A study of age and growth of *Gazza minuta* (Bloch) 
from Tuticorin waters of Southeast coast of India

D. Nagarajan
Associate Professor, Dept. of Zoology, Kamaraj College.

Abstract: Age and growth of Ponyfish *Gazza minuta* (Bloch) was estimated from the length frequency data. The growth parameters ‘$L_\infty$', 'K' and 't_0' were calculated as per Von Bertalanffy, Bagenal, Gulland & Holt, Ford-Walford, Powel and Wetheral methods and also through FISAT software. Von Bertalanffy growth equation fitted for the length at age data is $L_t = 181(1-\exp^{-1.7052(t+0.0019)})$. *G.minuta* attains a length of 104, 148, 167 and 172 mm in 0.05, 1.0, 1.5 and 1.75 years. The life span ($T_{max}$) is estimated to be 1.8 years. The estimated $w_\infty$ is 90.9 grams.

Keywords: *Gazza minuta*, Model progressive analysis, Growth parameters, $T_{max}$

I. INTRODUCTION

Knowledge on the growth and age of a fish is essential in understanding the dynamics of its populations. In fishery yield studies, the growth is a basic variable determining the exploitable stock and yield from the fishery, age at sexual maturity, suitability of different environments for growth. Age and growth studies in fishes help to know the age and class structure of the stock, fluctuations in the fishery caused by the presence or absence of various year classes. In the present study the age length keys are derived from the length frequency using various methods including ELEFAN method using FISAT package[1]. Determination of growth parameters of fish requires a reliable age-length key.

The important growth parameters are ‘$L_\infty$’, ‘K’ and ‘$t_0$’. $L_\infty$ is interpreted as “the mean length of very old (strictly: infinitely old) fish” and K is a “curvature parameter” which determines how fast the fish approaches $L_\infty$. The third parameter, $t_0$ also called “the initial condition parameter” determines the point in time when the fish has zero length. Biologically, this has no meaning, because the growth begins at hatching. Owing to the dearth of information on the age and growth of *Gazza minuta* for Gulf of Mannar, the present study was undertaken to estimate the age and growth of this species.

II. MATERIALS AND METHOD

A. Treatment of the data

The data were collected once in a weak by random sampling method from minimum of 10 trawlers from the commercial fish landings by trawls at Tuticorin fishing harbour along with catch and effort and species composition. Total length of 4602 specimens of *G.minuta* was measured. The weight of the fish landed was recorded by eye estimation since the fish were auctioned in lots in the auction hall. The length frequency data were grouped into 5 mm class intervals and each length group were raised for the sampling day’s catch and subsequently for the month’s catch by respective raising factors as per the method of Sekharan [2].

B. Model progression analysis (scatter diagram technique)

The integrated method i.e., the simultaneous application of Peterson’s method and the Modal progression analysis was used [3] to identify the various broods in a year and their growth in subsequent period. The length frequency data during 1993-1995 for *G.minuta* are given in Table 1 and 1a. The modes recognized in the length frequency data for various months are represented in the form of scatter diagram and the progress of mode was traced freehand through time. This line was extrapolated with reference to the inter-modal 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 guideline for tracing the growth history of the still older broods. When many similar trend lines were fitted, each are acted as guideline for tracing the growth history of the much older broods and also to correct, if necessary already fitted lines for the younger broods. The progression of modes through successive month along a series of trend lines, representing growth of various broods, is given in figure 1. The modes thus traced were tabulated chronologically [4] and the average sizes were calculated as shown in Table 2. The average sizes were plotted on an arithmetic graph against the age in months and a free hand curve was fitted through the plots and this may be considered as an empirical growth curve of the species as shown in figure 2. A fresh set of lengths attained by these species from the first month of its age onwards have been obtained from these empirical growth curves which enables to obtain the missing data at lower and higher size ranges. These data were used for further analysis to obtain the growth parameters ‘$L_\infty$’, ‘K’ and ‘$t_0$’ as per methods [5, 6, 7, 8, 9]. Estimates of $L_\infty$ and K were obtained by using FISAT software also [10].
C. The von Bertalanffy growth equation

The mathematical model derived by [11] was used to calculate the length of fishes at any given time. This equation is based on the concept that the growth is the result of anabolism and catabolism. The mathematical model expresses the length 'L' as a function of the age of fish, 't':

\[ L_t = L_\infty (1-e^{-kt}) \]  

(1)

Where \( L_\infty \) = asymptotic length, \( L_t \) = Length at age t, exp = natural logarithm, \( K = \) co-efficient katabolism, \( t = \) age of fish and \( t_0 = \) age at 0 length.

D. Begenal method

Begenal described the method of fitting von Bertalanffy's equation for estimating the parameters \( L_\infty, K \) and \( t_0 \). For this purpose von Bertalanffy's growth equation was rewritten as

\[ L_{t+1} = L_\infty (1-e^{-k}) + e^{-k} L_t \]

(2)

This equation gives linear relationship between the lengths at time 't' and at time 't+1':

\[ l_{t+1} = a + b \times l_t \]

Where \( a = L_\infty (1-e^{-k}) \) and \( b = e^{-k} \)

Applying standard methods of regression analysis the 'a' and 'b' for the values of \( l_t \) and \( l_{t+1} \) were obtained. For this purpose the equation

\[ l_{t+1} = a + b \times l_t \]

May be written in the general form.

\[ Y = a + bX \]

\[ b = \frac{N \times \sum XY - \sum X \times \sum Y}{N \times \sum X^2 - (\sum X)^2} \]

\[ a = \frac{\bar{Y} - b \times \bar{X}}{b} \]

and

\[ l_t = X \] and \( l_{t+1} = Y \)

The value of 'K' is derived from that of 'b' using the expression

\[ K = -\log_e b \]

(4)

\( t_0 \) was estimated by rewriting the von Bertalanffy's Growth equation as

\[ e^{-kt} + k \times t_0 = \log_e \frac{L_\infty}{L_t} \]

\[ k \times t_0 = \log_e \frac{L_\infty - L_t}{L_\infty - 1} + kt \]

\[ t_0 = \frac{1}{k} \{ (\log_e \frac{L_\infty}{L_t}) + kt \} \]

(5)

E. The Gulland and Holt plot

Growth parameters can be derived from age/length data by graphical methods for plots, which are always based on a conversion to a linear equation. These plots are named after the authors [12, 13]. The plot is obtained from the equation [7].

\[ \frac{\Delta L}{\Delta t} = K \times L_\infty - K \times \frac{L(t)}{\Delta t} \]

(6)

The length \( l(t) \) represents the length range from \( l(t) \) at an age \( t \) to \( l(t+\Delta t) \) at age \( t+\Delta t \). Thus, the natural quantity to enter into is the mean length Using \( l(t) \) as the independent variable and \( \Delta L/\Delta t \) as the dependent variable becomes a linear regression:

\[ \bar{L} = \frac{l(t+\Delta t) + l(t)}{2} \]

\[ \Delta L/\Delta t = a + b \times \frac{L(t)}{\Delta t} \]

The parameters \( K \) and \( L_\infty \) are obtained from \( K = -b \) and \( L_\infty = -a/b \)
This method [8, 13] was derived from the original growth equation (Eq.6.1) by a series of algebraic manipulations such as:

\[
l(t+\Delta t) = a + b \cdot l(t) \tag{7}
\]

Where \( a = L_\infty (1 - b) \) and \( b = \exp. (- K \cdot \Delta t) \)

Since \( K \) and \( L_\infty \) are constants, \( a \) and also \( b \) become constants if \( \Delta t \) is a constant. Using \( l(t) \) and \( l(t+\Delta t) \) as \((x,y)\), Eq. 6.7 can be used for linear regression. The growth parameters \( K' \) and \( L_\infty' \) are derived from

\[
K = -\left(1/\Delta t \right) \cdot Ln b \quad \text{and} \quad L_\infty = a / (1 - b)
\]

\( L_\infty \) can be estimated graphically from the intersection point of the regression line and the line \( l(t) = l(t+\Delta t) \) (the 45 degree line) because for very old fish, which have stopped growing we have \( L_\infty = l(t) = l(t+\Delta t) \). Also the methods [14] are based on a constant time interval \( \Delta t' \), that is to say that the method is applicable if we have pairs of observations.

\((t, L(t)), \ (t+\Delta t, L(t+\Delta t)), \ (t+2\Delta t, L(t+2 \Delta t)),\) etc.

It can be shown that the von Bertalanffy growth equation implies that:

\[
L(t+\Delta t) - L(t) = c \cdot L_\infty - c \cdot L(t) \tag{8}
\]

Where

\[ c = 1 - \exp. (- K \cdot \Delta t) \]

Thus, since \( K \) and \( L_\infty \) are constants, and if \( \Delta t \) remains constant, \( 'C' \) will remain constant and consequently Eq. (6.8) becomes a linear regression

\[ Y = a + b \cdot x \]

where

\[ Y = L(t+\Delta t) - L(t) \quad a = c \cdot L_\infty , \ b = - c \quad \text{and} \quad x = L(t) \]

The growth parameters are derived from

\[ K = - \left(1/\Delta t \right) \cdot Ln (1 + b) \quad \text{and} \quad L_\infty = - a/b \quad \text{or} \quad a/c \]

G. Powell – Wetherall method

Powell makes use of variance in length of fish caught from \( L' \) onwards and he proposes the following equation to get \( L_\infty \) and \( Z / K \).

\[
\overline{L} - L' = a + b \cdot L'
\]

where,

\[ L_\infty = -a/b \quad \text{and} \quad Z / K = - (1+b) / b \]

Thus, plotting \( \overline{L} \) against \( L' \) gives a linear regression from which \( a \) and \( b \) can be estimated and hence \( L_\infty \) and \( Z / K \).

H. The von Bertalanffy plot

This method can be used to estimate \( K \) and to from age/length data, while it requires an estimate of \( L_\infty \) as input. The growth equation can be rewritten

\[
-Ln \left(1 - L(t)/L_\infty \right) = - K \cdot t_0 + K \cdot t \tag{9}
\]

With the age, \( t \), as the independent variable \((x)\) and the left-hand side as the dependent variable \((y)\) the equation defines a linear regression, where \( K \) represents the slope and \(-K \cdot t_0 \) the intercept.

\[ K = b \quad \text{and} \quad t_0 = - a/b \]

The growth parameters are also estimated from the length frequency data by using FISAT software. The growth parameters \( W_\infty, K \) and \( t_0 \) in weight of these species is estimated from the corresponding weight obtained for the size at an interval of one month year as per their respective length-weight relationship by the method of Bagenal[6].

III. RESULT

From the length frequency data (Table 1 & 1a) progression of modes can be traced for the period ranging from 2 to 15 months (Fig. 1). A mode at 77.5 mm in October 1993 can be traced to 102.5 in December 1993 with a monthly growth of 12.5 mm. Two modes at 102.5 mm in December 1993 and August 1994 can be traced to 112.5 mm in January 1994 and September 1994 respectively, showing an average growth of 10 mm per month. Further, a mode at 112.5 mm in March 1994 has shifted to 152 mm in August 1994 showing a monthly growth of 6 mm.
Figure 1: Tracing the progression of modes by scatter diagram of modal length-month for *Gazza minuta* for Tuticorin during 1993 – 1995

The mode at 152.5 mm in August 1993 has shifted to 162.5 mm in October 1993 and another mode at 162.5 mm in March 1994 has shifted to 167.5 mm in September 1994 showing a monthly growth of 2.5 mm. A monthly growth of 12.5 mm between the length 77.5 and 102.5 mm, 10 mm between 102.5 to 112.5 mm, 6 mm between 112.5 to 152 mm and 2.5 mm between 152 to 162.5 mm were observed. Fish at the smallest modal length of 77.5 mm (from which growth could be traced) can be reasonably judged as 4 months old, with an average monthly growth of 19 mm. As per the empirical growth curve (Fig. 2) *G.minuta* attains 67, 106, 131.5, 149, 161 and 167 mm in 0.25, 0.5, 0.75, 1.0, 1.25 and 1.5 years with a growth rate of 22.3, 13, 8.5, 5.8
and 4 mm per month respectively. *G. minuta* is estimated to grow 63, 104, 131, 148, 160, 167 and 172 mm in 0.25, 0.5, 1.0, 1.25, 1.5 and 1.75 year. The life span (T max) of this species is estimated to be 1.8 years as per the equation: T max = 3/K. The growth parameters W∞, K and t0 of *G. minuta* are given in the table 2.

**Table 2: Growth parameter W∞ (g), K and t0 for G. minuta during 1993 to 1995 in Thoothukudi waters**

<table>
<thead>
<tr>
<th>Growth parameters</th>
<th>G. minuta</th>
</tr>
</thead>
<tbody>
<tr>
<td>W∞ (g)</td>
<td>90.9</td>
</tr>
<tr>
<td>K (year)</td>
<td>1.6756</td>
</tr>
<tr>
<td>t0 (year)</td>
<td>-0.0017</td>
</tr>
</tbody>
</table>

The growth parameters L∞, K and t0 obtained by the various methods of *G. minuta* are given in the table 3.

**Table 3: The L∞, K and t0 obtained by the various methods and their respective Table and Figure numbers for G. minuta during 1993 to 1995 from Thoothukudi waters.**

<table>
<thead>
<tr>
<th>L∞ (mm)</th>
<th>K (year)</th>
<th>t0 (year)</th>
<th>Method</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>181.0</td>
<td>1.7052</td>
<td>-0.0019</td>
<td>Bagenal</td>
<td>1985</td>
</tr>
<tr>
<td>-</td>
<td>1.8204</td>
<td>-0.0152</td>
<td>Von Bertalanffy</td>
<td>1934</td>
</tr>
<tr>
<td>182.5</td>
<td>1.6764</td>
<td>-</td>
<td>Guillard and Holt</td>
<td>1959</td>
</tr>
<tr>
<td>181.0</td>
<td>1.7057</td>
<td>-</td>
<td>Ford-walford</td>
<td>1946</td>
</tr>
<tr>
<td>181.0</td>
<td>1.7057</td>
<td>-</td>
<td>Chapman</td>
<td>1961</td>
</tr>
<tr>
<td>176.8</td>
<td>-</td>
<td>-</td>
<td>Powell Wetherall</td>
<td>1987</td>
</tr>
<tr>
<td>173.0</td>
<td>2.0000</td>
<td>-</td>
<td>Bhattacharya-FISAT</td>
<td>1967</td>
</tr>
<tr>
<td>174.0</td>
<td>1.8000</td>
<td>-</td>
<td>ELEFAN I - FISAT</td>
<td>1995</td>
</tr>
</tbody>
</table>

According to the von Bertalanffy growth equation

\[ L(t) = L_\infty(1 - e^{-Kt}) \]

The growth in weight may be described by the following von Bertalanffy growth equations[11].

\[ W(t) = W_\infty(1 - e^{-Kt})^{3/2} \]

As per the above equations the weight (in gram) attained at an interval of 0.25 year is given in the table 4.

**Table 4: The weight attained at an interval of 0.25 year for G. minuta during 1993 to 1995 in Thoothukudi waters.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Gram</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>3.7</td>
</tr>
<tr>
<td>0.50</td>
<td>16.7</td>
</tr>
<tr>
<td>0.75</td>
<td>33.4</td>
</tr>
<tr>
<td>1.00</td>
<td>48.9</td>
</tr>
<tr>
<td>1.25</td>
<td>61.4</td>
</tr>
<tr>
<td>1.50</td>
<td>70.6</td>
</tr>
<tr>
<td>1.75</td>
<td>77.2</td>
</tr>
<tr>
<td>W∞</td>
<td>90.9</td>
</tr>
</tbody>
</table>

Obtaining a reliable estimates of growth parameters for tropical species is hampered very much due to interference of various factors such as short life span, seasonal variations in growth within a year etc.,

Generally in nature the oldest fish in the stock grows to reach about 95% of its asymptotic length [15]. Assuming the maximum size encountered in the fishery ie., 166 mm for *G. minuta* and 166 to be 95 % of the L∞ and then the L∞ works out theoretically to 175 mm. The estimates of growth parameters obtained in the present study and earlier work in G.minuta in Indian waters are given in the table 5.

**Table 5: The growth parameters for G. minuta in Indian waters**

<table>
<thead>
<tr>
<th>Locality</th>
<th>Author</th>
<th>Year</th>
<th>Growth parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuticorin</td>
<td>Present</td>
<td>1986</td>
<td>L∞ (mm) 173-183</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>K (annual) 1.6764</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>t0 (annual) 0.0152</td>
</tr>
<tr>
<td>Portonovo</td>
<td>Jayabalan</td>
<td>2011</td>
<td>L∞ (mm) 160</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>K (annual) 0.8649</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>t0 (annual) -0.2316</td>
</tr>
<tr>
<td>Kerala coast</td>
<td>Abraham et al.</td>
<td>2011</td>
<td>L∞ (mm) 160</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>K (annual) 1.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>t0 (annual) -0.0001</td>
</tr>
</tbody>
</table>
The short lived species has small $L_\infty$ and a high K value and long lived species have a higher $L_\infty$ with a low K value [19]. The present study shows that $G.minuta$ is having small $L_\infty$ and higher K values indicating that these species are short lived like the Indian mackerel *Rastrelliger kanagurta* [20], oil sardine *Sardinella longiceps* [21], barracuda *Sphyraena obtusata* [22] and Secutor *insilator* [23]. The long lived species like seer fish *Scomberomorus commerson* [24] and *Rhzoprionodon acutus* [25] and perch *Lethrinus nebulosus* [26] have higher $L_\infty$ and small K. Larger pelagic fishes such as the king seer *Scomberomorus commerson* is reported to attain 500 to 600 mm in 6 months and about 800 mm in 1 year based on the daily growth ring [27]. Faster growth among the tropical species is not uncommon in view of the prevalent high temperature which profoundly influences the growth of the poikilotherms. The same is true for long lived tropical species also as reported by Kasim in the case of sharks. Naturally it is true from the present study and earlier reports that the *Gazza minuta* is small to medium sized fish with short life span ranging from 1.5 to 1.8 years with small $L_\infty$, large K value.

**IV. DISCUSSION**

Jayabal and Ramamoorthy [16] have estimated $L_\infty$, K and $t_0$ to be 160 mm, 0.8649/year and -0.2316 respectively for $G.minuta$ from Portonovo waters. The estimates obtained for this species in the present study are higher than that obtained by Jayabal [17] indicating a faster growth in this species from Tuticorin waters. The values estimated $L_\infty$, K and $t_0$ to be 160 mm, 1.70 / year and -0.2316 in Kerala coast [18]. The K values indicate the growth rate in Kerala coast and Tuticorin water is more or less same.
REFERENCES