

## GROWTH OF THE GREEN MUSSEL, *PERNA VIRIDIS* L., IN A SEA WATER CIRCULATING SYSTEM

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### ABSTRACT

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Growth of the green mussel, *P. viridis* L., was studied in a sea water circulating system for 12 months. The maximum growth rate was recorded during March-May, coinciding with the maximum abundance of phytoplankton. The other hydrological parameters did not show any marked correlation with growth rate, which was chiefly influenced by the availability of food. A significant relationship was noted between the shell length and total weight of the mussel, i.e.

$$W = 3.7522 L^{3.007}$$

The maximum growth rate (91.62%) was recorded at an early stage and was followed by a sharp decline to 5.78%. The growth pattern of the mussel fitted well with the von Bertalanffy growth equation:

$$Lt = 110 (1 - e^{-0.1124 (t + 0.0389)})$$

### INTRODUCTION

The green mussel, *Perna viridis* L., is widely distributed along the Indian coasts. It contributes to a sustenance fishery, particularly along the south-west coast (Jones and Alagarwami, 1973). Mussels are a cheap source of protein and have been cultured with great success at various places in India (Qasim et al., 1977; Nagappan Nayar, 1980; Parulekar et al., 1982). Much information is available on green mussel ecology and various attempts have been made to study the cultivation problems. Most of the earlier works report on natural bed or open sea mussel culture but this study describes the growth rate of mussels in an unfiltered sea water circulating system.

### MATERIALS AND METHODS

Mussel spat measuring 5-10 mm in length were collected from a natural bed during March 1982, cleaned, and allowed to attach to a rope hanging

from a raft as described by Qasim et al. (1977). About 100 individuals were attached to a rope and ten such ropes were transferred to a 10 m<sup>3</sup> fibre-glass experimental tank containing sea water pumped daily by a stainless steel 15 HP centrifugal pump (Chatterji et al., 1983). Transplanted mussels on ropes were monitored regularly and mortality, if any, recorded. However, mortality observed was negligible.

Hydrological parameters of the tank sea water were determined fortnightly using the methods of Strickland and Parsons (1968). The phytoplankton cells were counted by collecting 250 ml sea water samples from the inlet supply line of the fibre-glass tank. Lugol's iodine (0.5 ml) solution was added immediately and a subsample of 1 ml was withdrawn into a Sedwick Rafter cell for estimating total counts.

Monthly samples of 20 tank mussels were taken at random and measured to the nearest 1 mm with Vernier Calipers and the weights determined with a single pan Sartorius balance. The specimens were discarded after recording the measurements. The relationship between total length and mussel weight was worked out by regression analysis (least square method). The weight of each individual at each length interval was calculated by the allometric equation  $W = a L^b$  (where  $W$  is the weight of the mussel,  $L$  the length and  $a$  and  $b$  are additive and multiplying constants, respectively) and the length-weight curve was plotted.

Mean monthly length attained by the mussels was calculated and specific growth rate ( $G$ ) for each month was found by the following formula:

$$G = [(\log e L_2 - \log e L_1)/(T_2 - T_1)] \times 100 \text{ (Bal and Jones, 1960)}$$

where  $L_2$  and  $L_1$  are the lengths at the times  $T_2$  and  $T_1$ , respectively. The von Bertalanffy growth equation was fitted to the total length as described by Chatterji et al. (1979).

## RESULTS

The hydrological factors and their relationship with growth rate of the green mussel are shown in Fig.1 and the the specific growth rates are given in Table I. Growth rate was maximum during March-June and lowest during September-October; this coincided with the abundance of phytoplankton cells which was highest during March-May and lowest during the monsoon (June-September). There was a subsequent increase in the post-monsoon (October-June) resulting in a further increase in the growth rate during the post-monsoon.

Although water temperature did not show any consistent relationship with the growth rate, a high temperature during April-May coincided with a high growth rate in the same period. Salinity was found to be positively correlated with the growth rate of the mussel. High growth rate coincided with high salinity (Fig. 1). Dissolved oxygen, however, did not show any consistency in relation to mussel growth.

A significant relationship was found between mussel length and weight which can be expressed as  $W = 3.7522 L^{1.3007}$ . A smooth curve in Fig. 2 shows that increase in weight in relation to length is not apparent up to the length of 10 mm but is significant above 10 mm.

Seasonal growth has also been studied from the mean length attained by the green mussel in different months of the year, and the values of growth

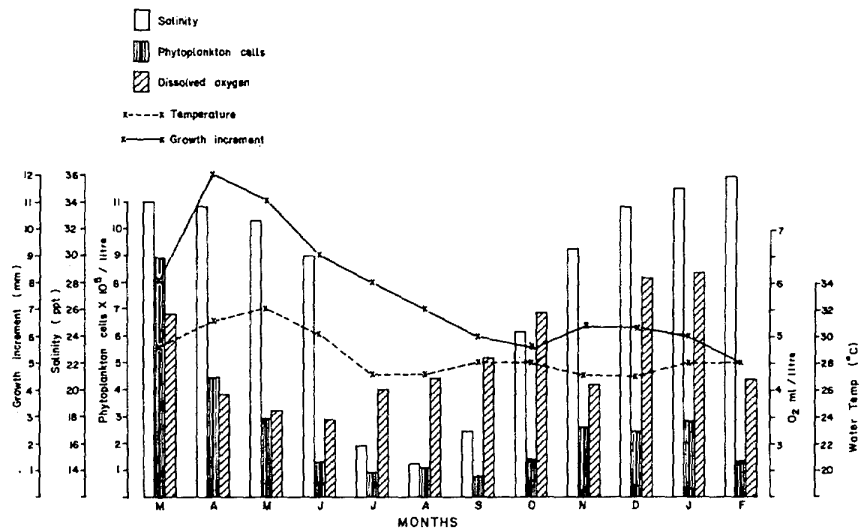


Fig. 1. Hydrological factors and growth rate of *Perna viridis*.

TABLE I

Average observed length and specific growth rate in each month

Month	Average observed length (mm) (mean $\pm$ S.E.)	Length determined by growth equation $Lt = L_{\infty} (1 - e^{-K(t-t_0)})$	Specific growth (%)
March	8 $\pm$ 1.089	12.6	91.62
April	20 $\pm$ 2.178	22.6	43.83
May	31 $\pm$ 2.722	31.9	35.48
June	40 $\pm$ 3.267	40.3	18.23
July	48 $\pm$ 4.356	47.8	13.61
August	55 $\pm$ 3.049	54.4	10.35
September	61 $\pm$ 3.484	60.2	7.87
October	66 $\pm$ 3.158	65.6	8.70
November	72 $\pm$ 5.336	70.2	8.00
December	78 $\pm$ 2.831	74.5	7.41
January	84 $\pm$ 6.969	78.2	5.78
February	89 $\pm$ 2.069	81.7	—

increment and relative growth as percentages of increment in total length are shown in Fig. 3. A rapid growth rate (in length) observed at an early stage was followed by a gradual decline in growth rate in the later stages (Fig. 3). Specific growth rate also decreases, from 91.62% to 5.78% (Table I), as the length increases.

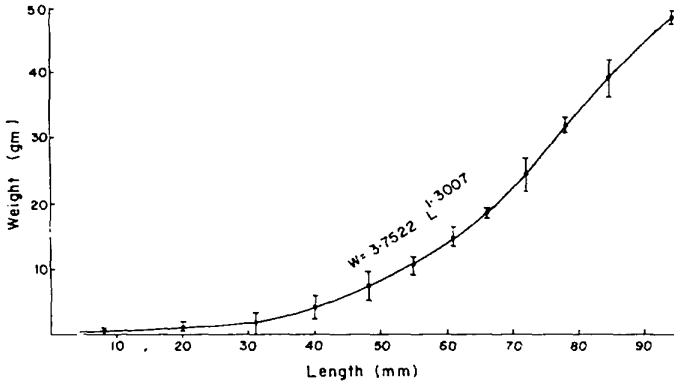


Fig. 2. Shell length and total weight relationship of *Perna viridis* (mean  $\pm$  S.E.).

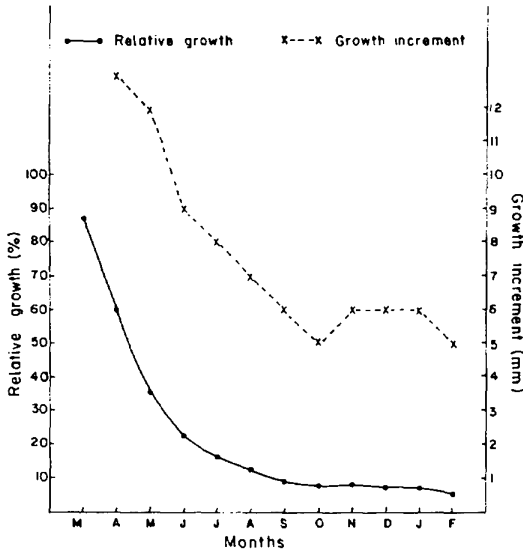


Fig. 3. Seasonal change in growth increment and relative growth rate (expressed as percent of total length per annum) of *Perna viridis*.

### Fitting the growth equation to the length

The method developed by Ford (1933) and Walford (1946) of plotting  $L_{t+1}$  against  $L_t$  was followed here to fit the growth equation. The ultimate length attained by *Perna viridis* L. is determined graphically at a point where the length at  $L_t$  equals the length at  $L_{t+1}$ . A line at  $45^\circ$  drawn through the zero point intersected the curve and this point of intersection indicated the asymptotic length ( $L_\alpha$ ) (Fig. 4).

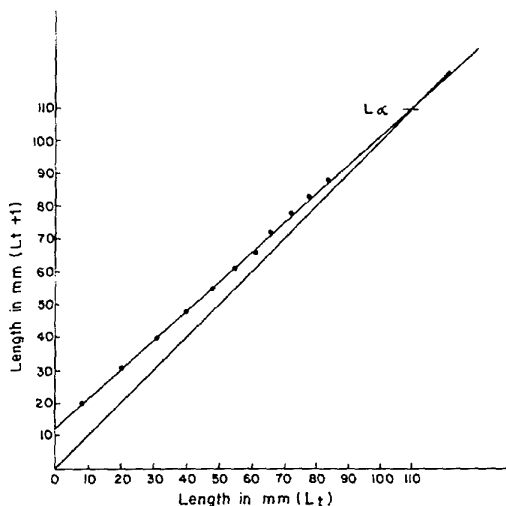


Fig. 4. Ford-Walford plot of growth of *Perna viridis*.

### Fitting the von Bertalanffy growth equation

The von Bertalanffy growth equation is expressed as:

$$L_t = L_\alpha (1 - e^{-K(t-t_0)})$$

where  $L_t$  is the length at time  $t$ ,  $L_\alpha$  is the asymptotic length,  $e$  is the base of the natural logarithm,  $K$  the coefficient of catabolism,  $t$  the time of observation, and  $t_0$  the age at which the mussel belongs to zero mm size.

The values estimated for the parameters are:  $L_\alpha = 110$  mm;  $K = 0.1124$ ;  $t_0 = -0.0889$ .  $t_0$  is calculated by the following formula given by Ricker (1958):

$$t_0 = [(\log e L_\alpha + K t_0) - \log e L_\alpha] / K$$

The value of  $\log e L_\alpha + K t_0$  is the Y-axis intercept (4.69) in Fig. 5, where  $\log e (L_\alpha - L_t)$  is plotted against mean monthly length. Substituting these values in the above formula,  $t_0 = -0.0889$  and the growth equation could be expressed as:

$$L_t = 110 (1 - e^{-0.1124 (t + 0.0889)})$$

The theoretical length in each month determined by this formula showed a close agreement with the average observed length attained by the mussel (Table I). It clearly indicates that the von Bertalanffy growth equation describes the growth of *Perna viridis* L. adequately as the mussels were taken from the same environment throughout the period of study.

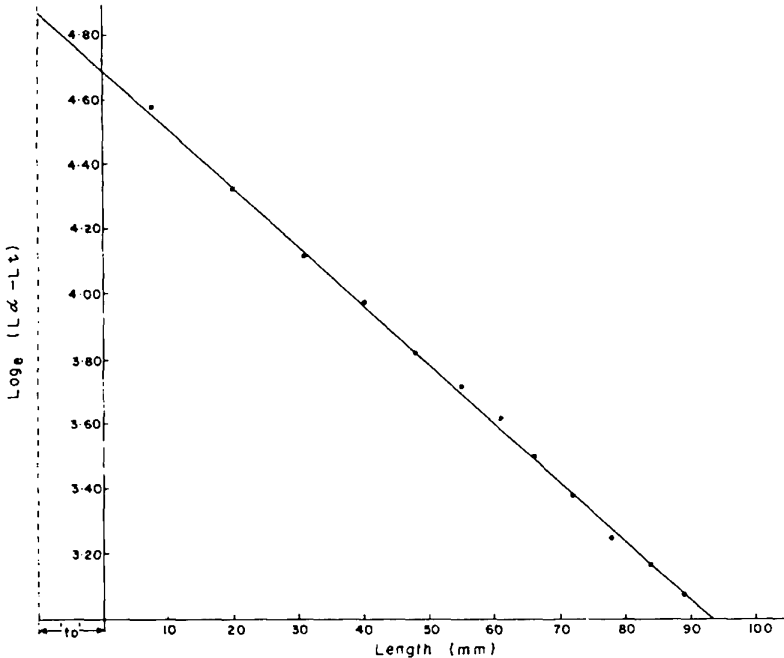


Fig. 5.  $\text{Log } e (L_{\infty} - L_t)$  plotted against length for estimation of  $t_0$  in *Perna viridis*.

## DISCUSSION

Bivalve growth has been studied successfully in waste recycling waters (Mann and Ryther, 1977) and in an upwelling aquaculture system (Roels et al., 1975) using phytoplankton cells injected into the medium for food. In the present study, the mussels only had access to the natural phytoplankton available in unfiltered sea water.

The interaction of salinity, temperature, availability of food and current in a particular environment is complex and it is difficult to estimate the exact effect of a particular parameter on the growth rate. However, the growth rate was found to be related to the availability of phytoplankton which forms the main food of the mussel. Raft-grown mussels have higher growth rates than mussels in natural beds (Mason, 1971; Qasim et al., 1977),

possibly because they are freely suspended in the water column and therefore have more access to phytoplankton food. In contrast, mussels in natural beds are overcrowded, stratified, and only have access to food in the water immediately above them. This probably results in a decreased growth rate. Mussel growth is reduced when food is scarce (Parulekar et al., 1982). Furthermore, Seed (1976) observed that mussels in the upper littoral zone showed a lower growth rate than sublittoral mussels, probably because the latter are constantly submerged and therefore feed longer. Changes in salinity and temperature significantly affected green mussel growth in the present study. This reinforces previous work by Flaws (1972), Dare and Davies (1975), Newell (1976), Qasim et al. (1977) and Hickman (1979).

Bivalve growth rate can be measured by the shell length increment time. The growth rate is faster at an early age than in the later stages of the life cycle (Hickman, 1979). The present study indicates that the metabolic activity is reduced with age, which accounts for the decrease in growth rate from 91.62% to 5.78%.

The relationship between length and weight was found to be significant ( $r = 0.93$ ) in mussels measuring more than 10 mm in length. The calculated  $b$  value is not significantly different from 1.3007, which indicates isometric growth of the mussel. The  $b$  value calculated by other workers for the green mussel varies from 2.4 to 4.5 (Rao et al., 1975; Shafee, 1976).

A comparison of the growth of green mussel in three different environments (floating raft, circulating sea water system and a natural bed) is given in Table II. The average annual growth observed in the natural environment was 60 mm while mussels grown on a raft showed an annual growth of 92.7 mm and in circulating unfiltered sea water 89 mm. This indicates that in a circulating system the mussels adapted well to the changing conditions in the laboratory and the growth was comparable to mussels grown on rafts in the open environment. However, in view of the fact that the establishment and operation of a circulating sea water system involves high capital and recurring costs, the applicability of the results of the present study to commercial production of mussels needs careful evaluation for economic feasibility.

TABLE II

A comparison of the mean monthly growth rate of *Perna viridis* in different environments

Habitat	Annual mean growth (mm)	Source
Intertidal natural bed	60.0	Qasim et al. (1977)
Subtidal raft culture	92.7	Parulekar et al. (1982)
Laboratory circulating seawater	89.0	Present study

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## REFERENCES

- Bal, J.N. and Jones, J.W., 1960. On the growth of brown trout of Llyn Tegid. Proc. Zool. Soc. Lond., 134: 1-41.
- Chatterji, A., Siddiqui, A.Q. and Khan, A.A., 1979. Studies on the age and growth of the bata, *Labeo bata* (Ham.) (Cyprinidae, Teleostei), from the river Kali, India. Hydrobiologia, 63: 167-179.
- Chatterji, A., Ingole, B.S. and Parulekar, A.H., 1983. Seawater circulating system and an aquaculture laboratory. Mahasagar, 16(1): 69-74.
- Dare, P.J. and Davies, G., 1975. Experimental suspended culture of mussels (*Mytilus edulis* L.) in Wales using spat transplanted from a distant settlement ground. Aquaculture, 6: 257-274.
- Flaws, D.E., 1972. Observations on mussel biology in the Cook Strait area. In: Report on Mussel Cultivation Seminar, October 1971. Tech. Rep. N.Z. Fishing Ind. Board, 5: 14-20.
- Ford, E., 1933. An account of the herring investigations conducted at Plymouth during the years from 1924-1933. J. Mar. Biol. Assoc. U.K., 19: 305-384.
- Hickman, R.W., 1979. Allometry and growth of the greenlipped mussel, *Perna canaliculus* in New Zealand. Mar. Biol., 51: 311-327.
- Jones, S. and Alagarwami, K., 1973. Mussel fishery resources of India. Proc. Symp. Liv. Res. Seas India, Central Marine Fisheries Research Institute, Cochin, India, pp. 641-647.
- Mann, R. and Ryther, J.H., 1977. Growth of six species of bivalve molluscs in a waste recycling aquaculture system. Aquaculture, 11: 231-245.
- Mason, J., 1971. Mussel cultivation. Underwater J., 3(2): 52-59.
- McLean, J.L., 1972. Mussel culture: methods and prospects. Aust. Fish. Pap., Fish. Div., Dep. Prim. Ind., Canberra, 20: 1-13.
- Nagappan Nayar, K., 1980. Present status of mussel culture in India. In: Workshop on Mussel Farming, held at Madras, India, 25-27 Sept. 1980. Centre of Advanced Studies in Mariculture; Central Marine Fisheries Research Institute, Cochin, India, CMFRI-CAS/MF/80/BP-3, pp. 1-10.
- Newell, R.C. (Editor), 1976. Adaptations to Environment. Essays on the Physiology of Marine Animals. Butterworths, London, Boston, 525 pp.
- Parulekar, A.H., Dalal, S.G., Ansari, Z.A. and Harkantra, S.N., 1982. Environmental physiology of raft-grown mussels in Goa, India. Aquaculture, 29: 83-93.
- Qasim, S.Z., Parulekar, A.H., Harkantra, S.N., Ansari, Z.A. and Nair, A., 1977. Aquaculture of green mussel *Mytilus viridis* L. Cultivation on ropes from floating rafts. Indian J. Mar. Sci., 6: 18-25.
- Rao, K.V., Krishnamurthy, L. and Dwivedi, S.N., 1975. Biology of the green mussel, *Mytilus viridis*. Indian J. Mar. Sci., 4: 189-197.
- Ricker, W.E., 1958. Handbook of Computation for Biological Statistics of Fish Populations. Fish. Res. Board Can. Bull. No. 119.



- Roels, O.A., Hames, K.C. and Sunderlin, B., 1975. The potential yield of artificial upwelling mariculture. In: G. Persoone and E. Jaspard (Editors), Proc. Tenth Eur. Mar. Biol. Symp. Ostend, Belgium, 17-23 Sept. 1975. Vol. 1. Universa Press Wetteren, pp. 385-394.
- Seed, R., 1976. Ecology. In: B.L. Bayne (Editor), Marine Mussels: their Ecology and Physiology. IBP 10, Cambridge University Press, London, pp. 13-66.
- Shafee, M.S., 1976. Studies on the various allometric relationships in the intertidal green mussel, *Perna viridis* L. of Ennore, Madras (1976). Indian J. Fish., 23(1/2): 1-9.
- Strickland, J.D.H. and Parsons, T.R., 1968. A practical handbook of seawater analysis. Fish. Res. Board Can. Bull., No. 167, pp. 1-310.
- Walford, L.A., 1946. A new graphic method of describing the growth of animals. Biol. Bull. (Woods Hole, Mass.), 90: 141-147.