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Current Approaches to Collective Burials in the Late European Prehistory

Edited by

Tiago Tomé, Marta Díaz-Zorita Bonilla, Ana Maria Silva, Claudia Cunha and Rui Boaventura

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Diet and ritual in the western Mediterranean Copper Age: human and animal stable isotopes from the collective burial at S. Caterina di Pittinuri (Sardinia, Italy)

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Abstract

C, N and O isotopic ratios, which reflect an organism's overall diet, were measured on human and animal remains from S. Caterina di Pittinuri, a Copper Age site in western Sardinia, to get a glimpse of the behavioral and ecological relations between species.

Humans, despite the coastal location, did not exploit marine resources; their diet included animal proteins, but was mainly based on crops. Swine values support previous identification as wild boars, stressing the ritual importance of wild game. The wider significance of the data is discussed, for both methodology and ritual economy.

Keywords

C*opper age, funerary archaeology, diet, Mediterranean, stable isotopes*

Résumé

Les rapports isotopiques de C, N et O ont été mesurés sur des restes humains et animales provenants des fouilles de S. Caterina di Pittinuri, un site de l'Age du Cuivre dans la Sardaigne occidentale, pour jeter un coup d'œil sur la diète et les liens parmi les espèces. Les habitants, malgré leur position coutière, négligeaient les ressources marines; leur diète se basait plus sur les céréales que sur les protéines animales. Les valeurs isotopiques portent à identifier les suidés comme des sangliers, ce qui souligne l'importance rituelle des animaux sauvages. Les données sont discutées, soit pour la méthodologie soit pour l'économie rituelle.

Mots-clés

Age du cuivre, archéologie funeraire, alimentation, Méditerranéen, isotopes stables

Introduction

From the first reactions to the most simplistic processualist views, it has been clear that what is represented in burial contexts does not linearly reflect social or behavioural features of the living community (Carr 1995). Burials, however, do provide a unique window into the material correlate of past lifeways in which the social organization and the belief systems were somehow reflected. Isotopic studies have grown in the last decades to become one of the main elements of the archaeological toolkit to explore the relationships between humans and the ecosystem, in the specific cultural fashions to be recognized and reconstructed for any given patio-temporal unit. In the very rare cases when faunal and human remains are found together, with stable isotopes we can have a glimpse on the ecological ties between humans and other species that were mediated by social and ritual practices.

Of course, single contexts and situations need to be carefully decoded and analysed at the proper scale, and the limits of representativeness must be clearly identified for any conclusions drawn. In the Western Mediterranean Copper Age, such ecological relationships provide indications on the complex link between the theorized subsistence patterns, and their realization in specific contexts and fields of practice, where humans, other living beings, and objects can be viewed as agents (Robb 2010; Robb 2004).

For instance, a general interpretive model for economic change in Western Europe has been that of the intensification of animal products exploitation, with an emphasis on the secondary ones (Sherratt 1983), a model that has stood the test of time (Greenfield 2010), but whose specific aspects need still need to be investigated from many theoretical and methodological perspectives, especially in the Mediterranean as opposed to the continental area, due to differential preservation of several types of investigative proxies. The rock-cut tomb of Santa Caterina di Pittinuri, an undisturbed context on the west coast of Sardinia (Figure 1.1), is an ideal case study to understand the interconnectedness of economy, ecology, and ritual in their links to funerary practices, as it offers material culture and both human and animal remains.

The corridor and room A (Figure 1.2) represent the location of ritual practices consisting of food processing and deposition; in the first two rooms the largest portion of ceramic materials and abundant animal bones were retrieved. Rooms B, C and D represent the final collective resting place for the large majority of human remains, disarticulated, commingled and accompanied, among other items, by a few silver rings and obsidian arrowheads (Cocco & Usai 1988). The liminal nature of the antechamber (room A) is also shown by the presence of only a few human skeletal remains, commingled with the majority of artefacts and animal remains. This is in line with current view that antechambers and central rooms were likely the location for primary deposition, followed by secondary, permanent deposition of the remains in peripheral rooms. Based mostly on ceramic style, with the addition of lithic and metal artefacts, the material assemblage recovered has been assigned to the local cultures named Filigosa and Abealzu (Cocco & Usai 1988), ascribed to the end of the 4th- first half of the 3rd millennium BC., which was later confirmed by radiocarbon dating.

Material, principles and methods

Twenty-one individuals (ten humans and 11 animals) were sampled for isotopic analyses. All available humans, represented by temporal, parietal and occipital bones from well-preserved cranial specimens to prevent multiple sampling of the same individuals, were from room C. Across the whole site, no bone specimen was recorded as articulated upon recovery (Cocco & Usai 1988): most showed intense carbonate concretions and a high degree of fragmentation (Buffa *et al*., 1995), and

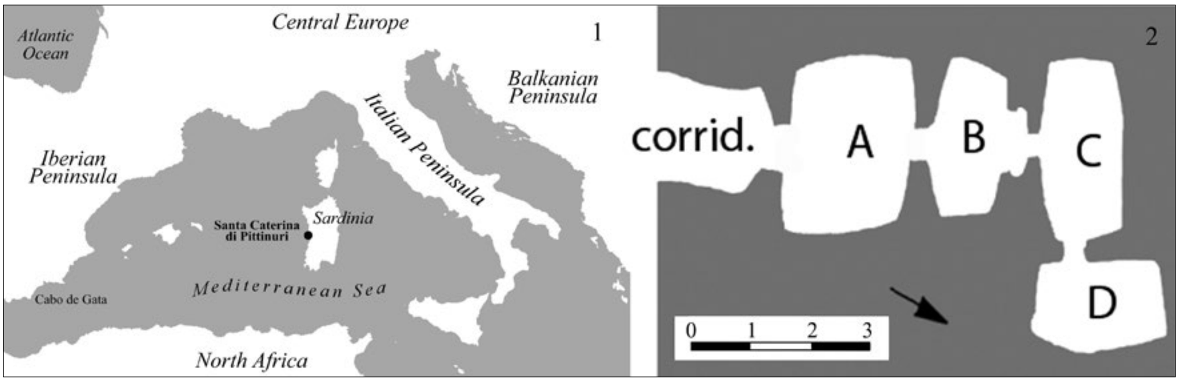

Figure 1. Santa Caterina di Pittinuri. 1: location within the Western Mediterranean. 2: plan of the rock-cut tomb.

even after refitting and restoration, very few turned out to be complete. Besides isolated teeth, found in large quantities in all rooms but especially in room C, the most frequent skeletal districts were hands and feet. The specimens also showed differential preservation across the tomb: in room A, they were very fragmented and had thick concretions; in room B, along with one cranium were some incomplete long bones and hand and foot bones; room C yielded the majority of the skeletal remains, whereas room D yielded only small fragments.

Considering bones only, the specimens were classified also for age at death (Borgognini Tarli & Pacciani 1993; Ferembach *et al*., 1980), and divided into adults + subadults, infants, and foetuses, keeping the rooms apart in calculating the Minimum Number of Individuals (Marini *et al*., 1997). A cumulative, updated MNI adding up the different rooms subtotals amounts to 86 individuals. Conversely, considering the likelihood that remains from different cells may have belonged to the same individuals, the MNI would coincide with room A, which had the highest estimate for each age class (30 individuals). Considering teeth instead, Vargiu *et al*. (2009) calculated the much higher number of 339 individuals. This implies that an at least ten-fold loss of bone/individuals has occurred since the beginning of depositions: presumably, skeletal remains represent the later depositions better and rather than the earlier ones, which might date back to the Middle-to-Late Neolithic.

Sex estimation (Ferembach *et al*., 1980) was carried out only in the rare cases which allowed it, resulting in the identification of 8 males and 7 females. This is a weak but important indication of burial without sex-based distinction. Stature was estimated based on the average length of complete long bones that showed sex-linked features (robusticity, muscular insertions etc.), according to Trotter and Gleser (1952): cm 164,0±5,1 (♂) and cm 153,5±5,6 (♀). Among the pathological conditions recorded (following Ortner & Putschar 1981) are arthrosis on vertebrae, metatarsals, metacarpals and phalanges, and frequent antemortem tooth loss. Based also on the isolated teeth, besides calculus and various degrees of tooth wear, this human group has shown the highest frequency of caries in the island's prehistory (Coppa, pers. comm. 2004).

The animal remains are composed mainly by swine/*Sus* (~40 individuals), with negligible amounts of sheep/goat. These Sus remains, largely represented by mandibles, were tentatively attributed to wild boars rather than domestic pigs, and showed no butchering cutmarks, suggesting they were not simply refuse from meals but rather offerings (Fonzo *et al*., 2013). The majority (classified according to Barone 1982; Wilkens 2003) came from room A and arrived to the laboratory in fragmentary conditions: they mainly consist of scattered lower teeth and incomplete mandibles, with a morphology suggesting, with some caution (Albarella *et al*., 2006), that most individuals were wild. Among the swine individuals identified, both sexes are represented; adults are prevalent, whereas subadults are a dozen or less (for age identification: Wilkens 2003).

From room A came also about ten ovine specimens (identified as in Boessneck *et al*., 1964; Zeder & Pilaar 2010) belonging to at least one adult and one subadult, and two fragments of bovine humerus and pelvis – the only remains pertaining to this species (unfortunately not available for sampling due to concerns regarding the preservation of diagnostic morphological features). In the middle of the room, on the floor, a fragment of antler and two incomplete deer mandibles were recovered, among the oldest *Cervus* remains recognized in Sardinia.

In the inner rooms a few teeth and long bones of *Sus* were recovered, which pertain to a foetus and an infant; furthermore, roughly ten ovine specimens – teeth and metapodia (the latter pertain to at least four individuals) one of which shows some traces of intervention on the distal end. Finally, one fragment of bovine tooth was also identified.

At least twenty individuals of *Prolagus sardus* and at least two foxes pertained to the top layers of all rooms except the corridor, and could therefore be intrusive. The study of a few hundred remains of microfauna and birds is still in progress.

Two radiocarbon dates are available from the collection (table 1). One, Beta-72235, has no specific recorded provenience within the tomb, and the associated $\delta^{13}C$ overlaps better with faunal values than with humans. The main point to underline is that the two dates are non-overlapping, and together cover a 2σ range of ~1200 years. The MNI of over 300 calculated based on teeth is therefore less surprising since it can be spread over a millennium or more, accounting for roughly 30 depositions per century, or ten per generation.

Both human and animal remains were sampled for C, N and O isotopes, which reflecting to some degree the food consumed over several years before an organism's death can be used as dietary and environmental proxies. The foundation of isotopic research is based on the principle that 'you are what you eat' – that is, the various tissues in an animal's body are derived from its dietary intake and, to some degree, they preserve a quantitative trace of it. The main food categories that can be easily identified as different from terrestrial C3 diets are C4 plants and marine resources; for an overview of the principles, methods, isotopic notation system and interpretive issues many works are available (Hoefs 1997; Jim *et al*., 2004; Schwarcz 2000; Tykot 2004). Whereas apatite $\delta^{13}C$ is an indicator of overall diet, collagen $\delta^{13}C$ and $\delta^{15}N$ derive mostly from protein intake.

Compared to diet, collagen $\delta^{13}C$ values are higher than the diet by about +5‰, apatite 13C are about +10-14‰; so, from average plant values of -26‰ in a typical C3 ecosystem, herbivore bone collagen is about -21‰, and bone apatite around -14‰. There is a smaller change going up the food chain, so human values within C3 ecosystems are typically around -19‰ (collagen) and -12‰ (apatite), with variation related to ecosystem-wide environmental factors (Van Klinken *et al*., 1994), to their intake of animal tissues (Ambrose & Norr 1993; Schwarcz 2000) and to differences in the source of carbohydrates and lipids. Nitrogen isotopic values increase typically by up to +6‰ per trophic level (O'Connell *et al*., 2012). In terrestrial ecosystems, nitrogen is fixed or absorbed by plants, and as the plant signature ($\delta^{15}N$ 0-4‰), is passed on up the food chain, average herbivore values are about 4-8‰, and carnivores values about 8-12‰ (in temperate environments). Marine ecosystems, due to their longer food chains, have a larger range of $\delta^{13}C$ and especially $\delta^{15}N$ values (Richards & Hedges 1999; Schoeninger & Deniro 1984).

Apatite $\delta^{18}O$ is generally correlated to both local temperature and local precipitation. The correlation between biogenic $\delta^{18}O$ in phosphates and carbonates on one hand, and meteoric water $\delta^{18}O$ values on the other, holds particularly for large mammals that are obligate drinkers, so we can use the oxygen isotopic signature in bone as a proxy to the atmospheric signature. Therefore, by its being a proxy for the climatic conditions at the time and place of tissue formation, it can help pinpoint individuals who spent part of their life elsewhere relative to the majority of a given group (Koch 1998; Kohn & Cerling 2002).

Site	Specimen Lab #	Refs.	# lab (USF)	# lab	Date BP ± error and $\delta^{13}C$	Range cal BC and probability (program Oxcal 4.0) 1σ	2σ
S. Caterina di Pittinuri	?	Dept. Archives*		Beta-72235	4050 ± 140 -21.3‰	cal BC 2871-2801 0.169 2792-2788 0.008 2780-2463 0.824	cal BC 2916-2199 0.998 2161-2153 0.002
S. Caterina di Pittinuri	cr. 10, room C	Lai 2008, 2009	9480	AA-72148	4496 ± 43 -20.2‰	cal BC 3336-3263 0.392 3244-3209 0.193 3192-3151 0.222 3138-3102 0.193	cal BC 3355-3087 0.953 3060-3030 0.047

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Table 1. The two radiocarbon dates from the rock-cut tomb at Santa Caterina di Pittinuri (Cuglieri, Sardinia).

For this study, ca. 1 g of bone was selected per individual, cleaned from soil or concretions, ultrasonicated and dried. Preparation (Tykot 2004) followed a procedure somewhat different from the standard, but of comparable quality (Ambrose 1990), which does not involve powdering and gelatinization and allows visual assessment throughout the process: samples were soaked in dilute NaOH to remove acid contaminants; collagen was extracted by soaking in dilute HCl in two or more ~24-h baths and for ~24 h in a methanol-chloroform solution to remove lipids. The resulting pellets were dried, aliquots weighed into tin capsules and analysed in continuous-flow mode with a Carlo-Erba 2500 Series II CHN analyser, coupled with a ThermoFinnigan Delta+XL stable isotope ratio mass spectrometer (precision 2σ better than ±0.3‰ for $\delta^{15}N$, than ±0.2‰ for $\delta^{13}C$). To assess reliability of results, besides visual inspection through preparation, C:N ratios were also used. To isolate the apatite, ~10 mg of bone powder per sample were treated with a ~72-hour bath in 2% sodium hypochlorite to dissolve the organic portion; non-biogenic carbonate was removed by soaking it for ~24 hours in a 1.0M buffered acetic acid/sodium acetate solution (Garvie-Lok *et al*., 2004; Koch *et al*., 1997; Lee-Thorp & Sponheimer 2003). 1 mg of the resulting powder was analysed on a ThermoFinnigan Delta+XL mass spectrometer, in dual-inlet configuration, equipped with a Kiel III individual acid bath carbonate system (precision 2σ better than ±0.04‰ for $\delta^{13}C$; than ±0.06‰ for $\delta^{18}O$). Both instruments are located at the Paleolab, University of South Florida.

As indirect proxies of the integrity of samples, carbonate yields were measured after each preparation step (Nielsen-Marsh & Hedges 2000). In order to monitor diagenetic processes, the Crystallinity Index (CI) and Carbonate to Phosphate ratio (C/P) were calculated from FTIR measurements, and the calcite and fluorapatite peaks were identified. Principles and details of this method, widely used in archaeological applications, are discussed elsewhere (Shemesh 1990; Weiner 2010: 286-292; Weiner & Bar-Yosef 1990; Wright & Schwarcz 1996). The infrared spectra were measured using a FTIR (Tensor 27, Bruker Optics) equipped with a diamond-ATR accessory and a DTGS detector. A number of 128 scans at a resolution of 4 cm^{-1} were averaged from wave number 2000 to 400 cm^{-1}.

Results and Discussion

For all results, see Table 2. While collagen yield was scarce and uneven (pig collagen was almost absent), the good quality of collagen is suggested by C:N ratios between 2.9 and 3.4, within the range of isotopically reliable collagen (Ambrose 1990). Concerning apatite results, the physiology-dependent species-specific distribution of apatite $\delta^{18}O$ and $\delta^{13}C$ (Fig. 2.a) is the best indicator that the original signal has not been homogenized by isotopically consistent diagenetic contaminant. The plot of CI and C/P ratio by species (Fig. 2.c) and the association of CI values and fluorapatite peaks (Fig. 2.d) shows as expected a strong inverse correlation, indicating the direction of a diagenetic process. The sharp distinction between human and animal remains could be explained by their different location: inside the tomb the former, in the antechamber (room A) and entrance corridor the latter. It is possible that human remains were more exposed to aerobic diagenetic processes as they lay in the inner burial space with no covering material and protected by stone slabs sealing the passage ways, whereas the animal remains in the corridor were buried by larger amounts of soil, as shown by the thickness of the layer (~90 cm vs. ~20 cm in rooms B, C, D, where human bones appeared on the surface: Cocco & Usai 1988). The origin of such thick layer could include soil washed inside by rainwater; dust brought in by wind; organic matter resulting from burning and decomposition of the offerings themselves near the hearth. Alternatively, a cause for the differential diagenetic indicators could be a different pre-burial treatment: cooking or boiling (Roberts *et al*., 2002) is likely for animals, as part of food processing, especially considering that there were no cutmarks indicating the use of sharp tools to disarticulate the many mandibles (Fonzo *et al*., 2013), so tendons and flesh must have been softened beforehand. Human remains must have lost their soft tissues without the application of a high temperature, being either left to natural decomposition or possibly defleshed (systematic examination to identify cutmarks has not been carried out yet).

A basic reading of the isotopic results already shows that the human diet, despite the coastal location, did not include any detectable amount of marine resources (Fig. 2.b). Animal values are within

USF	Lab #	Original						Collagen				Apatite			Apatite FTIR			
col	*apa*	*site*	*# ind.*	*location*	*species*	*sex*	*age*	*% wt.*	*C:N*	*δ¹³C*	*δ¹⁵N*	*δ¹³C*	*δ¹⁸O*	*δ¹³C col-apa*	*C/P*	*CI*	*fluora-patite*	*cal-cite*
9478	9488	S. Caterina P.	Cr.7	Room C	*Homo s.s.*	♀	Adult	0.0				-14.6	-5.0		0.022	5.651	Strong Peak	
9479	9489	S. Caterina P.	Cr.5	Room C	*Homo s.s.*	♂	Adult	2.8	3.4	-19.9	9.2	-14.2	-4.1	-5.7	0.052	5.25	Peak	No
9480	9490	S. Caterina P.	Cr.10	Room C, Basal ledge	*Homo s.s.*	♂	Adult	5.2	3.0	-19.6	8.8	-14.2	-4.2	-5.4	0.053	5.159	Peak	No
9481	9491	S. Caterina P.	Cr.11	Room C, Basal ledge	*Homo s.s.*	♂	Adult	3.5				-14.9	-4.3		0.047	5.228	Peak	No
9482	9492	S. Caterina P.	Cr.14	Room C	*Homo s.s.*	♂	Adult					-14.6	-4.3		0.033	5.491	Peak	No
9483	9493	S. Caterina P.	Cr.20	Room C	*Homo s.s.*	♀	Adult	0.0				-14.6	-4.6		0.041	5.676	Peak	No
9484	9494	S. Caterina P.	Cr.6	Room C	*Homo s.s.*	♀	Juvenile	0.2				-14.6	-4.3		0.025	5.724	Peak	No
9485	9495	S. Caterina P.	Cr.19	Room C	*Homo s.s.*		Infant	2.8	3.0	-19.4	9.8	-14.5	-4.3	-4.9	0.049	5.232	Peak	No
9486	9496	S. Caterina P.	Cr.2	Room C	*Homo s.s.*		Infant	2.3	3.0	-18.9	10.2	-14.4	-4.0	-4.5	0.039	5.156	Peak	No
9487	9497	S. Caterina P.	Cr.12	Room C	*Homo s.s.*		Infant	1.0	3.0	-19.5	9.7	-15.4	-4.3	-4.1	0.026	5.81	Shoul-der	No
					Averages					-19.5	9.5	-14.6	-4.3	-4.9				
					St. deviat.					±0.4	±0.5	±0.3	±0.3	±0.6				
8667	8636	S. Caterina P.	SCP A.96	Room A	*Sus s.*		2 yrs	1.3				-11.0	-4.4		0.307	3.431	No	No
8668	8637	S. Caterina P.	SCP A.89	Room A	*Sus s.*		18-24 mos	0.0				-9.2	-5.2		0.225	3.524	No	No
8669	8638	S. Caterina P.	SCP A.94	Room A	*Sus s.*		12-18 mos	0.0				-11.3	-3.7		0.176	3.75	No	No
8670	8639	S. Caterina P.	SCP A.174	Corridor	*Sus s.*		< 8 mos	3.6		-21.0	3.9	-10.7	-4.4	-10.3	0.181	3.946	No	No
8671	8640	S. Caterina P.	SCP A.112	Room A	*Sus s.*		> 4 yrs	0.1				-9.4	-5.3		0.654	3.635	No	Peak
8672	8641	S. Caterina P.	SCP A.164	Room A, floor	*Cervus e.*	♂	Adult	3.5		-21.6	4.5	-10.4	-4.4	-11.2	0.169	3.652	No	No
8673	8642	S. Caterina P.	SCP A.1	Room A	*Vulpes v.*		Adult	11.4		-18.8	7.0	-11.7	-2.7	-7.1	0.257	3.235	No	No
8674	8643	S. Caterina P.	SCP A.35	Room A	*Prolagus s.*		Adult	6.0		-21.6	5.3	-13.8	-1.1	-7.8	0.234	3.351	No	No
8675	8644	S. Caterina P.	SCP A.242	Room A	*Prolagus s.*		Adult	3.4		-21.8	2.7	-13.5	-1.1	-8.3	0.234	3.432	No	No
8676	8645	S. Caterina P.	SCP A.115	Room A	*Ovis/Capra*		< 20 mos	4.5		-20.7	7.2	-12.4	-1.1	-8.3	0.121	4.172	No	No
8677	8646	S. Caterina P.	SCP A.206	Room A	*Ovis/Capra*		Adult	2.1		-20.0	5.3	-11.7	-0.8	-8.3	0.291	3.405	No	No
					Averages					-20.8	5.1	-11.4	-3.1	-8.8				
					St. deviat.					±1.1	±1.6	±1.5	±1.8	±1.5				

Table 2. Santa Caterina di Pittinuri. All individual data, isotopic and FTIR values.

expected terrestrial, C3 ecosystems but their specific values deserve a closer consideration. The absence of any isotopic signal of marine resources places the economy of the group solidly within the Neolithic tradition that marginalized the sea as an important source of food (besides single studies, see Craig *et al*., 2006) by replacing it with a terrestrial domesticated landscape populated by animals and plants.

Interpretation of diet was cautiously carried out considering the different species represented, and must be tentative due to the modest numbers involved. As regards the origin of proteins in humans, several possibilities are to be considered, assuming a $\delta^{15}N$ interval of about 6‰ between consumed and consumer (O'Connell *et al*., 2012), and taking as reference points the averages of different

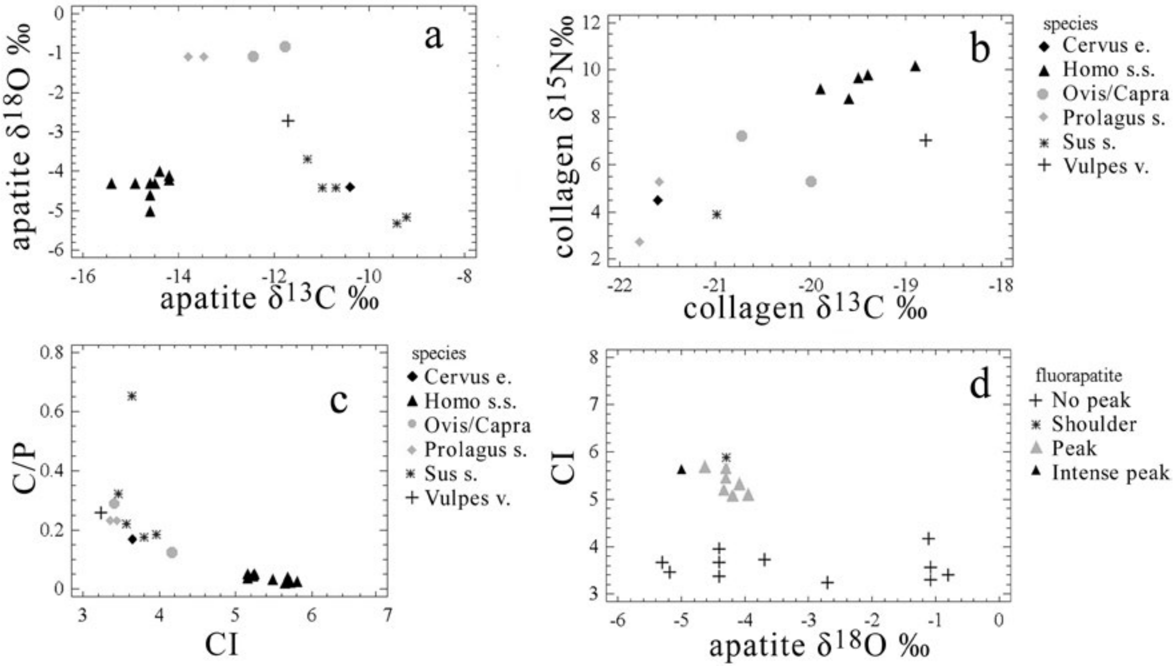

FIGURE 2. SANTA CATERINA DI PITTINURI, ROCK-CUT TOMB. ISOTOPIC AND FT-IR VALUES FOR PALEODIETARY, PALEOECOLOGICAL AND DIAGENETIC RECONSTRUCTION (SEE TEXT).

animals and values for plants (approximately around 1‰) and for legumes (likely a few permil negative). The interval between human adults on one hand and deer and pig on the other could derive from a diet where most proteins are from wild animals (with some from vegetal sources), but considering that consumption of wild game was rather occasional and linked to special events, this seems to be very unlikely. The interval with ovicaprines, a more realistic source of proteins, could reflect a fairly balanced origin of daily proteins from ovicaprines, supplemented by the non sampled bovines and by wild game, on one hand, and from vegetal sources on the other. Of course, if legumes were a substantial portion of human protein intake, the observed values would have to be considered as intermediate between extreme $\delta^{15}N$ values (up to 10‰ apart): in this case, animal sources too would have been substantial; however, a diet with a strong vegetal component without large amounts of cereal grains is also unlikely, so that in any case the quantity of animal proteins in daily diet was most probably quite small. Such scarce reliance on animal proteins can be underlined also comparatively: relative to other unpublished prehistoric Sardinian groups, and also elsewhere in the Mediterranean where the $\delta^{15}N$ human-herbivore interval is around or above 4‰ (Le Bras-Goude *et al*., 2006a; Le Bras-Goude *et al*., 2006b). The high prevalence of caries observed (Coppa, pers. comm.) possibly supports a strong reliance on starchy foods.

As concerns pigs, the protein portion of the diet, as inferred from collagen $\delta^{13}C$ and $\delta^{15}N$ on a single individual, corresponds with that of red deer and *Prolagus*, being even more depleted than sheep, supporting the identification of several individuals based on tooth morphology, as wild boars; the similarity with the value of deer and *Prolagus* suggests the forest as the most likely habitat. A similar diet for the whole group of represented pigs can only be suggested, based on the fairly consistent apatite values of the remaining four individuals (where variation can also depend on other environmental, behavioural and eco-physiological factors).

The two ovicaprine $\delta^{15}N$ values appear quite different, although within the range intermediate between humans and other herbivores; the interval can be attributed to age, with the 20 months-old sheep still carrying its enriched isotopic signal from breastfeeding. The values themselves, different from *Cervus* and *Sus*, could imply differences in the feeding areas; among many possibilities, pasture on fertilized fields, or in lowlands, or with scrubby rather than just grassy vegetation.

The greater number of apatite human samples analysed for $\delta^{13}C$ and $\delta^{18}O$ (Fig. 2.a) clusters tightly, indicating a diet and/or residence patterns less differentiated within the group compared to what is observed, for instance, at San Benedetto, Sardinia, earlier 4th millennium BC (Lai 2008: 312-316). From the few samples available, it would also seem that women were spending, or spent at some point in their life, part of the time at higher elevations or in cooler climates than men. Considering the general trend of gender roles as known for the prehistoric Western Mediterranean, it seems however unlikely that women were engaging in seasonal mobility; more likely, either men married in, which could then indicate matrilocality and/or they spent part of their lives more to the South, possibly on the Campidano plains. Alternatively, women from the mountains, North-northeast of the site, would be marrying into the area patrilocally. More focused studies on mobility involving Sr isotopes on teeth and bone could clarify these issues in the future. The infant values, difficult to interpret due to the wide age range estimated (6 year-span), are out of the scope of this paper.

Keeping in mind all these caveats on drawing inferences based on numerically very scarce data, we can cautiously suggest a possible overall scenario: since hunting, rather than barely a subsistence activity, was likely a key practice in structuring identities, maintaining gender roles and constructing social *personae*, the ritual offerings or remains of funeral feasting, consisting of defleshed body parts, apparently involved valued animals as wild game and not every-day, household-related foods.

Dairy products do not appear to leave a visible trace in the diet as would be expected with an intensification of their exploitation. Their production was already an intangible part of the Neolithic package, however their importance in daily diet had not become greater in the Copper Age group buried at Santa Caterina. Possibly this was due to the inability to digest milk, a genetic trait that became widespread only later (Leonardi *et al*., 2012). The presence of older bovines coupled with isotopic values suggesting a mostly vegetarian diet at Scaba 'e Arriu, another Copper Age site in Sardinia (Lai 2008: 317-323) indicates that use of animal traction power may have been an innovation adopted independently from the intensification of dairy products. The frequency of caries recorded in the Santa Caterina's group may derive from lack of the protective effect of dairy products (Johansson 2002).

The onset of rituals involving drinking can be inferred by the change in vessel types and dimensions, suggesting an increase in individual consumption rather than ordinary meals from common bowls; furthermore, there is an increased relevance of wild game among the faunal remains, even though daily diet relied on plants; finally, room C, where the human remains analysed come from, is also the one with the higher number of arrowheads (eight out of 11): these are perhaps complementary symptoms of the increasing social value ascribed to hunting as part of a progressive distinction of a more masculine field of action in inter-group relationships, communication and display, opposite to a feminine domain increasingly limited to the domestic sphere (Hayden 1998). While representing the beginning of a future evolution in which maleness is more strongly associated with generalized authority tied to force and wealth, this context maintains, or even emphasizes, communal values and a horizontal social structure (Crumley 1995), which was based on the recognition of different agents with special roles and skills, and the special qualities of exotic or simply unusual items as markers of different *personae* or different social settings (Helms 1993), such as finely crafted arrowheads, wild boar and deer meat, or silver rings. A society, however, still distant from any form of hierarchical structure.

Concluding remarks

The significance of the data discussed above is multifaceted and provides methodologically useful insights, for the understanding of diagenesis in Mediterranean rock-cut burials, and more broadly for the reconstruction of cultural ecology and ritual traditions in Mediterranean Copper Age. The general methodological issues in assessing human diets based on all available animal species represented as if they were a coherent whole emerge clearly, and this study confirms the need to culturally decode the relationship between signals of different species separately.

While no statistical significance can be attributed to the data presented, the first piece of evidence is presented for Western-central Mediterranean insular Copper Age diet and ecology. This human group can be added to the extensive corpus of data showing marginalization of marine resources occurred in the Mediterranean since the Neolithic: in fact, no isotopic trace of marine foods was detected at Santa Caterina di Pittinuri, despite the coastal location of the burial. Furthermore, there are no visible clues of increased reliance on animal products, whereas considering the interval between $\delta^{15}N$ in humans and ovicaprines as a strong reliance on vegetal foodstuffs seems more likely. This is coupled with the symbolic relevance of wild boar and deer hunting: it appears that rather than displays of a generalized symbolic currency readable as parallel to authority, funerals at Santa Caterina reflected a more specific value connected to a socially structuring activity disconnected from practical relevance. In turn, this is consistent with a more heterarchical social organization, in line with collective burial and the loss of individual identity in the shared ancestral memory of the community.

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