Chapter - 2

A study on the growth of tiger shrimp *Penaeus monodon* (Fabricius) in a recirculating seawater system
INTRODUCTION

The weight is considered to be the most appropriate parameter to study growth of an animal. The growth is primarily influenced either by intrinsic or genetic differences between species or population (Gentili and Beaumont, 1988; Peterson and Beal, 1989) or by extrinsic or environmental conditions including pH, salinity, temperature, the rate of water exchange, the quality of food available, and the duration of tidal exposure (Seed, 1976; Griffiths and Griffiths, 1987).

Information on the growth of shrimps is important in understanding the nature of the stock and the role played by various classes in the fishery. The knowledge of the condition under which optimum growth is possible and influence of various environmental factors on growth, help in better understanding of the eco-biology of the species. Moreover, these informations also form the basis for the calculations leading to our knowledge on mortality, survival rate, recruitment and population dynamics. It also helps to know the effects of various environmental parameters with the help of comparison of the rate of growth in different ecosystems. The result of such studies go a long way in proper management of the fishery. As detailed observations on the growth of *Penaeus*
monodon (Fabricius) under laboratory conditions are lacking, the present study was undertaken and reported in this paper.

MATERIAL AND METHODS

Samples for the present investigation were collected from a commercial hatchery from a single broodstock. The postlarvae (PL20) of *P. monodon* were transported to the laboratory carefully and with sufficient aeration. These postlarvae were treated with 10 ppm formaldehyde solution at first and then acclimated for 24 hours in 1000 l FRP tanks.

The growth study of *P. monodon* was carried out in 5 glass aquarium tanks (cap 200 l) connected with a recirculating seawater system where physical, chemical and biological parameters were controlled (Plate 2.1). The recirculating seawater system was also provided with a series of biofilters to control excess amount of nitrogenous waste and ammonia produced by the postlarvae (Chatterji *et al*., 1998, unpublished data).

In each glass aquarium tank, ten number of postlarvae of more or less same size, were kept for experimental purpose. The salinity (35 x 10⁻³), temperature (30° C) and pH (8.2) was maintained constant in each of the experimental tank
throughout the period of study. The postlarvae were fed up to 50 days with a formulated feed (Starter - B of Higashi 3000) and then with Grower A (Higashi 3000). The postlarvae were fed twice in a day with 10% of their body weight.

The unfed food particles and moult if any, were siphoned out every day. Weight of each of the individuals was recorded on an Electronic Digital Scale single pan balance (Essae Digi Model DC-80) after blotting the body of the animal on a blotting paper for the purpose of removing the water. The salinity of the experimental tank was measured with the help of a Refractometer (Atago, S/Mill, Japan) whereas, the pH with the help of a portable pH tester after calibrating it with standard pH buffers of 4.4, 7.0 and 9.2. The temperature in each experimental tank was maintained by thermostatically controlled heaters (range 20° to 100±1° C). Growth study was carried out for a period of three months. Mean weekly weights of the shrimps was determined and specific growth (G) was calculated following the equation given by Bal and Jones (1960):

\[
G = \frac{\log_e W_2 - \log_e W_1}{(T_2 - T_1)} \times 100
\]
where \( W_2 \) and \( W_1 \) were the weights of the animal at the time \('T_2'\) and \('T_1'\), respectively. \( W_1 \) and \( W_2 \) were the weights at the beginning and at the end of each of the weeks. Thus \( T_2 - T_1 \) was 1 in all sets of the experiment.

The von Bertalanffy's growth equation as described by Beverton and Holt, (1957) was fitted to the weight to determine the growth attained by the shrimps.

RESULTS

The growth of \( P. \) monodon was rapid at the early phase followed by a gradual decrease in the later period of the experiment (Fig. 2.1). The specific growth rate was decreased from 46.36\% to 11.69\% as weight of the shrimp increased during a period of 90 days (Fig. 2.2 and Table 2.1). Similarly the relative growth as percentage of increment in weight, was also decreased from 37.04\% in the first week to 11.8\% in the 13th week (Fig. 2.3). However, the increment in growth was relatively lesser in the early phase as compared to the later phases (Fig. 2.3). A maximum increment in growth was noticed during the 5th and 7th weeks whereas, an increasing trend in the growth increment was noticed from the 9th to the 13th weeks.
The method developed by Ford (1933) and Walford (1946) of plotting \( W_{t+1} \) against \( W_t \) was followed to fit the growth equation for the calculation of asymptotic weight (\( W_x \)). The ultimate weight recorded of \( P. \text{monodon} \) was determined graphically at a point where the weight at \( W_t \) equalled the weight at \( W_{t+1} \). A line at 45° plotted through the zero point which intersected the curve and indicated the asymptotic weight (\( W_x \)) (Fig. 2.4).

**Fitting the von Bertalanffy's growth equation**

The von Bertalanffy's growth equation for weight is described as:

\[
W_t = W_x \left[1 - e^{-K(t-t_0)}\right]
\]

In the above equation \( W_t \) is the weight at time 't', \( W_x \) is the asymptotic weight, 'e' is the base of the natural logarithm, 'K' the coefficient of catabolism, 't' the time of observation and 't_o' the growth at which the juveniles of \( P. \text{monodon} \) belong to zero g weight.

The values calculated for the above mentioned parameters were:

- \( W_x = 300 \text{ g} \)
- \( K = 0.013 \)
- \( t_o = -0.0769 \)
The values for 't₀' were calculated by the equation:
\[ t₀ = \left[ \log_e W_∞ + Kt₀ \right] - \log_e W / K \] (Ricker, 1958).

The values of \( \log_e W_∞ + Kt₀ \) of the above equation is the Y-axis intercept (5.702) in Fig. 2.5 where \( \log_e (W_∞ - W_t) \) is plotted against the mean weekly weights. These values were substituted in the above equation and 't₀' was calculated. Thus the growth equation could be expressed as:
\[ W_t = 300 \left[ 1 - e^{-0.013(t + 0.0769)} \right] \]

The theoretical weight attained in each week by each shrimp as calculated by the von Bertalanffy's equation showed a closed agreement with the average observed weight (Fig. 2.6 and Table 2.1) and described the growth of shrimps adequately in terms of weight where environmental parameters like salinity, pH, temperature and feed were kept constant in a recirculating seawater system.

**DISCUSSION**

Growth is considered to be one of the most important parameters in solving various problems related with the conservation, management and farming of commercially important species of the shrimps. The changes in growth rate and survival of penaeid shrimps in a particular environment...
are useful indicators of stressful culture condition because environmental factors are considered to be the major determents to growth. Variation in growth of aquatic animals is also of practical interest as it influences the harvest of fisheries and aquaculture system. Maximizing growth is critical to the development of commercial shrimp culture and food availability. Variation in growth is also important for the evaluation of processes related to the life history of the penaeid shrimps.

The study of growth of shrimps collected from the natural habitat is not an accurate method because of short life span and protracted spawning behaviour of the shrimp. These shrimps are migratory in behaviour and in a particular habitat both immigrants and emigrants are grouped together. This causes mixing of different stocks of populations and creates problem in the estimation of growth following various methods for studying the growth like size frequency distribution and mean sizes of the sample. Subrahmanyam (1973a) suggested that the growth in shrimps can be studied in brackish waters or estuarine ecosystems if these bodies are cut off from the sea for a prolonged period. This normally happens when the sand bars are formed at the mouth of these water bodies. The study on growth rate becomes easy from the period of the closure of the estuary or brackish water bodies till the reopening of the
mouth. However, the estimation of growth is considered to be more accurate if the shrimps are allowed to grow with known age, where different environmental parameters are also monitored, effectively (Subrahmanyam, 1973a, Guru et al., 1993).

*P. monodon* is one of the most important species as it grows rapidly among all penaeids in an aquaculture system. It is the only species that attained maximum size (250 mm) in one year in the estuaries and backwater areas or bodies. It is one of the best species for culture in coastal impoundments and paddy fields in Kerala (Subrahmanyam, 1973a).

The growth rate in *P. monodon* studied under simulated condition has been reported to be relatively less as compared to the growth rate observed in natural conditions (Subrahmanyam, 1973a). Guru et al. (1993) while studying the growth of *P. monodon* cultured in a natural pond for a period of 135 days, reported a maximum weight of 26.3 g in 135 days. However, Manik et al. (1978) observed that the juveniles of *P. monodon* attained a weight of 50 g during the same period. In the present investigation it was found that in a recirculating seawater system, the shrimps attained a maximum weight of 59.03 g in 90 days as compared to the 26.3 g in 135 days (Guru et al., 1993) and 50 g (Manik et al.,
The growth was relatively higher in the present investigation as compared to the investigations carried out by different workers. However, the growth was relatively low as compared to the shrimps grown under natural conditions. The reason might be the size of the aquarium tanks where space probably was a limiting factor.

Huang et al. (1975) observed that *P. monodon* attained a weight of 20 g in 5 months in an experimental culture system. In another study carried out by Apud et al. (1981) a weight of 7.24 g has been attained when the stocking density of the shrimp was kept at 20 pcs/m² and 26.6 g when the stocking density was 2.5 pcs/m². Liu and Mancebo (1983) found an average weight of 31.5 g within 106 days by feeding the animal with pelletized feed whereas, Liao (1977) reported a maximum weight of 25 g and 44 g when the shrimps were grown for 75 and 136 days respectively under natural conditions. However, Cheng and Chen (1990) observed a growth of 26.64 g when the shrimps were cultured for a period of 185 days.

There have been various attempts made to study the growth rate in terms of increase in the length of the shrimps. In India, the postlarvae of *P. monodon* has been found to attain a size of about 160-170 mm within 6 months (Subrahmanayan, 1973a) whereas, in Philippines it is reported to be 250 mm in
one year (Villadolid and Villaluz 1950). Similarly, in Indonesia, a maximum size of 200-250 mm was observed by Djajadiredja and Sachlan (1955). A maximum size of 28.2 mm has been reported within 26 days and 116.7 mm in 182 days when the shrimps were cultured with Chanos chanos (Kubo, 1956).

The growth in penaeid shrimps is a biological process and in farming practice, the size of the shrimp plays an important role as marketable shrimps of different sizes have different values. The knowledge on growth of shrimps at different stages is a useful tool for business purpose as the growth rate of penaeid shrimps is extremely diversified. It is expected that by undertaking such type of studies, a convenient and reliable short-term strategy will be evolved to evaluate the physiological condition of the cultured shrimps and detection of the effect of sub lethal stress caused due to change in the environmental conditions.

**ABSTRACT**

The growth of *Penaeus monodon* (Fabricius) was studied in the laboratory in a seawater recirculating system for a period of three months. A maximum growth (46.36%) was recorded at an early stage followed by a gradual decrease in the later period (11.69%). The environmental parameters like
salinity, pH, temperature were kept constant throughout the period of study.

The growth pattern of the shrimp fitted well with the von Bertalanffy's growth equation and can be described as: 

$$W_t = 300 \left[1 - e^{-0.013(t + 0.0769)}\right]$$
Plate 2.1: A recirculating seawater system
Table 2.1: Average observed weight, calculated weight, relative growth, specific growth and growth increment.

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Average observed weight (g) (± Mean)</th>
<th>Weight determined by growth equation ( W_t = W_s [1-e^{-\lambda(t-t_0)}] )</th>
<th>Relative growth (%)</th>
<th>Specific growth (%)</th>
<th>Growth increment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.86±0.67</td>
<td>4.22</td>
<td>37.04</td>
<td>46.36</td>
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</tr>
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<td>2</td>
<td>5.40±0.65</td>
<td>8.21</td>
<td>28.51</td>
<td>33.63</td>
<td>1.54</td>
</tr>
<tr>
<td>3</td>
<td>8.03±1.46</td>
<td>11.99</td>
<td>32.75</td>
<td>39.79</td>
<td>2.63</td>
</tr>
<tr>
<td>4</td>
<td>10.30±1.30</td>
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<td>22.03</td>
<td>24.91</td>
<td>2.27</td>
</tr>
<tr>
<td>5</td>
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<td>20.46</td>
<td>31.14</td>
<td>37.33</td>
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</tr>
<tr>
<td>6</td>
<td>19.30±1.63</td>
<td>24.66</td>
<td>22.48</td>
<td>25.51</td>
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<tr>
<td>7</td>
<td>25.10±2.83</td>
<td>28.90</td>
<td>23.10</td>
<td>26.28</td>
<td>5.80</td>
</tr>
<tr>
<td>8</td>
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<td>10.03</td>
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<tr>
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<td>46.46</td>
<td>10.79</td>
<td>11.48</td>
<td>4.60</td>
</tr>
<tr>
<td>12</td>
<td>52.43±3.93</td>
<td>50.99</td>
<td>18.74</td>
<td>20.84</td>
<td>9.83</td>
</tr>
<tr>
<td>13</td>
<td>59.03±7.26</td>
<td>55.59</td>
<td>11.18</td>
<td>11.69</td>
<td>6.60</td>
</tr>
</tbody>
</table>
Fig. 2.1: Mean weekly weight (g) attained by *P. monodon*.
Fig. 2.2: Weekly changes in specific growth (%) of *P. monodon*.
Fig. 2.3: Weekly change in growth increment and relative growth rate (expressed as percentage of total weight) of *P.* monodon.
Fig. 2.4: Ford-Walford plot of growth of *P. monodon*.
Fig. 2.5: $\log_e (W_\infty - W_t)$ plotted against weight for estimation of $t_0$ of $P.\ monodon$. 
Fig. 2.6: Weekly comparison between observed weight and calculated weight of *P. monodon*.