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Morphometry, length-weight relationships and condition index of *Parreysia favidens* (Benson, 1862) (Bivalvia: Unionidae) from river Seeta in the Western Ghats, India

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ABSTRACT

Allometry and condition index of the freshwater mussel *Parreysia favidens* (Benson, 1862) inhabiting the west flowing river Seeta at Seetanadi in the Western Ghats, India was studied between April 2005 and May 2006. Monthly sampling was carried out and a total of 2728 bivalves were collected for the study. The length-breadth and length-width relationships for the entire study period were L = 1.540 + 0.6742B and L = -0.0873 + 0.4561W respectively. The length-total weight, length-wet weight, length-shell weight and length-dry weight relationships were $W = 0.0003805L^{3.066}$, $W = 0.0000255L^{3.054}$, $W = 0.0000705L^{3.139}$ and $W = 0.0000042L^{3.110}$ respectively. The values of *b* indicated the relative growth in body weight and superior physiological condition of the mussels. The monthly mean data on condition index showed fluctuation. The maximum (16.36) condition was noticed during August 2005 and the minimum (4.16) in December 2005. The condition of mussels was fairly high during May to September. The best period for harvest of *P. favidens* in river Seeta could be between May and September. The hierarchical cluster analysis showed three major groups of biological variables and sample size alone formed a separate group.

Keywords: Allometry, Condition index, Freshwater mussel, Karnataka, River Seeta

Introduction

The Western Ghats of India is the habitat for numerous ecological and commercially important species of bivalve molluscs. However, scientific information concerning the species morphology, allometry and population ecology is very scanty. Freshwater mussels serve as important tools for monitoring the health of aquatic ecosystems because they are extremely sensitive to a wide range of environmental factors including the levels of dissolved oxygen in water. According to the report by IUCN, *Parreysia favidens* (Benson, 1862) is recorded from Bangladesh, India (Assam, Andhra Pradesh, Odisha, Maharashtra) and in the Terai region of Nepal. But, so far no reports are available from the Western Ghats, which is one of the biodiversity hot spots in the world (Budha and Daniel, 2010). The allometric principle of animal morphology has long been recognised since Huxley and Tessier (1936) who proposed the concept of allometry. Allometry is the study of relationship between two measurable variables, or in its most general sense, allometry is the study of size and its consequences (Reiss, 1989). The allometric relationships are generally explained by shell growth along the three dimensional axis. The study of shell dimensions in molluscs is aimed at ascertaining the interrelationships in growth of body characters. The influence of proximate or mechanistic 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. Relatively large variation in meat content occurs in bivalve molluscs depending upon the variation in physiological condition and environmental variables (Wibur and Owen, 1964). The biology of freshwater mussels *viz*., *Parreysia corrugata* (Nagabhushanam and Lomte, 1971; Lomte and Jadhav, 1980) and *Lamellidens* spp. (Narian, 1972; Nagabhushanam and Lohgaonker, 1978; Moorthy *et al*., 1983) inhabiting the Indian rivers has been reported previously. However, information on allometry and condition index of freshwater mussels from Indian region is lacking except for the reports of Desai and Borkar (1989) and Ramesha and Thippeswamy (2009). Further, there is a dearth of biological data on *P. favidens,* which is widely distributed throughout India (Subba Rao, 1989; Ramakrishna and Dey, 2007). Even though *P. favidens* is listed as 'least concern' by IUCN (Budha and Daniel, 2010), they are potentially susceptible to a number of threats mainly fishing, in the present study locality. Freshwater mussels have important relationship with fish especially for reproduction. Other threats *viz.,* habitat destruction, poor water quality, siltation and agricultural run-off may act directly on the mussel population or have an indirect impact through decline in the host fish species that are required to complete the mussel's life cycle. Therefore, a reduction in the diversity or abundance of freshwater mussels can indicate a negative change in the ecosystem. Hence, the present investigation was undertaken to study the allometry and condition in *P. favidens* inhabiting the river Seeta at Seetanadi, near Hebri, in the Western Ghats of Karnataka, India.

Materials and methods

Study site

Freshwater bivalve *Parreysia favidens* (Benson) samples were collected at monthly intervals between April 2005 and May 2006 from river Seeta (13°25'26'' N; 74°59'25'' E) near Hebri in Karnataka, India (Fig. 1). The River Seeta originates in the Narasimhaparvatha hill in the Western Ghats and flow westward in the coastal plain and drains into the Arabian Sea.

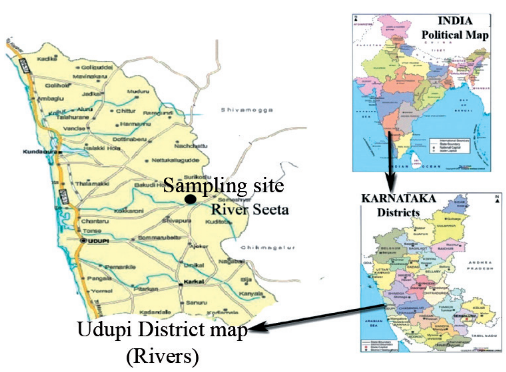

Fig. 1. Study area of *Parreysia favidens* in the river Seeta

Sample and analysis

A total of 2728 individuals of *P. favidens* (Fig. 2) were collected during the study period and subjected to morphometric measurements. During July and October 2005, organisms could not be sampled due to flooding. Shell length (maximum antero-posterior distance), height (maximum distance from hinge to ventral margin) and width or depth or thicknesses (maximum distance between outer edges of two valves) of individual organisms were measured accurately to 0.05 mm using Vernier calipers. Total weight of individual mussels was taken. The mussels were dissected to remove the meat which was then blotted and weighed individually. The individual weight of shell was also determined. The meat was dried at constant temperature of 60^{0}C for 2 days and weighed accurately to 0.001 g using an electronic balance. Allometric examination was done for morphometry, length-breadth, length-width and length-weight (length-total weight, length-wet weight, length-dry weight and length-shell weight) relationships (Pauly, 1983). The condition index of individual bivalve was determined (Baird, 1958).

Fig. 2. *Parreysia favidens* collected from river Seeta at Seetanadi

Statistical analysis

Dimensional relationships was estimated using the linear regression equation (Y = a + bX) and the length-weight relationship by a non-linear regression equation (W = aL^b) in which, *a* (intercept) and *b* (slope / equilibrium constant) are constants. Data on biological variables such as monthly mean values of length, breadth, width, total weight, shell weight, wet weight, dry weight, condition index and *b* values of length-breadth, length-width, length-total weight, length-wet weight, length-shell weight and length-dry weight were subjected to cluster analysis using SPSS software (version 13; SPSS Inc.), to understand the grouping of variables.

Results and discussion

Morphometric relationships

The calculated values of length-breadth and length-width relationships for the entire study period were: L = 1.5397 + 0.6742B and L = -0.0873 + 0.4561W respectively (Fig. 3). The monthly *b* values of length-breadth and length-width relationships varied from 0.5581 (November 2005) to 0.6915 (December 2005) and 0.3108

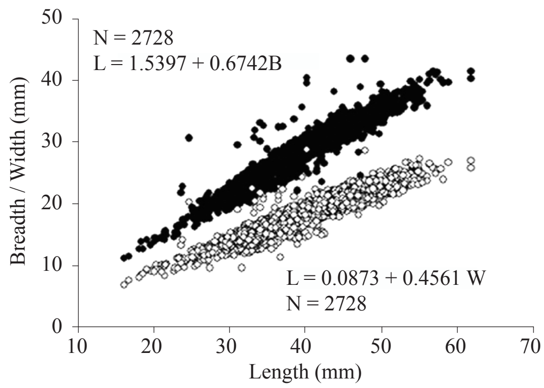

Fig. 3. Bivariate scatter diagram of length-breadth (dark circles) and length-width (open circles) relationships of *Parreysia favidens*

(November 2005) to 0.4619 (April 2005) respectively (Fig. 4). The linear relationships of length-breadth and length-width of *P. favidens* during the study period showed that the short individuals were of less height/thickness and inversely long individuals were wide/high (Fig. 3). The estimation rates of aquatic secondary production in a given ecosystem is possible with the knowledge of size and shape, differential body growth and population ecology of organisms (Wilber and Owen, 1964). The data on morphometric relationship in the present study revealed that the length, breadth and width were influenced by variation in size (Fig. 3). However, some individuals of same length showed different breadth and width, and these differences constituted shape variation as reported in other organisms (Jolicoeur and Worimann, 1960; Ramesha and Thippeswamy, 2009).

A variety of environmental factors are known to influence shell form in bivalves. The size of shell is more affected than their shape by fluctuation of ambient environmental parameters (Wilbur and Owen, 1964; Seed, 1968). Thus shape, rather than size generally provides more accurate knowledge on the dimensional relationships. During the present study period, the length of the mussels ranged between 16 and 62 mm. The average length was 40.48 mm, while the breadth and width of the mussels varied from 11.1 to 43.3 mm and 6.7 to 28.7 mm, respectively. The average breadth was 28.83 mm whereas the average width was 18.39 mm. The monthly *b* values of length-breadth and length-width showed fluctuation (Fig. 4) which may be due to the fact that, the shape is controlled by genetics of the organism and size by ambient environment as stated by Seed (1968). The *b* values of morphometric relationships are usually compared between dimensional growth of related species or same species in various geographical regions. In the present study, the *b* values of length-breadth and length-width relationships were 0.674 and 0.456, respectively. The *b* values of length-breadth and length-width relationships of *P. corrugata* from river Kempuhole, India were 0.585 and 0.333 respectively (Ramesha and Thippeswamy, 2009). The *b* values of length-breadth relationship of *Amblema plicata* at different sampling sites varied between 0.696 and 0.758 in the river Mississippi, USA (Hart, 1999). The morphometric relationships of *P. favidens* were in good agreement with the above mentioned studies.

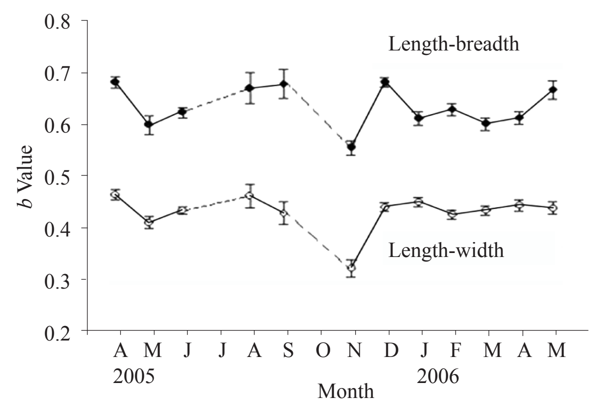

Fig. 4. Monthly variability in the *b* values (SD) of length-breadth and length-width relationships of *Parreysia favidens*. Vertical bars represent standard deviation.

Length-weight relationships

The estimated non-linear relationships such as length-total weight, length-wet weight, length-shell weight and length-dry weight of *P. favidens* are presented in Fig. 5. The calculated values for length-total weight relationship for the entire study period was $W = 0.0003805\ L^{3.066}$. The scatter plots for length-wet weight relationship

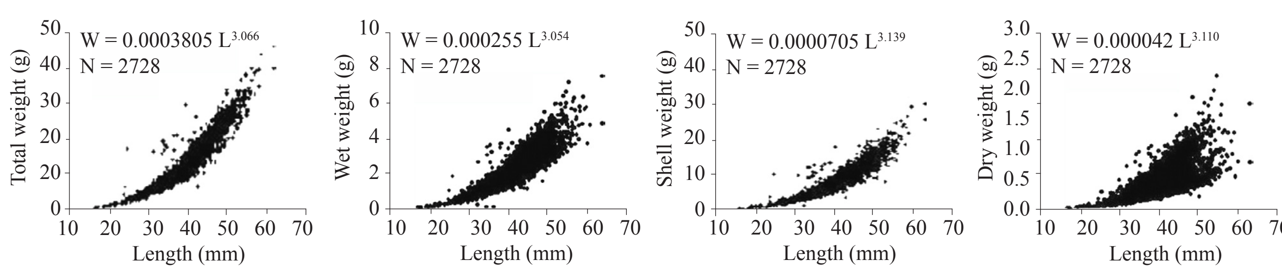

Fig. 5. Length-weight relationships of *Parreysia favidens*

(Fig. 5) showed that W = 0.0000255 $L^{3.054}$. The length - shell weight and length-dry weight relationships were: W = 0.0000705 $L^{3.139}$ and W = 0.0000042 $L^{3.110}$ respectively (Fig. 5).

All the length-weight relationships showed a non-linear pattern. The graph of length-wet weight and length-dry weight are also depicted in Fig. 5. The monthly *b* values of length-total weight relationship ranged from 2.635 (November 2005) to 3.167 (December 2005) (Fig. 6a); whereas the *b* values of length-shell weight varied from 2.632 (November 2000) to 3.171 (August 2005) (Fig. 6b). The *b* values fluctuated from 2.518 (April 2006) to 3.715 (August 2005) and from 2.579 (April 2006) to 3.196 (December 2005) for length-wet weight (Fig. 6c) and length-dry weight (Fig. 6d) relationships, respectively. The *b* values of length-weight relationships showed almost same pattern in the first four months of sampling period and thereafter the values increased from June to August. The *b* values of length-total weight and length-shell weight showed similar pattern during April to September and thereafter decreased. However, during November and December 2005, *b* values of both the relationships increased slightly and decreased thereafter. In length-wet weight, the values gradually decreased, except during March and November. The values of the length-dry weight relationship decreased during August onwards. In case of length-dry weight relationship, the *b* values gradually decreased from August 2005 onwards till April 2006.

The length-weight relationship provides a mathematical expression to the relationship between two variables, length and weight, and also provides a measure of deviation between two variables indicating the state or general well being of an organism. Length and weight of organisms have been highly correlated with life-history measures in cross taxonomic comparisons (Bonner, 1965; Peter, 1983). The bivalve molluscs are known to show variations in quality of meat depending on their environmental and physiological conditions as well as seasons. The skewed relationship in the present study indicated that short individuals were light and long individuals were heavy. Such observations in other organisms has been reported by Ramesha and Thippeswamy (2009), Bhattacharya and Banik (2012) and Sethi *et al*. (2012). Normally, as the age increases, the weight also increase; however, some individuals of the same age showed different weight and these differences could be due to reproductive strategies and environmental variables (Bauer, 1987; Haag and Station, 2003; Ravera *et al*., 2007).

The length-weight relationship is an important measure for identifying the condition of bivalves in all stages of its life cycle. It helps to compare the condition of the bivalves in the context of pollution within the species or between the species. In fisheries research, length–weight relationships are important for the estimation of weight, where only length data are available and as an index of the condition of the animal (King, 1995). The *b* value of length-total weight relationship in the present study was higher (3.006) than that of *Hyriopsis myersiana* from Thailand (Kovitvadhi *et al.,* 2008) and less than *Lamellidens carrians* from Khandepar River Goa, India (Desai and Borkar, 1989) and *Adonota woodiana* from Konin Lake, China (Afanasjev *et al.,* 2001). However, the present *b* value of the length-wet weight relationship (3.054) was less than *Margaritifera hembeli* at Loving Creek (3.290) and Beaver Creek (3.090) of Red River and higher than *M. hembeli* at Jaames Branch (2.750) and Jorden Creek (2.380) from Red River (Johnson and Brown, 1998), *Adonota woodiana* (2.149) from Konin Lake, China (Afanasjev *et al.,* 2001), *L. carrians* (1.832) at Khandepar River, Goa, India (Desai and Borkar, 1989) and *P. corrugata* (2.885) from river Kempuhole, India (Ramesha and Thippeswamy, 2009). In case of length-dry weight relationship, the equilibrium constant value of the present study was higher than *Unio pictorium*

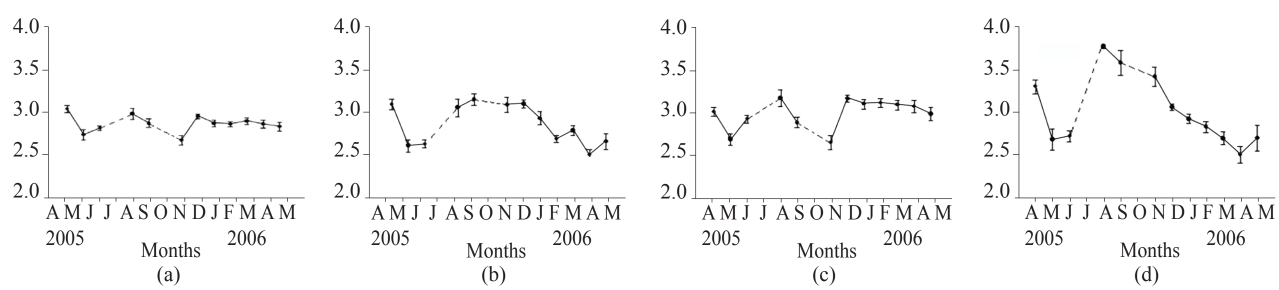

Fig. 6. Temporal variability in the *b* values of (a) length-total weight , (b) length-wet weight, (c) length-shell weight, (d) length-dry weight relationships of *Parreysia favidens.* Vertical bars represent the standard deviation.

mancus from Italy (Ravera *et al.,* 2007) and *L. carrians* from Khandepar River, Goa (Desai and Borkar, 1989). 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 linear relation ($b = 1$) was reported. The *b* values of length-weight relationships in the present study (Fig. 6) and the other studies mentioned above are in good agreement with Wilbur and Owen (1964). Moreover, these studies showed non-linear pattern in the length-weight relationships.

In length-weight relationship, the variation of equilibrium constant (*b*) from hypothetical unity suggests physiological deviations in condition. The monthly *b* values of length-total weight relationship varied from 2.635 (November 2005) to 3.089 (April 2005). However, for length-wet weight and length-shell weight relationships, the *b* values showed peaks during September (3.247) and August 2005 (3.171) respectively. High equilibrium constant values in the present study (Fig. 6) could be due to gonadal growth and high condition index (Fig. 7) from April to September 2005. 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 while release of gametes from the follicles and corresponding shrinking of gonadal mass result in lowering condition. Seasonal variations in the tissue mass or condition index of many bivalves follow a closely related pattern. Such pattern have been found useful for describing the period when harvesting could give maximum meat yield (Nair and Nair, 1987), for ecological purposes in elucidating the spawning period (Etim, 1990), and for bio-monitoring of environmental stress (Marcus *et al*., 1989).

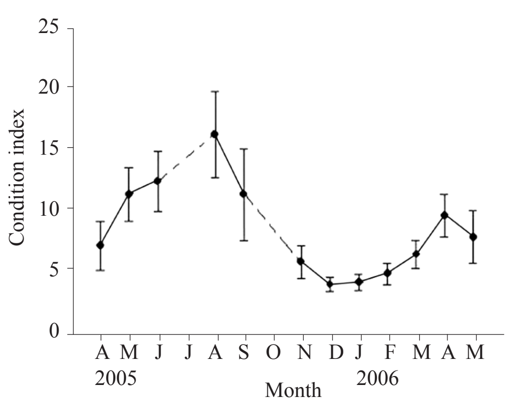

Fig. 7. Monthly variations in mean condition indices in *Parreysia favidens*. Vertical bars represent standard deviation.

Lowe-McConnell (1987) stated that many aspects could be accountable for the changes in fish growth such as variations in the habitat, fish activities, food availability and seasonal growth rates. The bivalves displayed marked seasonal variations in weight and biochemical content of the soft tissue (Williams and McMahon, 1989). In bivalves, the gonadal growth and maturation proceeds with bulkiness of soft body and consequent high body weights. Such sudden shift in the *b* values indicates the onset of maturation and gonadal growth in bivalves. Smith (1996) grouped the organisms into light ($b<3$), heavy ($b>3$) and isometric ($b=3$) demonstrating poor, over and symmetric growths in length and weight respectively based on their value (*b*) of equilibrium constant. In the present study, the *b* values are more than 3 indicating that the mussels are heavy to their length and in good condition.

Condition index

The data on monthly mean values of condition index of *P. favidens* revealed primary peak during August 2005 and secondary peak during April 2006 (Fig. 7). After the primary peak, the condition index suddenly decreased during September onwards and reached the lowest value (4.16) during December 2005; and thereafter, the condition of the mussels increased gradually. An examination of the temporal variation in the condition indices revealed obvious annual cycle of *P. favidens* (Fig. 7). The differences in the condition index observed in different months may be due to factors, such as environmental condition, food availability and the gonadal maturity (Jhingran, 1952; Bashirullah, 1975). The ideal period for commercial exploitation of *P. favidens* in river Seeta could be from May to September when the mussels are in good condition (more meat yield). The condition index of mussels may vary between the species and habitats. For example, study on condition index of *P. corrugata* from the river Kempuhole showed high condition between April and August (Ramesha and Thippeswamy, 2009).

The dimensional variables such as length, breadth as well as width and *b* values of length-breadth, length-width, length-total weight, length-shell weight, length-wet weight, length-dry weight formed one group and linked with other variables such as total weight, shell weight, wet weight, dry weight and condition index (Fig. 8) at correlation coefficient value of 0.5. The sample size N, linked separately with all other variables at very high correlation coefficient, reflecting significant influence of sample size on all the measured biological variables.

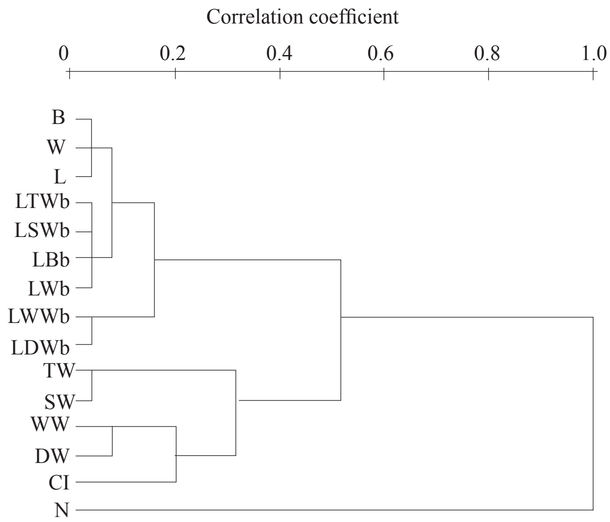

Fig. 8. Dendrogram (complete linkage) for biological variables of *Parreysia favidens*. L - length; B - breadth; W - width; TW - total weight; SW - shell weight; WW - wet weight; LB*b* - length-breadth *b* value; LW*b* - length-width *b* value; LTW*b* - length-total weight *b* value; LSW*b* - length shell weight *b* - value; LWW*b* - length-wet weight *b* value; LDW*b* - length-dry weight b value; CI - condition index; N-sample size.

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