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Shell morphometry of seven limpet species from coastal shell middens in southern Africa

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Abstract

Measurements of shell parts and features (elements) of marine limpets can be used to derive morphometric equations for estimating total shell lengths. This is demonstrated for seven limpet species commonly found on the southern African coast. The equations can be used to reconstruct whole shell lengths for highly fragmented limpet samples in prehistoric shell middens. A linear regression model is based on measurements of all shell elements, resulting in high coefficients of determination with excellent predictive power in most cases. These morphometric equations would enable archaeologists to derive more metrical information from fragmentary archaeological material than was previously the case. We also present a case study where morphometric equations of two limpet species are applied to an archaeological sample from the South African west coast for the purpose of investigating possible biases in limpet shell preservation. We conclude that small whole limpet shells survive longer than the bigger ones in this particular case, but that many more such case studies need to be conducted in order to fully understand differential preservation of southern African limpet shells in archaeological sites.

Keywords: Shell middens; Zooarchaeology; Shell analysis; Morphometry; *Cymbula*; *Scutellastra*; Southern Africa; Shell preservation; Shell taphonomy

1. Introduction

Archaeological sites on the south and west coasts of South Africa have received increasing international attention in recent years thanks to discoveries of Middle Stone Age (MSA) components with early remains of anatomically modern humans, as well as elements of material culture that point to early modern human behavior (Erlandson, 2001; Grine et al., 1998; Henshilwood et al., 2001, 2002; Rightmire and Deacon, 2001; Singer and Wymer, 1982). The uppermost levels of these deep, stratified deposits sometimes overlap the bases of several equally deep Later Stone Age coastal sites, and together they now form the very backbone of southern Africa's Stone Age sequence (Deacon and Deacon, 1999; Deacon and Geleinjse, 1988; Fagan, 1960; Goodwin, 1938; Goodwin and Malan, 1935; Inskeep, 1987; Klein, 1972; Marean et al., 2000; Shrire, 1962; Singer and Wymer, 1982; Thackeray, 2000; Volman, 1981; Wurz, 2002). They also provide data from which long-term palaeoenvironmental changes have been inferred (Avery, 1987; Cowling et al., 1999; Klein, 1972; Klein and Cruz-Uribe, 1987, 1996, 2000; Parkington et al., 2000; Shackleton, 1982; van Andel, 1989).

Overall, these sites provide insights into the cultural sequence and environmental background of Upper Pleistocene and Holocene indigenous societies, particularly the changing patterns in procurement of marine resources as sea-level recovered from its lowest mark during the Last Glacial Maximum (Inskeep, 1987; Klein, 1972; Parkington, 1981). Along the South African West Coast, such changes nicely track records of sea-surface temperature and sea-level changes for the southern Atlantic (Cohen et al., 1992; Jerardino, 1993).

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There are parallel increases in the forager population and residential permanence, increased consumption of marine resources, and local depletion of at least three species of gastropods within the last 3500 years (Jerardino, 1996; Jerardino et al., in press). Additional dietary and anatomical patterns have been derived from Holocene human skeletons recovered from the west and south coasts (Lee-Thorp et al., 1989; Pfeiffer and Sealy, 2006; Sealy and Pfeiffer, 2000). Other coastal sites have also provided key evidence that mark the introduction of pastoralism to southernmost Africa (Henshilwood, 1996; Sealy and Yates, 1994; Vogel et al., 1997). Thus, coastal sites have played a major role in the reconstruction of pre-colonial history of southernmost Africa, and continue to do so.

Quantitative and metrical analyses of marine invertebrate remains have provided both central and contextual evidence for the above reconstructions, a task which has often not been easy due to the fragmentary nature of archaeofaunal material. Fortunately, morphometric equations have been established for two species of mussels (Buchanan, 1985; Hall, 1980) and one species of crustacean (Jerardino et al., 2001), which have resulted in productive applications to archaeological case studies (Jerardino et al., in press; Thackeray, 1988).

Typical of the problem are the limpets *Cymbula* and *Scutellastra*, which are known to survive in South African shell middens, but often in statistically inadequate numbers. Archaeologists are thus forced to hugely increase overall sample size and also collect intact shells from material not sampled for marine shells in order to recover enough unbroken shells of these fragile taxa for measurement (Jerardino, in press). But excavations are increasingly faced with time and financial constraints that inhibit the recovery of voluminous shell samples. Planning and budgeting for a sampling strategy that maximizes the recovery of whole limpet shells is made doubly difficult by our inability to predict the degree of shell fragmentation ahead of excavations, let alone shell density, or the extent to which the shells will be cemented in hard matrix as often occurs in MSA components (Klein et al., 2004; Marean et al., 2004; Volman, 1978). Added to these concerns is the uncertainty whether the limpet size record based on whole shells is biased in any way. An argument could be made that larger limpets will survive better in shell midden deposits than smaller ones, thus inflating the mean length of the whole limpets recovered. A counter-argument would hold that small limpets can hide and be protected under larger shells and other spaces, and are thus less likely to fragment *in situ*. Consequently, mean length of whole limpets will distort in favor of smaller overall size. Because morphometric equations yield measurements from fragments, the potential biases introduced by measuring only whole limpets are eliminated.

The best way to overcome these problems is to develop morphometric equations for shells that allow the estimation of shell lengths from easily recognizable shell parts or shell features that survive in the highly fragmented archaeological record. Here, we propose suitable parameters of morphometric equations for seven limpet species commonly found at coastal sites in southern Africa, and apply some of these in a case study involving two of the most dominant limpet species (*C. granatina* and *S. granularis*) found in shell middens along the West Coast of South Africa. This case study is aimed at not only showing how sample sizes of shell measurements are increased with the use of fragmentary material. Here we take it further to check for possible preservational biases.

2. Materials and methods

The control samples used in this study were recently collected limpets in the reference collections of the Departments of Zoology and Archaeology at the University of Cape Town, and of IZIKO: South African Museum, Cape Town. Collection records show that most of the control specimens were collected live. A few with badly eroded apices, probably caused by wave action, were rejected. Table 1 shows the numbers of shells analyzed for seven different species, and the size ranges of each sample. None of the samples represents single localities. Instead, the geographic spread of collected specimens within each sample reflects the overall modern distribution of the species (Branch et al., 1999; Kilburn and Rippey, 1982). The one exception is the *S. granularis* sample, in which most shells came from just two locations on the West Coast, although its natural range extends much farther along south and east coasts where relatively warmer sea surface temperatures prevail (Kilburn and Rippey, 1982). The west/cold to east/warm temperature gradient appears to covary with the mineralogy and crystalline structure of the shell of *S. granularis*, specifically the thicknesses of calcitic and aragonitic layers within the shell (Cohen and Branch, 1992). However, there is no *a priori* reason why this trend should affect external shell morphometry.

The parts of the limpet shell selected for measurement are shown in Fig. 1. The choice of parts was guided by prior knowledge of typical limpet breakage patterns, also which parts were most likely to survive intact. Layout of the measurements was dictated by general shell shape. More measures could be taken on the star-shaped limpets characterized by prominent, long and, protruding ridges (*C. granatina*, *S. oculus* and *S. longicosta*). Fewer measures were possible on those with roughly oval bases and characterized by many thin and/or regularly spaced ridges (*S. granularis*, *S. argenvillei*, *S. barbara*, *S. tabularis*) (Fig. 1). Thanks to the prominent lateral ridges of the star shaped limpets, two additional measurements

Table 1
Numbers of shells analyzed and their size ranges for seven different limpet species

Species	No. of shells	Size range (mm)	
		Min	Max
C. granatina	94	20.8	96.4
C. oculus	112	29.2	120.3
S. argenvillei	97	28.3	95.3
S. barbara	82	26.3	99.1
S. granularis	102	17.3	68.9
S. longicosta	89	29.5	84.5
S. tabularis	63	28.0	135.1