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Human responses to Younger Dryas in the Ebro valley and Mediterranean watershed (Eastern Spain)

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ABSTRACT

The archaeological and chronological records of the Ebro River valley and the Mediterranean watershed (Eastern Spain) are examined to evaluate the effects of the Younger Dryas (Greenland Stadial 1) on the foragers of an area between 36° and 43° N. The conclusions will contribute to a more complete understanding of Younger Dryas effects in SW Europe.

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1. Introduction

The temperate, arid climate of Mediterranean Spain suggests paleoclimatological continuity from the Tardiglacial through the Younger Dryas. The effects of the Younger Dryas were mild and relatively gradual, lessened by both latitude and the influence of the Mediterranean Sea. In this region, there are no definitive markers of the boundary between tardiglacial conditions and postglacial ones, such as extinctions or migrations of cold-adapted fauna; except for traces in northern Catalonia, there were never reindeer in Mediterranean Spain, even at its coldest. Likewise, the Younger Dryas does not appear to have slowed sea level rise or the associated inundation of the coastline. In contrast to the record of Northern Europe, in Iberia the colonization of areas newly free of ice was limited to extremely high elevations and mountains. Neither do the Balearic Islands offer evidence of a human presence during this time. There is a growing consensus that the influence of these changes in prehistoric humans offers a point of reflection for current humanity (Straus and Eriksen, 1998), also confronting a rapid climate change – in this case caused by industrial societies.

The persistence of Paleolithic cultural traditions into the early Holocene has supported the use of "Epipaleolithic" to describe this process in much of southern Europe (see Fortea Pérez (1973) and references therein). However, during this transition, which coincides with the Younger Dryas, three important cultural transformations can be identified: a) the end of the Palaeolithic parietal and portable art; b) the abandonment of bone and antler as raw material for complex tools (harpoons or points with diverse basal treatments) and for ornaments; and c) in lithic industries, the continued production of laminar microliths and a general trend towards microlithization. Summarized dates indicate that these traits spread rapidly, though for different reasons in different regions of Iberia (Aura et al., 1998; Fullola, 2001; Garcia-Arguelles 2004).

2. Study area

The Iberian Peninsula is a patchwork of geomorphological and ecological landscapes with two large bioclimatic regions: the Euro-Siberian and the Mediterranean. In this geographical context, two areas of the Iberian Peninsula between 36° and 43° N are compared:

The Ebro valley is a natural corridor between the Cantabrian and Mediterranean regions, two very different bioclimatic zones. The Ebro valley is bounded by the Pyrenean, Catalan-Coastal and Iberian Ranges. Its altitude ranges from 100 to 2000 m asl.

The Mediterranean watershed is a narrow band of ±40 km from the current coastline to inland valleys, with altitudes between 0 and 1500 m asl. It is bordered by the Catalan-Coastal and the Betic Ranges. This coastal band is a natural corridor between the northeast and the southwest Iberian Peninsula. Within this Mediterranean region, two main areas are considered in this paper: Valencia and Andalusia. Both areas have a sparse record of open-air archaeological sites. However, more than fifty caves and rock-shelters have provided chronological, paleoenvironmental and archaeological data, but with differing scales of resolution (Fig. 1). The paucity of archaeological sites dating to the Younger Dryas may be a result of climate-induced erosion in these regions.

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Fig. 1. Main Eastern Spain sites mentioned in text and assigned to GI 1, GS 1 (Younger Dryas) and Preboreal.1: Abauntz; 2: Atxoste and Mendandia; 3: Zatoya; 4: Peña 14 and Legunova; 5: Chaves; 6: Forcas; 7: Peña del Diablo; 8: Los Baños; 9: Ángel; 10: Agut; 11: El Filador; 12: Els Diablets; 13:Cova Matutano; 14: Cova dels Blaus; 15: Cueva de la Cocina; 16: Les Malladetes; 17: El Collao; 18: Penya del Comptador 19: Tossal de la Roca and Coves de Santa Maira; 20: Cova de les Cendres; 21: Cueva de Nerja; 22: Hoyo de la Mina; 23: Gorham's cave.

3. Objectives

This paper evaluates the effect of the Younger Dryas (Greenland Stadial 1) on the activities of foragers in these regions of Eastern Spain. It critically reviews the available archaeological, chronostratigraphic and paleoenvironmental data from these regions, combining archaeological artifact typology with geochronology, from the end of GI-1 through the early Holocene. The objective is to draw a set of conclusions that will increase knowledge of the impact of the Younger Dryas on one of the warmer regions of southern Europe.

First, the chronostratigraphic and paleoenvironmental framework of the areas of study are described. The chronological framework focuses on the Younger Dryas, although it includes data from before and after the event (altogether, from 17 to 8.5 ka calibrated BP) to better assess the long-term trends. The compiled record of ^{14}C dates has been calibrated using CalPal software (Weninger et al., 2007). The accumulated probability curves of the calibrated dates are compared with two palaeo-climate proxies: the GISP2 Hulu Age Model from the Greenland Summit (Grootes et al., 1993; Meese et al., 1994; Sowers et al., 1993) and Sea Surface Temperature MD-950243 from the Alboran Sea (Cacho et al., 1999, 2001a). The regional data for the Younger Dryas are compared with global palaeoclimatological proxies.

Second, the main archaeological and cultural trends coincident with the Younger Dryas, both in technological production (lithic and bone tools) and in subsistence strategies (zooarchaeological and paelobotanical data) are summarized. In the Ebro valley, faunal preservation is irregular and pollen analysis provides the main paleobotanic data (González-Sampériz, 2004; González-Sampériz et al., 2006; Iriarte et al., 2008). In the Mediterranean region, the fauna is better preserved and paleobotanical estimations are supported by anthracological analyses (Badal and Carrión, 2001).

4. Palaeoclimatological framework

The stratigraphic sequences of the caves and rock shelters are discontinuous and attest to various erosive events, perhaps associated with changes in humidity/aridity (Fumanal, 1986). In the Mediterranean watershed, this is the case at Tossal de la Roca and Santa Maira (Valencia) and at Cueva de Nerja (Andalusia), where

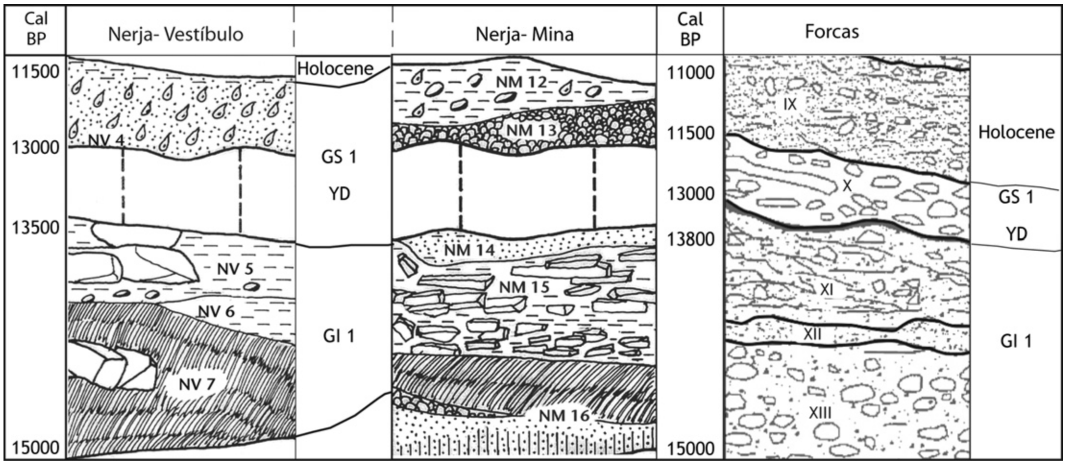

Fig. 2. Lithostratigraphic sections from Las Forcas (Ebro valley, after Utrilla and Mazo, 2007) and two sectors from Cueva de Nerja (Southern Spain). The Nerja sections do not show levels of clasts attributed to the Younger Dryas (Jordá Pardo, 1986).

the deposits dated to the Younger Dryas are associated with erosion events (Jordá Pardo, 1986; Cacho et al., 2001b; Jordá Pardo and Aura, 2008). In the Ebro valley, cold events are recorded in Forcas-1 level 10; Peña 14 level d, and Peña del Diablo-1, level 2 (Utrilla and Montes, 2007, 2009a) and at other sites in the northeast peninsula (Bergadà, 1998). The lithostratigraphy shows scarce amounts of oblate éboulis clasts attributed to Younger Dryas frost action (Fig. 2).

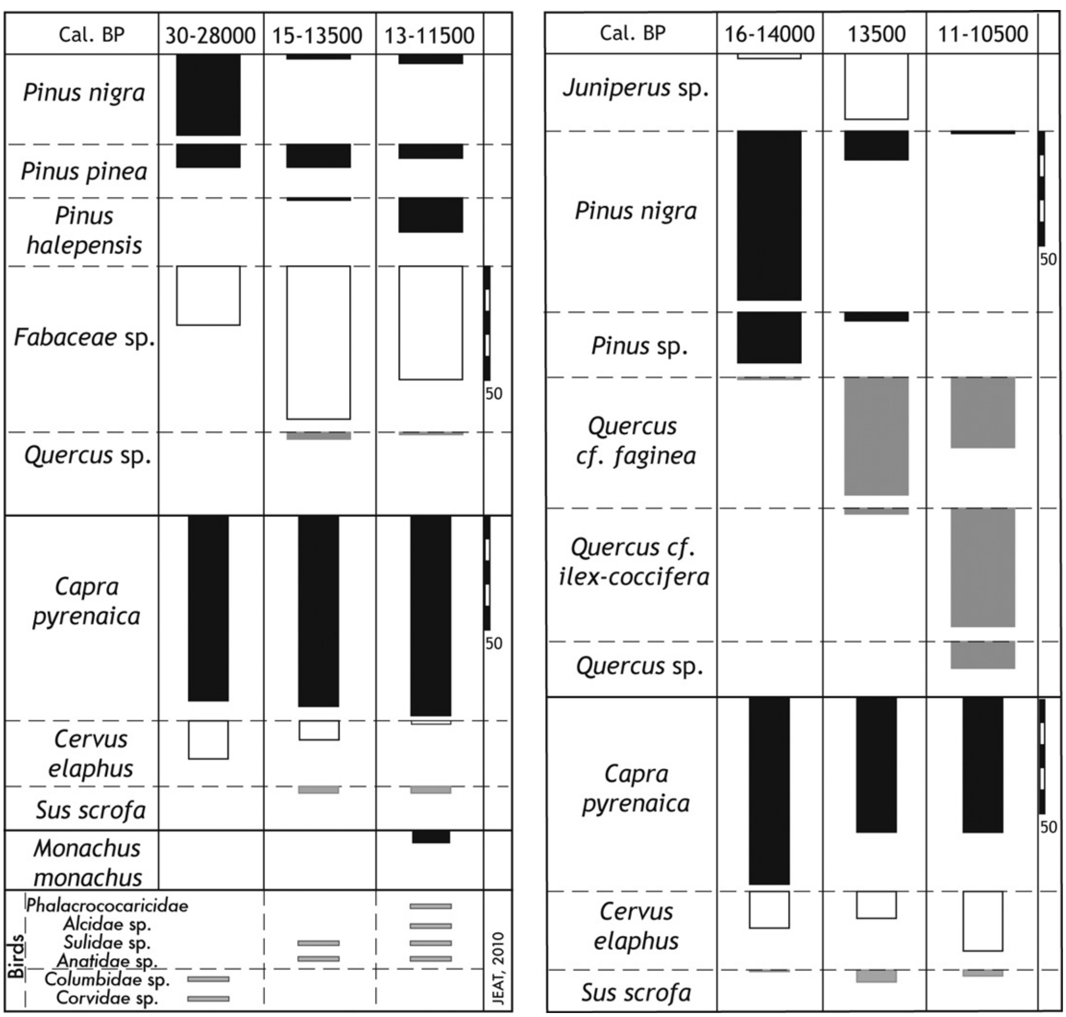

Fig. 3. Diachronic percentage of main floral and faunal taxa from Valencian (Tossal de la Roca: Cacho et al., 1995; Cacho and Jordá Pardo, 2009) and Andalusian sites (Cueva de Nerja: Aura et al., 2002a,b and 2009). Fauna is expressed as NISP, charcoal frequency taxa and marine-birds composition from Nerja. Right side: Diachronic percentage of main floral and faunal taxa from Valencian (Tossal de la Roca: Cacho et al., 1993; Cacho and Jordá Pardo, 2009). Left side: Andalusian sites (Cueva de Nerja: Aura et al., 2002a,b, 2009). Fauna is expressed as NISP, charcoal frequency taxa and marine-birds composition from Nerja.

The archaeobotanical record at the Pleistocene–Holocene boundary shows a diverse landscape with upward migration of *Pinus* sp. and *Juniperus* sp. steppe and woodland, and expansion of oak. During the Younger Dryas, cold is recorded in the form of expansion of xerophytic species (Carrión et al., 2010). The palynological record from the El Portalet peatbog sequence reflects the paleoclimatic evolution and vegetation history in the central-western Pyrenean Range. Data from the basal part of the sequence (ca. 33,000 cal BP) confirms that the last deglaciation occurred earlier in the Pyrenees than in northern latitudes of Europe. An interruption in sedimentation during the Younger Dryas stade suggests that the lake may have been frozen, although this period was not long enough to result in any substantial glacier readvance (González-Sampériz et al., 2006).

Data from Nerja Cave show important changes in both continental and marine areas (Fig. 3). During the Pleniglacial period, the *Pinus nigra* charcoal record suggests 13–17 °C as the annual average temperature (Badal, 1998), whereas the superficial marine water from the Mar de Alborán (MD95-2043) ranged between 10 and 12 °C. During the GI-1 period, Mediterranean warm species increase and *Pinus nigra* falls, but in YD it is associated with the current Mediterranean taxa, *Pinus halepensis*. In the GI-1 period the sea water temperature oscillated between 12 and 14 °C, with a minimum range of 11 °C in YD (Cacho et al., 1999, 2001a).The presence of cold fauna in the Mediterranean region of Iberia is sporadic. Data from the remains of four mature individuals of *Mammuthus primigenius* from the Padul peatbog (Betic Range, Grenada, S Spain) dated to 40-30 ka cal BP have recently been published (Álvarez-Lao et al., 2009). However, during the Last Glacial Maximum and in the Late Glacial, cold fauna are recorded only on the northern edge of the Ebro valley. The last record of reindeer is in the Cantabrian and Pyrenean ranges in GI 1 (González Sainz, 1989). Meanwhile, fauna in the east and south of Iberia indicate open pine forest with red deer, ibex, lynx and rabbit (Villaverde et al., 1998).

The zooarchaeological record from the Younger Dryas does suggest cold climatic conditions, but only in the marine fauna from Nerja, including molluscs (*Pecten maximus*, *Littorina* sp. or *Nuccella lapillus*), fish (*Melanogramus aeglephinus* and *Pollachius pollachius*) and birds (*Pinguinus impennis*) (Jordá Pardo et al., 2003; Aura et al., 2002a, 2002b). The marine-birds recorded in GI-1 and GS-1 suggest sea level rise and the proximity of the coastline (Fig. 3).

5. Chronology

The chronological framework centers on the Younger Dryas, although data before and after were considered for a better assessment of trends. A total of 179 dates from 36 sites, between 17 and 8.5 ka cal BP, were used. Of the ^{14}C dates, 95 are conventional and 83 are AMS. There is also a single thermoluminescence date.

The final analysis focused on 60 dates with standard deviations of less than 100 years: 34 dates from Ebro valley and 26 from the Mediterranean region (Valencia and Andalusia). Calibration of ^{14}C dates was done used the CalPal 2007 Hulu calibration curve (Weninger et al., 2007). The result is a database of calibrated dates (Tables 1 and 2).

The site levels and dates have been grouped into four archaeological sub-divisions: A1) Final Magdalenian, A2) Mediterranean Microlaminar Epipalaeolithic and Azilian, A3) Final Epipalaeolithic with mini-microliths, and B1) Mesolithic with notches and denticulates. The final Mesolithic (B2), a phase with blades, trapezes and triangles of 'Cocina type' (Fortea Pérez, 1973), is not considered in this paper. CalPal was used to draw different cumulative probability curves: first, a single curve for each region; and second, separate curves both for each region and for the four archaeological horizons considered.

Table 1

Site and level	Phase	Lab. No	Age BP		Age Cal BP (p 95%)	Age Cal BC (p 95%)	Sample	Reference
Peña 14-b	B	GrN-25999	8000 ± 80	80	9110 - 8590	7160 - 6640		Montes et al., 2006
Atxoste V	B	GrA-13448	8030 ± 50	50	9100 - 8700	7150 - 6750	Bone	Alday y Cava, 2006
Los Baños -2b1	B	GrA-21556	8040 ± 50	50	9100 - 8700	7150 - 6750		Montes et al., 2006
Legunova -1	B	GrA-24292	8200 ± 50	50	9340 - 8980	7390 - 7030	*Charcoal*	Montes et al., 2006
Ángel 2 - 2b	B	GrA-22836	8310 ± 60	60	9510 - 9110	7560 - 7160		Montes et al., 2006
Ángel 1-8d	B	GrA-22826	8390 ± 60	60	9540 - 9260	7590 - 7310		Montes et al., 2006
Atxoste VI	B	GrA-15699	8760 ± 50	50	9990 - 9550	8040 - 7600	Bone	Alday y Cava, 2006
Forcas II -Ib	B	Beta-59997	8650 ± 70	70	9830 - 9470	7880 - 7520		Utrilla & Mazo, 2007
Legunova 2	B	GrA-24294	8800 ± 60	60	10210 - 9570	8260 - 7620	*Charcoal*	Montes et al., 2006
Atxoste D	B	GrA-13473	8840 ± 50	50	10250 - 9650	8300 - 7700	Bone	Alday y Cava, 2006
Atxoste VI	A3	GrA- 15858	9550 ± 60	60	11190 - 10630	9240 - 8680	Bone	Utrilla et al., 2010
Atxoste VIb2	A3	GrA-35142	9510 ± 50	50	11170 - 10570	9220 - 8620	Bone	Utrilla et al., 2010
Atxoste -e	A3	GrA-35141	9450 ± 50	50	10860 - 10540	8910 - 8590	Bone	Utrilla et al., 2010
Forcas I-9	A2	GrN-17785	9712 ± 75	75	11350 - 10750	9400 - 8800	Charcoal	Utrilla et al., 2010
Peña 14 -d	A2	GrN-26000	10630 ± 100	100	12840 - 12320	10890 - 10370	Charcoal	Montes, 2005
Legunova -m	A2	GrA-24295	10760 ± 60	60	12790 - 12670	10840 - 10720	Charcoal	Montes, 2005
Urratxa III -II	A2	Ua-11433	10240 ± 100	100	12490 - 11530	10540 - 9580	Bone	Muñoz & Berganza, 1997
Portugain -I	A2	GrN-14097	10370 ± 90	90	12690 - 11890	10740 - 9940	Bones	Barandiarán & Cava 2008
Forcas I -10	A2	GrA-32955	11015 ± 45	45	13080 - 12760	11130 - 10810	Bone	Utrilla & Mazo, 2007
Legunova -q	A1	GrA-27846	11240 ± 60	80	13270 - 13030	11320 - 11080	Charcoal	Montes, 2005
Atxoste VII	A1	GrA-22900	11800 ± 60	60	13830 - 13550	11880 - 11600	Bone	Utrilla et al., 2010
Atxoste -VIIb	A1	GrA-22865	11720 ± 70	70	13810 - 13450	11860 - 11500	Bone	Alday, 2002
Atxoste -VIIc	A1	GrA-22866	11760 ± 70	70	13810 - 13530	11860 - 11580	Bone	Alday, 2002
Abauntz -2r	A1	CAMS9918	11760 ± 90	90	13840 - 13480	11890 - 11530	Charcoal	Utrilla & Mazo, 1996
Forcas I -13a	A1	GrA-33987	12010 ± 60	60	14060 - 13740	12110 - 11790	Bone	Utrilla & Mazo, 2007
Atxoste -f2	A1	GrA-19554	12070 ± 60	60	14340 - 13700	12390 - 11750	Bone	Alday, 2002
Atxoste -g	A1	GrA-19502	12200 ± 90	90	14780 - 13820	12830 - 11870	Bone	Alday, 2002
Zatoya -Iib	A1	GrN-23998	12205 ± 90	90	14790 - 13830	12840 - 11880	Bones	Barandiarán & Cava 2001
Abauntz (harpoon)	A1	GrA-39336	12220 ± 60	60	14750 - 13870	12800 - 11920	Charcoal	Martínez et al., 2006
Forcas I -13d	A1	GrA-32957	12440 ± 50	50	15010 - 14610	13060 - 12660	Bone	Utrilla & Mazo, 2007
Legunova -q	A1	GrA-22089	12500 ± 90	90	15250 - 14570	13300 - 12620	Charcoal	Montes, 2005
Atxoste -h2	A1	GrA-19503	12540 ± 80	80	15280 - 14680	13330 - 12730	Bone	Alday, 2002
Forcas I -14	A1	GrA-33986	12600 ± 60	60	15320 - 14840	13370 - 12890	Bone	Utrilla & Mazo, 2007
Chaves -2b	A1	GrN-15635	12950 ± 70	70	15690 - 15370	13740 - 13420	Bones	Utrilla, 1995

Table 2

Site and level	Phase	Lab. No	Age BP		Age Cal BP (p 95%)	Age Cal BC (p 95%)	Sample	Reference
El Collao VI	B	UBAR-928	8080 ± 60	60	9230 - 8710	7280 - 6760	*Human bone*	VV AA, 2008
Penya del Comptador	B (?)	Beta-156025	8570 ± 40	40	9600 - 9480	7650 - 7530	*Human bone*	Aura et al., 2006
Santa Maira W 3-18	B	Beta-24410	8690 ± 50	50	9820 - 9500	7870 - 7550	*Human bone*	Aura et al., 2009
El Collao IV	B	UBAR-927	8760 ± 100	100	10240 - 9440	8290 - 7490	*Human bone*	Aparicio, 2008
Santa Maira W 3-21	B	Beta-24411	8810 ± 50	50	10230 - 9590	8280 - 7640	*Cervus elaphus*	Aura et al., 2009
Tossal de la Roca IIb (ext)	A3	Gif-7064	9150 ± 100	100	10580 - 10140	8630 - 8190		Cacho et al., 2001
Santa Maira W 4. 5	A3	BETA-156021	9370 ± 40	40	10720 - 10480	8770 - 8530	*Vicia / Lathyrus*	Aura et al., 2006
Santa Maira W 4.4	A3	BETA-131578	9760 ± 40	40	11260 - 11140	9310 - 9190	*Charcoal*	Aura et al., 2006
Santa Maira W 4. 12	A3	Beta-158013	9820 ± 40	40	11300 - 11180	9350 - 9230	*Quercus sp.*	Aura et al., 2006
Nerja NV-4	A2	BETA-156020	10040 ± 40	40	11820 - 11300	9870 - 9350	*Capra pyrenaica*	Jordá & Aura, 2006
Malladetes - E	A2	KN-I/915	10370 ± 100	100	12700 - 11860	10750 - 9910	*Charcoal*	Fortea & Jordá, 1976
Diablets 1-1	A2	Beta-127570	10320 ± 40	40	12460 - 11940	10510 - 9990		Casabó, 2004
Diablets 3-1	A2	Beta-127573	10860 ± 40	40	12900 - 12700	10950 - 10750		Casabó, 2004
Nerja NT16	A2	Beta- 195996	10890 ± 50	50	12950 - 12710	11000 - 10760	*Charcoal*	Jordá & Aura, 2008
Santa Maira W 5	A1	BETA-149948	11590 ± 70	70	13630 - 13310	11680 - 11360	*Capra pyrenaica*	Aura et al., 2005-06
Nerja NT17	A1	Beta- 193273	11810 ± 40	40	13810 - 13570	11860 - 11620	*Charcoal*	Jordá & Aura, 2008
Tossal de la Roca I	A1	BETA-134880	11820 ± 40	40	13830 - 13550	11880 - 11600	*Charcoal*	Cacho et al., 2001
Cova Fosca	A1	CF	12130 ± 100	100	14710 - 13710	12760 - 11760	*Human bone*	Olària, 2003
Hoyo de la Mina- 6	A1	Ua-19443	12255 ± 100	100	14890 - 13850	12940 - 11900	*Charcoal*	Ferrer et al., 2006
Carihuela III	A1	Beta-74380	12320 ± 60	60	14900 - 14060	12950 - 12110		Vega et al., 1997
Cendres Xa	A1	BETA-142284	12470 ± 100	100	15250 - 14410	13300 - 12460	*Charcoal*	Villaverde & Román, 2005-06
Cendres XIc	A1	Ly-5220	12650 ± 80	80	15420 - 14860	13470 - 12910	*Charcoal*	Villaverde et al., 1999
Tossal de la Roca II	A1	BETA-134882	12800 ± 40	40	15510 - 15230	13560 - 13280	*Charcoal*	Cacho et al., 2001
Cendres XI c17	A1	Cendres-XIc17	13120 ± 60	60	16490 - 15410	14540 - 13460	*Charcoal*	Villaverde & Román, 2006
Tossal de la Roca III	A1	BETA-134877	13690 ± 50	50	17010 - 16850	15060 - 14900	*Charcoal*	Cacho et al., 2001
Cendres XIc	A1	Ly-5834	13840 ± 85	85	17140 - 16900	15190 - 14950	*Charcoal*	Villaverde et al., 1999

Single regional curves show similarities between the Ebro valley and Mediterranean coastal watershed. The gap indicated just before the Younger Dryas in both curves (ca. 13.4–13 ka cal. BP) may be related to taphonomic or sedimentary processes. In the Ebro valley curve, the persistence of an isolated Late Magdalenian site *ca.* 12.9 ka cal BP was recognized, which could be analyzed from a regional perspective (Fig. 4). A second gap is present in the middle of A-3 sub-horizon in the Mediterranean curve of ^{14}C dates (12.9–11.8 ka cal. BP) and between A-3 and B-1 in the Ebro valley curve (11.8–11.5 ka cal. BP) (Fig. 5).

The two regional curves arranged by the main cultural traditions show the difficulty of separating these units, as each of the four sub-horizons displays a remarkable continuity. Traditionally, the Late Magdalenian has been considered as the origin of both the Mediterranean Epipalaeolithic and the Cantabrian Azilian. It is sometimes difficult to attribute these assemblages to one archaeological culture or another.

6. Archaeological sequence

Changes in artifact styles and chronological data from well known archaeological sites provide the bases for the establishment of two main archaeological episodes and their sub-divisions between 17 and 8.5 kya cal. BP (Fig. 6).

An older episode (A) shows significant continuity with the end of Upper Palaleolithic, and contains several sub-horizons:

A1) Upper and Final Magdalenian, dating to GI-1 (*ca.* 17–13.2 ka cal. BP).

A2) Cantabrian-Pyrenean Azilian (13–10.9 ka cal. BP) and the Mediterranean Epipalaeolithic or Epimagdalenian (12.9–11.4 ka cal. BP), coinciding with the Younger Dryas. Bone industries are minimal: flat harpoons in the Azilian, and a small number of awls and points in the Epipalaeolithic.

A3) The end of the Epipalaeolithic has a bladelet tradition (ca. 11.1–10.4 ka cal. BP), containing mini- or "pigmy" microliths (triangles and segments, double points of "*sauveterrian* style" less than 10 mm). There is no agreement about this facies, characterized by a microlaminar knapping technique and recognized in only a few sites. It may be derived from the final Magdalenian, or could perhaps be considered the first geometric Epipalaleolithic (Fortea Pérez, 1973; Vega et al., 1994; Casabo, 2004).

A second episode (B) shows a break with the archaeological traditions in A. This is the Mesolithic of expedient flakes, notches and denticulates (ca. 10.1–8.7 ka cal. BP); important changes in lithic knapping techniques are evident. Bone tools are unusual: a few awls and very rare points. Different types of stratigraphies and sequences exist (Fig. 7). Frequently, the sites with final Magdalenian levels also have Epipalaeolithic or Azilian layers. Continuity among Epipalaeolithic sub-horizons (A2 and A3) is limited to a few sites. The Mesolithic period (B) is better documented in the Ebro valley than in the Mediterranean region.

^{14}C dates obtained from some of the Catalonian deposits (Vaquero et al., 2002), NE Iberia, indicate contemporaneity between the end of the Epipalaeolithic bladelet tradition (A2-A3) and the Mesolithic (B), whose dates from the Alaric Agut site are older than those of Aragon and Valencia regions, where there is no apparent overlap between horizons A and B. This Mesolithic (B1) is unknown in the southern regions of Murcia and Andalusia, where documented erosive hiatuses could explain its absence (Aura, 2004).

7. Subsistence strategies

Despite the different records in the regions, occupation continuity in some sites before and after the YD is evident (Fig. 7). There are well known sites on the coast, but also in mountain areas, even above 1000 m. Open-air sites increase after the B horizon, during the Mesolithic (Utrilla and Montes, 2009b).

Although there are some problems concerning faunal preservation and data, Fig. 3 shows examples that can be considered as representative with the available information. Some major points provide a general picture of subsistence strategies during the Younger Dryas.

a) Mediterranean regions were more influenced by aridity than Eurosiberian ones (Sánchez Goñi and D'Errico, 2005); this may have contributed to the diverse diets seen in Mediterranean

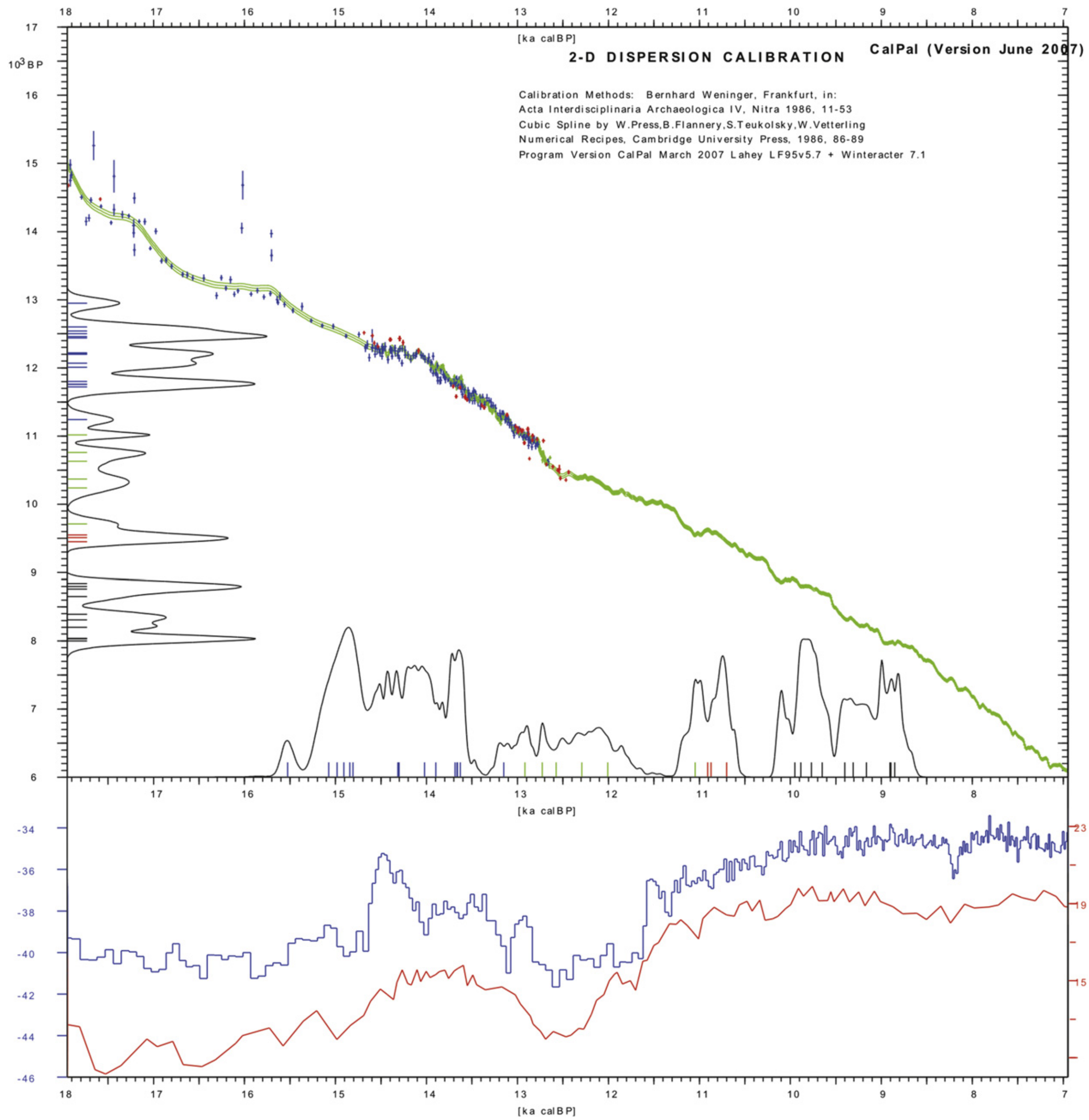

Fig. 4. Cumulative probability curve of the valid radiocarbon dates from the Mediterranean watershed of Iberia calibrated with CalPal 2007 Hulu calibration curve (Weninger et al., 2007) and comparison with the high resolution palaeoclimatological proxies: ^{18}O GISP2 Hulu Age Model (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and SST MD95-2043 (Cacho et al., 2001a). *X*-axis: calibrated ages; *Y*-axis: BP ages; line colours on *x* and *y* axis: blue, dates from A1 (= Upper and Final Magdalenian levels); green, dates from A2 (= Epipalaeolithic levels); red, dates from A3 (= Epipalaeolithic sauveterroid levels); and black, dates from B1 (= Mesolithic of Notches and Denticulates levels). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Spain. The Mediterranean regional subsistence strategy combined the exploitation of a few larger game species (*Capra pyrenaica*, *Cervus elaphus, Sus scofra*, *Equus* sp.*, Bos sp. Rupicapara rupicapra* or *Capreolus capreolus*), with small prey (*Oryctolagus cuniculus*, *Lepus* sp.*, Erinaceus europeus* and birds), and small carnivora (*Lynx pardina*, *Felis sylvestris* or *Vulpes vulpes*) (Aura et al., 2009).

b) Assemblages dominated by *Cervus elaphus* and *Capra pyrenaica* are a combined reflection of site environment and altitude and hunting specialization (Davidson, 1981: Pérez-Ripoll and Martínez Valle, 2001).

c) *Equus* sp. and *Bos* sp. decreased in frequency through the Late Glacial, but were more abundant in northern sites such as Peña Diablo, Vergara, and Alexandre (Utrilla and Montes, 2007), and especially in the Holocene Mesolithic B at Mendandia rock-shelter (layer IV), located in the upper Ebro basin and considered as a kill site specialized in *Bos primigenius* (Alday and Cava, 2006).

d) Small prey display high frequencies of NISP (notably, rabbits) and were constant and readily available resources, and birds become more abundant during the Late Glacial. Regional diversification and intensification in the use of the available resources were discussed in a recent paper (Aura et al., 2009).

e) In the Mediterranean region, the presence of marine resources – shellfish and fish – at both inland and coastal

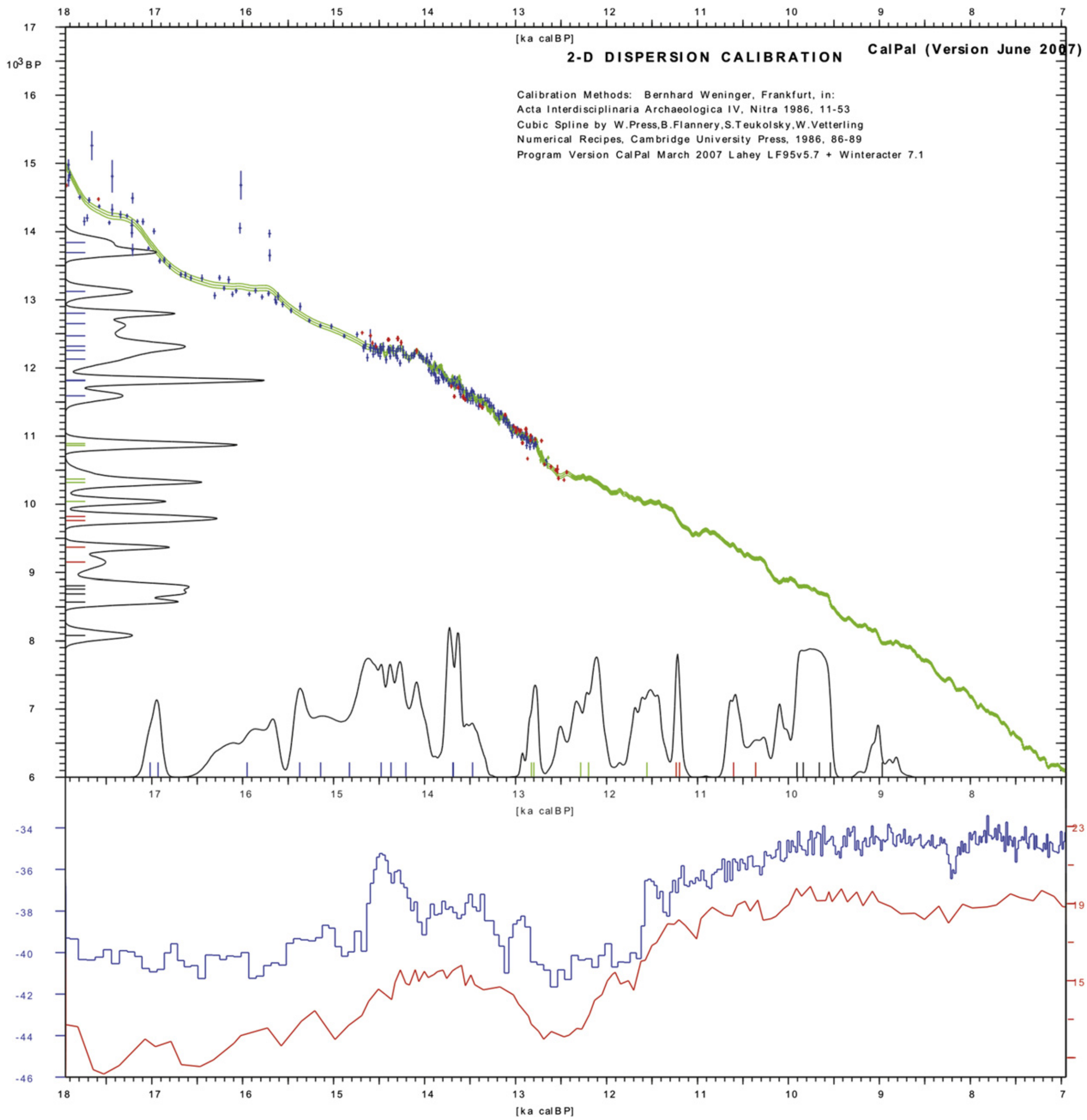

Fig. 5. Cumulative probability curve of the valid radiocarbon dates the Ebro valley (Northeast of Iberia) calibrated with CalPal 2007 Hulu calibration curve (Weninger et al., 2007) and comparison with high resolution palaeoclimatological proxies ^{18}O GISP2 Hulu Age Model (blue) (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and SST MD95-2043 (red)(Cacho et al., 2001a). *X*-axis: calibrated ages; *Y*-axis: BP ages; line colours on *x* and *y* axis: blue, dates from A1 (= Upper and Final Magdalenian levels); green, dates from A2 (= Epipalaeolithic or Azilian levels); red, dates from A3 (= Epipalaeolithic with pigmy microliths levels); and black, dates from B1 (= Mesolithic of Notches and Denticulates levels). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

sites suggests the seasonal or simultaneous use of these territories. The Andalusian coast provides important information on marine resource exploitation in the Younger Dryas (e.g. Cueva de Nerja): marine mammals, birds, fish, shellfish, urchins, and crabs are all represented (Aura et al., 2009).

f) The diversity of plant species represented increased during the Younger Dryas: *Quercus* sp, *Sorbus* sp., *Prunus* sp., *Vicia/Lathyrus* sp. were added to *Pinus pinea*, already present in the Middle Palaeolithic (Gibraltar) and Upper Palaeolithic – Epipalaeolithic (Nerja) (Badal, 1998; Aura et al., 2005). Throughout the Holocene, *Corylus avellana* (hazel) nuts are documented in the Ebro basin and northeast of Iberia, but not in the southern Mediterranean zone (Aura, 2004). (Fig. 12)

8. Burial practices and symbolism

During the final Magdalenian and the Epipalaeolithic, the portable art was reduced to a few engraved figurative representations of ibex and red-deer on small pebbles, and the recent discovery in Valencia of some rock engravings with a Paleolithic style (Martínez Valle et al., 2009).

The Mesolithic also saw some changes in the gastropod species used in personal ornaments. During the final Magdalenian and the Epipalaeolithic, *Cyclope neritea* and *Theodoxus fluviatilis* were the most common species (B. Avezuela, personal communication). During the Mesolithic, the first was scarce and the most frequently employed were *Nassa reticulata* and *Columbella rustica*, both in the

cal BP			Archaeological sub-horizons		Ebro valley						Mediterranean watershed			
8 700 – 10 100	HOLOCENE	MESOLITHIC	Notches-Denticulates	B1		Legunova - 2	Forcas II-1b	Atxoste D VI - V	Peña 14 - b			Tossal 2-A	Sta Maira (W) 3	
10 100 – 11 700	HOLOCENE	EPIPALAEOLITHIC	Pigmy microliths / '*Sauveterroid*'	A3				Atxoste 2 VIb				Tossal 2-B	Sta Maira (W) 4-A	Nerja
11 700 – 12 900	GS -1 (YD)	EPIPALAEOLITHIC	Azilian / Epipalaeolithic (Epimagdalenian)	A2		Legunova - m	Forcas I-10		Peña 14 - d	Peña Diablo -2		Tossal I (int)	Sta Maira (W) 4-B	Nerja V 4
12 900 – 15 000	GI -1	PALAEOLITHIC	Upper-Final Magdalenian	A1	Chaves 2b	Legunova - q	Forcas I-13a -14	Atxoste h-2-f-2 VII - c - d			Cendres XI	Tossal II /III (int)	Sta Maira (W) 5 (E) II-sup	Nerja V 5 M 16

Fig. 6. Chronological and archaeological framework of the sites from the Ebro valley and Mediterranean watershed, Iberian Peninsula.

Ebro valley and the Mediterranean region. The latter is considered a Mediterranean species, although it also appears, from the final Magdalenian and Azilian (Álvarez Fernández, 2006) to the Mesolithic (Alday et al., 2010), in some upper Ebro and Cantabrian (Atlantic coastal) sites.

Paleolithic burials are scarce in Iberia, especially as compared with the rest of Western Europe. In eastern Spain only two burials have been described: one from the final Magdalenian (Cova Fosca) and the other from the Epipalaeolithic (Nerja). Both are individual burials with evidence of simple rites and grave goods. The Mesolithic shows a change: there are some sites with several sepultures (El Collado: MNI 15; Penya del Comptador: MNI 3) and others with human bones with fractures and anthropic marks (Santa Maira: MNI 3). They could be related to alimentary cannibalism or to funerary practices prior to the burial (Aura, 2009).

The ultimate abandonment of the *parietal* and portable art of Palaeolithic style coincided with the end of Epipalaeolithic time. Changes in personal ornaments and especially in Mesolithic funerary practices, including the appearance of the first necropolis, could be considered as human responses developed just after the Younger Dryas (Fig. 8). However, these changes are not accompanied by an increase in the number of settlements or in their size. In the Ebro valley, specialized seasonal use of the rock-shelters has been suggested, which may be closely linked to open-air camps, still scarcely known (Alday et al., in press). An increase in open-air sites is attested in the central Mediterranean region during sub-horizon B2: Geometric *(Tardenoisian)* Mesolithic (Martí et al., 2009).

9. Discussion

The Iberian Late Glacial and early Post-glacial archaeological record (GI-1, GS-1 and early Holocene) in the two regions of Mediterranean Spain discussed here is discontinuous and at present is essentially known from multistratified caves and rock shelters. Stratigraphic levels with clasts attributed to cold conditions and gelifraction during the Younger Dryas are only recognized in archaeological sites of the Ebro valley (Utrilla and Montes, 2007). In southern Spain, the presence of clasts is associated with either the Greenland Interstadial 1b cold episode or the Intra-Allerød Cold Period (IACP) (Jordá Pardo and Aura, 2008).

The effects of the Younger Dryas on the vegetation and fauna of the Mediterranean regions of the Iberian Peninsula were different than those in the Eurosiberian region. Paleobotanical data identify the Younger Dryas as the final episode of a larger transition between the Pleniglacial landscapes and those of the Holocene (Carrión et al., 2010).

Charcoal studies at prehistoric sites from this period show an increasing spread of forest species, as does the faunal record, which includes wild boar, roe deer and small carnivores (Fig. 3). In contrast, the marine fauna of southern Mediterranean Spain suggests very cold conditions linked to the input of Atlantic waters through the Strait of Gibraltar (Aura et al., 1998, 2002a).

In both regions of eastern Spain, there is a limited number of calibrated ^{14}C dates for the Younger Dryas. There are two reasons for the paucity of high-quality dates. First, the Younger Dryas was a brief period that coincides with changes in atmospheric $^{14}CO_2$ content (Meissner, 2007). Second, there are no systematic, critical studies of these dates; in many cases the taxonomy and taphonomy of the dated samples are unknown.

Despite this deficiency, it is possible to identify general patterns common to these two regions (Figs. 9–12):

- The upper and final Magdalenian (17.-13.2 ka cal BP) and the earliest phases of the Azilian/Mediterranean Epipalaeolithic

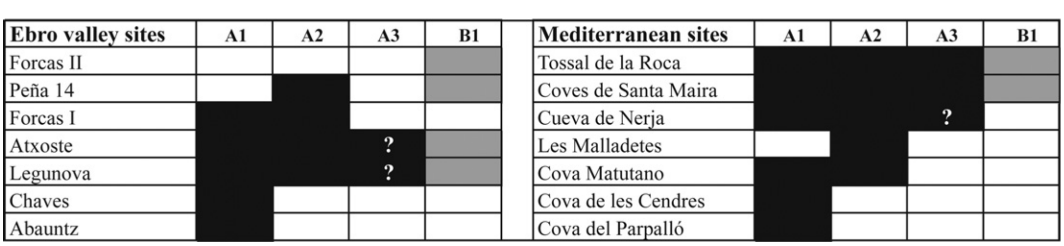

Fig. 7. Main site-types and archaeological sequence continuity along GI-1, GS-1 and Early Holocene.

		Archaeological sub-horizons		Cal. BP	Number of Burials	
HOLOCENE	MESOLITHIC	Geometric *'Tardenoid'*	B2	8 700	*(19)*	24
HOLOCENE	MESOLITHIC	Notches-Denticulates	B1	10 100	*(5)*	
HOLOCENE	EPIPALAEOLITHIC	Pigmy armatures / *'Sauveterroid'*	A3	11 200		1
GS -1 (YD)	EPIPALAEOLITHIC	Azilian / Epimagdalenian	A2			
GI -1	PALAEOLITHIC	Upper-Final Magdalenian	A1	13 200		1
				15 000		

Fig. 8. Burial data from the Iberian Mediterranean region (Aura, 2009b).

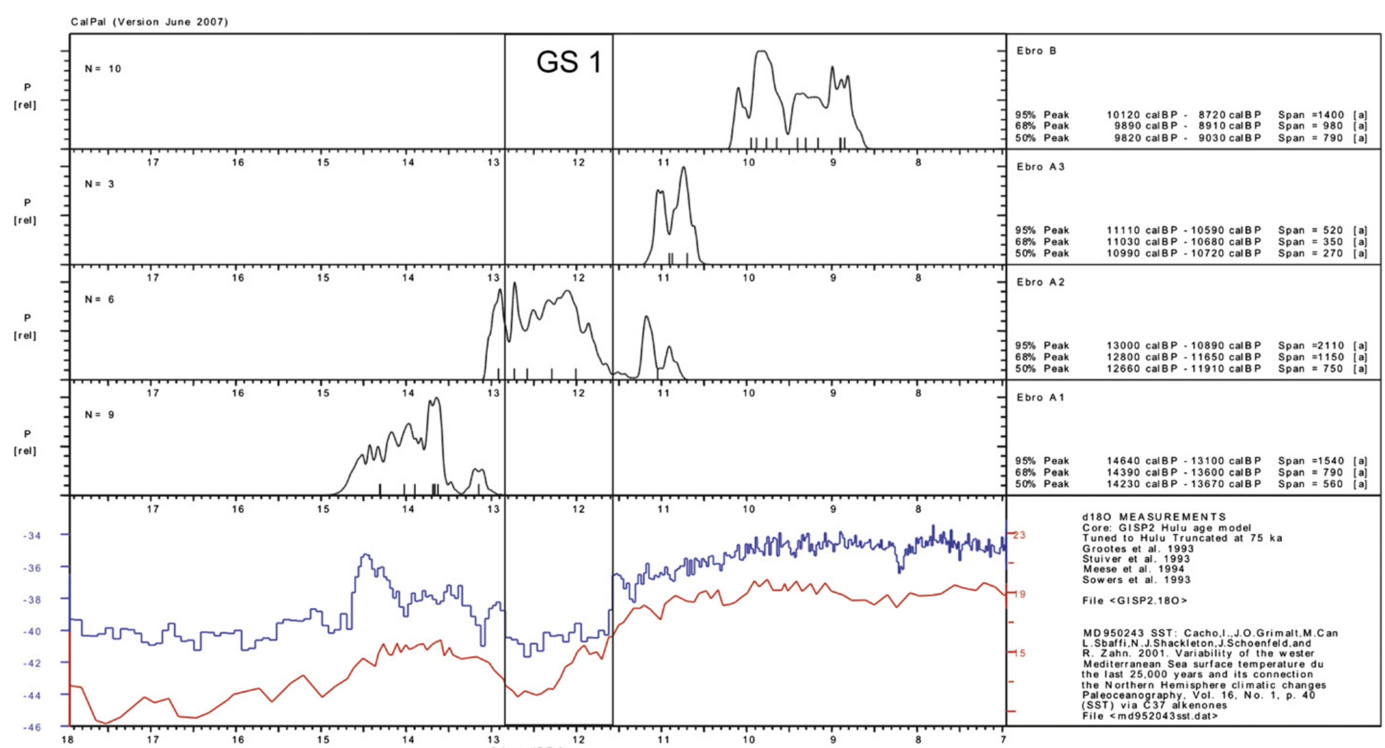

Fig. 9. The Ebro valley. Calibration curves for the four archaeological sub-horizons considered (drawn with CalPal, 2007 Hulu, Weninger et al., 2007) and comparison with high resolution palaeoclimatological proxies ^{18}O GISP2 Hulu Age Model (blue) (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and SST MD95-2043 (red) (Cacho et al., 2001a) (A1: Upper and Final Magdalenian; A2: Epipalaeolithic or Azilian; A3: Epipalaeolithic with pigmy microliths; B1: Mesolithic of Notches and Denticulates). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

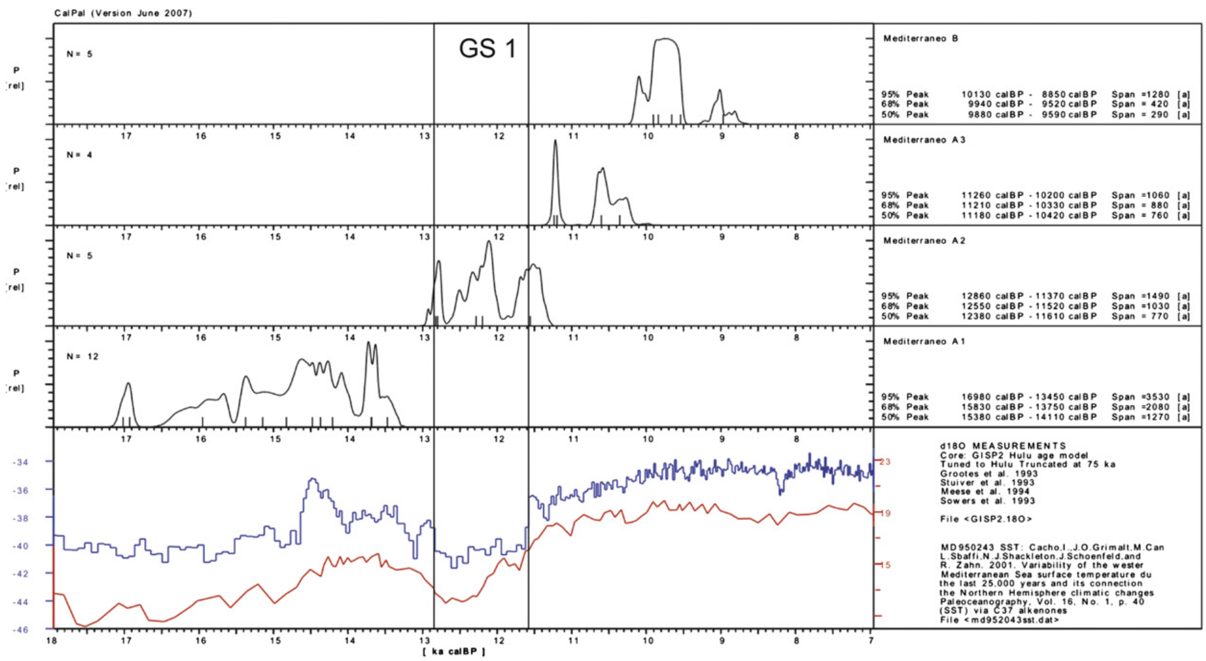

Fig. 10. The Mediterranean watershed (CalPal, 2007 Hulu, Weninger et al., 2007). Calibration curves for the four archaeological sub-horizons considered (drawn with CalPal, 2007 Hulu,Weninger et al., 2007) and comparison with high resolution palaeoclimatological proxies δ ^{18}O GISP2 Hulu Age Model (blue) (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and SST MD95-2043 (red)(Cacho et al., 2001a) (A1: Upper and Final Magdalenian; A2: Epipalaeolithic; A3: Epipalaeolithic sauveterroid; B1: Mesolithic of Notches and Denticulates). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

(13-11 ka cal BP), though occasionally difficult to separate, predate the Younger Dryas. It is difficult to distinguish between A1 and A2 sub-horizons when the main morphotypes are absent: harpoons in the Mediterranean, Pyrenees and Cantabrian areas.

- Mediterranean Epipalaeolithic - Azilian are the only regional archaeological sub-horizons dated to the Younger Dryas.
- The later phases of the Epipalaeolithic (A3), with “pigmy” and *sauveterrian* elements is dated between 11.2-10.2 ka cal. BP in the Mediterranean region, and 11.1–10.6 ka cal. BP in the Ebro valley.
- A new technological model in both regions with an industry characterized by notched and denticulate flakes marks the rise of the Mesolithic (ca. 10.1–8.7 ka cal. BP).

Combined with this chronological model, the stratigraphic data indicate the regional archaeological sequence summarized in Fig. 6. No stratigraphic sequence contains Epipalaeolithic Sauveterrian layers that overlie levels with Magdalenian, Azilian, or Mediterranean Epipalaeolithic materials. No deposit containing Mesolithic materials is followed by Azilan/Epipalaeolithic layers.

The transformation from a Palaeolithic/Epipalaeolithic laminar technology to a Mesolithic flake technology is also attested in other regions, including the northern Pyrenees (Alday, 2006) and probably, the Cantabrian Asturian facies belongs to the same innovative tradition. It is a post YD tendency that coincides with the maximum Holocene forestation. It has been sometimes suggested that there

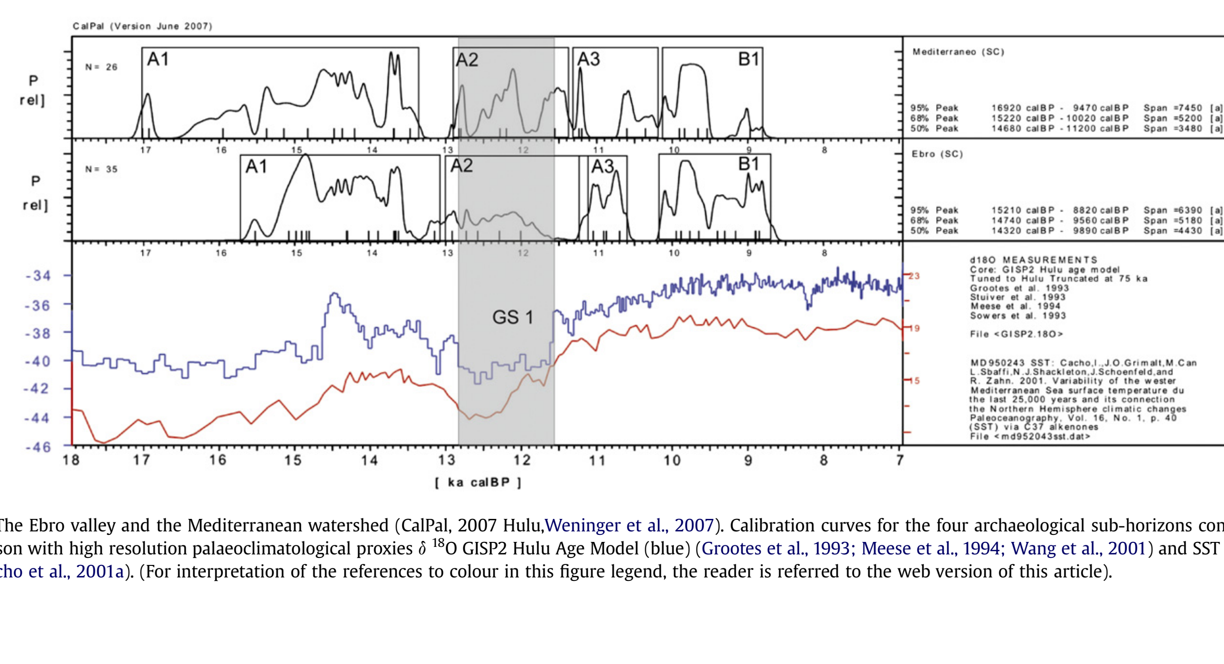

Fig. 11. The Ebro valley and the Mediterranean watershed (CalPal, 2007 Hulu,Weninger et al., 2007). Calibration curves for the four archaeological sub-horizons considered and comparison with high resolution palaeoclimatological proxies δ ^{18}O GISP2 Hulu Age Model (blue) (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and SST MD95-2043 (red)(Cacho et al., 2001a). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

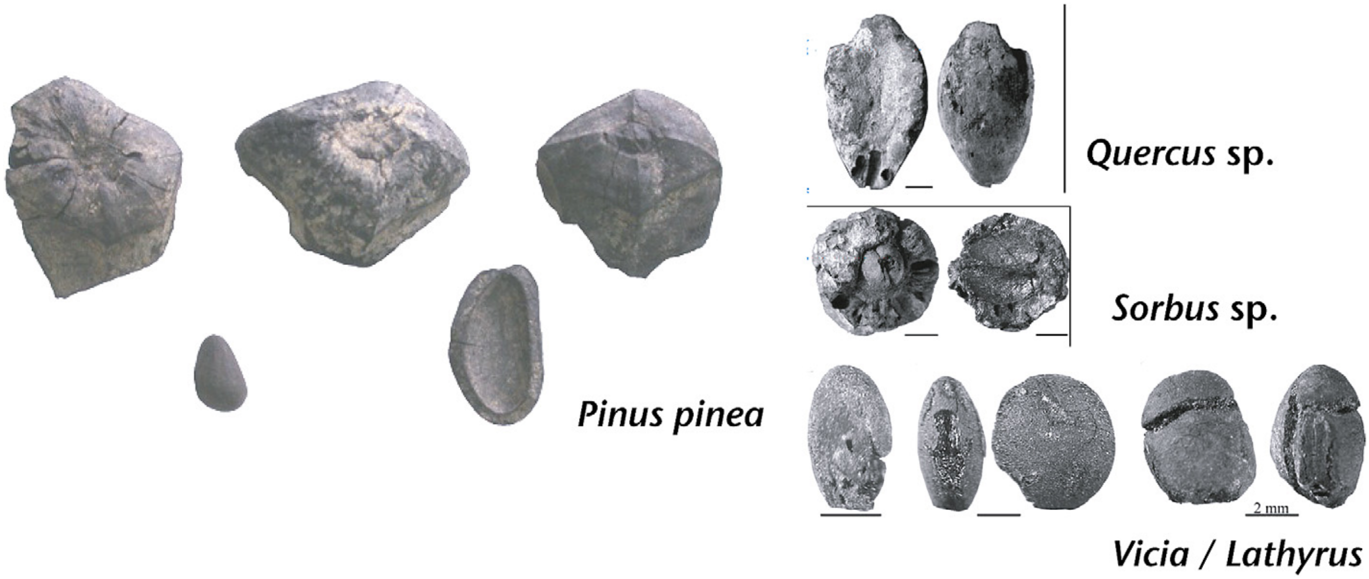

Fig. 12. Floral resources dated to YD and Preboreal. 1: *Pinus pinea* from Nerja, and *Quercus* sp, *Sorbus* sp. and *Vicia/Lathyrus* sp. from Santa Maira (Photos: E. Badal and G. Pérez- Jordá).

was a relationship between this 'expedient' technology and woodworking in order to produce a diversified toolkit, including projectiles (Montes et al., 2006). But to explain this technological change as a simple adaptive choice among all the possibilities, does not consider other aspects of human behavior (Bamforth and Bleed, 1997) such as those relative to funerary practices or symbolic behaviour.

10. Conclusions

The Younger Dryas marks the end of archaeological traditions closely linked to the Upper Palaeolithic. Lithic and bone industries display an accelerated rate of change. This period also marks the end of the Magdalenian tradition of *portable art* and isolated individual burials. However, site occupation and subsistence strategies indicate continuity between the Final Magdalenian and the Epipalaeolithic. The numbers of sites is very similar and the Younger Dryas does not seem to reflect changes in the demography of human foragers in eastern Spain. Some sites (Nerja, Malladetes, Santa Maira) show erosive hiatuses that have seriously affected analysis of the Pleistocene–Holocene transition analysis. In any case, the most obvious changes in lithic knapping techniques, subsistence, mortuary practices and art date to the Mesolithic.

Together, these data suggest a general assessment of the impact of the Younger Dryas on this region:

1. At the end of GI-1, common processes indicate a strong flow in the transmission of cultural patterns, with regional variations (Epipalaeolithic Mediterranean vs. Azilian/Cantabrian; Mediterranean gastropod species used as ornaments in the Upper Ebro and Cantabrian regions).
2. Further regional fragmentation may have occurred during GS-1, alongside general development (continuity in the occupation of sites, the last Azilian harpoons, generalization in the use of freshwater and marine resources, few individual burials, etc.). Change is increasingly regional, and cultural variations occur rapidly (González Sainz, 1989).
3. The typology manifests changes with the beginning of the Mesolithic occurrence. Even if the open-air camps are not well known, there was an increasing trend to develop logistic strategies.
4. The Holocene consolidation brings indications of a deeper change: a technological change can be seen in new tool styles (in both lithic and bone industries). The subsistence economy shifted towards forest exploitation; and finally, this produced both a definitive end to the portable Paleolithic art and the onset of a tradition of multiple burials. These data could reinforce the idea of major social complexity linked to demographic transformations, including changes in the symbolism and mortuary practices after the Younger Dryas.

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