Indian J. Fish., 61(4) : 48-54, 2014

Allometry and condition index in the freshwater bivalve *Parreysia favidens* (Benson, 1862) from river Bhadra, India

SEETHARAMAIAH THIPPESWAMY*, SHETTIGAR MALATHI AND N. M. ANUPAMA

Department of Environmental Science, Mangalore University, Mangalagangothri
Mangalore – 574 199, Karnataka, India
e-mail: stswamy @yahoo.com

ABSTRACT

The morphometry, length-weight relationship and condition index of the freshwater bivalve *Parreysia favidens* (Benson, 1862) inhabiting the river Bhadra in the Western Ghats were examined from October 2001 to December 2002. The linear regression equations of length-breadth and length-width for the entire study period were L = 0.2653 + 0.5992 B and L = 0.2176 + 0.4403 W respectively. The monthly *b* values of length-breadth and length-width relationships varied from 0.5371 (November 2002) to 0.6915 (July 2002) and from 0.4132 (October 2002) to 0.5242 (July 2002) respectively. The data on length-total weight ($W= 0.2418\ L^{2.785}$), length- wet tissue weight ($W=0.04859\ L^{2.599}$) and length-dry weight ($W=0.01177\ L^{2.499}$) showed non-linear patterns. The coefficient of allometry, *b* ranged from 2.2485 (November 2002) to 3.4107 (July 2002) for length-total weight relationship and from 2.2779 (December 2002) to 2.8346 (January 2002) for length-wet tissue weight relationship. The values for length-dry tissue weight relationship fluctuated between 2.1528 (December 2002) and 2.9736 (January 2002). The monthly mean values of the condition index varied from 4.57 (October 2001) to 8.95 (April 2002). The variation in condition index followed the breeding period and seasons. The data indicated that the condition of mussels was fairly good from April to October. The best time for commercial exploitation appears to be during April to October when the mussels are in good condition.

Keywords: Condition, Freshwater mussel, Length-weight relationship, Morphometry, *Parreysia favidens,* Western Ghats

Introduction

Though freshwater mussels are not commercially very important as source of food, these mussels support small-scale fisheries in some parts of India and are potential candidate species for freshwater pearl production. Molluscs form a major group of benthic invertebrates, providing food for a number of fish (Hora, 1952; Vaas and Vaas, 1959). The freshwater bivalves typically live partly buried in the sand or mud and are encountered in greater abundance in waterways located in alluvial soil areas with soft soil substrate. Freshwater mussels are very important components of aquatic ecosystems and often dominate benthic biomass and production (Negus, 1966).

Shell size (length, breadth, width), total weight and combined calculation of the size–weight ratio are generally used for analyses of the morphological development of the shell (Anderson and Gutreuter, 1983). Size–weight relationships are important basic data that explain the changes of shell proportions in bivalves found in natural or culture systems due to water depth (Claxton *et al.,* 1998; Lajtner *et al*., 2004), currents (Blay, 1989), water turbulence (Hinch and Bailey, 1988), type of sediment (Lajtner *et al*., 2004), type of bottom (Claxton *et al*., 1998) and water quality (Lajtner *et al*., 2004). Studies on bivalve growth and allometric relationships are essential for generating useful information for managing resources, understanding changing environmental conditions and pollution as well as phenotypic variability in populations of the mussels (Boulding and Hay, 1993; Caceres-Martinez *et al*., 2003).

Freshwater mussels are widely distributed in Indian water bodies (Ramakrishana and Dey, 2007). Some aspects of the biology of *Parreysia corrugata* (Ramesha and Thippeswamy, 2009; Malathi and Thippeswamy, 2011) and *Lamellidens* spp. (Nagabhushanam and Lohgaonker, 1978; Desai and Borker, 1989) in Indian rivers have been reported. In the present study, an attempt has been made to understand the allometry and condition index in *P. favidens* inhabiting the river Bhadra, in the Western Ghats of Karnataka.

Materials and methods

Samples of the freshwater bivalve *Parreysia favidens* were collected at monthly intervals from the river Bhadra at Khodi near N. R. Pura (13^0 28^1 N, 75^0 29^1 E) in the Western Ghats of Karnataka from October 2001 to December 2002, except for the months of November 2001, June 2002 and August-September 2002. A total of 2,376 individuals ranging in size from 2.06 to 8.95 cm were individually measured for shell length (maximum antero-posterior distance), breadth (maximum distance from hinge to ventral margin) and width (maximum distance between outer edges of two valves), to the nearest 0.05 mm using vernier calipers. Then the tissue from each sample was removed, and weighed individually after blotting. The tissue was dried at a constant temperature of 60°C for 2 days and weighed to nearest 0.001g. Allometry was examined for length-breadth, nearest length-width and length-weight (length-total weight, length-wet tissue weight and length-dry tissue weight relationships. Shell cavity volume of individual mussels was determined using xylene to calculate condition index (Baird, 1966). The morphometric relationship was estimated (Poole, 1974) using the linear regression equation Y = a + b X, where *a* (intercept) and *b* (slope) are constants. The allometric length-weight relationship was calculated (Pauly, 1983) using the non-linear regression equation, $W = a L^b$, where *a* and *b* (equilibrium constant) are constants.

Results and discussion

In the present study, the observed values of length against their respective breadth and width revealed linear relationships (Fig. 1). The calculated regression equations of length-breadth and length-width for the entire study period were L= 0.2653 + 0.5992 B and L = 0.2176 + 0.4403 W respectively. The data also showed that 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 organisms (Jolicoeur and 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. The monthly *b* values of length-breadth relationship ranged from 0.5371 (November 2002) to 0.6915 (July 2002) whereas the values for length-width relationship varied from 0.4132 (October 2002) to 0.5242 (July 2002) (Fig 2).

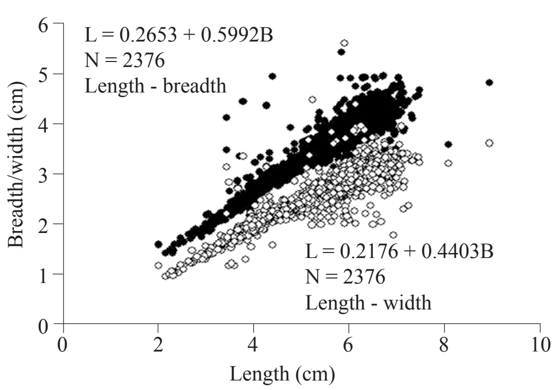

Fig. 1. Bivariate scatter diagram of length-breadth (dark circles) and length-width (open circles) relationships of *Parreysia favidens*

Shell length and shell breadth have been demonstrated to be important tools in estimating the growth of many

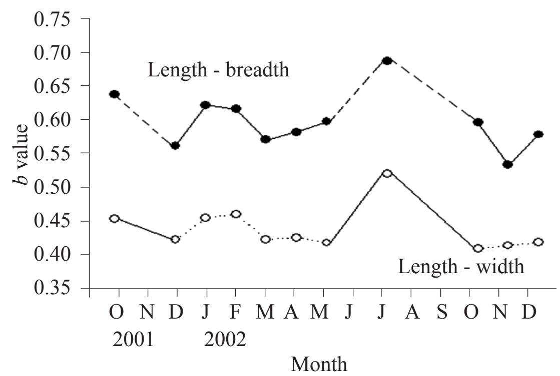

Fig. 2. Monthly variability in the *b* values of length-breadth and length-width relationships of *Parreysia favidens*

freshwater bivalves (Bailey and Green, 1988; Garton and Haag, 1991; Smit *et al*., 1992; Sprung, 1992). Bivalve shell growth and shape are influenced by abiotic and biotic factors. Temperature and growth relationships have been linked to changes in the overall size and differences in growth rates of freshwater mussels (Tevesz and Carter, 1980). Environmental parameters, population density and reproductive state can also influence measures used to estimate growth (Jantz and Neumann, 1992; Smit and Van Heel, 1992). In some cases, more energy goes towards tissue growth than shell growth. Due to the influence of local environment or population conditions, the relationship of shell length to tissue weight is required before the estimation of growth in a population.

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 contributed to the shape variation (Jolicoeur and 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 (Wilbur and 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 monthly variations in shell dimensional relationships are linearly related but the values of intercept and slope are different, thus depicting the seasonal variations in environmental parameters and physiological status of the population. The *b* value of length-breadth and length-width relationships in the present study was higher than that of *Anodonta cygnea* from Cambridge (Aldridge, 1999) and *Parreysia corrugata* from river Kempuhole, India (Ramesha and Thippeswamy, 2009) and lesser than that of *Hyriopsis myersiana* from Thailand (Kovitvadhi *et al.,* 2008) (Table 1). However, the *b* value of length-breadth relationship in the present study was less than that of *P. corrugata* (Malathi and Thippeswamy, 2011) and the *b* value of length-width relationship was more than that of *P. corrugata*.

The data on length-weight relationship showed that variables were non-linearly related and the short individuals were light. The relationship between length-total weight ($W= 0.2418\ L^{2.785}$) (Fig 3a), length-wet tissue weight ($W=0.04859\ L^{2.599}$) (Fig. 3b) and length-dry weight ($W=0.01177\ L^{2.499}$) (Fig. 3c) are presented. The data on monthly *b* values (equilibrium constant) are presented in Fig. 4. The values ranged from 2.2485 (November 2002) to 3.4107 (July 2002) for length-total weight relationship (Fig. 4a) and from 2.2779 (December 2002) to 2.8346 (January 2002) for length-wet tissue weight relationship (Fig. 4b). The values for length-dry tissue weight fluctuated between 2.1528 (December 2002) and 2.9736 (January 2002) (Fig. 4c). The *b* values of length-total weight, length-wet tissue weight and length-dry tissue weight relationships showed similar trend throughout the study period.

Allometric relationships possibly 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 and Sand-Jensen, 1990). The skewed relationship in the present study indicated that short individuals are light and long individuals are heavy (Fig. 3). 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

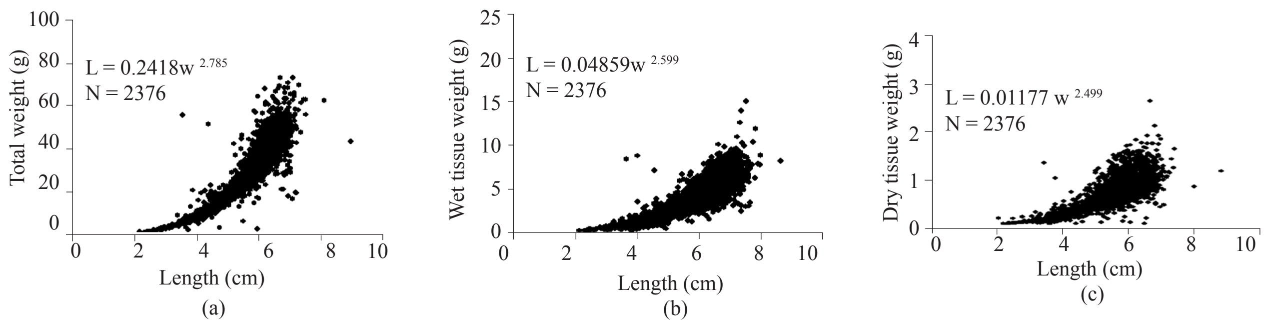

Fig. 3. Length - total weight, length-wet weight, and length-dry weight relationships of *Parreysia favidens* during the study period

Table 1. The *b* values reported for morphometric and length-weight relationships in freshwater bivalves

Species	L-B	L-W	L-TW	L-WW	L-DW	Location	Reference
Anodonta cygnea				2.990		Lagadone Stream, Northern Italy	Ravera and Sprocati (1997)
” ”	0.450	0.371				Wicken Lode, Cambridge U.K	Aldridge (1999)
Anodonta grandis			2.950			Lake in central Alberta.	Hanson *et al*. (1988)
Hyriopsis myersiana	0.951	1.043	2.976			Bangkok, Thailand	Kovitvadhi *et al*. (2008)
Parreysia corrugata	0.585	0.333	2.777	2.885	2.832	Kempuhole, tributary of River Nethravathi, India	Ramesha and Thippeswamy (2009)
” ”	0.603	0.432	2.666	2.669	2.937	Malthi River, tributary of River Tunga, India	Malathi and Thippeswamy (2011)
Unio pictorum					2.980	Lake Maggiore, Italy	Ravera *et al*. (2007)
” ”					2.920	Lake Candia, Italy	Ravera *et al*. (2007)
Parreysia favidens	0.599	0.440	2.785	2.599	2.499	River Bhadra, India	Present study

L-B: length-breadth; L-W: length-width; L-TW: length-total weight: L-WW: length-wet weight: L-DW: length-dry weight.

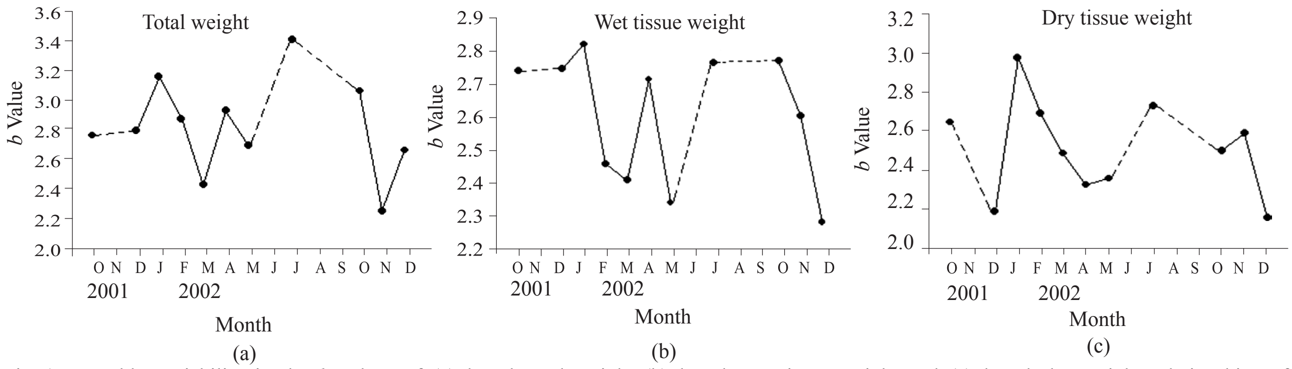

Fig. 4. Monthly variability in the *b* values of (a) length-total weight (b) length-wet tissue weight and (c) length-dry weight relationships of *Parreysia favidens*

these differences might probably be due to physiological condition of mussels and variation in environmental parameters (Seed, 1968; Thippeswamy and 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 nonlinear 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. The monthly variation in all length-weight relationships (length-total weight, length-wet weight, length-dry weight) showed similar pattern during the study period. In length-total weight relationships, *b* value showed peak during October 2002 (3.4107). However for length-wet weight (2.8346) and length-dry weight (2.9786) relationships, the *b* values showed peak in January 2002. Such sudden shift in the *b* values indicated the onset of maturation, gonadal growth and high condition index.

The *b* value of length-total weight relationship in the present study was less (2.745) than that of *Hyriopsis myersiana* reported from Thailand (Kovitvadhi *et al.,* 2008) and *Anodonta grandis* from Central Lake Alberta (Hanson, 1988) and more than that of *Parreysia corrugata* from river Kempuhole (Ramesha and Thippeswamy, 2009) and *P. corrugata* from River Malthi (Malathi and Thippeswamy, 2011). The present *b* value of the length - wet weight relationship was also less than *Anodonta cygnea* at Lagadone stream, Northern Italy (2.99) and *P. corrugata* (2.885) of River Kempuhole India and *P. corrugata* (2.669) from Malthi River (Malathi and Thippeswamy, 2011) (Table 1). In the case of the length-dry weight relationship, the equilibrium constant value of the present study was less than *Unio pictorium mancus* from Italy (Ravera *et al.,* 2007), *P. corrugata* from Kempuhole (Ramesha and Thippeswamy, 2009) and *P. corrugata* from Malthi River (Malathi and Thippeswamy, 2011).

Monthly mean variability of condition index of *P. favidens* is presented in Fig. 5 and the values varied from 4.57 (October 2001) to 8.95 (April 2002). During the study period, the major peak was distinct during April 2002. The maximum (18-21) condition index was represented by only few individuals. The values of condition indices showed decreasing trend from October to December 2002 during the study period. However, from January 2002 onwards, it showed increasing trend till July except in May 2002. Build up of condition started from January 2002 onwards (Fig. 5). Data on the frequency distribution of condition index in various class intervals during the entire period are presented in Fig. 6 (a-k). The condition index showed only one peak, at 3-6 class intervals. The maximum (18-21) condition index was represented by only one individual during March 2002. From October 2001 to February 2002, the primary peak was observed for the class group 3-6 and was shifted to group 6-9 during March 2002. During April, the mode was shifted to 9-12 size groups. However during May, the mode was again shifted back to 6-9 size groups and the decreasing trend was continued till December 2002. The data on condition index for the entire study period is presented in Fig. 6. The data revealed only one peak at 3-6 size class.

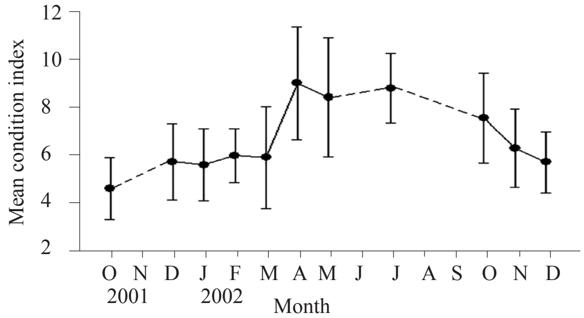

Fig. 5. Monthly variations in mean condition indices in *Parreysia favidens*. Vertical bars represent the standard deviation

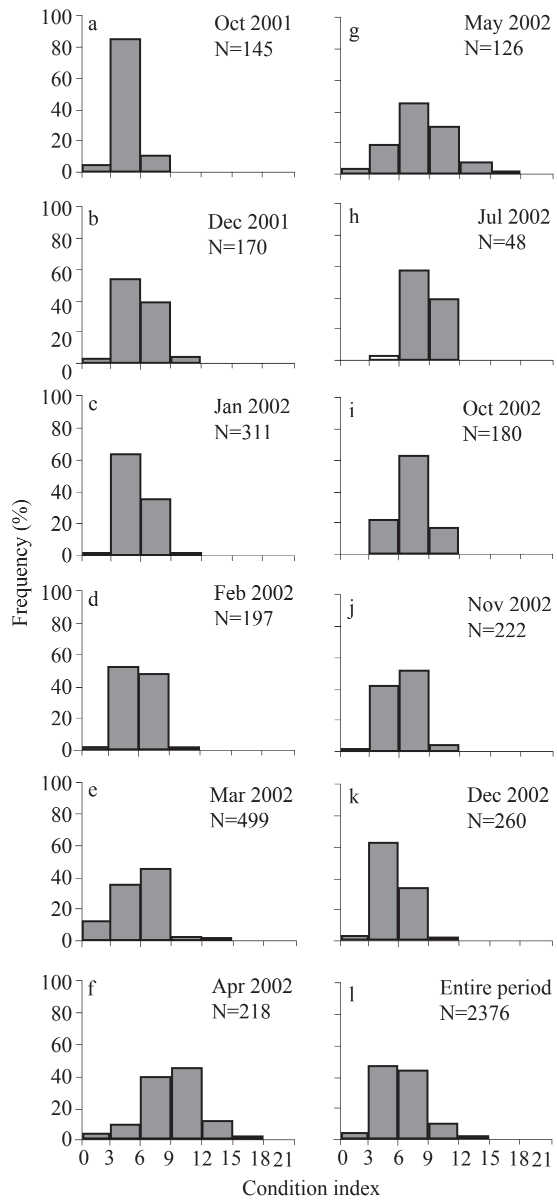

Fig. 6. Percentage frequency of condition index in *Parreysia favidens* during the study period

The data on condition index of mussels revealed that the reproduction of mussels is from February to July. In bivalves, when gonadal growth and maturation occurs, it results in the bulkiness of soft body. Based on available data, it is suggested that the ideal period for commercial exploitation of *P. favidens* from the river Bhadra was from February to July when the meat yield is highest. The maximum meat size of the mussels is achieved as they approach their reproductive stage. Accumulation of gametes in follicles and resultant bulkiness of the gonad result in increased condition while release of gametes from the follicles and corresponding shrinking of gonadal mass result in lowering of condition (Joseph and Madyastha, 1982). Variation in tissue condition also depends on availability of food resources, spawning condition and temperature (Garton and Haag, 1993; Allen *et al*., 1999). The most favourable period for harvesting mussels in study area is from February to July since the meat yield is high during this period.

Acknowledgements

The first author is grateful to the Ministry of Environment and Forests (MoEF), Government of India for financial support. This work forms the part of research project No. F.30/5/97-RE sanctioned to the first author by MoEF.

References

Aldridge, D. C. 1999. The morphology, growth and reproductive biology of Uniodiae (Bivalvia) in Fenland Water Way. *Hydrobiologia,* 495: 41–45.

Allen, Y. C., Thompson, A. B. and Ramcharan, W. C. 1999. Growth and mortality rates of the zebra mussel, *Dreissena polymorpha*, in the Lower Mississippi River. *Can. J. Fish. Aquat. Sci.*, 56(5): 748–759.

Anderson, R. O. and Gutreuter, S. J. 1983. Length, weight, and associated structural indices, In: Nielsen, L. A. and Johnson, D. L. (Eds.), *Fisheries Techniques*. American Fisheries Society, Bethesda, MD., USA, p. 283-300.

Bailey, R. C. and Green, R. H. 1988. Within-basin variation in the shell morphology and growth rate of a freshwater mussel. *Can. J. Zool.,* 66: 1704–1708.

Baird, R. H. 1966. Factors affecting the growth and condition of mussels (*Mytilus edulis* L.). *Fish. Invest. Minist. Agric., Fish. Food, London, Ser., II*, 25: 1-33.

Blay, J. 1989. Morphometric length–weight relationships and length distributions of five populations of the freshwater bivalve *Aspatharia sinuate* (Unionacea, Mutelidae) in Nigeria. *Malacologia,* 30: 365–372.

Bonner, J. T. 1965. *Size and cycle: an essay on the structure of biology*. Princeton University Press, Princeton, USA.

Boulding, E. G. and Hay, T. K. 1993. Quantitative genetics of shell form of an intertidal snail: constraints on short-term response to selection. *Evolution,* 47: 576-592.

Caceres-Martinez, J., Rio-Portilla, M. A., Gutierrez, S. C. R. and Humaran, I. M. G. 2003. Phenotypes of the California mussel, *Mytilus californianus*, Conrad (1837). *J. Shellfish Res.,* 22: 135-140.

Claxton, W. T., Wilson, A. B., Mackie, G. L. and Boulding, E. G. 1998. A genetic and morphological comparison of shallow- and deep water populations of the introduced dreissenid bivalve *Dreissena bugensis*. *Can. J. Zool*., 76: 1269–1276.

Desai, P. V. and Borkar, M. R. 1989. A study of allometric relationship in *Lamellidens corrianus. Ind. J. Fish.,* 36: 180-182.

Garton, D. W. and Haag, W. R. 1991. Heterozygosity, shell length and metabolism in the European mussel, *Dreissena polymorpha,* from a recently established population in Lake Erie. *Comp. Biochem. Physiol.,* 99A: 5-48.

Hanson, J. M., Mackay, W. C. and Prepas, E. E. 1988. Population size, growth, and production of a unionid clam, *Anodonta grandis simpsoniana*, in a small, deep Boreal Forest lake in central Alberta. *Can. J. Zool*., 66: 247–253.

Hinch, S. G. and Bailey, R. C. 1988. Within-and among-lake variation in shell morphology of the freshwater clam *Elliptio complanata* (Bivalvia: Unionidae) from south-central Ontario lakes. *Hydrobiologia*, 157: 27–32.

Hora, S. L. 1952. Control of molluscan fauna through the culture of *Pangasius pangasius* (Hamilton). *Curr. Sci.,* 21: 164-165.

Isham, L. D., Moore, H. B. and Smith, F. G. W. 1951. Growth rate measurement of shipworms. *Bull. Mar. Sci. Gulf Caribb.,* 1: 136-147.

Jantz, B. and Neumann, D. 1992. Shell growth and aspects of the population dynamics of *Dreissena polymorpha* in the River Rhine, In: Neumann, D. and Jenner, H. A. (Eds.), *The zebra mussel Dreissena polymorpha. Limnologie till*, Gustav Fischer Verlag, Stuttgart, Germany, p. 50-66.

Jolicoeur, P. and Worimann, J. E. 1960. Size and shape variation in the painted turtle. A principal component analysis. *Growth*, 24: 339-354.

Joseph, M. M. and Madhaystha, M. N. 1982. Gametogenesis and somatic versus gonadal growth in the oyster *Crassostrea madrasensis* (Preston). *Indian J. Mar. Sci.,* 11: 303-310.

Kovitvadhi, S., Kovitvadhi, U., Sawangwong, P., Trisaranuwatana, P. and Machado, J. 2008. Morphometric relationship of weight and size of cultured freshwater pearl mussel, *Hyriopsis (Limnoscapha) myersiana*, under laboratory conditions and earthen pond phases. *Aquacult. Int.,* 17: 57–67.

Lajtner, J., Marusic, Z., Klobucar, G. I. V., Maguire, I. and Erben, R. 2004. Comparative shell morphology of the zebra mussel *Dreissena polymorpha* in the Drava River (Croatia). *Biologia*, 59: 595–600.

Malathi, S. and Thippeswamy, S. 2011. Morphometry, length-weight and condition in *Parreysia corrugata* (Mullar 1774) (Bivalvia: Unionidae) from river Malthi in the Western Ghats, India. *Int. J. Biol. Sci.,* 2: 43-52.

Nagabhushanam, R. and Lohgaonker, A. L. 1978. Seasonal reproductive cycle in the mussel, *Lamellidens corrianus*. *Hydrobiologia*, 61: 9-14.

Negus, C. L. 1966. A quantitative study of growth and reproduction of unioid mussels in the river Thames at Reading. *J. Anim. Ecol.*, 35: 513-532.

Nielsen, S. L. and Sand-Jenson, K. 1990. Allometric scaling of maximal photosynthetic growth rate of surface/volume ratio. *Limnol. Oceanogr.*, 35: 177-181.

Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap*., 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.

Ramakrishna and Dey, A. 2007. *Handbook on Indian freshwater mollusks*. Zoological Survey of India, Calcutta, 399 pp.

Ramesha, M. M. and Thippeswamy, S. 2009. Allometry and condition index in the freshwater bivalve *Parreysia corrugata* (Muller) from river Kempuhole, India. *Asian Fish. Sci*., 22: 203-214.

Ravera, O., Frediani A. and Riccardi, N. 2007. Seasonal variation in population dynamics and biomass of two *Unio pictorum mancus* (Mollusca, Unionidae) population of two lakes of different trophic state. *J. Limnol.*, 66: 15-27.

Seed, R. 1968. Factors influencing shell shape in the mussel *Mytilus edulis. J. Mar. Biol. Ass. U.K.,* 48: 561-584.

Smit, H. and Van Heel, E. D. 1992. Methodical aspects of a simple allometric biomass determination of *Dreissena polymorpha* aggregations. In: Neumann, D. and Jenner, H. A. (Eds.), The zebra mussel *Dreissena polymorpha. Limnologie aktuell.* Gustav Fischer Verlag, Stuttgart, Germany, p. 79-86.

Smit, H., Bij de Vaate, A. and Fioole, A. 1992. Shell growth of the zebra mussel (*Dreissena polymorpha* Pallas) in relation to selected physiochemical parameters in the Lower Rhine and some associated lakes. *Arch. Hydrobiol.,* 124: 257-280.

Sprung, M. 1992. Observations on shell growth and mortality of *Dreissena polymorpha* in lakes. In: Neumann, D. and Jenner, H. A. (Eds.), *The zebra mussel Dreissena polymorpha. Limnologie aktuell,* Gustav Fischer Verlag, Stuttgart, Germany, p. 19-28.

Tevesz, M. J. S. and Carter, J. G. 1980. Environmental relationships of shell form and structure of Unionacean bivalves. In: Rhoads, D. C and Lutz, R. A. (Eds.), *Skeletal growth of aquatic organisms*. Plenum Press, New York, p. 265-322.

Thippeswamy, S. and Joseph, M. M. 1988. Seasonable variability in the condition of the wedge clam *Donax incarnates* (Gmelin). In: Joseph, M. M. (Ed.), *Proceedings of the first Indian fisheries forum*. Asian Fisheries Society, Indian Branch, Mangalore, p. 247-249.

Vass, K. F. and Van Oven Vass, A. 1959. Studies on the production and utilisation of natural food in Indonesian carp ponds. *Hydrobiologia*, 12: 308-392.

Wilbur, K. M. and Owen, G. 1964. Growth. In: Wilbur, K. M. and Yonge, C. M. (Eds.), *Physiology of mollusca,* Academic Press, New York, p. 211-242.

Date of Receipt : 19.02.2009
Date of Acceptance : 12.05.2014