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Allometry and condition index in the wedge clam *Donax incarnatus* (Gmelin) from Malpe beach, south west coast of India

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The relationship of length-breadth and length-width were B = 0.1763 + 0.6758L and W = - 0.3346 + 0.4068L respectively for the wedge clam, *Donax incarnatus*. The monthly b values of length-breadth relationship varied from 0.6252 (November, 2005) to 0.7928 (December, 2004). In length-width relationship, the b values varied from 0.3536 (March, 2005) to 0.4482 (September, 2005). The data on length-total weight, length-wet weight, length-dry weight and length-shell weight relationships were $W = 0.000112L^{3.1805}$, $W = 0.000010L^{3.3731}$, $W = 0.000013L^{2.8182}$ and $W = 0.000059L^{3.2416}$ respectively. The b values ranged from 2.5032 (January, 2005) to 3.5826 (May, 2005) for length-total weight relationship, whereas the values for length-shell weight varied between 2.4677 (January, 2005) and 3.8330 (May, 2005). The b values fluctuated between 2.5774 (December, 2004) and 3.7589 (November, 2005) for length-wet weight relationship. In the case of length-dry weight relationship, the b values ranged from 2.2571 (February, 2005) to 3.4753 (November, 2005). The studies on morphometry in *D. incarnatus* showed a linear relationship, whereas length-weight relationships showed non linear pattern. Seasonal fluctuations in condition index were probably related to cycles of gonadal growth and spawning.

[Key words: Shell dimensions, weight, allometry, wedge clam, Malpe**]**

Introduction

Along the Indian coast, the subtidal and intertidal regions of the rocky and sandy shores are inhabited by burrowing organisms. The members of the family Donacidae are found in the intertidal and subtidal sandy shores in both tropical and temperate regions of the world and are the most dominant organisms in the macrofauna of sandy shore ecosystem. Several species of the genus Donax of the family Donacidae are found in the intertidal zone along the Indian coasts. The wedge clams are consumed by coastal people as food along the Indian coasts. Some aspects of the donacids such as morphometric analysis[1-6], age and growth[7,8,] mortality rates[2,5,6], condition index[9,10], reproductive biology[2,11-13], biochemical analysis[14-16], heavy metal analysis[18-20], rearing of larvae[21] and wedge clam associated with environment parameters[9,22-24] have been carried out from India. There is no study on the allometry and condition index of the edible wedge clam, *Donax incarnatus* (Gmelin) inhabiting the sandy beach of Malpe, which is a tourist place.

Materials and Methods

A total of 2394 individuals of *Donax incarnatus* were collected from Malpe beach (Long. 31º 21′N and Lat. 74º 41′E; Fig. 1) near Udupi, Karnataka (India) from December 2004 to November 2005 using randomly placed quadrants (1 m^2 area, up to 10 cm depth). In the laboratory, the clams were subjected to morphometric measurements. Shell length (maximum antero-posterior distance), breadth (maximum distance from hinge to ventral margin) and width (maximum distance between outer edges of two valves) of individual organisms were measured accurately to 0.1 mm using vernier callipers. Total weights of individual clams were determined. Clams were then opened, separated meat, blotted and weighed individually. Individual weight of shell was also determined. Meat was dried at a constant temperature of 60^{o}C for 2 days and weighed accurately to 0.001 g. Allometry in morphometric analysis (length-breadth, length-width) and length-weight (length-total weight, length-shell weight, length-wet weight, length-dry weight) were calculated

using the linear equation, $Y = a + bX$ and $W = aL^b$ respectively, where a (intercept) and b (slope) are constants[25]. Xylene was used to determine the cavity volume of individual clams in order to avoid errors resulting from surface tension[9]. Condition index (CI) was determined following the method described by Baird[26].

Results

The length-breadth and length-width relationships of *Donax incarnatus* are presented in Fig. 2. Data revealed that the calculated values presented a best fit to the actual observed measurements of thickness and breadth. Relationships are linearly related and showed that long individuals are wide and high (more thickness) and inversely, short individuals are narrow and low (less thickness).

The calculated linear equation of length-breadth and length-width relationships were $B = 0.1763 + 0.6758L$ and $W = - 0.3346 + 0.4068L$ respectively.

Monthly 'b' values of length-breadth relationship ranged from 0.6252 (November, 2005) to 0.7928 (December, 2004), whereas the b values for length-width relationship varied from 0.3536 (March, 2005) to 0.4482 (September, 2005) (Fig. 3). Size range of clams ranged from 2.6 to 26.2 mm in length. Length-weight relationship of clams is presented in Fig. 4 and the relationship was non-linear pattern. Length-total weight, length-wet weight, length-dry weight and length-shell weight relationships were $W = 0.000112L^{3.1805}$, $W = 0.000010L^{3.3731}$, $W = 0.000013L^{2.8182}$ and $W = 0.000059L^{3.2416}$ respectively.

The data on monthly b values of length-weight relationships are shown in Fig. 5. The b values ranged from 2.5032 (January, 2005) to 3.5826 (May, 2005) for the length-total weight relationship, whereas the values varied between 2.4677 (January, 2005) and 3.8330 (May, 2005) for the length-shell weight relationship. Numerical values of total weights of clams obtained would have been affected slightly by any residual water retained within the shell. On the other hand, the b values fluctuated between 2.5774 (December, 2004) and 3.7589 (November, 2005) for the length-wet weight relationship. In the case of dry weight, the b values ranged from 2.2571 (February, 2005) to 3.4753 (November, 2005).

The monthly mean variability in the values of condition index with increase in size of the clams is presented in Fig. 6 and the values varied from 3.17 (June, 2005) to 17.32 (November, 2005). In one present study only one peak was distinct in the month of November. Alternative decreased and increased

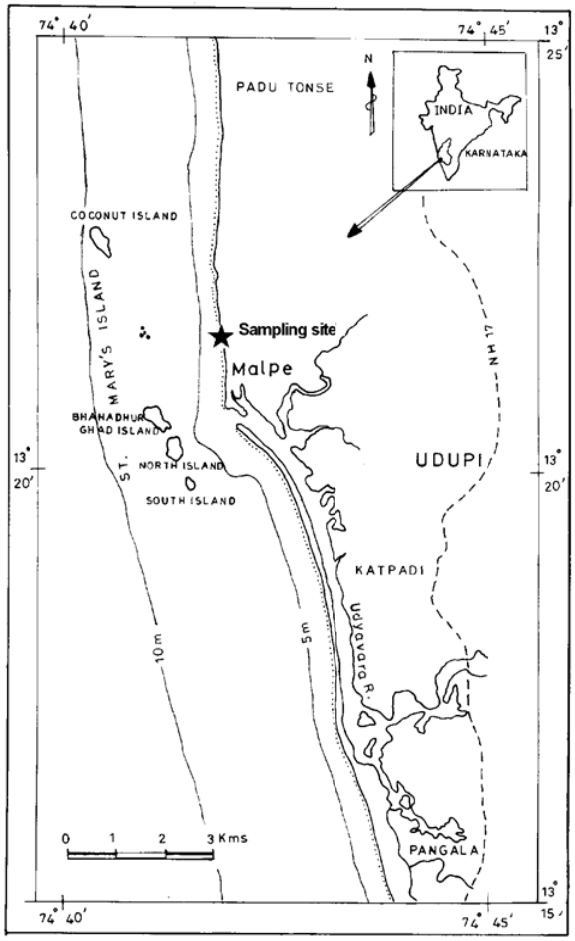

Fig. 1 — Map of the study site "Malpe beach", near Udupi, Karnataka.

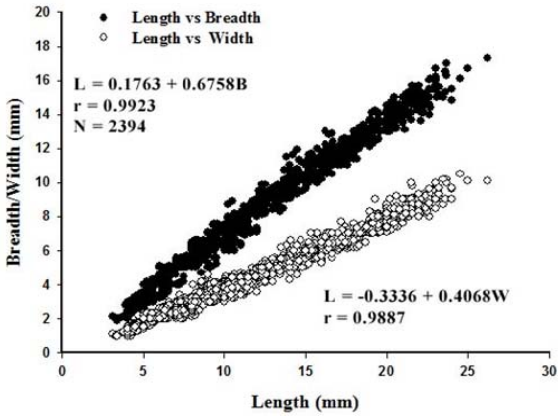

Fig. 2 — Bivariate scatter diagram of length-breadth and length-width relationships of *Donax incarnatus*. Open circles indicate length-width relationship and dark circles indicate length-breadth relationship.

values of condition indices with the gradual elevation of the curve were noticed. Data on the frequency

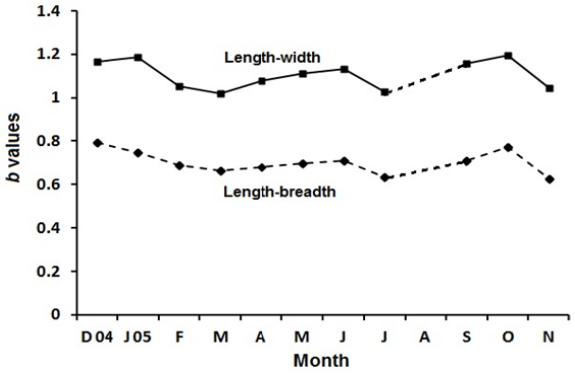

Fig. 3 — Monthly variability in the b values of length-breadth and length-width relationships of *Donax incarnatus*. Sampling was not carried out during August 2005.

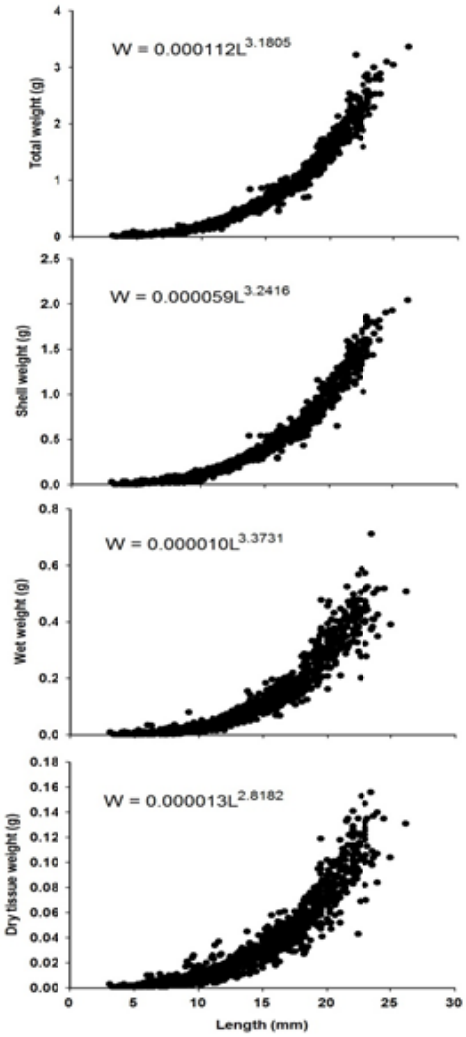

Fig. 4 — Length- weight relationships in *Donax incarnatus* during the entire study period.

distribution of condition index in various class intervals during the entire period are presented in Fig. 7.

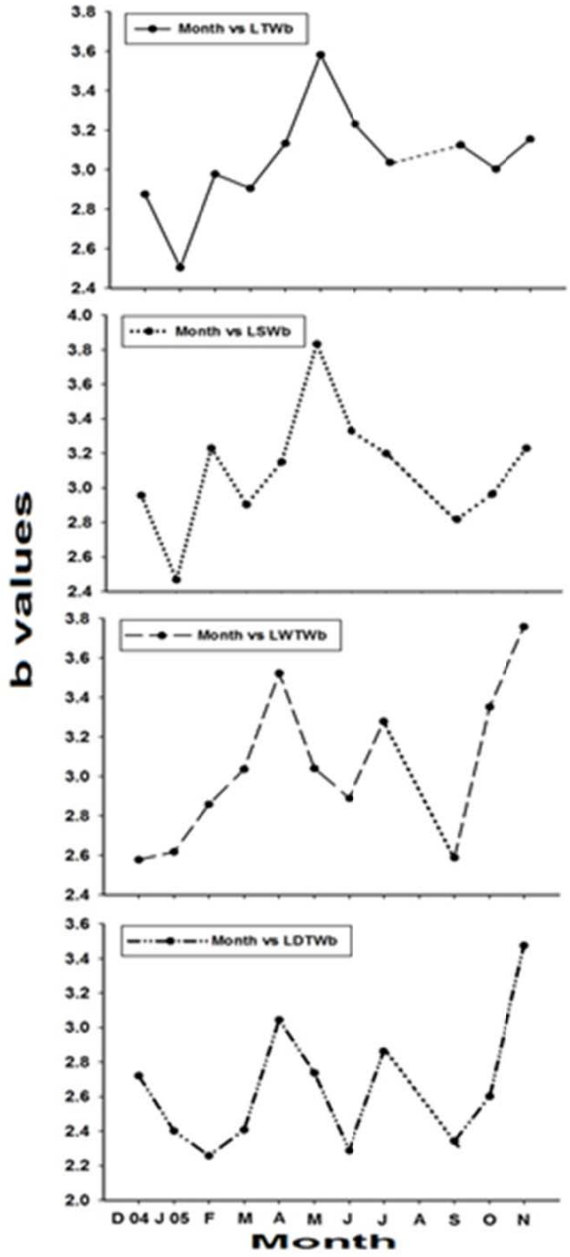

Fig. 5 — Monthly variability in the b values of length-weight relationships of *Donax incarnatus.*

The condition index showed one peak at 4-7 size groups and the maximum (34-37) condition index was represented by only one individual during September 2005. The percentage distributions of monthly condition index are depicted in Fig. 8. During February-March and June, > 80% of clams were in condition < 7.0 (condition index).

Discussion

In molluscs, as in other animals, the growth rate of the various parts of the body may not be uniform,

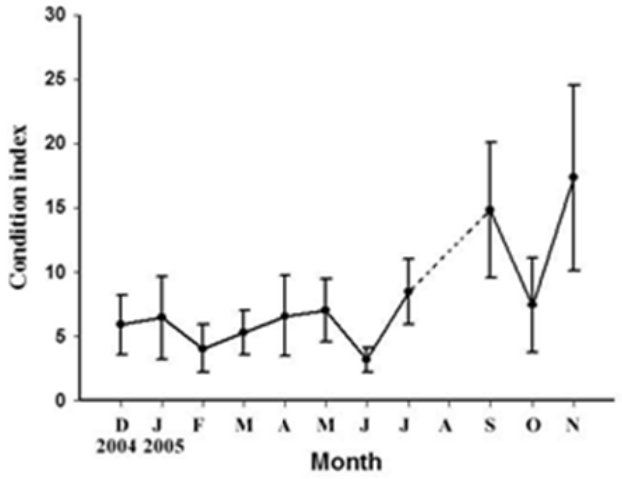

Fig. 6 — Monthly variation in the mean condition index in *Donax incarnatus*. Vertical bars represent the standard deviation.

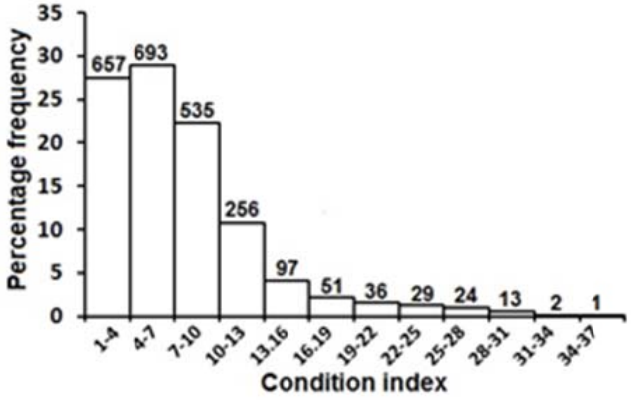

Fig.7 — Percentage frequency distribution of the condition index in *Donax incarnatus* during the entire period.

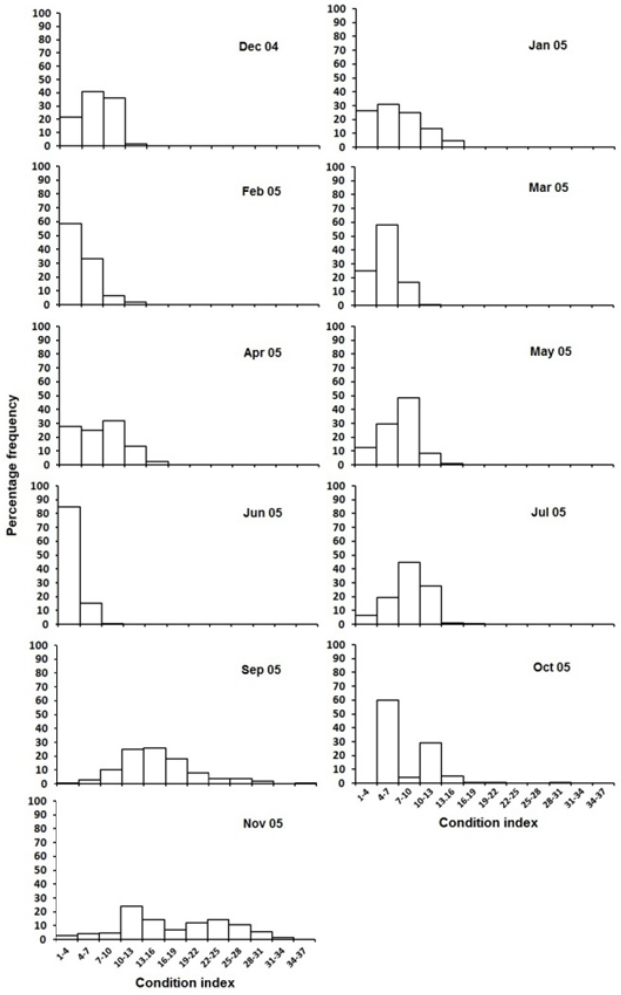

Fig. 8 — Monthly frequency distribution of the condition index in *Donax incarnatus*.

with the result that the relative proportions of the body changes, with increase in size. Nielsen and Sand-Jensen[27] reported that allometric relationships describe rates for a wide range of metabolic process and over a wide range of organisms. Studies on allometric growth in *Donax incarnatus* from the Indian coasts8,9 have been reported. Length-breadth and length-width relationships are linearly related in Fig. 2 indicating long individuals are wide and high (more thickness). In contrast, short individuals are narrow and low (less thickness). Thus, the size of clams is more affected than their shape. Shape is controlled by its genetics and size of ambient environment. In the present study, the b values of the length-breadth and length-width relationships were 0.6758 and 0.4068 respectively, and the b value of the length-breadth relationship is almost same as in *D. incarnatus* (b = 6754) from Panumbur beach, Mangalore9 and less than the values in *D. incarnatus* (b = 1.13) from Benaulim beach, Goa[4].

In the present study, the estimated b values of length-total weight, length-wet weight, length-dry weight, and length-shell weight were 3.1805, 3.3731, 2.8182 and 3.2415 respectively. According to Wilbur and Owen[28], the b values usually remains between 2.4 and 4.5, and when it is equal to 3 the relation is called isometric growth[29]. From Fig. 4, it is very clear that the dots are skewed on each diagram indicating long individuals are heavy and short individuals are light. We can conclude that the weight of clams also increases as age increases as seen in other previous works. However, some individuals of the same age show different weight and these differences may be probably because of physiological condition[10] of clams and variations in environmental parameters[30]. Data on monthly variation (Fig. 5) in length-dry weight

relationship showed that peak value in November, 2005. In the case of relative growth in wet-weight as compared to length was also the highest as seen in relative growth in length-dry weight in November, 2005. Highest total weight appeared in May, 2005 due to increase the shell weight compared with length. Wedge clams display marked seasonal variations in weight[8] and biochemical composition[16,31], suggesting that the change in dry weight would indicate a relatively greater increase in soft tissues as growth proceeds, perhaps indicating progressive development of the gonads. High condition index of *Donax incarnatus* just prior to spawning due to the increase in the total bulk of gonad forms the major part of the visceral mass has been reported by Thippeswamy and Joseph[10] at Panambur beach. Thus the 'b' values indicate gonadal growth and maturation also.

At the present study area, *Donax incarnatus* seems to spawn continuously since small clams were observed throughout the year as seen in other areas[5,32]. However, continuous recruitment of this species has not been observed along the south east coasts of India. On the other hand, though Jamaican and Indian beaches are located in tropical zones, their more defined settlements seem to be associated with lower salinity levels caused by the influence of a more defined rainy seasons[22,33]. Relative growth in body weight is indicated by the monthly values of equilibrium constant. Talikhedkar et al.[3] suggested that an increase in salinity during the period from February to June accelerated the growth of *D. cuneatus.* However, during monsoon a decrease in salinity and during winter a low salinity seemed to retard growth.

Several workers have studied the condition index of bivalves. Baird[26] measured the condition index in both mussels and oysters, and expressed the condition index as percentage of shell cavity by meat. In marine bivalves, there are few important factors which contribute to increase the condition indices. Condition index and cycles of gonadal development follow each other closely. Gametogenesis and release of gametes appears to have a direct impact on the condition of wedge clam. Spawning process depends on a complex interaction of several endogenous and exogenous factors, whereas the duration of maximum values of condition index corresponds to the pre-spawning peak of gonad index.

Spawning was found to play a significant part in affecting the condition of some other molluscs also[34-36]. Thippeswamy and Joseph[10] and Hemachandra and Thippeswamy[37] suggested that breeding in the marine bivalves of Mangalore and Malpe regions commenced only after the cessation of the south-west monsoon, and in most bivalve, gonads are in a state of sexual quiescence during the low saline monsoon period. Based on our data, it is reasonable to believe that this holds well in the present instance also as indicated by the first appearance of spat in September. In general, 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 case, variation in condition index 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. The values of condition index ranged from 1.25 (February, March, April, June) to 35.00 (September) in the present study. Present data suggests that irrespective of the fact that condition index increased or decreased with the wedge clam size as well as the percent condition index (i.e. rate of change in condition index) decreased with increase in size of the clam and showed a close relationship between the gonadal growth and fattening cycle and the condition indices.

It is apparent that while biometric relationships (between length and breadth, length and width, length and total weight, length and shell weight, length and wet tissue weight and length and dry tissue weight) tended to be stable in *Donax incarnatus* population, some difference occurred in other allometric relationships which could be attributed to physiological and ecological variations. Seasonal fluctuations in condition index were probably related to cycles of gonadal growth and spawning.

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