

Shell dimension relationship to soft tissue weight in the fisheries management of soft bottom bivalve *Acra senilis* (L) from southeastern Nigerian mangals

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ABSTRACT

Morphometric relationship of shell length, width and height and living space (volume) as growth estimators were evaluated for *Acra Senilis* (L) in south eastern Nigeria. When applied to live weight, each parameter proved a good estimator (r^2 values 78 to 85%). This was not the case with soft tissue weight (wet, dry or ash-free-dry weight) as each parameter was not reliable in predicting its growth (r^2 values 15 to 35%). Significant differences were observed in the b value for shell volume to weight relationship of bivalves collected during the dry season (Nov – Feb) and those of wet season (April to July).

INTRODUCTION

Shell dimensions and their inter-relations in bivalves mollusks have been reported by workers (Weymouth, 1923; Newcombe, 1935; Morton, 1976; Hibbert, 1977; Bailey and Green, 1988; Rose and Lima, 1994; Ravera and Sprocati, 1997; Etim, 1993; Daval 2001).

Shell growth is correlated with the growth of soft tissues in bivalves and studies on shell dimensions help to determine the optimum marketable size of commercial bivalve species.

Acra senilis (L) is a large and fleshy bivalve that attains a shell of up to 15cm. Indigenous communities living in the coastal regions of South Nigeria exploit it as an important subsistence food source (Etim, 1993). It is a sturdy animal and has excellent attributes for mariculture (Etim, 1993; Morton, 1976). Growth studies of allometric relationships are essential for managing fisheries resources and understanding fluctuating environmental conditions and the integrity of the environment with respect to pollution (Palmer, 1990; Boulding and Hay 1993). Often growth is estimated by measuring shell dimensions or volume of the animals, because they are simple and non-destructive methods that can be executed in the field (Ross and Lima, 1984). Once allometric relationship is establish shell measurement is a sufficient surrogate to estimate biomass and total flesh production (Hibbert, 1977; Rodhouse et al, 1984; Rose and Lima, 1994; Deval, 2001). It is however not in all cases that shell variable estimates the flesh weight of organisms.

Certain conditions such as the physiological state of the animal (Rueda and Urban, 1998), population status (Seed, 1968) and physical and biological change in the habitat (Thorarinsdottir and Johannesson, 1996) are known to affect the growth of bivalve and can alter the allometry between the shell and the flesh. The robustness of the relationship between the shell morphology and total tissue component should therefore be established before using shell measurement to estimate soft tissue growth in a bivalve population (Ross and Lima, 1994). The purpose of this study was to determine whether shell dimensions of length, height and width, and shell volume have a strong relationship that can be used to monitor biomass production in populations of *A. senilis* in Southern Eastern Nigerian mangrove swamps. Because variation in the allometric relationship may occur between sexes, reproductive seasons and changing environmental conditions, their study also examined differences in shell biomass relationships between sexes collected during the dry and wet periods of the year.

MATERIALS AND METHODS

Adult *A. senilis* (shell length 80 – 150mm) were collected by hand at approximately monthly intervals (May, 1989 – August 1990) from a tidal mud flat of the Bonny – Port Harcourt mangrove swamp, South Eastern Nigeria. The live organisms collected were taken to an experimental hatchery in ARAC (African Regional Aquaculture Centre) near University of Port Harcourt in, Nigeria, where they were maintained in 2001 static concrete tanks containing some aerated muddy sand and filtered estuarine water of 1ppt salinity.

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Manuscript received by the Editor November 22, 2007; revised manuscript accepted June 21, 2008.

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To clear stomach, the animals were left for 24hrs after which 50 to 70 samples were randomly selected for measurement. The shell length was recorded as the greatest dimension of the anterior-posterior axis, while the shell width was the maximum lateral axis. The shell height was the maximum distance recorded from the hinge to the opposite side (Ventral side) of the shell. All dimensions were measure to the nearest 0.01cm using a vernier caliper. Total body volume measurements were made to the nearest 0.1ml by water displacement (Quale and Newkirk, 1989). After towel-drying the shell, live weights (LIW) were determined to the nearest 0.01g. Sexes were determined based on the colour of the gonads. The gonad is grayish black in females and milky white in males. The wet tissues were blotted dry and their weights measured to the nearest 0.001g with a Sartorius B3105 electronic balance.

The dry weights (DRW) were recorded after freezer-drying the tissue to a constant weight for 72hr. the ash content was determined after burning the dry materials for 24hrs at 450°C. The ash free dry weight (AFDW) was calculated by subtracting the ash content from dry weight. The relationship between shell dimensions of length, height, width and shell volume to live weights (LIW), dry weights (DRW) and (AFDW) were independently evaluated using log – transformation of the equation.

$$Y = aX^b \quad (1)$$

where Y is LIW (g) or soft tissue (SW, DRW, or AFDW in grams) and X is one of the dimensions (length, height, width in centimeters) **a** is the intercept and **b** is the slope parameter. The volume live weight relationship was also evaluated separately for females and males as well as for clams collected during the dry season (Nov – Feb) and the wet season (April – August). Regression line slopes were tested for significant differences from zero using the F-statistics. Difference between male and female regression lines and that of season were tested using the two tailed students' t-test (Fowler et al, 2000). Regression analyses were carried out with the aid of statistical version **b** (Start Soft, 2002).

RESULTS

The slopes of the regression lines are all significantly different from zero. A strong correlation was obtained between the shall dimensions of length, height, width and shall volume and live weight (Table. 1). 78 percent of the variation in the latter is accounted for by variation in either shell dimensions or volume. The volumes appear to be the best estimator of the live weight r^2 of 85%. When applied however to soft tissue weights, either in wet, dry or ash-free basis, none of these shell variables was a reliable predictor as r^2 values ranged from 15 – 35.

As volume displacement gives the best estimation for live weight, we applied this shell variable to demonstrate the differences in live weight of each sex with seasons (Table.2). The slopes showed

constant high values during the wet season as regression line was significantly lower for wet season than the dry season and this indicates more variability in live weight during the wet season than in the dry season. During the dry season, the slope of the males regression line was significantly lower than for the wet season ($t = 3.1.89$, d.f. = 64, $p < 0.05$), while the slope for the female did not differ significantly different gradient ($t = 2.318$ d.f. = 64, > 0.05). when data from both sexes were combined a significantly different gradient ($t = 2.318$ d.f = 130, $p < 0.05$) were observed for samples collected in the two seasons. When data collected from both sexes in the same season, were compared the result was not significant (dry season $t = 1.261$, d.f. = 83, $p > 0.05$, wet season: $t = 1.586$, d.f. = 54, $p < 0.05$).

DISCUSSION

A strong correlation was shown between shell dimension and volume to live weight though little relationships were observed, between shell dimensions and the soft tissue for these organisms is in Bonny Mangroves. This implies that the soft tissue changed very little with steady growth of the clams.

The b value for the length – weight relationship is in agreement for other bivalve molluscs (Park and oh, 2002). The grown shell which increase the weight of the animal due to either increased shell mass or a greater capacity to retain water is perhaps the major reasons why there exit the strong correlation between shell size and flesh tissue of *A. senilis*. This is contrary to that reported for most other bivalve species, such as *Chamaelea gallina* (Daval 2001), *Artica islandica* (Thorarinsdottir and Johannesson, 1996), *Mercenaria mercenaria* (Hibbert 1977) and *Mytilus edulis* (Rodhouse et al 1994). However Gimin et al, 2004 reported a strong correlation between shell size and flesh tissue for *Polymesoda erosa* similar to the present studies. The growth of an individual bivalve seem to be limited by the enormous energy invested on the shell. This has become a necessity if the animal has to survive the naturally harsh intertidal environment. The need for strong shells and ability to survive in harsh estuarine areas might have evolutionarily channeled an enormous energy to shell growth rather than soft tissue embasement. Thus the growth of individual is limited (Currey, 1998).

A. senilis habitats in south eastern mangrove ecosystem are in the mid high tide to high tidal areas of estuaries where the bottom could be exposed for long period to irradiation, ambient air temperature, etc for very long periods. The animals typically burry themselves in the soft muddy sediment with only small portions of the shell and siphon emerging to filter tidal water. The benthos are potentially exposed to desiccation, fluctuating salinities, and low pH, the later being indicated by the shape of the shell which shows evidence of erosion by the mangrove soil acidity (Morton, 1985). The necessity for thicker and heavier shells than normal has been noticed in bivalves

Table 1. Morphometric relationships of shell dimension (mm) and volume (ml) to soft tissue (g) and live weight (g) of *Acra senilis*
 (n = sample size, a = intercept; b = gradient, SE = standard error, r² = coefficient of determination, all values significant (p<0.001), STWW denote soft tissue wet weight.

Relationship	n	b±SE	r ²	F-test
Soft tissue wet weight	386	2.841± 0.1862	0.316	132.08
STWW length vs STWW	0.234			
Heights vs STWW	386	1.631±0.2851	0.219	86.8
	0.851			
WIDTH vs STWW	386	1.885±0.1681	0.314	132.8
	0.896			
Volume vs STWW	296	0.764±0.1151	0.273	68.5
	0.289			
Soft tissue dry weight (STDW)				
Length vs STDW	386	1.856±0.1685	0.301	130.4
	0.068			
Height vs STDW	386	1.185±0.1617	0.152	60.5
	0.236			
Volume vs STDW	298	0.623±0.148	0.232	48.9
	0.121			
Live weight (LIW)				
Length vs LIW	386	3.09±0.081	0.868	1785.2
	0.401			
Height vs LIW	386	3.046±0.0625	0.801	1201.8
	1.565			
Width vs LIV	386	2.663±0.0386	1.081	3201.3
	4.216			
Volume vs LIV	298	0.8865±0.0181	0.968	2898.9
	2.124			
Ash-free dry weight (AFDW)				
Length vs AFDW	298	2.089±0.3012		89.8
	0.034		0.351	
Height vs AFDW	298	1.246±0.2983		37.9
	0.186		0.186	
Weight vs AFDW	298	2.106±0.342		41.1
	0.301		0.2688	
Volume vs AFDW	298	0.812 ±0.0896	0.263	49.6
	0.122			

Table 2. Morphometric relationships of shell volume (ml) to live weight (LIW) (g) of female and male *Acra senilis* in the wet and dry season n, a, b, SE, r² are in Table 1

Sex	season	n	b ±SE	r ²	F-test
Male	dry	65	1.026 ±0.0312	0.956	2212.4
		2.014			
Male	wet	50	1.216 ± 0.0626	0.964	521.0
		0.921			
Female	Dry	60	0.921 ± 0.0568	0.952	498.5
		2.326			
Female	Wet	52	0.989 ± 0.0628	0.030	326.1
		1.651			
Male	+Dry	125	0.921 ± 0.0116	0.981	1978.8
Female		2.486			
Male	+Wet	102	1.116 ± 0.0386	0.926	602.2
Female		1.328			

inhabiting periodically dry zone (Seed, 1968), such as the estuarine and shallow marine environment (Tokeshi et al 2000).

These adaptive features of the shell help to protect the soft tissue of the animal against adverse abiotic conditions prevalent in the estuarine environment and predation.

The slow rate of tissue growth is of ecological and physiological significance for the survival of this benthos exposed to extended period of emersion. At low tide period, when the clams are exposed and the valves are tightly closed, there is a need to retain a large volume of water inside the shell to provide a watery milieu within the shell (Seed 1968). If the soft tissue grows steadily, it will occupy a large part of the space inside the shell, which means that more water will be needed to support the metabolic needs of the increased tissue within a highly limited space within the shell (Gimin, 2004).

The values of the gradient (b) for the shell volume and weight relationship of the bivalves in the rainy season are significantly different from those obtained during the dry season. This may be due to the greater intensity animals spacing regime during the wet season (Ewa-oboho and Abby Kalio, unpublished data).

From this study it could be informed that shell dimensions or volume are not very good estimators for biomass of *A. senilis*. However for monitoring the growth of this species in nature the morphometric relationship between shell length, width or volume to live weight can be used.

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