

Asian Fisheries Society, Manila, Philippines

Allometry and condition index in the freshwater bivalve *Parreysia corrugata* (Muller) from river Kempuhole, India

MUDIGERE M. RAMESHA* and SEETHARAMAIAH THIPPESWAMY

Department of Environment Science,
Mangalore University,
Mangalagangothri-574199,
Mangalore, Karnataka, India

Abstract

Allometry and condition index of freshwater bivalve *Parreysia corrugata* (Muller) inhabiting the river Kempuhole, tributary of river Nethravathi, in the Western Ghats were examined from April 2005 to May 2006. The length-breadth and length-width relationships for the entire study period were $L = 2.314 + 0.585B$ and $L = 1.907 + 0.333W$ respectively. The b values of length-breadth and length-width relationships varied from 0.5518 (March 2006) to 0.6519 (August 2005) and 0.2986 (July 2005) to 0.3735 (August 2005) respectively. The relationships between length-total weight, length-wet weight, length-shell weight and length-dry weight were $W = 0.0003428L^{2.777}$, $W = 0.00004197L^{2.885}$, $W = 0.0001738L^{2.802}$ and $W = 0.00001127L^{2.832}$ respectively. The monthly equilibrium constant values of length-total weight relationship ranged from 2.606 (July 2005) to 2.945 (August 2005), where as for length-shell weight relationship, the values ranged from 2.691 (May 2006) to 3.1 (August 2005). The best values fluctuated between 2.781 (June 2005) and 3.58 (July 2005) for length-wet weight, while the values for length-dry weight fluctuated between 2.665 (April 2006) and 3.668 (October 2005). The monthly values of equilibrium constant indicated the relative growth in body weight of *P. corrugata*. The values of condition indices showed significant fluctuations. The highest condition index (15.1) was recorded during April 2005 where as the lowest (4.4) was in January 2006. The data indicated that the condition of mussel was fairly good from April to August 2005. The best time for commercial exploitation appears to be during this period. The condition index showed decreasing trend from September onwards and reached the lowest value during January. Thereafter, the condition gradually increased. Seasonal fluctuation of condition in *P. corrugata* was probably, related to reproductive activity. The ambient environmental variables and biological variables of *P. corrugata* revealed that a total of 5 component which accounted for 94.24% of total variance.

*Corresponding author: Tel: +91-821-2287261
E-mail address: rmudigere@yahoo.com

Introduction

Allometry is the study of consequences of size and shape. In allometry, the relationship between the two parts of same organism over a wide size range is calculated (Reiss 1989). The influence of proximate factors will cause differences in the intercept and slope of the allometry. In allometric length-weight relationship the variation in equilibrium constant represents the growth in weight than that of length and provides information on the physiological deviations in condition of bivalves. Relatively large variations in meat content occur in bivalve mollusks depending upon the physiological condition and variation in environmental parameters (Wilbur & Owen 1964). Allometric relationships and condition index of several marine bivalves along the Indian coast have been reported. The information on allometry and condition index of freshwater bivalve from India is meager (Desai & Borkar 1989). However, a few reports are available on the various aspects of biology of freshwater mussels from India (Nagabhushanam & Lomte 1971; Narian 1972; Nagabhushanam & Lohgaonker 1978; Lomte & Jadhav 1980 and Moorthy et al. 1983). Freshwater mussels are consumed by human beings and play a very significant role in benthic ecosystems. Local tribal people residing on the riverbanks also eat these *Parreysia corrugata*. Though *P. corrugata* are not commercially very important from the viewpoint of food source, these mussel support small fisheries in other part of India and is a potential candidate species for freshwater pearl production. Further *Parreysia* spp. is known to have medicinal importance (Dey 2007). There is a dearth of biological information on *Parreysia corrugata* inhabiting Indian freshwater bodies. Hence, an attempt has been made to understand the allometry and condition index in *Parreysia corrugata* inhabiting the river Kempuhole, tributary of river Nethravathi, in the Western Ghats of Karnataka.

Materials and Methods

Samples of freshwater bivalve *Parreysia corrugata* were collected at monthly intervals from the river Kempuhole (75°26'49" N, 12°46'3" E) at Hosmata, near Subhramanya town from April 2005 to May 2006. A total of 3,339 individuals ranging from 13 to 53.7 mm size were individually measured for shell length (maximum antero-posterior distance), breadth / height (maximum distance from hinge to ventral margin) and width / depth / thickness (maximum distance between outer edges of two valves) accurately to 0.05 mm using vernier calipers. The tissue was removed and weighed individually after blotting. The weight of each shell was determined. The tissue was dried at a constant temperature of 60°C for 2 days and weighed accurately to 0.001 g. Allometry was examined for morphometry (length-breadth, length-width) and length-weight (length-total weight, length-wet tissue weight, length-dry tissue weight and length-shell weight) relationships. Shell cavity volume of individual mussels was determined using xylene to calculate condition index (Baird 1958) using the following equation.

$$\text{CI} = \frac{\text{Dry tissue weight}}{\text{Shell volume}} \times 100$$

Morphometric relationship was estimated (Poole 1974) using linear regression equation $Y = a + bX$, where a (intercept) and b (slope) are constants. The allometric length-weight relationship was calculated (Pauly 1983) using a non-linear regression equation $W = aL^b$, where a and b (equilibrium constant) are constants. The monthly mean values of length, breadth, width, total weight, shell weight, wet weight, dry weight, condition index, b values of length-breadth, length-width, length-total weight, length-wet weight, length-shell weight and length-dry weight and water quality parameters such as water temperature, chloride, alkalinity, total hardness, calcium and magnesium were subjected to Principal Component Analysis (PCA) and Cluster Analysis (CA) (Davis 1973; Lewis-Bek 1994).

Results

Morphometric relationship

The data on morphometric relationship between length-breadth and length-width is presented in Fig. 1.

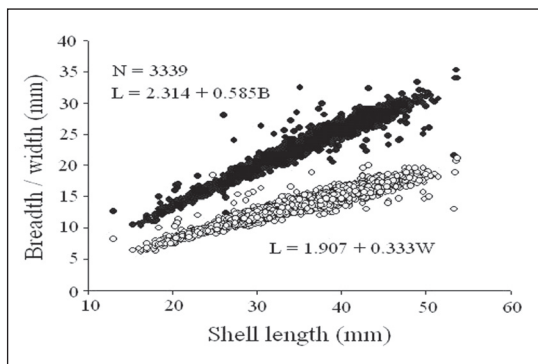


Figure 1. Bivariate scatter diagram of length-breadth and length-width relationships of *Parreysia corrugata*.

The data revealed that the variables are linearly related and showed short individuals are narrow (less height) and low (less thickness) and inversely long individuals are wide (more height) and high (more thickness) as reported elsewhere in higher organism (Jolicoeur & Worimann 1960). Clearly this reflects the fact that length, breadth and width are influenced by size. However, some individuals of same length showed different breadth and width, and these differences constituted the shape variation. During the present study the calculated

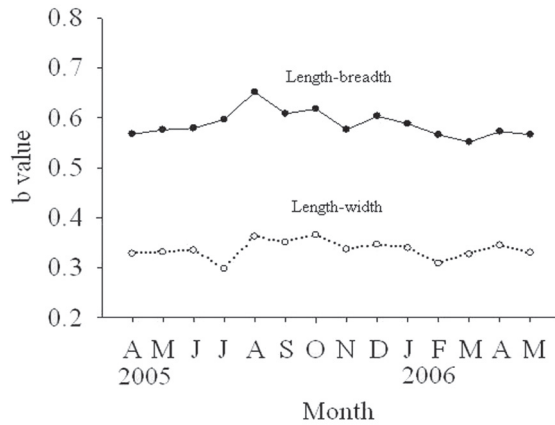


Figure 2. Monthly variability in the b values of length-breadth and length-width relationships *Parreysia corrugata*.

values of length-breadth and length-width relationships for the entire study period were $L = 2.314 + 0.585B$ and $L = 1.907 + 0.333W$ respectively. The monthly b values of length-breadth and length-width varied from 0.5518 (March 2006) to 0.6519 (August 2005) and 0.2986 (July 2005) to 0.3735 (August 2005) respectively (Fig. 2).

Length-weight relationship

The data on length-weight relationship is presented in Fig. 3.

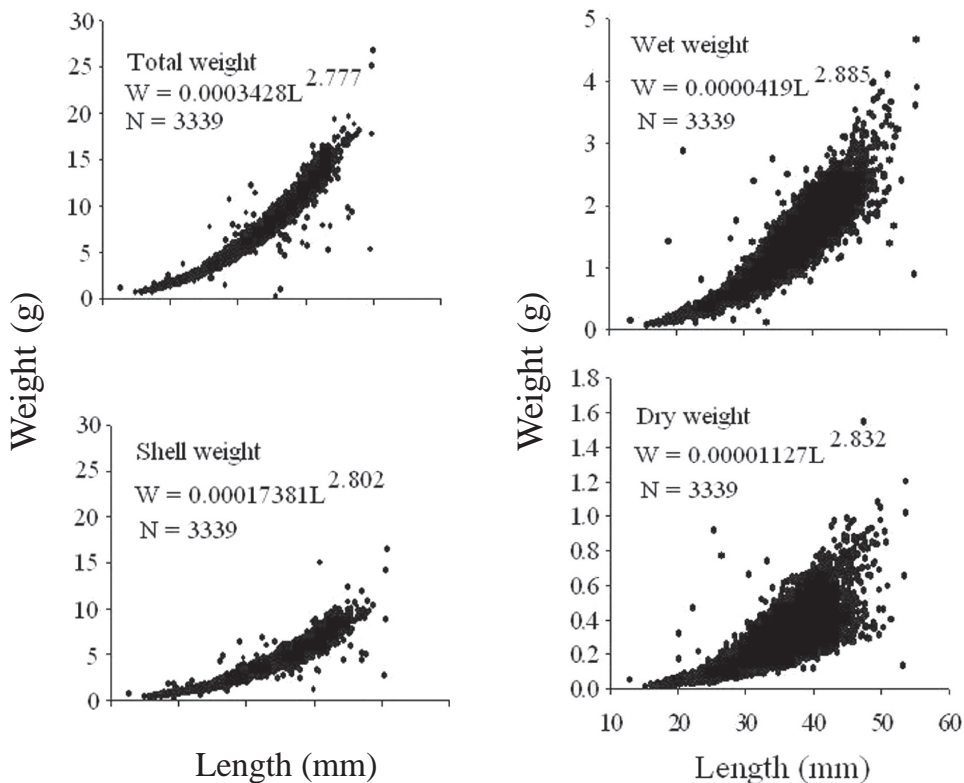


Figure 3. Monthly variability between the length and weight relationships of *Parreysia corrugata*.

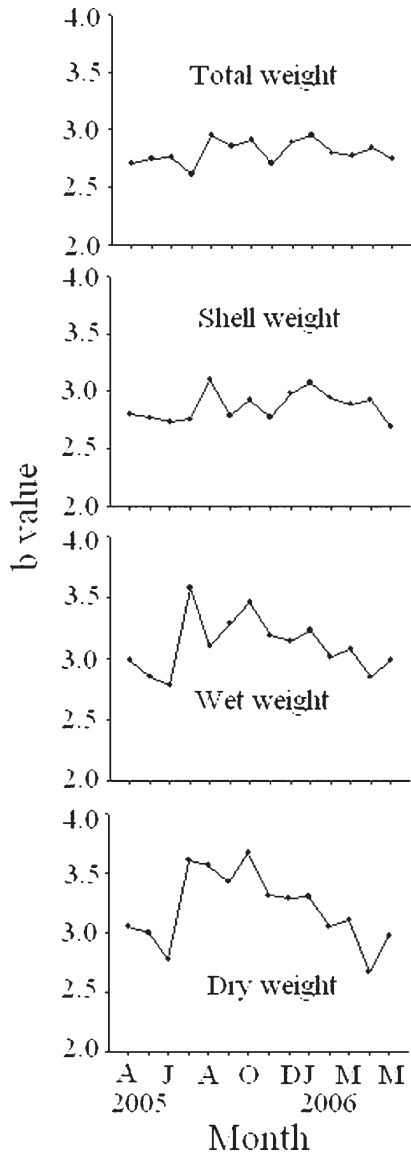


Figure 4. Monthly variability in the b values of length-weight relationships of *Parreysia corrugata*.

The data showed that variables are non-linearly related indicating short individuals are heavy. The relationship between length-total weight ($W=0.0003428L^{2.777}$), length-wet weight ($W=0.00004197L^{2.885}$), length-shell weight ($W=0.00001738L^{2.802}$) and length-dry weight ($W=0.00001127L^{2.832}$) were calculated. The data on monthly b values (equilibrium constant) are presented in Fig. 4. The values ranged from 2.606 (July 2005) to 2.945 (August 2005) for the length-total weight relationship and values ranged from 2.691 (May 2006) to 3.1 (August 2005) for length-shell weight relationship. The b values fluctuated between 2.781 (June 2005) and 3.580 (July 2005) and 2.665 (April 2006) and 3.668 (October 2005) for length-wet weight and length-dry weight respectively. The b value of length-total weight and length-shell weight relationships showed almost the same pattern throughout the study period (Fig. 4.) whereas, length-wet weight and length-dry weight showed seasonal fluctuations.

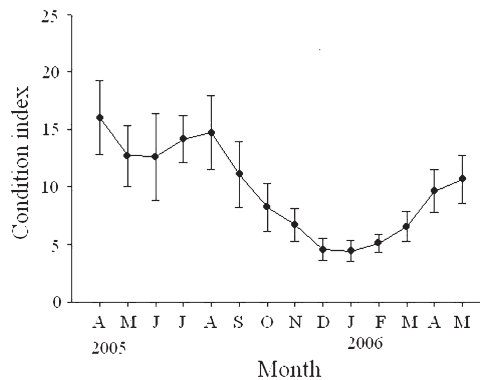


Figure 5. Monthly variations in mean condition indices in *Parreysia corrugata*. Vertical bars represent the standard deviation.

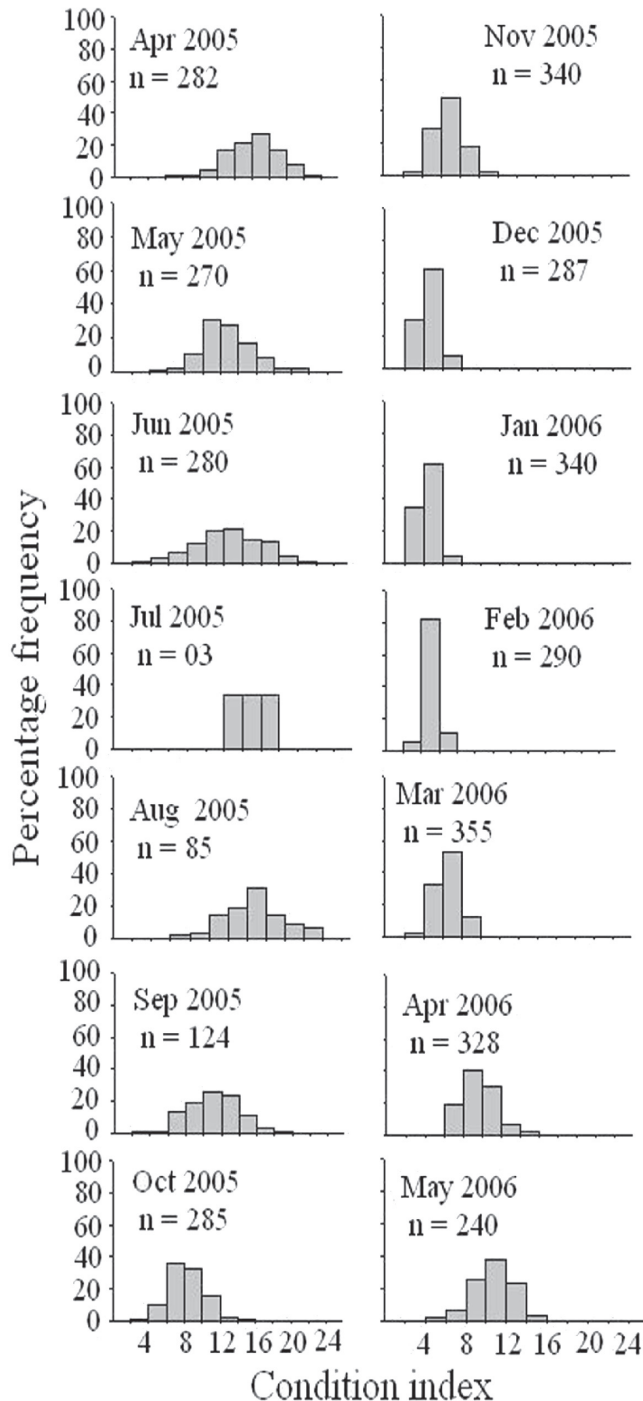


Figure 6. Percentage frequency of condition index in *Parreysia corrugata*

Condition index

Monthly mean variability of condition index of *Parreysia corrugata* is presented in Fig. 5 and the values varied from 4.41 (January 2006) to 15.99 (April 2005). During the study period only one peak was distinct during August 2005 and the maximum (22-24) condition index was represented by only few individuals. The values of condition indices showed decreasing trend from April to June 2005 and again reached the highest peak (14.71) during August 2005. There after condition index suddenly decreased during September to January 2006. Build up of condition started from January 2006 onwards (Fig. 5).

The organism having condition index less than 2 could not be collected during the study period. The percentage distribution of index of condition in monthly samples (Fig. 6) during the entire study period revealed the following observations; During April 2005 the mode at the class group 16-18 and in May 2005 condition index was shifted back to 10-12 class group. The mode gradually reached to 14-16 during August 2005. However, during September 2005 the mode was again shifted back to 10-12 size group and the decreasing trend was continued till February 2006. March 2006 onwards the

condition index increased and reached the peak at 10-12 size group during May 2006.

Multivariate statistical analysis

The application of Principal Component Analysis (PCA) has showed the possible correlation between the ambient environmental variables and biological variables of *P. corrugata*. The eigen values and their contribution to the total variance indicated a small number of components that could adequately explain the observed correlations among the large numbers of observed variables. A total of five components showed eigen value more than one in the present study (Table 1). The plots of principal component axis 1 and axis 2 showed 4 different groupings of environmental variables and biological variables of *P. corrugata* (Fig. 7).

Table 1. Eigen values of ambient environmental and biological variables of *Parreysia corrugata*. Abbreviations: L, length; B, breadth; W, width; TW, total weight; SW, shell weight; WW, wet weight; DW, dry weight; LBb, length-breadth b value; LWb, length-width b value; LTWb, length-total weight b value; LSWb, length-shell weight b value; LWWb, length-wet weight b value; LDWb, length-dry weight b value; CI, condition index; N, sample size.

	Component				
	1	2	3	4	5
L	0.965	0.028	0.188	-0.027	-0.168
B	0.962	0.016	0.186	-0.004	-0.188
W	0.972	0.069	0.206	-0.011	-0.035
TW	0.990	0.052	0.112	-0.008	-0.044
SW	0.989	0.097	-0.011	-0.030	-0.083
WW	0.691	0.515	0.042	-0.464	-0.022
DW	0.155	0.784	0.117	-0.567	0.027
CI	-0.603	0.704	0.039	-0.292	-0.076
LBb	-0.622	0.108	-0.414	0.519	0.345
LWb	-0.248	-0.055	-0.018	0.238	0.924
LTWb	-0.061	-0.179	0.030	0.687	0.626
LWWb	-0.135	-0.682	0.108	0.196	0.656
LSWb	0.025	-0.132	0.126	0.940	0.229
LDWb	-0.689	-0.379	-0.409	0.327	-0.117
N	0.681	-0.217	0.526	-0.027	0.354
WT	0.140	0.371	0.659	-0.584	-0.107
HCO3	0.282	0.020	0.868	0.195	-0.038
Chl	0.079	0.913	0.268	0.051	-0.183
TH	0.260	0.583	0.684	-0.076	0.167
Ca	-0.080	0.530	0.578	-0.413	-0.248
Mg	0.360	0.455	0.572	0.139	0.353

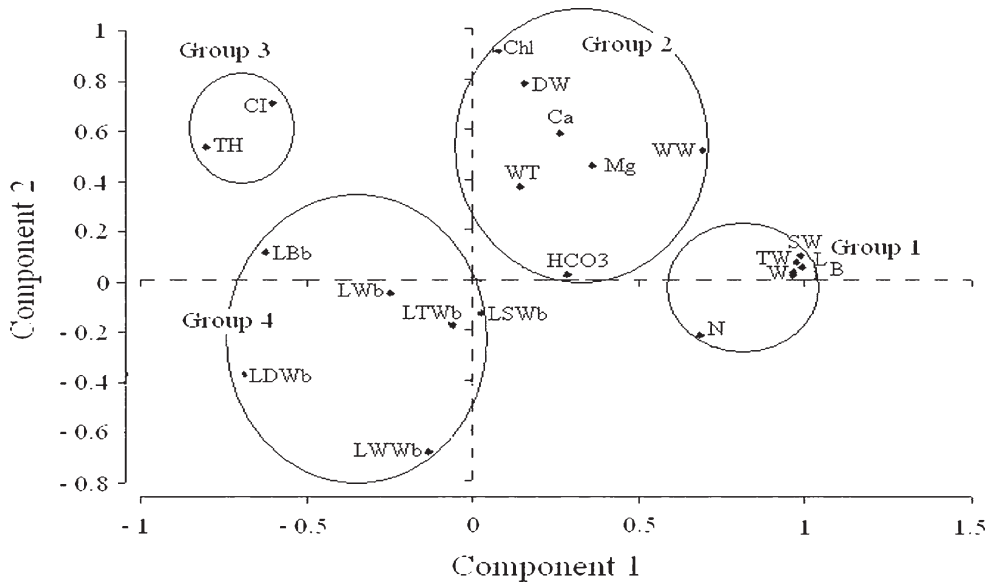


Figure 7. Principal component plots of component 1 and component 2 of ambient environmental and biological variables of *Parreysia corrugata*. Abbreviations: L, length; B, breadth; W, width; TW, total weight; SW, shell weight; LBb, length-breadth b value; LWb, length-width b value; WW, wet weight; DW, dry weight; LTWb, length-total weight b value; LSWb, length-shell weight b value; LWWb, length-wet weight b value; LDWb, length-dry weight b value; CI, condition index; N, sample size.

The hierarchical cluster analysis using complete linkage showed two major groups of biological variables of *P. corrugata* (Fig. 8).

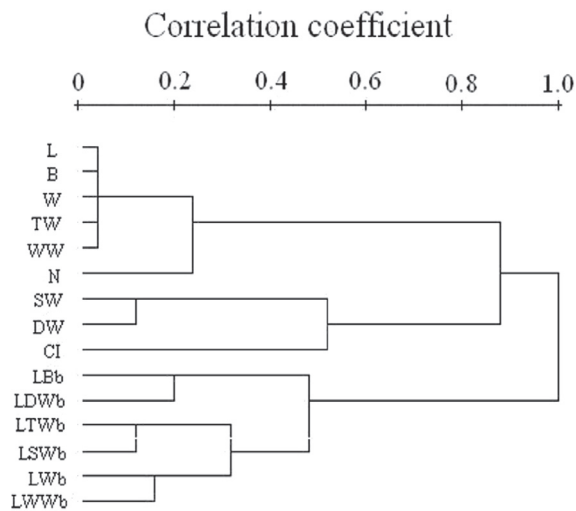


Figure 8. Dendrogram (complete linkage) of biological parameters of *Parreysia corrugata*. Abbreviations: L, length; B, breadth; W, width; TW, total weight; SW, shell weight; WW, wet weight; DW, dry weight; LBb, length-breadth b value; LWb, length-width b value; LTW b, length-total weight b value; LSWb, length-shell weight b value; LWWb, length-wet weight b value; LDWb, length-dry weight b value; CI, condition index; N, sample size.

Discussion

The correlation between morphology and life-history strategies of aquatic organisms is well documented. Approximation of growth rates and rates of estimation of aquatic secondary producers under given conditions in different eco-systems is possible, provided knowledge exists on their size and shape, differential body growth and population ecology. The data on morphometric relationship in the present study clearly reflects the fact that length, breadth and width are influenced by variation in size. However, some individuals of the same length showed different breadth and width, and these differences constituted the shape variation (Jolicoeur & Worimann 1960). A variety of environmental factors are known to influence shell form in bivalves. Size of shell is more affected than their shape by fluctuation of ambient environment (Seed 1968; Wilbur & Owen 1964). Thus shape, rather than size generally provides more precise information of the dimensional relationships. Probably, shape is controlled by the genetics and size by ambient environment.

The possibility that allometric relationships describe the rates for a wide range of metabolic process and over a wide range of organisms' size and types has important ecological implications (Nielsen & Sand-Jensen 1990). The skewed relationship in the present study indicated that short individuals are light and long individuals are heavy (Fig. 2). This clearly points out that as age increases the weight of the mussel also increases. However, some individuals of the same age showed different weight and these differences might probably be due to physiological condition of mussels and variation in environmental parameters (Seed 1976; Thippeswamy & Joseph 1988). Lengths and weights of the organisms have been shown to be highly correlated with life-history measures in cross-taxonomic comparisons (Bonner 1965; Peter 1983). The mussels maintained their non-linear pattern throughout their life (Fig. 3). However, b values were different which could be related to reproductive cycle. Similar observation was made by Desai and Borkar (1989) who reported a non-linear relationship in *Lamellidens corrianus* inhabiting Khandepar River, Goa.

In allometric length-weight relationship, the most interesting component is the equilibrium constant b, the variations of which from hypothetical unity suggested physiological deviations in condition. According to Wilbur and Owen (1964), the values of equilibrium constant b lie between 2.4 and 4.5 in most of the bivalves with exception of the worm like *Teredo* (Isham et al. 1951) in which a more nearly linear relation ($b = 1$) was reported. Perusal of data on monthly variation in bivalves in length-dry tissue weight (Fig. 5) indicated a more or less identical trend with peak (3.668) in October 2005. This revealed that relative growth in body weight as compared to length was the highest in October 2005. The same pattern was seen in all length-weight relationships (length-total weight, length-wet weight length-dry weight, length-shell weight). In length-total weight

relationships, the monthly *b* values varied from 2.606 (July 2005) to 2.945 (August 2005). However, for length-wet weight and length-shell weight the *b* values showed the peak during July 2005 (3.58) and August 2005 (3.1) respectively. In bivalves, when gonadal growth and maturation occur, it results in bulkiness of soft body and consequent high body weights. Such sudden shift in the *b* values indicated the onset of maturation and gonadal growth in bivalves. Thus, high equilibrium constant values in the present study might be due to gonadal growth and high condition index. In most bivalves, gonads growth prior to spawning results in increasing the total bulk as gonad forms the major part of the visceral mass. In such animals variation in index of condition reflects the reproductive status. Accumulation of gametes in follicles and resultant bulkiness of the gonad result in increased condition index, while release of gametes from the follicles and corresponding shrinking of gonadal mass result in lowering condition. Whether this is true in *Parreysia corrugata* could be verified only from its gonadal histology.

Principal Component Analysis applied for ambient environmental variables and biological variables of *P. corrugata* revealed a total of 5 components, which accounted for a total variance of 94.24%. The 1 component (length, breadth, width, total weight, shell weight, dry weight, sample size, *b* value of length-breadth and length-dry weight) accounted for as much variance as possible (44.6%) followed by 2 component (dry weight, condition index, chloride and *b* values of length wet weight) accounted for 23.89% of variance, component 3 (water temperature, alkalinity, total hardness, calcium, magnesium) accounted for 14.08% of total variance and components 4-5 together accounted for 11.67% of variance. The component 4 (*b* values of length-total weight and length-shell weight) accounted for 6.47% and component 5 (*b* values of length-width) accounted for 5.19% of total variance. The variables of all the 5 components have positive values except component 1 in which *b* values of length-breadth and length-dry weight were negative. Group 1 consisted of biological variables such as length, breadth, width, total weight, shell weight and sample size. Group 2 included biological parameters (wet weight, dry weight) and ambient environmental variables (water temperature, alkalinity, calcium, magnesium, chloride). Group 3 consists of condition index (biological variable) and total hardness (environmental variable). Group 4 also included only biological parameters (*b* values of morphometric and length-weight) (Fig. 7). The hierarchical cluster analysis showed two major groups (Fig. 8). Group A with 2 sub groups A1 (length, breadth, width, total weight, shell weight, sample size) and A2 (wet weight, dry weight, condition index). Group 2 included *b* values of morphometric and length-weight relationships.

The condition index of mussels revealed that the reproduction of mussels is from April to August. Based on available data it is suggested that the ideal period for commercial exploitation of *Parreysia corrugata* from the river Kempuhole was from April to August when the meat yield is highest. The maximum meat size of the mussels is

achieved as they approach their reproductive stage. The most favorable period for harvesting mussels is from April to August since the meat yield is high. Further, the meat of the mussel is usually tasty and rich in nutrition before harvesting. The harvesting of mussel is easy during April-June, when water level decreases in river. During July and August, the harvesting of mussel is usually difficult due to river flooding by south west monsoon and mussels will not be harvested and thus allowing the mussel population for future recruitment. The harvesting of mussel could be carried out considering the maximum sustainable yield (MSY) without over exploitation. The maximum economic yield (MEY) is possible only after delineating the nutritive value of mussel and market condition.

Acknowledgement

The first author is grateful to Mangalore University for financial assistance during the study period.

References

- Baird, R.H. 1958. Measurement of condition in mussel and oyster. *Journal of Conseil International pour l'Exploration de la Mer* 23: 249-257.
- Bonner. J.T. 1965. *Size and cycle: an essay on the structure of biology*, Princeton University Press, Princeton, USA.
- Dasai, P.V. and M.R. Borkar. 1989. A study of allometric relationship in *Lamellidens corrianus*. *Indian Journal of Fisheries* 36 (2): 180-182.
- Davis, C.J. 1973. *Statistics and data analysis in geology*. John Wiley, New York.
- Dey, A. 2008. Commercial and medicinal importance of Sundarbans. *Records of the Zoological Survey of India. Occasional paper* 289: 1-54, ZSI, Kolkata.
- Isham, L.D., H.B. Moore and F.G.W. Smith. 1951. Growth rate measurement of shipworms. *Bulletin of Marine Sciences of the Gulf and Caribbean* 1(2): 136-147.
- Jolicoeur, P. and J.E. Worimann. 1960. Size and shape variation in the painted turtle. A principal component analysis. *Growth* 24(4): 339-354.
- Lewis-Bek, S.M. 1994. *Factor analysis and related techniques*. Sage Publications. London. 424 pp.
- Lomte, V.S. and M.L. Jadhav. 1980. A study on the crystalline style of freshwater mussel, *Parreysia corrugata*. *Hydrobiologia* 69(1-2): 175-178.
- Moorthy, K.S., M.D. Naidu, C.S. Chetty and K.S. Swami. 1983. Changes in carbohydrates metabolism in tissue of freshwater mussel (*Lamellidens marginalis*) exposed to phosphamidon. *Bulletin of Environmental Contamination and Toxicology* 30(1): 219-222.
- Nagabhushanam, R. and V.S. Lomte. 1971. Biochemical studies in freshwater mussel, *Parreysia corrugata*. *Hydrobiologia* 37(3-4): 545-552.
- Nagabhushanam, R. and A.L. Lohgaonker. 1978. Seasonal reproductive cycle in the mussel, *Lamellidens carrianus*. *Hydrobiologia* 61(1): 9-14.
- Narain, A.S. 1972. *Blood chemistry of Lamellidens carrianus*. *Cellular and Molecular Life Sciences* 28(5): 507-508.
- Nielsen, S.L. and K. Sand-Jensen. 1990. Allometric scaling of maximal photosynthetic growth rate of surface / volume ratio. *Limnology and Oceanography* 35: 177-181.
- Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fisheries technology paper* 235: 52 pp.
- Peter, R.H. 1983. *The ecological implications of body size*. Cambridge University Press, Cambridge.
- Poole, R.W. 1974. *An introduction to quantitative ecology*. McGraw-Hill, Tokyo. 532 pp.

- Reiss, M.J. 1989. *The allometry of growth and reproduction*, Cambridge University press, New York. 279 pp.
- Seed, R. 1968. Factors influencing shell shape in *Mytilus edulis* L. *Journal of Marine Biological Association of United Kingdom* 48: 561-584.
- Seed, R. 1976. Ecology. In: *Marine mussels, their ecology and physiology*. (ed. B.L. Bayne), pp. 13-56. Cambridge University Press, Cambridge.
- Thippeswamy, S. and M.M. Joseph. 1988. Seasonable variability in the condition of the wedge clam *Donax incarnates* (Gmelin). *Proceedings, The First Indian Fisheries Forum*. Asian Fisheries Society, Indian Branch, Mangalore, pp. 247-249.
- Wilbur, K.M. and G. Owen. 1964. Growth. In: *Physiology of mollusca*, (ed. K.M. Wilbur and C.M. Yonge). Vol. I; pp. 211-242. Academic Press, New York.