Indian J. Fish., 61(4) : 18-23, 2014

Population density, biomass and allometric relationship of shortneck clam *Paphia malabarica* (Chemnitz, 1782) from estuarine regions of Goa, west coast of India

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ABSTRACT

Studies on morphometry and length-weight relationship of *Paphia malabarica* were carried out in samples collected during March 2009 to March 2010 at two locations in Goa. Morphometric relationships between length-breadth and length-depth variables were found to be linearly related. However, the relationship between length-total weight, length-shell weight, length-wet weight and length-dry weight showed a nonlinear isometric pattern at both stations. Data also indicated significant spatio-temporal variation in the density, biomass and dimensions among clams at the two sampling stations. The clam population density was compared with relevant physico-chemical parameters and is discussed in the present study. Chlorophyll *a* of water sample was observed to be the major water quality parameter influencing the density of *P. malabarica* at both the stations.

Keywords: Allometry, Goa, Length-weight relationship, *Paphia malabarica*

Introduction

Bivalve growth is mostly estimated by measuring the shell dimensions and rings or the volume of the animal (Deval, 2001). Allometry involves study of the change in proportion of various parts of an organism as a consequence of growth (Reiss, 1989). Such relationships are often observed between shell parameters and body weight that help to estimate the soft body biomass of living bivalves (Dame, 1972). Various allometric relationships in bivalves have been reported (Thippeswamy and Joseph, 1992; Rivonkar *et al.*, 1993; Gaspar *et al.*, 2001). A number of environmental factors like latitude, depth, shore level, tidal level, currents, water turbulence, wave exposure, type of bottom and type of sediment (Dame, 1972; Claxton *et al.*, 1998; Akester and Martel, 2000) are known to influence shell morphology and relative proportions of any bivalve species. However, no information is available on the allometry of *P. malabarica* and their relationship with environmental parameters from Goa coast, India. *Paphia malabarica* forms abundant and commercially important clam beds in the estuaries of Mandovi (Chicalim) and Zuari (Nerul) from where it is harvested round the year. The present study was undertaken on the allometry of *P. malabarica* to find out the locational variability in the relationship, in response to ambient environment.

Materials and methods

Specimens of *P. malabarica* were collected monthly from Zuari and Mandovi estuaries at Chicalim (lat. 15° 24' 35" N, long. 73° 52' 59" E) and Nerul (lat. 15° 30' 55" N, long. 73° 46' 59" E), respectively, during March 2009 to March 2010 during ebb tide (Fig. 1). Population densities were assessed using standard quadrat (625 cm^2) method. Nine quadrats were placed randomly over each bed in a manner to cover maximum area of the individual bed following random number method. Clams were separated by sieving sediment through 500 µm mesh. Population density was converted into nos. m^{-2} and biomass was expressed as g m^{-2} (wet weight). A total of 1871 specimens ranging in size from 17.5 to 55 mm from Chicalim and 1338 specimens ranging in size from 18 to 45.5 mm from Nerul, were individually measured for their length, breadth, depth, total weight, shell length, flesh wet weight and dry weight. Shell length (the maximum distance along the long axis of the valves), depth (the maximum thickness between the two valves when they are closed) and breadth (the maximum distance along the short axis of

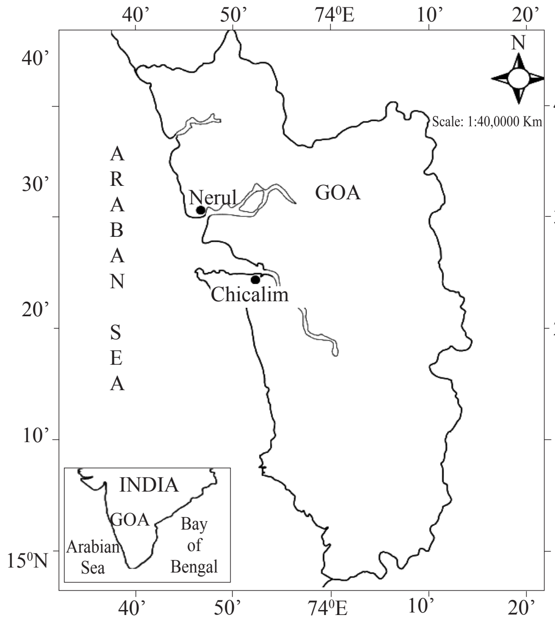

Fig. 1. Map of Goa showing the study area.

the valves) were measured to the nearest 0.01 mm using Vernier calipers. Total weight, shell weight, flesh (wet and dry) weight of individual specimens were determined using a monopan electronic balance (Mettler Toledo) to an accuracy of 0.01g. The dry weight of tissue was obtained after removing the shell and drying it at constant temperature of 60 ºC for 48 h.

The estimation of the morphometric relationships between the shell dimensions (length, depth and breadth) were independently evaluated (Pauly, 1983) using the linear equation $Y = a + bX$, where a (intercept) and b (slope) are constants. The estimation of length-weight relationship was done (Pauly, 1983) by $W = aL^b$, (where *a* and *b* are constants). The degree of association between the variables was evaluated by the correlation coefficient (r) (Pauly, 1983). A study of ecological parameters *viz*., salinity, chlorophyll *a*, was also conducted using standard methods (Parsons *et al*., 1984). Sediment grain size was analysed by pipette method (Buchanan, 1984). Pearson's correlation coefficient was performed for the relation between the different environmental and biological parameters of *P. malabarica*. Two way ANOVA and Tukey's (honestly significant difference) post hoc analysis was performed to find if there is any significant variations in biological parameters between stations and months. Statistical analysis was carried out using Statistica 6 software package.

Results and discussion

Salinity of water varied from 1.00±0.57 psu to 36±1.00 psu (Fig. 2). Higher salinity values during the pre-monsoon and post-monsoon seasons (Fig. 2) may be attributed to low rainfall and less flow of freshwater (Das *et al*., 1972; Dehadrai and Bhargava, 1972). However, decreased salinity during monsoon can be attributed mainly to heavy precipitation and the influx of freshwater (Dehadrai and Bhargava, 1972). In general, Chicalim showed higher salinity than Nerul, probably because of the greater tidal influence, larger opening at the mouth and reduced riverine discharge (Selvakumar *et al.*, 1980). The highest chlorophyll *a* concentration of 4.93±0.35 µg l^{-1} observed during January 2010 at Chicalim (Fig. 2) is due to of high temperature and high saline condition (Pednekar *et al.*, 2011). During monsoon season, both the estuaries receive considerable amount of detrital materials, suspended terrigenous matter through river run-off and the resulting turbidity restricts light penetration in the water column limiting phytoplankton production. Thus, the increased nutrient although are introduced into the system by land run-off, there is no effective utilisation of nutrients by phytoplankton, which is the reason for the low value of chlorophyll *a* (0.70 ± 0.00 µg l^{-1} during August 2009 at Nerul) during monsoon season (Fig. 2). High chlorophyll *a* during post-monsoon in

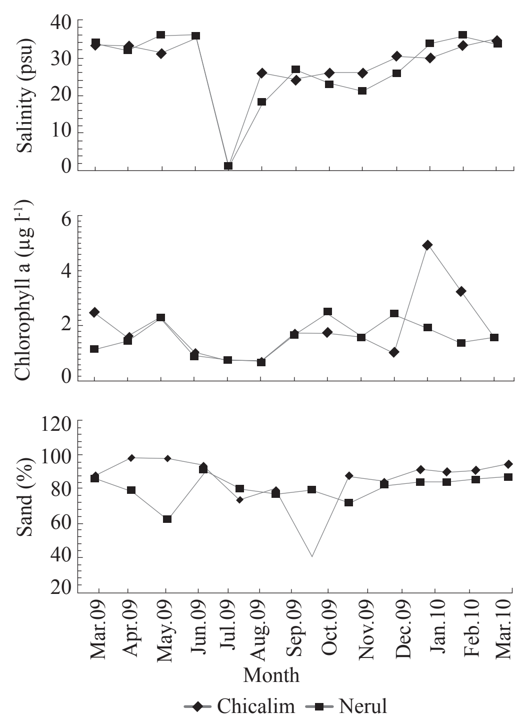

Fig. 2. Monthly variation in hydrological and sediment parameters

the present study agrees with the earlier observation by Krishnakumari *et al.* (2002). Sediment texture analysis revealed sand (40.94±0% to 98.72±0.01%) as a predominant component of bivalve beds (Fig. 2).

The dimensional relationships are important to understand the various aspects of a species such as growth, ecology and physiology (Gaspar *et al*., 2001). The present data showed that the morphometric relationships between length-breadth and length-depth variables are linearly related at both stations The relationship between length-breadth, length-depth, length-total weight, length-shell weight, length-wet tissue weight and length-dry weight are given in Fig. 3 and 4 showed that short individuals are narrow (less height) and low (less thickness), where as long individuals are wide (more height) and high (more thickness) (Fig. 3). This shows that length, breadth and depth are influenced by variation in size (Ramesha and Thippeswamy, 2009). Similar linear relationship has also been reported for bivalve species (Durve and Raja, 1965; Thippeswamy and Joseph, 1992; Thippeswamy and Hemachandra, 2008). Fluctuation in ambient environmental parameters affects the shape of the organisms; hence shape of bivalves gives more information of the dimensional relationship than size (Thippeswamy and Joseph, 1992). The values of equilibrium coefficient (b) of morphometric relationships are used to compare between dimensional growth of related species or same species in different habitats (Thippeswamy and Hemachandra, 2008). In the present study, the *b* values of length-breadth and length-depth for *P. malabarica* were found to be higher than those reported from Shirgaon and Bhatye estuaries of Ratnagiri, Maharashtra (Mohite, 2010).

The nonlinear relationships observed in the present study between length-total weight, length-shell weight, length-wet tissue weight, and length-dry weight at both the stations (Fig. 4) were also reported by others (Thippeswamy and Joseph, 1992; Gaspar *et al.*, 2001; Thippeswamy and Hemachandra, 2008; Charef *et al.*, 2011). The value of *b* obtained for length-weight relationship at both the stations is 3, indicating isometric relationship (Fig. 4). *b* value represents relative growth in weight as compared with length of organism. Gaspar *et al.* (2001) and Charef *et al.* (2011) reported an isometric relationship in different clam species. Positive allometric growth was observed between

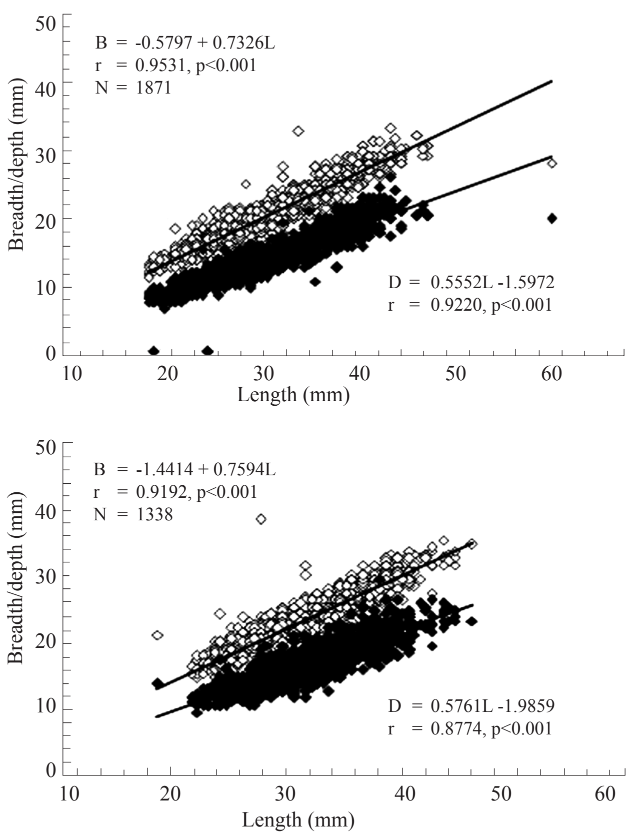

Fig. 3. Length-breadth and length-width relationship of *P. malabarica* at (A) Chicalim and (B) Nerul.

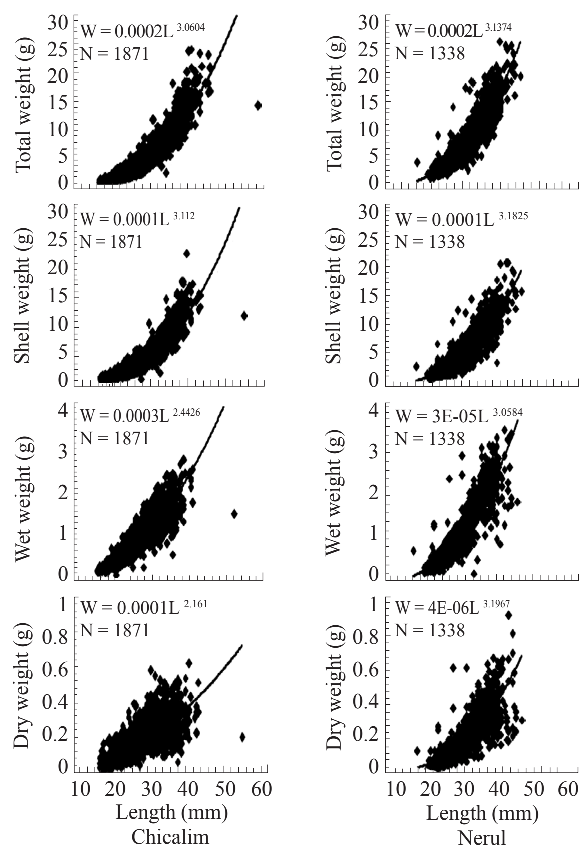

Fig. 4. Length-weight relationships of *P. malabarica* at Chicalim and Nerul.

length-wet weight and length-dry weight relationships at Chicalim (Fig. 4). Relationship between length-breadth and length-depth showed negative allometric relationships at both the stations, indicating that growth in length is superior to the weight gain. The monthly *b* values for length-total weight and length-shell weight showed a similar trend with peak during September at Chicalim and October at Nerul. *b* values obtained for length-weight relationship in *Marcia opima* were close to unity (Suja and Muthiah, 2008). Thippeswamy and Joseph (1992) reported highest *b* value during November in *Donax incarnates*.

Density and biomass of *P. malabarica* showed significant variation between stations ($p<0.001$) and months ($p<0.001$). Post hoc test showed significantly high density of 500±107.77 nos.m^{-2} at Chicalim during post-monsoon period which is the result of breeding and settlement of young ones in the previous months as indicated by smaller shell length (23.71±2.95 mm) (Fig. 5) dominating population (Modassir, 1990; Sivadas *et al.*, 2011). There was significant variation in allometry of *P. malabarica* among stations ($p<0.001$) and months ($p<0.001$). The biomass values varied from 8.68 ± 0.32 g m^{-2} to 25.21 ± 3.45 g m^{-2} at Chicalim, while at Nerul it ranged from 10.50 ± 0.44 g m^{-2} to 37.40 ± 2.19 g m^{-2}. The higher biomass values were found during the period, when the large-sized individuals were the dominant component of the population at both the stations (Fig. 5) as seen by positive correlation ($r=0.96$, $p<0.001$ at Chicalim and $r = 0.96$, $p<0.001$ at Nerul). Similarly the lowest biomass values coincided with the occurrence of an abundant number of young individuals during post-monsoon period (Fig. 5).

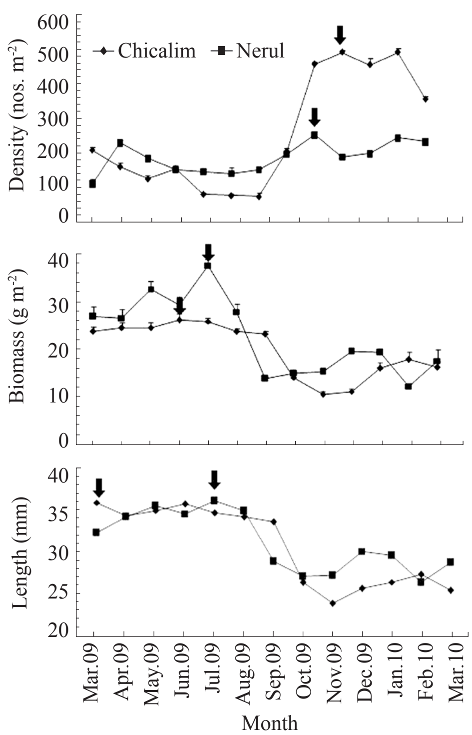

Fig. 5. Average density, biomass and length of *P. malabarica* during the entire study period

The higher density of *P. malabarica* during pre and post-monsoon season coincided with high chlorophyll *a* ($r=0.48$, $p<0.01$ at Chicalim and ($r=0.39$, $p<0.05$ at Nerul) levels in the present study, which is a quantitative measure of the amount of phytoplankton. Rivonkar *et al*. (1993) also demonstrated difference in bivalve growth rate with food availability. Salinity is a unique factor initiating functional responses in marine and estuarine animals. Mohan and Velayudhan (1998) reported that *P. malabarica* can tolerate salinity in the range of 12 to 40 ppt. The significant positive correlation of density with salinity ($r=0.36$, $p<0.05$ at Chicalim) points towards the fact that *P. malabarica* grows best at such salinity (Gireesh and Gopinathan, 2004). Further, the occurrence of *P. malabarica* in large numbers in sandy sediment ($r=0.38$, $p<0.05$) suggests that this species is typical of such habitat (Parulekar *et al.*, 1984). The annual mean length and total weight of the clams at Nerul station (31.20 ± 3.62 mm, 8.6 ± 3.48 g m^{-2}) were higher than those from the Chicalim (30.64 ± 4.86 mm, 7.88 ± 3.65 g m^{-2}). The higher size and total weight of *P. malabarica* observed at Nerul compared to Chicalim may be because the local fishermen observe a moratorium of about 5 to 6 months (August to January) on fishing clams at Nerul. This is the breeding season for *P. malabarica*, during which the clams get opportunity to reproduce and grow. Such ban on clam fishing is not observed at Chicalim thereby the population is relatively smaller in size due to overexploitation. Mohite (2010) reported breeding and spawning of *P. malabarica* during September to January *i.e.,* after monsoon, along west coast. However, the availability of clams from Chicalim and Nerul throughout the seasons indicates their tolerance to the different types of environmental conditions and adaptability to different season and region. Therefore, it can be concluded from the study that environmental parameters can have close relation on population as well as growth of the clam *P. malabarica*. The results revealed that chlorophyll *a* was the major water quality parameter influencing the density of estuarine clams. Results of the present study give an overall idea about the relative growth of body parts of *P. malabarica*. However for specific biological evaluation of the growth progression, long-term monitoring is required. This will help to understand the dynamics of this species and the data generated can be used for growth enhancement in commercial cultivation of the species. Further long term ecological studies should also be undertaken to carefully monitor shellfish exploitation.

Acknowledgements

The authors thank the Director, CSIR-NIO, Goa for his encouragement. The first author was supported by Council of Scientific and Industrial Research, (CSIR) Govt. of India fellowship. This is contribution number XXX of NIO, CSIR.

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Date of Receipt : 04.06.2012
Date of Acceptance : 12.05.2014