Journal of Archaeological Science: Reports xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Capturing Roman dietary variability in the catastrophic death assemblage at Herculaneum

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ARTICLE INFO

Keywords:
Herculaneum
Stable isotopes
Palaeodiet
Vesuvius

ABSTRACT

Here we present a comparative study of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope data from 81 individuals from the catastrophic death assemblage at Herculaneum (79 CE) and compare these with the attritional sites of Velia (Salerno, Italy, 1st–2nd century CE) and Isola Sacra (Rome, Italy, 1st–2nd century AD). The instantaneous deposition of the Herculaneum assemblage highlights some interesting differences in our contextual and methodological understanding of stable dietary isotopes, suggesting that isotopic variation between sites may sometimes be a result of greater temporal variability rather than truly comparable differences. Our results suggest that the people of Herculaneum obtained a relatively small proportion (ca. 30%) of their dietary carbon from marine foods; the majority originating from terrestrial foodstuffs of a similar carbon isotopic composition, most likely cereals. Also observed is a generally greater dietary isotopic enrichment in male individuals than females. We infer that males had greater access to fish which may be reflective, in part, of the sociodemographic framework characteristic of Roman society. Finally, we highlight the methodological challenges which may be faced when undertaking comparisons of $\delta^{13}C$ and $\delta^{15}N$ data between the various age-related strata of a population, particularly due to the slow and variable rate of collagen turnover.

1. Introduction

The health and economic 'well-being' of the Roman world is a fundamental benchmark in the historic investigation of past civilisations. Although the study of the Roman productive economy is extensive, our knowledge regarding the distribution of wealth and differences in living conditions in Roman society is limited to partial and incomplete records (Garnsey and Saller, 2015). We do not yet know how food was distributed to different elements of the population, between households, villages or towns. Historical accounts (Rackham, 1967; Edwards, 2001; Wolf, 2010) and archaeological evidence from animal and plant remains (Meyer, 1980; Pagano, 1994; Reese, 2002; Rowan, 2014; Robinson and Rowan, 2015) provide specific information regarding the types of foods that were eaten but lack the resolution required to quantify dietary content, or to study dietary variability within societies. Such information is crucial if we are to make meaningful comparisons between Roman and other pre-modern and developing societies, and to clarify relationships between social status, health and nutrition.

Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope analysis of bone collagen offers a direct approach to the inter- and intra-population study of ancient diet. Isotopic signals represent a direct measure of an individual's average dietary intake during the period of bone collagen formation. These analyses are particularly useful for discriminating diets of coastal inhabitants with access to mixed marine and terrestrial diets, and where the major dietary sources (e.g. marine fish, terrestrial herbivores, terrestrial omnivores and cereal grains) have distinct isotope values. So far, the analyses of over 500 individuals from Roman Imperial period necropolises in southern Italy have succeeded in identifying relative isotopic differences within and between assemblages, attributed to differences in occupation, age and sex, and mainly relating to the differential consumption of marine foods (Prowse et al., 2004; Craig et al., 2009; Killgrove and Tykot, 2013; Killgrove and Tykot, in press). Nevertheless, the analysis of diet in such attritional death assemblages is heavily burdened by methodological and interpretative limitations. Unlike census data, skeletal assemblages from burial

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http://dx.doi.org/10.1016/j.jasrep.2017.08.008
Received 31 March 2017; Received in revised form 1 August 2017; Accepted 7 August 2017
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grounds are palimpsests that gradually accumulate over time, and their fidelity to any living population is undermined by both selective burial and selective mortality (Wood et al., 1992; Roberts and Grauer, 2001; Jackes, 2011; DeWitte and Stojanowski, 2015). For example, individuals who were afforded cremation, a common Roman funerary custom, cannot be studied, whilst frail individuals who succumbed to disease are likely to be over-represented in the younger age classes (Wood et al., 1992).

In studying stable isotopic data from a sample of 81 individuals from the catastrophic death assemblage at Herculaneum (Bisel, 1991; Capasso and Domenicantonio, 1998; Capasso and Capasso, 1999; Capasso, 2000; Mastrolorenzo et al., 2001; Mastrolorenzo et al., 2010; Petrone, 2011), we hope to circumvent these problems and derive a clearer picture of dietary variability in at least one Roman town. All were victims of the 79 CE eruption of Vesuvius and were discovered within 9 *fornici* (stone vaults) running adjacent to the seafront (Fattore et al., 2012). The stable isotope data for 72 individuals were originally reported in Craig et al. (2013) but here we investigate these data with respect to new osteological information regarding the age and sex of the skeletons. Notably, this revision identified one of the 72 individuals (F8I10) as a juvenile. In addition, we also report new isotopic data from 9 infants and juveniles (< 20 years of age). Albeit a modest sample of a small Imperial coastal town of ca. 4–5000 residents (Wallace-Hadrill, 2011), the assemblage contains a broadly equal mixture of adult males and females, with juveniles and infants also represented (Capasso, 2000; Mastrolorenzo et al., 2001). Whilst some selectivity in those sheltering in the vaults is to be expected, the assemblage offers a rare glimpse of contemporary Roman life, where sudden and collective death negated the selective biases usually faced in osteoarchaeological analysis. Therefore, we are able for the first time to quantify the differential access to foods within an ancient 'living' population.

2. Methods

Collagen for the new 9 samples was extracted from bone and analysed by EA-IRMS exactly as described previously (Craig et al., 2013). In the majority of for both these samples and those presented in Craig et al. (2013), rib samples were chosen (Craig et al., 2013; see Supporting information, Table 1) and any samples showing signs of pathological change were excluded. Briefly, bone samples (0.5–1 g) were coarsely ground and demineralised (0.6 M HCl, 4 °C, 3–12 days), samples were rinsed with distilled water and then gelatinised (pH 3 [0.001 M] HCl, 80 °C, 48 h). The supernatant containing the collagen was filtered (30 kDa, Amicon® Ultra-4 Centrifugal Filter Units, Millipore, Billerica, MA, USA), frozen, and lyophilised. Collagen samples (1 mg) were analysed in duplicate or triplicate by EA/IRMS in a Sercon GSL analyser coupled to a Sercon 20–22 Mass Spectrometer (Sercon, Crewe, UK) at the University of York, or a Roboprep Combustion Device coupled to a Europa 20–20 Mass Spectrometer (PDZ-Europa, Crewe, UK). The analytical error, calculated from repeated measurements of each sample and measurements of the bovine control from multiple extracts, was < 0.2‰ (1σ). Accuracy was determined by measurements of international standard reference materials (IAEA 600, IAEA N2, IA Cane) within each analytical run, with the error being less than < 0.5‰ in all instances. The difference in the $^{15}N/^{14}N$ ratio between the sample and the internationally defined standard AIR (atmospheric air) in ‰ units is referred to as $\delta^{15}N$, and $\delta^{13}C$ refers to the difference in $^{13}C/^{12}C$ ratio between the sample and the internationally defined standard, PDB (Vienna Peedee Belemnite Limestone). The reported ratios are calculated using the equation:

$$\delta x = ((R_{sample} - R_{standard})/R_{standard}) \times 1000$$

For Herculaneum, the ^{14}C offset attributable to the marine reservoir effect was estimated for each sample using the following regression equation derived from radiocarbon dating and stable isotope analysis of 9 samples (Craig et al., 2013):

$$y = 34.3 - 300x,\ R^2 = 9.1 \text{ where } y = {}^{14}C \text{ offset (years) and } x = \delta^{15}N \text{ value (‰)} \quad (1)$$

These 9 individuals are a sub-sample of the 81 individuals analysed for $\delta^{13}C$ and $\delta^{15}N$ in the current study.

The calculated ^{14}C offset from the above equation was used to estimate the % of total carbon derived from a marine source, assuming a maximum reservoir age of 390 years corresponding to 100% marine derived carbon. The % of marine protein contribution to collagen was derived through linear interpolation of values between the terrestrial endpoint (+7.2‰) and marine endpoint (+16‰). The latter were derived from measurements of contemporary herbivore and marine fish values, using similar assumptions as previously reported (Craig et al., 2013). All statistical analysis was carried out using R version 3.1.2.

The human osteological material was analysed according to the common standards reported in the literature (Krogman and İşcan, 1986; Buikstra and Ubelaker, 1994; White and Folkens, 2005). Sex determination in the adults was obtained by the application of the visual assessment of the morphological traits of skull and pelvis (Ferembach et al., 1980; White and Folkens, 2005). Age at death was determined using multiple age indicators. For adult individuals, methods included: degenerative changes of the pubic symphysis (Todd, 1921), the auricular surface of the innominate (Buikstra and Ubelaker, 1994), and the sternal ends of ribs (Işcan et al., 1984); ecto- and *endo*-cranial suture closure (Buikstra and Ubelaker, 1994). For individuals still growing at the time of death the following criteria were applied: stages of epiphyseal fusion (Scheuer et al., 2010), long bone dimensions (Scheuer et al., 2010), and the stages of formation and eruption of teeth (AlQahtani et al., 2010). The analyses were independently performed by three observers (PP, LF, AS) and cases of discrepancy were resolved by a fourth joint and consensual analysis (on the reliability of the age-at-death assessment see (Baccino et al., 1999; Garvin and Passalacqua, 2012). The extraordinary preservation state of the skeletal and dental material allowed for the age at death to be determined by 5 year intervals for subadults and 10 year intervals for adult individuals (the last age class being 50 +), thus permitting comparison with almost contemporaneous central Italian skeletal series (Prowse et al., 2004; Prowse et al., 2005; FitzGerald et al., 2006; Craig et al., 2009; Crowe et al., 2010; Petrone et al., 2011).

The Herculaneum sample set reported in this paper is composed of 81 individuals: 28 females, 37 males, 6 unsexed individuals older than 15 years and 10 individuals (< 15 years) which were unsexed, see Supplementary information, Table 1.

For the dietary reconstruction, we included the biological sub-adults (age 15–20, 5 males, 2 females, and 4 unsexed) within the analysis of the adult individuals on the grounds that they probably ate an adult diet, being classed 'social' adults in accordance with the trend of traditional Roman life (Treggiari, 1993).

3. Results and discussion

3.1. Dietary variation at Herculaneum and other coastal roman sites

The carbon and nitrogen stable isotope data for the Herculaneum population are reported in Supporting information, Table 1. These include all the data reported in Craig et al. (2013) plus those from an additional 9 infants and juveniles. Overall, the isotope data for all individuals > 15 years fall within the range of similar age cohorts from other coastal Imperial necropolises (Fig. 2). These are Isola Sacra (Prowse et al., 2004; Crowe et al., 2010), the cemetery that served Portus Romae - the gateway to Rome, and Velia - a small coastal town south of Naples (Craig et al., 2009) (Fig. 1). The $\delta^{13}C$ values at each of the three sites have comparable ranges (Herculaneum = −18.2‰ to −20.2‰; Isola Sacra = −17.8‰ to −19.5‰; Velia = −18.7‰ to −20.0‰) but the variances are significantly different between sites (Fligner-Killeen test of homogeneity of variances; $x^2 = 6.8$, $p = 0.03$).

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