

# Bioanthropological Analysis of the Individuals Buried in the Multi-Layered Tomb of Bingia 'E Monti (Gonnostramatza - Or - Sardinia): First Results

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## Introduction

The tomb of Bingia 'e Monti (Gonnostramatza, Central Sardinia) was discovered by E. Atzeni, professor at the University of Cagliari, and excavated under his supervision in 1991. Later, the human remains were entrusted to the Department of Experimental Biology for analysis. The large number of specimens and their bad conditions have caused long restoration times, whereas its being characterized by collective burial complicates the identification of individuals. This multi-layered burial, pertinent to the transition between the Copper and Bronze Ages, only site in Sardinia where a golden necklace was recovered, is particularly important because it contained human remains belonging to at least four distinct phases: Sant'Iroxi (Early Bronze Age 2 = EBA2, 2000-1800 BC), Bonnannaro (Early Bronze Age 1 = EBA1, 2300-2000 BC), Bell Beaker (Final Copper Age, 2500-2300 BC), and traces of the underlying Monte Claro phase (Copper Age, 2800-2400 BC). Due to various disturbances related to reuse and both human and natural factors, the interpretation of the layers has proved to be complex. In order to understand the ways by which Beaker culture arrived to Sardinia in the framework of the changes at the European scale catalyzed interest on the human groups it is associated with, in an effort to integrate anthropometrics, paleopathology and paleodiet to identify dynamics in epidemiology, economy, and social facts in a diachronic perspective.

## Materials and Methods

A multidisciplinary group has been working for several years on 42 boxes of human, animal and minor cultural remains, which after cleaning, restoration, labeling and cataloging, are currently under examination; we present here the first results. Up to now, the needed chronological controls (radiocarbon dating) have yielded partial confirmation to the recorded cultural sequence. Due to diagenesis, most skeletal remains, especially those from the top layers, are badly preserved, highly fragmentary, and very altered, particularly the cortical bone. Over ten thousand bone fragments have been estimated, and ca. 1165 teeth (few for the MNI, possibly some were lost in screening). The number of intact elements is small, and it refers mostly to foot and hand bones. During excavation, 126 crania/ individuals were recognized, of which 39 in the top layer, gathered together as an expression of ritual activity. Very few individuals per phase were recovered still articulated. The rest, except a few articulated portions, are commingled skeletal elements deposited in layers separated by collapsed stones. Intense work was necessary to refit the fragments, and in this phase different methods were applied depending on the conditions of the remains. Methods were those typically applied on macroscopic traits, both metric and non-metric. Sex estimation was carried out combining different procedures (Ferembach *et al.*, 1979). For age-at-death estimation for adults, the degree of cranial suture synostosis and of toothwear were used (Lovejoy *et al.*, 1985), and on the few articulated individuals, also the morphology of pubic symphysis and of the ribs'sternum endings (İşcan *et al.*, 1985). For subadults, the degree of fusion of epiphysis and diaphysis (Scheuer and Black, 2000) and the sequence of dental eruptions (Übelaker, 1989) were considered. Stature estimation combines several procedures (Manouvrier, 1893; Trotter and Gleser, 1952). Identification of pathology follows Ortner and Putschar

(1985) and Aufderhide and Martin (1998), whereas stress markers were detected after Mariotti *et al.* (2007). Determination of the minimum number of individuals (MNI) was based on the elements most represented because most resistant, as the mastoid bone. Teeth were analyzed macroscopically to detect morphological and pathological traits.

Stable isotopic analyses as tools to trace dietary patterns have been applied, after discovery of the main principles, to human and animal samples in a variety of cultural and biological contexts. The foundation of isotopic research with particular reference to nitrogen and carbon isotopes is the principle that 'you are what you eat', a simplified way to mean that tissues in an animal's body are derived from its dietary intake with predictable intervals, and give insights to reconstruct the original signature of such diet (Ambrose, 1993). Stable isotope concentrations are expressed as the difference in the ratio of the heavier isotope to the lighter isotope ( $^{13/12}\text{C}$ ,  $^{15/14}\text{N}$ ,  $^{18/16}\text{O}$ ) between the sample and agreed reference materials, and values as  $\delta$  in parts per 1000 (‰). C stable isotope analysis of collagen is best used to investigate the ecological basis of an individual's dietary protein, notably marine vs. terrestrial ecosystems and  $\text{C}_3$  vs.  $\text{C}_4$  ecosystems. In Mediterranean prehistory, except for a few cases, marine foods have been nutritionally unimportant (Craig *et al.*, 2006), whereas there is now some evidence for  $\text{C}_4$  plants from the Middle-Late Bronze Age (Tafari *et al.*, 2009). For most analyzed remains, however,  $\delta^{13}\text{C}$  shows a small range that yields limited dietary information. N stable isotopes, among several other confounding factors, reflect an organism's position in the food chain, with predictable intervals for each step, making them the best indicator of a carnivorous vs. vegetarian diet, and revealing marine food contributions (higher  $\delta^{15}\text{N}$ , more animal protein).  $\delta^{15}\text{N}$  increases typically by +3–5‰ per trophic level. In terrestrial environments, nitrogen is fixed or absorbed by plants: as the signature ( $\delta^{15}\text{N} \sim 0\text{--}4\text{‰}$ ) is passed on up the food chain, herbivores' values are  $\sim 4\text{--}8\text{‰}$ , and carnivores'  $\sim 8\text{--}12\text{‰}$  (marine ecosystem's longer food chains result in larger ranges of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ). Collagen reflects mainly the protein intake, whereas  $\delta^{13}\text{C}$  in bone apatite reflects all macronutrients in the diet (Jim, *et al.*, 2004), although the latter are not yet available for this site. In this paper we present the results of collagen  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  for 26 adult individuals mainly of unidentifiable sex, pertaining to two phases,  $n=16$  to the EBA1 phase (Bonnannaro), and  $n=10$  to the Bell Beaker phase, which includes both subgroup A ('decorated':  $n=8$ ) and B ('undecorated':  $n=2$ ). Collagen was extracted from ca. 1g of bone per individual with several baths of NaOH and HCl, and defatted using a  $\text{H}_2\text{O}$ -chloroform-methanol mixture, at the Dept. of Inorganic and Analytical Chemistry, Univ. of Cagliari. Samples were analyzed by mass spectrometry at the Godwin Lab, Dept. of Earth Sciences, University of Cambridge.

Besides a few vertebrate bones, among the animal remains gasteropod shells were recovered, the only ones already analyzed. Determination at the family, genus and whenever possible species for each specimen was carried out by comparison with modern shells from the same region

(Marmilla), reference works, including recent monographs. Minimum number of individuals (MNI) was calculated following Ložek (1964), by counting apical portions. The few, small cultural items found among the remains (the most relevant ones had already been studied and are now at the Archaeological Museum in Cagliari), are ornamental pieces made of bone, shell, deer and boar teeth, and obsidian flakes.

## Results

An interdisciplinary collaboration based on the documents that were made available enabled the distinction of the human remains into groups of pertinence to each cultural phase. Preliminary restoration was fundamental in that it allowed a correct attribution of fragments, so modifying the original estimation of individuals represented, which was based only on crania. (Zuncheddu, 2011). The study of the remains revealed a skeletal population of all ages and both sexes. Examination of cranial specimens resulted in a total of 58 adults (of which 7 elderly), 14 subadult and 24 individuals of indeterminate age; the remaining 30 are small cranial portions that cannot be considered separate individuals. As for distribution by sex, 21 males and 5 females were identified, whereas for the remaining there were not sufficiently diagnostic elements. Isolated postcranial bones provide, at the moment, only occasional physical stress markers that cannot be related to any specific individual. Similarly, variation in the dimensions and angles of femoral necks were recorded. Only on two articulated males from the EBA1 layer, laid crouched on their left side with their limbs flexed, there is some more information: ind. 71,  $\sim 35$  years old, was  $\sim 166$  cm tall, and several foot bones showed degeneration due to arthrosis. Ind. 76 was dolichocephalous, and died at  $\sim 25$  years of age. Restoration allowed the recognition of a remarkably old individual (cr. 121) and, concerning paleopathological observations, one case of *in vivo* cranial trephination (cr. 100) (Fig. 1). Some cranial fragments of the top layers (EBA2) show hyperostosis, but the number of individuals they pertain to cannot be assessed yet.

From the analysis of teeth, a pattern of tooth wear increasing over time has been recorded (11.9, 18.2 and 29.8% respectively for the Beaker, EBA1 and EBA2 phases), with consistently low frequency of caries (0.8% and 1.0% in the Beaker and EBA1 phases, absent in the EBA2). Regarding the paleodietary study, collagen preservation and reliability, besides visual assessment and semi-quantitative methods, was ensured by % C:N ratio (Ambrose, 1990). Yields were consistently low (range 0.1% to 6.4%, averages  $1.1\% \pm 1.1$  for Beaker,  $1.9\% \pm 1.7$  for EBA1), but C:N ratios were all within the range expected for preserved signals, between 3.1 and 3.3. Average  $\delta^{13}\text{C}$  values for the two phases are similar:  $-19.3 \pm 0.4\text{‰}$  (Beaker) and  $-19.4 \pm 0.2\text{‰}$  (EBA1); somewhat less homogeneous appear to be  $\delta^{15}\text{N}$  values, which decrease from  $11.1 \pm 0.9\text{‰}$  (Beaker) to  $10.4 \pm 1.0\text{‰}$  (EBA1): they indicate a virtually terrestrial diet, despite the presence of brackish water lagoons at walking

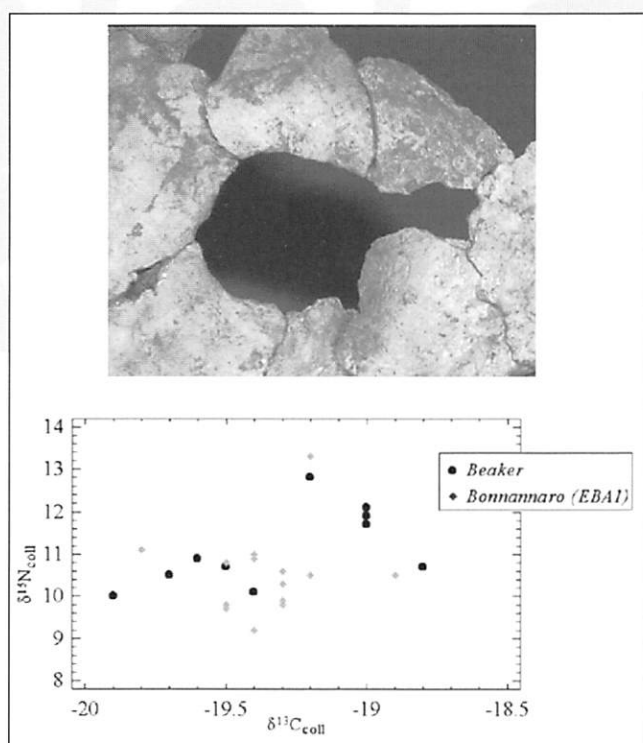


Fig. 1. Left: detail of cranial trephination, cr. 100; right: scatterplot of stable isotopic values for the two phases Bell Beaker and EBA1 (Bonnannaro).

distance (~15 km); no trace of C4 plants. Without a faunal baseline, we cannot safely say more than this. Malacological remains include species pertaining to 8 taxa. The most abundant species recorded is *Rumina decollata* (19, 51% of MNI), other species belong to the families *Helicidae*, *Hygromiidae*, *Pomatiasiididae*, *Oxychilidae*. Among the cultural materials, the deer canines have been found to be close to males, although detecting association of specific items with individuals remains mostly tentative in such a context of commingled skeletal elements.

## Discussion

As a limitation, we must keep in mind that the data presented here are affected by differential resistance to diagenetic agents, with a natural prevalence of robust adult male bones in such conditions as to be studied; it should be underlined that most remains of subadults belong to the higher layers (EBA2 and EBA1). The trepanned cranium belongs to the EBA1 (as most of the occurrences in Sardinian contexts). The oldest identifiable individual, the female cr. 121, belongs to the Bell Beaker A phase, to this, together with cr. 120, the golden necklace could have been associated.

The decrease in  $\delta^{15}\text{N}$  could between Beaker and EBA1 phases could indicate decreasing consumption of animal protein; however, aridity is also correlated with higher  $\delta^{15}\text{N}$ , as previous research has potentially detected at a nearby site in the same phase; results from apatite  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  may provide further elements of interpretation.

A comparison with other groups within Sardinia, after correcting values for synchronic climatic variation (Lai, 2008), shows a good overlap with other prehistoric diets, with averages closer to some Copper Age populations and higher  $\delta^{15}\text{N}$  compared to previous data from nearby Beaker and EBA1 sites, which could be linked to higher animal protein intake and/or lower intake of legumes ( $^{15}\text{N}$ -depleted relative to cereal grains), besides environmental change.

The malacological study suggests the presence of a degraded landscape, probably a patchwork of shrubs and pastures with dispersed rocky outcrops.

These first results, as the study progresses toward completion, are encouraging for the great potential of this collection, as many others, in the framework of a reappraisal of highly fragmentary skeletal collections.

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