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FOR APPROVAL

Investigating prehistoric diet and lifeways of early farmers in central northern Spain (3000–1500 CAL BC) using stable isotope techniques

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Abstract
This work focuses on reconstructing past diets and animal management during Prehistory in Central Northern Spain, spanning the NE area of the Old Castilian Plateau to the Cantabrian coast, from c. 3000–1500 BCE. During this time, early farming communities made changes in their models of production and social reproduction that crystallised in the emergence of social complexity. To investigate these changes, we reconstructed the past diet of these early farming populations by using stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$) of human and animal remains from the recently excavated sites of Abrigo de la Castañera in Cantabria and Arroyal I, El Hornazo, Fuente Celada and Ferrocarril-La Dehesa in Burgos. The human remains derived from a range of burial contexts including pit graves, megalithic monuments and burial caves. To provide initial insights into animal management during this timeframe, associated faunal remains were also studied as a baseline. In total, 52 samples were analysed, including 17 human burials and 35 animal specimens (cattle, sheep, pig, red deer and dog). Results show that humans in these sites consumed relatively similar diets, comprising of a predominantly C3 diet including animal protein. Animal management patterns indicate a wider use of the landscape for herbivore grazing. The differing diets of dogs at El Hornazo provide insights into the relationship that they had with humans and tentatively suggests differences in the diet of working animals versus household pets. The $\delta^{34}S$ values of two individuals from Arroyal I indicate that they came from different regions, implying a level of inland mobility during the Chalcolithic.

Keywords Diet · Stable isotopes · Spain · Prehistory · Neolithic · Chalcolithic · Animal management · Bronze age

Introduction

The arrival of agriculture and livestock to the Iberian Peninsula promoted changes in social and economic structures (Rojo Guerra et al. 2012). The new species and products were linked to a dramatic change in economy that, unlike hunting and gathering, required long-term planning and investment in the production of food, with deferred results (Vicent 1990, 1998) and gave rise to a new type of people; farmers. These new agricultural economies needed specific requirements to be able to thrive (e.g. political control over territory, agrarian capital, storage of goods, long-term management of resources). It was mastering these conditions that led to the origins of the first complex societies. The current paradigm, accepted by most scholars (see Bernabeu 2003; Delibes de Castro and Fernández Manzano 2000; Díaz del Rio 2006) is that, such socio-economic political differences began to become visible in the interior and North of the Iberian Peninsula during Chalcolithic (c. 3300–1900 BCE) (Delibes de Castro

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and Fernández Miranda 1993; Delibes de Castro et al. 1995). One of the consequences of the new situation was the emergence of regional differences that are observed within the archaeological record (Bernabeu 2003). For example, the size and type of settlements changed during the Chalcolithic along the Iberian Peninsula (c. 3000–2200 BCE). While small and open settlements dominated, the northern and eastern regions of the peninsula, fortified settlements appeared in the western and southern regions (Garcia Sanjuán and Murillo-Barroso 2013; Rojo Guerra et al. 2005). During the Final Chalcolithic and Early Bronze Age (c. 2200–1900 BCE), there was a diversity and richness of the Bell Beaker settlements and burial assemblages in Iberia (Garrido-Pena 2014). Later, during the Middle and Final Bronze Age (c. 1900–1000 BCE) in the North and centre of the peninsula, economy and society seem to have stabilised without significant changes, compared to the previous stages (Díaz del Rio 2001, 2006). Nevertheless, little is currently known about the diet and economy of these past populations.

To explore the economy and lifeways of the Prehistoric inhabitants of Central Northern Spain, this research is focused on sites located from the NE of the Castilian Plateau to the Cantabrian coast (Fig. 1) between c. 3000 and 1500 BCE. To date the subsistence strategies of the past populations inhabiting this region are poorly known. From the Northern plateau, Chalcolithic human remains are rare (Carmona Ballestero et al. 2013) and faunal assemblages recorded from such sites are relatively small (Riquelme Cantal 2009; Marín-Arroyo 2011). The situation is similar in the Cantabrian coast, in the northernmost part of the study region, with few zooarchaeological studies existing from this time period (Altuna 1980; Altuna and Mariezkurrena 2012; Altuna and Mariezkurrena 2011; Castaños 1984; Mariezkurrena 1990; Ontañón Peredo 2003; Peréz Ripoll and López Gila, 2012). Recent excavations at Arroyal I (Carmona Ballestero and Arnaiz Alonso in press), Fuente Celada (Alameda Cuenca-Romero et al. 2011; Carmona Ballestero 2013) and El Hornazo (Carmona Ballestero 2013; Carmona Ballestero et al. 2013), all located in the province of Burgos, and El Abrigo de la Castañera (Sierra Saínz-Aja 2014) in Cantabria have revealed assemblages of human skeletal remains from mortuary contexts, in addition to associated mammal remains. Dietary stable isotope analysis of these human and animal elements presents a valuable opportunity to understand the economic behaviour of these early farmers, during a period of emerging social complexity.

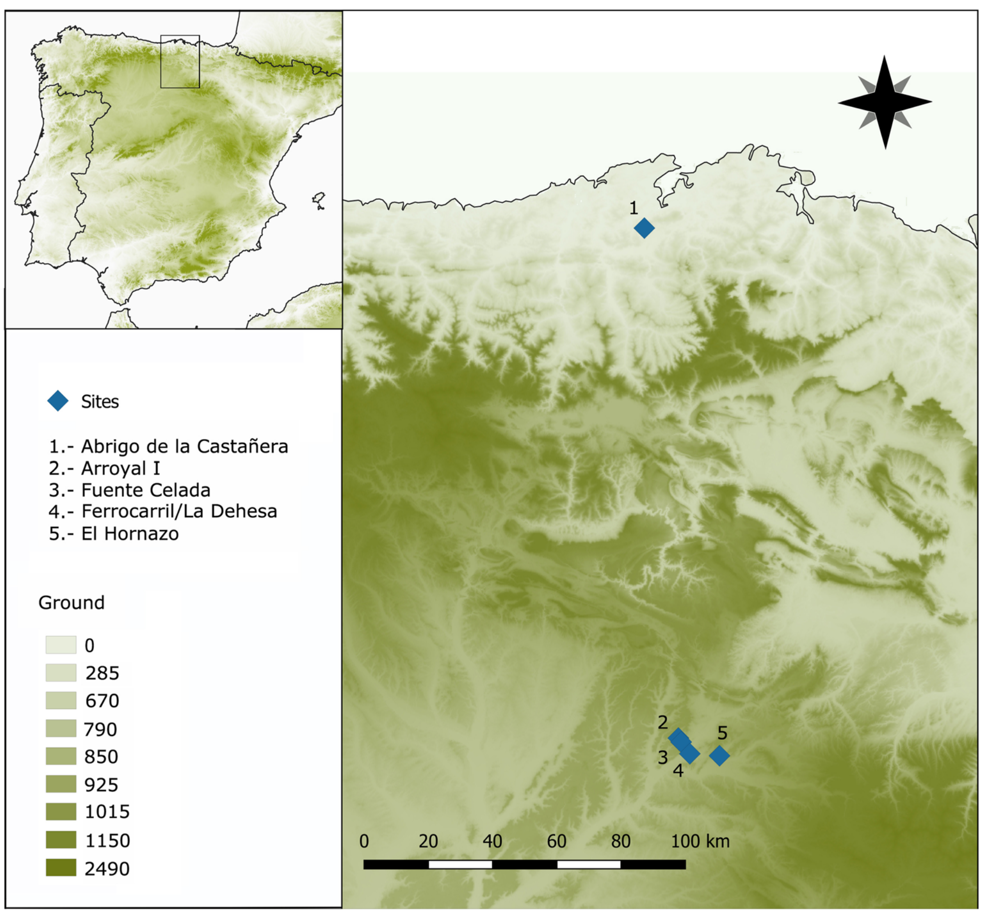

Fig. 1 Map of the northern Spain showing the location of the sites studied from the Castilian Plateau and the Cantabrian Region

Stable isotope analysis has commonly been used in archaeology since the mid-1980s as a technique for reconstructing palaeodietary behaviour, providing insights into human nutrition and economic strategies (Schoeninger et al. 1983; DeNiro 1985; Schoeninger and DeNiro 1984; Chisholm et al. 1982). Stable isotope analysis of bone collagen is a reflection of diet consumed by an individual over the last 10–15 years of life, informing on long-term average diet. This method is especially valuable in determining C_3 and C_4 plant consumption (Tieszen 1991), the use of animal protein, and the inclusion of marine foods in diet (Schulting and Richards 2002). Although there have been numerous applications of this technique in Prehistoric Europe (e.g. Richards et al. 1998; Schulting et al. 2010; Oelze et al. 2011; Tafuri et al. 2009), it is only in recent years that this subject has received attention in Spain, with studies attempting to redress this balance in the Mediterranean Coast (Salazar-García et al. 2014) and the Basque Country in the north of Iberia (Fernández-Crespo and Schulting 2017; Fernández-Crespo et al. 2018; Fontanals-Coll et al. 2015; Sarasketa-Gartzia et al. 2018).

Stable isotope analysis of animal bone collagen related to human remains can not only provide a valuable baseline for human diet but also provide valuable insights into animal management practises (e.g. Jones and Mulville 2016, 2018; Stevens et al. 2013; Müldner et al. 2014). In this study, $\delta^{13}C$ and $\delta^{15}N$ analysis of animal bone collagen will also be used to explore the use of the landscape by these early farming populations.

Materials and methods

The sites included in this comparative study are from Central Northern Spain, spanning the NE area of the Old Castilian Plateau to the Cantabrian coast (Fig. 1). Within this wider geographical region, the sites derive from two environmental zones. Four of the sites (Arroyal I, El Hornazo, Fuente Celada and Ferrocarril-La Dehesa) are located in the NE area of the Spanish North Plateau, an inland region with a cool and dry continental Mediterranean climate. This area is characterised by long and cold winters and short and warm summers and a strong contrast between day and night temperatures. In contrast, El Abrigo de la Castañera is located in the Cantabrian region which has an Atlantic climate and lies close to the coast. The Cantabrian Region today is characterised by year-round rainfall and limited seasonal temperature variation (Peel et al. 2007). The distinctly different environmental conditions of the two regions mean that there is potential for different models of dietary behaviour and animal management. A summary of the samples analysed from each site is presented in Table 1.

The sites

Arroyal I (Alfoz de Quintanadueñas, Burgos, Castile and León, Spain)

The site of Arroyal I (Fig. 1) was excavated between 2011 and 2012 by a research team from the University of Burgos. The site is a megalithic tomb comprising of a rectangular chamber (3 × 3.5 m), a long corridor (6 m) and a stone mound. The tomb was used as a collective burial location over a period of 400 years during the Late Neolithic (c. 3300–2900 BCE, Table 2), before it was abandoned (Carmona Ballestero and Arnaiz Alonso in press). During the Chalcolithic, the tomb came back into use when it was extensively remodelled. At that time, Neolithic layers were almost entirely removed; the corridor was filled with rocks and sediment (as a closure event) and a stone wall and a floor of limestone blocks were built inside the chamber. Following this, several consecutive and isolated burials were interred. One of these contained a young individual, dated to c. 2465–2211 BCE (Table 2), that was buried with a set of four vessels (two bell beakers bowls and two carinated ones), surrounded by human long bones and skulls from previous contemporaneous burials. In the next phase of activity, the dolmen was closed re-using materials from the site (in a secondary position) and the external mound height was increased. Finally, an isolated pit grave containing a female human body was created inside the mound, which dateds to c. 2348–2200 BCE (Table 2).

El Hornazo (Villímar, Burgos, Castile and León, Spain)

El Hornazo is a 'field of pits' located in Villímar, Burgos (Fig. 1). In 2004, a research team excavated an area of almost 1 ha where 179 different structures were discovered, including pits, ditch pits, pit-graves and post holes (Carmona Ballestero 2013). This site represents a Chalcolithic settlement divided into three different activity areas: habitation, storage and resource processing. In the storage area, two pit-graves were documented. The first grave (Pit 103) included a human subadult, buried with a bowl, infilled with sediment and few domestic remains that is dated to c. 2576–2473 BCE. In the second pit (Pit 140), dating to c. 2860–2574 BCE, another subadult was found buried in a crouched position. Deposits within Pit 140 contained domestic remains including pottery and animal bones. A single biconical bead was registered as a grave-good inside Pit 140. AMS dates of the human remains belong to the Pre-Beaker Chalcolithic (Table 2). In conjunction with the radiocarbon dates, the stylistic and typological attributes of archaeological remains determined that the entire aggregate of negative structures were formed during a single phase of occupation.

Table 1 Summary of the human and animal species sampled for $\delta^{13}C$ and $\delta^{15}N$ analysis from each site

Site	Location	Period	Human	Horse	Cow	Sheep	Ovicaprid	Pig	Red deer	Dog	Total
Ferrocarril-La Dehesa	Burgos	Middle Bronze Age	1	–	–	–	–	–	–	–	1
Abrigo de la Castañera	Cantabria	Bronze Age	3	–	–	–	1	3	–	–	7
El Hornazo	Burgos	Chalcolithic (Pre-Beaker)	2	–	6		4		1	4	17
Fuente Celada			3	–	4	1	3		–	–	11
Arroyal I		Chalcolithic		1	–	2	–	–	–		3
		Chalcolithic (Beaker)	5	–	2	1	–	–	–	1	9
		Chalcolithic (Non-Beaker)	2	–	–	–	–	–	–	–	2
		Late Neolithic	2	–	–	–	–	–	–	–	2
Total			18	12	4	1	8	3	1	5	52

Fuente Celada (Alfoz de Quintadueñas, Burgos, Castile and León, Spain)

Fuente Celada, located in Quintanadueñas (Burgos), was excavated in 2008 by the same research team of El Hornazo. It is a settlement with many rock-cut pits ('silos') that was occupied initially during the Neolithic and before the main focus of occupation occurred in the Early Chalcolithic (Alameda Cuenca-Romero et al. 2011; Carmona Ballestero 2013). In addition to a more domestic area (containing 'silos', post holes, mud fragments used in the huts, stone mortars and other domestic remains), human remains were discovered inside several pits, dating to the Chalcolithic between c. 2900 and 1900 BCE. Pit 19 contained a young woman, buried in an unusual inverted position (almost vertically placed, with the head at the bottom and the feet at the top). This pit also contained the largest accumulation of potsherds found at the site (1018 fragments, 19.5% of the total) dated to c. 2860–2574 BCE. In Pit 5, the disarticulated human remains of three individuals (a subadult and two male adults) were recorded, also belonging to the Chalcolithic (Table 2).

Ferrocarril-La Dehesa (Alfoz de Quintadueñas, Burgos, Castile and León, Spain)

Ferrocarril-La Dehesa is also located in Quintanadueñas (Fig. 1). The site was partially excavated in 1981 by opening a small sondage, before an open excavation area was conducted by L. Villanueva Martín and M. E. Delgado Arceo in 2016. In total, 147 contexts or activity areas were registered within this settlement: most of them simple rock-cut pits ('silos') but with a few dwellings, kilns and a pit-grave. In all cases, the features were filled with deposits containing domestic remains. The site is dated by relative methods with the *Cogotas* I type pottery, either in its formative phase (Protocogotas) or advanced phase one (Cogotas I Pleno) to the Middle Bronze Age (c. 1750–1450 BCE). The tomb (Pit 700) included an adult individual, deposited in a foetal position without any grave goods.

El Abrigo de la Castañera (Obregón, Cantabria, Spain)

El Abrigo de La Castañera is situated in the south of Santander Bay, in Cantabria (Fig. 1). This is the only site in this study that is located near the Atlantic Sea, which has a distinctive climatic and environmental context in comparison to the sites located in the province of Burgos. The site is an 85-m^2 deep rock shelter, that is a part of a seven-cave karst complex, oriented towards the NE. The site was surveyed in the late 1960s (Gomarín Guirado 1972) and partially excavated during the 1970s (Rincón Vila 1982, 1985). Later, it was subsequently studied by local archaeologists (Ruiz Cobo and Serna González, 1999; Ruiz Cobo 1991, 1996). Since 2011, a multidisciplinary research team led by C. Vega-Maeso has been excavating the shelter and surveying its surroundings.

The rock shelter has evidence of domestic use, including living areas, and an animal corral, during the Neolithic and Chalcolithic. A well-preserved Bronze Age stratigraphy linked to funerary events (c. 2100–1500 BCE, Table 2) was also recorded within the shelter (Vega-Maeso 2017). During recent excavations, human remains from at least six individuals were recovered associated with faunal remains (including domestic and wild species), lithic and bone industry, shells and pottery (Sierra Sainz-Aja 2014).

Sample preparation

Samples were prepared using facilities in the Institute of Biomedicine and Biotechnology at the University of Cantabria in Spain. Collagen extraction was undertaken following procedures outlined in Richards and Hedges (1999). Bone fragments between 0.6 and 0.8 g were cleaned by abrasion to remove any possible surface contamination before demineralisation in 0.5 M HCL at 6–8 °C for between 3 and 10 days. Samples were then washed using de-ionised water. Samples were gelatinised in a weak acidic solution (pH 3 HCL) at 70 °C for 48 h, then filtered with 5–8 µm Ezee® filters, prior to freeze-drying. Samples were analysed for $\delta^{13}C$, $\delta^{15}N$ and two samples were additionally analysed for

Table 2 Radiometric dates available from Arroyal I, El Hornazo Fuente Celada in Burgos and Abrigo de la Castañera in Cantabria

Site	ID	Date B.P.	Date calibrated 2σ	Species/material	Activity area/context	Period/ archaeological group	Reference
Arroyal I	UGAMS-15903	3870,30	2465 BC (89.7%) 2278 BC 2250 BC (4.3%) 2229 BC 2220 BC (1.4%) 2211 BC	Human bone collagen	SU 25 Inhumation 2	Chalcolithic (Beaker)	Carmona and Arnaiz (in press)
Arroyal I	UGAMS-15904	3850,30	2458 BC (75.7%) 2269 BC 2260 BC (19.7%) 2206 BC	Human bone collagen	SU 25, skull 1	Chalcolithic (Beaker)	Carmona and Arnaiz (in press)
Arroyal I	UGAMS-15905	3860,30	2461 BC (84.3%) 2276 BC 2254 BC (11.1%) 2210 BC	Human bone collagen	SU 25.skull 2	Chalcolithic (Beaker)	Carmona and Arnaiz (in press)
Arroyal I	UGAMS-15906	4370,30	3089 BC (9.7%) 3054 BC 3031 BC (85.7%) 2907 BC	Human bone collagen	SU 10	Late Neolithic	Carmona and Arnaiz (in press)
Arroyal I	UGAMS-15907	4410,30	3309 BC (0.7%) 3299 BC 3283 BC (0.5%) 3276 BC 3265 BC (4.1%) 3240 BC 3106 BC (90.2%) 2917 BC	Human bone collagen	SU 34	Late Neolithic	Carmona and Arnaiz (in press)
Arroyal I	UGAMS-15908	4430,30	3326 BC (20.7%) 3231 BC 3224 BC (0.4%) 3220 BC 3174 BC (1.8%) 3160 BC 3120 BC (72.4%) 2926 BC	Human bone collagen	SU 39	Late Neolithic	Carmona and Arnaiz (in press)
Arroyal I	MAMS-14857	3837,25	2348 BC (95.4%) 2200 BC	Human bone collagen	SU 19	Chalcolithic (Non-Beaker)	Carmona and Arnaiz (in press)
Arroyal I	15B/0254	3860,40	2431 BC (93.3%)2262 BC 2254 BC (2.1%) 2210 BC	Human bone collagen	SU 21	Chalcolithic (Non-Beaker)	Carmona and Arnaiz (in press)
El Hornazo	UGAMS-7566	4290,25	2927 (95.4%) 2878	Animal Bone collagen	Pit 94, SU 958	Chalcolithic (Pre-Beaker)	Carmona 2013
El Hornazo	UGAMS-8820	4200,25	2893 (27.5%) 2850 2814 (52.9%) 2741 2729 (14.4%) 2694 2685 (0.7%) 2680	Seed	Pit 30; SU 303	Chalcolithic (Pre-Beaker)	Carmona 2013
El Hornazo	UGAMS-6838	4010,25	2576 (95.4%) 2473	Human bone collagen	Pit 103; SU1031	Chalcolithic (Pre-Beaker)	Carmona 2013
El Hornazo	UGAMS-6995	4100,25	2860 (22.1%) 2809 2752 (8.0%) 2721 2702 (65.3%) 2574	Human bone collagen	Pit 140; SU1401	Chalcolithic (Pre-Beaker)	Carmona 2013
Fuente Celada	UGAMS-7565	6120,30	5208 (23.4%) 5144 5139 (9.4%) 5091 5083 (62.6%) 4961	Human bone collagen	Pit 62, SU 622	Early Neolithic	Carmona 2013
Fuente Celada	UGAMS-7563	4200,25	2893 (27.5%) 2850 2814 (52.9%) 2741 2729 (14.4%) 2694 2687 (0.7%) 2680	Animal bone collagen	Pit 42; SU 424	Chalcolithic (Pre-Beaker)	Carmona 2013
Fuente Celada	UGAMS-7561	4170,25	2880 (19.8%) 2835 2817 (75.1%) 2667	Animal bone collagen	Pit H15; SU 152	Chalcolithic (Pre-Beaker)	Carmona 2013

Table 2 (continued)

Site	ID	Date B.P.	Date calibrated 2σ	Species/material	Activity area/context	Period/ archaeological group	Reference
Fuente Celada	UGAMS-7559	4100,25	2643 (0.5%) 2640 2860 (22.1%) 2809 2752 (8.0%) 2721 2702 (65.3%) 2574	Human bone collagen	Pit 5; SU 53, indiv. 2	Chalcolithic (Pre-Beaker)	Carmona 2013
Fuente Celada	UGAMS-7562	4100,25	2860 (22.1%) 2809 2752 (8.0%) 2721 2702 (65.3%) 2574	Human bone collagen	Pit 19; SU 193	Chalcolithic (Pre-Beaker)	Carmona 2013
Fuente Celada	UGAMS-7560	4030,25	2620 (95.4%) 2474	Human bone collagen	Pit 5; SU 53, indiv. 3	Chalcolithic (Pre-Beaker)	Carmona 2013
Fuente Celada	UGAMS-7564	3790,25	2292 (95.4%) 2140	Animal bone collagen	Pit 60; SU 601	Chalcolithic (Non-Beaker)	Carmona 2013
Abrigo de la Castañera	UGAMS-10907	3290,25	1623 (95.4%) 1507	Animal bone collagen	SU 1	Early Bronze Age	Vega Maeso 2017
Abrigo de la Castañera	UGAMS-16015	3530,25	1935 (95.4%) 1771	Human bone collagen	SU 105	Early Bronze Age	Vega Maeso 2017
Abrigo de la Castañera	UGAMS-10908	3590,25	2022 (14.4%) 1990 1985 (81.0%) 1888	Human bone collagen	SU 2	Early Bronze Age	Vega Maeso 2017
Abrigo de la Castañera	ICA14B/1116	3750,40	2286 (95.4%) 2035	Human bone collagen	SU 3	Early Bronze Age	Vega Maeso 2017

$\delta^{34}S$ (samples SUC28 and SUC19) using mass spectrometry at Iso-Analytical (Crewe, UK).

The $\delta^{13}C$ values and $\delta^{15}N$ values are reported relative to the international standards V-PDB and AIR standards. In-house standards were used to calculate analytical error which was ± 0.1‰ (1σ) or better. All specimens discussed further had % C values above 35%, % N values above 15% and C:N values between 2.9 and 3.4 indicative of in vivo collagen (De Niro 1985; van Klinken 1999). The $\delta^{34}S$ values are reported relative to the international standard VCDT. Quality indicators of C:S values between 600 ± 300 and N:S values between 200 ± 100 (Nehlich and Richards 2009). All sample information, raw data and quality indicators for each sample are included in the Supplementary Material.

Results and interpretation

The results obtained are presented alongside initial interpretation about human diet and animal management at each archaeological site. The subsequent discussion is focused on the wider implications of these results in terms of the Prehistoric economies and lifeways in Central Northern Spain.

Arroyal I (Alfoz de Quintanadueñas, Burgos, Castile and León, Spain)

The human stable isotope values from Arroyal I ($n = 9$) form a main cluster of individuals dated to the Late Neolithic, Chalcolithic and Beaker period, with $\delta^{13}C$ values ranging between − 19.3‰ and − 19.7‰, and $\delta^{15}N$ values ranging between 9.2 and 10.9‰ (Fig. 2; Fig. 3). One individual (SUC28) plotted away from this main cluster with a lower $\delta^{13}C$ value of − 20.8‰, while the $\delta^{15}N$ value of 10.3‰ is similar to the $\delta^{15}N$ values observed in the main cluster. The humans have $\delta^{15}N$ values 3–4‰ higher than the herbivores sampled from the site, which is a typical relationship between consumers and prey during the Holocene (Hedges and Reynard 2007) and suggests that the humans were eating a C_3 diet that included animal protein (meat and potentially milk).

Individual SUC28 appears to have consumed a different diet to the other humans sampled based on the $\delta^{13}C$ values observed. To explore the relationship of this individual and the main cluster, $\delta^{34}S$ analysis was undertaken. Collagen from SUC28 and SUC19 was analysed to explore whether these individuals were derived from the same place. SUC28 yielded a $\delta^{34}S$ value of 14.8‰ and SUC19 had a $\delta^{34}S$ value of 10.2‰ (Table 3) indicating that these individuals derived from regions that were isotopically different in sulphur, likely representing geographically distinct locations.

El Hornazo (Villímar, Burgos, Castile and León, Spain)

The Chalcolithic humans from El Hornazo ($n = 2$), have $\delta^{13}C$ values between − 19.2 and − 19.7‰ and $\delta^{15}N$ values of 8.6‰ and 9.5‰ (Fig. 3; Table 3), indicative of terrestrial diet of animal protein in addition to plant products. One of the four dogs sampled has values indistinguishable from the humans analysed ($\delta^{13}C$ − 19.1‰, $\delta^{15}N$ 8.2‰). The other dog specimens plotted have $\delta^{15}N$ values ranging between 6.3‰ and 6.4‰ and $\delta^{13}C$ values between − 20.2‰ and − 20.7‰, demonstrating differing dietary behaviour of dogs at the site. The

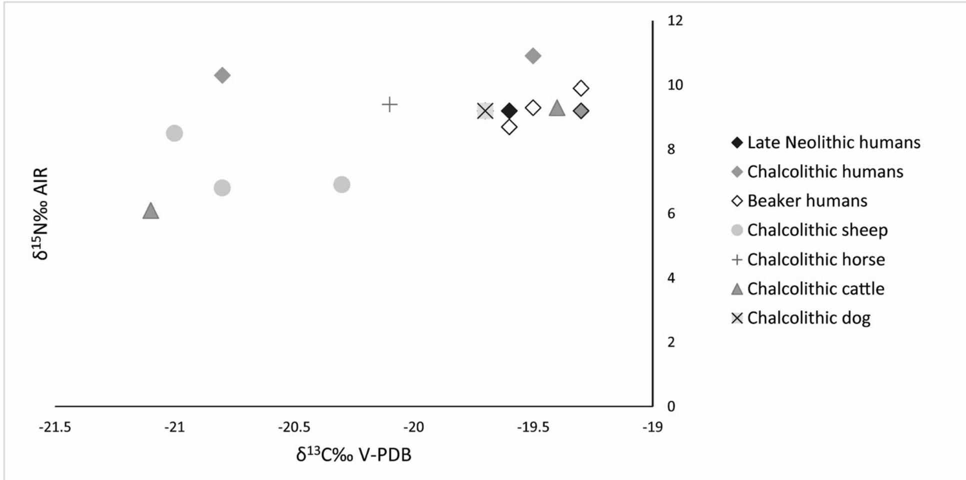

Fig. 2 Human and animal bone collagen δ^{15}N and δ^{13}C values analysed from Arroyal I

cattle have δ^{15}N values ranging between 5.3‰ and 8.3‰, with δ^{13}C values lying between − 19.3 and − 20.8‰ (Fig. 3). Two of the ovicaprids and one cow are plotted with the human specimens exhibiting higher δ^{13}C and δ^{15}N values. Cow 'a' (Fig. 3) had a lower δ^{13}C value of − 19.3‰.

Fuente Celada (Alfoz de Quintadueñas, Burgos, Castile and León, Spain)

The Fuente Celada humans ($n = 3$), dating to the Chalcolithic, had δ^{13}C values ranging between − 19.3 and − 19.5‰ and δ^{15}N‰ values ranging between 8.3 and 9.2‰ (Fig. 4; Table 3). The tight range in values observed suggests that these individuals consumed a very similar diet, including terrestrial animal protein.

The faunal data show a wide dispersal of stable isotope values. Whilst the sheep and ovicaprids had a relatively small range in δ^{13}C values of between − 20.1‰ and − 20.7‰, the δ^{15}N values were much greater, between 4.3‰ and 6.8‰. The larger range in δ^{15}N values could indicate a greater diversity in the diet of these animals, potentially representing different pasturing locations or differences in winter foddering within the population analysed.

The cattle from the site have a wider range in δ^{13}C values between − 20.4‰ and − 21.3‰ and a smaller δ^{15}N range than the ovicaprids, between 4.8‰ and 5.4‰. The wider range of δ^{13}C values could also be indicative of differing management practises of individuals, such as the use of a variety of pastures or foddering animals on differing plants.

Ferrocarril-La Dehesa (Alfoz de Quintadueñas, Burgos, Castile and León, Spain)

Only one human specimen was available to study from this site and attributed to the Middle Bronze Age. This individual is plotted next to the Chalcolithic specimens of Fuente Celada, located in the same village (Fig. 4). The individual from Ferrocarril-La Dehesa has a δ^{13}C value of − 19.6‰ and δ^{15}N value of 9.1‰ implying a diet rich in animal protein as seen in neighbouring Fuente Celada.

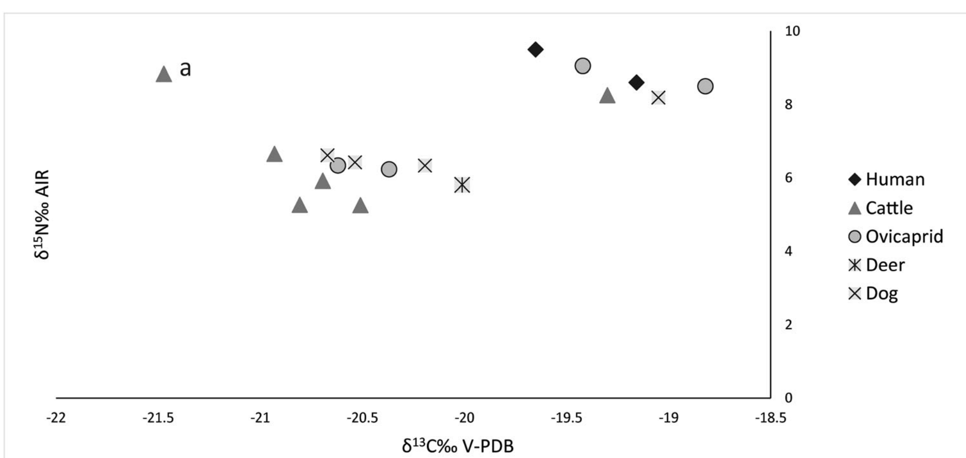

Fig. 3 Human and animal bone collagen δ^{15}N and δ^{13}C values analysed from El Hornazo. The specimen labelled as 'a' is discussed in more detail in the text

Table 3 Human and animal $\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$ values from each of the sites analysed in this study

Site	Lab number	Period	Species	$\delta^{15}N$ ‰	$\delta^{13}C$ ‰	$\delta^{34}S$ ‰
Arroyal I	S-UC 12	Late Neolithic	Human	9.2	− 19.6	–
Arroyal I	S-UC 28	Chalcolithic	Human	10.3	− 20.8	14.8
Arroyal I	S-UC 13	Chalcolithic	Human	9.2	− 19.3	–
Arroyal I	S-UC 14	Chalcolithic	Human	10.9	− 19.5	–
Arroyal I	S-UC 15	Late Neolithic	Human	9.2	− 19.7	–
Arroyal I	S-UC 16	Beaker	Human	9.2	− 19.3	–
Arroyal I	S-UC 17	Beaker	Human	8.7	− 19.6	–
Arroyal I	S-UC 18	Beaker	Human	9.3	− 19.5	–
Arroyal I	S-UC 19	Beaker	Human	9.9	− 19.3	10.2
Arroyal I	S-UC 20	Chalcolithic	Sheep	6.8	− 20.8	–
Arroyal I	S-UC 21	Chalcolithic	Horse	9.4	− 20.1	–
Arroyal I	S-UC 22	Chalcolithic	sheep	6.9	− 20.3	–
Arroyal I	S-UC 23	Chalcolithic	Sheep	8.5	− 21.0	–
Arroyal I	S-UC 24	Chalcolithic	Dog	9.2	− 19.7	–
Arroyal I	S-UC 25	Chalcolithic	Cow	6.1	− 21.1	–
Arroyal I	S-UC 26	Chalcolithic	Cow	9.3	− 19.4	–
El Hornazo	S-UC262	Chalcolithic	Human	8.6	− 19.2	–
El Hornazo	S-UC263	Chalcolithic	Human	9.5	− 19.7	–
El Hornazo	S-UC264	Chalcolithic	Cow	8.3	− 19.3	–
El Hornazo	S-UC265	Chalcolithic	Dog	8.2	− 19.1	–
El Hornazo	S-UC266	Chalcolithic	Ovicaprid	9.0	− 19.4	–
El Hornazo	S-UC267	Chalcolithic	Ovicaprid	8.5	− 18.8	–
El Hornazo	S-UC268	Chalcolithic	Cow	6.7	− 20.9	–
El Hornazo	S-UC269	Chalcolithic	Ovicaprid	6.3	− 20.6	–
El Hornazo	S-UC270	Chalcolithic	Ovicaprid	6.2	− 20.4	–
El Hornazo	S-UC271	Chalcolithic	Cow	5.3	− 20.5	–
El Hornazo	S-UC272	Chalcolithic	Cow	5.9	− 20.7	–
El Hornazo	S-UC273	Chalcolithic	Deer	5.8	− 20.0	–
El Hornazo	S-UC274	Chalcolithic	Dog	6.6	− 20.7	–
El Hornazo	S-UC275	Chalcolithic	Cow	8.8	− 21.5	–
El Hornazo	S-UC276	Chalcolithic	Dog	6.3	− 20.2	–
El Hornazo	S-UC277	Chalcolithic	Dog	6.4	− 20.5	–
El Hornazo	S-UC278	Chalcolithic	Cow	5.3	− 20.8	–
Fuente Celada	S-UC279	Chalcolithic	Human	8.9	− 19.3	–
Fuente Celada	S-UC280	Chalcolithic	Human	9.2	− 19.2	–
Fuente Celada	S-UC281	Chalcolithic	Human	8.3	− 19.5	–
Fuente Celada	S-UC282	Chalcolithic	Cow	4.8	− 20.6	–
Fuente Celada	S-UC284	Chalcolithic	Cow	5.3	− 20.8	–
Fuente Celada	S-UC285	Chalcolithic	Cow	4.9	− 20.4	–
Fuente Celada	S-UC286	Chalcolithic	Cow	5.4	− 21.3	–
Fuente Celada	S-UC287	Chalcolithic	*Sheep*	5.8	− 20.3	–
Fuente Celada	S-UC288	Chalcolithic	Ovicaprid	6.8	− 20.7	–
Fuente Celada	S-UC289	Chalcolithic	Ovicaprid	4.3	− 20.5	–
Fuente Celada	S-UC290	Chalcolithic	Ovicaprid	6.4	− 20.1	–
Ferrocarril-La Dehesa	S-UC261	Middle Bronze Age	Human	9.1	− 19.6	–
Abrigo de la Castañera	S-UC01	Early Bronze Age	Pig	5.2	− 22.0	–
Abrigo de la Castañera	S-UC06	Early Bronze Age	Pig	4.9	− 21.2	–
Abrigo de la Castañera	S-UC07	Early Bronze Age	Ovicaprid	3.7	− 21.6	–
Abrigo de la Castañera	S-UC08	Early Bronze Age	Pig	3.0	− 23.0	–

Table 3 (continued)

Site	Lab number	Period	Species	$\delta^{15}N$ ‰	$\delta^{13}C$ ‰	$\delta^{34}S$ ‰
Abrigo de la Castañera	S-UC09	Early Bronze Age	Human	9.3	− 20.8	–
Abrigo de la Castañera	S-UC10	Early Bronze Age	Human	9.5	− 21.3	–
Abrigo de la Castañera	S-UC11	Early Bronze Age	Human	10.1	− 20.6	–

El Abrigo de la Castañera (Obregón, Cantabria, Spain)

The humans analysed from El Abrigo de la Castañera ($n = 3$) belong to the Early Bronze Age and have $\delta^{13}C$ values ranging between − 21.3‰ and − 20.8‰ and $\delta^{15}N$ values ranging between 9.2 and 10.1‰ (Table 3; Fig. 5). This is indicative of a diet comprising of animal protein, mirroring the pattern seen at El Hornazo, Fuente Celada, Arroyal I and the individual from Ferrocarril-La Dehesa.

All humans and animals have lower $\delta^{13}C$ values than seen at the other sites (Figs. 5 and 6). This difference could be due to the location of La Castañera, which is in Cantabria, whereas the other sites are analysed from Burgos. Cantabria is a distinctive region, with the Atlantic Ocean running along the northern edge and the mountain range of the Cantabrian Cordillera to the South, making it climatically different to the Northern Meseta. Few contemporary studies from Northern Spain exist, but red deer sampled from Neolithic, Chalcolithic and Bronze Age levels at El Mirón Cave, also located in Cantabria, have $\delta^{13}C$ values ranging between − 22.2 and − 20.9‰ (Stevens et al. 2014). The environmental differences between these two regions likely explain the difference in $\delta^{13}C$ values seen between El Abrigo de la Castañera and the other sites studied.

Of the faunal remains analysed, two of the three pigs have stable isotope values typical of consuming in an open landscape with $\delta^{13}C$ values of −22.0‰ and − 21.2‰ (Fig. 5; Table 3). The other pig specimen has a much lower $\delta^{13}C$ value of − 23.0‰ (Fig. 5; Table 3), which is typical of an animal feeding in a forested environment, under the influence of the canopy effect (Van der Merwe and Medina 1991).

Discussion

Diet in early prehistoric northern Spain

The $\delta^{13}C$ values of the humans and animals analysed were consistent with individuals consuming a diet dominated by terrestrial C_3 resources expected for this time period (Fig. 6). At Arroyal I, Fuente Celada and El Hornazo, there was a trend towards human $\delta^{13}C$ values being higher than − 20‰ (Fig. 6). This is not unusual for Southern Europe, where a notable difference to Northern Europe is observed, with the latter typically falling within values of − 23 to − 20‰ (Ambrose 1993; Pollard 2007) and represents different environmental and climatic conditions between European regions.

The sites represent different burial types and chronological periods, with Arroyal I being a megalithic monument, Fuente Celada containing several pit human burials, an individual burial from Ferrocarril-La Dehesa, also found in a pit grave, and burials within the rockshelter of La Castañera. Despite differences in chronology and burial type, the stable isotope evidence of diet for all individuals were remarkably similar (aside from the $\delta^{13}C$ values at El Abrigo de la Castañera

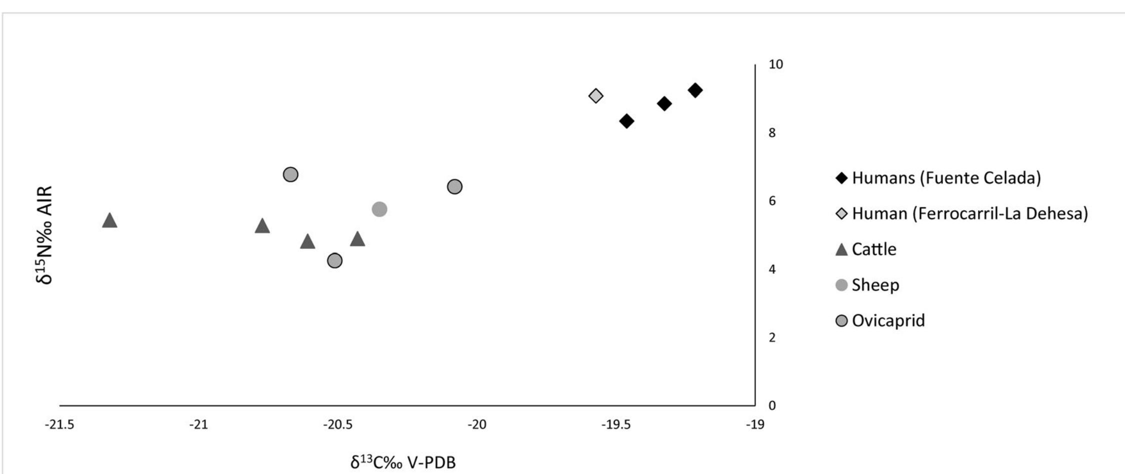

Fig. 4 Human and animal bone collagen $\delta^{15}N$ and $\delta^{13}C$ values analysed from Fuente Celada plotted with the human specimen available from Ferrocarril-La Dehesa

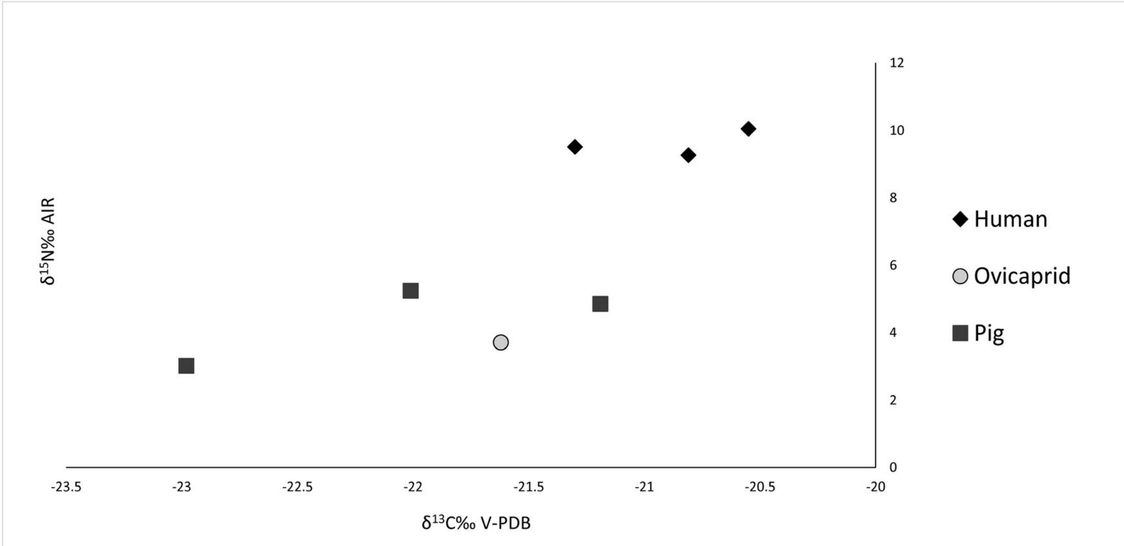

Fig. 5 Human and animal bone collagen δ^{15}N and δ^{13}C values analysed from El Abrigo de la Castañera

discussed previously in the results) (Fig. 6), with humans at all sites plotting c. 3–4‰ higher in δ^{15}N than the contemporary herbivores. The signatures observed are consistent with a mixed diet, including animal protein, likely in the form of meat and potential milk products. The diet of Chalcolithic, Neolithic and Bronze Age individuals within these sites was relatively homogenous at least in terms of the quantity of protein consumed. This initial evidence contrasts with evidence from the Late Neolithic/Early Chalcolithic in La Rioja Alavesa region (Basque Country), where monumental graves were observed to have higher δ^{13}C and δ^{15}N values than the cave burials, consistent with potentially different agricultural strategies and access to pastures, linked to differential social status (Fernández-Crespo and Schulting 2017). Further work in the Northern Cantabrian region would help to explore potential links between burial types and social status.

The question of whether milk and dairy products were being produced and consumed at these sites remains open. The small zooarchaeological assemblages available for these sites prevent detailed mortality profiles from being generated, which can give insights into milk, meat and wool economies (Payne 1973). Cattle dominated the faunal assemblages at both Fuente Celada (Riquelme Cantal 2009) and El Hornazo (Marín-Arroyo 2011), followed by ovicaprids. Some

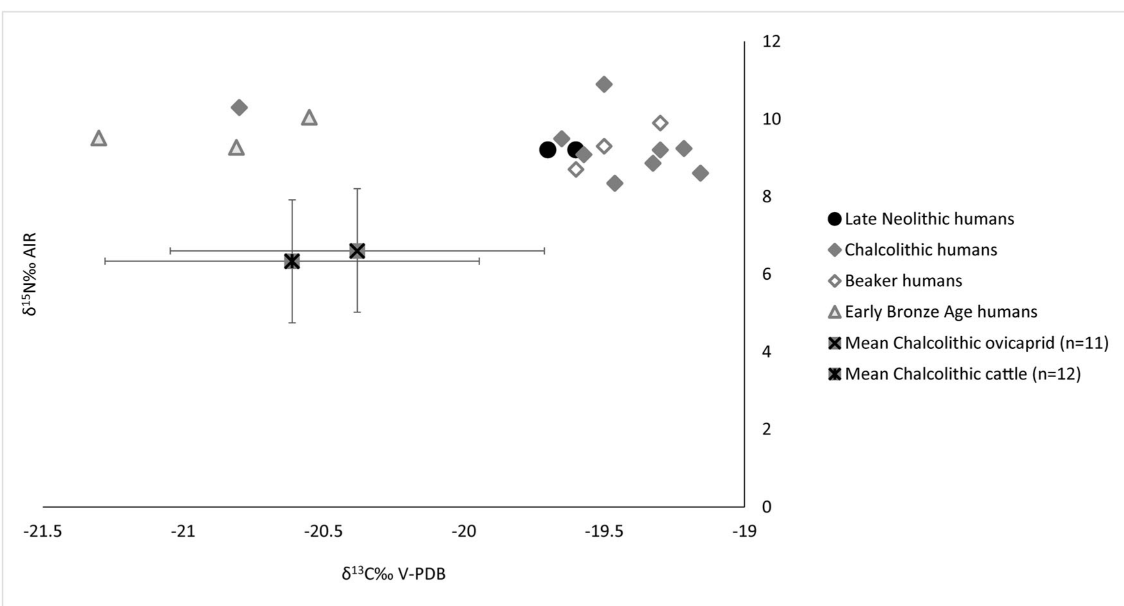

Fig. 6 Human bone collagen δ^{15}N and δ^{13}C values analysed from Arroyal I, El Hornazo, Fuente Celada, Ferrocarril-La Dehesa and Abrigo de la Castañera with mean Chalcolithic ovicaprid and cattle values. Error bars represent 1σ

immature cattle were also identified at El Hornazo (Marín-Arroyo 2011), which is more typical of dairying economies (Payne 1973). The limited zooarchaeological datasets available, together with other indirect evidence, such as the analysis of the ceramic assemblages, indicate that at least from the Chalcolithic period milk was consumed, mostly from bovines (Carmona Ballestero 2013: 302–306). During the Bronze Age, vessels called encellas (cheese strainer) became commonly produced, which is considered a good indication of when dairy products like cheese became a regular part of diet (Salque et al. 2013). Lipid residue analysis of Neolithic pottery from the Iberian Peninsula showed the presence of dairy fats, with dairying thought to be taking place in open air sites (Spiteri et al. 2016), showing that the capacity for milk production existed, at least, in the Mediterranean coast and it is not unreasonable to suggest that it was part of the economy at the Northern Iberian plateau sites.

Despite the evidence of riverine fish being recorded in pottery contents in Arroyal I (Ordoñez et al. 2017) and La Castañera (Vega-Maeso, pers. comm.), there is no evidence of routine freshwater fish or marine protein consumption at these sites visible in the bone collagen evidence. This suggests that, if they were being consumed at the sites, then it was not in sufficient quantities to be registered in the long-term bone collagen record and would indicate infrequent or occasional use of these resources. Similar stable isotope studies carried out in Neolithic and Chalcolithic sites across the Iberian Peninsula show similar results with no evidence of aquatic resource consumption registering in bone collagen values achieved (Arias Cabal 2005; Fernández-Crespo and Schulting 2017; Fontanals-Coll et al. 2015; Salazar-García 2011; Sarasketa-Gartzia et al. 2018).

In terms of possible plant material available, wheat and barley are the most commonly identified cereals of the Neolithic-Bronze Age in the Iberian Peninsula (Buxó and Piqué 2008) and crucial plant sources within human diet. It is possible that pulses, such as peas, lentils and fava beans, which appear in the Iberian Peninsula from the early Neolithic onwards (Zapata et al. 2004), were also a component of diet at this time. Of the terrestrial C_4 plants, millet is documented in the Iberian Peninsula during the 3-2nd Millenia BCE, before becoming more widely cultivated in the 1st millennium BCE (Buxó and Piqué 2008; Moreno-Larrazabal et al. 2015). Foxtail millet (*Setaria italica*) was identified in Kobaederra cave during Chalcolithic (c. 3331–2906 BCE) and Arenaza during the Bronze Age (c. 2136–1746 BCE) (Zapata 2002), both sites located in Bizkaia (Basque Country). In the studied sample, if C_4 plants were a component of human diet, then they were not being consumed in sufficient quantities to register in the bone collagen record. Other studies of Neolithic, Chalcolithic and Bronze Age diets in Spain show similar results with C_3 signatures evidence in Neolithic and Chalcolithic Iberia (Fernández-Crespo and Schulting 2017; Fernández-Crespo et al. 2018; Fontanals-Coll et al. 2015; Sarasketa-Gartzia et al. 2018).

At the sites analysed, the carpological record for Fuente Celada was sparse with only 13 fragments of plant remains recorded (from Pits 42 and 35), showing the presence of wild strawberry (*Fragaria vesca*), bread/macaroni wheat (*Triticum aestivum*/*durum*) and emmer (*Triticum sp.*). Despite being a small assemblage, it gives an insight into the crops being produced by these populations and in the case of the wild strawberry, the plants available in the wider area. Wild resources have also been identified in assemblages from the North-East of the Iberian Peninsula including, acorns, hazelnuts and wild grapes (Antolín and Jacomet 2015), indicating that wild plants may have played an important role in diet, alongside the domestic crops. In El Hornazo, a storage pit (Pit 130) with intact contents, including a mixture of wheat (*Triticum aestivum*/*durum*) and sloes (*Prunus spinosa*) was preserved (López-Dóriga et al. 2011). One of the limitations of stable isotope analysis is that it is biassed towards representing protein consumption, meaning that there is a trend towards representing high protein products, such as those from animals, which can mask the contribution of plants to diet (Hedges and Reynard 2007) and, knowing the exact proportions of plant contributions to diet is challenging to establish.

Insights into animal management in northern Spain

The small number of animal remains studied for stable isotope analysis means that it is only possible to make tentative comments about the animal management strategies used at the sites, but can provide initial insights into prehistoric pastoralism in Nothern Spain. The range of $\delta^{13}C$ values of the herbivores was all consistent with those expected for open C_3 environments.

The stable isotope values of the faunal remains from Fuente Celada showed relatively large ranges in $\delta^{13}C$ values of cattle and $\delta^{15}N$ values of sheep, indicating that these animals were not necessarily consuming a homogenous diet. It is possible that a range of different pastures was used, resulting in isotopically dispersed values of those animals. The scale of movement of animals between pastures is a matter of debate. Sheep transhumance from the Neolithic period onwards has been identified using incremental analysis of tooth bioapatite $\delta^{13}C$ and $\delta^{18}O$ values (Tornero et al. 2018), which in the bone collagen record of animals could produce averaged values that differ from each other, especially if animal movements vary seasonally or annually. Transhumance over larger distances requires relatively complex infrastructure in terms of territories occupied in the wider landscape and would be logistically and politically complex to negotiate (Carmona Ballestero 2013). Instead, it is possible that animals were grazed in various pastures, representing different biotopes within the same political regions. This scenario could be indicative of smaller scale movements within individual group territories, which is consistent with models of landscape use in Later Prehistory in Central Iberia as proposed by Díaz del Río (2001, 2006). This pattern of small-scale animal movements also identified in bone collagen $\delta^{13}C$ and $\delta^{15}N$ analysis at the prehistoric site of Danebury (United Kingdom), where animals kept in different parts of the landscape had characteristically different $\delta^{13}C$ and $\delta^{15}N$ values (Stevens et al. 2013). Another explanation could be that different fodder was used, at different times, during the occupation of the site, and could suggest changing agrarian economies.

The faunal cattle and sheep with higher $\delta^{15}N$ values may represent younger animals exhibiting a nursing effect, which typically elevates $\delta^{15}N$ by approximately one trophic level due to the consumption of their mother's breastmilk (e.g. Schurr 1997; Fuller et al. 2006) and could explain their elevated $\delta^{13}C$ and $\delta^{15}N$ values relative to other herbivores at the site. Whilst individuals did not have the porous bone structure, typically associated with infantile individuals, the lack of distal ends of bones with fusion evidence means that they could be animals exhibiting nursing signatures. The cow labelled as individual 'a' in Fig. 3 has an unusually high $\delta^{15}N$ value of 8.8‰, combined with a lower $\delta^{13}C$ value of −21.5‰. The lower $\delta^{13}C$ suggests that this individual may have been raised on an isotopically different region to the other individuals analysed. This may be indicative of the use of multiple pasture landscapes in the management of animals, with pastures further afield potentially being used to raise animals before bringing them to the site for slaughter. This could be due to seasonal uses of different tracts of land, which if used routinely could impact on the long-term bone collagen record of an individual. Another possibility is that this animal bone could be from an animal trade on the hoof or a cut of meat traded to the site. The trade of perishable goods is relatively complex to track archaeologically, in comparison to items such as ceramics or lithics. Zooarchaeological methods can often distinguish between producer and consumer sites, where trade and exchange were central to the economy (Crabtree 1990), but occasional or infrequent trade or exchange of animals would require individual life histories of animals to be created and is more complex to establish when only small assemblages are available. Future incremental analysis of available animal teeth for $\delta^{13}C$ and $\delta^{18}O$ analysis would help to establish more about Prehistoric landscape use and could provide insights into the possible exchange of animals.

The similarity in the wild red deer $\delta^{15}N$ value from El Hornazo and the majority of the domestic herbivores at the site (and at Fuente Celada, also located in the same village) suggest that sheep and cattle were occupying similar parts of the landscape as the red deer. A further implication, based on the similarity of $\delta^{15}N$ values of the wild and domestic species, is that the cattle and sheep analysed were not fed on crops that were enriched with manure, which would then produce elevated $\delta^{15}N$ values in plants (Bogaard et al. 2007) and thus consumers of these plants. The $\delta^{13}C$ values of the domestic herbivores are slightly lower than the wild red deer (which would not typically be subjected to anthropogenic management processes) and could hint at the cattle and sheep being fed on some domestic crops, potentially as winter fodder. Differences in the stable isotope values of wild and domestic species at the Neolithic site of La Draga was also attributed to the use of crops as fodder for the domestic stock (Navarrete et al. 2017), which supports this hypothesis.

The three suid specimens sampled at El Abrigo de la Castañera had different diets. One of the *Sus* sampled had a lower $\delta^{13}C$ value, which is characteristic of an animal feeding in a forested environment (van der Merwe and Medina 1991). Osteologically, it was not possible to determine if these animals were domestic or wild. If these individuals were all domestic, the implication is that differential animal management was being employed. Studies of Neolithic pigs in England have shown that domestic pigs may have been herded under partially wooded environments (Hamilton et al. 2009). This may, to some extent, have been a method of protecting crops from pig rooting, which can damage plants and shoots (Ballari and Barrios-García 2014). Alternatively, the specimen from La Castañera may be a wild boar, which typically inhabit forested environments and would explain the lower $\delta^{13}C$ value. If true, this would suggest that wild animals were exploited, either through targeted hunting or chance encounter. The presence of red deer in the faunal assemblages at Fuente Celada (Riquelme Cantal 2009) and El Hornazo (Marín-Arroyo 2011) also shows that wild animals were used, as an occasional supplementary resource for these farming populations, and wild boar may also have been an additional resource exploited.

The relationship between humans and dogs

Dogs have been used as a proxy for human dietary behaviour (e.g. Clutton-Brock and Noe-Nygaard 1990; Fischer et al. 2007; Schulting and Richards 2002b) and how far they accurately represent human diet in archaeological populations has been debated (Guiry 2012). It is generally accepted that the diet of dogs generally tracks that of the human population they live with, irrespective of temporal and geographical situation or the culture of populations (Guiry and Grimes 2013). The Chalcolithic dog from Arroyal I was indistinguishable from the human $\delta^{13}C$ and $\delta^{15}N$ values, indicating that this animal had a similar diet to the humans, either through intentionally being fed scraps from the human table or scavenging refuse from human waste. At El Hornazo, the situation is more complex also during Chalcolithic, with one dog reflecting the human diet exactly plotting alongside the humans, and three other dogs plotted with the herbivores. This suggests that dogs are not necessarily a good proxy for human diet in this region. The difference in the diet of the dogs may represent the role of dogs at the site, in terms of whether they are household pets, being fed scraps from the human table (including meat) or whether they were working animals, that may have consumed a more regimented diet comprising predominantly of vegetal matter.

Prehistoric population movements in the northern Iberian Peninsula

The movement of human populations during Neolithic, Chalcolithic and Bronze Age period in Europe is currently a subject of great interest and genetic evidence has demonstrated links between Neolithic Iberian populations and central European Beaker populations (Olalde et al. 2018), indicating the large-scale movements involved. The large difference between the $\delta^{34}S$ values of the two individuals analysed from Arroyal I suggests that they were not from the same location, which is also supported by SUC28 having a lower $\delta^{13}C$ value than other individuals in the population analysed. Published relationships of $\delta^{34}S$ values show that within living populations, an average range of 1.9‰ in sulphur values is observed, with slightly higher range of 2.4‰ between archaeological populations (Nehlich 2015: 8). The large difference between the $\delta^{34}S$ values of both individuals indicates that these people lived in different locations before they came to be interred at the site. It could be suggested that individual SUC28 came from a more saline or coastal environment due to the higher $\delta^{34}S$ value. The effect of salinity on $\delta^{34}S$ values has been demonstrated, with coastal $\delta^{34}S$ values reaching up to + 20 (Nehlich 2015). The effects of salinity on baseline $\delta^{34}S$ values can reach distances of up to 30 km from the coast, although the effects become less potent with distance (c. 10‰) (Nehlich 2015). The $\delta^{13}C$ of individuals can also be affected by salinity, although archaeological studies of human and animal bone show that sea spray can cause elevated $\delta^{34}S$ of ~ + 14 to + 18 whilst still producing $\delta^{13}C$ values of ~ − 23 to − 21‰ (Nehlich 2015, based on data from Craig et al. 2006; Fornander et al. 2008; and Linderholm et al. 2008a, b). A likely location of origin of this person could be, perhaps further north, towards the Cantabrian coast, which is geographically the closest coastline to the site. This hypothesis is supported by the individual having a $\delta^{13}C$ that plots within the range of humans analysed at El Abrigo de la Castañera, which is also located in Cantabria (Fig. 1). Recent work at the sites of Santimamiñe and Pico Ramos, in the Basque Country, exploring late Neolithic and Chalcolithic populations using $^{87}Sr/^{86}Sr$ analysis demonstrated that there were movements of the populations between the Pyrenees to the Biscayan coast (Sarasketa-Gartzia et al. 2018), showing that there was fluidity in the population of earlier prehistoric populations in the Northern Iberian Peninsula. In Arroyal I, there is no other evidence of contact with the coast, despite its relative proximity. In contrast, El Hornazo contained one of the few maritime shells located in a non-funerary Chalcolithic inner context (Gutiérrez Zugasti et al. 2014). Until now, seashells were the only signs of contact between the inland inhabitants of the North Castilian plateau and the coast. Therefore, smaller scale intra-regional movements might have been common also during the period and region of study in these farming populations.

Studies of ceramics from the Cantabrian Region provides further evidence for the movement of populations in Prehistory (Vega Maeso 2017). The distribution of decorative motifs and shapes on pottery artefacts appear to relate to the movement of people, particularly women, rather than the exchange of vessels (Vega Maeso 2017). The tentative results from this, also indicate that the individuals buried at Arroyal I are not necessarily all local to the area and supports other evidence for population movement within the Iberian Peninsula during the Chalcolithic and Bronze Age periods. A similar hypothesis was proposed at the Chalcolithic site of La Atalayuela in La Rioja, where two individuals interred at the site with outlying $\delta^{13}C$ values were interpreted as potentially being from different regions (Fernández-Crespo et al. 2018) again suggesting population fluidity within different regions in Prehistoric Northern Spain.

Conclusions

This study has provided valuable insights into the economy, animal management and mobility of early farmers of the Northern Spain Plateau, a region which has received little attention so far. Analysis of bone collagen $\delta^{13}C$ and $\delta^{15}N$ values from human remains from different mortuary sites dating between the Neolithic and Bronze Age shows that the diet of individuals analysed was remarkably similar. Humans consumed a predominantly C_3 terrestrial diet, including animal protein (meat and likely milk/dairy products) and wider regional archaeobotanical evidence suggests that diet would also have included C_3 plants, such as wheat and barley and vegetables. The faunal samples provided insights into animal management. The diversity in $\delta^{13}C$ and $\delta^{15}N$ values suggests a wider use of the landscape in the management of herbivores, possibly with the access of animals to different pastures with diverse biotopes. Further work using tooth incremental isotope analysis would be valuable in exploring this concept and to explore whether there is evidence of seasonal changes in diet related to animal movements or foddering strategies. Differences were observed between individuals from the coast and those of the interior, with lower $\delta^{13}C$ values likely due to baseline environmental differences between the two regions and $\delta^{34}S$ analysis of two individuals suggests a level of inland mobility during this time. Based on the similarities of diets between individuals analysed, it appears that the socioeconomic conditions experienced between the Neolithic and Bronze age in central Northern Spain remained stable or without remarkable dietary changes. This study has helped to expand our understanding of diet, economy and lifeways of an understudied location, where few skeletal remains are available and has demonstrated the need for further research in the region to provide detailed reconstructions of agricultural practises, diet and mobility of Prehistoric populations.

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