

Integrating Bioarchaeology and Chronology at Los Melgarejos to Understand Ditched Enclosures in Copper Age Iberia

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In Iberia, ditched enclosures appeared during the Copper Age (late fourth to third millennium BC). These sites are linked by their circular organization, communal labour investment, and complex temporality, but vary markedly in their distribution, function, and scale. Though archaeological attention has focused on ‘mega-sites’, an assessment of small-scale enclosures in marginal environments is key to understanding the social dynamics that facilitated their emergence. Here, the authors present results from Los Melgarejos (Getafe, Spain), the first Iberian Chalcolithic enclosure (3 ha) to be extensively documented, with all structures and seven per cent of the enclosure ditches excavated. Bioarchaeology, mortuary archaeology, isotope analyses ($\delta^{13}C_{\text{coll}}$, $\delta^{13}C_{\text{ap}}$, $\delta^{15}N$), and radiocarbon dating are employed to compare lived experiences of diet, stress, trauma, and funerary ritual at small- and large-scale enclosures. Comparisons with the mega-site of Marroquíes reveal similarities in lived experience and ritual practice, as well as regional differences in dietary isotopes, highlighting the utility of multiscalar comparisons for understanding prehistoric lifeways.

Keywords: ditched enclosures, mega-sites, Copper Age, Iberia, bioarchaeology

INTRODUCTION

Iberian Copper Age (c. 3200–2200 BC) communities stand in sharp contrast to the smaller, dispersed Neolithic sites (c. 5600–3200 BC) which preceded them (Chapman, 2008). During the third millennium, peninsular societies were characterized by a growing reliance on domesticates, denser populations, an abundance of new

iconography and material culture, and an astonishing expansion of exchange networks, which drew in objects and materials from across Europe, Africa, and Asia (Lillios, 2018, 2020; Díaz-del-Río, 2020, 2021). The most remarkable development, however, is the emergence of new kinds of sites that required structural and scalar modifications to earlier forms of social organization. By the final quarter of the

fourth millennium, Iberian communities were constructing larger, more permanent settlements whose configuration entailed marshalling communal labour for the construction of large-scale architecture such as ditches, fortifications, and tombs. At least two sites—Marroquíes (Jaén; Zafra et al., 2003) and Valencina-Castilleja (Seville; Fernández Flores et al., 2016; García Sanjuán et al., 2018)—are extraordinary in their spatial scale (Figure 1, nos. 5 and 6). Covering 113 and 450 ha respectively, these sites are comparable in size to the Chalcolithic (*c.* 4800–2700 BC) Trypillian mega-sites of the Ukrainian steppe (Gaydarska & Chapman, 2022) and dwarf any settlements that emerged during the later Bronze Age.

Unsurprisingly, some of the most publicized scholarship concerning the Iberian Copper Age has focused on the appearance and organization of these sensational sites. Just as biologists have defined charismatic megafauna as ‘popular, charismatic species that serve as symbols and rallying points’ for the public (Leader-Williams & Dublin, 2000: 56), we might consider places like Marroquíes and Valencina-Castilleja to be ‘charismatic mega-sites’ whose unprecedented size and unique character attract inordinate archaeological attention. Conservationists, however, also underscore that megafauna represent only one part of an ecological network that links larger and smaller species in interdependent webs (Entwistle & Stephenson, 2000). Despite

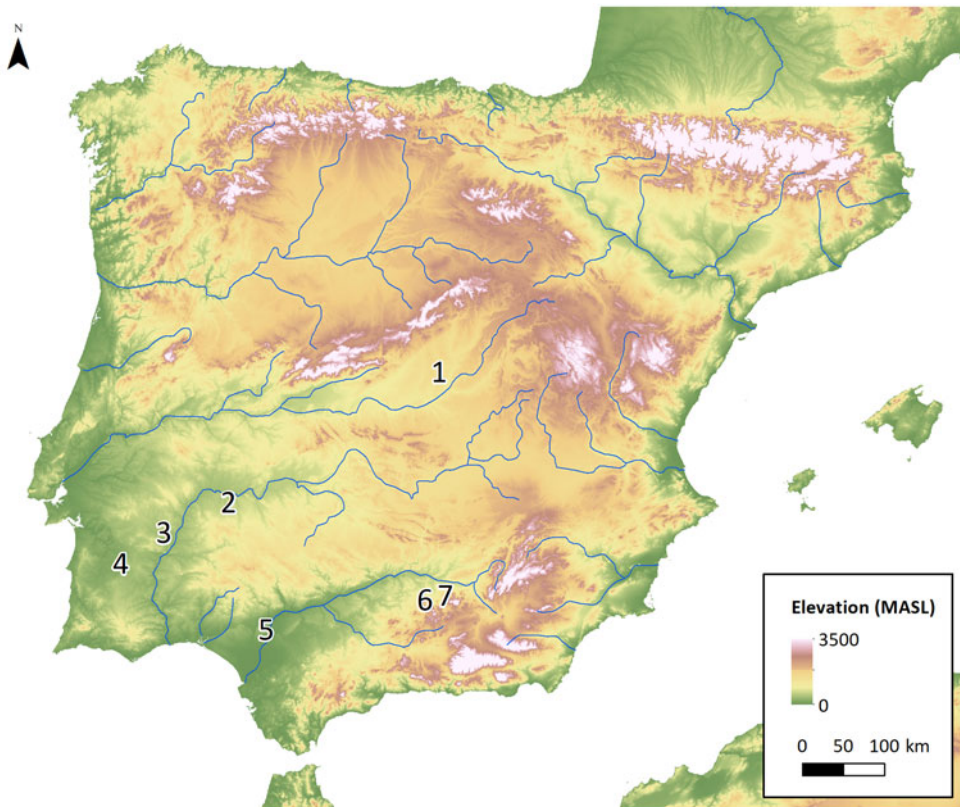


Figure 1. Location of sites mentioned in the text. 1. Los Melgarejos; 2. La Pijotilla; 3. Perdigões; 4. Porto Torrão; 5. Valencina-Castilleja; 6. Marroquíes; 7. Venta del Rapa.

the allure of ‘charismatic mega-sites’, archaeologists must likewise recognize that such locales did not exist in a social vacuum. Smaller-scale communities of the third and fourth millennium BC were connected to, in communication with, and at times part of the mega-sites that were their neighbours.

These smaller-scale communities are coming into focus as growing numbers of ditched enclosures have been discovered over the last quarter century, with an at least six-fold increase in the number of known sites between 1996 and 2020 (Lillios, 2020: 218). Due largely to open area excavations since the 1990s, the number of enclosures known for the Meseta (the central Iberian plateau) increased to fifty even two decades ago (Díaz-del-Río, 2004a: 109). Despite the growth in excavation and survey of ditched enclosures, the largest sites of the period still attract most attention. We argue that assessing the social dynamics of contemporaneous small-scale settlements is essential for understanding why some communities were able to attract and maintain greater flows of people and goods while other groups largely replicated the scale and tenor of Neolithic lifeways.

At 3 ha in size extension, Los Melgarejos (Getafe, south of Madrid) is the first fully mapped and extensively excavated Copper Age enclosure in Iberia (Figure 1). The site has five concentric ditched enclosures (Ditch 5 is the most central, Ditch 1 the outermost), three interspersed palisade lines, over twenty-two dwellings, many with evidence of remodeling, and over a thousand underground structures (Figure 2). Fourteen of these include deposits of at least forty-eight individuals. We use four lines of evidence—bioarchaeology, mortuary archaeology, paleodiet, and radiocarbon dating—to make explicit comparisons between funerary practices and the lived experience of diet, disease, stress, and trauma at Los Melgarejos and the contemporaneous mega-site of Marroquies.

Both settlements replicate traditional forms of enclosure organization, but the sites are strikingly different in scale and are located in distinct environments, the former in the semi-steppes of the central Meseta and the latter in the ecologically rich Guadalquivir Valley. We ask how a small enclosure compares to a mega-site in terms of its inhabitants’ eligibility for mortuary treatment, lived experiences of disease and stress, and inter-individual dietary differentiation. Finally, we examine the temporal trajectory of mortuary practices at Los Melgarejos and Marroquies to elucidate the role of funerary ritual as a coalescent social mechanism for Copper Age communities.

DITCHED ENCLOSURES IN THE LATER PREHISTORY OF IBERIA

Ditched enclosures are emblematic of the material variability and social experimentation characteristic of the Iberian Copper Age. These sites typically consist of a series of concentrically arranged U- or V-shaped circular ditches together with a frequently dense and apparently random distribution of a wide variety of pits (Díaz-del-Río, 2003; Márquez-Romero & Jiménez-Jáimez, 2013). Though a recurring and identifiable site type, they are a phenomenon with multiple social uses. Some have a clear domestic component, with dwellings within the perimeters of the innermost ditches, as at Marroquies, while others that to date lack such evidence, such as Perdigões, are interpreted as ritual aggregations. Ditched enclosures also vary considerably in size, ranging from less than one hectare to up to 70 ha (Porto Torrão), 80 ha (Pijotilla), 113 ha (Marroquies), or 450 ha (Valencina-Castilleja) (Hurtado Pérez, 1986; Lillios, 2020: 186). Indeed, Marroquies and Valencina-Castilleja are some of the largest concentrations of human activity known for late prehistoric Europe,

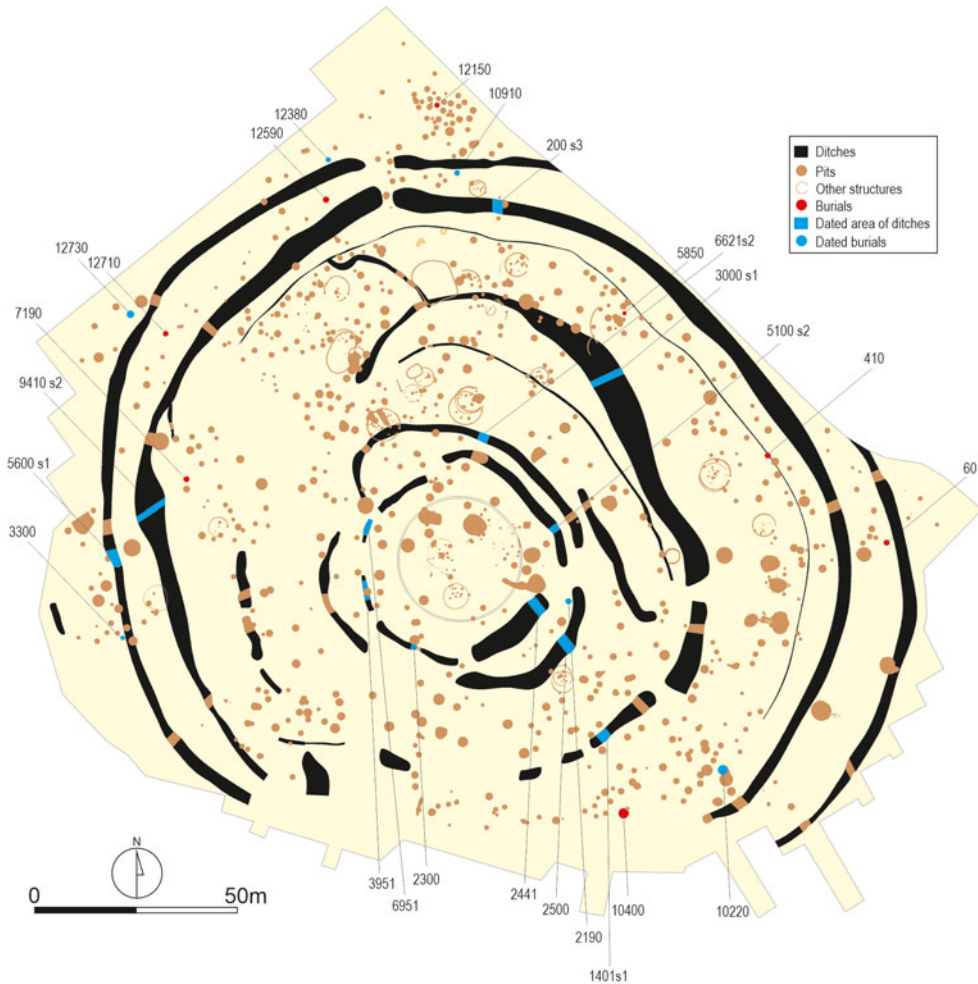


Figure 2. Plan of Los Melgarejos and location of formal mortuary features.

rivalled only by the Trypillian mega-sites of Ukraine (Gaydarska & Chapman, 2022). Geographically, ditched enclosures are found in most of central and southern Iberia, although their density is mainly a consequence of the intensity of regional archaeological research (see Díaz-del-Río, 2004a: fig. 1; Márquez-Romero & Jiménez-Jáimez, 2013: fig. 1; Valera, 2015: fig. 1). Despite distinctions in function, size, and distribution, ditched enclosures are linked by their circular organization, labour investment, complex temporality, and incorporation of ritual practice.

The enclosures that have received the most intense archaeological and public scrutiny are those which incorporate either abundant evidence of ritual and exotic raw materials, such as Perdigões (Valera et al., 2014), or those of a spectacular scale. Even sites linked by their massive size, however, attest to the functional variability characteristic of ditched enclosures. Interpretations of Valencina-Castilleja, for example, vary regarding the permanency of occupation. Some scholars interpret the site as a seasonal ritual occupation, pointing to the paucity of cores and knapping

debris, to high-value faunal remains being selected and transported, and to the absence of domestic architecture. In this perspective, Valencina-Castilleja represents a palimpsest of activity built up through occasional or seasonal occupations (García Sanjuán et al., 2017: 254). Others suggest a more permanent occupation, although they concede that human activity was not contemporaneous throughout the entire extent of the site (Schumacher et al., 2021). Perhaps the most reasonable suggestion is that of Gaydarska and Chapman (2022: 56), which proposes ‘sandwiching episodes of burial, production, permanent residence and seasonal visits of various durations’.

In contrast to Valencina-Castilleja, the 113 ha site of Marroquíes is more familiar to archaeologists in terms of both form and organization. Aggregation at this settlement began during the first half of the third millennium BC; during a peak period of activity *c.* 2450 cal BC, the Marroquíes community worked to replicate the structure of smaller, ditched enclosures across Iberia, though on a much larger scale (Díaz-del-Río, 2004a: fig. 5). The site consists of at least six concentric enclosure ditches (the six ditches are numbered from 0 in the centre to 5, the outermost), some partially demarcated by stone and/or adobe walls, as well as extensive evidence of domestic architecture, especially within the first five rings; the outermost ditch encloses a system of agricultural fields (Zafra et al., 2003; Díaz-del-Río, 2004b). Human remains are ubiquitous, interred in subterranean necropolises and a series of artificial mortuary structures, and as depositions in the enclosures themselves (Cámara Serrano et al., 2012; Beck et al., 2018; Díaz-Zorita Bonilla et al., 2020). While studies of regional settlement patterns reveal periods of population dispersal and consolidation (Díaz-del-Río, 2004b), smaller enclosures such as Venta del Rapa (Lechuga Chica et al., 2014) persisted in the hinterlands of

Marroquíes during and beyond the period of peak labour investment in the mega-site (*c.* 2500–1900 BC), suggesting that aggregation was an option rather than an obligation. Such neighbouring communities are likely to have provided sources of additional food, labour, and social interaction.

Although Marroquíes has more evidence for permanent residence than Valencina-Castilleja, seasonal or temporal variation in use is not unusual in Iberian ditched enclosures; detailed analyses of the temporality of these sites are critical if we are to move beyond the simplistic binary of ‘seasonal *versus* permanent’. Similarly, understanding the attraction of mega-sites requires attention to the alternatives. Did people who lived in smaller-scale enclosure sites enjoy benefits in the form of reduced disease and stress? Are there distinct patterns of dietary differentiation and mortuary practice at the smaller enclosures? Focusing on the fully-excavated enclosure of Los Melgarejos—located in an area that was ecologically more marginal—allows us to tease apart the influence of site size and local environment on life and death in Copper Age ditched enclosures.

DITCHED ENCLOSURES OF THE MESETA AND THE SITE OF LOS MELGAREJOS

The interior of the Iberian Peninsula is a 600 m high, 181,000 km² Tertiary plateau known as the Meseta Central (Díaz-del-Río, 2006: fig. 6.1). The Meseta is divided by the 440 km long Central Range that cuts across the plateau; it runs south-west to north-east, splitting the plateau into two basins: the Duero Basin to the north and the Upper Tagus-Guadiana Basin to the south, both drained by their eponymous major rivers (Loidi, 2017). These elevated sub-mesetas have a continental climate, with a geology characterized by clayey substrates such as gypsum, limestone, and marls (Loidi, 2017: figs 1.2 and 1.3).

This plateau lacks the environmental conditions that allowed for the rise of some of the best-known mega-sites, which frequently combined excellent connectivity, a high potential for agriculture, livestock, and forestry, and access to diverse natural resources. Despite its more marginal environments, characterized by poorer soils and a harsher climate, river basins throughout the interior plateau were occupied by humans since the Pleistocene.

This deep occupational history is documented in the Jarama River Basin and its tributaries. At a smaller scale, the Jarama Basin combines good agricultural soils with direct access to permanent water, lowland resources (e.g. salt, flint, limestone), and proximity to resources of the central Sierra highlands (e.g. granite, copper) (Figure 1). The low population densities for Iberian later prehistory—estimated to be half a million for the entire peninsula—suggest that access to agricultural land was never a critical factor for Copper Age communities (Díaz-del-Río, 2021: 173).

Ditched enclosures have been known in this region since 1997, as a direct consequence of the first development-led open area excavations there (Díaz-del-Río, 2004a). The continuous expansion of urban development and infrastructure has multiplied the number of excavated ditch enclosures in the region. Most ditched enclosures in central Iberia were established and abandoned during the central centuries of the third millennium BC (2800–2400 cal BC). These sites are consistently associated with areas of sedimentary geology and show considerable variability in size. The majority cover less than 0.1 ha (Díaz-del-Río, 2004a; Delibes et al., 2014) and all occupy areas with a comparatively limited carrying capacity. At 15 ha, Camino de las Yeseras, located in one of the most fertile locations in the region at the confluence of the Jarama and Henares rivers, is the largest enclosure

known for central Iberia (Liesau et al., 2008).

The 3 ha enclosure of Los Melgarejos is located some 25 km away from Camino de las Yeseras. Situated on the slope of the gentle hills south of Madrid, it lies 2 km from the Arroyo Culebro, a tributary of the Manzanares River. Unlike the alluvial deposits of Camino de las Yeseras, Los Melgarejos is located on gypsum soils that exhibit a minimum horizon development. Nevertheless, surveys indicate that at least five Copper Age ditched enclosures were present in the small Arroyo Culebro valley, of which Los Melgarejos is the largest.

MATERIALS AND METHODS

Standard osteological, isotopic, and radiocarbon methods were used during our analyses. These methods are fully detailed in Supplementary File 1. All statistical analyses and visualizations were performed in the R statistical environment (R Core Team, 2023). Supplementary tables and figures are prefixed here with S, e.g. Table S1, Figure S2. All supplementary materials including the isotopic data, radiocarbon dates, and the code for analysis and visualization, can be found on the online repository for this project, which is hosted by Zenodo (<https://doi.org/10.5281/zenodo.13627495>).

RESULTS

Bioarchaeology

At least forty-eight individuals are represented in the mortuary features at Los Melgarejos. The site includes a high proportion of subadults (42 per cent; defined as individuals with a midpoint age estimate of <18 years) relative to adults (58 per cent) when compared to other late

prehistoric sites in Iberia (Waterman & Thomas, 2011; Beck, 2016). Of the subadults, children ($n = 7$, 35 per cent), juveniles ($n = 7$, 35 per cent), and adolescents ($n = 6$, 30 per cent) are equally well represented. Older adults are underrepresented (Table 1), but this may be an artefact of the dental aging system that was the only strategy available for assessing age for half the adults (Gilmore & Grote, 2012). Sex could be estimated for twenty-six out of forty-eight individuals (54 per cent), using either standard non-metric traits or ancient DNA analysis (full aDNA results will be published later; the methods and results for genetic estimation of sex are available in Supplementary Report 1); of these individuals, twenty were female or probable female, four were male or probable male, and two were indeterminate.

People at Los Melgarejos exhibited pathologies common for prehistoric Iberian populations, including insults indicative of metabolic disturbances, age degenerative conditions, non-specific indicators of infection, fractures, and dental pathologies (Table 2). Only four out of forty-eight individuals (8 per cent) sustained fractures. Two young adult females (3302, 12737 Ind. 5) had healed distal ulnar fractures, while one adult male (12382) had a healed fracture of the left third metatarsal. The fourth affected individual showed cranial trauma, an injury more likely to indicate interpersonal violence than post-cranial trauma (Walker, 2001). The young adult male 10912 Ind. 1 had antemortem and healing trauma to the left parietal and perimortem trauma, with evidence of radiating fractures and flaking, on the right parietal and right anterior mandible.

While fractures reflect accidents and interpersonal violence, hypoplasias reflect periods of non-specific but pronounced physiological stress such as weaning, malnutrition, insufficient diet, infectious disease, toxins, or trauma, occurring when tooth crowns are

formed during gestation and childhood (Bereczki et al., 2019). In total, twenty-five out of 571 teeth (4 per cent) with observable enamel at Los Melgarejos showed linear enamel hypoplasias (Table S1). The condition affected eight out of thirty-five individuals (23 per cent) with at least one enamel observable tooth (Table S2). Aside from hypoplasias, there was little evidence of dental pathology, with no abscesses and few caries, spalled crowns, or resorbed sockets.

Mortuary archaeology

There were three categories of formal mortuary features at Los Melgarejos: single deposits containing one individual ($n = 4$), double deposits containing at least two individuals ($n = 7$), and multiple deposits containing three or more individuals ($n = 3$) (Table 1). Isolated elements were also deposited outside formal funerary contexts ($n = 8$), either in pits within ditch fill, or outside the enclosures themselves. These additional contexts comprised small deposits of cranial fragments ($n = 4$), long bone fragments ($n = 2$), one metatarsal ($n = 1$), and a commingled deposit of adult long bones and subadult pelvis and cranial fragments ($n = 1$). Except for the subadult from the commingled deposit, all isolated deposits were adult, based on size and morphology (Table S3, Figure S1).

Within the formal mortuary features, grave inclusions were rare, consisting of faunal remains, lithics, or ceramics. As is typical for Chalcolithic enclosures, formal mortuary features were located along the outer border of the site, either between Ditch 1 and 2 or abutting the interior edge of Ditch 2 (Figure 2). UE 2190 (UE refers to the Spanish *unidad estratigráfica* or stratigraphic unit), located inside Ditch 4, was the only exception.

Single deposits contained individuals of both sexes and a broad range of ages;

Table 1. Demography and artefacts in the Los Melgarejos mortuary features. For age, C = child; J = juvenile; Ad. = adolescent; YA = young adult; MA = middle adult; OA = old adult; A = adult. For sex; F/PF = female or probable female; I = indeterminate; M/PM = male or probable male; NP = estimation of sex not possible.

Feature ID	Type	Age								Sex			Artefacts			
		MNI	C	J	Ad.	YA	MA	OA	A	F/PF	I	M/PM	NP	Fauna (g)	Ceramics (g)	Artefacts of note
UE 60	Single	1			1					1				350	23155	2 bone awls; 1 flint fragment; 1 hammer; 1 bifacial tool
UE 410	Multiple	14	1	2	7		1	3	1	1			12	<10	1910	1 variscite bead; 13 flint fragments
UE 2190	Single	1	1						1					390	9400	7 flint fragments; 1 denticulate; 1 retouched flake
UE 3300	Double	2	1		1				1		1			42	4550	2 flint fragments; 1 core; 1 flake
UE 5850	Double	2	2										2	2384	3300	3 bone awls; 1 pierced pottery fragment; 4 flint fragments; 1 sickle blade
UE 7190	Double	2			1	1			1	1				200	3700	1 ground stone
UE 10220	Multiple	7	2	2		2		1	3				4	550	13250	1 pierced pottery fragment; 89 flint fragments; 1 flake; 1 denticulate; 1 abrupt tool; 1 leaf-shaped tool
UE 10400	Double	2	1					1					2	54	2550	25 flint fragments; 1 core
UE 10910	Double	3		1	1			1	2		1			166	5000	1 flint fragment; 1 abrupt; 1 arrowhead preform
UE 12150	Single	1	1										1	0	304	
UE 12380	Single	1			1						1			700	8500	5 flint fragments
UE 12590	Double	2		1	1				1			1	1	350	4500	1 ground stone fragment; 15 flint fragments
UE 12710	Double	2	1			1			1			1	1	0	885	
UE 12730	Multiple	8	2	2		2	2		4	2	1	1	1	750	6250	3 flint fragments; 1 arrowhead; 1 leaf-shaped tool
Total	14	48	7	7	6	15	6	1	6	16	4	4	24			

Table 2. Frequency of pathologies at Los Melgarejos; counts and percentages refer to the number of individuals affected.

Pathology	Count	%	Sample (n)
<i>Cribra orbitalia</i>	6	0.27	Individuals with at least one orbit preserved (22)
Porotic hyperostosis	5	0.14	Individuals with portions of at least one parietal preserved (35)
Osteoarthritis	6	0.13	All individuals (48)
Abnormal bone formation	5	0.10	All individuals (48)
Abnormal bone loss	5	0.10	All individuals (48)
Fractures	4	0.08	All individuals (48)
Hypoplasia	8	0.23	All individuals with teeth with observable enamel (35); 25/571 (4%) of teeth with observable enamel affected
Caries	6	0.15	Individuals with at least one tooth (39); 11/670 (11%) teeth affected
Calculus	29	0.74	Individuals with at least one tooth (39); 271/665 (41%) teeth with enamel surfaces not obscured by sediment had calculus
Antemortem tooth loss	4	0.17	Individuals with at least one socket observable (23); 6/490 (1%) observable sockets resorbed
Dental spalling	5	0.13	Individuals with at least one tooth (39); 6/670 (1%) teeth affected

these depositions all incorporated faunal remains (Figures S2–S5; Table S4). Double deposits were the most common form of mortuary feature (seven out of fourteen, 50 per cent) (Figures S6–S16). Most double deposits (five out of seven, 71 per cent) included elements from at least one additional, poorly represented, individual (Table S5), suggesting that movement of human remains post-skeletonization was relatively common. Only two of these ‘additional’ individuals (the humerus, clavicle, and scapula designated 10912 Ind. 3 and the additional juvenile innominate designated 12738 Ind. 6.2) were included in the MNI for the site, because more precise data on age or sex were available for these elements. Almost all age categories and both sexes were represented in double deposits, though most commonly adults were paired with younger individuals (Table S6). Body positioning was variable, but in four of the double deposits, individuals seem to have been placed next to one another. Grave inclusions in the double deposits were limited, consisting of faunal remains, ceramic sherds, lithics, and ground stone.

In both the single and double deposits, levels of skeletal completion ranged from three to eighty-one per cent, while dental completion ranged from zero to 100 per cent (Table S4, 6), suggesting a mixture of primary and secondary burials.

Though only three of the fourteen mortuary features were categorized as multiple deposits, twenty-nine out of forty-eight individuals (60 per cent) were interred in these structures (Figures S34–S37; Tables S6–S8). As each multiple deposit represents a distinct process of deposition, these features are summarized individually at greater length in Supplementary File 2.

Isotope analysis of diet

Subsistence at Los Melgarejos conformed to the terrestrial C₃ diet typical for Iberian Copper Age sites (Beck et al., 2018; Díaz-Zorita Bonilla et al., 2019) (Figure 3A), with an average human $\delta^{13}\text{C}$ value of $-18.4\text{‰} \pm 0.35$ (range: -19‰ to -17.4‰) and an average human $\delta^{15}\text{N}$ value of $10.0\text{‰} \pm 0.91$ (range: 8.2‰ to 13.4‰).

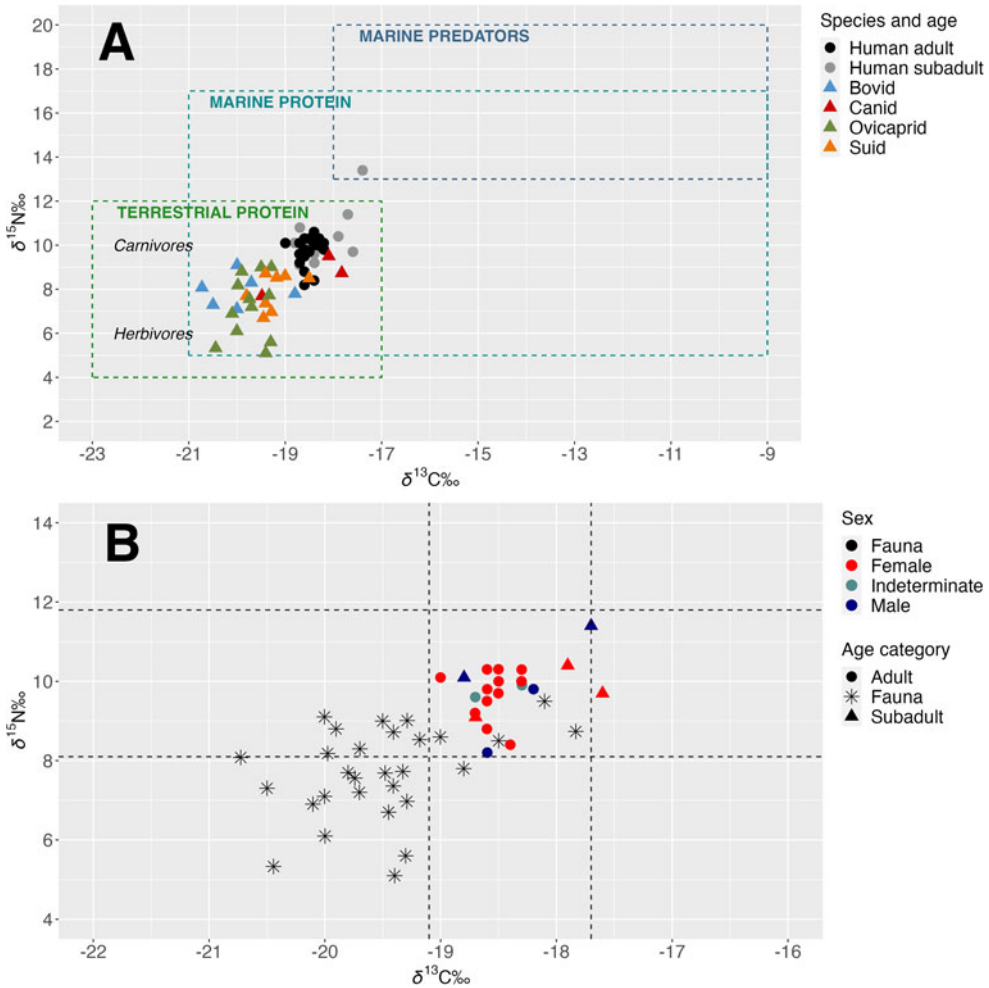


Figure 3. A. $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ for Los Melgarejos humans ($n=31$) and fauna ($n=29$) relative to dietary boundaries from Lai (2008). **B.** $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ for Los Melgarejos humans by broad age category and sex.

Examining for $\delta^{15}\text{N}$ by age category showed the effects of breastfeeding on the youngest individuals in the sample; the average for children (11.2‰ , $n=4$) was higher than for juveniles (9.8‰ , $n=4$), adolescents (9.9‰ , $n=3$), and adults (9.7‰ , $n=20$). Aside from typical early life enrichment, no patterning linked to age or sex was evident (Figure 3B).

Comparing $\delta^{13}\text{C}_{\text{ap}}$ to $\delta^{13}\text{C}_{\text{co}}$ to differentiate between whole diet and dietary protein (Kellner & Schoener, 2007) revealed a

diet derived from C_3 protein sources with mixed contributions from C_3 and C_4 energy (Figure 4). Comparisons of the dietary isotopic results from Los Melgarejos to a sample of roughly contemporaneous complex sites from across Iberia show that diet at Los Melgarejos was enriched relative to other sites in the peninsula (Figure 5). Notably, a similar increase has also been observed between megalithic and Argaric populations in southeastern Iberia (Aranda Jiménez et al., 2022).

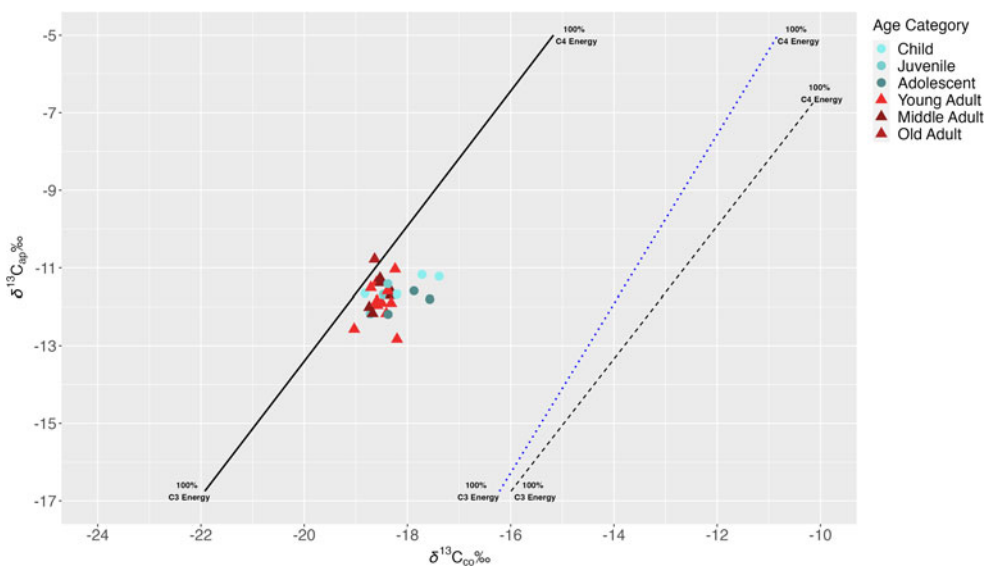


Figure 4. Comparisons of whole diet ($\delta^{13}\text{C}_{ap}$) and dietary protein ($\delta^{13}\text{C}_{coll}$) sources for Los Melgarejos humans ($n = 29$) by age category. Solid line = C_3 protein; dotted blue line = marine protein; dashed black line = C_4 protein.

Radiocarbon dating

Twenty-five radiocarbon dates were obtained from bone collagen, twelve from humans interred in mortuary features (Table 3), and thirteen from domestic animals recovered from the five enclosures. Non-modelled calibrated dates all fall within the third millennium BC, consistent with regional Copper Age chronologies (Table S9). The independent modelling of the ditches and deposits of human remains showed that enclosures were back-filled beginning 2760–2580 cal BC (2σ ; median 2665) and ending between 2565–2400 cal BC (2σ ; median 2515), with a span of 25–265 years (2σ ; median 145). Mortuary practices began between 2590–2470 cal BC (2σ ; median 2510) and ended between 2460–2325 cal BC (2σ ; median 2425), with a span of 15–190 years (2σ ; median 75).

These independently modelled dates suggest that, at Los Melgarejos, enclosure ditches were backfilled before the site was

first used for mortuary ritual. To evaluate this possibility, we ran both contiguous (Phase 2 starts when Phase 1 ends) and sequential (idem but with a possible gap) models, with Phase 1 being the ditched enclosures and Phase 2 being the burials. Both models showed a high agreement (Table S10), confirming the likelihood that the enclosures had been backfilled when the first individuals were buried. The site, however, was not used solely for mortuary activity after the ditches were filled. Site stratigraphy shows that many houses were erected on top of ditch fill. These dwellings necessarily post-date the act of filling the ditches, and were most probably contemporary with the mortuary features. Refuse disposal patterns in pits surrounding the houses suggest that many pits were also associated with these houses. Taken together, stratigraphic analyses, radiocarbon dates, and analyses of material culture thus suggest that the houses built atop ditch fill, refuse pits, and mortuary features are all contemporaneous,

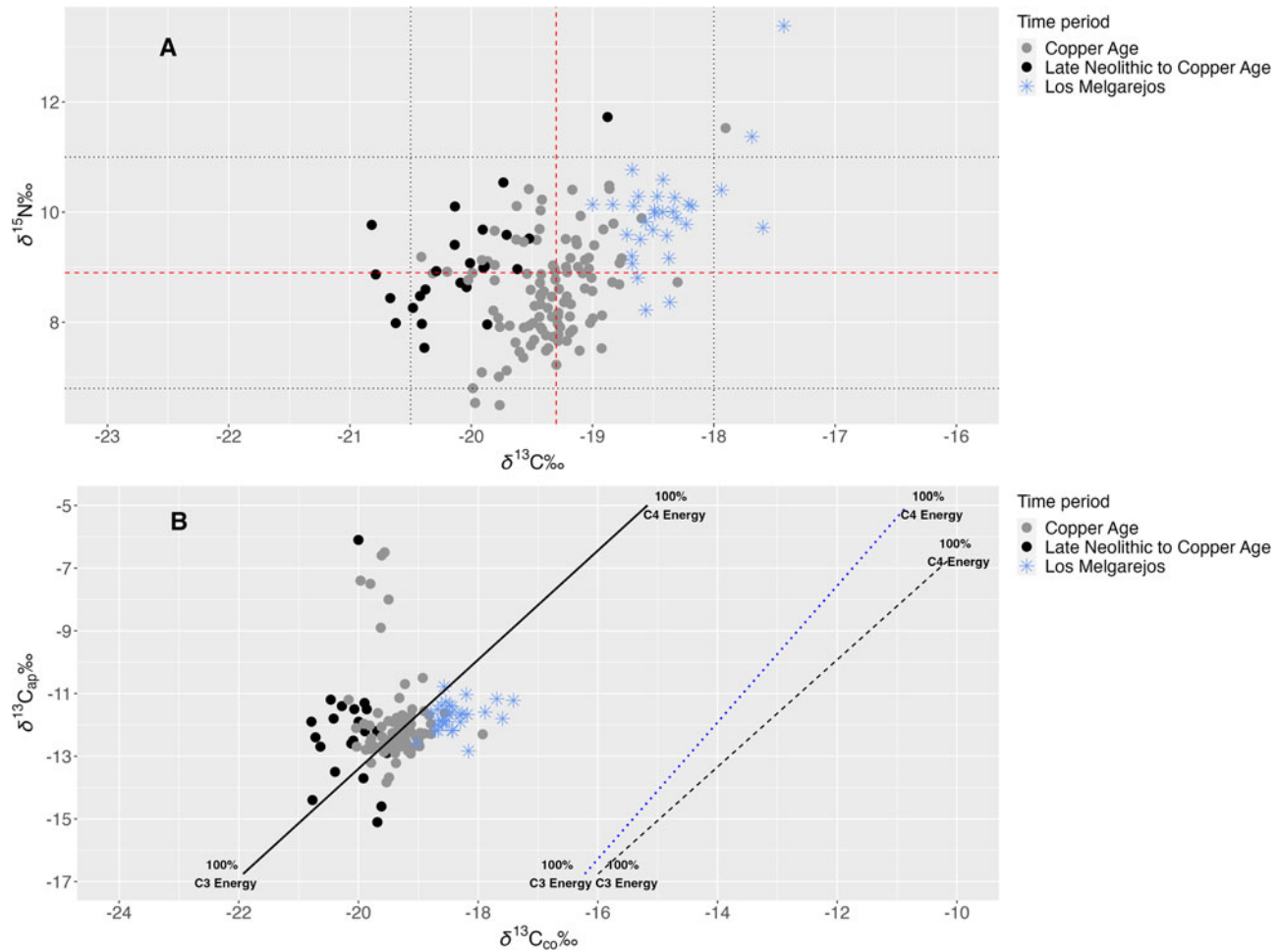


Figure 5. A. $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ for a sample of humans from contemporaneous complex sites from the Iberian Peninsula ($n = 133$) and Los Melgarejos ($n = 31$). B. Comparisons of whole diet ($\delta^{13}\text{C}_{\text{ap}}$) and dietary protein ($\delta^{13}\text{C}_{\text{co}}$) sources for sample of comparative sites from 5A ($n = 112$). Solid line = C₃ protein; dotted blue line = marine protein; dashed black line = C₄ protein.

indicating that the main period of observable activity at the site was likely contemporary with or post-dated the infilling of the enclosures. This dynamic corresponds to a pattern previously suggested for the whole region (Díaz-del-Río et al., 2017b; Díaz-del-Río, 2021) and is comparable to the rhythm of site use at Marroquíes, where human occupation and activity are attested both before and after the enclosure ditches had been filled (Díaz-Zorita Bonilla et al., 2018). Unlike other areas of Iberia, in the middle Tagus Basin the boom in Copper Age mortuary practices (Figure 6) most likely coincided with the demise of the ditched enclosures.

DISCUSSION: MORTUARY TREATMENT AND LIVED EXPERIENCE AT LARGE AND SMALL ENCLOSURE SITES

Comparing the new data from Los Melgarejos to previous analyses of Marroquíes (Beck, 2016, 2017; Beck et al., 2018; Díaz-Zorita Bonilla et al., 2018) underscores that, despite their striking disparity in size, these ditched enclosures share

several key features. For this comparison, we included only individuals from Necropolises 1, 2, and 4 at Marroquíes, as these are the mortuary areas for which the most extensive bioarchaeological analyses have been conducted and the same osteological methods as at Los Melgarejos were employed (Beck, 2016, 2017). First, most individuals were buried with other people; only four out of forty-eight individuals (8 per cent) at Los Melgarejos and two out of 280 individuals (<1 per cent) at Marroquíes were interred in single depositions. Except for neonates, individuals of all ages and both sexes had access to the full range of available mortuary treatment. These mortuary populations are dominated by young adults (31 per cent at Los Melgarejos, 57 per cent at Marroquíes), followed by children and juveniles. Females were more frequently identified than males, though the sex ratio of 5:1 at Los Melgarejos was notably more skewed than the ratio of 1.5:1 at Marroquíes; the higher number of female adults at Los Melgarejos is in keeping with recent research showing a clear female sex bias at particular megalithic sites from late prehistory (Díaz-Zorita Bonilla et al., 2024). At both sites, osteological estimates

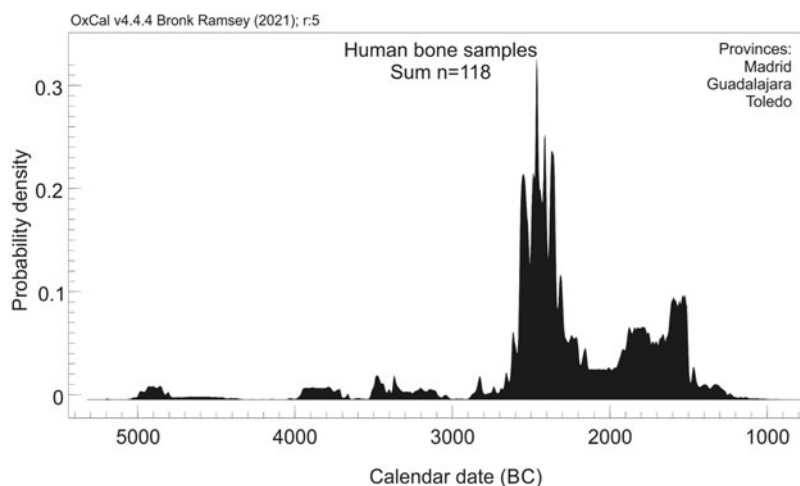


Figure 6. Probability distributions of 118 calibrated radiocarbon dates for human bone samples from the provinces of Madrid, Toledo, and Guadalajara (6015–3050 BP) (IDEArq n.d.).

of sex were not possible for approximately half the mortuary sample (54 per cent at Los Melgarejos; 47 per cent at Marroquíes) due to the poor preservation of the remains or low representation of skeletal elements.

Faunal remains, ceramics, and lithics were the most frequent artefacts documented at Los Melgarejos (Table 1). Some mortuary areas at Marroquíes contained more impressive offerings, such as the possible bone hairpins, sword blade with rivets and large ceramic vessels from Necropolis 2, or the bronze axe and dagger, ceramics, and lithics from Marroquíes Altos. The tombs of Necropolis 1, in contrast, contained only large ceramic sherds or burials of whole animals (Beck, 2016, 2017). Although some graves at Marroquíes contained a greater quantity and quality of artefacts than those at Los Melgarejos, both sites lacked the elaborate grave goods made of exotic raw materials such as ivory, amber, and ostrich eggshell characteristic of Chalcolithic centres such as Valencina-Castilleja, Los Millares, or Perdigões. Accordingly, neither Marroquíes nor Los Melgarejos appear to have been incorporated into the long-distance exchange networks or systems of specialized craft working that underlay the production and circulation of these kinds of artefacts.

The inclusion of animal remains in mortuary structures was a common feature of ditched enclosures, reported at Marroquíes and Venta del Rapa, among others (Márquez-Romero, 2006; Cámara Serrano et al., 2012; Lechuga Chica et al., 2014; Beck, 2016). The zooarchaeological analysis of the Los Melgarejos assemblage is ongoing, but all samples selected for isotopic analysis were common domesticates (i.e. bovids, suids, ovicaprids, canids). While domesticates such as cattle, goats, sheep, and pigs were an important form of material wealth for Copper Age communities, dogs were also frequently interred within mortuary structures, highlighting that different

species were likely to have had different ritual and social meanings in funerary contexts (Márquez-Romero, 2006).

In addition to similarities in the artefacts included their mortuary features, the two enclosures show similarities in their organization of mortuary space. At Marroquíes, all known mortuary features were located outside the fourth ditch, while at Los Melgarejos, all mortuary features except UE 2190 were located beyond the third ditch. Although the deceased were relegated to the spatial peripheries of both sites, they were not socially isolated. There is instead ample evidence for recurrent interaction between the living and the dead. At Marroquíes, for example, the remains of at least ten individuals who died at different points in time were deposited in the north-eastern section of Ditch 5, mixed with faunal remains and material culture in a ritual deposit (Díaz-Zorita Bonilla et al., 2020). At Los Melgarejos, five of the seven double deposits contained small numbers of elements from additional individuals, suggesting the repeated movement of remains post-skeletonization.

The parallels in funerary treatment and artefacts suggest that Marroquíes and Los Melgarejos had similar practices surrounding the treatment of the dead. The bioarchaeological record also attests to similarities in lived experiences of stress, trauma, and diet. For example, only four out of forty-eight individuals (8 per cent) had fractures at Los Melgarejos, a frequency comparable to the low levels of trauma observed at Marroquíes, and in Chalcolithic Iberia more generally (Jiménez-Brobeil et al., 2009; Beck, 2020: 161–63; Díaz-Zorita Bonilla, 2017). Linear enamel hypoplasias affected the same proportion of observable teeth at Los Melgarejos (25 out of 571, 4 per cent) and Marroquíes (175 out of 3953, 4 per cent). At Los Melgarejos, affected individuals were concentrated in three out of fourteen mortuary features; at

Marroquies, individuals with hypoplasias were concentrated in three out of six mortuary features in Necropolis 1 and three out of seven mortuary features in Necropolis 2 (Beck et al., 2018). This pattern suggests that individuals buried together may have shared experiences of pronounced physiological stress during childhood. Alternatively, as recent research is increasingly demonstrating a genetic component to enamel hypoplasias (Alotaibi et al., 2022), such concentrations may reflect the spatial clustering of biologically related individuals. Unfortunately, genetic preservation in this sample was insufficient to evaluate such relatedness.

Diet at Los Melgarejos reflected the standard late prehistoric Iberian focus on C₃ terrestrial resources. Marroquies shows greater variability in both adult $\delta^{13}\text{C}$ (range = 2‰; σ = 0.4‰) and $\delta^{15}\text{N}$ (range = 3.7‰; σ = 0.8‰), than the values for Los Melgarejos adult $\delta^{13}\text{C}$ (range = 0.8‰; σ = 0.2‰) or $\delta^{15}\text{N}$ (range = 2.5‰; σ = 0.6‰). This disparity may relate to sample size differences, with the number of adults sampled for Marroquies ($n = 62$) over three times greater than that for Los Melgarejos ($n = 20$). When considering the entire mortuary sample, the dietary

outliers ($\pm 2\sigma$ from mean) for both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ are one child (12747 Ind. 7, nine months to two years old, $\delta^{15}\text{N} = 13.4\text{‰}$) and one adolescent (10912 Ind. 2, twelve to fifteen years old, $\delta^{13}\text{C} = -17.9\text{‰}$). This patterning mirrors Marroquies, where subadults were more commonly dietary outliers than adults (Beck et al., 2018: tab. 3).

The Los Melgarejos population is itself an outlier, with the highest average $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for all sites in the Copper Age comparative sample (Figure 7), and a pronounced carbon enrichment relative to other late prehistoric Iberian sites (Figure 5), a pattern already highlighted for the region by Díaz-del-Río et al. (2017b). The results of the carbon isotope analyses for individuals buried at Los Melgarejos show a mixed diet of C₃ and C₄ plants. The high levels of $\delta^{13}\text{C}$ for some individuals reflect values compatible with the consumption of C₄ plants such as those from the *Poaceae*, *Chenopodiaceae*, and *Cyperaceae* families; wild species from these families are quite common in southwestern Europe, with those from *Poaceae* being most abundant (see Pyankov et al., 2010 for a detailed list), and C₄ plants are common for the Iberian Peninsula

Table 3. Radiocarbon dates from human collagen.

Feature	Individual	Lab code	Age	Sex	BP	$\pm 1\sigma$	Date range cal BC (1σ)
2190	2192	ETH-115046	Juvenile	Female	4032	24	2580–2485
3300	3303	ETH-115047	Child	Probable male	4052	25	2625–2495
10220	10223 Ind. 7	SUERC-99520	Middle adult	Female	3962	21	2565–2460
10220	10223 Ind. 8	SUERC-99519	Adolescent	Female	3926	21	2470–2345
10910	10912 Ind. 1	ETH-115039	Young adult	Male	3917	24	2465–2350
10910	10912 Ind. 2	ETH-115040	Adolescent	Female	3887	24	2465–2350
10910	10912 Ind. 3	SUERC-99518	Adult	Probable female	3937	24	2465–2350
12380	12382	ETH-115045	Young adult	Male	3885	24	2455–2305
12730	12733 Ind. 1	ETH-115042	Middle adult	Female	4013	24	2570–2475
12730	12734 Ind. 2	ETH-115043	Child	Probable male	3922	24	2470–2345
12730	12737 Ind. 5	ETH-115041	Adult	Female	3957	24	2565–2455
12730	12738 Ind. 6.1	ETH-115044	Juvenile	Indeterminate	3935	24	2475–2345

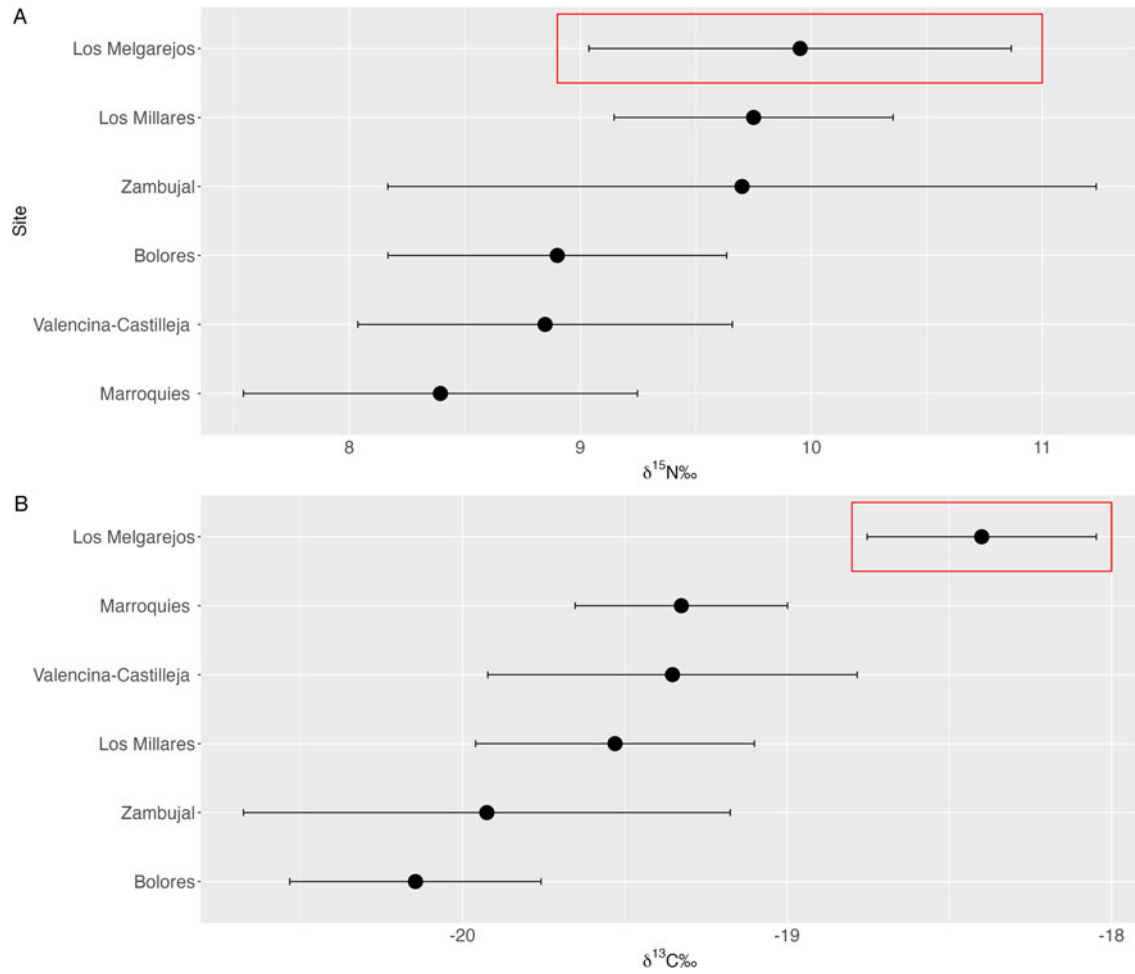


Figure 7. A. Mean and range of $\delta^{15}\text{N}$ values from sites in contemporaneous sample of complex Copper Age sites. Sites ordered by median $\delta^{15}\text{N}$ from lowest to highest; B. Mean and range of $\delta^{13}\text{C}$ values for the same sites, ordered by mean $\delta^{13}\text{C}$ from lowest to highest. In both A and B, Los Melgarejos marked with red box.

specifically (Olmedilla & Rodríguez-García, 2010; Santana et al., 2010). Indeed, pollen analyses of Copper Age sites in the Madrid region reveal a highly anthropized landscape with semi-steppe vegetation, including many subfamilies of C_4 plants (López-Sáez et al., 2010: 11) and highlight the burning of plants and potential use of fertilizer at some sites. While consumption of C_4 plants, burning, fertilizer use, and environmental factors such as aridity could all contribute to increased $\delta^{13}C$ and $\delta^{15}N$ values, comparisons of the human and faunal data (Figure 3) show that, aside from one canid, animals at Los Melgarejos do not display this enrichment. It is thus possible that the dietary enrichment relates directly to human subsistence strategies such as the consumption of local C_4 plants, increased consumption of higher trophic level fauna or dairy products, or the use of fertilizers in agricultural practices (Aranda Jiménez et al., 2022). The combined results of the carbon and nitrogen isotopic analyses allow us to reconstruct the environment and dietary habits of the human group, who were likely consuming domestic animal and/or dairy products and a mixture of C_3 and C_4 plants. Alternatively, similar increases in $\delta^{15}N$ that have been observed in south-eastern Iberia have been suggested as reflecting manuring or increasing aridity during the transition to the Bronze Age (Aranda Jiménez et al., 2022). Further regional studies examining the relationship between local ecology, archaeological evidence of subsistence practices, and human and faunal isotope values will help elucidate these patterns.

The radiocarbon dates from Los Melgarejos reveal a complex chronology of funerary practices. When compared to a regional sample of ^{14}C dates, the exponential increase in funerary evidence dated to c. 2500 cal BC coincides with the gradual abandonment of most of the dated ditched

enclosures by 2450 cal BC (see Díaz-del-Río et al., 2017a: 82). If we accept this pattern, the abandonment of all ditched enclosures at Melgarejos is earlier than or contemporary with the dated burials. The radiocarbon data also reveal that mortuary features in different areas of the site were used simultaneously. The earliest dates come from burials within the second ditch (UE 2190) and outside the fifth ditch (UE 3300) (Figure S39). The next phase of activity involved interments between Ditches 1 and 2 (12382; all individuals from UE 10910) and outside Ditch 1 (12734 Ind. 2; 12738 Ind. 6.1). This second phase of activity is attested by dates from single, double, and multiple interments, suggesting all categories of mortuary features were used at the same time.

Finally, the dating of multiple individuals from two of the multiple deposits (UE 10220; UE 12730) revealed that such structures have a complex chronology. In both features, earlier dates were from individuals that came from higher in the structures' stratigraphy. While this may reflect the fluctuation of the radiocarbon curve during the middle of the third millennium BC, it could also represent multi-stage mortuary practices that consolidated individuals from different points in time in the same mortuary facility. If multi-stage mortuary processing and funerary reuse were customary for the multiple deposits, they may have been used for several generations; the combined dates from UE 12730, for example, have a span of 35 (1σ) to 165 (2σ) years for all burial activities.

CONCLUSION

Comparing the mega-site of Marroquies to the smaller settlement of Los Melgarejos shows that, despite the scalar

differences between the settlements, their communities exhibited similarities in mortuary practices and lived experiences of disease, stress, and trauma. The occupants of each site exhibited comparable patterns of disease and stress, with low levels of trauma and infectious disease and moderate levels of dental pathology. Individuals with linear enamel hypoplasias were concentrated in certain structures at both sites, suggesting that those buried together may have experienced similar levels of physiological stress in childhood or may have been biologically related. Isotopic analyses of diet show limited inter-individual differentiation based on age or sex, except nursing-related enrichment for the very youngest individuals. Diet is one area, however, where the two sites diverge. The enriched $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of the Los Melgarejos sample may partly reflect the more arid environment of the central plateau but may also represent the influence of local subsistence patterns or agricultural techniques. If the high nitrogen values for humans at Los Melgarejos are indicative of differential access to meat or secondary products, then people living at this smaller-scale enclosure may have had better dietary options than their neighbours at large-scale enclosures such as Marroquíes (Figure 7B). Alternatively, the high values could reflect distinct animal management practices, such as the foddering of domesticates using resources with higher nitrogen values, or differences in dietary practices, such as the consumption of pigs that had been fed high-protein waste. The $\delta^{15}\text{N}$ values at Los Melgarejos are unlikely to reflect freshwater fish consumption because of the absence of zooarchaeological evidence at Chalcolithic sites in this region.

Continuous interaction between the living and the dead was a customary component of Chalcolithic funerary ritual, and mortuary practices were complex and variable at both enclosures, including primary

burial, secondary burial, and the recurring movement of human remains post-skeletonization. At Marroquíes, such rituals were foundational; some of the earliest radiocarbon dates at the site come from the necropolis of Marroquíes Altos. Fragmentary and commingled human remains were also deposited in enclosure ditches, a practice observed at other enclosures across Iberia. At Los Melgarejos, features such as UE 2190 hint at similar forms of ritual deposition; here, the skull of an eight- to ten-year-old female was placed in a pit half filled with sediment. Unlike at Marroquíes, however, this ritual deposition may well have marked the closure of a cycle of collective ditch construction. Targeted radiocarbon dating also shows that multiple mortuary features, and multiple categories of mortuary features, were used simultaneously at both sites, hinting at the use of such spaces to express some form of social identity, perhaps related to kinship or residential groups.

Comparing the bioarchaeology, mortuary practice, diet, and chronology of Los Melgarejos and Marroquíes shows that people at some large-scale Iberian Copper Age sites led lives that shared many traits with those of their smaller-scale neighbours. Though the 'charismatic mega-sites' of Valencina-Castilleja and Marroquíes act as magnets for public and professional attention, they must be situated within their regional contexts. Multi-proxy and multiscale archaeological approaches are thus essential for developing an anthropological understanding of pattern and process in Copper Age lifeways in the Iberian Peninsula.

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SUPPLEMENTARY MATERIAL

Supplementary materials, including figures, tables, an R markdown document explaining the script, and the raw data are available on the repository Zenodo (<https://doi.org/10.5281/zenodo.13627495>).

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Bioarchéologie et chronologie au service de l'étude des enceintes à fossés chalcolithiques en Ibérie : le site de Los Melgarejos

Les enceintes à fossés, qui émergent en Ibérie au cours de l'âge du Cuivre (quatrième et troisième millénaires av. J.-C.), se distinguent par leur plan circulaire, un effort commun investi dans leur construction et une chronologie complexe ; leur distribution, fonction et dimensions varient cependant considérablement. Les recherches ont surtout porté sur les « méga-sites » mais il est essentiel d'évaluer les sites de moindre taille pour comprendre les dynamiques sociales qui ont mené aux enceintes circulaires. Les auteurs de cet article présentent les résultats d'une étude de Los Melgarejos (Getafe, Espagne), la première enceinte chalcolithique à avoir été entièrement fouillée (4 ha). Leurs analyses bioarchéologiques,

archéo-thanatologiques, isotopiques ($\delta^{13}C_{co}$, $\delta^{13}C_{ap}$, $\delta^{15}N$) et radiocarbone permettent de comparer le vécu de l'alimentation, du stress, des traumatismes et des rites funéraires dans les grande et petites enceintes. La comparaison entre Los Melgarejos et le méga-site de Marroquíes révèle des ressemblances dans le vécu et les pratiques rituelles, mais aussi des différences dans l'alimentation, ce qui souligne les avantages que les analyses à échelles multiples présentent pour notre compréhension des modes de vie préhistoriques. Translation by Madeleine Hummler

Mots-clés: enceintes à fossés, méga-sites, âge du Cuivre, Ibérie, bioarchéologie

Die Erforschung der kupferzeitlichen Kreisgrabenanlagen in Iberien: integrierte bioarchäologische und chronologische Ergebnisse aus Los Melgarejos

In Iberien erschienen die Kreisgrabenanlagen während der Kupferzeit im vierten und dritten Jahrtausend vor Chr. Diese Anlagen sind durch ihre kreisförmige Gestaltung, eine gemeinsame Teilnahme in ihrem Bau und eine komplexe Chronologie verbunden; sie unterscheiden sich aber sehr in ihrer Verbreitung, Funktion und Ausmaß. Obwohl die archäologischen Untersuchungen sich besonders auf die „Mega-Anlagen“ konzentriert haben, ist eine Bewertung der kleineren Anlagen für unser Verständnis der sozialen Verhältnisse, welche die Entstehung der Kreisanlagen ermöglichten, entscheidend. Die Verfasser des Artikels berichten über die Ergebnisse ihrer Untersuchung von Los Melgarejos (Getafe, Spanien), die erste vollständig ausgegrabene kupferzeitliche Kreisgrabenanlage in Iberien (4 Hektaren). Ihre Analysen der Bioarchäologie, der Grabsitten, der Isotopen ($\delta^{13}C_{co}$, $\delta^{13}C_{ap}$, $\delta^{15}N$) und der Radiokarbonaten betreffen die Erfahrungen, die Ernährung, die Belastungen, die Traumata und die Bestattungssitten der Bevölkerung in großen und kleinen Anlagen. Der Vergleich dieser Daten zeigt, dass das Leben und die Bestattungsrituale in der „Mega-Anlage“ von Marroquíes ähnlich wie in Los Melgarejos waren. Jedoch hat die Analyse der Isotopen ergeben, dass es regionale Unterschiede in der Ernährung gab. Dies betont den Wert von multiskalaren, vergleichenden Untersuchungen von vorgeschichtlichen Lebensweisen. Translation by Madeleine Hummler

Stichworte: Kreisgrabenanlagen, „Mega-Anlagen“, Kupferzeit, Bioarchäologie