


Diet and mobility patterns in the Late Prehistory of central Iberia (4000–1400 cal BC): the evidence of radiogenic ($^{87}\text{Sr}/^{86}\text{Sr}$) and stable ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) isotope ratios

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Abstract This study examines strontium, oxygen, and carbon isotope ratios ($^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, $\delta^{13}\text{C}$) in dental enamel and bone apatite from 82 individuals interred at Late Neolithic, Chalcolithic, and Bronze Age burial sites near Madrid, Spain, to discern variations in dietary patterns and identify possible migrants. Questions about mobility patterns and subsistence practices have played a central role in the scholarship of Late Prehistoric central Iberia in the last 20 years, but the archaeological record has still not been able to provide clear answers. This study adds valuable data to this line of research. The results of this study suggest that migration from regions with different geologic landscapes was uncommon in these communities. For the identified migrants, based upon the $^{87}\text{Sr}/^{86}\text{Sr}$ values, several of the identified non-local individuals originate from regions with substantially older lithological features and possible places of origin are being investigated. As it is not possible to discern individuals who may have moved from regions with similar geologic landscapes using this methodology, these data provide the minimum number of

migrants, and it is conceivable that the number of non-locals in this sample may be higher. Combining multiple lines of material and biological evidence and the completion of Sr isotope mapping in the Iberian Peninsula will help to clarify these findings. Stable carbon isotope data provide new and direct evidence of regional changes in consumption patterns. In particular, this study provides some possible evidence for the consumption of C₄ plants in third-millennium BC central Spain.

Keywords Stable isotopes · Radiogenic isotopes · Mobility · Diet · C₄ plants · Late Prehistory · Spain

Introduction

This study uses strontium, oxygen, and carbon isotope ratios ($^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, $\delta^{13}\text{C}$) in dental enamel and bone apatite from 82 humans interred at Late Neolithic, Copper, and Bronze Age sites in Central Spain in order to identify mobility patterns and potential variations in dietary patterns. For decades, mobility and pastoralism have been key themes in the scholarship of central Iberian Late Prehistory (e.g., Maluquer de Motes 1972). This has been largely due to a combination of two factors. First, semi-nomadic pastoralism has traditionally been considered the preferred subsistence practice in the environmental conditions of the Spanish Meseta, which, with a 600-m-high Tertiary plateau, has a pseudo-steppe landscape, with patches of cereal fields, oak woodlands (mostly *Quercus ilex* and *Q. faginea*) and shrubs, dry and hot summers, and cold and rainy winters. Second, prehistoric settlement locations favored river basins, where rich soils and permanent pasture lands can be found, and the archaeological record for this time is defined by reiterative clusters of pit

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features, with scarce evidence for dwellings and an absence of deep-stratified sites. These features further suggest that semi-nomadic pastoralism—perhaps combined with seasonal, rainfall agriculture—was the major mode of subsistence (e.g., Blasco 1994). Thus, although this interpretation was first challenged two decades ago (Díaz-del-Río 1995), most scholars still agree that there is evidence for some degree of population mobility in this region and time, especially when compared to their contemporary southeastern and subsequent Iron Age populations (cf. Blanco 2011; Lull et al. 2013).

Our knowledge of prehistoric subsistence strategies in Central Spain has frequently relied on a poorly preserved archaeological record, with fragmentary, commingled, and, often only partially studied, faunal collections. Part of this pattern has changed throughout the last decades, as a result of the boom and bust cycle of the construction bubble in Central Spain and its effects on the exponential increase of open-area excavation of sites. Although analyses of most faunal collections remain incomplete and we consequently lack a comprehensive synthesis, today we know that Late Prehistoric groups relied heavily on a combination of domestic animals (in order of importance: cows, sheep/goats, and pigs) and opportunistic and seasonal hunting of wild fauna (Liesau 2011: 168).

Unfortunately, our understanding of agricultural strategies in late prehistoric central Spain is even less advanced. Systematic flotation has not been used as a standard practice during the excavation boom in the region, and when applied, results have often had poor recovery rates (e.g., Díaz-del-Río et al. 1997). Accordingly, our information on cultivated crops is derived from a limited number of sites and contexts and it is likely not representative. Nevertheless, we have evidence that wheat, barley, and legumes are present in the area from the Early Neolithic onward, although we lack information as to their probable variations through time.

While, in the past, the scarcity of faunal and palaeobotanical information has impeded the study of patterns of prehistoric human dietary change, new approaches are now possible. Extensive excavations of burials have provided an ample amount of recovered human remains. Many of these assemblages have been well mapped, dated, and analyzed, resulting in detailed reports and publications and provide the basis for work promoting a regional synthesis (Aliaga 2014; Pérez-Villa 2015). As the mobile or sedentary nature of prehistoric groups is at the heart of the discussion of prehistoric social structure and subsistence patterns, isotopic analyses of human remains are an effective and timely alternative to other standard bioarchaeological methods. This is because stable and radiogenic isotope analyses provide a way to quantify the diet and mobility patterns of individual humans and animals and, when such data are combined, these patterns in prehistoric communities.

Methods

Isotope analyses of archaeologically recovered human remains have become a significant part of archaeological and bioanthropological research because these analyses can provide a record of diet and mobility patterns from prehistoric communities. Many general reviews of isotopic research in archaeology have been published (cf. Ambrose and Krigbaum 2003; Katzenberg 2008; Makarewicz and Sealy 2015; Schoeninger and Moore 1992), and the body of work related to these methodologies continues to expand.

Strontium isotopes are incorporated into the tissues of plants, animals, and humans through nutrient intake. The isotopic composition of this bioavailable Sr depends on the local geology (the types and age of rocks) and the types of soils and sediments in the subsurface. As dental enamel is formed during childhood and not subsequently remodeled, its $^{87}\text{Sr}/^{86}\text{Sr}$ ratio records the geologic signature of an individual's childhood landscape (Beard and Johnson 2000; Price et al. 1994). Oxygen isotope values ($\delta^{18}\text{O}$) provide information about water sources and can also be used to distinguish between plants and animals from different geographic locations (Stuart-Williams et al. 1996; White et al. 2004). In particular, $\delta^{18}\text{O}$ depletion is associated with increased precipitation and/or lower temperature (Bradley 1999; Price and Burton 2011: 91–92). In bone and enamel apatite, $\delta^{13}\text{C}$ values are used to evaluate patterns of plant and animal consumption within the whole diet (Krueger and Sullivan 1984; Lee Thorp et al. 1989).

For the $^{87}\text{Sr}/^{86}\text{Sr}$ analysis, enamel surfaces were cleaned with acetone and the top layer of enamel was removed. Next, a small amount of enamel (10–15 mg) was removed with a Dremel tool. Enamel was removed from the tooth in a lengthwise fashion from the crown tip to root in order to incorporate enamel from the entire time of crown formation. Bone samples were cleaned and ground into powder using a Dremel tool. Strontium was extracted from acid-digested enamel samples using Sr spec ion-exchange resins in the University of Iowa Department of Earth and Environmental Sciences clean lab (Waight et al. 2002; Waterman et al. 2014). $^{87}\text{Sr}/^{86}\text{Sr}$ ratios were obtained by running each sample on the Nu Plasma HR multicollector inductively coupled plasma-mass spectrometer (MC-ICP-MS) housed at the University of Illinois Department of Geology MC-ICP-MS Laboratory. ^{88}Sr voltages were monitored to insure that samples had Sr concentrations sufficient for accurate measurement with the MC-ICP-MS. $^{87}\text{Sr}/^{86}\text{Sr}$ ratios were accepted when ^{88}Sr was measured between 5 and 19 V. All ratios were normalized to the NIST 987 international strontium carbonate standard value of 0.710268 (McArthur et al. 2001), which had a reproducibility of ± 0.000050 (2 SD, $n = 91$).

When looking to identify non-local individuals in a burial population, the local bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ isotope

composition must first be defined. There are two established methods used to estimate the local $^{87}\text{Sr}/^{86}\text{Sr}$ range for archaeological samples when regional $^{87}\text{Sr}/^{86}\text{Sr}$ maps are not available: (1) the mean of the human dental enamel analyzed ± 2 SD (Bentley et al. 2004; Price et al. 2002) or (2) the mean of the local faunal remains analyzed ± 2 SD. For the fauna, it is best to have animals with very limited geographic ranges (e.g., rabbit or snails) recovered from the same archaeological sites as the human samples (Bentley et al. 2004; Price et al. 2002). Price et al. (2002) suggest that samples from larger fauna be included, to better understand the migration ranges of multiple species that may relate to human migration patterns. In accordance with these suggested practices, the local bioavailable Sr composition range in this study is defined by 2 standard deviations from the mean of the combined selected human $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. The calculations were first done with all of the human samples. Next, because the bone samples are more likely to be contaminated with the local $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the burial soil and first molars that may contain $^{87}\text{Sr}/^{86}\text{Sr}$ ratios from breast milk, these samples were excluded from a second set of calculations. Ratios from the local fauna ($n = 15$) were also examined to help calibrate the local range (Table 1).

For the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ data, all bone and tooth samples were sent to the Laboratory for Archaeological Science at the University of South Florida for processing. There collagen and apatite samples were obtained using the techniques described by Tykot (2006). All collagen yields and C/N ratios in collagen were measured, as yields of less than 1% have been found to be too degraded for reliable analysis, and C/N ratios between 3.7 and 2.9 are generally found to indicate good preservation (DeNiro 1985; Tykot 2002). In order to remove any non-biogenic carbonates that may have leached into the bone apatite from the burial environment, all bone apatite was pretreated with a buffered acetic acid solution. Such treatments have been found effective in removing postmortem contamination while retaining the *in vivo* isotopic signature (Koch et al. 1997; Tykot 2002). The faunal bone samples were analyzed for carbon, nitrogen, and oxygen isotopes using a CHN analyzer coupled with a Finnigan MAT Delta Plus stable isotope ratio mass spectrometer using continuous flow for the bone collagen, and a Finnigan MAT Delta Plus instrument using a Kiel III device with 100% phosphoric acid at 90 °C was used for the bone apatite and enamel samples.

The carbon and oxygen ratios are reported using the delta (δ) notation and calibrated to an international standard using the following standard formula: $\delta = [(R_{\text{sample}}/R_{\text{standard}}) - 1] \times 1000$, where R_{sample} is the ratio of the heavy isotope to light isotope in the sample (e.g., $^{13}\text{C}/^{12}\text{C}$ or $^{15}\text{N}/^{14}\text{N}$), R_{standard} is the ratio of the heavy isotope to light isotope in the reference standard, and δ is the difference in isotopic composition of the sample relative to that of the reference, expressed in parts per thousand (‰) (see Tykot 2006). The $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ notations are calculated using ambient inhalable reservoir

(AIR) and the Pee Dee Belemnite (PDB) standards. The analytical precision of the employed instrument was $\pm 0.1\text{‰}$ for the $\delta^{13}\text{C}$ data and $\pm 0.2\text{‰}$ for the $\delta^{18}\text{O}$ data.

Regional context, selected sites, and samples

In this study, the geographical research area is essentially divided into two structural-lithological regions: the northern sierras and the southern Tagus river basin. Sierras were formed during the Cenozoic, out of igneous and metamorphic rocks of the Paleozoic granite shelf plateau. The Tagus basin is mainly composed by detrital rocks (sands and marls) with some chemical and lacunar facies (gypsum and limestones) (Instituto Geológico y Minero de España 1988). The region has its highest point at 2430 m and the lowest at 430 m.a.s.l., and has a substantial spatial ecological variability. All 15 sampled sites belong to the basin and are mainly distributed along the Tagus and its tributaries (Fig. 1). To date, there are no excavated Late Prehistoric sites in the sierras, and later sites have poor preservation of bone samples. The samples in this study thus cover a 90-km-long transect cutting through the Tagus river basin, from the 800 to 600 m.a.s.l., distributed throughout Quaternary, Cenozoic, and Cretaceous formations.

Late Neolithic settlement sites are virtually unknown in the region. It is currently assumed that groups were somehow small and mobile, all of which would explain the general lack of archaeological evidence. When found, sites are typically defined by clusters of underground features, frequently interpreted as storage pits and other domestic facilities (Díaz-del-Río 2006: 68–70). A generalized expansion of settlement sites is documented throughout most of Iberia during the Copper Age (3100–2200 cal BC). Like many other regions, the Tagus basin flourishes with settlements that largely cluster throughout the most fertile river banks: a region like Madrid, with its 8000 km² virtually surveyed, shows a shift from just 31 Neolithic to over 500 possible Copper Age locations. Sites are again defined by underground features, now in dense clusters that extend from one to occasionally over 10 ha. The main features that define this period are ditched enclosures (Díaz-del-Río 2004), evidence nowadays widespread throughout most of Iberia (Jiménez-Jáimez 2015). Finally, Bronze Age sites are frequently smaller, with similar locations, and again comprising pit clusters of different extensions. Perhaps, their most salient features are the lack of enclosures and the generalized presence of individual burials adjacent to other domestic facilities (Díaz-del-Río 2006: 75).

Certainly, the region is known to have a considerable funerary record for both the Copper and Bronze ages (Aliaga 2014; Pérez-Villa 2015). Although there is funerary evidence over most of the course of the Late Prehistory, it peaks by the mid third millennium BC (Fig. 2), coinciding with the demise of ditched enclosures throughout the region. While this

Table 1 Analyzed samples and results

Proj. no.	Site	S. Unit	Sex	Age	Fauna sample	Period	Sample $^{87}\text{Sr}/^{86}\text{Sr}$	$^{87}\text{Sr}/^{86}\text{Sr}$	USF no.	$\delta^{13}\text{C}_{\text{en}}$	$\delta^{18}\text{O}_{\text{en}}$	$\delta^{13}\text{C}_{\text{co}}$	$\delta^{15}\text{N}$	C/N
1	Casa Montero	2781	f	Adult I		BA	M2	0.71001	19501	-11.7	-3.4			
2	Casa Montero	2486	m	Adult I		BA	M2	0.71021	19502	-9.8	-2.7			
3	Caseño de Perales 2	Fondo K XVI	f	Adult II		BA	M	0.71054	19503	-10.5	-3.2			
4	El Congosto	1324	f	Adult III		BA	M	0.70924	19504	-11.4	-3.0			
5	El Congosto	1325	f	Adult		BA	M	0.71008	19505	-11.0	-3.6			
6	El Muladar	1212	?	Adult I		BA	I	0.71209	19506					
7	El Muladar	1213	?	Infant II		BA	M	0.71163	19507	-11.9	-3.3			
8	Fuente de la Mora	1121	?	Infant II		BA	M1	0.71007	19508	-10.2	-3.3			
9	Góquez 085	2275	?	Infant I		BA	M1	0.70960	19509	-10.9	-3.3			
10	Góquez 085	992	f	Adult		BA	M2	0.71066	19510	-11.0	-3.5			
11	Góquez 047	9142	?	Adult		CA	M2	0.70935	19511	-10.7	-3.9			
12	Góquez 085	1602 (h.1)	?	Adult		BA	M2	0.71111	19512	-10.3	-3.3			
13	Góquez 047	9030/9031	?	Adult		CA	M2	0.70920						
14	Góquez 085	1602 (h.2)	?	Adult		BA	M2	0.70991	19513	-11.2	-3.7			
15	Góquez 047	5130 (h.2)	?	Adult I		CA	M2	0.70966	19514	-10.4	-2.9			
16	Góquez 087	3304	m	Adult I		BA	M2	0.70948	19515	-10.5	-4.0			
17	Góquez 087	4304	m	Adult II		BA	M2	0.70916	19516	-10.8	-2.9			
18	Góquez 087	2805	?	Adult		BA	Skull frag	0.70949						
19	Góquez 087	303	?	Adult II		BA	M2	0.70976	19517	-10.3	-3.2			
20	Góquez 087	1704	f	Adult IV		BA	Skull frag	0.70961						
21	Góquez 087	3303	m	Adult I		BA	M2	0.70949	19518	-9.5	-4.1			
22	La Dehesa Pol. 25	A22W	?	Infant II		BA	I	0.71004	19519	-11.8	-2.6			
23	La Dehesa Pol. 25	F3 A9	?	Infant II		BA	M2	0.70972	19520	-11.2	-3.5			
24	La Dehesa Pol. 25	F3 A9	?	Infant II		BA	M2	0.71005	19521	-10.9	-3.7			
25	La Dehesa Pol. 25	A21	f	Juvenile		BA	M	0.70956	19522	-10.6	-3.3			
26	La Dehesa Pol. 25	A22 (h.2)	m	Adult I		BA	Rib	0.70962						
27	La Ocañuela	1224	m	Adult IV		LN	M2	0.70875	19523	-12.8	-3.2			
28	Los Chorrillos	325	m	Adult II		BA	M	0.70869	19524	-11.4	-3.1			
29	Pista de Motos	960 (h.1)	f	Adult IV		BA	M	0.71489						
30	Pista de Motos	960 (h.3)	m	Adult IV		BA	Rib	0.71097						
31	Pista de Motos	857	?	Adult III		BA	M	0.71201	19525	-12.1	-3.0			
32	Los Berrocales (AP)	Tomb 2 UE 1108	m	Adult I		BA	M1	0.70965	19526	-11.1	-3.1			
33	Los Berrocales (AP)	Tomb 2 ue 1203 h.2	m	Adult I		BA	M2	0.70959	19527	-10.9	-3.8			
34	Los Berrocales (AP)	Tomb 2 ue 1203 h.1	?	Juvenile		BA	M2	0.70964	19528	-10.2	-4.0			

Table 1 (continued)

Proj. no.	Site	S. Unit	Sex	Age	Fauna sample	Period	Sample $^{87}\text{Sr}/^{86}\text{Sr}$	$^{87}\text{Sr}/^{86}\text{Sr}$	USF no.	$\delta^{13}\text{C}_{\text{en}}$	$\delta^{18}\text{O}_{\text{en}}$	$\delta^{13}\text{C}_{\text{co}}$	$\delta^{15}\text{N}$	C/N
35	Los Berrocales (AP)	Tomb 2 ue 1203 h.3	?	Infant I		BA	M (dec)	0.71063	19529	-11.2	-2.6			
36	Los Berrocales (AP)	Tomb 3 UE 1176	f	Adult		BA	Premolar	0.70920	19530	-10.7	-2.7			
37	Los Berrocales (AP)	Tomb 4 UE 1254	?	Adult		BA	M1	0.71119	19531	-12.4	-1.9			
38	Los Berrocales (AP)	Tomb 5 UE 1267	f	Adult II		BA	M	0.71006	19532	-11.4	-4.1			
39	Los Berrocales (AP)	Tomb 7 UE 1641	f	Adult		BA	M2	0.70872	19533	-11.3	-4.6			
40	Los Berrocales (AP)	Tomb 9 UE 1821	?	Adult I		BA	M	0.71025	19534	-12.3	-1.7			
41	Los Berrocales (AP)	Tomb 10 UE 1829	?	Adult		BA	M	0.71028	19535	-10.8	-3.1			
42	Los Berrocales (AP)	Tomb 11 UE 1886	?	Adult		BA	M	0.71432	19536	-11.3	-2.8			
43	Los Berrocales (E)	Tomb 13 UE 109	?	Adult I		BA	M	0.70996	19537	-11.4	-2.9			
44	Los Berrocales (E)	Tomb 14 UE 250	f	Adult I		BA	M	0.71151	19538	-12.1	-2.5			
45	Los Berrocales (E)	Tomb 16 UE 435	m	Adult II		BA	M2	0.71046	19539	-11.0	-2.6			
46	Los Berrocales (E)	Tomb 17 UE 401	m	Infant II		BA	M1	0.70951	19540					
47	Los Berrocales (E)	Tomb 20 UE 830	f	Juvenile		BA	M2	0.71847	19541	-11.4	-3.6			
48	Los Berrocales (E)	Tomb 21 UE 966	?	Infant II		BA	M1	0.71042	19542	-11.3	-0.6			
49	Los Berrocales (E)	Tomb 22 UE 1162 h.1	f	Adult I		BA	M1	0.70933	19543	-12.0	-3.7			
50	Los Berrocales (E)	Tomb 22 UE 1162 h.2	?	Infant II		BA	M1	0.71019	19544	-11.7	-2.2			
51	Los Berrocales (E)	Tomb 23 UE 1176	f	Adult II		BA	M2	0.71191	19545					
52	Los Berrocales (E)	Tomb 24 UE 1186	f	Adult I		BA	M2	0.71021	19546	-11.7	-2.3			
53	Los Berrocales (E)	Tomb 25 UE 1212 h.1	f	Adult I		BA	M2	0.71106	19547	-11.4	-3.0			
54	Los Berrocales (E)	Tomb 26 UE 1244	?	Infant II		BA	M1	0.70980	19548	-11.4	-2.7			
55	Los Berrocales (E)	Tomb 27 UE 1246	f	Adult		BA	M1	0.70933	19549	-12.1	-1.6			
56	Los Berrocales (E)	Tomb 28 UE 1261	f?	Adult II		BA	M2	0.71456	19550	-12.2	-3.8			
57	Los Berrocales (E)	Tomb 30 UE 1327	m	Adult I		BA	M2	0.71116	19551	-10.8	-3.6			
58	Los Berrocales (E)	Tomb 32 UE 1424	m	Adult I		BA	M2	0.71012	19552	-11.3	-4.0			
59	Los Berrocales (E)	Tomb 33 UE 1456 h.1	?	Adult		BA	M	0.70959	19553	-10.6	-2.7			
60	Los Berrocales (E)	Tomb 33 UE 1456 h.2	?	Juvenile		BA	M	0.71022	19554	-11.2	-1.8			
61	Los Berrocales (E)	Tomb 35 UE 1794	m	Adult		BA	M2	0.70972	19555	-10.8	-4.1			
62	Los Berrocales (E)	Tomb 36 UE 1803	m	Adult II		BA	M1	0.70933	19556	-11.2	-2.4			
63	Los Berrocales (E)	Tomb 37 UE 1902	f	Adult II		BA	M2	0.71097	19557	-12.2	-2.7			
64	Los Berrocales (E)	Tomb 38 UE 1934	?	Adult I		BA	M2	0.71003	19558	-11.6	-3.4			
65	Los Berrocales (E)	Tomb 39 UE 1944	f	Adult I		BA	M2	0.71233	19559	-11.6	-3.8			
66	Los Berrocales (E)	Tomb 40 UE 1946	?	Adult		BA	M2	0.71027	19560	-12.0	-2.0			
67	El Rebollosillo	Individuo 1	?	Adult		CA	Temporal left	0.70830						
68	El Rebollosillo	Individuo 2	?	Adult		CA	Temporal right	0.70816						
69	El Rebollosillo	Individuo 3	?	Infant		CA	Temporal left	0.70811						

Table 1 (continued)

Proj. no.	Site	S. Unit	Sex	Age	Fauna sample	Period	Sample $^{87}\text{Sr}/^{86}\text{Sr}$	$^{87}\text{Sr}/^{86}\text{Sr}$	USF no.	$\delta^{13}\text{C}_{\text{cen}}$	$\delta^{18}\text{O}_{\text{en}}$	$\delta^{13}\text{C}_{\text{co}}$	$\delta^{15}\text{N}$	C/N
70	El Rebollosillo	Individuo 4	?	Infant		CA	Temporal left	0.70808						
71	El Rebollosillo	Individuo 5	?	Adult		CA	Temporal right	0.70829						
72	El Rebollosillo	Individuo 6	?	Adult		CA	Temporal right	0.70810						
73	El Rebollosillo	Individuo 7	?	Juvenile		CA	Temporal right	0.70828						
74	El Rebollosillo	Individuo 8	?	Adult		CA	Temporal right	0.70822						
75	El Rebollosillo	Individuo 9	?	Adult		CA	Temporal right	0.70817						
76	El Rebollosillo	Individuo 10	?	Adult		CA	Temporal right	0.70821						
77	El Rebollosillo	Individuo 11	?	Adult		CA	Temporal right	0.70846						
78	El Rebollosillo	Individuo 12	?	Adult		CA	Temporal right	0.70831						
79	El Rebollosillo	Individuo 13	?	Adult		CA	Temporal right	0.70863						
80	El Rebollosillo	Individuo 14	?	Adult		CA	Temporal right	0.70815						
81	El Rebollosillo	Individuo 14	?	Adult		CA	M2	0.70938	19561	-10.4	-3.1			
82	El Rebollosillo	Individuo 15	?	Adult		CA	Temporal left	0.70898						
83	El Rebollosillo	Individuo 15	?	Adult		CA	M2	0.70896	19562	-10.9	-4.4			
84	El Rebollosillo	Individuo 16	?	Adult		CA	Temporal right	0.70825						
85	El Rebollosillo	Individuo 16	?	Adult		CA	M1	0.70922	19563	-11.3	-2.5			
87	Bajo del Cercado	1164	?	Infant	<i>Felis catus</i>	Visigoth	Mandible	0.71184	19565	-11.5	-0.9	-18.6	12.1	3.3
88	Casa Montero	16,225		Adult	<i>Oryz. cuniculus</i>	Contemp.	Humerus	0.70973						
89	Caserío de Perales 2	Fondo K XVI		Infant	<i>Sus sp</i>	BA	Mandible	0.71272	19566	-11.1	-4.3	-18.8	7.4	3.4
90	El Congosto	559		Infant	<i>Canis familiaris</i>	Visigoth	Mandible	0.70943	19567	-11.6	-1.4	-18.8	11.6	3.3
91	Gózquez	6145		Adult	<i>Erinaceus europ.</i>	Contemp.	Mandible	0.70948						
92	Gózquez	2493		Adult	<i>Oryz. cuniculus</i>	Contemp.?	Mandible	0.70953	19568	-11.5	0.0	-20.8	6.4	3.3
93	Gózquez 087	2003		Infant	<i>Canis familiaris</i>	BA	Mandible	0.70945	19569	-10.4	-3.9	-19.1	9.4	3.4
94	La Dehesa Pol. 25			Adult	<i>Canidae</i>	BA	Metapodial	0.70962						
95	Los Chorrillos	311		Adult	<i>Bos</i>	BA	Metacarpal	0.70999						
96	Pista de Motos	851		Adult	<i>Lepus sp.</i>	Contemp.?	Humerus	0.71048	19570	-13.4	-3.7	-21.0	3.6	3.3
97	El Rebollosillo	Cata 9/Nivel 1		Adult	<i>Oryz. cuniculus</i>	Contemp.	Mandible	0.70809	19571	-8.8	-1.6	-19.1	6.6	3.5
98	El Rebollosillo	Cata 9/Nivel 1		Adult	<i>Vulpes vulpes</i>	Contemp.	Mandible	0.70819	19572	-10.7	-0.6	-21.4	4.4	3.3
99	Los Berrocales	ue 1127		Adult	<i>Oryz. cuniculus</i>	Contemp.	Tibia	0.71052	19573	-11.2	-0.2	-21.5	9.8	3.3
100	Los Berrocales	ue 1128		Adult	<i>Ovis/Capra</i>	BA	Mandible	0.71158	19574	-13.6	-2.1	-22.2	5.7	3.3

(?) Unidentifiable

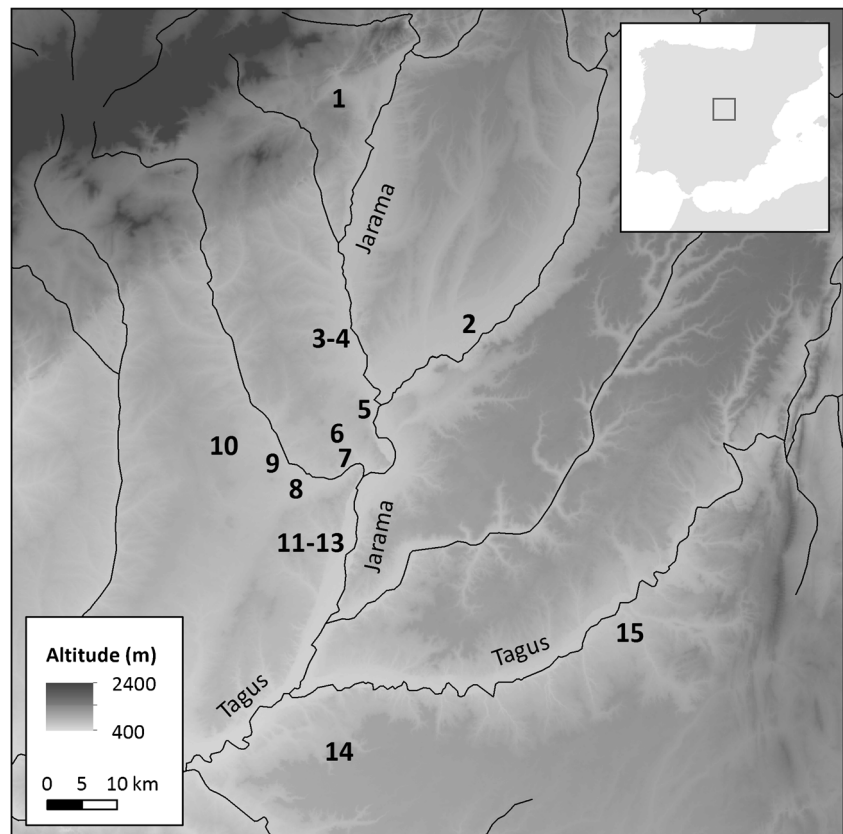
increase in funerary activities is initially characterized by collective burial practices, it is progressively substituted by individual burials, a pattern that can also be observed in other regions of Iberia (Balsera et al. 2015: 145).

This variable frequency in burial practices, peaking by 2500 cal BC, has inevitably influenced our sampling strategy, biasing the collection towards the second half of the third and the first half of the second millennia, with just one case for the Late Neolithic, the individual burial of La Ocañuela (Toledo). Out of the remaining 13 sites with human samples, the Copper Age site of El Rebollosillo is the only secondary burial analyzed. The site is a small natural cave of approximately 23 m² located in the Cretaceous carbonate rocks of the karstic masifs immediately south of the Spanish Central Range (Díaz-del-Río et al. 2017). It is one out of the several caves formed during the Pliocene that are known to have sheltered burial activities throughout Late Prehistory. All the rest belong to sites located south of the Central Range, in both Miocene (seven cases) and Quaternary (four cases) deposits. These are all individual burials except for two infant crania recovered inside the same feature at the Bronze Age site of La Dehesa. Buried individuals were interred in pits usually in flexed fetal position, and these burials generally lacked metal tools or adornments or other grave goods that are often interpreted as relating to status (Pérez-Villa 2015: 145–160).

The sampled population consists of 13 infants, 5 juveniles, and 64 adults (Table 1). Biological sex was not assigned in 45 cases, in 12 cases because the individuals were infants at the time of death, and for the rest, because skeletal preservation was too poor for determination. Out of the remaining 37, 16 were determined to be male and 21 female. The chronology of the human sample is as follows: one belongs to the Late Neolithic, 19 to the Copper Age, and 62 to the Bronze Age. Dates have been assigned by association with diagnostic items in 39 cases, while the remaining 43 have been radiocarbon dated, all directly obtained from human bones except for one charcoal sample (Table 2). Dates belong to 10 of the 14 sampled sites (contextual details can be found in Aliaga 2014; Aliaga and Megías 2011; Díaz-del-Río et al. 2017; Domínguez and Vírveda 2009; Martín Bañón 2007; Pérez-Villa 2015; Ríos 2011).

Because of the variability in preserved material, it was not possible to sample the same skeletal element from each individual. Ideally, second molars would have been selected, which begin formation during early childhood, but when unavailable, first and third molars were selected, which represent a formation time period of infancy to early childhood and late childhood to early adulthood (Smith 1991). For some molars, when teeth were not recovered in situ, it was not possible to assign proper tooth designations. For several of the sampled

Fig. 1 Location of sampled sites. 1 El Rebollosillo, 2 La Dehesa, 3 El Muladar, 4 Bajo del Cercado, 5 Casa Montero, 6 Los Berrocales, 7 El Congosto, 8 Caserío de Perales 2, 9 Pista de Motos, 10 Fuente de la Mora, 11–13 Gózquez 047/085/087, 14 La Ocañuela, 15 Los Chorrillos



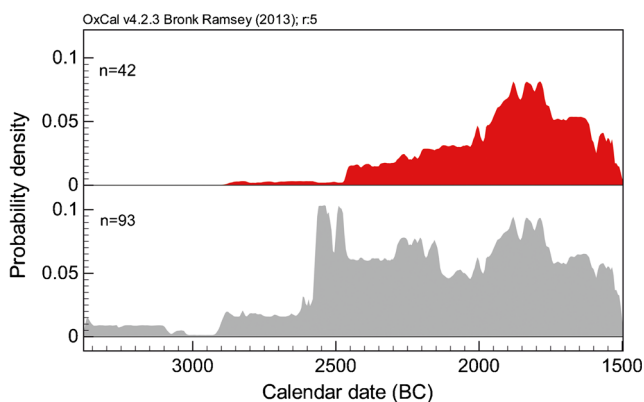


Fig. 2 Summed radiocarbon probability distributions for 42 Southern Meseta's individual burials (*red*) and 93 individual and collective burials (*grey*). Radiocarbon dates and references can be found at the “Radiocarbon Date Archive for Andorra, Portugal and peninsular Spain”: <http://www.idearqueologia.org>

infants, other teeth were chosen as the adult molars had not yet formed. In some cases, when dental remains were not available, the human bone was sampled. As the bone is subject to diagenetic changes, these materials are less likely to accurately identify migrants through Sr or O in bone or enamel apatite.

The analyzed faunal remains are more varied chronologically than the humans. Sites and species were selected in order to outline an initial plot of the regional Sr signature. Out of the 14 samples from 12 sites, 5 are directly associated to Bronze Age contexts: *Sus*, *Canidae*, *Bos*, and *Ovis/Capra*. Although recovered from Copper and Bronze Age contexts, all rabbits and hare are most probably intrusive fauna, as is the only hedgehog sample. Finally, the *Felis catus* and one of the *Canis familiaris* were recovered from Late Antiquity contexts.

Results

The calculations with all of the human data and the human data with bone samples and first molars excluded yielded the same local range (Fig. 3). Based on this analysis, the local range for the surveyed sites in the Madrid region is defined as 0.707 to 0.713. As all of the fauna data fit within the bioavailable range defined by the human samples, no adjustments were made based on the fauna. Using this range, we were able to identify four clear outliers who exhibit $^{87}\text{Sr}/^{86}\text{Sr}$ isotope ratios outside of the local range (0.71489, 0.71432, 0.71847, 0.71456) (Fig. 3). The fact that only 4/82 (4.9%) individuals can be identified as non-locals suggests that inter-regional mobility may have been less common in this area than in Southwestern Spain and Portugal, where slightly higher ratios of non-locals have recently been identified in Copper Age burials (Waterman et al. 2014; Waterman 2012). However, because this methodology cannot identify individuals who moved from locations with similar geological features and some of the bone samples may not exhibit migrant signatures

due to diagenesis, the number of non-locals in this study should only be interpreted as representing the minimum number (MNM).

Three of the four identified immigrants from the Bronze Age site of Los Berrocales are likely female, which suggests the possibility of a pattern of exogamy in which females marry outside of their natal community. However, more data would be needed to establish this as a regional or even a local pattern. Based on the higher $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, at least three migrants may have come from regions with substantially older geologic lithologies such as the nearby Guadarrama sierra (Villaseca et al. 1998). Based on these findings, mobility may well have been a strictly regional phenomenon, since distance from these sites requires less than a 2-day walk.

Data of $\delta^{18}\text{O}$ in meteoric precipitation collected since the year 2000 by the Spanish Monitoring Network of Isotopes in Precipitation (REVIP) offer a weighted mean of -7.07‰ for the city of Madrid, while offering lower values (-11 to -8‰) for the central mountain chain (Díaz-Teijeiro et al. 2009). Díaz-Teijeiro et al. (2009) report that all these values are strongly tied to factors such as altitude and continentality. Thus, similar variation should be expected between lower altitude sites such as ours and samples from the higher sierras, of which we lack to date.

Our $\delta^{18}\text{O}$ values for humans ranged from -4.6 to -1.6‰ (-3.1‰ mean) (Fig. 4). These values are substantially higher than contemporary data from precipitation (Díaz-Teijeiro et al. 2009). This difference could relate to isotope fractionation from water source to consumer, variability in water source, and/or climatic fluctuations over time. Additionally, these higher values may relate to the consumption of animal milk. Based upon the same principles of oxygen isotope fractionation that causes breast milk consumption to result in higher $\delta^{18}\text{O}$ values (Wright and Schwarcz 1998), the consumption of animal milk may also increase $\delta^{18}\text{O}$ values (Lai 2008). By this time in prehistory, the gene mutation for lactose persistence had spread throughout populations in Europe and there is archaeological evidence of dairying throughout Western Europe (Gerbault et al. 2011). More data on current environmental and prehistoric values in humans and animals are needed in this region to clarify these findings.

The results of the oxygen isotope analysis did not identify any additional non-locals, nor did those who exhibited non-local Sr signatures exhibit $\delta^{18}\text{O}$ values that fell on the high or low ends of the $\delta^{18}\text{O}$ range for the surveyed burial populations on a whole. The range of $\delta^{18}\text{O}$ values for the sampled fauna was even larger than for the human population (0.0 – 4.3‰), and animals with the highest oxygen isotope values were commonly herbivores, such as rabbits, while carnivores and omnivores had some of the lowest values. Thus, we cannot tie these differences fully to trophic level and animal diet. Instead, this is most likely a result of the wide chronological distance between samples and evidence that water sources

across the sampled region were fairly heterogeneous in terms of $\delta^{18}\text{O}$ values. These findings correspond somewhat to the observed contemporary pattern of $\delta^{18}\text{O}$ value variation in the region. Precipitation, temperature, and regional and seasonal fluctuations in temperature and rainfall are probably influencing the observed human and animal variations. Moreover, as teeth reflect a small window of time during dental development, seasonality may be more strongly influential in this dataset than it would be if we had sampled bone apatite. While the fauna data are valuable in identifying the variability of bioavailable oxygen isotopes in the region, sampling water sources as well as additional fauna in future studies would help to explain regional patterns.

In strictly C_3 ecosystems, humans should exhibit a $\delta^{13}\text{C}$ apatite or enamel signature of roughly -14‰ and in C_4 ecosystems a $\delta^{13}\text{C}$ apatite signature close to ~ 0 . Mixed diets and environments are suggested by intermediate values (Lai 2008; Tykot et al. 2009; Kohn and Cerling 2002). $\delta^{13}\text{C}$ values in dental enamel ranged from -9.5 to -12.8‰ (Fig. 4). There is no clear correlation between the age or sex of the individual and the higher $\delta^{13}\text{C}_{\text{ap}}$ values. While in several cases, high $\delta^{13}\text{C}_{\text{ap}}$ values in sampled first molars could be due to breast milk consumption as these teeth form during late infancy and early childhood, second and third molar exhibit similar, and in many cases, higher values. Thus, we must look for another source for this $\delta^{13}\text{C}$ enrichment.

Two main sources of higher $\delta^{13}\text{C}$ values in human diets come from marine proteins and C_4 (or Crassulacean acid metabolism (CAM)) plants. As this region is not in close proximity to the sea, we suggest that certain C_4 (or CAM) plants may have been consumed. Additional isotopic data from bone collagen that includes $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values from these same sites would help to clarify this dietary information, and a new study is currently being undertaken to acquire these data. Recently, Fernández-Crespo and others (2017: 331) have suggested that the aridity shown by the palaeoenvironmental record for La Mancha, south of our case-study area, may be behind similar enriched values obtained from the Bronze Age site of El Azuer. Also, some isotopic enrichment in animal tissues from the Late Neolithic onward could be linked to the “canopy effect,” wherein dense forest canopies produce more $\delta^{13}\text{C}$ -depleted plants near the forest floor and anthropogenic deforestation leads to higher $\delta^{13}\text{C}$ values in some terrestrial herbivores as they begin to feed in more open landscapes and/or fallow agricultural fields (van der Merwe and Medina 1991), while the use of fertilizers may also lead to slight $\delta^{13}\text{C}$ enrichment in C_3 plants by increasing the soil salinity (Farquhar et al. 1989). Thus, further information on long-term environmental conditions and agricultural practices in prehistoric Iberia may lend valuable data to these investigations.

When burial sites with $\delta^{13}\text{C}$ data from at least five individuals are compared using *t* tests, we found that the contemporary burials of Los Berrocales and Gózquez (which lie 15 km

apart) exhibit a highly statistically significant difference in $\delta^{13}\text{C}$ values ($p = .00006$), suggesting strong dietary differences perhaps related to C_4 or CAM plant consumption. This may provide evidence that settlements practiced some specialization when it came to food production and consumption and that there may have been substantial dietary variability in the region during the Bronze Age.

Discussion

Our study suggests that inter-regional human mobility was lower in the Late Prehistory of Central Spain than was previously thought. However, some migrants may have been overlooked with the employed methodology. The higher ratios of the migrants suggest migration for more mountainous regions or highlands into the river valley. Exogamy has been occasionally suggested as an explanation for other Copper or Bronze Age regional patterns, such as pottery production and distribution (Abarquero 2005; Carmona 2011), and we may see some evidence for female exogamy, perhaps reflecting some scale of patrilocality, at Los Berrocales. If so, this would contrast with the matrilocality proposed for their contemporary and overtly more complex southeastern groups of El Argar (Lull 2000). However, without more isotopic data documenting female mobility, this finding remains speculative.

Perhaps, one of the most intriguing results of this study relates to diet change and variability throughout the Late Prehistory of Iberia. Although evidence is still patchy, some form of C_4 plant consumption, as evidenced by enriched $\delta^{13}\text{C}_{\text{ap}}$ values in human skeletons, has been documented in the Estremadura region of Portugal during the Copper Age (Waterman et al. 2016). Additionally, we have similar findings among some Bronze Age populations of La Mancha (Nájera et al. 2010; Salazar et al. 2013) and now have evidence of some $\delta^{13}\text{C}$ enrichment in the diets of Copper and Bronze Age populations of the Upper Tagus basin. This suggests that these higher values may not be exclusively tied to environmental factors, as southern Portugal and Central Spain have distinctly different Atlantic and Continental climates. While the contemporaneity of all sampled populations would favor a common cause for these higher $\delta^{13}\text{C}$ values, other aspects of population demographics, such as the sedentariness or social complexity, do not provide answers, as there seem to be appreciable differences between all three regions (e.g., Díaz-del-Río 2006; Brodsky et al. 2013; Aranda et al. 2008; Lillios 1991). Of course, we cannot rule out the availability and consumption of an indigenous C_4 or CAM plant that may have been useful as a dietary supplement in the context of a semi-steppe environment with a xeric regime, such as the southern Spanish Meseta (e.g., purslane, Tankersley et al. 2016) or

Table 2 List of dated samples and results

No.	Site	Location	Region	S. unit/tag	Lab code	BP	SD	$\delta^{13}\text{C}$	cal BC 2σ	Sample
1	Casa Montero	Vicálvaro	Madrid	2781	Beta-295151	3130	50	-18.7	1510–1270	Human bone
2	Casa Montero	Vicálvaro	Madrid	2486	Beta-295150	3320	40	-18.1	1700–1500	Human bone
4	El Congosto	Rivas Vaciamadrid	Madrid	1324	KIA27583	3345	35	*	1740–1530	Human bone
9	Gózquez 085	San Martín de la Vega	Madrid	2275	CNA2348	3355	35	-18.02	1750–1530	Human bone
10	Gózquez 085	San Martín de la Vega	Madrid	992	CNA2349	3360	35	-19.27	1750–1530	Human bone
11	Gózquez 047	San Martín de la Vega	Madrid	9142	CNA2350	3890	35	-19.27	2480–2230	Human bone
12	Gózquez 085	San Martín de la Vega	Madrid	1602 ind. 1	CNA2351	3405	35	-19.99	1870–1610	Human bone
13	Gózquez 047	San Martín de la Vega	Madrid	9030/9031	CNA2352	3890	35	-19.71	2480–2230	Human bone
15	Gózquez 047	San Martín de la Vega	Madrid	5130 ind. 2	Beta-134865	4100	80	-25	2880–2480	charcoal
17	Gózquez 087	San Martín de la Vega	Madrid	4304	CNA2353	3520	35	-16.78	1940–1740	Human bone
18	Gózquez 087	San Martín de la Vega	Madrid	2805	CNA2354	3470	35	-18.59	1890–1690	Human bone
19	Gózquez 087	San Martín de la Vega	Madrid	303	CNA2355	3525	35	-18.17	1950–1750	Human bone
20	Gózquez 087	San Martín de la Vega	Madrid	1704	CNA2356	3495	35	-17.21	1920–1690	Human bone
21	Gózquez 087	San Martín de la Vega	Madrid	3303	CNA2357	3475	35	-17.22	1890–1690	Human bone
27	La Ocañuela	Ocaña	Toledo	1224	Beta-232895	5180	40	-19.80	4220–3810	Human bone
28	Los Chorrillos	Estremera	Madrid	325	CNA2358	3755	35	-17.85	2290–2030	Human bone
29	Pista de Motos	Madrid	Madrid	960 ind. 1	DSH261	3269	21	*	1620–1500	Human bone
32	Los Berrocales (AP)	Madrid	Madrid	Burial 2 ind. 1	CNA373	3515	40	-19.86	1950–1700	Human bone
33	Los Berrocales (AP)	Madrid	Madrid	Burial 2 ind. 2	CNA372	3540	50	-20.28	2030–1740	Human bone
36	Los Berrocales (AP)	Madrid	Madrid	Burial 3	Ua41485	3405	33	*	1870–1620	Human bone
38	Los Berrocales (AP)	Madrid	Madrid	Burial 5	CNA2359	3585	35	-17.86	2040–1780	Human bone
41	Los Berrocales (AP)	Madrid	Madrid	Burial 10	CNA2360	3530	35	-18.76	1950–1750	Human bone
42	Los Berrocales (AP)	Madrid	Madrid	Burial 11	CNA2361	3315	35	-18.91	1690–1500	Human bone
46	Los Berrocales (EE)	Madrid	Madrid	Burial 17	CNA367	3550	60	-18.16	2120–1690	Human bone
53	Los Berrocales (EE)	Madrid	Madrid	Burial 25	CNA2362	3370	35	-19.51	1750–1540	Human bone
64	Los Berrocales (EE)	Madrid	Madrid	Burial 38	CNA2363	3435	35	-18.14	1880–1640	Human bone
66	Los Berrocales (EE)	Madrid	Madrid	Burial 40	CNA368	3565	45	-16.52	2030–1770	Human bone
67	El Rebollosillo	Torrelaguna	Madrid	Individual 1	CNA4006	4065	31	-18.60	2850–2480	Human bone
68	El Rebollosillo	Torrelaguna	Madrid	Individual 2	CNA4007	4004	31	-18.51	2620–2460	Human bone
69	El Rebollosillo	Torrelaguna	Madrid	Individual 3	CNA4008	4005	30	-16.30	2580–2460	Human bone
70	El Rebollosillo	Torrelaguna	Madrid	Individual 4	CNA4009	3995	31	-19.52	2580–2460	Human bone
71	El Rebollosillo	Torrelaguna	Madrid	Individual 5	CNA2364	4015	35	-18.49	2630–2460	Human bone
72	El Rebollosillo	Torrelaguna	Madrid	Individual 6	CNA4010	3989	31	-19.58	2580–2460	Human bone
73	El Rebollosillo	Torrelaguna	Madrid	Individual 7	CNA2365	4005	35	-18.54	2620–2460	Human bone
74	El Rebollosillo	Torrelaguna	Madrid	Individual 8	CNA4011	4007	31	-19.21	2620–2460	Human bone
75	El Rebollosillo	Torrelaguna	Madrid	Individual 9	CNA2366	4020	35	-18.37	2630–2460	Human bone
76	El Rebollosillo	Torrelaguna	Madrid	Individual 10	CNA4012	4086	30	-16.02	2860–2490	Human bone
77	El Rebollosillo	Torrelaguna	Madrid	Individual 11	CNA2367	3915	35	-19.06	2490–2290	Human bone
78	El Rebollosillo	Torrelaguna	Madrid	Individual 12	CNA4013	4024	30	-15.95	2620–2470	Human bone
79	El Rebollosillo	Torrelaguna	Madrid	Individual 13	CNA4014	3774	30	-16.22	2300–2050	Human bone
80	El Rebollosillo	Torrelaguna	Madrid	Individual 14	CNA2368	4000	35	-19.42	2620–2460	Human bone
82	El Rebollosillo	Torrelaguna	Madrid	Individual 15	CNA2369	4020	35	-17.88	2630–2460	Human bone
84	El Rebollosillo	Torrelaguna	Madrid	Individual 16	CNA2370	4090	35	-18.81	2870–2490	Human bone

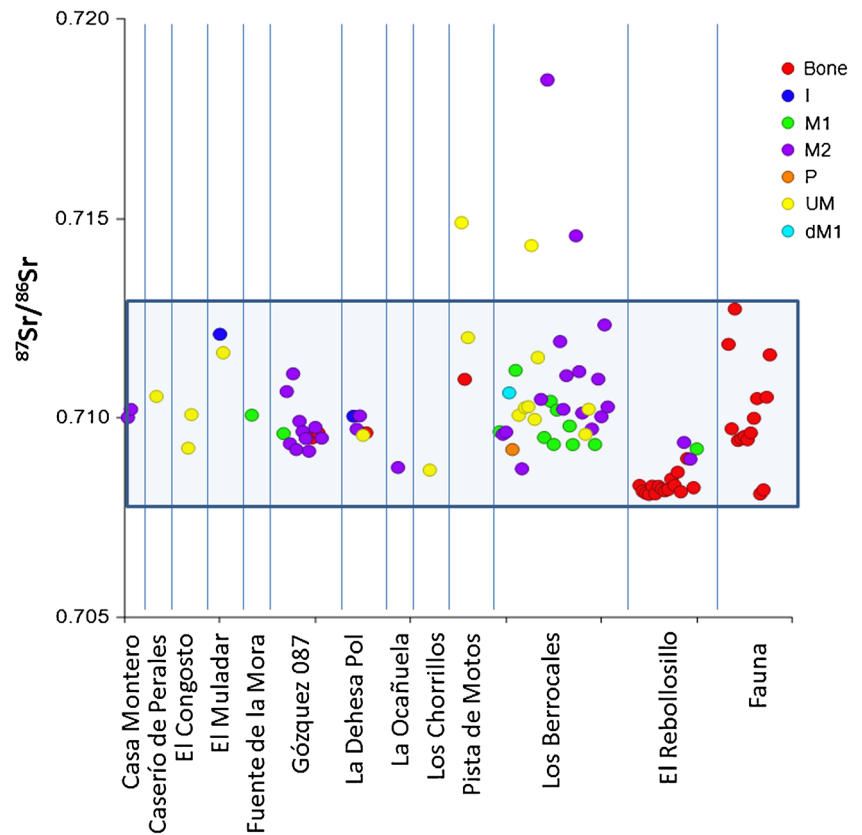
All unpublished except for no. 4 (Martín Bañón 2007); no. 15 (Díaz-del-Río 2004); no. 29 (Dominguez and Virseda 2009); and nos. 36, 46, and 66 (Aliaga and Megías 2011)

*not reported

of seaweed intake in the case of Portuguese coastal groups (Waterman et al. 2016).

Although more data are needed, our results suggest that an increase of some form of C_4 plant consumption probably

Fig. 3 $^{87}\text{Sr}/^{86}\text{Sr}$ values by sample type and site. Blue shading shows bioavailable local $^{87}\text{Sr}/^{86}\text{Sr}$ range



began in central Iberia by mid-third millennium BC and became a staple throughout the Bronze Age. This is also suggested by the lowest $\delta^{13}\text{C}_{\text{ap}}$ value of the Late Neolithic sample recovered from La Ocañuela (Toledo), to our knowledge, the only documented individual burial for this chronology in the whole region (ca. 4000 cal BC), and the observed shift to enriched $\delta^{13}\text{C}_{\text{ap}}$ values in sample 15, dated to 2880–2480 cal BC, with similar values to other mid-third-millennium BC samples such as numbers 11 and 81, both from the collective cave of El Rebollosillo, dated to 2640–2410 cal BC. It should be also noted that the only prehistoric sheep analyzed has the lowest $\delta^{13}\text{C}_{\text{en}}$ values of the whole sample, while both *C. familiaris* and *Sus* sp., probably sheltered and fed livestock, fall within Bronze Age human values.

Higher $\delta^{13}\text{C}$ values in Late Copper Age and Bronze Age human samples from non-coastal areas such as the Spanish Meseta could be interpreted as an evidence for the consumption of imported millets. This is however unlikely. Third-millennium BC carpological remains of *Panicum miliaceum* and *Setaria italica* are extremely sparse in Iberia (Moreno-Larrazabal et al. 2015), and none has been directly dated. The earliest for the former belongs to the northern Portuguese Copper and Iron Age site of Crasto de Palheiros, associated to an occupation dated between 2650 and 2470 cal BC (Sanches 2008: 46), while the multi-stratified site of Kobaederra cave, in northern Spain, has

the earliest evidence for the latter, dated to 3310–2900 cal BC. Finally, a single seed of *Panicum* sp. (not necessarily *P. miliaceum*) has been recovered from a burial context in Camino de las Yeseras (Madrid, Spain) (Peña-Chocarro et al. 2011: 273) dated to 2580–2470 cal BC (Ríos 2011: 77). There are later—and again scanty—Bronze Age evidences for millet throughout Iberia, while the first fully developed cultivation of *P. miliaceum* is documented in some regions such as the northwest only by the fourth to third century BC (Moreno-Larrazabal et al. 2015).

Be it a result of a cultural use of available autochthonous plants or of the consumption of millet, central Iberian populations seem to have changed their diet and productive habits, integrating some form of C_4 plant intake by at least ca. 2500 cal BC. The claim for a shift in consumption patterns would require of further support. Additional data could be obtained combining results from phytoliths, starch remains analyses on grinding stones, and human dental calculus (e.g., Liu et al. 2015). If further evidence is found, the introduction of millet in agricultural practices would involve the incorporation of a summer cultigen into the already staple wheat and barley agriculture. Such a change in agricultural production would suggest some shift in subsistence practices, or economic aspects of crop production and trade, and would provide more evidence against the theories that these groups were highly mobile.

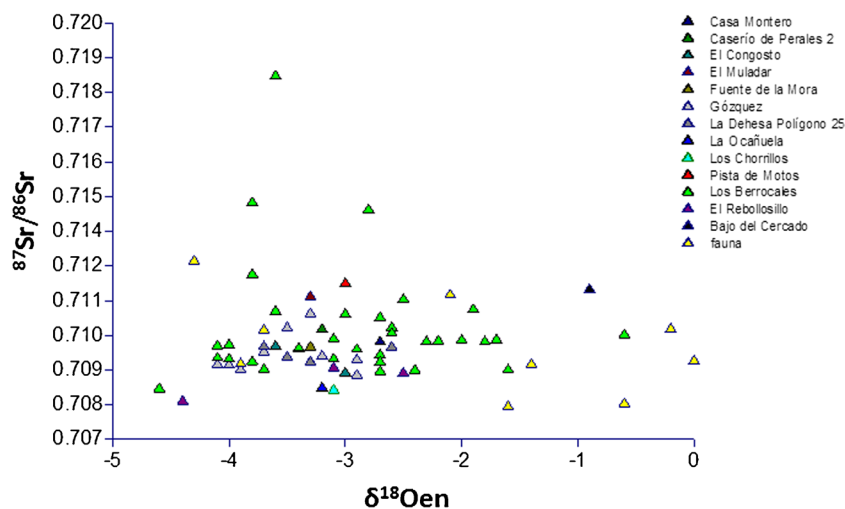


Fig. 4 Scatterplot of $^{87}\text{Sr}/^{86}\text{Sr}$ and $\delta^{18}\text{O}$ values from humans and faunal samples. One non-local individual from Pista de Motos (0.71490) not included as $\delta^{18}\text{O}$ values were not obtained. Only three outliers are shown as sample 29 lacks associated $\delta^{18}\text{O}$ value

In sum, our isotopic analyses suggest that human mobility in the Late Prehistory of Central Spain was lower than has been proposed in the more traditional culture historical perspective via other (largely ambiguous) archaeological data. The scant evidence that we did find documenting migrants in these burials offers new perspectives on the way in which these small human groups may have organized their social reproduction through exogamic marriage practices. The isotopic data presented here have also provided new evidence of possible changes in consumption patterns during the third millennium BC. Thus, we propose that using stable and radiogenic isotope analyses, in combination with more traditionally derived archaeologically data, allows for more nuanced insights into regional changes in agricultural and economic practices and helps to clarify our understanding of a dynamic time period in Iberian prehistory.

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