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A Comparative Study on the Growth of Black Clam (Villorita Cyprinoides) In Cochin Estuary with Special Emphasis on Impact Of A Salinity Barrier At Thannemukkom

Authors
A.U.Arun
Department of Zoology, St.Peter's College Kolenclhery.
Kolenchery- 682 311, Kerala.

Abstract
Temperature, salinity and bottom sediment texture are important hydrographic parameters influencing the growth and survival of bivalves. Regular tidal flow, estuarine circulation and other allied hydrographic parameters in the Cochin Estuary has changed due to regular closure and opening of a salinity barrier at Thannemukkom. The environmental conditions on either side of the barrier (site A at south of bund and site B at north of bund) showed a clear and distinct variation in hydrographical parameters due to the existence of Thanneermukkom bund in between them. At site A the frequency of temperature fluctuation was high and the dominant environment was freshwater when compared with site B. Sediment texture at site A was sandy silt and at site B was silty sand. Even though a clear and perfect shift in modal values from month to month were not observed due to high rate of fishing mortality and regular breeding, monthly shift in modal value showed a slightly parabolic curve at both stations. The theoretical maximum length at Site A (54mm) closely agreed with the estimated maximum length from the population (52.6 mm), similarly at the Site B the theoretical maximum length was 52 mm and observed length was 50.8 mm. Growth rate of smaller clams were found to be higher than larger clams. All the growth models showed that organisms at Site B grow faster than station I, it is established by high "K" values at Site A (0.40) than Site B (0.32). It was observed that total mortality (fishing mortality) was higher at site B (7.2) than site A (3.16).
Key words: bivalves, Thanneermukkom bund, mode, Bertalanffy growth equation.

Introduction

In bivalves, as in other animals, the growth rate of various body parts may not be uniform resulting in changing their relative proportions with increase in size. A variety of environmental factors such as season, region, salinity, temperature etc. influence the growth in molluscs. So an analysis on growth of an organism with respect to its environment is important not only for interpreting its adaptation to environmental changes but also to understand the exact impact of rapidly changing environment on the species. In an environment the response of an aquatic organism varies with the 'physiological state' of an organism. Alterations in the growth pattern occur during definite stages of growth and different seasons, because increasing proportion of energy consumed by the organism is utilized for different purposes, hence a thorough knowledge on the growth of a bivalve mollusc along with its different life stages and seasons is very imperative especially for the successful exploitation of its fishery potential. Due to the paucity of this information in molluscs in general, and in *Villorita cyprinoides* (Fig.1) in particular, an investigation on this aspect has been taken up to fill up the vacuum.

Age and growth studies provide an insight in to age class structure of the stock, changes in abundance and their relation to fishing (FAO, 2010). Longevity and rate of growth are helpful in describing the present status and the past history of a population along with the future course of the fishery, besides this, shell dimensions of clams give an idea about the optimum marketable size of clams. In recent years, considerable emphasis has been given in India to culture the edible bivalve molluscs such as oysters, mussels and clams, since they form a subsidiary fishery in most of the coastal and estuarine regions. Though many species of commercially important bivalves occur along the Indian coast, little attention was paid by past workers on various aspects of growth despite the fact that this field offers a large number of unanswered questions.

Thanneermukkam bund was constructed (1974) to prevent salt-water incursion and to promote two crops of paddy in about 50,000 ha. of low lying fields in the Kuttanadu area(Arun, 2005). The bund has been functional since 1976 and remains closed from January to May every year. This has resulted in drastic ecological changes in the lake, particularly south of the bund, affecting the distribution, survival and abundance of the living resources in the estuary, and causing depletion of the black clam in several localities, besides this dredging conducted in several parts of the estuary has aggravated this problem.

Materials and methods

Study area

Two sampling sites in Cochin estuary were selected for the estimation of natural growth studies of *Villorita cyprinoides*(Fig.1).

Fig.1

One site was selected south of Thanneermukkom bund (Site A) (Fig.2) and another on the north of bund (Site B). Regular fortnight sampling for hydrographic parameters and natural growth studies was carried out from Site A and Site B for a period of two and half years (November 2013 to April 2016).

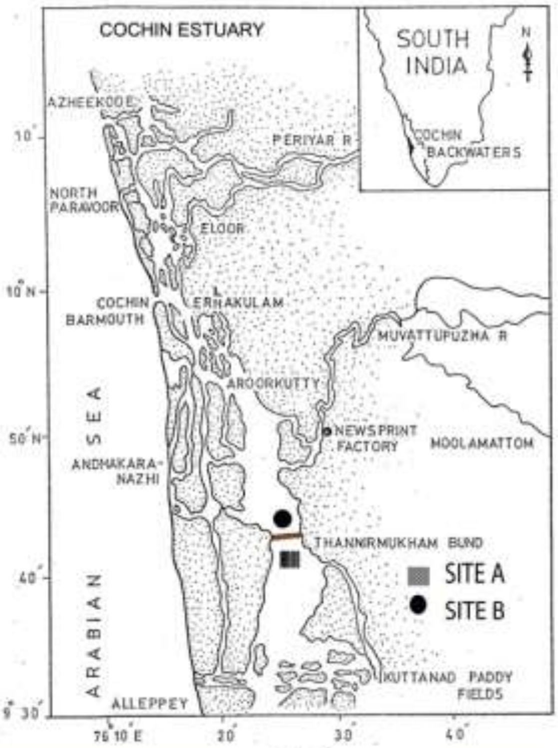


Fig.2

Hydrographic parameters

Bottom samples were taken for measuring Hydrographic parameters. Among different parameters temperature was measured by centigrade mercury thermometer, salinity by Mohr's titration method (Strickland and Parsons, 1968) and sediment texture by the method proposed by Carver (1971).

Growth

Von Bertalanffy growth equation by ELEFAN I (Electronic Length Frequency Analysis) were made use for population study. Growth parameters 'Lα' and 'k' values were estimated using ELEFAN I method in FISAT programme (Gayanilo *et al, 1994*.) (FAO and ICLARM). The recruitment pattern was estimated using FISAT programme.

Study on the growth rate of *Villorita cyprinoides* was based on random samples collected fortnightly from two stations (Stations I and III (Site A and Site B) in Cochin estuary during the period between November 2013 and April 2016. Clams were collected using Van Veen Grab of 0.05 m^2 capacity. Clams along with sediment were collected using the grab, and the sediment was sieved with 5 mm sieve so as to allow the sand to pass through the meshes leaving the clams in the sieve. These clams were then kept it in water of habitat nature. Length, breadth and depth of each clam were measured with vernier calipers correct to one-tenth of millimetre. The greatest anterior-posterior measurement was taken as length.

Shell length was taken as the standard measurement for determining age and growth of the clam *Villorita cyprinoides*. The frequency distribution of length was assessed by taking the class interval as 2 mm. The monthly size frequencies were then converted into percentage of total number of animals present in the sample, which formed the basis for the interpretation of population structure. By using ELEFAN I, progression of the modal value was noted and the growth of the clam was determined.

It is assumed that the growth in terms of length follows the von Bertalanffy Growth Factor (Bertalanffy, 1938,1957) which is given by $Lt = L\alpha\ (1- e - k\ (t - t0))$

Where 'Lt ' is the length at age 't', 'Lα ' is the theoretical maximum length; 'K' is the growth coefficient. Here't_0' is assumed to be zero because ELEFAN routine (Pauly and David, 1981) does not estimate it.

Mortality of clams was determined by Beverton and Holt model (1956). Mortality was estimated by substituting the values in the formula given below.

$$Z = K(L\propto - L^*)/L^* - Lc)$$

Here

Z = Total mortality

K= From VBG model

$L\propto$ = From VBG model

L* = Mean length

Lc = Group showed the highest frequency

$$Z = M+F$$

Here

Z = Total Mortality

M = Natural Mortality

F = Fishing Mortality

If the species is actively fished by the fishermen community Z = F.

Results

Temperature

Significant variation in temperature at different stations during different seasons was observed in this study. While comparing stations on either side of bund, Site A situated south of bund showed frequent fluctuation in temperature varied from 33.8 ^{0} C to 27.1^0 C and at Site B situated north of bund the variation of temperature was between 33.4 ^{0} C and 26^0 C (Graph.1).

Salinity

Site A had a freshwater dominated environment with measurable salinity occurring only during pre – monsoon. At Site B there was a mixed salinity (Graph. 2).

Sediment Texture

It was noted that sediment texture at both stations varied considerably during the study. At Site A the percentage of sand varied between 18.7 % (April) to 95.96 %(January) and silt varied between 3.49 % (January) and 61.49 % (April), whereas the clay varied between 0.55 %(January) and 23.08 %(April). At Site A the substratum was always silty sand except in March, April and May. During March it was sandy silt but in April and May it was clayey silt (Graph.3, Graph.4 and Graph.5)). Average percentage of sand, silt and clay at site B was 96.46, 1.35 and 2.19 respectively. At Site B the dominant sediment texture was sand except during June(Fig.3 and Fig.4).

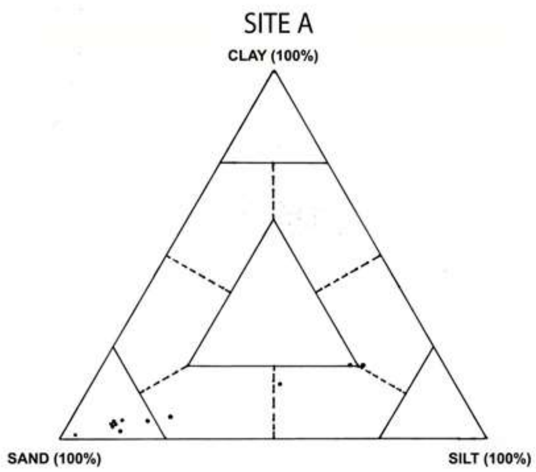


Fig 3

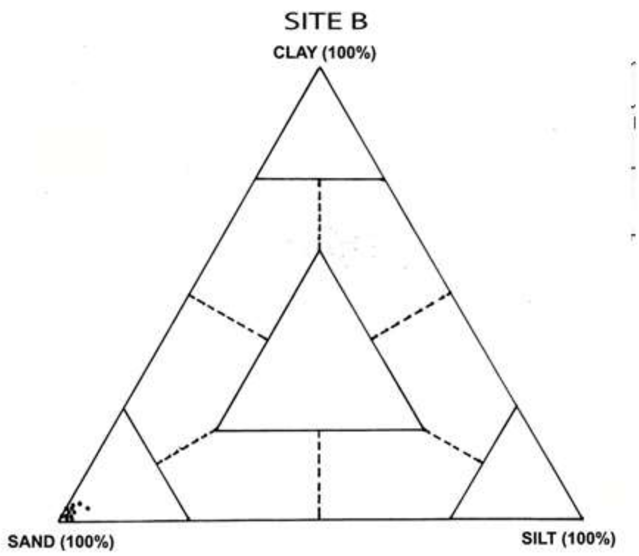


Fig 4

Growth by change in mode

The length frequency analysis of clams was carried out (November 2013 to April 2016) for a period of thirty months. At Site A the size of clam collected for length frequency measurements ranged from 7 mm to 47.2 mm(Graph. 6), whereas at Site B it was between 7.3 mm to 36.4 mm(Graph.7). Length frequency distribution showed that the smallest organisms included in the stock at Site A was during March-May and September-December, at Site B it was during February-May and August-December.

At Site A the mode observed during November '13 was 11mm long. During December ' 13 the mode was shifted to 13.9 and registered an increment of 2.9 mm (Graph 8 a, b,c,d). During next month (January '14) the same mode again shifted to 14.8 mm with monthly increment of 0.9 mm. During February and March no such shift in mode values were noticed. The same mode (mode in January) was again observed during April'14 with a value of 19.1 mm and the average monthly increment was 1.43 mm. During May the mode shifted to 20.9 mm with a monthly increment of 0.8 mm. After a gap of two months the same mode (mode in May) again appeared during August '14 (23.5 mm), the average monthly increment was 0.87 mm. During October'14 the same mode (mode in August) shifted to 24.1 mm with monthly increment of 0.3 mm. The mode observed during December '14 and February '15 was 26.4 mm and 28.1 mm respectively. After a long gap of nine months the same mode (mode in February) was again observed during November '15 with a value of 34.1 mm.

At Site B During February'15 clams with a size of 10.9 mm were observed in the sample, this mode shifted to 16.8 mm in April'15, 20 mm in June '00, 26.2 mm in Septmber'15, 30 mm in November'15 and 32.8 in January'16. Average monthly mode shift calculated was 1.83 mm. Compared to Site A, Site B (Graph.9 a, b,c,d), did not show any gradual mode change from month to month. Monthly variation in modal value showed a slightly parabolic curve at both stations.

Growth by VBG Model

Results obtained from ELEFAN I showed that the Lα values of clams collected from Site A was 54.4 mm (Graph 6) and same for the calms in Site B was 52 mm (Graph.7). 'K' value of 0.4 was observed at station I and 0.34 at Site B. More or less a good fit was observed at both the stations in VBG model. The theoretical maximum length at Site A (54) closely agree with the estimated maximum length from the population (52.6 mm), similarly in the Site B the theoretical maximum length was 52 mm and observed length was 50.8 mm.

VBG equation for Site A: $\mathbf{Lt = 54.4 (1- e^{-0.4(t - t_0)})}$

VBG equation for Site B: $\mathbf{Lt = 52 (1 - e^{-0.34 (t - t_0)})}$

Comparing Site A and B, VBG growth model showed higher growth rate for Site A than Site B. Annual average growth at Site A was 17.94 mm and at Site B was 14.99 mm. Average growth during six months was 9.86 mm and 8.13 mm at Site A and B respectively.

Mortality

It was observed that Total mortality (Fishing mortality) was higher at Site B than Site A. Total mortality (Fishing mortality) at Site A was 3.16 and at Site B it was 7.2. Total mortality (Fishing mortality) at Site B was more or less double to that of Site A. According to VBG model breeding of clam takes places in Site A during early March and at Site B it was during late December

Discussions

Though there was some shift in the mode values from month to month especially in Site A, a clear and perfect shift in the mode values of histogram from one month to another is lacking. Two factors need to be borne in mind in the interpretation of these histograms namely; the effect of (a) fishing and (b) spawning on the size groups of successive samples (Abraham, 1953). According to him in dense clam bed, fishing is said to affect the size groups more or less proportionately, but spawning would mask growth because of large additions to the lower size groups. In this study the sites selected, especially Site B was an active fishing ground and breeding took place twice in an year at both stations. This may be the reason that there was no clear and continuous shift in the modal values from one month to another during study period in both sampling stations especially in Site B.

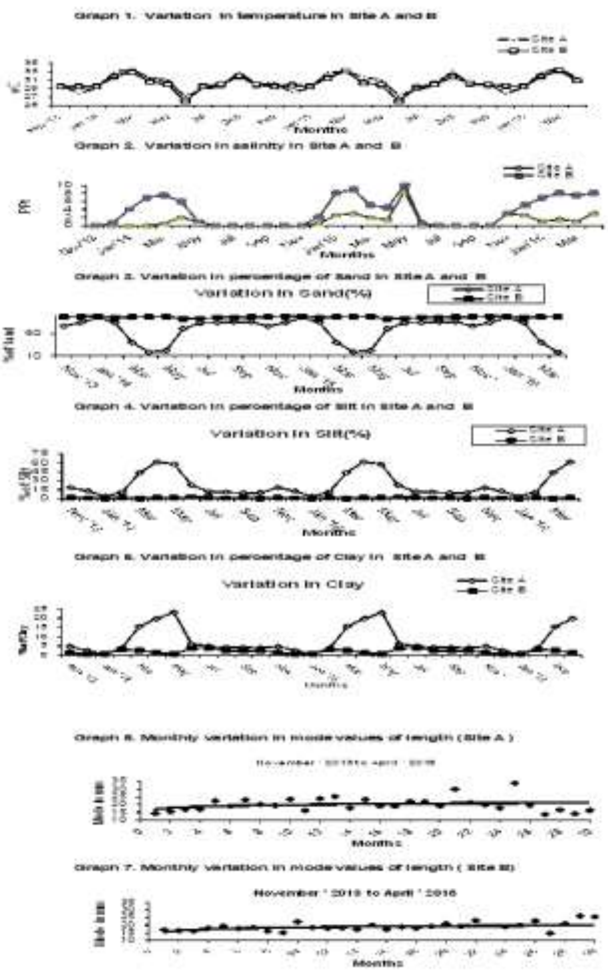
In this study at Site A small clams of size 11 mm were observed during November '13. The clam which attained a size of 11 mm in November '13 should have originated during June/July, which means that small clam grew up to 11 mm in 5-6 months. Kizhakudan (1993) reported that *Villorita* can grow up to 10 mm in 6 months. Variation in mode values showed that average monthly growth of clams from Site A was 1.83 mm. VBG model showed that the reproduction at Site A took place during late December and at Site B it was during early March. These observations coincide with the smear analysis.

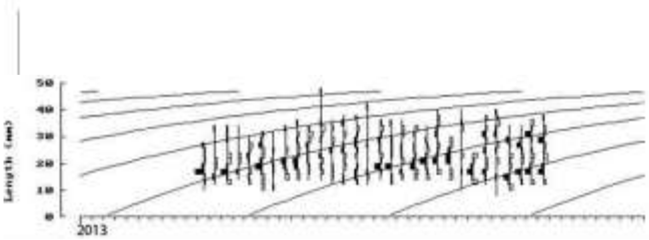
Majority of the published data showed that the very young bivalve molluscs in Indian waters grow quite rapidly in size in their first part of life, but this growth rate decreases as the animals grow in size. This suggests the possibility of a decreased growth rate in the older individuals as an effect of size as well as the age. Cage culture growth studies revealed that smaller clams grow faster than larger ones. Among the four class ranges (1-1.5 cm, 1.5 – 2 cm, 2 – 2.5 cm and 2.5 – 3 cm) selected for studies at all the stations, class range 1-1.5 cm showed higher growth rate and class range 2.5 – 3 cm showed the lower growth rate. Similar observations were made by Rao (1951) in *Katelysia opima*, Abraham (1953) in *Meretrix casta*, Nayar (1955) in *Donax cuneatus*, Alagarswami (1966) in *Donax fabe*, Daniel *et. al.*, (2011) in Galatea paradoxa, Mane (1974) in *Katelysia opima* and Rao (1988) and Thippeswamy and Joseph (1991) in *Donax incarnatus*. Spear and Glud (1957) have reported that environment and not heredity that is important in determining the growth of the soft clam *Mya arenaria*, Comparing Site A and B it was observed that higher growth rate was at Site B than Site A, besides that, Site A showed a decrease in growth rate from January to May in all class ranges. This may be due to the accumulation of silt and clay at station I during the closure of bund (December to May). Swan (1953) and Pratt (1953) reported that linear growth of clams *Mya arenaria* and *Mercenaria mercenaria* was higher in sediment with sandy texture than muddy one. Another reason for better growth at Site B compared to Site A may be the prevalent typical estuarine environment (Saline mixed water) at Site B when compared to that at Site A (freshwater). Abraham (1953) compared two clam beds at Adyar and concluded that growth of clams is much more rapid in the backwater than in the river.

In VBG model the coefficient K is the rate at which the animal's size approaches the theoretical maximum, which can be used to compare the growth of related species or that of same species in varied habitats (Thippeswamy and Joseph, 1991) (Juriæ, 2012). Because 'K' denotes the rate at which the growth decreases to reach the maximum, lower values of 'K' denote faster rate of growth. According to them (Thippeswamy and Joseph 1991) 'K' can be used as an index of the intrinsic development rate of a species and has importance in intra and inter-specific comparison of growth. It was observed that Site B showed lower 'K ' values (0.34) than station I (0.4), so it implies that growth rate is higher at Site B than station I, this result coincides with the results obtained in the cage culture.

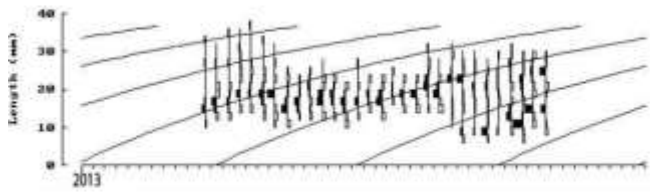
More or less same growth rate was observed at Site B in VBG model analysis and cage growth. But at Site A there was some difference between these two methods. The difference in the rate of growth of these two sets of clams may perhaps be traced to the probable over-crowding and restricted feeding of clams in cage. Difference in growth rate of caged organisms and natural populations were reported by Durve (1970). It was observed that the total mortality of clams in both stations are very high especially at Site B, which was due to the heavy fishing of calms in that area. In the present study the L α and K value was found to be 54.4 mm and 0.4 in Site A, and 52 mm and 0.32 in Site B. Joseph and Joseph (1988) reported that Lα and K of *Villorita cyprinoides* in Gurpur-Nethravathi estuary in Karnataka was 39.96 mm and 0.1289, whereas Nair (1975) reported that in *Villorita cyprinoides var. cochinensis* the calculated Lα was 53.45 mm.

Hence, it can be concluded that existence and periodical opening and closure of Thanneermukkom bund has been destroying the ecology of clam beds and threatening the very existence of clams in the estuary. So proper management measures should be taken to maintain the ecology of clam beds and clam fishery of this estuary.





Graph.8. Modal value change at Site A



Graph.9. Modal value change at Site B

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