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A Research Agenda for the Archaeomalacological Study of Prehistoric Human Ecology in the Coastal Zone of NW Sicily

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ABSTRACT: NW Sicily has a high density of coastal sites with occupation spanning the Upper Palaeolithic, Mesolithic and Neolithic periods. The region, the sites and the shellfish remains within them constitute an important resource for investigating important issues, including the potential for coastal environments to support sustained hunter-forager exploitation and settlement, and the role of coastal resources in changing economies. Our research involves a combination of archaeological, palaeoecological, neoecological and geochemical approaches (stable isotope, XRD and SEM) to the analysis and interpretation of prehistoric shellfish assemblages. Three of our research themes are developed in this paper: coastal ecology and prehistoric shellfish exploitation, oxygen isotopes in modern and archaeological shells, and shell artefacts and the symbolic significance of shells. We stress the importance of modern ecological and biological analogue studies for the interpretation of archaeomalacological data.

KEY WORDS: PREHISTORIC SICILY, HUMAN COASTAL PALAEOECOLOGY, ARCHAEOMALACOLOGY, SHELLFISH EXPLOITATION, OXYGEN ISOTOPES, SEASONALITY, SHELL ARTEFACTS, SYMBOLISM OF SHELLS

RESUMEN: La Sicilia noroccidental es rica en yacimientos costeros que cubren el intervalo del Paleolítico Superior hasta el Neolítico. La zona, los asentamientos y los vestigios de moluscos dentro de ellos constituyen un recurso importante en el estudio de temas trascendentales entre los que destacamos el potencial de las zonas costeras para soportar una actividad sostenida de caza y recolección así como el papel de los recursos costeros en las cambiantes economías. Nuestra investigación implica una combinación de analíticas arqueológicas, paleoecológicas, neoecológicas y geoquímicas (isótopos estables, XRD y SEM) en el estudio e interpretación de las colecciones prehistóricas de conchas. En este trabajo se exponen tres de nuestras líneas de investigación, referidas a la ecología costera y su relación con la recolección prehistórica de conchas, a los isótopos de oxígeno en muestras actuales y arqueológicas y a los utensilios elaborados con conchas en relación con el significado simbólico de las mismas. Enfatizamos la importancia de los estudios actuales basados en la ecología y la biología, como base de la interpretación de los datos arqueomalacológicos.

PALABRAS CLAVE: SICILIA PREHISTÓRICA, PALEOECOLOGÍA HUMANA DE COSTA, ARQUEOMALACOLOGÍA, EXPLOTACIÓN DE CONCHAS, ISÓTOPOS DE OXÍGENO, ESTACIONALIDAD, UTENSILIOS EN CONCHA, SIMBOLISMO DE LAS CONCHAS

INTRODUCTION

Current Issues in Human Coastal Palaeoecology

Human palaeoecology in coastal environments is a complex multi-facetted topic which we cannot consider in detail here. Two currently important topics of research and debate are central to our work: (1) issues of access to and control of coastal resources and (2) the role of coastal (and other marine) resources in changing subsistence systems.

Current research in human social ecology focuses on the complex inter-play between scarcity of resources, decision-making strategies, and the resilience of those resources and the social groups dependent on them (e.g. Adger, 2000, 2003; Sneddon, 2000). There is some evidence in the archaeological record that human foraging can deplete spatially-restricted resources in littoral habitats (e.g. Mannino & Thomas, 2002) and that foragers can adapt to such resource depression in various ways (e.g. Nagaoka, 2002). The archaeological record of coastal regions offers valuable data for the investigation of human responses to environmental and resource change, because resources are focussed within a relatively narrow inter-tidal zone in which access to sub-tidal resources can potentially be controlled or regulated. Environmental changes, such as rising sea levels, can lead to changes in the range of habitats and resources available and (especially on islands) can constrain the size of resource territories. An important consequence of environmental change in coastal zones would be a shift in the types of food resources available, challenging human social groups to respond to new resource opportunities.

Coastal environments, providing access to diverse terrestrial, littoral and marine resources, are increasingly seen as important arenas for human social evolution (Bailey & Milner, 2003). There has been an important recent debate about the changing role of marine resources in the Neolithic, following the adoption of agriculture (Hedges, 2004; Lidén *et al.*, 2004; Milner *et al.*, 2004). This has focussed on the later Mesolithic and early Neolithic of western Europe, but other areas of the world can contribute usefully to the discussion, especially the Mediterranean, with its rich archaeological record of prehistoric coastal resource exploitation.

ECOLOGY OF PREHISTORIC SHELLFISH EXPLOITATION IN THE COASTAL ZONE OF N.W. SICILY

Our project investigates the ecology of prehistoric exploitation of inter-tidal resources, especially shellfish, and the impact (if any) of exploitation on those resources. The 'big ideas' which the research seeks to address include the potential for coastal environments to support sustained hunter-forager exploitation and settlement, and the role of coastal resources in economies, e.g. following the adoption of agriculture. The research considers such ideas within a broader view of the ecology of prehistoric coastal subsistence, to encompass environmental change, changes in resource availability and selection, and the social ecology of resource access and exploitation, including the possible control of coastal resource territories. Methodologically, the project adopts a combination of archaeological, ecological, palaeoecological and geochemical approaches which are applied to a number of important coastal prehistoric sites in northwestern Sicily.

The rich archaeological record of prehistoric coastal occupation in northwest Sicily has numerous sites with Upper Palaeolithic, Mesolithic and Neolithic occupation, clustered in a fairly restricted geographical area (Figure 1). Most of these sites are in caves, many have been excavated and abundant remains of shellfish have been found in most of them. There are radiocarbon dates for some sites, but in most cases sequences are based on stone tool typologies (Leighton, 1999). A few caves have sequences spanning from the end of the Palaeolithic (Final Epigravettian) through to the Neolithic, while others have only one or two major cultural phases. Apart from the artefacts and (in some caves) notable rock engravings, little is known about the prehistoric occupants of these cave sites, or of their economy and environment. The Grotta dell'Uzzo is the chief exception, being a site for which the shellfish and other zooarchaeological remains have been studied (details are given below). The vertebrate zooarchaeological remains from the Grotta di Cala dei Genovesi have also been studied (Cassoli & Tagliacozzo, 1982), but not the shellfish.

Little is known about Pleistocene and Holocene environments in the coastal zone of N.W. Sicily. Research has mainly concentrated on relative sea levels (e.g. Antonioli *et al.*, 2002; Lambeck *et al.*,

FIGURE 1

Map of northwestern Sicily showing the location of some of the important prehistoric sites.

2004). Recent studies on a speleothem from a now-submerged cave on the island of Marettimo, and on accreted vermetid reefs in the vicinity of San Vito lo Capo, have produced data on the rates of sea level change and, equally importantly, demonstrated the relative tectonic stability of the west of Sicily over the last 125 ka (Antonioli *et al.*, 2002; Lambeck *et al.*, 2004; Silenzi *et al.*, 2004). The demonstration that the region has been tectonically stable over the period of time relevant to our project means that present-day hydrographic maps can be used for palaeogeographical modelling. We hope to model, for different time periods, variation in the inter-tidal habitats for marine molluscs as a means towards interpreting their exploitation by prehistoric human foragers.

AN ARCHAEOMALACOLOGICAL RESEARCH AGENDA FOR N.W. SICILY

Some of our broader research themes are outlined above. The quality of the archaeological and archaeomalacological records available for coastal north-west Sicily has led us to identify the following as worthwhile research topics:

– past coastal environments (climate, the types of shores existing at various times, and the mollusc communities on them),
– how environmental changes affected the exploitation of inter-tidal resources by human foragers,
– the impact (if any) of human exploitation on shellfish resources,
– changing patterns of shellfish exploitation in relation to changes in subsistence economies or in the use of coastal occupation sites,
– radiocarbon dating of marine shell carbonates to establish the chronology of shellfish exploitation,
– the use of oxygen isotope analysis to determine the seasonality of shellfish exploitation,
– the social ecology of coastal resource exploitation, including patterns of mobility, resource access (and possible territories),
– exchange or trade of shells or shell objects,
– shells in art, symbolism and ritual, and the association of shellfish remains with other evidence for symbolic or ritual behaviour (e.g. cave art or human burials),
– the technology and social context of shell working and use of shell artefacts,
– changes in the ecology or biogeography of shellfish species, especially the potential role of anthropic impacts.

These topics are being addressed using a range of sources and methods:

1. Archaeological sources: to establish the stratigraphic and cultural contexts of the shellfish assemblages, their chronology and associations with artefacts and other zooarchaeological, archaeobotanical and, where available, human bioarchaeological data;
2. Palaeoenvironmental sources and methods: mainly geomorphological studies of sea level change and reconstructions of palaeo-coastal environments;
3. Archaeomalacological methods: identification, quantification and biometry of species present; taphonomic studies of shellfish processing and of shell modification for artefact production;
4. Bio-geochemical analyses of shell carbonates, especially ^{14}C for radiocarbon dating, $\delta^{18}O$ for palaeotemperatures and season of collection, and $\delta^{13}C$ to provide information about inter-tidal palaeo-ecosystems. We also propose to use elemental analyses of shell composition (e.g. Ca, Mg & Sr) for palaeoenvironmental investigations. X-ray diffraction analyses and scanning electron microscope imaging are used to validate the mineralogy of the archaeological shells selected.

We outline below progress on three aspects of our investigations.

COASTAL ECOLOGY AND PREHISTORIC SHELLFISH EXPLOITATION

The present-day shores of north western Sicily are mainly rocky, with limited areas of sandy or shingle beaches. The most ubiquitous and abundant mollusc species on these rocky shores are *Monodonta turbinata* (Born, 1780), *M. articulata* Lamarck, 1822, *Patella caerulea* Linnaeus, 1758, *P. rustica* Linnaeus, 1758 and *P. ulyssiponensis* Gmelin, 1791. The same taxa, apparently collected for food, dominate the assemblages in the prehistoric sites of the region, along with *Patella ferruginea* Gmelin, 1791 (a species now extinct in Sicily and which we discuss below). The inter-tidal zone on modern rocky shores is quite narrow, reflecting the low tidal amplitude characteristic of the Mediterranean Sea. The abundance and density of marine molluscs in the inter-tidal is low, in consequence of the restricted space available and the low biological productivity of these shores. If these factors were similar in the past, littoral foragers would have to exploit quite extensive areas of shore to collect sufficient shellfish for food. It is likely, therefore, that shellfish were either a minor food resource or a resource that was exploited only episodically, perhaps at particular seasons. Possibly, too, these inter-tidal populations of molluscs would have been susceptible to depletion by over harvesting. These are issues which we will investigate in the archaeomalacological assemblages from the various sites.

Despite the dominance of rocky shores in the region, sediment shores (with sandy, muddy or gravelly substrata) appear to have existed in the late Pleistocene and early Holocene between the westernmost coast of Sicily and what are now the islands of Levanzo and Favignana. The mollusc assemblages from Upper Palaeolithic (Epigravettian) deposits in cave sites on Levanzo include rocky shore species and taxa (such as *Ostrea* sp. and *Cerastoderma* sp.) characteristic of unconsolidated substrata. These sediment shores appear to have existed before rising sea levels submerged the low-lying stretches of land that once connected these islands to the mainland.

As noted above, *Patella ferruginea* is present in virtually all the Upper Palaeolithic coastal sites, often in large numbers and with large shell sizes (e.g. at the Addaura caves). Through the Mesolithic and Neolithic periods it declines progressively in abundance, and shell size, as seen at the Grotta dell'Uzzo (Compagnoni, 1993) and at Grotta d'Oriente (Maninno & Thomas, 2004). A similar decline has also been noted at the site of Grotta della Madonna, in Calabria on the Italian mainland (Durante & Settepassi,1972). Today, the species faces extinction, being restricted to a few protected localities in the western Mediterranean and listed as the most endangered marine invertebrate species in Europe (Paracuellos *et al*., 2003). A recent study by Guerra-García *et al*. (2004) on a population enclave of the species in northern Africa suggested that predation by humans is the main contributing factor to the decline of the species. Studying this species in archaeomalacological assemblages from NW Sicily should contribute to the debate over the relative impact of human predation and environmental change in bringing about its decline. This may, in turn, prove helpful to current efforts for the conservation of the species.

OXYGEN ISOTOPES IN MODERN AND ARCHAEOLOGICAL SHELLS

Our work on oxygen isotopes in shell carbonates has two main purposes: to determine the season of collection of shellfish and to determine the temperature ranges recorded in shells over the various archaeological periods as a proxy record for inshore sea surface temperatures. It is important to select carefully the species that will be used for isotope work and also to undertake modern analogue studies to 'calibrate' the palaeo-isotope data.

SELECTION OF SPECIES FOR OXYGEN ISOTOPE ANALYSIS

We have selected *Monodonta turbinata* (= *Osilinus turbinatus*) as the target species in our study because:

- it is a ubiquitous and abundant species, both ecologically and archaeologically,
- it is ecologically co-existent with the other main species present in the archaeomalacological assemblages and was probably collected at the same time as these other species; it should therefore be representative of broader patterns of mollusc exploitation,
- the aragonitic shell of this species can be shown to be well preserved and therefore suitable for both stable isotope analyses and radiocarbon dating,
- the species has been shown to record significant shifts in oxygen isotope ratios (variation in $\delta^{18}O$ of at least 3 ‰) that appear to be correlated with temperature changes (Schifano & Censi, 1983).

Moreover, work on the closely-related eastern Atlantic species *Monodonta lineata* (da Costa, 1778) showed that shell carbonate $\delta^{18}O$ values are a good indicator of season of death (Mannino *et al.*, 2003). The criteria for selecting mollusc species as ecological indicators and for isotope analysis are discussed in detail by Mannino & Thomas (2007).

MODERN STUDIES ON THE SPECIES

Biological and ecological surveys of *M. turbinata* are being undertaken to study:

- population dynamics, especially periods and rates of recruitment, population density and age structures, longevity, etc.,
- growth patterns in marked individuals at regular intervals over time,
- isotopic variation at regular intervals over time, to be correlated with measurements of seawater temperatures and salinities.

We are investigating populations of the species at four 'permanent' localities in western Sicily. In addition, 'standing crop' population studies of the species are being made at various localities across the modern (but mainly western Mediterranean) geographical range of the species. Here we will outline some of the results from our studies of a population on the island of Favignana.

Mark-release-recapture studies are underway to study patterns of shell growth through the year. At each locality, large numbers of shells have been marked with individual patterns of shallow holes on their under surfaces (Figure 2.A), the shells are then measured, and other features recorded, before being notched at the growing aperture edge (Figure 2.B) and carefully put back onto the shore. At periodic intervals the shores are revisited and intensively searched for marked individuals. The average amounts of shell growth through an annual cycle of growth are shown in Figure 3. Shells grow in each season of the year, but most growth occurs in the autumn/fall and winter periods. Isotope values for the spring and summer are therefore more likely to be time-averaged than those for the rest of the year. This needs to be considered when interpreting isotope data from archaeological shells.

Monthly visits have been made to the Favignana population to collect living shells for isotope analysis of shell-edge carbonates, to measure sea surface temperatures, and to take seawater samples to determine variations in salinity and $\delta^{18}O$ VSMOW (the latter to establish temperature calibration for $\delta^{18}O$ values in archaeological shells). Figure 4 shows the relationship between monthly sea surface temperatures and monthly shell edge values of $\delta^{18}O$. The relationship is highly significant ($r^2 = 0.9127$), showing that the shell-edge $\delta^{18}O$ values closely track seawater temperatures, giving confidence in the use of *M. turbinata* for palaeo-isotope studies.

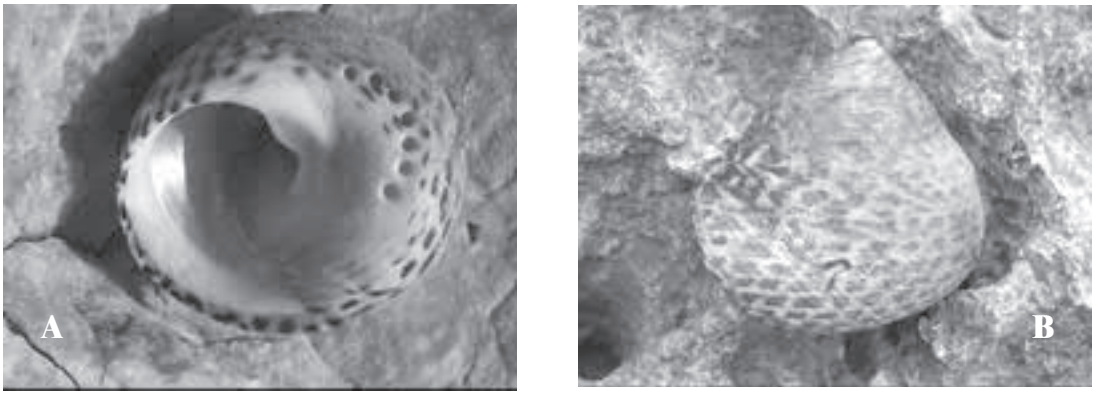

FIGURE 2

A: Shell of *Monodonta turbinata* with individual specimen code (Specimen 52, San Vito lo Capo); B: Notched shell of *M. turbinata*, with subsequent shell growth (Specimen 50, San Vito lo Capo). Both specimens were marked in October 2005, when they had diameters of 21.9 mm (Specimen 52) and 22.7 mm (Specimen 50). When recovered in January 2006, Specimen 52 had a diameter of 23.1 mm, with a 'linear' growth increment along the shell periphery of 8.6 mm since being notched, and Specimen 50 had a diameter of 23.8 mm and a 'linear' growth increment of 8.0 mm.

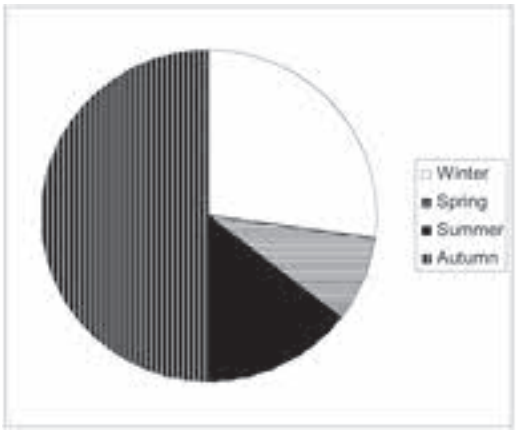

FIGURE 3

Pie chart of seasonal growth based on the mark-recapture studies at the Favignana (Cala Grande) locality.

Our work on *M. lineata* showed that shells could be sampled for long sequences of isotope values (to show annual and inter-annual variations) or for short sequences near the shell edge for determination of seasonality (Mannino *et al.*, 2003). Figure 5.A shows a shell of *M. turbinata* sampled for a long series of samples for $\delta^{18}O$ analysis, while Figure 5.B shows another shell of this species that has been sampled to yield a short shell-edge series of $\delta^{18}O$ values. In the next section we consider the results of applying these sampling methods to shells from the site of Grotta dell'Uzzo, to determine patterns of seasonal exploitation through the phases of occupation of the site.

SEASONS OF SHELLFISH EXPLOITATION AT THE GROTTA DELL'UZZO

The Grotta dell'Uzzo is the best-studied prehistoric site in western Sicily, with a deep stratigraphic record spanning through the Mesolithic to the early Neolithic. Tagliacozzo (1993, 1994) gives details of the stratigraphy, the main archaeological phases and the vertebrate zooarchaeology. The marine and terrestrial mollusc assemblages have been analysed by Compagnoni (1993). We have undertaken radiocarbon dating of shells of *M. turbinata* from the site (Mannino *et al.*, 2006), which complement and significantly add to the few existing charcoal-based dates.

Figure 6 shows an oxygen isotope profile ($\delta^{18}O$ values) in a shell from the early Mesolithic phase, with winter periods (lower temperatures) shown by high $\delta^{18}O$ values and summer by the lowest $\delta^{18}O$ values. The aperture edge (sample 1) value reveals that this shell was harvested in the winter. Details of the reconstruction of seasonality of shellfish exploitation at the Grotta dell'Uzzo are given by Mannino *et al.* (2007). The inferred patterns of seasonal exploitation of *M. turbinata* are shown in Figure 7. The main seasons in which shellfish were exploited are the autumn/fall and winter, although there is interesting variation between the layers and cultural phases. In the early

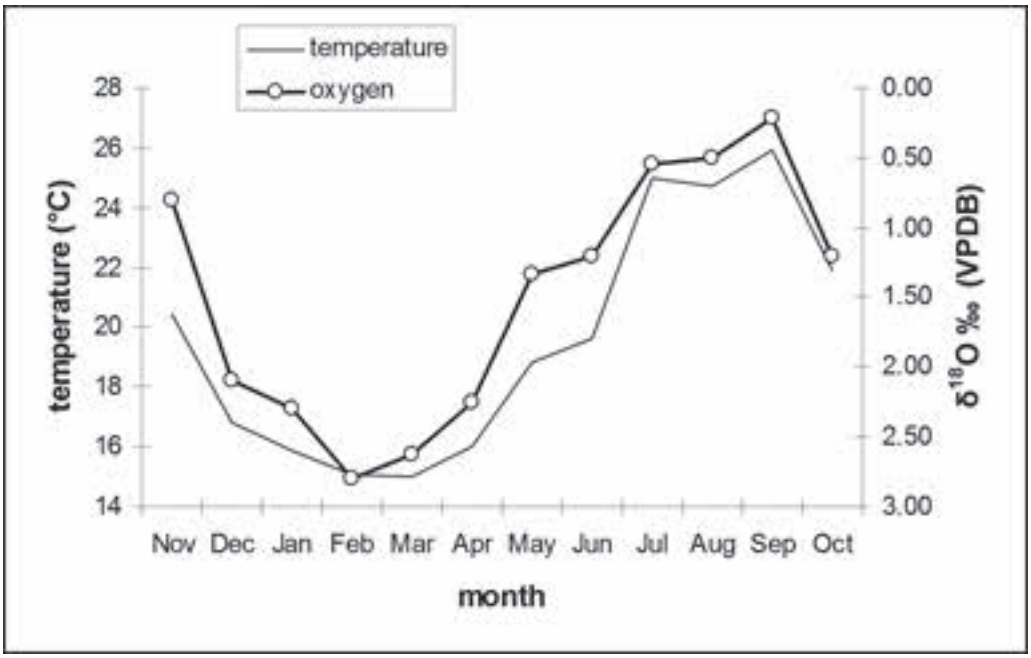

FIGURE 4

Monthly shell edge $\delta^{18}O$ values in *M. turbinata* and inshore sea surface temperatures, from ecological surveys at the Favignana (Cala Grande) locality (November 2002-October 2003).

Mesolithic, exploitation is mainly in the winter and extending into the spring (A18/19). During the later Mesolithic, indicated here by Cut 18, shellfish were collected in each of the seasons of the year, although it is not clear if this represents all-year-round occupation or episodic visits to the cave in every season. During the 'transitional phase', said by the excavators to be transitional between the later Mesolithic and the early Neolithic, the seasonality data for Cut 12 indicate autumn/fall and winter periods of collection. There is, therefore, no evidence from the shellfish of a shift in occupation towards sedentism at this time. In the early Neolithic (Cut 10) there is a broadening of the seasons from the preceding phase, but no evidence for summer exploitation. By the late stages of the early Neolithic (Cuts 7/8), exploitation of intertidal shellfish appears to have become highly seasonal again, being mainly in the winter and autumn/fall. It is possible that in the early Neolithic the cave was used for pastoral purposes, with herds of domesticated animals being brought down from the mountains to the coast for overwintering (Mannino *et al.*, 2007).

SHELL ARTEFACTS AND THE SYMBOLIC SIGNIFICANCE OF SHELLS

Although the majority of shells found in prehistoric sites in NW Sicily appear to represent food refuse, some were clearly used either as shell artefacts (Ricordi, 1997), usually as beads or pendants, or were deposited in what appear to be 'ritual' contexts. Almost invariably the shells used for artefacts were of species different from those collected for consumption. As for many other areas in the Mediterranean, the main species used for ornaments is *Columbella rustica* (Linnaeus, 1758), the shells having been collected from beach deposits for this purpose. In most cases, shell artefacts have not been found in specific archaeological contexts, with the notable exception of two 'necklaces' associated with two prehistoric, burials at the Grotta d'Oriente on the island of Favignana (Mannino, 2004; Mannino & Thomas, 2004). These 'necklaces' were composed of *Luria lurida* (Linnaeus, 1758) shells combined with, in one case (burial 'A': Late Upper Paleolithic or Mesolithic), valves of *Ostrea* sp. and,

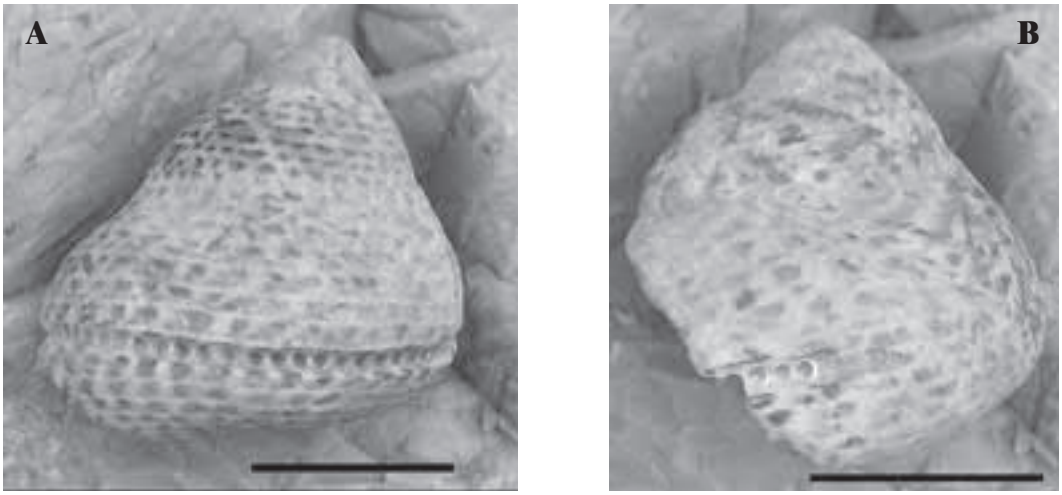

FIGURE 5

A: Shell of *M. turbinata* sampled for a long sequence of $\delta^{18}O$ values (scalebar = 10 mm). B: Shell of *M. turbinata* sampled for a short edge sequence of $\delta^{18}O$ values. In this example four samples have been drilled, the one at the very edge of the aperture being only partially visible, but in most cases three samples are taken. (scalebar = 10 mm).

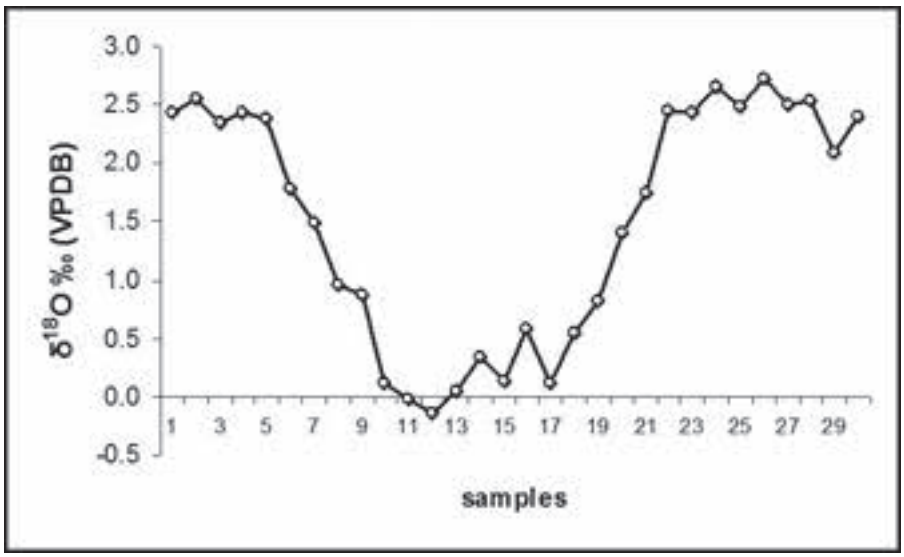

FIGURE 6

Graph of $\delta^{18}O$ values in a long sequence in a shell of *M. turbinata* from Trench A, Cut 19 of the Grotta dell'Uzzo. Sample number one is at the aperture edge of the shell.

in the other (burial 'B': Mesolithic), valves of *Spondylus gaederopus* Linnaeus, 1758. One of the 'necklaces' also has a shell of *Conus mediterraneus* Hwass in Bruguière, 1792, apparently as a substitute for a shell of *L. lurida*. Ochre was used liberally in both burials and all the shells have traces of ochre on them. Many of the shells have evidence of polished wear on their surfaces and on the perforations, suggesting that they had been worn by one or more 'owners' over some time and confirming that they had not been manufactured specifically for the funerary ritual.

The technology applied for the production of these ornaments varied from none (many of the

FIGURE 7

Pie charts of seasons of collection of *M. turbinata* for the various occupation phases at the Grotta dell'Uzzo.

beach-worn *C. rustica*), direct percussion (in the case of some *C. rustica* and in some shells from Grotta d'Oriente), to linear abrasion creating grooves either to perforate the shell directly (as for some *L. lurida* and a valve of *S. gaederopus*) or to thin the shell down to permit a percussion hole to be made. It is not yet clear if these linear grooves were cut using some kind of 'saw' or by using abrasive mineral powders, or both. Figure 8 shows part of the (reconstructed) necklace from Burial 'A' at the Grotta d'Oriente. Two beads of *L. lurida* shells are shown, both having percussion holes. The outer surface of an *Ostrea* valve pendant is shown on the left of the Figure, the perforation having been produced by the 'groove technique'. This valve was also deliberately abraded and polished around its edge, changing the shape of the valve to a broad oval. The inner surface of the other *Ostrea* valve has numerous short incisions cut around the edge, which are stained with ochre, as can be seen on the right-hand specimen in Figure 8.

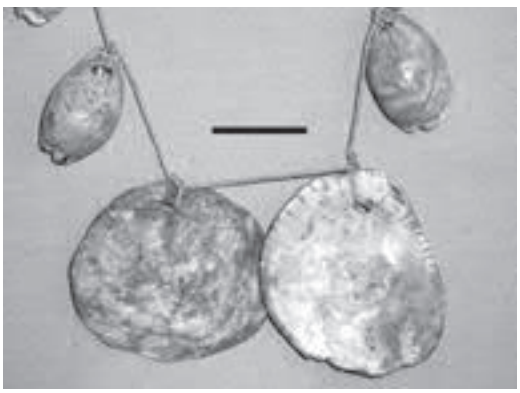

FIGURE 8

Shell beads (*Luria lurida*) and pendants (*Ostrea* sp.) from burial 'A' at Grotta d'Oriente. (Scale bar = 30 mm).

Shells were also deposited in prehistoric ritual contexts without apparently having been modified as artefacts. Examples of this can be found in burial 'A' from the Grotta d'Oriente (Mannino, 2004: 17) and in burial 'Uzzo V' from the Grotta dell'Uzzo (Borgognini Tarli *et al*., 1993: 98). In both cases a large but unmodified shell of *Patella ferruginea* had been carefully placed on the upper part of the body as an apparently symbolic element in the burial ritual.

CONCLUSIONS

We have outlined the aims and methods of our archaeomalacological project in north-western Sicily, and also the results of our archaeological and ecological studies on the selected 'indicator species' *Monodonta turbinata*. Much work is currently in progress, both on ecological monitoring and on the analysis of assemblages of molluscs from a number of important prehistoric sites in the region. The ecological work is a vital component of the project. While some species of marine molluscs are reasonably well known in ecological terms, most are not. Even where certain species appear to have been studied in depth, the data gathered by marine biologists to address the sorts of questions they are (rightly) concerned with may not always be appropriate for answering questions of interest to archaeomalacologists. In addition, a close familiarity with the living animals, their behaviour and variation (within and between populations), is vital for appreciating the archaeomalacological potential of different species of molluscs.

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