \alpha\ (1-e^{-k}) + e^{-klt} \qquad (2)$$

This is a linears equation in terms of 'Lt' and Lt+1 as shown below:

$$Lt + 1 = a + bLt \qquad (3)$$

Where
$a = L\ \alpha\ (1-e^{-k})$
$b = e^{-k}$

By this method of least square analysis, the values of 'b' and 'a' were calculated for *T. brunneus*. The value 'k' can be determined from e^{-k} by using the formula,

$$K = \log e;\ be = \log 1/e^{-k} = \log e \qquad (4)$$

The 't_o' can be calculated using the formula,

$$t_o = 1/k \log eL\alpha - \log e\,(L\alpha - Lt) \qquad (5)$$

Month Mode Curve: The length frequency method based on scatter diagram of modes, adapted by [8,9] has been followed to identify various broods and their growth, when breeding occurs for a long periods.

Ford-Walford Graph: Geometric methods to determine [17, 18] the growth in terms of length similar to that given by [7]. This graphic method is based on the assumption that the successive increment added to the length at definite time interval decreases in magnitude in a geometric progression till a limiting value of total length, ultimate length at infinity ($L\alpha$) is approached.

RESULTS

Size (Length) Frequency Method: Length measurements from May 2007 and April 2008 of *T. brunneus* obtained from random samples taken at various intervals throughout the year were used and the length frequency histograms for male (779) and females (748). for the period May ' 2007 to April '2008 are shown in (Fig.1). The male snails showed a growth of

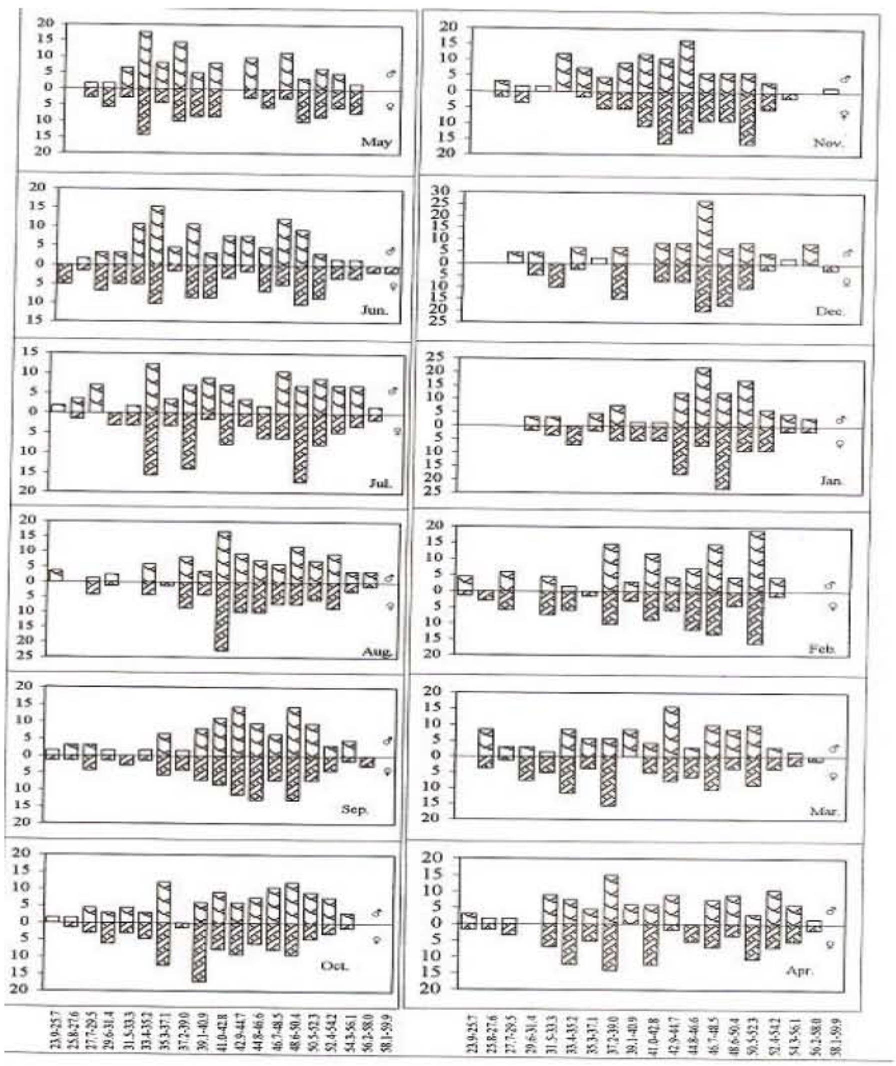

Fig. 1: Size frequency histogram for male and female of *T. brunneus*

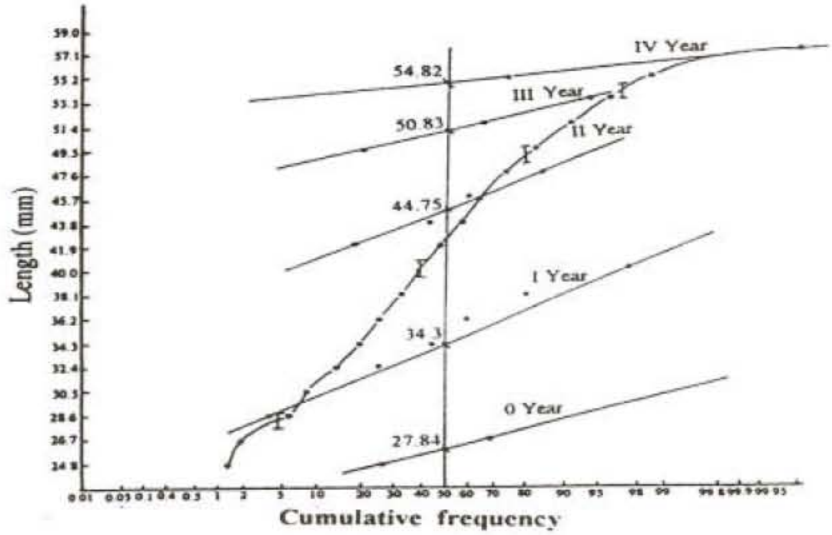

Fig. 2: Probability plot for male *T. brunneus*

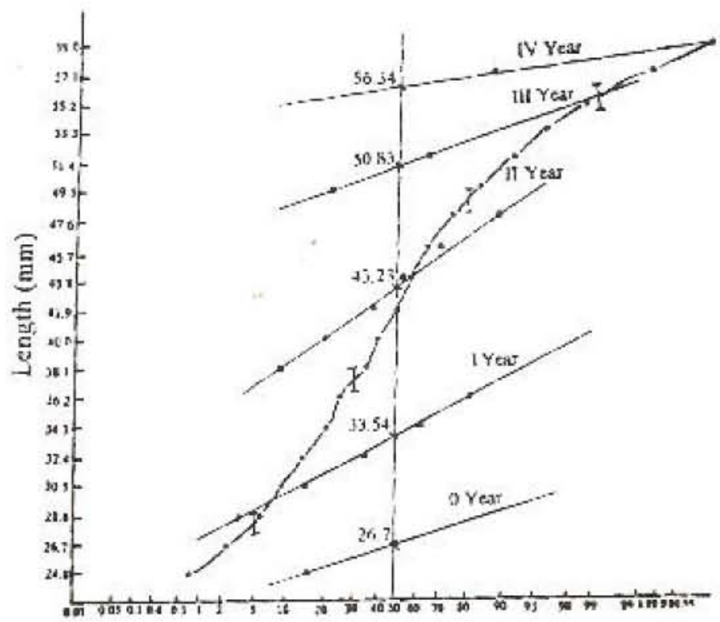

Fig. 3: Probability plot for female *T. brunneus*

28.06 mm during the first year, 41.74 mm in the second year and 2.10 mm in the third year. The growth of females was found to be 31.92mm in first year, 42.28 in second year, 49.88 in third year and 55.58mm in the fourth year. Thus, this method has its own limitation and hence other methods were employed to calculate the age and growth of these snails. The longevity was found to be more than four years as observed by this method.

Probability Plot Method: The data collected for Peterson's method were utilized for this study. The cumulative percentage of occurrence of different size groups for this period was plotted in arithmetic probability paper in order to note the points of inflection.

Through the probability plot method, the male of *T. brunneus* was found to attain 34.3mm in the first year, 44.75 in second year, 50.83 in third year and 54.82 mm in fourth year (Fig.2). The female was found to reach 33.54, 43.23, 50.83 and 56.34mm during the first, second, third and fourth years respectively (Fig.3). In this method also it is observed that the age was not less than four years.

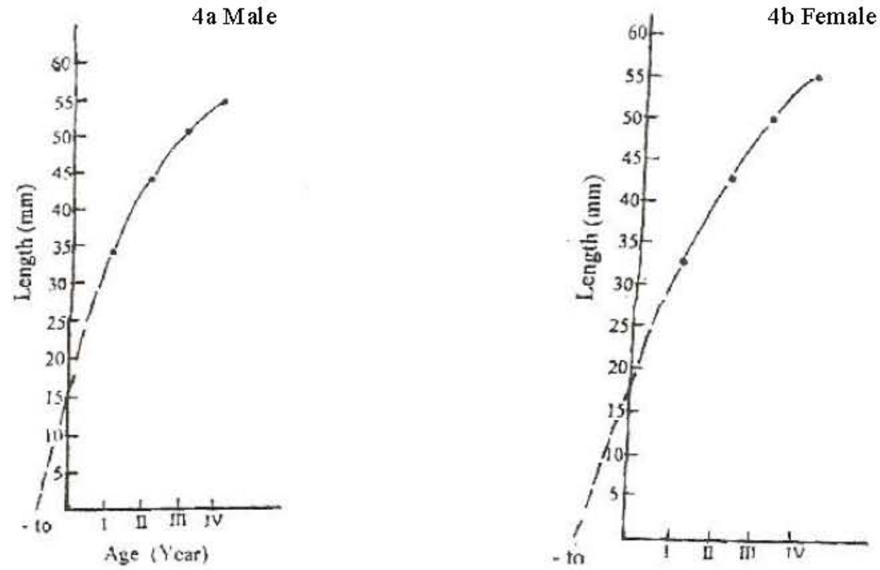

Fig. 4a,b: von Bertalanffy's growth curve for male and female of *T. brunneus*

Table 1: Growth of *T. brunneus* (Male) as estimated by various methods

S.No.	Methods employed	I Year	II Year	III Year	IV Year
1	Probability method	34.3	44.75	50.83	54.82
2	von Bertalanffy's equation method	34.2682	44.6597	50.9625	54.7782
3	Peterson's method	28.06	41.74	52.10	-
4	Months mode curve	35.25	43.80	49.50	53.30

$L\alpha$:60.6625 K:0.5005 t_o:-0.6625

Table 2: Growth of *T. brunneus* (Female) as estimated by various methods

S.No.	Methods employed	I Year	II Year	III Year	IV Year
1	Probability method	33.54	43.23	50.83	56.34
2	von Bertalanffy's equation method	33.5620	43.3163	50.7284	56.3542
3	Peterson's method	31.92	42.28	49.88	55.58
4	Months mode curve	34.30	41.90	48.36	53.30

$L\alpha$:74.1210 K:0.2752 t_o:-1.1908

Von Bertalanffy's Growth Equation: By using the von Bertalanffy's growth equations, the asymptotic length or maximum attainable length of *T. brunneus* was found to be 74.1210 mm for female and 60.6625 mm for male. The age at the origin of the growth curve for *T. brunneus* was -0.6625 for male and for female -1.1908. The co-efficient of catabolism in *T. brunneus* was 0.5005 for male and for female 0.2752.

In the present study, the age and the corresponding length of animals obtained from the probability plot methods were used to construct von Bertalanffy's growth curve (Fig. 4a, b). The von Bertalanffy's equations for growth rate in this species may be given as follows:

$$Lt = 6006625\ [1-e^{-0.5005(t+0.6625)}] \text{ for male}$$

and

$$Lt = 74.12.10\ [1-e^{-0.2752(t+1.1908)}] \text{ for female}$$

The length calculated for different years using this equation is plotted along with the observed length for the same period, which shows a general agreement in growth pattern. The theoretical growth curves for male and females of *T. brunneus* are presented in (Fig. 4a, b). From the growth equation, it can be observed that the males of *T. brunneus* attains a length of 34.2682, 44.6597, 50.9625 and 54.7782 mm and the female 33.5620, 43.3163, 50.7284 and 56.3542 mm in the first, second, third and fourth years respectively (Table 1, 2).

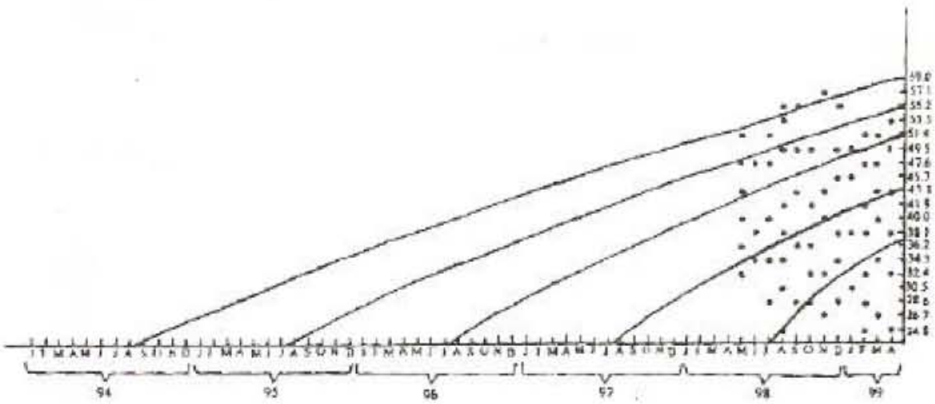

Fig. 5a: Scatter diagram of modes – months for males of *T. brunneus*

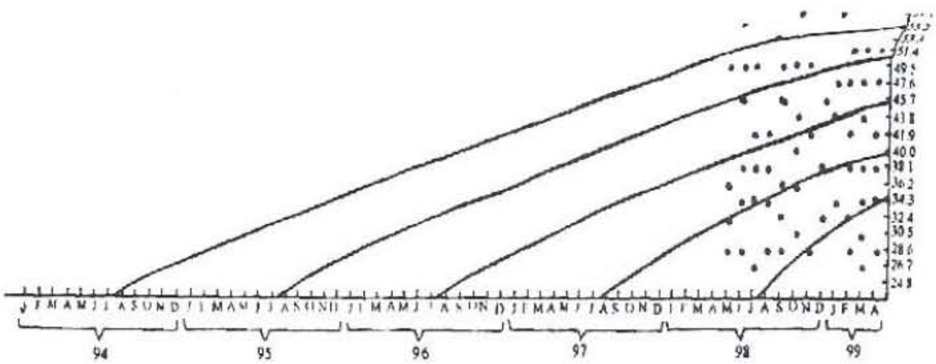

Fig. 5b: Scatter diagram of modes – months for females of *T. brunneus*

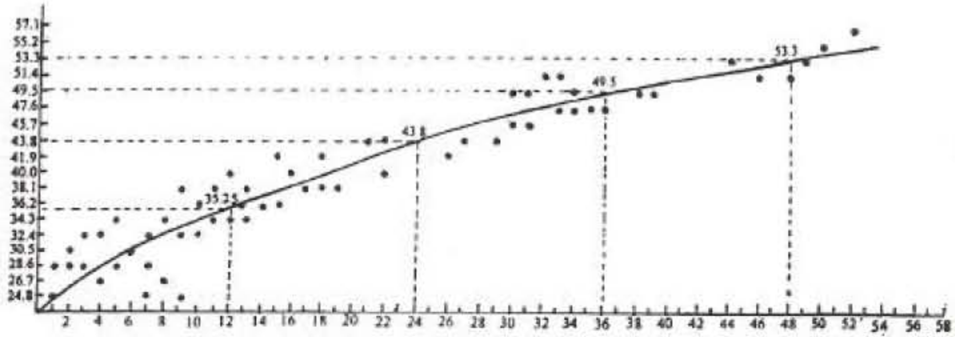

Fig. 6a: Growth of male *T. brunneus* based on scatter diagram of modes - months

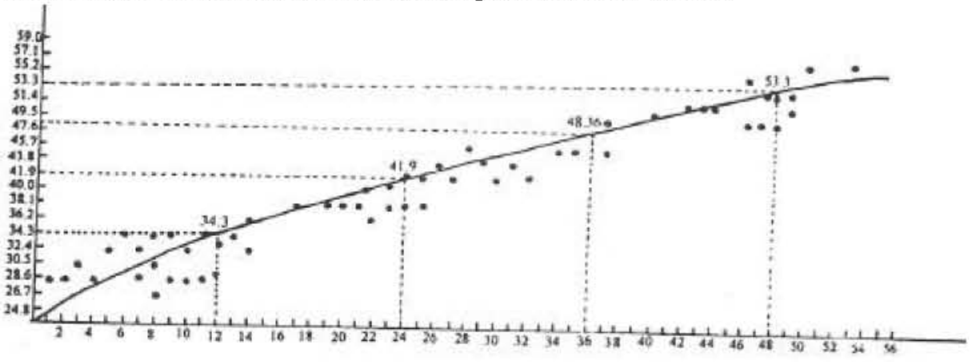

Fig. 6b: Growth of male *T. brunneus* based on scatter diagram of modes - months

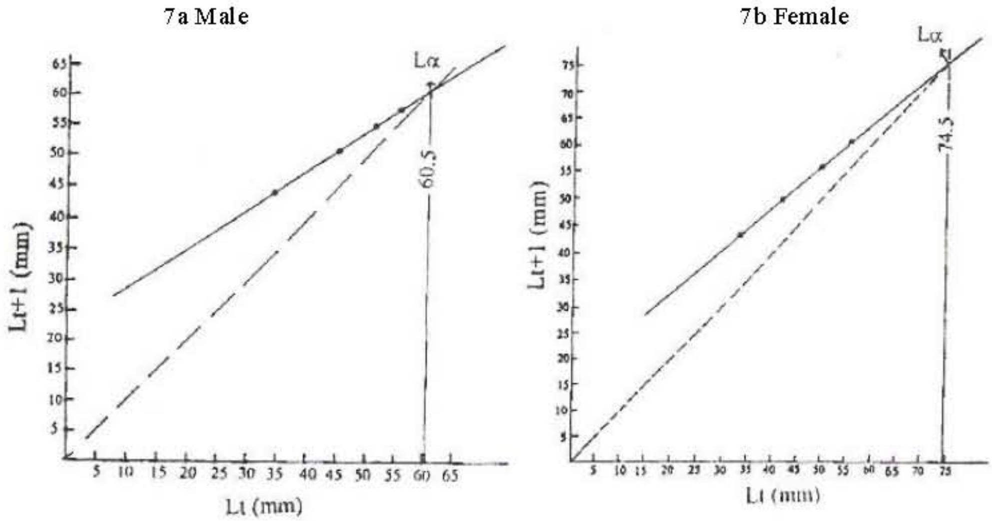

Fig. 7a,b: Ford –Walford graph for male and female of *T. brunneus*

Months Mode Curve: The modes recognized in the length frequency data for various months were represented in the form of scatter diagram of modes, separately for the two sexes of *T. brunneus*. The probable course of progression of modes lying closet to the time axis was traced by fixing a free hand trend line. This line was extrapolated with reference to the intermodal slope so as to intersect the time axis in order to trace the time of brood origin. This trend line leading from the time axis to the highest modal value in the series was the first guide line for tracing the growth history of the still older broods. When many similar trend lines were fitted, each one acted as a guide line for tracing the growth history of the much older brood and also to correct if necessary the already fitted lines for the younger broods (Fig. 5a,b)

The progression of modes through successive months along a series of trend lines representing the growth of the brood of male and female is summarised for the species (Fig. 6a, b), where the fitted trend line represents growth of male and female. The growth in different months for the brood could be read from (Fig. 6a & 6b). Mean growth based on values for the brood and the missing values were known from the fitted growth lines (Fig. 6a, b). From the graph only one brood could be during the first, second, third and fourth years respectively. Similarly female were found to grow upto 34.30, 41.90, 48.36 and 53.30mm during the respective years first to fourth.

Ford-walford Graph: Ford-Walford graph was constructed for *T. brunneus* (Fig. 7a, b) by plotting Lt+1 against Lt Where 'Lt' is the length of animal at a particular age. The straight line obtained from the graph was intersected by a 45O diagonal from the origin which indicates the Lα (Length at infinite). The Lα value obtained for *T. brunneus* was 60.5 (Fig. 7a) for male and 74.5mm for female (Fig.7b) which very well coincided with the results of von Bertalanffy's equation for *T. brunneus*.

DISCUSSION

The growth of *T.brunneus* estimated by employing the size (Length) frequency method, probability plot, theoretical growth curve using von Bertalanffy's equation and months mode curve showed more or less similar results. The growth rate of *T. brunneus* decreases with an increase in age. According to the probability method, the first year group, which showed the maximum growth rate attained the length of 34.3mm in male and 33.54mm in female. The growth rate declined gradually through 10.50, 6.08 and 3.99mm in male and 9.69, 7.60, 5.51mm in female during second, third and fourth years respectively. The present observation is substantiated by the statement of [19] from his studies that the relative growth decreases with an increase in age in different molluscs and [20] who suggested that the specific growth rate decline more and more as the age of the molluscs is increased.

Various environmental factors are known to influence molluscan growth [21]. Several investigations have found that both in tropical and temperate waters growth rate of the mollusc is not uniform throughout the year. The growth rate is faster in their early part of life than during the later [20,22].

The growth rate of *T. cornutus* and found that the shell length increment from the first to fifth year was 32.3, 22.0, 15.1, 10.3 and 7.0mm respectively [23]. The growth observed by [24] in *Trochus tentorium* by probability plot method was 19.14mm (first year) 24.36mm (second year) and 27.60mm (third year)

Effects of population density and limitations of food resources seem to be more probable causes for growth rate variations, as previously demonstrated for many intertidal gastropods [25-29]. Studies by Seed [30,31] and [32] showed that other factors, almost certainly nutritional could similarly result in crossing over of growth curves from different populations. Hence, size related changes in diet, food availability or other aspects of interspecific competition might have important consequences for wide scale as well as local growth investigation.

However the growth studies using empirical models do not explain why members of some species invariably grow to larger sizes when compared to members of other species. For instance *T. marmoratus* a member of *Turbo* spp. Grows to a much larger size than other members of Turbo. The growth is a far too complicated process to be described in a biologically meaningful way by a mechanistic model with a few parameters [33]. There must be some sort of internal control in growth. Genetically determined variation in growth rate has been found even within species [34].

The age of *T. brunneus* appears to be four years and above as estimated by various methods. Longevity data of molluse were assembled by [35-39] and they have observed the longevity of *T. marmoratus* to be 3 years, *Trochus niloticus* 4 or 5 years and *Gibbula umbilicalis* 4 or 5 years.

Estimated a 10 to 15 years life span for *Monodonta lineata* in N. Brittany, but only 4-5 years on the Atlantic coast near Biarritz [40,41]. Other estimates of the longevity of Trochacean gastropods are 5 years for *Gibbula* umblicalis [36], 12 years for *Trochus niloticus* [42] and 19-30 years for *Tegula funebralis* [43]. Others include $2^1/_2$ years for *Umbonium vestiarium* [4], $3^1/_2$ years for *Clithon oualaniensis, C. retifera* [44] and 3 years for *Trochus tentorium* [24].

ACKNOWLEDGEMENT

The authors are grateful to the Director of CAS in Marine Biology and authorities of Annamalai University for facilities provided.

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