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Radiocarbon dates, climatic events, and social dynamics during the Early Neolithic in Mediterranean Iberia

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ABSTRACT

Our goal in this paper is to examine the socioecological dynamics of the Early Neolithic period in Iberia in order to test the usefulness of temporal probability curves built from dated sites as a relative proxy for exploring possible links between trends in population patterns and climatic fluctuations. We compare the information for the entire Iberian Peninsula with four Mediterranean regions, investigating the climate–population relationships that emerge when we zoom into particular regions. We evaluate climatic and other possible causes of similarities in the shapes of temporal probability curves across the Peninsula, associated with demographic changes in the Early Neolithic sequence. Changes in subsistence patterns identified in empirical data from sites like Cendres cave (Alicante province), together with computational modeling that simulates long-term socio-ecological processes, suggest key variables that can help account for local dynamics. Theoretical approaches from Complex System Theory and Evolutionary Archaeology can help us to better understand evolutionary processes including the spread of farming.

1. Introduction

Research on European Neolithic sequences has underlined the potential of both global exogenic (mainly climatic Holocene events) and/or endogenic forces behind major changes in social evolutionary processes. Authors such as Gronenborn (2009, 2010) have focused on the role of climatic fluctuations detected in the Holocene marine and terrestrial climate records for the spread of farming from the Near East to Europe at a supra-regional level. He also emphasizes the need to zoom in to compare chronologies of local and regional fine-resolution data. Shennan et al. (2013) calculated summed ^{14}C probability densities from multiple sites at pan-European and regional scales as a relative demographic proxy to be compared with other general and fine-resolution climatic proxies. Both authors agree about the importance of carefully examining the relationships between particular abrupt climatic fluctuations and shifts in cultural sequences that occur at roughly the same time. Specifically the chronology for the end of the Early Neolithic in Central Europe (LBK) is used to explore alternative hypotheses related to the effects of climatic events (7.1 k event–5b IRD event) (Gronenborn, 2009) or endogenous drivers (Shennan, 2013; Shennan et al., 2013) on social change. Shennan et al. (2013) take a more expansive geographic perspective in recent work that examines radiocarbon probability curves as demographic proxies for the entirety of Western Europe excluding southern regions (Iberia and Italy). These authors identify a general pattern of a population boom coincident with the arrival of food production economies, followed by a rapid decline some centuries later in multiple European regions. Comparing these population proxies with paleoclimate proxies of the middle Holocene, they conclude that fluctuations in population densities were not directly linked with the main climatic events. Instead, they propose that endogenous causes are more probable for these patterns in evolutionary socioeconomic processes at the beginning of the Neolithic period, perhaps related to a rapid population increase that lead to unsustainable levels, or other hypothetical internal causes (Shennan et al., 2013).

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Recently, we tried to analyze similar relationships between relative Summed Calibrated Data Probability Distribution (SCDPD) of radiocarbon dates and climatic events in Iberia (Bernabeu Aubán et al., 2014). We examined its utility to observe trends in population dynamics for the Iberian Peninsula at a general scale, and within several sub-regions. We also compared demographic patterns with global and regional climatic proxies. As with the patterns reported by Shennan and colleagues from other areas of Europe, our analyses indicate a population boom that emerged after the arrival of the Neolithic in Iberia around 7650 cal BP, followed by a bust coincident with the end of the Early Neolithic sequences (Impressed Ware Culture) following the end of the VIII millennium cal BP. Additionally, we concluded that despite a general correspondence between climatic events at 8.2 and 7.1 cal BP (5a and 5b IRD events) and fluctuations in SCDPD, important discrepancies appear when we zoom into regional and local scales. In this paper, we take a longer-term perspective of socio-ecological changes by extending SCDPD from the Mesolithic to the Middle Neolithic. This allows us to examine the demographic trends of the Neolithic in the context of the longer history of human settlement in Iberia by focusing particularly on the Mediterranean zone of the Iberian Peninsula.

2. Regional setting

The Iberian Peninsula, around 580.000 km^2 in area, includes two main bioclimatic regions characterized by continental and Mediterranean ecological conditions respectively. This creates a mosaic of diverse ecosystems depending on altitude, latitude, and the distance to the sea. Since the beginning of the Holocene, progressive climatic amelioration has been reflected in the palynological and charcoal records (Carrión et al., 2010). The warmer and wetter conditions at the beginning of the Holocene are indicated by the increase of deciduous forest (oak) and the upward migration of conifers (*pinus sp* and *juniperus sp*). The Mediterranean area of Iberia is traversed by two main corridors, the Mediterranean Sea and the Ebro river, that facilitated human interaction and social networks as seen in similarities in prehistoric artifact assemblages.

The Mesolithic precursors to the Neolithic appear in the material culture as a regional manifestation of the broader Castelnovian Tradition, characterized by the microblade geometric microlithic technology with trapezes that appeared in the first half of the IX millennium cal BP (Utrilla and Montes, 2009). Several centuries later, at the beginning of the VIII millennium cal BP, triangles began to dominate the geometric microlith assemblages.

The first domesticates in Iberia appear in the Early Neolithic around 7650 cal BP at sites located in core areas such as the Llobregat valley in Catalonia (Guixeres de Vilobí: OxA26068, 6655, 45 and El Cavet: OxA26061, 6536, 36—Oms et al., 2014), and Southern Valencia region (Cova d'En Pardo: Beta231880, 6660, 40—García Atiénzar, 2009; Cova de les Cendres: Beta239377, 6510, 40—Bernabeu and Molina, 2009; Barranquet: Beta221431, 6510, 50—Bernabeu et al., 2009; Cova de l'Or—UCIAMS66316, 6475, 25—Martí, 2011; Mas d'Is: Beta162092, 6600, 50 and Beta166727, 6600, 50—Bernabeu, 2006; Sarsa: OxA26076, 6506, 32—García Borja et al., 2012; Falguera: 6510, 80—García Puchol et al., 2009), in addition to other inland sites as Chaves in the Ebro valley (GrA38022, 6580, 35—Baldellou, 2012) or Carigüela in Eastern Andalusia (Col1565, 6749, 39—Medved, 2013) Belonging to the impressed ware cultural complex, the Early Neolithic presents common material characteristics throughout western Mediterranean region. The rapid spread of the Neolithic way of life, documented by direct radiocarbon dates of domestic species, has been attributed to a process of maritime pioneer colonization (Zilhão, 2001). A mixed model that combines endogenous expansion of farming groups with a still poorly understood contribution of local hunter-gatherer groups is the most widely accepted hypothesis for Neolithic dispersals inland (see García Puchol et al., 2009; Juan Cabanilles and García Puchol, 2013; Bernabeu and Martí, 2014). In recent years, new archaeological discoveries have added data that connect some stylistic aspects of initial Neolithic ceramics with southern France and Ligurian impressed pottery (e.g., Barranquet and Mas d'Is, located in Valencia region—Bernabeu et al., 2009).

3. Material and methods

Following protocols established in previous studies (Gamble et al., 2005, Shennan et al., 2013; Timpson et al., 2014), we calculated SCDPD curves as a relative demographic proxy to observe long-term trends in population. Williams (2012) notes several problems that potentially affect the validity of this method, based on the assumption that the number of archaeological sites can be linked to the number of available radiocarbon dates; and that a sufficiently large number of dates can mitigate biasing effects in the samples. He suggests filtering the radiocarbon dates to use in this way by excluding those with large standard deviations (SD) in order to reduce some of these problems. In the aforementioned paper (Bernabeu Aubán et al., 2014), we compiled all radiocarbon dates for Iberia, except for those in the northwestern regions of Cantabria and Galicia. In this contribution we have extended the compilation of radiocarbon dates to the entire Iberian Peninsula, and temporally from the beginning of the IX millennium until the end of the VII millennium cal BP with the goal of obtaining a broader chronological perspective. This dataset, compiled from published works and other publically-available radiocarbon data (Juan Cabanilles and Martí, 2002;; Bernabeu, 2006;; Carvalho, 2008; Catalunya C14,; Rojo et al., 2012;; Fano et al., 2014), contains 1271 radiocarbon dates between 8000 and 5000 BP. Table 1 details the radiocarbon dates classified by materials and regions. For calculating SCDPD curves, we only use radiocarbon dates with a standard deviation ≤200, and exclude dates on shell due to potential problems related to the marine reservoir effect (Ascough et al., 2005). Nonetheless, this filtered dataset includes a large number of dates, covering the entire Iberian Peninsula, and is comparable to other recently published work (Balsera et al., 2015).

Table 1
List of radiocarbon dates by materials and regions. SD (standard deviation average).

	Iberia	Northeast	Ebro valley	East	East/Southeast
All dates	1271	172	195	77	128
Sites	359	60	35	18	32
Charcoal	563	98	82	38	45
Bone	410	46	95	35	46
Seed/fruit	131	23	15	4	23
Shell	112	0	0	0	6
Other	22	0	0	0	7
Indeterminate	33	5	3	0	1
Dates selected	1108	158	186	75	114
Sites	324	58	34	18	27
SD	65.8	75.1	55.4	65.1	66.8

An aspect of this approach that has been criticized is that bias can be introduced by variability in the number of dates for each site, together with differences in the research interests of archaeologists by region, as well as the different visibility of sites and structures (Crombé and Robinson, 2014). In recent work, several kinds of correction factors have been introduced in order to mitigate this bias through combining dates from a single site according to different criteria (Shennan et al., 2013; Balsera et al., 2015). While this approach can moderate this particular kind of error, it also can introduce other biases relating to the criteria used for combining dates from a site. Consequently, we decided to use an alternative method that filters dates by site and combines them at intervals of 50 years. First we calibrated all dates in Oxcal 4.2 (Bronk Ramsey, 2009) using the Intcal curve 2013 (Reimer et al., 2013), and then we distribute the dates (2 sigma range) by the 50-year temporal interval. This results in an average SD of 65.8, which is acceptable according to criteria proposed by Williams (2012), and a final number of 1108 dates for calculating SCDPD curves.

The distributions obtained correspond well with the number of sites dated by interval and serve as another proxy to illustrate diachronic trends in population dynamics. This also can help assess whether or not the SCDPD curves suffer from any of the problems referred to previously (Crombé and Robinson, 2014; Wood, 2015). We generated probability distributions curves and site count curves for the Iberian Peninsula and four regions of Mediterranean Spain in the broad sense (including Ebro Valley): Catalonia to the Ebro river (Northeast region), the upper and middle Ebro Valley, the eastern region (south of Ebro river to Júcar basin), and the east/southeast region (south of Júcar basin to Eastern Andalusia; Fig. 1).

In order to better compare results from different regions and the entire peninsula, we converted the results to standardized Z-score values. As shown in Fig. 2, both the SCDPD (Zdates) and site number (Zsites) curves are very similar. However, the site frequency curve does not show the same range of Z-scores, suggesting that some sites are overrepresented with respect to the number of dates obtained from them. This may be due, at least in part, to the special interest in archaeological research to date the beginning of the Neolithic. Hence, we use Zsites curves along with Zdates curves in other aspects of our analysis.

In order to evaluate possible climatic impacts on socioecological dynamics we used a well-known global paleoclimate proxy, the GISP2 ice core (Grootes et al., 1993; Meese et al., 1997), along with several well dated local proxies: the $\delta^{18}O$ curve based on the *G. bulloides* record from core MD99-2343 in the Balearic sea (Frigola et al., 2007); and core MD952043 that shows the variation in surface temperature in the Alboran sea (Cacho et al., 1999). Different information and resolution is visible from these proxies that help to identify local manifestations of global episodes such as the 8.2 and 7.1 ka coldest and driest events. These episodes coincide with 5a and 5b Holocene IRD events that correspond with iceberg discharges that supplied fresh water to the North Atlantic.

Holocene climate fluctuations are unequally represented in the terrestrial and marine records (Cacho et al., 1999). The clearest signal is associated with the MD952043 Alboran Sea core, where a decrease in surface temperature of 1 °C is associated with the 8.2 event (Cacho et al., 1999). Cortés et al. (2012) have claimed that, a climatic and environmental crisis reflected in the decrease of marine productivity in southern Iberia is visible in the following centuries (between 8 and 7.3 cal BP), affecting the last hunter-gatherer populations who quickly became farmers.

In the MD99-2343 core of Menorca, Frigola et al. (2007) identified nine $\delta^{18}O$ enrichment events that are related to colder surface conditions. These oscillations coincide with the North Atlantic episodes. The coldest event is M8, spanning 9000–7800 cal BP, and involving the 8.2 ka event (Frigola et al., 2007). The M7 event shows another colder oscillation that can be linked with the 7.1 ka event. In summary, global patterns of climatic fluctuations can be observed in several local proxies, particularly marine proxies, but the variability in their impacts requires better local resolution in order to compare the direct effects on socioecological dynamics in Iberia (Bernabeu Aubán et al., 2014).

4. Results

Fig. 3 shows the SCDPD curve for Iberia from the late Mesolithic through Middle Neolithic. Despite the use of a more extensive radiocarbon sample, we can observe trends similar to those in previous work (Bernabeu Aubán et al., 2014): a rise in the number

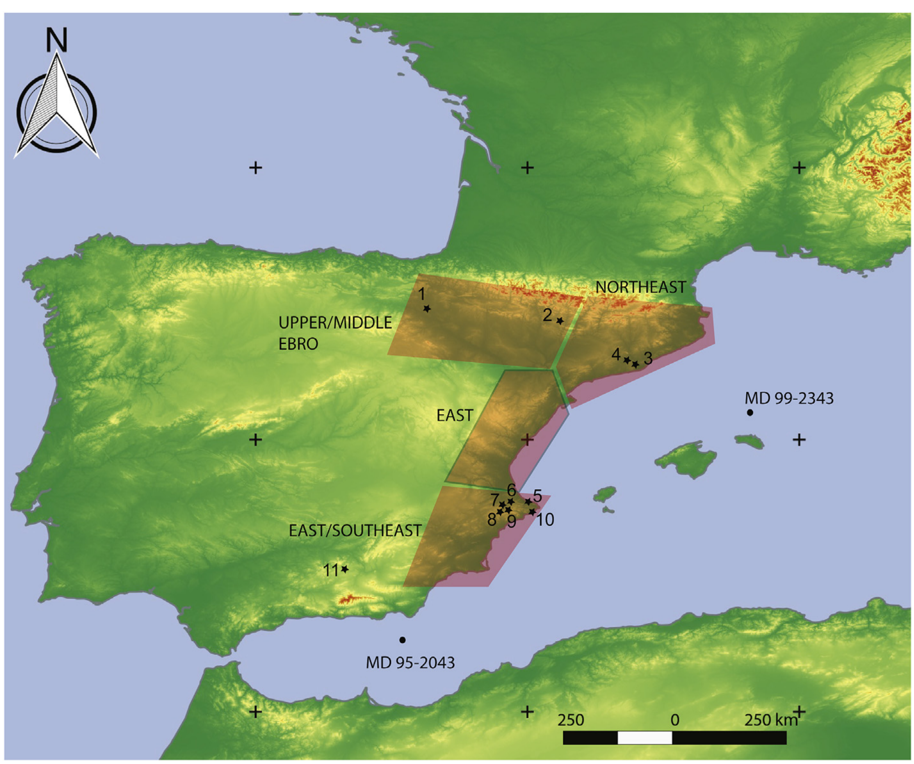

Fig. 1. Map of Iberia with indication of the Mediterranean regions and main sites considered in this work. 1: Husos II; 2: Chaves; 3: Can Sadurní; 4: Guixeres de Vilobí; 5: Barranquet; 6: Cova de l'Or; 7: Sarsa; 8: Falguera; 9: Mas d'Is; 10: Cendres; 11: Carigüela.

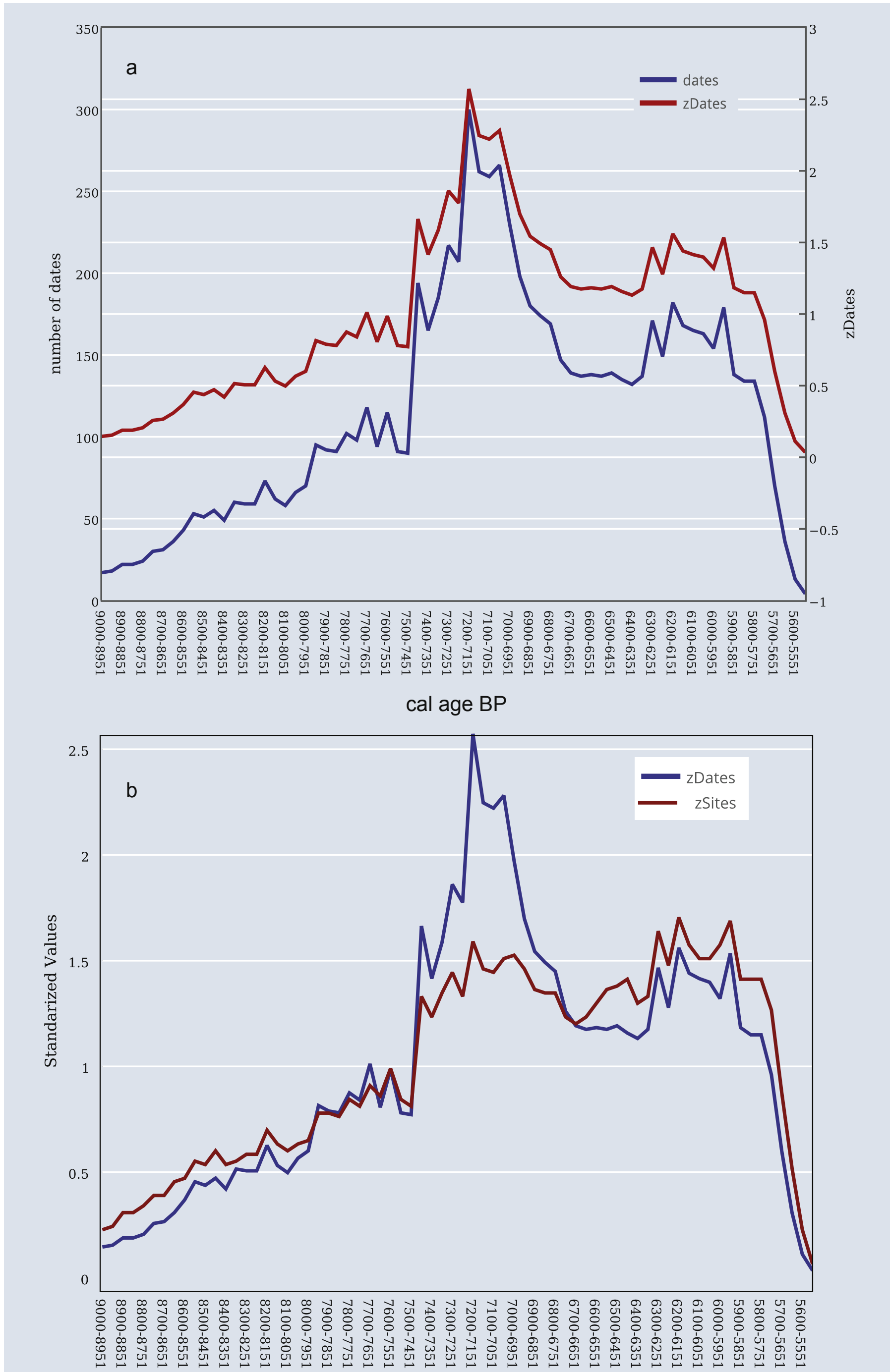

Fig. 2. Comparison between SCDPD of Iberia from dates (blue line) and Z standarised dates (red line) (a), and the Z standarised values by dates (blue line) and sites (red line) (b). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

of radiocarbon dates and dated sites coinciding with the most probable date for the Neolithic arrival, commonly placed around 7650-7600 cal BP, followed by a fall at the end of VIII millennium. Can we relate this changing pattern with any climatic event? While there is no clear relationship between the initial Neolithic growth of the curve and any climatic event at the scale of Iberia, there is an approximate match between the fall of the dating curve, and the event at 7.1 ka. We explore this co-occurrence at greater regional detail, focusing on Mediterranean Spain.

4.1. Regional variability

Fig. 4 shows the curves for each of the four previously described regions of Mediterranean Iberia, along with the standardized values for dated sites. Although the four regions present similar general trends there are some interesting particularities. The common pattern consists of the sharp increase related to the appearance of domestic economies in the four areas followed by a drop in radiocarbon dated sites some centuries later. This type of

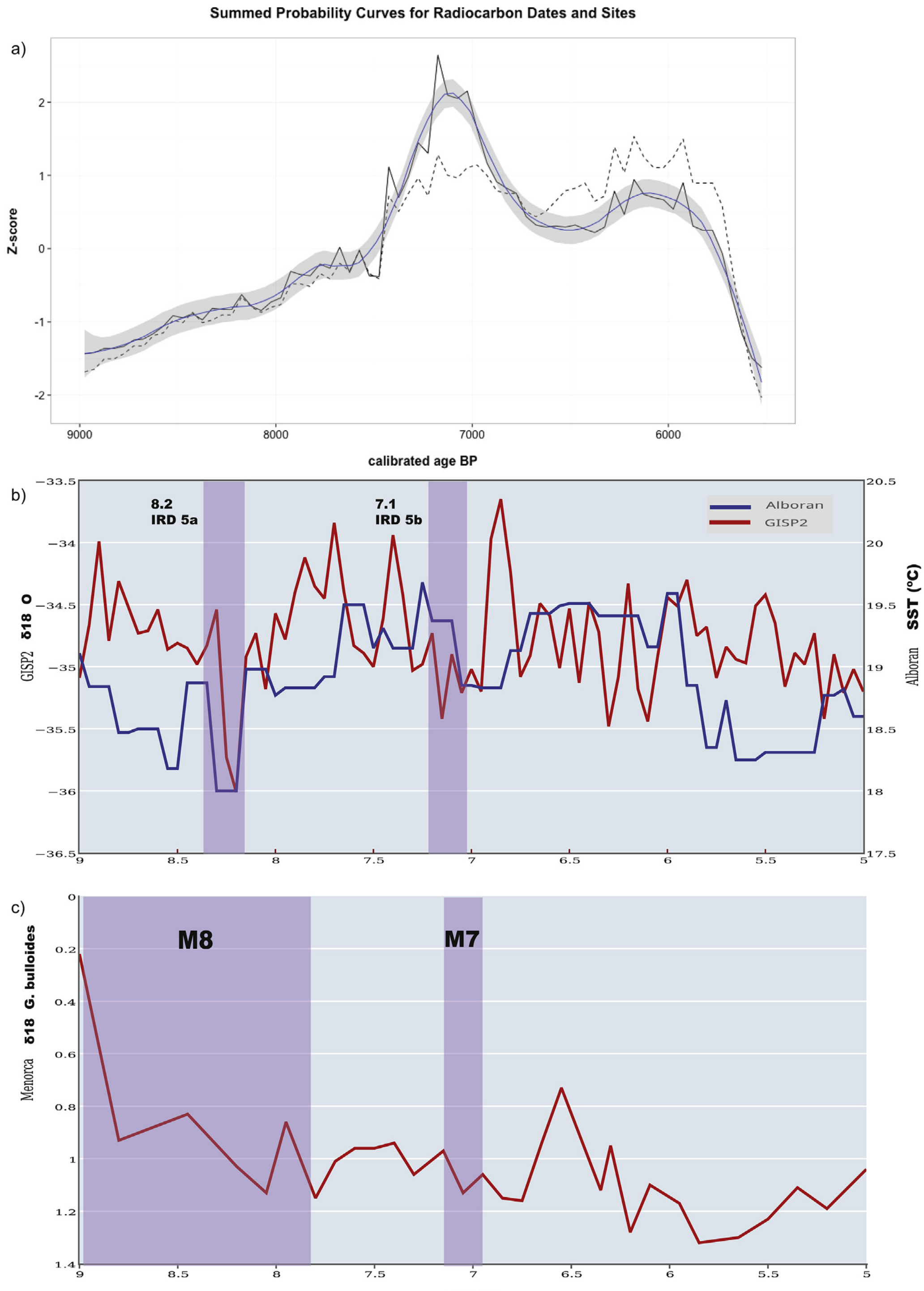

Fig. 3. Comparison between Z standarised values by dates (solid line) and sites (dashed line) from selected radiocarbon dates of Iberia (a) with GISP2 ice core (Grootes et al., 1993; Meese et al., 1997) and MD952043 Alboran Sea core (Cacho et al., 1999) (b) and MD99-2343 core of Menorca (Frigola et al., 2007) (c).

rise/fall cycle is visible among all the regional sequences plotted, but the one related to the beginning of the Neolithic is sharper. Nevertheless there are regional differences in the timing and shape of these cycles.

The curves of NE (158 dates from 58 sites) and ESE (114 dates from 28 sites) regions are similar except for the Mesolithic period (Fig. 4); in both regions radiocarbon dates of domestic resources indicate a similar chronology for the beginning of the Neolithic (c. 7650–7600 cal BP). Despite differences in the curve for the Mesolithic, mainly due to the absence of Late Mesolithic sites in the NE (Vaquero and García-Argüelles, 2009), the rise of the curve associated with the first Neolithic is equally marked in both regions. What looks different is the fall-off pattern after the initial Neolithic that is much less pronounced in the NE than in the ESE region. Finally, there is a second rise and fall pattern that is associated with the Middle Neolithic on both regions.

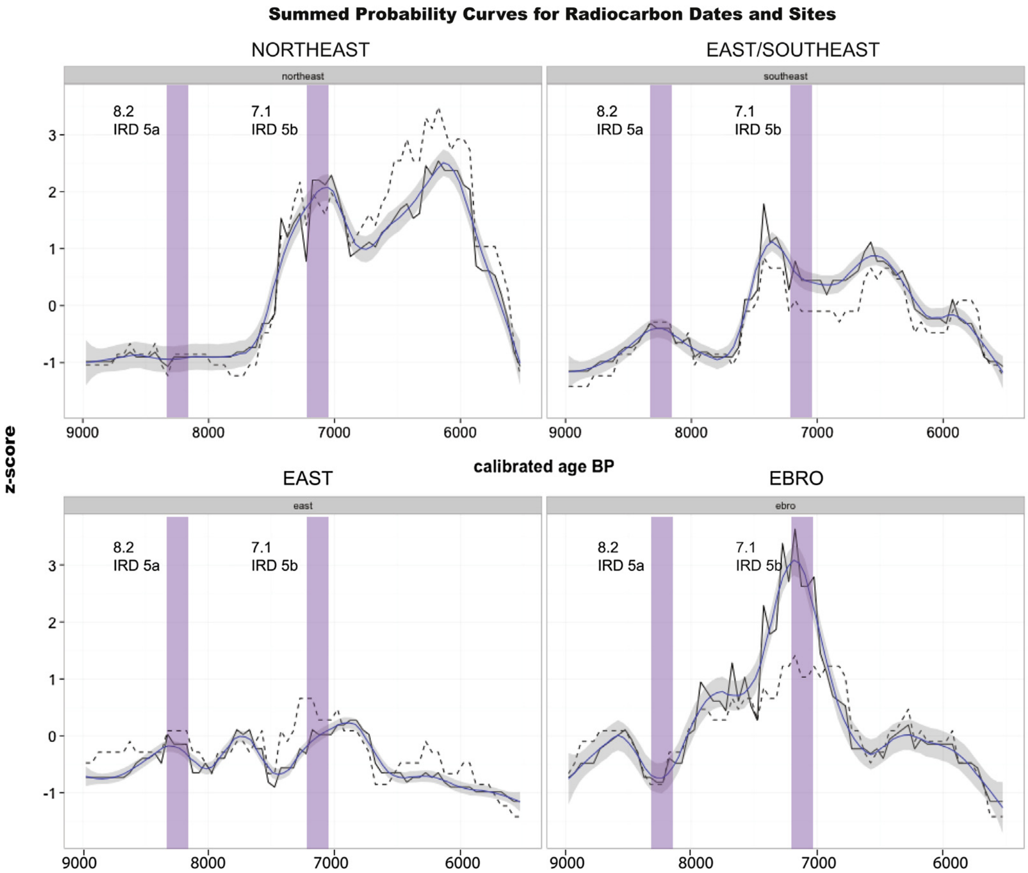

Fig. 4. Zsites values by temporal intervals in Northeast, East/Southern, East and Ebro regions. Comparison between Z standarised values by dates (solid line) and sites (dashed line).

The Ebro valley curve (186 dates from 34 sites) shows a less pronounced rise starting around c. 7500 cal BP that can be explained by the documentation of numerous late Mesolithic sites dating to the first half of the VII millennium cal BP (Fig. 4). The fall-off is visible after 7000 cal BP, with a much steeper decline than in all other regions. The East region displays a curve similar to the Ebro valley (Fig. 4), but is based on a smaller sample (75 dates from 18 sites). If it is not an effect of the small sample, the interpretations are similar in both cases with an initial rise during the earliest Neolithic. In contrast, the decline of the curve is pronounced in both regions, and shows no rise associated with Middle Neolithic visible in NE and SE.

Interestingly, there are significant cultural transformations in all these regions that coincide with the drop in the Neolithic radiocarbon dates. During the period of initial growth (c.7450–7150 cal BP), Neolithic villages were established and organized the new territories that included cave sites, hunting grounds, and rock art sanctuaries. Pottery styles define two major areas: the Cardial around the coast and the Epicardial inland (Ebro valley). This suggests the development of geographically extensive social networks within which information and commodities flowed, affecting extensive regions at different scales and intensity. However, from the end of VIII millennium cal BP, pottery styles became more regional, indicating a fragmentation of previously established networks.

In summary, it seems clear that:

a) There is a recurrent pattern of demographic rise-and-fall during the Neolithic in all regions. This Early Neolithic demographic event (c. 7600–6900 cal BP) is similar to that described in other parts of Europe (Gronenborn, 2009; Shennan et al., 2013).
b) At the scale of Iberia, there is a broader co-occurrence of global climatic events (in the case the 7.1 ka event) and the observed decline in the Neolithic radiocarbon dates, as noted earlier (Bernabeu Aubán et al., 2014) and supported in another recent paper using a broader radiocarbon data set (Balsera et al., 2015).
c) However, the timing, size and slope of the curve differs between regions. In other words, if there are climatic impacts on Neolithic settlement and subsistence, the effects are not the same across the regions analyzed here.

In short, climatic events affected human societies, but the consequences were regionally variable. This variation could be due to differences reflecting the importance of biotic factors and human economic behavior, especially land use. Since both factors–ecology and human behavior-are historically contingent, it would be surprising to find the same effects everywhere. Assuming this, it seems clear that what we need are not only new, high-quality proxy records both of human and environmental conditions, but a way to understand how different local dynamics could result in global patterns of change.

5. Discussion

Other possible drivers than help us to understand the regional diversity need to be explored. The dynamics of landuse–landscape interactions of agricultural communities over generations at the local scale at which human decisions took place seems to be a good avenue for study.

5.1. A socio-ecological perspective

Recent research (Barton et al., 2010a,b, 2012) has shown that modeling the dynamics of landuse–landscape interactions of agricultural communities over generations could help us to better understand the process underlying the population decline of Early Neolithic societies. We focus specifically on the ESE region, one of the most intensively studied areas for the Neolithic transition in Iberia (Garcia Puchol, 2005; Fernández Lopez de Pablo and Gómez Puche, 2009; García Atienzar, 2009; Bernabeu et al., 2012). Within this area, the Serpis Valleys is a small region (about 1.250 km^2) that has been the focus of a collaborative research project for over two decades (Barton et al., 1999, 2002, 2004a, 2004b; Bernabeu et al., 1999, 2000, 2006, 2012; García et al., 2009; McClure, 2011; McClure et al., 2008, 2009).

A component of this work is the MedLand project, designed to carry out computational experiments on the long-term interactions between society, land-use, and environmental change (Barton et al., 2010a,b, 2012). Its results suggest that some kinds of agricultural practices could have a beneficial effect over small communities located at valley bottoms. However, as communities grow past a locally determined threshold size, the consequences of identical land-use practices change, with the potential for leaving a catchment unsuitable for farming.

One strategy to mitigate such environmental degradation is to reduce community size through emigration or fission. Another less obvious solution discovered in these experiments is to increase the amount of grazing relative to cultivation, in order to move the impacts of soil erosion. Conservation measures, like terracing, also could be instituted but we have no clear indicators about the existence of these practices during the Neolithic.

How could this kind of process have been responsible for the shifts described in the entire system? And how can we evaluate it? The answer to the first question relies on theoretical questions about how we can understand the processes of socio-economic changes. We will return to this question at the end of the text. First, we need to explore the possible archaeological indicators to assess whether the strategies specified in the model actually occurred in the same region where model was run.

5.2. Fission, migration and economic transformation

In the ESE region, the Serpis valley is the area where the first Neolithic settlers were established around c. 7600 cal BP (Bernabeu and Martí, 2014). Recent studies (García Atiénzar, 2009; Jover Maestre et al., 2014) indicate that the occupation of the areas situated south of the Serpis valleys is more recent. The few available radiocarbon dates and the analysis of archaeological findings (mainly pottery decoration) suggest that a process of colonization of new areas by fission of early groups could have taken place from c. 7300/7200 cal BP. It is unclear if it was simply a process resulting from community growth, or if it was fueled by the kind of negative feedback between agro-pastoral practices and the landscape suggested by the model. In any case, it should be noted that changes in settlement pattern begin to emerge in the Serpis valley after c. 7200 cal BP.

More interesting are the changes that took place in the subsistence system. Several authors emphasize that by mid-VII millennium cal BP, both agriculture (Pérez Jordà et al., 2013) and livestock (García Atiénzar, 2006) underwent significant changes. In order to assess if there were substantial changes in pastoral activities and their timing, we look to shifts in specialized places in livestock management: the pens. In Mediterranean prehistory, these places were often caves used for sheltering livestock in small-scale migratory cycles and this practice continued until recently (Seguí, 1999). These sites provide opportunities to obtain better information about site functionality, and more specifically about the relative importance of changing strategies in herding.

Traditional approaches to identifying sheepfolds in cave deposits involve geo-archaeological methods to identify typical layers resulting from the continued use of certain places as livestock pens (Brochier et al., 1992). Moreover, ethnoarchaeological studies focusing on pastoralist campsites and associated material culture conclude that herders rarely leave much behind (Ammerman et al., 1978; Robertshaw, 1978). Combining these two approaches, we use the case of Cendres Cave to illustrate this issue.

5.3. Cendres Cave

Located near the shoreline at Cap de la Nau in Alicante province (Spain), Cendres cave is a large cavity with two accessible spaces: an outer area (30 by 25 m) and an interior area (30 by 50 m). Excavations were carried out from 1981 to 1991 in the interior, and have been published recently (Bernabeu and Molina, 2009). Throughout a 3.5 m sequence, various overlapping levels reflect the changing occupation of the cave between the Early Neolithic and Bronze Age, ranging from c. 7500 cal BP to 3800 cal BP (Fig. 5). This gives us the opportunity to observe the effect of occupation dynamics in the cave over a long period of time. The sequence has been divided in two main phases according to its presumed functionality. The lower occupation phase, dated from c. 7500–7000 cal BP, has been interpreted as a multifunctional site, a place where different activities took place.

The function of the cave changed after about c. 6900 cal BP. This phase is interpreted as a livestock pen, resulting from the recurrent use of the cave to house flocks of sheep and goats. Domestic activities may have been conducted at the same time in other parts of the cave, as has been recently reported for the case of Cueva del Toro (Éguez et al., 2014). However, at Cendres cave, shift in use in the excavated areas is clearly evident by the coprolite distribution

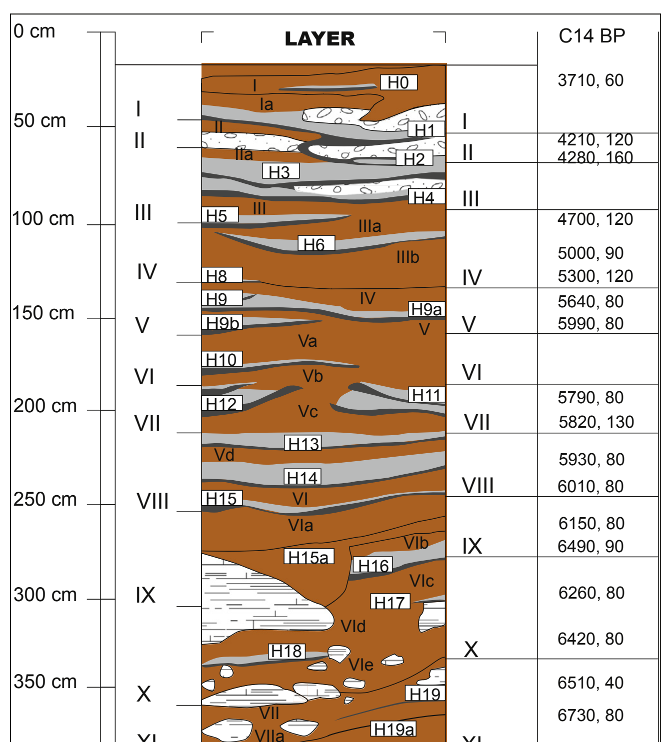

Fig. 5. Neolithic sequence in Cova de les Cendres (Moraira, Teulada, Alacant).

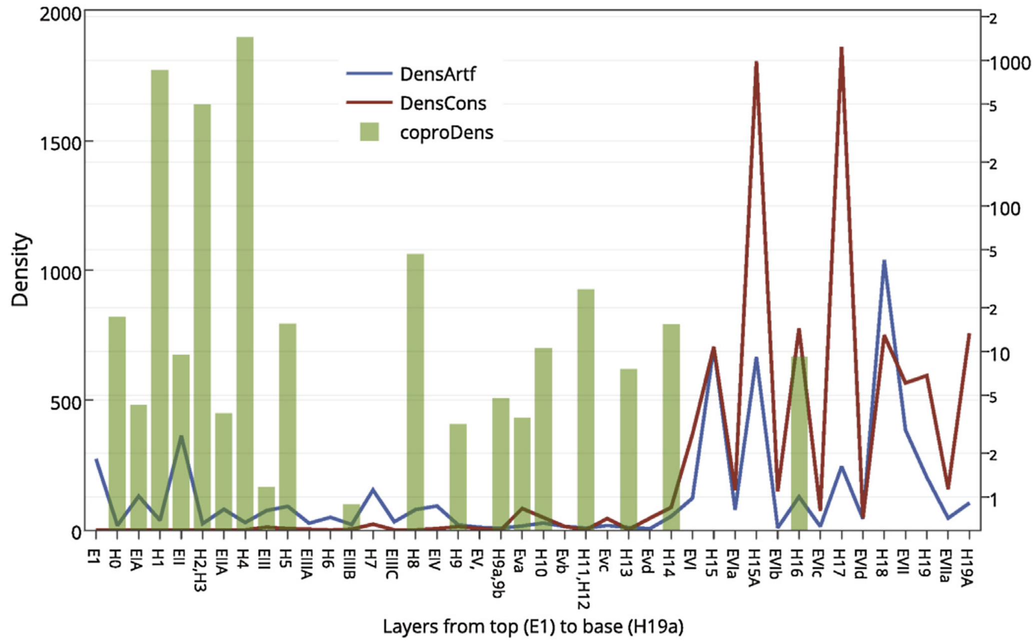

Fig. 6. Density distributions of different kind of artifacts and resources discarded in Cendres cave. Green bar reflects the density of coprolyts. DensArtf (artifact density), DensCons (resources density), CoproDens (coprolyte density). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

in the upper part of the sequence as shown in Fig. 6. In this part, the stratigraphy is composed of a succession of ashy layers with a dark-brown base resulting from fires (Fig. 5). These are known as "*fumiers*", layers formed as a result of the use of the cave as a corral. Other levels are sandwiched between them, formed as a result of the usual processes of stratification. Coprolites are found mainly in the former. Prior to layer H14 there is a possible single event, but two clusters of coprolite concentrations were observed: from layer H14 to layer H8; and from layer H4 to layer H1 (Fig. 6). In the lower cluster, the coprolite concentration is spaced so that each episode of stabling is separated from the next by another level without residues. This is not the case with the second cluster that also has a higher density of coprolites.

These differences are likely the result of different livestock management factors (e.g. herding strategies, herd size, continuity, etc.). The important question for our purposes, however, is if we can determine the main function of a particular site. Of course, herders conduct different activities (e.g., using fireplaces, repairing pottery or making tools), and these may be not the same activities they practice in other, non-specialized places, nor in the same volume or intensity. These issues may be evaluated using the archaeological record.

In the Fig. 6 we plot the density distributions of different kind of artifacts and resources discarded in Cendres cave, together with coprolite accumulations. It seems clear that the lower layers have a greater density of archaeological materials. From h14 upwards, when the cave becomes a corral, artifact density decreases dramatically, suggesting a reduction in activity.

This is the kind of pattern we expect to find associated with a specialized pen site. The radiocarbon dates place this change between c. 6900–6800 cal BP. Other caves, like Cova de l'Or show a similar pattern (Badal García et al., 2012), but with a weaker resolution. In addition changes in other data have implications for settlement patterns (Bernabeu et al., 2012). Shifts in subsistence and interaction networks suggest broad scale changes in the regional system, after 6500 B P. Similar transformations of cave use have been documented elsewhere in Mediterranean Iberia, such as at Cueva del Toro (Éguez et al., 2014), or Los Husos II (Fernández Eraso and Polo Díaz, 2008). This information supports the interpretation about the changing patterns of herding strategies suggested by the model, placing this transformation around the beginning of VII millennium cal BP.

6. Conclusions

Our aim in this work has been to analyze ways in which evolutionary processes were related to the Early Neolithic sequence in Iberia by combining information on population trends and data provided by local scenarios through virtual laboratories and the archaeological record. We use SCDPD curves as a relative proxy for prehistoric population trends (Shennan et al., 2013), enhancing this method through the use of standardized Z scores and comparisons with the number of sites dated with a series of the temporal intervals. The standardized SCDPD and site frequency curves are compared with global and local climatic proxies in order to evaluate possible relationships with climatic events. The Iberian data presented here mirrors the general pattern observed in other European Neolithic sequences with respect to a rise in population (coinciding with the arrival of food production economy) followed by a fall some centuries later (at the end of the Early Neolithic period). But when we observe the details by region, some variability in this general pattern emerges. The relationship between climatic events and the fluctuations in the SCDPD and site frequency curves show covariance at some times and in some regions, but also display important regional diversity.

The usefulness of the method in the future will require increasing the number of accurate ^{14}C dates, and comparisons with other archaeological proxies (Wood, 2015). Despite the possible impact of climatic events on prehistoric social and subsistence systems, it is necessary to investigate other internal factors to understand how local processes (sometimes acting together with climate and other times acting independently) can influence the emergence of properties that affect the entire system. The MEDLAND project provides hypotheses about the socio-ecological consequences of initial Neolithic settlement and land-use, and the study of the archaeological record from the Serpis Valley allows us to investigate the important changes detected at the end of the Early Neolithic. From current data, a new subsistence pattern with changes in livestock and agricultural practices has been proposed. As suggested (Bernabeu Aubán et al., 2014), these local shifts may have removed key groups from regional social networks, potentially resulting in the fragmentation of networks established earlier, limiting the information flow over the entire network, and then modifying the system at a global scale.

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