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Climate deterioration and subsistence economy in prehistoric Southern Iberia: an evaluation of potential links based on regional trajectories

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Abstract

The potential impact of climatic deterioration on societal breakdowns in prehistory is often based on the mere coincidence of archaeological and palaeoclimatological proxies. For a more profound discussion, climate-sensitive archaeological parameters need to be identified. As agriculture and livestock are significantly affected by the recent climate crisis, the analysis of archaeobotanical and archaeozoological remains can deepen our understanding of this topic. Here, we analyze regional trajectories in subsistence and seasonal precipitation variability across southern Iberia focusing on well-known prehistoric breakdowns around 2200 and 1600 BCE. Results suggest that the ratios of the importance of sheep/goat versus swine and sheep/goat versus cattle, respectively, may serve as a proxy for prehistoric mobility. The importance of hunting deer represents a proxy for societal turnover. While no direct link is evident between climate deterioration and the archaeozoological data, archaeobotanical data reveals a potential relation to precipitation variability. In particular, a close connection to reductions in cold-season precipitation in south-east Iberia appears likely for the ratio between barley and naked wheat. The increased importance of drought-tolerant barley correlates with a trend to reduced cold-season precipitation levels after ca. 2700 BCE. We hypothesize that prehistoric people in south-east Iberia cultivated more barley in order to adapt to periods of drier cold-season climate.

1. Introduction

In Iberian prehistory distinct societal breakdowns have taken place. For the southern Iberian Peninsula, such extraordinary events have been documented. For instance, the abandonment of various prehistoric settlement sites along with long-lasting ritual practices occurred around 2200 BCE in south-west (SW) Iberia (Valera 2015, Blanco-González *et al* 2018, Hinz *et al* 2019). The speed of such transformations that took place within some decades (Lull *et al* 2013b, García Sanjuán *et al* 2018)—and also include a breakdown of ivory trade networks (Schuhmacher 2022)—imply a social collapse in SW Iberia at that time. In contrast, in south-east (SE) Iberia human activity increased during that time despite generally arid conditions (Schirrmacher *et al* 2020b, Weinelt *et al* 2021, Benítez de Lugo Enrich and Mejías Moreno 2022). This boom in human activity is ascribed to the El Argar society, which subsequently collapsed around 1600 BCE during a period characterized by environmental degradation (Castro *et al* 1999, Lull *et al* 2011, 2013b).

Multiple causes for these societal breakdowns, including conflict (Lull *et al* 2013b, 2015) and climatic deterioration (Hinz *et al* 2019, Schirrmacher *et al* 2020b), have been proposed. Particularly, a possible climatic impact on prehistoric societies during these times is suspected, as these periods coincide with well-known global climate events such as Bond-Events and the 4.2 ka event, respectively (Bond *et al* 2001, Bini *et al* 2019). However, up to now the identification of a climatic impact on these breakdowns is often based on a mere coincidence of certain developments, which are not necessarily linked. For a discussion of possible causal relationships between climatic deterioration and societal breakdowns climate-sensitive archaeological proxies need to be identified. One fundamental pillar of human society revealing a high sensitivity to climate change since Neolithization is subsistence economy. Even during the ongoing climate crisis, agricultural production and livestock struggle across many regions (Lobell and Field 2007, Vogel *et al* 2019, Goulart *et al* 2021). In particular, the Iberian Peninsula constitutes a regional hotspot with up to 50% variability in wheat and barley yields that are affected by precipitation variability during modern times (Ray *et al* 2015, Frieler *et al* 2017, Cammarano *et al* 2019, Bento *et al* 2021). Noteworthy are different sensitivities to climatic deterioration among different cereal taxa with barley being exceptionally well adapted to arid environments such as SE Iberia (Harlan and Zohary 1966, Riehl 2019). An increasing ratio of barley to naked wheat has thus been proposed in prehistoric studies as an indicator of risk management related to climatic crisis (Halstead and Jones 1989, Marston 2011, 2015).

An overall decline in crop yields during dry years will have negative impacts on livestock as well. Apart from decreased precipitation levels limiting fodder availability, increased temperatures pose a major threat to livestock (Nardone *et al* 2006, Abdul Niyas *et al* 2015). Specifically, livestock species have different ecological niches and thus display different vulnerabilities to harsh climatic conditions. For example, under hot and dry conditions sheep and goat are usually preferred over cattle and pig (Seo *et al* 2009, 2010, Seo 2015). Such a relationship has also been suggested in prehistoric studies (Mace 1993, Allentuck and Rosen 2019). However, changes in the livestock composition can also be related to a change in lifestyle (e.g. increase in pastoralism) (Miller *et al* 2009, Marston 2011).

Altogether, the development of different cultivated and gathered plants as well as livestock and hunted animal species may help to decipher the impact of climatic deteriorations on prehistoric human societies.

In this study, we aim to discuss a potential climatic impact on prehistoric societal developments across southern Iberia beyond just coinciding data records. We achieve this by multi-proxy analyses of regional trajectories in the potentially climate-sensitive subsistence economy and their visual and statistical alignment with seasonal precipitation reconstructions. We focus our discussion on the long-term developments from the Neolithic until the early Iron Age (5500–500 BCE) with a further emphasis on the aforementioned societal breakdowns around 2200 BCE and 1600 BCE.

2. Methods

Archaeobotanical, archaeozoological, and palaeoclimatological data have been collected from the literature and public data repositories. We collected archaeobotanical data from 63 sites (2928 samples); archaeozoological data from 82 sites (a minimum of 322 samples/contexts); and 104 palaeo-precipitation datasets (45 annual mean and 59 cold-season). Detailed lists of included sites/archives are provided in supplementary tables 1 and 2.

For the archaeobotanical analysis several key categories have been identified: naked barley, hulled barley, naked wheat, einkorn, emmer, and millet as main cereals, as well as legumes, fruits, esparto grass (*Stipa tenacissima*), flax, and oat as supplementary cultivated or wild plants. For the archaeozoological analysis, we identified four main categories that are the most common domesticated and wild species: sheep-/goat, cattle, swine, and deer. It should be noted that the 'swine' category may include both, wild and domesticated species as these are often difficult to differentiate in the archaeozoological record. We did not include identified wild pig species and further consider the majority of pigs during the analyzed period as domesticated species. As such, we discuss the 'swine' category along with other domesticated archaeozoological taxa. A detailed description of the included plant and animal taxa for each category is provided in table 1.

All collected datasets have been assigned to a regional cluster (figure 1). We subdivided the southern Iberian Peninsula into south-western (SW) and south-eastern (SE) regional clusters. The clusters are based on regional archaeological trajectories during the Copper Age and the Bronze Age and have been applied in many studies so far (Lillios *et al* 2016, Schuhmacher 2017, Blanco-González *et al* 2018, Schirrmacher *et al* 2020b, Weinelt *et al* 2021). Both regional clusters have not been isolated from each other and a certain degree of interaction took place (Chala-Aldana 2022, Díaz-Zorita Bonilla *et al* 2022). The chosen boundary between the clusters agrees well with the current 500 mm annual precipitation isobar (figure 1). Thus, the climatic significance of the separation of these regional clusters is highlighted.

The archaeobotanical, archaeozoological, and palaeoclimatological data have each been combined into regionally averaged composite curves. The archaeozoological and archaeobotanical records have been aggregated by an aoristic approach (Mischka 2004, Palmisano *et al* 2017, Roberts *et al* 2019). During this approach the respective data is 'divided' across its chronological range into 100 year bins.

Table 1. Overview of archaeobotanical and archaeozoological categories and the respective included taxa.

Category	Taxa
Archaeobotany	
Naked barley	*Hordeum vulgare nudum*
Hulled barley	*Hordeum vulgare vulgare*
Naked wheat	*Triticum aestivum/compactum/durum/turgidum*
Einkorn	*Triticum monococcum*
Emmer	*Triticum dicoccum*
Millet	*Panicum miliaceum, Setaria italica*
Legumes	*Lathyrus sp.* cult., *Lens culinaris, Pisum sativum, Vicia sp.* cult., undetermined legumes
Fruits	*Olea sp., Quercus sp., Corylus sp., Pistacia sp., Vitis vinifera, Ficus sp., Arbutus unedo, Rubus sp., Bromus sp.*, undetermined fruits
Esparto grass	*Stipa tenacissima*
Flax	*Linum usitatissimum*
Oat	*Avena sp.*
Archaeozoology	
Sheep/goat	*Ovis aries, Capra sp.* (mostly *Capra hircus*)
Cattle	*Bos sp.*
Swine	*Sus sp.*
Deer	*Cervus elaphus, Capreolus capreolus* (vestigial)

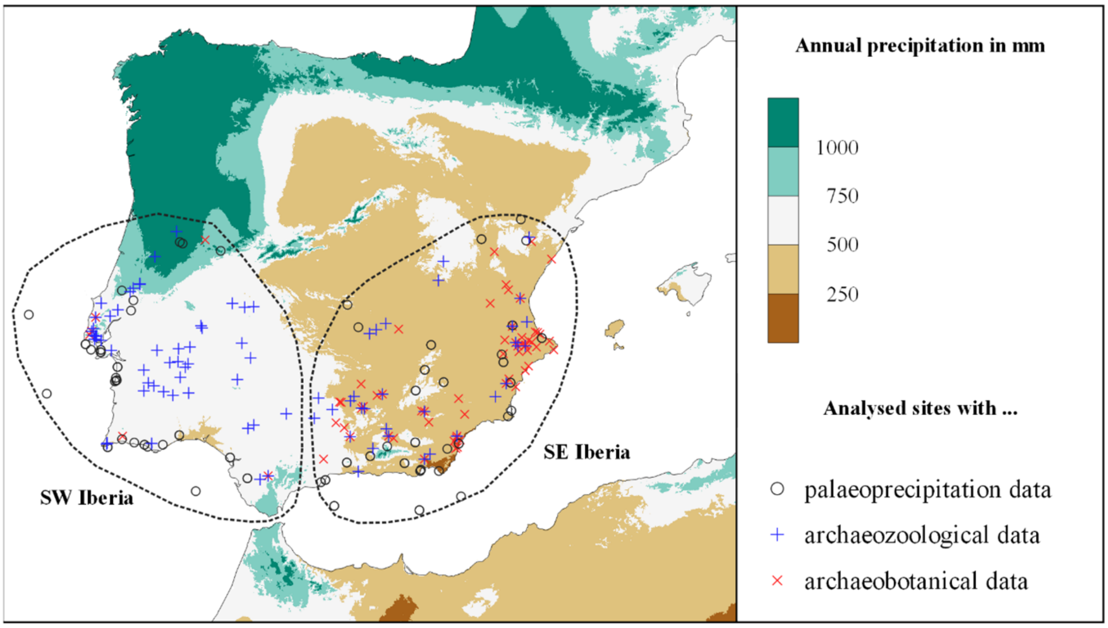

Figure 1. Overview of the study area. The map shows the modern annual mean distribution of precipitation on the Iberian Peninsula (Fick and Hijmans 2017). The locations of analyzed archaeological and palaeoclimatological sites are shown. The dotted circles enclose the two subregions within the southern Iberian Peninsula.

Accordingly, the chronological uncertainty of the regional composites is based on the chronologies of the individual sites, which is in this case usually in the range of several centuries. The chronological range of each collected archaeological site (phase) is shown in supplementary table 1. With this, the overall chronological uncertainty of the archaeological data is comparable to the mean chronological uncertainty of the palaeoclimatic composites (see supplementary table 2 for average chronological uncertainties of each archive and supplementary file 1 for updated age models). The individual palaeoclimatic datasets have been aggregated into regional and seasonal composites using a local Gaussian, regression (see supplement for further details). Both approaches, aoristics and local Gaussian regression, integrate a bootstrapping approach, which allows the presentation of the uncertainty (i.e. regional heterogeneity) within each composite curve. In addition, composite kernel density estimates of summed radiocarbon probability distributions (SPDs) have been calculated for each regional cluster to indicate the timing of prominent archaeological developments in each region.

A detailed description of the methodological approach is provided in the supplement of this article. In addition, all raw data including the programming code for reproducing the analysis is archived at Zenodo (https://doi.org/10.5281/zenodo.10020818).

3. Results and discussion

3.1. Neolithic and Chalcolithic developments

During much of the Neolithic until ca. 3500 BCE, both regional clusters show a large agreement in the overall archaeozoological developments (figures 2 and 3). In both regions, a dominance of sheep and goat is suggested, which is much more pronounced in SE Iberia probably related to topographic conditions (Supplementary figures 2 and 4). It needs to be cautioned, though, that the results during this phase are based on only a few studied sites. The first notable change in the archaeozoological record of both regions occurs around 3500 BCE (figures 2 and 3). At that time an increase in both swine and cattle is noted while sheep and goat decrease (figures 4 and 5). Notably, these developments are coherent with an increase in analyzed sites (figures 2 and 3), but also with an increase in radiocarbon based human activity reconstructions in both regions (figures 4 and 5). An increase in sites and associated human activity at that time suggests the establishment of a more sedentary lifestyle. This is in line with the beginning of the construction of ditched enclosures (Valera 2012, Blanco-González *et al* 2018, García Sanjuán *et al* 2018) as well as prominent fortified settlements such as Zambujal (Kunst and Lutz 2008) and unusual long-distance migration during that time in SW Iberia (Waterman 2023). Moreover, in SE Iberia, an increase in sedentism around that time is well known (McClure *et al* 2006, Chapman 2008, García Sanjuán *et al* 2016). The archaeozoological results imply that a change from sheep and goat to swine and cattle as preferred domesticated animal species is a characteristic feature of this development in southern Iberia. A similar composition of livestock is also found in other sedentary societies across the Mediterranean at this time (Allentuck and Rosen 2019). This agrees with sheep and goat being regarded as tracers of pastoralism and high mobility in prehistoric and modern settings (McClure *et al* 2006, Degen 2007, Miller *et al* 2009, Marston 2011). In addition, a prevalence of swine during the Chalcolithic in SW Iberia is commonly linked to settled agricultural economies (Pérez Ripoll 1999) and size differences in SW Iberia large game were interpreted as possibly showing a relaxation of hunting pressure on these animals (in comparison to the Mesolithic), possibly already during the Neolithic but specifically in the Chalcolithic (Davis and Mataloto 2012, Davis and Detry 2013).

In SW Iberia, no particular climatic developments are noted around 3500 BCE, but reconstructed annual precipitation levels in SE Iberia suggest a prominent transition to drier conditions after ca. 3500 BCE (figure 5). This prominent increase in aridity is in line with the overall climatic developments in the Mediterranean including the end of the African Humid Period and the establishment of the modern Mediterranean-type climate with its pronounced seasonality in the region (deMenocal *et al* 2000, Jalut *et al* 2009, Walczak *et al* 2015, Baldini *et al* 2019, Finné *et al* 2019). The reason why no corresponding development is notable for SW Iberia might be related to the higher exposure to the Atlantic climate regime (Martin-Vide and Lopez-Bustins 2006, Schirrmacher *et al* 2020a, Liu *et al* 2023) and/or proxy sensitivity. Regarding the latter, it should be noted that the majority of proxies used to reconstruct annual mean precipitation levels are xerophytic pollen percentages (supplementary table 2). These plants are particularly adapted to seasonal aridity (Cariñanos *et al* 2004). Accordingly, the rapidly increasing abundance of xerophytic plants at that time points to the onset of seasonal (i.e. summer) aridity in southern Iberia. Generally, seasonal aridity is much more pronounced in SE Iberia compared to SW Iberia, where fewer xerophytic plants grow. In conclusion, albeit more pronounced in SE Iberia, the establishment of the Mediterranean-type climate around 3500 BCE likely affected both regions.

Archaeological and climatic developments around 3500 BCE could have well happened coincidently within the respective age uncertainties (±300 years for the climatic reconstruction and up to several centuries for the archaeological data). However, a direct causal relationship between the archaeozoological and climatic data would assume a decrease of cattle and swine during climatic stress (Mace 1993, Seo 2015, Allentuck and Rosen 2019). While a direct relationship to increasing sedentism appears highly likely for the archaeozoological developments around 3500 BCE in both regions, the increase in sedentism itself could well be an adaptation to the establishment of summer aridity in the area. However, the lack of any archaeobotanical response during this time likely counteracts this hypothesis. An alternative explanation for why there is no archaeobotanical response might be that naked wheat, which was the dominant cereal taxa at that time, was grown as winter wheat. Consequently, profound aridity during the summer season possibly had only a limited impact on the societies' agriculture at that time.

In this respect, it is interesting that the major event in the archaeobotanical record of SE Iberia (i.e. a distinct transition from wheat to barley dominance) around 2700 BCE occurred at the onset or acceleration of a regional aridity trend in cold-season

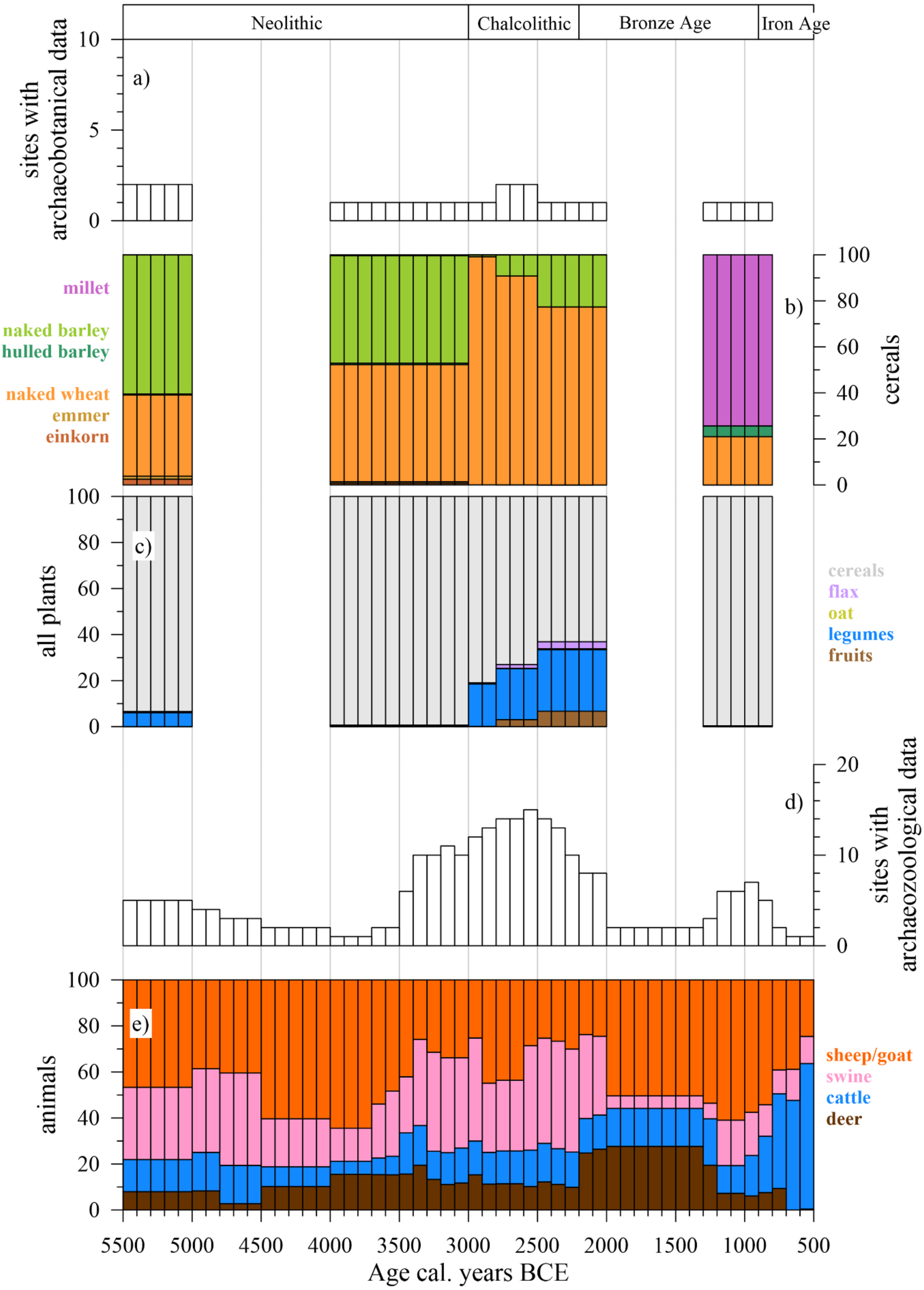

Figure 2. Archaeobotanical and archaeozoological results from southwest Iberia. (a) The number of sites with archaeobotanical remains per 100 year temporal bin is shown above (b) the respective regional mean of the cereal taxa proportions. The periods between 5000–4000 BCE and 2000–1300 BCE are not documented by any sites after applying the quality criterion (i.e. minimum 100 counted archaeobotanical remains). Proportions of other cultivated and wild plants are shown in relation to the total cereal proportions in (c). At the bottom the number of sites with archaeozoological remains (d) are shown on top of (e) the corresponding animal taxa proportions.

precipitation in both regional clusters at that time (figures 4 and 5). The mean chronological uncertainty of the climatic reconstructions at this time is around ±300 years. Unfortunately, the overall archaeobotanical results for the SW Iberian cluster are not representative as the results are only based on at maximum two archaeological sites (figure 2). Thus, it is not possible to evaluate whether this

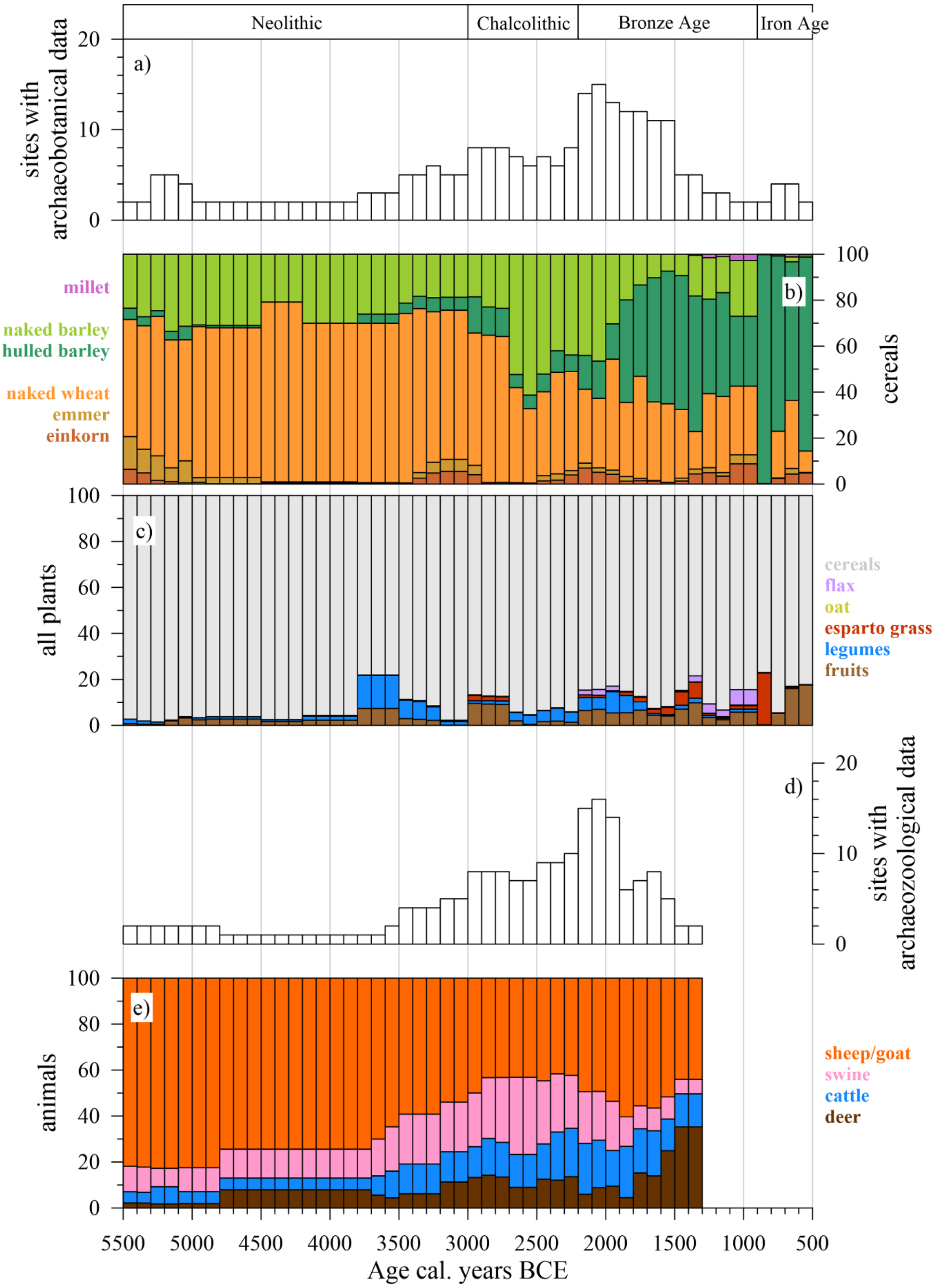

Figure 3. Archaeobotanical and archaeozoological results from southeast Iberia. (a) The number of sites with archaeobotanical remains per 100 year temporal bin is shown above (b) the respective regional mean of the cereal taxa proportions. Below that the proportions of other cultivated and wild plants are shown in relation to the total cereal proportions (c). At the bottom the number of sites with archaeozoological remains are shown (d) on top of (e) the corresponding animal taxa proportions.

distinct transition in the archaeobotanical record is a regional phenomenon. Nevertheless, such a change from wheat to barley dominance could well point towards an adaptation strategy related to climate change in prehistoric Mediterranean societies (Halstead and Jones 1989, Riehl 2009, Marston 2011, 2015). A cultural response to decreasing cold-season precipitation in SE Iberia at that time is also underpinned by a good correlation with the barley to wheat ratio (rho $= -0.74$; $p < 0.05$).

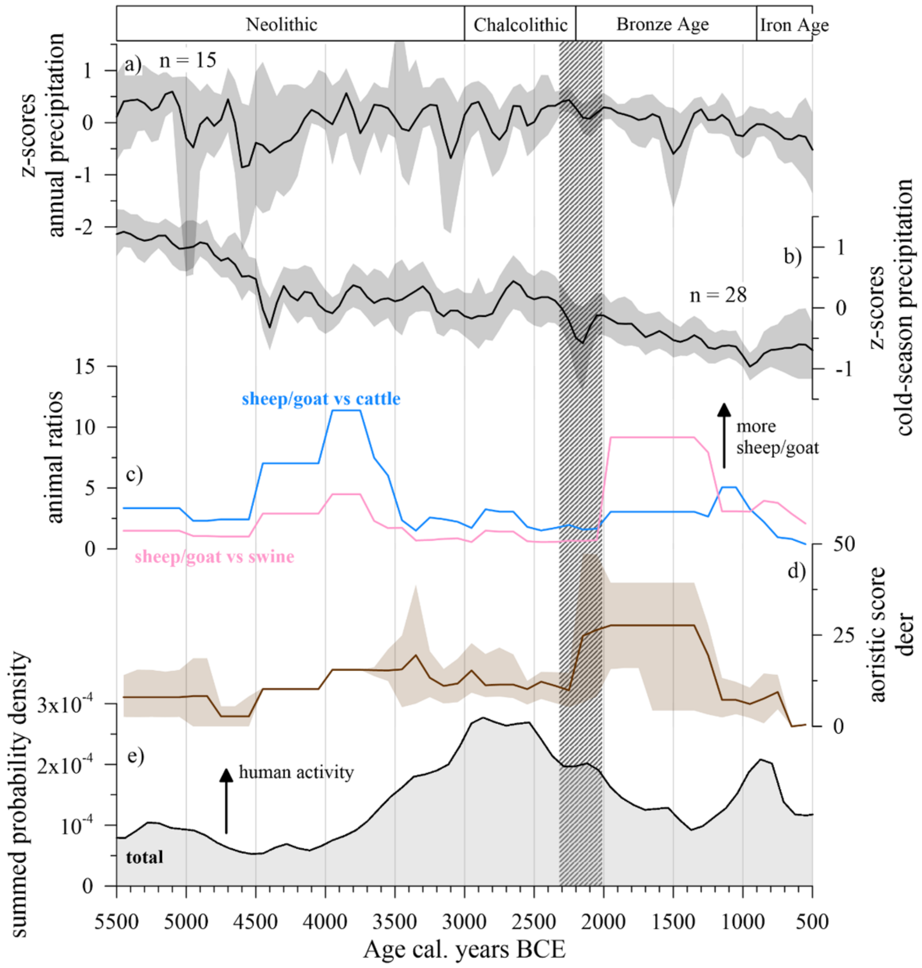

Figure 4. Comparison of precipitation variability to prehistoric subsistence in southwest Iberia. Composite records of (a) annual mean and (b) cold-season precipitation proxies is shown along with their 95% probability interval (grey shading). Below that (c) the animal ratios of sheep/goat vs cattle (blue) and swine (pink) are shown above (d) the aoristic score of deer and its associated 95% probability interval (brown shading). Reconstructed human activity from archaeological radiocarbon dates (2945 dates from 491 sites) (e) in presented at the bottom. The hatched bar indicates the period of major societal turnover around 2200 BCE.

3.2. Chalcolithic to Bronze Age transition around 2200 BCE

The time around 2200 BCE can be characterized as a period of fundamental societal transformation in southern Iberia. The archaeological record of SW Iberia features a pronounced societal breakdown noted through a decline in human activity (figure 4) and the abandonment of various sites including, for example, ditched enclosures (Valera 2015, Blanco-González *et al* 2018, García Sanjuán *et al* 2018). Furthermore, a breakdown of trade networks (Schuhmacher 2022) along with the establishment of a semi-nomadic lifestyle is suggested for the majority of societies (Lull *et al* 2013b, Valera 2015). Indeed, the archaeozoological data suggests a sharp increase in the hunting of deer after ca. 2200 BCE followed by an increase in the sheep/goat to swine ratio, both indicating an increase in pastoralism (O'Shea 1989, Miller *et al* 2009, Marston 2011, Valente and Carvalho 2014) and thus, serving as an indicator of societal breakdown and crisis in this case (Almeida and Valera 2021). While human activity in SW Iberia rapidly decreased after 2200 BCE, it sharply increased in SE Iberia (figure 5) (Schirrmacher *et al* 2020b, Weinelt *et al* 2021). This boom in human activity in SE Iberia is associated with a transition from the Chalcolithic Los Millares to the El Argar society (Chapman 2008)—the latter often considered as the first political and hierarchical society in Iberia (Lull *et al* 2011). During this period, defensive hilltop sites ensuring a good visual control over surrounding areas are the prominent settlement type to be found (figure 5) (Chapman 2008). Similar social trajectories with El Argar are also evident in southern Meseta and Valencia (Aranda *et al* 2008, Chapman 2008, Lull *et al* 2011) and as such a general archaeological feature of the SE Iberian cluster.

The occurrence of a contemporaneous cold-season aridity event around 2200 BCE (±300 years) in both regions (figures 4 and 5) highlight the possibility of a climatic influence on the archaeological developments in southern Iberia. So far, a climatic influence on this societal breakdown has been intensively discussed but still remains rather elusive (Blanco-González *et al* 2018, Hinz *et al* 2019,

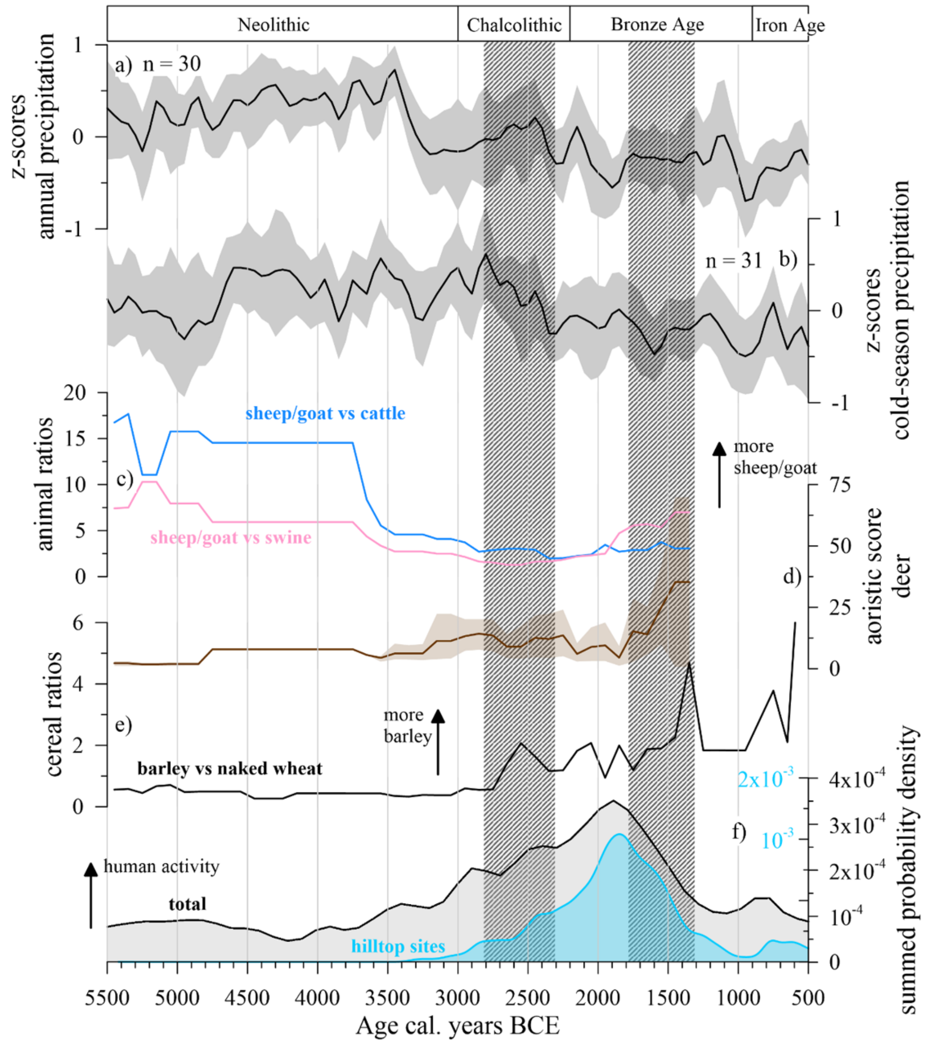

Figure 5. Comparison of precipitation variability to prehistoric subsistence in southeast Iberia. Composite records of (a) annual mean and (b) cold-season precipitation proxies is shown along with their 95% probability interval (grey shading). Below that (c) the animal ratios of sheep/goat vs cattle (blue) and swine (pink) are shown above (d) the aoristic score of deer and its associated 95% probability interval (brown shading). (e) The ratio of total barley (naked and hulled) to naked wheat is shown. Reconstructed human activity from archaeological radiocarbon dates for entire SE Iberia (2992 dates from 392 sites) and hilltop sites exclusively (blue; 535 dates from 51 sites) (f) in presented at the bottom. The hatched bars indicate the transitional period towards overall decreased cold-season precipitation around 2700 BCE as well as the period of major societal turnover around 1600 BCE.

Weinelt *et al* 2021). Due to the lack of archaeobotanical data for SW Iberia, it is difficult to reliably discuss a relationship between the societal breakdown and the 4.2 ka event in this region. Contrary to known adaptations related to the 4.2 ka event in the Levant (Riehl 2009), no adaptive response in the archaeobotanical data is notable during this period in SE Iberia. However, this must not necessarily mean that prehistoric societies in the area were not affected by climatic deterioration during the 4.2 ka event. For instance, it has been proposed that large fortified wells (motillas) in the river plains of the Guadiana have been constructed in close relation to the 4.2 ka event (Benítez de Lugo Enrich and Mejías 2017, Benítez de Lugo Enrich and Mejías Moreno 2022). The motillas were able to access the groundwater and thus, provide an innovation at that time due to which SE Iberian societies likely became less dependent on short-term aridity events (Benítez de Lugo Enrich and Mejías 2017). In addition, isotopic evidence from prehistoric crops suggest that irrigation techniques were also practiced at suitable sites such as Peñalosa (Mora-González *et al* 2019) and Terlinques (Mora-González *et al* 2016). But, rain-fed cereal agriculture likely prevailed in the hilltop sites (e.g. Gatas and La Bastida) (Knipper *et al* 2020). Altogether, it appears possible that SE Iberian societies managed to cope with short-term aridity events during this period by altering their cereal spectrum towards barley already around ca. 2700 BCE and by the application of irrigation where possible.

3.3. Bronze Age and early Iron Age developments

In SW Iberia the Bronze Age period is characterized by a lack of evidence for settlement activity (Lull *et al* 2013a, Valera 2015, Blanco-González *et al* 2018). In consequence radiocarbon-inferred human activity remains relatively low (figure 4). In SE Iberia, on the other hand, human activity boomed (figure 5) associated with El Argar and related societies. During the El Argar period, many hilltop sites emerged (figure 5) (Chapman 2008). These are proposed to have controlled the subsistence economy in the surrounding plains, which was mainly based on barley cultivation (Castro *et al* 1999, Aranda *et al* 2008, Lull *et al* 2011, Delgado-Raack and Risch *et al* 2015). The demographic peak in SE Iberia occurred between ca. 2000 and 1800 BCE. During the same time the sheep/goat to swine ratio increases (figure 5). In this case, an increase in pastoralism cannot explain this development. Based on a close correlation of the archaeozoological data with the elevation of the sites (rho = 0.89; $p < 0.05$; Supplementary figure 2) and the peak in hilltop settlements (figure 5), we argue that the increase in sheep and goat after ca. 2000 BCE reflects the decision of the argaric society to settle on hilltops—landscapes, in which sheep and goat likely have been the preferable livestock species.

The collapse of the El Argar society is dated to around 1550 BCE (Lull *et al* 2013b) and also well-conceived from the human activity (figure 5). This collapse is characterized by a further increase of sheep and goat (in relation to swine) as well as a pronounced increase in the hunting of deer (figure 5). Here, these developments again appear to suggest an increase in pastoralism after the argaric breakdown. Notably, the period around 1600 BCE (±260 years) is also characterized by a distinct drop in cold-season precipitation levels (figure 5). This aridity event is accompanied by an increase in esparto grass (*S. tenacissima*) in the archaeobotanical record (figure 3); a plant species known as tracer of aridity (Maestre *et al* 2007). A contemporaneous increase in the importance of barley peaking at ca. 1400 BCE is also evident. Such an increase in barley cultivation during the late argaric period has been noted by earlier studies and is often related to intense environmental overexploitation practiced by the argaric society (Castro *et al* 1999, Lull *et al* 2013b). Finally, this has been proposed to contribute to the collapse of the argaric system (Lull *et al* 2013b). Our analysis of regional precipitation variability suggests that in combination with environmental overexploitation, a pronounced decrease in cold-season precipitation could have resulted in challenging agricultural conditions potentially leading to the collapse of the argaric society.

Another notable change occurred at the Bronze Age/Iron Age transition in both regions. At that time, an increased number of settlements is noted again in SW Iberia (Blanco-González *et al* 2018). The archaeozoological data suggests that this development is accompanied by an increasing importance of cattle (in favor of sheep and goat) and a reduction in the hunting of deer (figure 4). Thus, an increase in sedentism can be inferred for this period in SW Iberia and agrees with increasing human activity in the area (figure 4). Despite the lack of archaeozoological data in the SE, similar developments (i.e. an increase in human activity) is noted around 900 BCE (figure 5). In SE Iberia, the increase in human activity is accompanied by an increase of fruits after ca. 700 BCE in the archaeobotanical record (figure 3). All these developments in both regions occurred during a pronounced drop in cold-season precipitation at 900 BCE (±270 years) (figures 4 and 5). Again, this dry event is signified by a pronounced increase in drought-tolerant esparto grass (*S. tenacissima*) in SE Iberia (figure 3). A distinct increase in barley during this time (figure 5) points to a potential adaptation of SE Iberian societies during this period. However, as the archaeobotanical data is just based on a few sites during this period (figure 3), final conclusions should be made with caution. The archaeological developments in both regions after ca. 900 BCE are more likely related to the arrival of the Phoenicians in southern Iberian coastal areas and the related onset of, e.g., arboriculture (Suárez-Padilla *et al* 2021, Peña-Chocarro and Pérez-Jordà 2022). This is as well emphasized by decreasing elevation and distance to the coast of the studied archaeological sites (supplementary figures 2 to 4).

4. Conclusion

The parallel discussion of regional trajectories of animal husbandry and agriculture with seasonal precipitation variability between 5500 and 500 BCE allows a deeper discussion of a potential climatic influence on known societal breakdowns in southern Iberia. We suggest that certain archaeobotanical taxa are sensitive to precipitation variability especially in SE Iberia. A particular impact of cold-season precipitation reductions on the barley vs. naked wheat development was noticed. For instance, a long-term reduction in cold-season precipitation starting around 2700 BCE is coincident with a reduction in wheat and an increase in drought-tolerant barley. We suggest that after this period, prehistoric people in SE Iberia cultivated more barley in order to adapt to reduced cold-season precipitation. Interestingly, prehistoric societies appear to have been less prone to climate change along with the onset of the Mediterranean-type climate and its associated summer aridity after ca. 3500 BCE. Around this time no specific change in the spectrum of cultivated crops is noted. However, it is around that time when a pronounced decrease in the importance of sheep and goat in accordance with an increase in swine and cattle is observed suggesting an increase in sedentism in southern Iberia. Accordingly, an opposite development of these animal ratios after a pronounced societal collapse around ca. 2200 BCE in SW Iberia likely mirrors increased mobility and pastoralism. Similar developments are noted after ca. 1600 BCE related to the collapse of the El Argar society in SE Iberia. Another particular feature of both societal breakdowns appears to have been played by the hunting of deer, which increases during both periods in the respective region. Consequently, we suggest that the archaeozoological data is primarily a function of societal decisions. These decisions, in turn, may well have been influenced by climatic forces. An impact of a coincident reduction in cold-season precipitation with the societal turnover around 2200 BCE in SW Iberia remains speculative due to the lack of archaeobotanic data. The argaric collapse, on the other hand, was likely influenced by a distinct reduction in cold-season precipitation as indicated by an increase in barley cultivation starting at ca. 1600 BCE.

Data availability statement

The data that support the findings of this study are openly available at the following URL/DOI: https://doi.org/10.5281/zenodo.10020818.

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