AGE AND GROWTH
X. AGE AND GROWTH

INTRODUCTION

A study on age and growth of fish is one of the important aspects. It is necessary to know the dominant age groups for a proper assessment of fish stocks and consequently for rational exploitation and management. Growth study of fish gives some idea as to which age group the full exploitation can be geared, since fast-growing fish species can sustain a more intensive fishery than a slow-growing one. This study is also important to evaluate the survival and mortality rates of various year classes of fish. Aging techniques, the methods for back calculation of fish length, the techniques to ascribe the present status, the past history and future course of fishery are accurate and refined. Naturally, age and growth analysis can be more significant and valuable from both scientific and commercial points of view.

The age determination study in tropical fishes is difficult due to stable environment and continuous breeding habits and the difficulties are explained by Qasim (1973b). Still few workers attempted to study this aspect with the help of hard parts in fishes like, *Rastrelliger kanagurta* (Seshappa, 1969) and *Polynemus heptadactylus* (Kagwade, 1971).

There have been relatively few investigations on the genus, *Pomadasys* from different waters. Nammalwar (1974) investigated the age of *Pomadasys hasta* from their skeletal structure in Indian waters. Manooch (1976) analysed the scales and otoliths of the white grunt, *Haemulon plumeiri* of the family Pomadasyidae for age determination from North and South Carolina. Nolf and Lapierre (1976) collected the otoliths of teleost from the sediments of the sables do Bois-Gouet and recorded the presence of 22 indicative species of which rich assemblage in Pomadasyidae was noticed.
Druzhinin and Filatova (1979) estimated the age of *Plectorhinchus pictus* of the family Pomadasyidae from the bottom trawl catches in Gulf of Aden. Wallace and Schleyer (1979) used the otoliths for determination of age of *Pomadasys commersonni*. Blake and Blake (1981) observed the growth rings in the scales of *Pomadasys macracanthus* (Gunther) collected from a Mexican Pacific coastal lagoon. Brothers and McFarland (1981) studied the correlations between otolith and growth of *Haemulon flavolineatum* of the family Haemulidae.


The length frequency distribution of *Pomadasys corvinaeformis* from Fortaleza country, Ceara State, Brazil was studied by Costa *et al.* (1995). Ximenes Carvalho and Fonteles Filho (1996) studied the age and growth of the tomtate, *Haemulon acroleineatum* from Ceara State, Brazil. Ahmad and Ghais (1997) studied the relationship between age and heavy metal content in the otoliths of *Pomadasys stridens* (Forskcal, 1775) from the Arabian Gulf.

Reviewing the literature showed a lacuna in the age and growth study of *P. maculatum* from Indian waters. Therefore the present investigation was carried out.
MATERIAL AND METHODS

For the present study, total length of 1721 individuals comprising 952 males and 769 females of *Pomadasys maculatum* were collected from the commercial trawl landings at Royapuram Fishing Harbour, Chennai. The two sexes were dealt separately. Length measurements were classified into different size groups with a class interval of 5 mm and the percentage frequencies have been calculated separately for males and females.

RESULTS

i) AGE

a) Length frequency method

This method has been widely employed for age and growth studies. Length measurement (from December 1995 to November 1996) obtained from random samples taken at various intervals throughout the year were used for this analysis.

The principles underlying this method may be summarized as follows:

1. The length of individuals of each age group or breed are approximately 'normally' distributed ideally in a population with restricted spawning seasons.

2. Growth is such that modes of the length distribution of successive age groups or breeds in samples taken from the population are separated along the length axis and may be readily distinguished.

3. When length frequency distribution of a sample containing a number of age groups (or) broods is drawn a polymodal curve is obtained; the separate modes represent the approximate mean size of the constituent age groups.
The method is useful to find the average size of the earlier year classes; with advance in age, growth slows down which results in overlapping of modes and makes it difficult to separate them in the case of forms without a short or restricted spawning. A possible way is however to trace the monthly growth rate in different stages and to compute from this approximately the average size for different ages.

The length frequency pattern for the period from Dec. 1995 - Nov. 1996 for males and females of \textit{P. maculatum} are shown in Figs. 31 & 32.

In males, earlier mode in the group of 91 - 95 during Dec. '95 has been traced to 166 - 170 group during Sep. '96 recording 95 mm growth in 9 months period ie. in one year they might have grown to \((75 \times 12) / 9 = 100\) mm.

This growth in group 101 - 105 during April '96 has been traced to 116 -120 mm group during Feb. '96 recording 15 mm growth in 10 months period ie. in 12 months they might have added a growth of \((15 \times 12) / 10 = 18\) mm. So at the end of 24 months they will be in 118 mm.

The growth in group May '96 has been traced 146-150 group during Feb. '96 recording 30 mm growth in 9 months period. So in 12 months they will be growing to \((30 \times 12) / 9 = 40\) mm. So at the end of 36 months they will be 158 mm. Further modes could not be traced in males.

In females, earlier mode (91 - 95) in July '96 has been traced to 166 - 170 mm growth during June '96 recording 95 mm growth in 11 months time. So in 12 months period they might have grown to \((95 \times 12) / 11 = 104\) mm.

This growth in group (106 - 110 mm) during March '96 has been traced 136 - 140 mm group during Nov. '96 recording 30 mm growth in 8 months period ie. in 12 months. \((30 \times 12) / 8 = 45\) mm which is added to the first year growth. So at the end of 24 months they will be \((104 + 45) = 149\) mm.
This growth in group (151 - 155 mm) during Dec. '95 has been traced to 181 - 185 mm group in Nov. '96 recording 30 mm growth in 11 months time. So in 12 months period \((30 \times 12)/11 = 33\) mm. This is added to the previous months growth ie. \(149 + 33 = 182\) mm. So at the end of 36 months they will be in 182 mm. Further modes could not be traced in females.

The problems which usually arise in the interpretation of modes are:

1. Length frequency distribution of each group is not always uniform and normal, which means separation of modes is difficult and sometimes impossible. The prolonged spawning period and selection of fishing gear are causes for more variations. However, length frequency distribution based on large random samples collected over a long period often show fairly reliable modes.

2. Difficulty may be experienced in assigning successive modes to specific broods unless the age of first captured by the sampling gear is known.

3. The growth rate and increase in size may not be appreciable as to recognize distinct modes in the length frequency distribution, particularly for the larger size groups.

b. Months mode curve

The length frequency method based on the scatter diagram of modes as adopted by Devaraj (1977), Sriraman (1978) has been followed to identify the various broods and their growth, when breeding was continuous involving the production of many broods a year.

The modes (Fig. 33) recognised in the length frequency data for the various months were represented in the form of a scatter diagram of modes separately for the two sexes of \(P.\ maculatum\).
The probable course of progression of the mode lying closest to the time axis was traced by fixing a free hand trend line. This line was extrapolated with reference to the inter model 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 model value in the series was the first guidelines for tracing the growth history of the still older broods. When more and more of similar trend lines were fitted, each one acts as the guide line for tracing the growth history of the much older broods and also to correct if necessary the already fitted lines for the younger broods (Fig. 34). The data were first fitted for the males. Since the brood origin (time) must be the same for both males and females, while treating the data for the females (Fig. 34) the values have been duplicated for the males also so far as the brood origin was concerned.

The progression of modes through successive months along the series of trend lines representing the growth of various broods is summarized in (Fig. 34) and the fitted trend lines there in represent the growth of the male and female respectively of *P. maculatum*. Mean growth based on values for various broods and the missing values found from the fitted growth lines were read from Fig. 34. It was also possible to estimate the time (in days) involved between successive broods based on Fig. 34 and the mean time value between two successive brood origins could thus be derived. From the graph it was possible to trace 4 broods in a year.

c) Probability plot method

This method is used for species which have prolonged spawning seasons, as this is not possible by Peterson method. Secondly, certain year classes may not be represented in the commercial catches and overlapping of distribution of older size groups is likely to yield erroneous results by Peterson method. The probability plot method (Harding, 1949; Cassie, 1954) of separating the polymodel length frequency distribution has been used here to find out the model lengths of different year classes.
By using this method, the males of *P. maculatum* attained 105 mm in 0 year class, 113.5 mm in the first year, 135.5 mm in the second and 156.0 mm in the third year and in fourth year it was 173 mm (Fig. 35).

Females of *P. maculatum* were found to attain a size of 102 mm in 0 year classes and to grow up to 115.5 mm during the first year. The second year class reached 140 mm and third year class 168 mm and fourth year classes up to 183 mm (Fig. 36). Growth appears to be similar for males and females. The life spawn appears to be four years and above for this species.

ii. GROWTH

a) Von Bertalanffy's equation

The mathematical model derived by Von Bertalanffy (1938) was used to calculate the lengths of fish at any given time. The mathematical expression is helpful in interpolation and extrapolation, and also in production computation (Pantalu, 1963; Kamal, 1969). Since growth is the net result of anabolism and catabolism, a growth curve in length fits well with the growth rate of many species of fish (Beverton, 1954; Beverton and Holt, 1957). This equation gives a linear relationship between lengths, at time 't' and at time t + x and is expressed as follows:

\[
L_t = L \cdot \frac{1 - e^{kt - t_0}}{1 - e^{kt}}
\]

where
- \( L_t \) = Length at age 't'
- \( L \) = asymptotic length
- \( e \) = base of Naparian or natural logarithm
- \( k \) = Coefficient of catabolism
- \( t \) = age of fish
- \( t_0 \) = arbitrary origin of growth curve
The lengths calculated for different years by using the equation was plotted along with the observed length for the same period which showed general agreement in the growth pattern. This also showed a high degree of agreement with different lengths during growth calculated by the probability plot technique and to the length frequency analysis in the males and females of *P. maculatum*. The theoretical growth curves for males and females are shown in Fig. 37.

Based on this, the length of males of *P. maculatum* was found to be 122 mm in the first year, 148 mm in the second year and 167 mm in the third year and 183 mm in the fourth year. For females it was 123 mm in first year, 148 mm in the second year, 167 mm in the third year and 182 mm in the fourth year.

**b) Ford-Walford plot**

Ford (1933) and Walford (1946) developed independently an empirical expression similar to that of Von Bertalanffy. According to them, growth is progressed till it attains the maximum in genetic increase. The method of Walford (1946) was used for plotting $L(t + \Delta t)$ against $L(t)$. Length of male and females of *P. maculatum* were subjected to the above analysis (Fig. 38).

For males of *P. maculatum*

$$L(t) = 304.5154 (1 - e^{-0.1354(t + 2.8501)})$$

and for females

$$L(t) = 261.0389 (1 - e^{-0.1857(t + 2.4679)})$$

For easy comparison, the estimation of age and growth of *P. maculatum* based on one year data using different methods are presented in Table 33 and 34.
DISCUSSION

The rate of growth in both sexes almost appears to be similar. The growth rate observed to be high in the young is found to decline with increasing age. This agrees with Medawar's fifth law of growth, "Specific growth rate declines more and more slowly as the organism increases in age". Brown (1957) and Minot (1908) observed that the specific growth rate in most animals is highest in the earlier stages and it decreases with increasing age.

Salinity, temperature, oxygen, food supply, disease and parasitation, physiological stresses like gonad maturation or incubation of eggs, density of population and consequent availability of space for individuals, competition for the same type of food by different species or different animal forms etc. seem to have a direct bearing on the growth rate in general.

As far as the knowledge of the author, this is the first of its kind to study the age and growth in Indian waters especially in *P. maculatum*. Due to the paucity of relevant studies, these data could not be compared and discussed.
Table 33. Length obtained during different years of growth for *P. maculatum* (male)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Methods employed</th>
<th>I Year</th>
<th>II Year</th>
<th>III Year</th>
<th>IV Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Peterson's method</td>
<td>100.00</td>
<td>118.00</td>
<td>158.00</td>
<td>--</td>
</tr>
<tr>
<td>2.</td>
<td>Months mode curve</td>
<td>122.00</td>
<td>141.00</td>
<td>167.00</td>
<td>183.00</td>
</tr>
<tr>
<td>3.</td>
<td>Probability plot method</td>
<td>113.50</td>
<td>135.50</td>
<td>156.00</td>
<td>173.00</td>
</tr>
<tr>
<td>4.</td>
<td>Von Bertalanffy's equation</td>
<td>122.00</td>
<td>148.00</td>
<td>167.00</td>
<td>183.00</td>
</tr>
</tbody>
</table>

\[
L_\infty = 304.5154
\]

\[
K = 0.1354
\]

\[
-t_0 = 2.8501
\]
### Table 34. Length obtained during different years of growth for *P. maculatum* (female)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Methods employed</th>
<th>I Year</th>
<th>II Year</th>
<th>III Year</th>
<th>IV Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Peterson's method</td>
<td>104.00</td>
<td>149.00</td>
<td>182.00</td>
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</tr>
<tr>
<td>2.</td>
<td>Months mode curve</td>
<td>123.00</td>
<td>148.00</td>
<td>167.00</td>
<td>182.00</td>
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<tr>
<td>3.</td>
<td>Probability plot method</td>
<td>115.50</td>
<td>140.00</td>
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<td>183.00</td>
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<tr>
<td>4.</td>
<td>Von Bertalanffy's equation</td>
<td>123.00</td>
<td>148.00</td>
<td>167.00</td>
<td>182.00</td>
</tr>
</tbody>
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\[
L_{\infty} = 261.0389 \\
K = 0.1857 \\
-t_0 = 2.4679
\]
FIG. 31. Length frequency distribution in males of *P. maculatum* during Dec. 95 to Mar. 96

<table>
<thead>
<tr>
<th>Length in mm</th>
<th>Dec'95</th>
<th>Jan'96</th>
<th>Feb'96</th>
<th>Mar'96</th>
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<tbody>
<tr>
<td>91 - 100</td>
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<td>101 - 105</td>
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<td>106 - 110</td>
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<td>111 - 115</td>
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<td>116 - 120</td>
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<td>126 - 130</td>
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<td>131 - 135</td>
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<td>136 - 140</td>
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<td>141 - 145</td>
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<td>146 - 150</td>
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<td>151 - 155</td>
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<td>156 - 160</td>
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<td>161 - 165</td>
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<td>166 - 170</td>
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<td>171 - 175</td>
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<td>176 - 180</td>
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<td>181 - 185</td>
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<tr>
<td>186 - 190</td>
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</tbody>
</table>

Length in mm
Fig. 31. Length frequency distribution in males of *P. maculatum* during Apr. 96 to Jul. 96

- **Apr'96**
- **May'96**
- **Jun'96**
- **Jul'96**

Length in mm
Fig. 31. Length frequency distribution in males of *P. maculatum* during Aug. 96 to Nov. 96.
Fig. 32. Length frequency distribution in females of *P. maculatum* during Dec. 95 to Mar. 96
Fig. 32. Length frequency distribution in females of *P. maculatum* during Apr. 96 to Jul. 96.
Fig. 32. Length frequency distribution in females of *P. maculatum* during Aug. 96 to Nov. 96
Fig. 33. Size distribution of catches of *P. maculatum* and model progression
Fig. 35. Growth of *P. maculatum* based on probability plot technique (males)
Fig. 36. Growth of *P. maculatum* based on probability plot technique (females)
$L(t) = L_u \left(1 - e^{-at}\right)$
Intercept = La \times (1-e^{-\lambda t})