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Climate change and population dynamics during the Late Mesolithic and the Neolithic transition in Iberia

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ABSTRACT – *This paper explores how Early Holocene climate changes in the Western Mediterranean would have affected Late Mesolithic settlement distribution and subsistence strategies in Iberian Peninsula, thereby giving rise to various adaptive scenarios. The current radiocarbon data set concerning the Neolithisation process has revealed the rapidity of the spread of farming in Iberia. Considering both the implications of the last hunter-gatherers' adaptation strategies and the population dynamics of agro-pastoral communities, we address the migration patterns underlying the Mesolithic-Neolithic transition. In conclusion, we propose that the initial colonization process was the result of two successive and spatially heterogeneous migrations: Maritime Pioneer Colonization and targeted migration to places favorable to the new economic system.*

IZVLEČEK – *V članku raziskujemo kako bi zgodnje holocenske klimatske spremembe v zahodnem Sredozemlju vplivale na pozno mezolitsko razporeditev naselbin in na prehranjevalne strategije na Iberskem polotoku in s tem povzročile nastanek različnih prilagoditvenih scenarijev. Trenutna serija radiokarbonskih datumov, povezanih s procesom neolitizacije je razkrila hitrost širjenja poljedelstva na Iberskem polotoku. Ob upoštevanju obojega – vpletenosti prilagoditvenih strategij zadnjih lovcev in nabiralcev ter populacijske dinamike poljedelsko-pastirskih skupnosti, opazujemo selitvene vzorce, ki so podlaga mezolitsko – neolitskega prehoda. V zaključku predlagamo, da je bil začetni proces kolonizacije rezultat dveh zaporednih in prostorsko heterogenih migracij: pomorske pionirske kolonizacije in ciljne migracije na prostore naklonjene novemu ekonomskemu sistemu.*

KEY WORDS – *climate change; 8200 calBP event; Mesolithic-Neolithic transition; migration*

Introduction

As elsewhere in Europe, the origin of the Neolithic in Iberia is related to the introduction of technical and economic innovations in food production by means of different migration processes and subsequent cultural interaction with local populations of hunter-gatherers (*Zilhão 2001; Bernabeu 2002*). Consequently, one can expect a regionally diverse and complex process modeled by both environmental and social factors.

In the 90's, discussions on the Neolithic transition in Iberia were framed within the migrationist and indigenist debate (*e.g. Bernabeu 1996; Vicent 1997*) and the refutation of polygenist models (*Zilhão 1993; Bernabeu et al. 1999*). However, during the last 10 years, the chronology of the first ceramic contexts and domesticates have enjoyed renewed interest as a result of the incorporation of new data from the Iberian interior and the Northern Façade (see below). In the context of the whole of Iberia, both regions, as counterparts of other traditional research areas such as eastern Spain and Portugal, focus most of the current debate on the timing and mechanisms behind the farming expansion (*e.g. Al-*

day 2005; Bernabeu 2007; Cruz and Vicent 2007; Carvalho 2003; Juan-Cabanilles and Martí 2002; Martí 2008; Rojo et al. 2006 among others).

In this context, the relationship between environmental and cultural dynamics regarding the Neolithic transition has been placed on a secondary level of analysis and interpretation. With the exception of Zilhão, who has openly argued how these factors explain the absence of a Mesolithic population in the central hinterlands of Portugal and Spain (*Zilhão 2000; 2001*), very little attention has been paid to this issue until recently.

Nevertheless, new paleo-environmental evidence and archaeological data on the Late Mesolithic record seem to indicate that some transformations in the settlement and subsistence patterns erupted suddenly:

1. A geographically circumscribed distribution of Mesolithic settlement. There is still a lack of archaeological information regarding the Late Mesolithic from several areas, such as Spanish Meseta and Catalonia, and research bias alone cannot explain this.

2. Variable reliance on aquatic resources shown among the last groups of hunter-gatherers. The available information on paleodiets and isotopic analyses of Mesolithic populations from Portugal, Cantabrian Façade and the central Mediterranean coast of Spain, have provided new data of relevance to this issue, reflecting regional disparities. In this sense, the degree of dependence of the Mediterranean samples is remarkably inferior to those recorded in Portuguese and Cantabrian shell middens.

From an evolutionary perspective, if the first point can be linked to the dynamics of environmental change and to the adjustments that Mesolithic population made, the second is a direct outcome of these adaptations.

This paper will explore how Early and Middle Holocene environmental changes could have affected the geographical distribution, organization and subsistence of Late Mesolithic settlements. This period witnessed the appearance of the Neolithic in Iberia, providing various opportunities for ongoing farming dispersal processes in the western Mediterranean. A critical review of the last foragers evidence in Iberia is essential to establish a coherent frame of hypotheses about the role of indigenous populations in the economic and demographic changes that occurred during the Neolithic transition.

The paper is in two parts. First, we present a general overview of Early-Middle Holocene environmental dynamics and Late Mesolithic settlement distribution in Iberian Peninsula. Second, we discuss the effects of the 8200 calBP event on regional settlement organization and sedimentation dynamics. Finally, we suggest how these dynamics would have affected subsistence patterns on the basis of paleodietary studies.

In the second part, we present empirical evidence from the earliest Neolithic sites from the latest regional studies in the Iberian bibliography. We then revisit different models of the transition to farming in the Iberian Peninsula, prior to sketching new interpretations that emphasize population dynamics and environmental changes alongside the Mesolithic-Neolithic transition. Also, since the Neolithisation process entailed complex demographic transformations, we discuss paleogenetics and population replacement regarding the Iberian data. Finally, we propose some directions for future research.

The body of Mesolithic and Neolithic radiocarbon dates for the Iberian Peninsula has been particularly increased and enhanced in recent times due to the systematic application of sample selection protocols (*Juan-Cabanilles and Marti 2002; Rojo et al. 2006; Bernabeu 2006; Carvalho in press*). The current compilation – in Tables 1 and 3 – has been built on the basis of a series of radiocarbon dates from single, short-lived samples: cultivated plants (mainly cereals), non-domesticated short-lived fruits (acorns), domestic fauna and human bones, following Venice's 1998 conference recommendations (*Ammerman and Biagi 2003*). Individual AMS ^{14}C dating of key specimens overrides the risk of dealing with disturbed contexts and with intrusions from overlying levels (*Bernabeu et al. 1999; Zilhão 2001*) and eliminates the possibility of the 'old wood' effect in the case of charcoal (*Zilhão 2001; Zapata et al. 2004. 285*). In addition, we have excluded from this analysis the radiocarbon determinations on shell samples – although the correction can be determined, their reservoir effect values, locally and diachronically, are subject to considerable variation (*e.g. Soares and Dias 2006*) and have not been established on the basis of short-lived samples from Neolithic contexts. Consequently, an unpredictable degree of uncertainty affects radiocarbon determinations on shell samples, and do not allow a comparisons with other Iberian contexts. On the other hand, we have included the radiocarbon dates of human remains from the Muge sites (Cabeço da Arruda, Cabeço da

Amoreira and Moita do Sebastião), calibrated considering several potentially changeable factors such as the percentage of marine resources consumed revealed by isotopic analyses, and the local estuarine reservoir effect (*Martins et al. 2008*), which is different from that established by Soares (*1993*)[1].

Early-Middle Holocene environmental changes and Late Mesolithic distribution

In current debates on the Neolithic transition in Iberia, the distribution of the last hunter-gatherer populations during the Neolithisation process is one of the main issues. In the last decade, Iberian archaeology has witnessed an outstanding advance in knowledge of the Late Mesolithic, which has changed the traditional archaeological sequence (*Fortea 1973*). Today, the Mesolithic in the Iberian Peninsula (*c.* 10 800–7200 calBP) is comprised of two successive industrial complexes that led regionally different cultural traditions: the flake-rich assemblages complex that dominated during the Boreal period and the Geometric Mesolithic, also generally called the Late Mesolithic, the main cultural features of which are presented below:

● *Flake rich assemblages complex:* The main distinguishing feature of this complex is a lithic industry based on flake technology with no – or very little – evidence of blade production. Lithic assemblages vary from flint to quartzite, but flake artifacts, especially notches and denticulates, and massive tools, comprise all of them. There are several denominations in the archaeological literature to define this kind of lithic industry (Mesolithic Macrolithic or Generic Mesolithic), including archaeological entities such as the 'Notches and Denticulates Mesolithic' (henceforth ND Mesolithic) (mainly in the Mediterranean region, the Ebro Valley and the Pyrenees) (*Alday 2006a; Cava 2004*) or Asturian (see *Straus 2008* for a recent revision). This complex dates between 10 200 and 8400 calBP, except the Asturian in the western Cantabrian region, where this complex is not well distinguished in typological terms from the Late Mesolithic phase due to the scarcity of geometric microliths at many open air sites.

● *Late Mesolithic phase A:* During this phase of the Iberian Mesolithic, there is a marked technological change with the re-introduction of blade debitage technology, the microburin technique and the configuration of trapezoidal microliths with abrupt retouch. This phase lasts from 8400 to 7900 calBP.

● *Late Mesolithic phase B:* Considered an evolution from the previous phase, it is characterized by the presence of triangles among the geometric microliths. In this sense, the most outstanding phenomenon is the emergence of specific microlith types with a regionally discrete distribution: triangles with concave sides known as 'Cocina triangles' at Valencia and Aragón regions, 'Sonchamp points' in the western Pyrenees and 'Muge triangles' in Portugal very similar to their Cocina correlatives. This phase lasts from 7900 calBP up to the beginning of the Neolithic in the different regions of Mediterranean Iberia (7500–7200 calBP).

● *Late Mesolithic phase C:* this is considered the terminal development of the Mesolithic industries that paralleled the expansion of the Early Neolithic (*Fortea 1973; Juan-Cabanilles 1990*). It is characterized by triangles and segments with bifacial retouch. However, its Mesolithic cultural affiliation is now subject to review, given the recent documentation of this set of geometric armatures from the beginnings of the Neolithic at some Cardial and Epicardial sites such as Chaves Cave (*Cava 2000*) with no underlying layers of Mesolithic occupation. In fact, the identification of Phase C, in typology, technology, stratigraphy and absolute chronology is ambiguous and not clearly isolated from earlier or later occupations (*Juan Cabanilles and Martí 2007–2008*).

As noted for other southern European regions (*Biagi 2003; Binder 2000; Juan-Cabanilles and Martí 2002; Carvalho in press*), considerations about the Late Mesolithic in terms of social geography and population dynamics should be grounded on a critical evaluation of chronology and the archaeological evidence, *i.e.* on the radiocarbon framework and the lithic industries. According to this, the map in Figure 1 gives an accurate picture of Late Mesolithic distribution (phases A and B) in the Iberian Peninsula (Fig. 1). It is based on a complete compilation that encompasses different kinds of archaeological site (rock-shelters, open-air sites and lithic scatters), with radiocarbon dates or accurate typological information published until 2002 (*Juan-Cabanilles and*

1 Calibrations, as well as the corresponding graphs, were obtained using the Version 4.1. of the OxCal Program (*Bronk-Ramsey 2009*), based on the IntCal04 curve (*Reimer et al. 2005*). All radiocarbon dates mentioned are in years BP and BC after calibration, and based on extremes of the 2 sigma range.

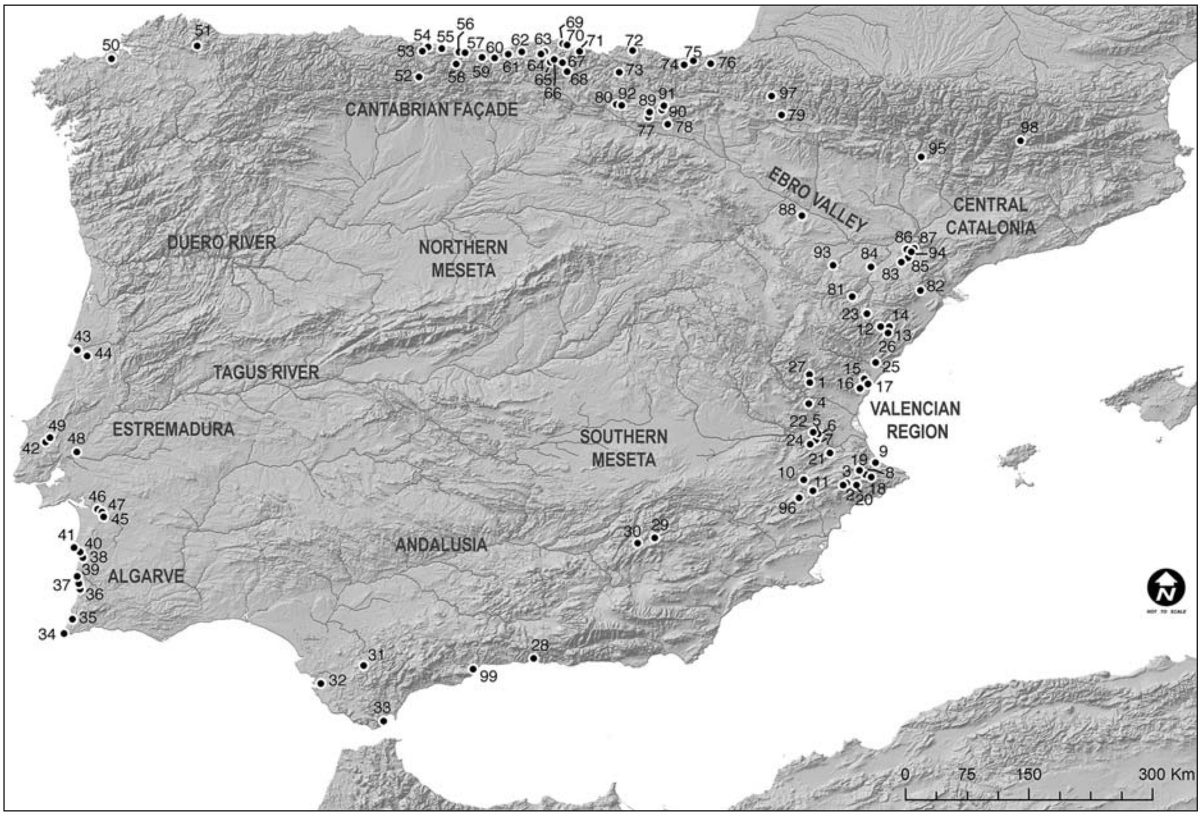


Fig. 1. Regional distribution of Late Mesolithic sites in Iberian Peninsula. 1. Llatas; 2. Gelat.; 3. Falguera; 4.Vacas; 5. Polvorosa; 6. Cocina; 7. Anna; 8. Tossal de la Roca; 9. Collado; 10. Casa de Lara; 11. Huesa Tacaña; 12. Mas Nou; 13. Mas de Martí; 14. Mas de Sanç; 15. Ballester; 16. Cavall; 17. Estany; 18. Santa Maira; 19. Encantada; 20. Regadiuet; 21. Peñeta; 22. Ceja; 23. Mas Cremat; 24. Zorra; 25. Sitjar; 26. Assud; 27. La Mangranera; 28. Nerja; 29. Nacimiento; 30. Valdecuevas; 31. Frailes; 32. Retamar; 33. Río Palmones; 34. Roca das Gaviotas; 35. Castelejo; 36. Montes Baixo; 37. Fiais; 38. Medo Tojeiro; 39. Vidigal; 40. Samouqueira; 41. Vale do Pincel; 42. Forno Telhas; 43. Forno da Cal; 44. Buraca Grande; 45. Arapouco; 46. Rebolador; 47. P. Sao Bento; 48. Muge region (Cabeço da Amoreira, Cabeço da Arruda, Moita do Sebastião); 49. Abrigo Bocas; 50. Reiro; 51. Xestido III; 52. Espertín ; 53. Colomba; 54. Coberizas; 55. La Riera; 56. Sierra Plana; 57. Mazaculos; 58. Los Canes; 59. Covajorno; 60. El Aguila; 61. Pendueles; 62. Toralete; 63. La Garma A; 64. Truchiro; 65. Cubío Redondo; 66. Cofresnedo; 67. La Chora; 68. Tarrerón; 69. La Fragua; 70. El Perro; 71. La Trecha; 72. Pareko Landa; 73. Urratxa; 74. Linatzeta; 75. Herriko Barra; 76. Marizulo; 77. Monticocha; 78. Peña Marañón; 79; Padre Areso; 80. Socuevas; 81. Angel; 82. Vidre; 83. Costalena; 84. Salada Grande; 85. Pontet; 86. Sol Piñera; 87. Serda; 88. Cabezo Cruz; 89. Mendandia; 90. Kanpanoste G.; 91. Atxoste; 92. Fuente Hoz; 93. Los Baños; 94. Botiqueria; 95. Forcas II; 96. Lagrimal; 97. Aizpea; 98. Margineda; 99. Bajondillo.

Marti 2002). We have updated it by adding new data, published since then (see below).

The body of archaeological data displays clear evidence of occupation in the Mediterranean Façade, the Ebro Valley, the Cantabrian Façade and central and south Portugal. Of course, this picture results from different regional research trajectories, which have produced quantitatively and qualitatively diverse information. However, the current distribution pattern does not differ substantially from that published seven years ago.

The central Mediterranean area (the Valencia region) has a significant number of Late Mesolithic sites (for a recent revision, see *Aura et al. in press*). Recent work has discarded previous Late Mesolithic attributions, such as the site of Arenal de la Virgen (*Fernández et al. 2008*), but added some new sites, such as Mas de Martí (*Fernández et al. 2005*), Santa Maira (*Aura et al. 2006*), Mas Gelat (*Miret el al. 2007*), Mas de Sanç (*Fernández 2006*), Cueva del Lagrimal (*Gómez and Fernández 2009*) and Mas Cremat (*Vicente et al. 2009*). Moreover, a previously known site, Falguera, has recently been published in full (*García and Aura 2006*).

As a result of continuous and intensive archaeological research, the Ebro Valley provides an outstanding Late Mesolithic record (*Alday 2002; Barandia-*

SITES	CONTEXT	SAMPLE MATERIAL		SAMPLE REFERENCE	^{14}C age (BP)	CalBP 2σ range	CalBC 2σ range	Ref.
PORTUGAL								
Cabeço da Arruda	Skeleton N	H	*Homo*	TO-356	6360 ± 80	7170-6680	5220-4730	1
Cabeço da Arruda	Skeleton D	H	*Homo*	TO-355	6780 ± 80	7690-7370	5740-5420	1
Cabeço da Arruda	Skeleton 42	H	*Homo*	TO-359a	6960± 60	7790-7440	5840-5490	1
Cabeço da Arruda	Skeleton A	H	*Homo*	TO-354	6970 ± 60	7860-7560	5910-5610	1
Cabeço da Arruda	Skeleton III	H	*Homo*	TO-360	6990 ± 110	7930-7450	5980-5500	1
Cabeço da Arruda	CA-00-01	H	*Homo*	TO-10217	6620 ± 60	7520-7230	5570-5280	1
Cabeço da Arruda	CA-00-02	H	*Homo*	TO-10216	7040 ± 60	7870-7570	5920-5620	1
Fiais	–	B	*Bone*	ICEN-141	6180± 110	7233-6913 (1s)	5400-4800	2
Fiais	S.XIX, A10, z.244	B	*Mammal*	TO-706	6260 ± 80	7126-7026 (1s)	5470-5000	2
Fiais	–	B	*Bone*	ICEN-110	6870± 220	8160-7330	6250-5350	2
Moita do Sebastiao	Skeleton CT	H	*Homo*	TO-135	6810 ± 70	7570-7250	5620-5300	1
Moita do Sebastiao	Skeleton 41	H	*Homo*	TO-134	7160 ± 80	7940-7590	5990-5640	1
Moita do Sebastiao	Skeleton 24	H	*Homo*	TO-132	7180 ± 70	7950-7620	6000-5670	1
Moita do Sebastiao	Skeleton 29	H	*Homo*	TO-133	7200 ± 70	7970-7640	6020-5690	1
Moita do Sebastiao	Skeleton 22	H	*Homo*	TO-131	7240 ± 70	7980-7640	6030-5690	1
Samouqueira I	c.2	H	*Homo*	TO-130	6370 ± 70	6800-6633 (1s)	5480-5210	2
Vidigal	c.2 (shell midden)	B	*Bones*	GX-145557	6030 ± 180	7439-6305	5490-4356	3
Vidigal	c.3 (paving)	B	*Bones*	Ly-4695	6640 ± 90	7738-7274	5789-5325	3
Cabeço da Amoreira	Skeleton ?	H	*Homo*	TO-11819R	7300 ± 80	8050-7660	6100-5710	1
Cabeço da Amoreira	Skeleton 7	H	*Homo*	Beta-127450	6850 ± 40	7610-7380	5660-5430	1
Cabeço da Amoreira	CAM-00-01	H	*Homo*	TO-10218	6630 ± 60	7460-7170	5510-5220	1
Cabeço da Amoreira	CAM-01-01 (139)	H	*Homo*	TO-10225	6550 ± 70	7980-7640	5630-5370	1
Vale de Boi	c.2	H	*Homo*	TO-12197	7500 ± 90	8551-8020	6602-6071	4
CANTABRIAN STRIP AND PYRENEES								
Linatzeta	–	H	*Homo*	KIA-33193	7315 ± 35	8300-8002	6351-6053	5
Los Canes	Skeleton 6-III	H	*Homo*	AA-6071	6930 ± 95	8015-7518	6066-5569	6
Los Canes	6-II feet	H	*Homo*	AA-5295	6860 ± 65	7932-7566	5983-5617	6
Los Canes	Skeleton 6-II	H	*Homo*	AA-5296	6770 ± 65	7826-7460	5877-5511	6
Los Canes	Skeleton 6-II	H	*Homo*	AA-11744	7025 ± 80	8052-7615	6103-5666	6
Los Canes	Skeleton 6-I	H	*Homo*	AA-5294	6265 ± 75	7424-6904	5475-4955	6
Colomba	Shell midden	H	*Homo*	TO-10223	7090 ± 60	–	5910-5534	7
Cubio Redondo	Shell midden	B	*Cervus*	Beta-106050	6630 ± 50	7622-7421	5673-5472	8
Cofresnedo	Cof.5	B	*Roe-deer*	GrA-20146	6865 ± 45	7847-7581	5898-5632	7
Urratxa	Level fertile	B	*Bone*	Ua-11435	6995 ± 80	8025-7607	6076-5658	7
Urratxa	Level fertile	B	*Bone*	Ua-11434	6940 ± 75	7969-7585	6020-5636	7
MEDITERRANEAN REGION AND EBRO VALLEY								
El Collado	Burial 12	H	*Homo*	UBAR-281	7640 ± 120	8989-8050	7040-6101	9
El Collado	Burial 12	H	*Homo*	UBAR-280	7570 ± 180	9033-7858	7084-5909	9
Mas Cremat	Level_III	F	*Sorbus*	Beta-232342	6780 ± 50	7787-7507	5838-5558	10
Cingle Mas Nou ent	–	H	*Homo*	Beta-170715	6920 ± 40	7929-7623	5980-5674	11
Cingle Mas Nou 3	–	H	*Homo*	Beta-170714	6910 ± 40	7924-7620	5975-5671	11
Falguera	–	S	*Olea sp.*	AA-2295	7410 ± 70	8404-8013	6455-6064	12
Lagrimal	Level_IV	B	*Ibex*	Beta-249933	6990 ± 50	7960-7676	6011-5727	13
Botiquería	Level_4	B	*Bone*	GrA-13267	6830 ± 50	7835-7568	5734-5663	14
Botiqueria	Level_2	B	*Bone*	GrA.13265	7600 ± 50	8554-8205	6605-6256	14
Aizpea	Level_B	B	*Bones*	GrA-779	6600 ± 50	76133-7335	5664-5386	15

Tab. 1. Late Mesolithic radiocarbon dates on short lived samples. H = human bone; B = bone; F = fruit; S = seed. References. 1: **Martins et al 2008*****; 2:*** **Lubell et al. 2007*****; 3:*** **Carvalho in press*****; 4:*** **Carvalho et al. 2008*****; 5:*** **Tapia et al. 2008*****; 6:*** **Arias 2005/2006*****; 7:*** **Fano 2004*****; 8:*** **Ruíz and Smith 2001*****; 9:*** **Guixé et al. 2006*****; 10:*** **Vicente et al. 2009*****; 11:*** **Olària and Gusi 2005*****; 12:*** **Barton et al. 1990*****; 13: Inedit; 14:*** **Barandiarán and Cava 2000*****; 15:*** **Barandiarán and Cava 2001.**

rán and Cava 2000; Cava 2004; Utrilla et al. 1998). Sites extend from the Lower Aragon region, with a clear spatial continuity into north Valencia, through the High Ebro Valley and the central and western Pre-Pyrenees. Recently, some new sites has been published in full, such as Mendandia (*Alday 2006b*) or Los Baños (*Utrilla and Rodanés 2004*), and some new Late Mesolithic sites with radiocarbon dates have been reported, such as Cova del Vidre (*Bosch 2008*) and Cabezo de la Cruz (*Picazo and Rodanés 2008*). The latter site fills the gap in the Late Mesolithic record in the south central area of the Ebro Valley.

In Andalusia, in southern Iberia, the Late Mesolithic remains understudied. The references traditionally cited are some interior rock shelter sites, such as Nacimiento and Valdecuevas, or possible lithic scatters like Los Frailes (*Juan-Cabanilles and Martí 2002*). In recent years, a few open-air Late Mesolithic sites have been published in full for the Algeciras Bay area, such as Embarcadero del Rio Palmones (*Ramos and Castañeda 2005*) and El Retamar, on the Atlantic coast of Cadiz (*Ramos et al. 2002*). El Retamar is considered Neolithic by its excavator (*Ramos et al. 2005*), although the lithic assemblage – overwhelmingly dominated by trapezoidal microliths and microburins – and the radiocarbon dates suggest the existence of a preceramic occupation phase[2]. At the Malaga coast, the recent revision of two long cave sequences – Nerja and Bajondillo caves- has yielded Late Mesolithic evidence (*Aura et al. 2005; Cortés 2007*, respectively).

In Portugal, the main clusters of Late Mesolithic sites are located around the Lower Tagus, Sado and Mira estuaries and the Alemtejo coastline (for regional syntheses, see *Bicho 1994; Zilhão 2000; Carvalho 2002; 2003*). A secondary cluster is documented in the Rio Maior at the Estremadura region (Forno da Telha and Abrigo das Bocas), which is interpreted in terms of logistic dependence on the Muge Mesolithic sites (*Carvalho 2003*). Recently, new research projects have added some New Late Mesolithic sites in the Algarve (*Carvalho et al. 2005; 2008; Stiner et al. 2003*). To the north, in the Alto Douro, only the Prazo site has produced possible evidence of Late Mesolithic occupation; however, in the light of the provenance and nature of the radiocarbon dates (charcoal samples), its Mesolithic attribution is not unanimously accepted (for a detailed discussion, see *Carvalho 2003; Zilhão 2003; Monteiro-Rodrigues 2003*).

Along the north Iberian coast, some dispersed Late Mesolithic sites have been reported in Galicia (*Vázquez 2004*); however, the main archaeological evidence comes from an area between the eastern half of Asturias and the Basque Country (*Fano 2004; Straus 2004; 2008*). Previous approaches to this region traditionally outlined the importance of coastal adaptations in the settlement distribution with the abandonment of the mountain inland after the Azilian. However, archaeological research in recent years has changed this perspective. Late Mesolithic occupations are also documented for inland locations, such as Los Canes Cave (*Arias 2005*), and even in high mountain areas such as Espertin (*Fuertes and Neira 2006*). Also, some Late Mesolithic sites (most of them shell middens) dated to 7700–6600 BP have been reported recently, such as Linatzeta (*Tapia et al. 2008*), Cubio Redondo (*Ruiz and Smith 2001*), Colomba (*Arias 2005/2006*), Truchiro, Toralete, Coberizas, Covajorno, El Aguila, Pendueles, and Sierra Plana (*Fano 2004*). Complete publications of new Late Mesolithic sites include Cofresnedo (*Ruiz and Smith 2003*).

In contrast to the regions mentioned above, there is a lack of Late Mesolithic data in two large Iberian regions: the central region, the Tertiary plateau known as the Spanish Meseta, and Catalonia in northeast Spain. The interpretation of this 'archaeological silence' requires detailed discussion, using both paleoenvironmental evidence and the representativeness of the archaeological research. Some scholars have suggested that the human population of the Iberian Peninsula interior during the Early and Middle Holocene was rather low until the beginning of the Neolithic (*Zilhão 2000.144; Straus 2008*). Early Holocene reforestation would have produced a reduction in herbivorous biomass, making the area less attractive relative to coastal and estuarine areas. Consequently, scattered settlement or very low population densities lead to a poor archaeological record. At present, this interpretation is still supported by current paleo-environmental and archaeological evidence.

Effectively, North Meseta pollen records indicate a forest re-colonization from the beginning of the Ho-

2 Radiocarbon dates from this site also display a disparity with different statistical result. For instance, a single feature -hearth 18- provides two radiocarbon dates elaborated on shell samples with a difference of 500 years (Sac 1525: 6900±70 BP and Beta–90122: 6400±85 BP); the oldest one is statistically similar to another one coming from a different sector of the same site (Sac–7020±100 BP), which fit within the chronological limits of the Late Mesolithic.

locene, and the progressive replacement of pine formations by oak forests. During the Boreal period, forest expansion reached its maximum extent, as reflected in both the Sanabria reservoir and the Sanguijuelas Lagoon pollen diagrams, where tree pollen dominated by Quercus comprises 70% and 90% respectively (*McKeever 1984; Muñoz et al. 2001*).

During this period of forest expansion, the number of archaeological sites declines drastically. Final Paleolithic sites with Magdalenian industries are well known in the North Meseta (*Diez and Delibes 2006*). In contrast, the number of Preboreal sites decreases significantly, and there is no (stratigraphic, chronological or industrial) reliable evidence of Boreal sites or Late Mesolithic sites from North Meseta (*Alday 2005; Corchón 2006*).

In this sense, some presumed Mesolithic attributions published recently need to be revisited. For example, Jiménez-Guijarro (*2005 and 2008*) has pointed out the presence of Late Mesolithic occupations in the Madrid region at the Ventana Cave and at the open air site of Verona II. However, the published archaeological evidence lacks radiocarbon dates, stratigraphy or diagnostic artifacts to confirm such an attribution[3]. In addition, other archaeological deposits considered by this author as Late Mesolithic, such as Verdelpino or the Níspero caves (*Jiménez-Guijarro 1999*) are not Late Mesolithic, but Epipaleolithic, dating to the Early Holocene.

There is still a notable lack of Late Mesolithic, especially considering that systematic extensive survey programs have been developed in the North Meseta (*Balbín et al. 1997; Rojo and Kunst 1999*). Furthermore, several Holocene archaeological sequences have been excavated in recent years, such as El Mirador Cave (*Vergès et al. 2008*), El Portalón Cave (*Ortega et al. 2008*), and the Carlos Alvarez rock shelter (*Rojo et al. 2008*), but no Late Mesolithic levels have been reported.

Catalonia, in north-east Spain, is another second region where no Late Mesolithic sites have been documented. This lack of data does not seem to be the result of bias in archaeological research. Early Holocene occupations with Epipaleolithic and Sauveterrian industries on the central coast of Catalonia and in the Interior Valleys of Lerida (sites like Parco, Filador, and Balma de Gai) (*García-Argüelles 2006*) are well documented. In addition, many Boreal ND Mesolithic sites are documented for the same areas (Parco and Filador) (*García-Argüelles 2006*), the south east Pyrenean foothills (*Martínez-Moreno 2006*) and in central and southern Catalonia (*Vaquero 2006*). The last Mesolithic occupations documented in Catalonia are from the ND Mesolithic complex – level A of the rock-shelter at Cativera – dating to 9000–8600 calBC (*Allué et al. 2000*). A gap of more than 1200 years separates the most recent evidence of foragers from the earliest Cardial Neolithic context.

The lack of Late Mesolithic sites in Catalonia might be related to a broader process of settlement reorganization documented in the Mediterranean at the end of the Boreal period (*Fernández and Jochim in press*). In this sense, it should be noted that the last ND Mesolithic occupations documented in Catalonia – the Cativera and Molí del Salt sites – are recorded in the upper section of their stratigraphic sequences, while in the neighboring central Ebro Valley, the ND Mesolithic inaugurates the occupation of many rock shelters which display a clear occupational continuity thereafter, during the Late Mesolithic (*Montes et al. 2006*).

The settlement reorganization implies a general increase in the number of Late Mesolithic sites, as well as changes in the settlement pattern, with a significant increase in open-air sites around inland and coastal lagoons. Necropolises, such as El Collado (*Aparicio 1990; García Guixé et al. 2006*) or Mas Nou (*Olària et al. 2005*), completely absent in the ND Mesolithic archaeological record, are another innovation of this period.

In Portugal, the Late Mesolithic witnessed the emergence of year-round residential campsites located in highly productive estuarine areas. The most visible manifestations from the Atlantic period are shell middens with a complex interior spatial organization that included a number of post-holes and pit structures, such as roasting and storage pits, hearths, etc, and necropolises formed by numerous inhumations (*i.e.* Moita do Sebastião) (*Roche 1972*). Regarding the Boreal period, the settlement pattern was reorganized, and sites are clustered only in estuarine areas, leaving inland territories, like the Estremadura plateau case, uninhabited (*Araujo 2003*).

3 At the Ventana Cave, the presence of trapezes with bifacial retouch and the length and width of the trapezes with abrupt retouch is quite similar to the microlith assemblages founded in Megalithic tombs during the Middle Neolithic (*Alegre 2005; Fernández et al. 2009*).

Environmental dynamics and Late Mesolithic settlement organization: the 8200 calBP event

The 8200 calBP event in southern Europe is currently being considered as the main environmental factor triggering the dispersal of agriculture (*Weninger et al. 2006; Budja 2007*), land use changes (*González-Sampériz et al. 2008; Fernández and Jochim in press*), or the cause of the chronological gaps observed in the radiocarbon record between the Late Mesolithic and the Early Neolithic periods (*Berger and Guilaine 2009*).

In contrast to the eastern Mediterranean, the 8200 calBP event in Iberia fell between Late Mesolithic phases A and B. Recently, scholars have used its effects to explain changes in land use patterns that potentially affected both the regional distribution and settlement organization of the last forager populations in Portugal (*Zilhão 2003; Carvalho in press*), the Ebro Valley (*Utrilla 2005; González-Sampériz et al. 2008*) and the Mediterranean region (*Fernández and Jochim in press*). A different issue turns on the potential relationship between this climatic event and sedimentation dynamics, as might be suggested by the increasing documentation of sites having a stratigraphic hiatus between the Late and the Early Neolithic occupations (*Berger and Guilaine 2009*).

In Portugal, the relationship between the 8200 calBP event and the decline in marine productivity has been pointed out to explain the habitat concentration on the large estuarine areas such as the Lower Tagus and the Sado (*Zilhão 2003; Carvalho in press*). According to this hypothesis, this climatic episode allowed a freshwater current to reach the Portuguese coast, reducing coastal upwelling activity. The main indicator to support this relies on the diachronic variation in the reservoir effect along the Portuguese coast during the Holocene being considered as a coastal upwelling proxy (*Soares and Dias 2006*). However, the chronological correlation between coastal upwelling activity and changes in the settlement pattern is not completely clear due to the current chronological scale for determining the reservoir effect on the basis of radiocarbon dates of shell and charcoal samples.

What seems clear from the archaeological evidence is the crucial effect of this climatic crisis on the abrupt change in coastal occupation and subsistence patterns documented from the Boreal to the Late Mesolithic periods (*Araujo 2003; Bicho 2006; Carvalho in press*). For the former period, a higher number of small or medium size shell middens have been documented at different coastal locations in the Algarve, Alemtejo and Estremadura regions, while the Late Mesolithic witnessed habitat concentration around the main estuaries, with a significant increase in shell midden size. A lower degree of residential mobility, with mostly round year occupation, is reflected by the documentation of necropolises on the shell middens, and a higher dependence on aquatic resources, estimated at around the 40%–50% of the diet on the basis of the stable isotopic evidence (*Lubell et al. 1994*). In this sense, a strong chronological correlation between Lower Tagus estuarine adaptations and the beginning of the 8200 calBP event can be established if isotopic corrected human bone samples are considered on the basis of the local determination of the reservoir effect at the Muge region (*Martins et al. 2008.83*)[4]. In addition, around 8150 calBP, the development of the Lower Muge shell middens was enabled with an abrupt change from fluvial to estuarine environments, which led the to formation of productive shell beds (*van der Shrieck et al. 2008*).

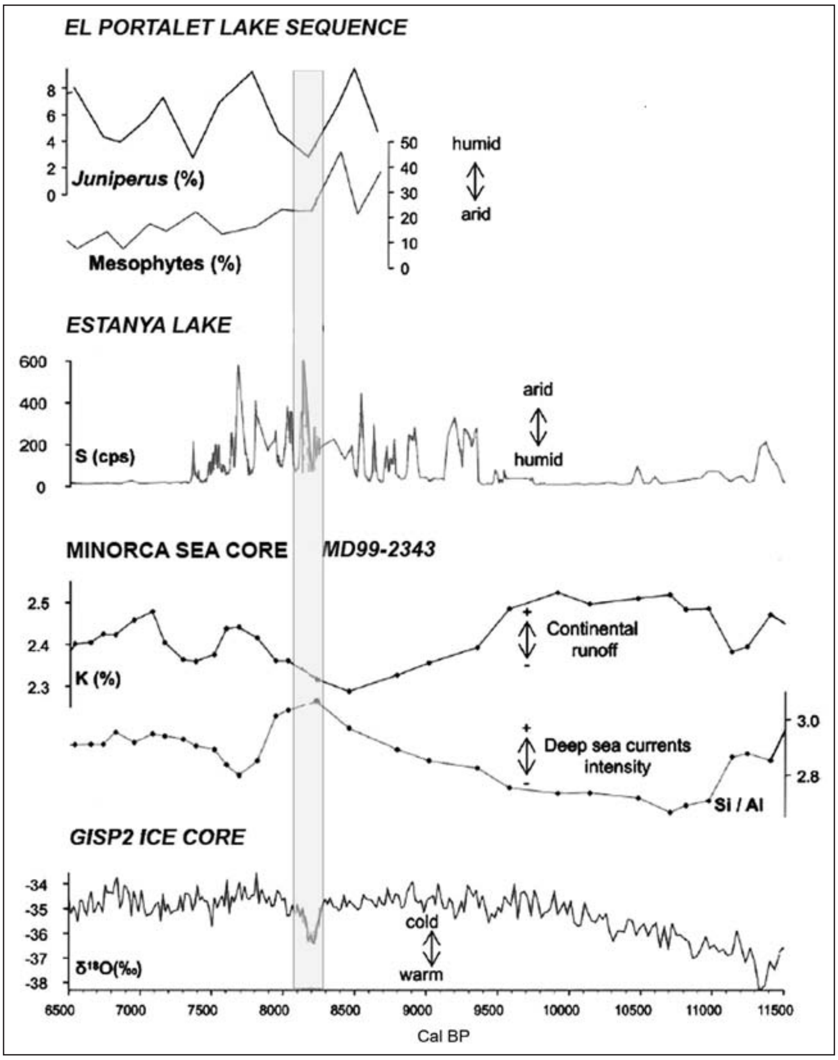
In the Mediterranean climatic region of Iberian Peninsula, a significant number of paleo-environmental studies – including both marine and lake cores – have recorded short-term stepped variations in temperature, water balance input and vegetation during the 8200 calBP (Fig. 2). Isotopic analysis from three marine cores located in the Alborán sea (*Cacho et al. 1999*) and close to the Menorca island (*Frigola et al. 2007; Jiménez-Espejo et al. 2007*) have documented a downturn of 2° C in sea surface temperature. According to Frigola *et al.* (*2007.13*), this change was associated with a persistent positive index in the North Atlantic Oscillation that produced colder and drier conditions in the Iberian Peninsula (Fig. 2).

Multi-proxy studies from several continental lakes show a chronological correlation with lower lake levels in La Estanya Lake in the pre-Pyrenean mountains (*Morellón et al. 2007.12–13*) and in Salinas Playa Lake, more than 600km further south in southeast Spain (*Giralt and Julià 2003.321*).

Vegetation changes have been documented in several natural and archaeological deposits in eastern Spain, indicating an interruption in the temperate

4 The old wood effect problems in radiocarbon dating on Muge shell middens have been broadly discussed in recent approaches (*Zilhão 2001; Jackes and Meicklejohn 2006; Roksandić 2006; van der Shriek et al. 2008*).

Fig. 2. Early to Middle Holocene environmental dynamics from different paleoclimatic proxies in the Mediterranean region of Iberia where the 8200 cal yr BP event is detected (source: González-Sampériz et al. 2009.Fig.4 *adapted). Juniperus and Mesophhytes percentages at Portalet lake sequence (*González-Sampériz et al. 2006*); Sulphur (S) content (count per seconds) (*Morellón et al. 2008*); Minorca Drift record (Core MD99–2343, Mediterranean Sea) Potassium (K) -percentage (%) and Silicon/Aluminium (Si/Al) ratio (*Frigola et al. 2007*) and Greenland GISP2 ice core oxygen isotope curve (*Grootes and Stuiver 1997*). A grey band marks the 8.2 ka event as referenced at the GISP2 ice core (*Grootes and Stuiver 1997*).*



and moister conditions that had resulted in forest expansion since the beginning of the Holocene (*López Sáez et al. 2007*). During the 8200 calBP event, El Portalet Lake underwent an abrupt decrease in Juniperus, Betula, Corylus and deciduous Quercus taxa (*González-Sampériz et al. 2006.49*). Further south, the San Rafael sequence at Almeria also records an abrupt change from mesic to xeric vegetation (*López Sáez et al. 2007*). In the Central Ebro Desert, multi-proxy lake records of Guallar and Hoya del Castillo lagoons show a stepped increase of microfossil charcoals around 8.3 ka BP caused by natural fires as a result of a general decline in annual rainfall. The increase in microfossil charcoal is also associated with vegetation changes, mainly the development of fire-resistant evergreen oaks such as hermes oak and, especially, cork oak, which replaced the pine forests (*Davis and Stevenson 2007.1706*). Finally, although pollen reconstructions from Late Mesolithic archaeological deposits in caves or rock shelters are deficient to document the 8200 calBP event, several sites such as the El Nacimiento or El Bajondillo caves saw an increase in xeric species (*López Sáez et al. 2007*).

In Northern Iberia, the paleo-environmental data required to detect the short-term vegetation changes produced by such climatic crisis are less informative. In the north west sector (Galicia), an episode of oak forest retreat has been recently correlated with the 8200 calBP event, changing the traditional interpretation by which the regression of forest biomass was caused by Epipaleolithic populations (*Martínez-Cortizas et al. 2009.82*). In contrast, in the central sector of the northern Iberian Peninsula (the Western Pyrenees, East Cantabrian Mountains and the Upper Ebro Valley), no relevant vegetation changes have been documented for the 8th millenium, which displays a continuous expansion of deciduous forests and a progressive decline in pine formations (*Iriarte 2009*). Unfortunately, the archaeological information is biased, given the poor preservation of palynomorphs at relevant Late Mesolithic sites such as Mendandia, Kanpanoste and Kanpanoste Goikoa (*Iriarte 2009.70*).

The ecological impact and its consequences on human land-use patterns in the Mediterranean region, especially in the Central Ebro Valley, are the subject of lively debate. The climate in this particular area is Mediterranean, with a continental influence, resulting in semi-arid conditions manifested by hot summers, cold winters, low annual precipitation and high evapo-transpiration index. Some scholars, like P. Utrilla and P. González-Sampériz, have correlated the lack of Mesolithic sites dated *c.* 7300–6800 BP at the Bajo Aragón with this aridity crisis. This chronological gap is related to the documentation of sterile levels in the main Mesolithic rock shelters of the area, such as Botiqueria, Los Baños, Angel, and Pontet. These authors argue that these arid conditions compelled people to move to other, wetter areas such as the High Ebro Valley, the eastern, central Pyrenees, or the Maestrazgo (*Utrilla 2005; González-Sampériz et al. 2008*). Consequently, Lower Aragon witnessed no human occupation or very low occupation intensity until the beginning of the Neolithic.

Nevertheless, other authors have recently argued for a shorter chronological influence, considering an individual evaluation of the stratigraphy and the radiocarbon dates (*Fernández and Jochim in press*). Furthermore, similar situations of site abandonment might potentially be identified in other Iberian areas under Mediterranean-continental influence, such as South Valencia or the central Pre-Pyrenees foothills. Effectively, sites such as Forcas II and Falguera also document sterile layers formed during part of the 8200 calBP climate crisis bounded by Mesolithic occupations (*Fernández and Jochim in press*). However, the main discussion point relies on the human responses to such abandonment episodes. Utrilla and González-Sampériz interpret the sterile levels in terms of population dynamics, arguing for a depopulation of Lower Aragon and subsequent migration to other, wetter areas (*Utrilla 2005; González-Sampériz et al. 2008*).

In contrast, we consider that these might be better explained as result of readjustments in the logistic mobility system, due to the functional characteristics of the archaeological sites, with desertion episodes as forest logistic sites whose faunal assemblages are mainly composed of red deer among the ungulates (Botiqueria, Los Baños and Pontet). The potential effects of water availability and vegetation changes on key herbivore biomass, such as red deer, might explain an increase in the risk assumed in hunting parties (*Fernández and Jochim in press*). In fact, such readjustments to the logistic mobility system implies the appearance of alternative logistic campsites in high altitude mountain areas specializing in ibex, such as La Cova del Vidre (*Bosch 2008*), with a clear connection with Lower Aragón.

In this sense, one of the clearest examples of the strategic interest of this kind of high-altitude mountain area on land use patterns in the Mediterranean façade of Iberia is represented by the Mas Nou site. This is an open-air site located in the highlands of the limestone plateau of Sierra d'en Seller (Castellón) at 940m a.s.l. with an inhumation pit containing the human remains of seven individuals (*Olària et al. 2005*). This particular case, which is completely different from the burial contexts associated with coastal or estuarine occupations, could reflect the exertion of property rights over mountain areas as a result of the climatic crisis (*Fernández 2006*).

The last point to be stressed regarding the impact of the 8200 calBP event on the Iberian Late Mesolithic record relies on taphonomic and archaeological formation processes. In the Mediterranean region of Spain, the presence of a significant stratigraphic hiatus between the Late Paleolithic levels (Magdalenian) and the earliest Neolithic occupations has been recurrently documented in long archaeological sequences in cave deposits such as Cendres Cave, Malladetes Cave (*Fumanal 1995*) and En Pardo Cave (*Soler et al. 2008*). Even though its genesis regarding such climatic events still needs to be confirmed, it is clear that any Late Mesolithic traces in these archaeological deposits have been beheaded or severely affected. A closer causal relationship might be argued to explain, in the same geographic area, the increasing number of rock shelters, which document chronological gaps, eroded surfaces or the stratigraphic hiatus between the Late Mesolithic (phase A) and the Early Neolithic occupations. At Balma Margineda site (Andorra), level 4S corresponding to a Late Mesolithic trapeze phase, was affected by a clear truncation episode which separate this occupations from the Early Cardial Neolithic levels (*Berger and Guilaine 2009; Brochier 1995*). At Mas de Marti rock shelter (Castellon); several gravel laminations interpreted as eroded surfaces have been recorded between level 3 (Late Mesolithic trapezes phase) and level 2 (Early Neolithic Epicardial phase) (*Fernández et al. 2005*). At Tossal de la Roca site, the upper section of the archaeological sequence comprises level I, with a lithic industry of trapezes and a radiocarbon date, overlaid in erosive contact by level Sup, which contains cardial ceramics (*Cacho et al. 1995*). Finally, at Falguera site, an erosive hiatus 25cm thick (level VII) separates the Late Mesolithic level VIII (with trapezes) from the subsequent Early Neolithic occupations documented in level VI (*García and Aura 2006*).

These examples warn against the problems of detecting the Final Mesolithic in the current archaeological record. Obviously, to avoid biased interpretations, considerations of population dynamics should be grounded on the evaluation of the archaeological evidence on a micro-regional scale, considering the role of site formation processes in the chronological gaps – something that still need to be done.

A possible way to detect such terminal Mesolithic evidence in disturbed archaeological contexts is to use individual short-lived samples. For instance, at the Lagrimal Cave in Alicante, the AMS radiocarbon determination of an ibex bone from level IV with anthropogenic fractures and cut marks has provided the most recent chronological evidence for a Late Mesolithic context (Phase B) in the southern Valencia region (Tab. 1). This fact clarifies previous approaches that had outlined the presence of a chronological hiatus of six centuries between the last Late Mesolithic (Phase A) and the first Early Neolithic contexts in this area (*Bernabeu 2006*).

Paleodiets: varying reliance on aquatic resources

One of the biggest contributions to Iberian Mesolithic archaeological research in recent years has come from paleodiet studies on the basis of δ C^{13} and δ N^{15} isotopic analyses. Although this kind of approach can be traced back to the mid-90's in Portugal (*Lubell et al. 1994*), fresh evidence from another Iberian regions such as Cantabria and the Central Mediterranean have recently been published (*Arias 2005/2006; García Guixé et al. 2006*), providing a first data set to compare Late Mesolithic subsistence patterns on a broader scale (Tab. 2).

Portugal has the biggest regional data set in terms of number of sites and individuals analyzed (*Lubell et al. 1994; Jackes and Meiklejhon 2004; Roksandic 2006; [Umbelino 2006 in Carvalho 2007]*). Notoriously representative, the Muge shell middens record concentrates the highest number of isotopic determinations for the Late Mesolithic period: Cabeço da Arruda (10)[5], Moita do Sebastião (9), Cabeço da Amoreira (5), and Cova da Onça (1). In the Alemtejo region, mainly the Sado estuary, isotopic determinations are less significant quantitatively: Cabeço do Pez (3), Amoreira (2), Arapouco (1), Poças de Sao Bento (1), Vale de Romeiras (1) and Algarão da Goldra (2) (*Umbelino 2006 in Carvalho 2007*). Finally, in the Algarve, the site of Vale de Boi provides a single determination (*Carvalho et al. 2008*).

For the Neolithic period (*c.* 5200–3000 calBC), the Portuguese data set comprises an outstanding number of sites and determinations, mainly in the Estremadura region: Gruta do Caldeirão (2), Algar do Picoto (2), Lapa dos Namorados (1), Lapa da Bougalheira (1), Costa do Pereiro, Algar do Barrao, Lugar do Canto, Casa da Moura (4), Algar do Bom Santo (5), Pedreira de Salemas (1), Gruta do Correiro Mor (1), Monte do Castelo, and Lapa do Fumo (*Carvalho 2007*).

The first paleodiet studies undertaken for Muge sites estimated a diet contribution of aquatic origin proteins at about 40–50% (*Lubell et al. 1994*). However, the pattern is more complex if radiocarbon chronology and new isotopic determinations are considered. For instance, Jackes and Meiklejohn (*2004*) suggest a trend along the Late Mesolithic occupation towards a more terrestrial diet, which they interpret in terms of decreasing shellfish availability due to variations in tidal influence at the Lower Tagus estuary (*Van der Schreck et al. 2007*). Furthermore, the relationship between changes in the estuarine regime and the reliability of aquatic resources in Muge has been pointed out to interpret the isotopic values from the oldest individual (skeleton 6 from Cabeço da Arruda), which has a lower significant marine protein contribution (24%) and who lived right before the estuary's maximum extent (*Martins et al. 2008*). Thus, the Muge area points to a sequence of dietary changes closely related to the local evolution of the estuarine regime, which led to the formation of rich shell beds: a first occupation with a lower reliance on aquatic resources (24%), followed by a phase with a significant increase in marine protein input (45–50%) and, finally, a trend towards a more terrestrial diet, when the tidal influence decreased, becoming less productive in terms of shellfish availability.

Apart from Muge, the available data from other Portuguese regions during the Late Mesolithic is quite variable. For instance, at the Sado estuary, the shell midden of Arapouco reflects a comparable aquatic protein input to that of the Muge sites, while other Late Mesolithic sites located far inland, such as Amo-

5 The number indicates the quantity of individuals analyzed.

reiras and Cabeço do Pez, reflect a more terrestrial input. This dual pattern might be interpreted as the result of the geographic coexistence of human groups with varying reliance on aquatic and terrestrial resources (*Umbelino 2006 in Carvalho 2007*).

In contrast, the Portuguese data for the Early Neolithic (Caldeirao, Correio Mor, Casa Moura) indicates a significantly different subsistence pattern based on terrestrial origin diet (*Lubell et al. 1994; Carvalho 2007*).

Further North, in the Cantabrian region, the paleodiet studies of Late Mesolithic samples comprise six individual determinations from two different sites: a shell midden at Colomba (1 individual) and a sepulchral cave at Los Canes (five individuals) (*Arias 2005/2006*). The isotopic value from the Colomba sample indicates a similar diet contribution from aquatic (marine) and terrestrial proteins. This pattern is very similar to those obtained in other, older Cantabrian shell middens dated to the Boreal period, such as J3 and Poza l'Egua. In contrast, the five individual determinations from the Los Canes site show the main protein contribution was of terrestrial origin. On this basis, P. Arias has suggested the coexistence of different populations with a differential reliance on marine and terrestrial resources during the Late Mesolithic. For the Neolithic period, the only Cantabrian determination comes from the Megalithic tomb of Cotero de la Mina, which indicates a terrestrial origin diet (*Arias 2005/2006*).

In the Mediterranean region, the shell midden at El Collado is the only Late Mesolithic site with paleodiet reconstructions based on stable isotopic analysis. This site includes a cemetery with fifteen individual burials, with nine skeletons analyzed (*García Guixé et al. 2006*). The most striking result from this shell midden is the low reliance on marine foods – only 25% for two individuals, with the highest $\delta^{13}C$ values, while the rest of the sample has lower values, and in three cases the diet proteins are all terrestrial. García Guixé *et al.* interpret these results considering two hypotheses: either a different dietary adaptation, where the use of terrestrial resources played a higher role in subsistence patterns than in other European Mesolithic populations, or the less productive nature of Mediterranean sea shellfish compared to Atlantic species.

Although the current body of data is still too thin to reach meaningful conclusions on the Iberian scale, several observations can be made.

First, a different evolutionary pattern of reliance on aquatic resources can be established in those areas where anthropological series allow a diachronic approach (Portugal and Cantabrian strip). In Portugal, a clear trend towards an increasing contribution of aquatic diets from the Boreal Mesolithic to the Late Mesolithic is observed, which fit with changes documented in the settlement pattern. In contrast, the Cantabrian samples record significant aquatic protein input in the Boreal period, while the Late Mesolithic ones show the opposite situation, with samples from coastal sites having about 50% of marine proteins and an inland site whose diet is mostly terrestrial. In both regions, Neolithic samples indicate a dietary shift, with a higher contribution from terrestrial proteins.

Second, the reliance on aquatic resources between the Muge and the Mediterranean samples is considerably different. It is true that in the El Collado case, the lower number of radiocarbon dates (just two determinations from the same individual) does not allow a determination of diachronic trends. However, it should be noted that the same kind of adaptations – shell middens – led to different results in terms of protein intake.

Third, the current data set suggests the coexistence of neighboring coastal and inland Mesolithic populations, with different diets. As Arias states, the Cantabrian case mentioned above is paradigmatic, but a similar situation has been recently suggested for the Sado estuary (*Martins et al. 2008*). Finally, there are no discernible differences in isotope values between males and females in any studies published thus far.

Even though it is always necessary to incorporate new sites and samples, the main hypothesis is that during the Neolithic transition, the last Iberian hunter-gatherer populations faced various cultural contacts under distinctive subsistence conditions.

The dispersal of agriculture in Iberia: chronological framework and spatial distribution

In the last seven years, remarkable advances have been achieved regarding the chronology and geography of the initial spread of farming in Iberia. Unlike previous Iberian syntheses (*Zilhão 2000; Bernabeu 2002; Juan-Cabanilles and Martí 2002*), mainly focused in traditional research areas such as the Spanish Mediterranean coast and Portugal, new Neolithic archaeological sites located in Iberian Meseta or in the Cantabrian façade have provided fresh evidences, including direct radiocarbon dates on crops (*Zapata et al. 2004; Stika 2005*). Figure 3 and Table 3 show the geographic location and absolute chronology of the earliest farming contexts dated by radiocarbon in the different Iberian regions. The distribution information for all 38 dates is plotted in Figure 4.

Considering both the radiometric data and the geographical distribution of the present evidence, some observations on the timing and spatial patterning of first Neolithic contexts in Iberian Peninsula can be made.

● The earlier antiquity of the Iberian Neolithic coastal regions (except the North façade) and its clustered and discontinuous spatial distribution. Dates from the Mediterranean coast of Spain (Mas d'Is and Nerja cave) and Portuguese Estremadura remain the oldest Neolithic contexts (5600–5500 calBC), that is, assemblages of pottery and domesticates (plants and animals). The chronology of these first farmer sites

SITE	CONTEXT	REF. LAB.	DATA BP	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	Ref.
PORTUGAL						
Moita do Sebastião	Ossada 22	TO–131	7240±70	–16.1	12.2	1
Moita do Sebastião	Ossada 29	TO–133	7200±70	–16.9	10.4	1
Moita do Sebastião	Ossada 24	TO–132	7180±70	–16.8	11.9	1
Moita do Sebastião	Ossada 41	TO–134	7160±80	–16.7	11.2	1
Moita do Sebastião	Skeleton 16	Beta–127449	7120±70	–16.8	–	2
Moita do Sebastião	Ossada CT	TO–135	6810±70	–15.3	13.4	1
Cabeço da Amoreira	Skeleton ?	TO–11819R	7300±80	–16.3	–	3
Cabeço da Amoreira	Skeleton 7	Beta–127450	6850±40	–16.5	11.9	2
Cabeço da Amoreira	Burial CAM–00–01	TO–10218	6630±60	–17.1	–	4
Cabeço da Amoreira	Burial CAM–01–01	TO–10225	6550±70	–20.1	8.2	4
Cabeço da Arruda	Skeleton 6	Beta–127451	7550±100	–19	–	2
Cabeço da Arruda	Burial CA–00–02	TO–10216	7040±60	–17.9	10.6	4
Cabeço da Arruda	Ossada III	TO–360	6990±110	–17.7	11.2	1
Cabeço da Arruda	Ossada A	TO–354	6970±60	–19	12.2	1
Cabeço da Arruda	Ossada 42	TO–359a	6960±70	–17.2	11.8	1
Cabeço da Arruda	Ossada D	TO–355	6780±80	–18.9	10.3	1
Cabeço da Arruda	Burial CA–00–01	TO–10217	6620±60	–18.1	10.5	4
Cabeço da Arruda	Ossada N	TO–356	6360±80	–15.3	12.5	1
Cova da Onça	Skeleton ?	Beta–127448	7140±40	–17.2	–	2
Vale Boi	c.2	TO–12197	7500±90	–18.3	11.6	5
MEDITERRANEAN REGION AND EBRO VALLEY						
El Collado	Ind. 1 (indet.)	–	–	–19.5	10.2	6
El Collado	Ind. 2 (female)	–	–	–19.1	8.9	6
El Collado	Ind. 3 (male)	–	–	–17.6	10.2	6
El Collado	Ind. 4 (male)	–	–	–17.6	12.8	6
El Collado	Ind. 5 (female)	–	–	–18.2	10.6	6
El Collado	Ind. 6 (male)	–	–	–18.2	10.9	6
El Collado	Ind. 7 (female)	–	–	–17.9	8.9	6
El Collado	Ind. 12 (male)	UBAR–281	7640 ± 120	–19	9.5	6
El Collado	Ind. 12 (male)	UBAR–280	7570 ± 180	–	–	6
El Collado	Ind. 13 (male)	–	–	–18.1	10.4	6
CANTABRIAN STRIP						
Colomba	Shell midden	TO–10223	7090±60	–15.8	12.5	7
Los Canes	6–III	AA–6071	6930±05	–19.3	7.7	7
Los Canes	6–II (feet)	AA–5295	6860±65	–19.2	9.4	7
Los Canes	6–II (skeleton)	AA–5296	6770±65	–19.7	8.1	7
Los Canes	6–II (skeleton)	AA–11744	7025±80	–19.6	7.8	7
Los Canes	6–I	AA–5294	6265±75	–20	7.9	7

Tab. 2. Stable isotopic values ($\delta^{13}C$ and $\delta^{15}N$) of Late Mesolithic skeletons from different Iberian regions. References: 1: **Lubell and Jackes 1994*; 2:*** **Umbelino 2006*; 3:*** **Detry 2007*; 4:*** **Roksandić 2006*; 5:*** **Carvalho 2007*; 6:*** **Guixé et al. 2006*; 7:*** **Arias 2005/2006.**

partly overlaps. Moreover, their geographical distribution offers a clustered pattern in several regions, such as in southern Valencia, central Catalonia, Algarve and Estremadura, and south of Andalusia.

The Valencia region is now the area with the oldest radiocarbon dates on cereals retrieved from open-air sites like Mas d'Is (*Bernabeu et al. 2003*). Caves were used as habitations (*e.g.* Or Cave, Cendres Cave) (*Marti et al. 1980; Bernabeu et al. 2001*), and together with rock shelters, they were also used for stabling (*e.g.* Falguera) (*García and Aura 2006*). Recently, a new Early Neolithic site resulting from rescue excavations – El Barranquet – has yielded an old radiocarbon date in sheep bone (*Esquembre et al. 2008*), and one ceramic context dominated by impressed non-Cardial ceramics very similar to the Ligurian phasies of Sillon d'Impressions documented in southern France (*Bernabeu et al. in press*).

Central Catalonia is the second cluster of Early Cardial Neolithic sites documented in Iberia, containing information of both open-air sites (village dwellings) and caves, but until recently poorly dated with radiocarbon determinations based on non-determined charcoal samples (*Mestres 1995*). Recently, Can Sadurní Cave has provided the earliest dates on cereal for the area (5470–5300 calBC), although the sample is a cluster of charred cereals (27 gr.) retrieved from the same ceramic ware (*Blasco 2005*).

In Portugal, the empirical regional evidence of some of the earliest Neolithic contexts derive from the western Algarve and northern Estremadura (*Zilhão 2000; Carvalho et al. 2008*). Radiocarbon determinations from the early Neolithic contexts in the Algarve region are based on shell samples (Cabranosa and Padrão) (*Zilhão 1997.36*). In northern Estremadura, the caves of Almonda and Caldeirão have yielded dates from short-lived materials (adornments, and sheep and human bones) dated to 5400 calBC and 5300 calBC, respectively (*Zilhão 1992; 2001*).

Finally, in the southern Mediterranean region of Andalusia, Nerja cave contained one of the oldest sheep bone samples (*c.* 5600–5400 calBC), although the archaeological context of the sample was disturbed (*Aura et al. 2005*).

● Agriculture rapidly reached the deep interior of Iberia. Traditionally, Spanish research considered some Cardial inland enclaves such as the site of Chaves and Forcas II in Upper Aragon (*Utrilla et al. 1998*) and Carigüela in Upper Andalusia (*Juan-Ca-*

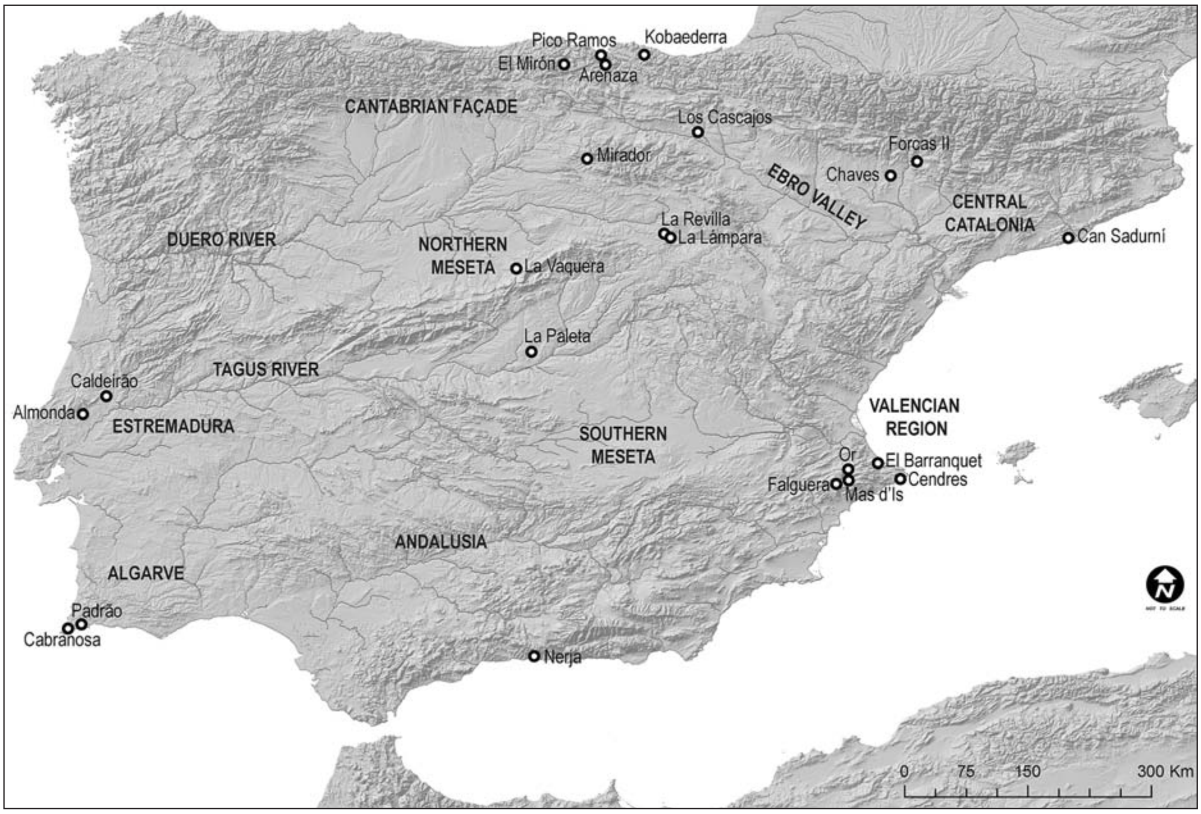


Fig. 3. Regional distribution of the earliest farming contexts in different Iberian regions (see Tab. 3 and Fig. 4).

SITES	CONTEXT	SAMPLE MATERIAL	SAMPLE REFERENCE	^{14}C age (BP)	CalBP 2σ range	CalBC 2σ range	Ref.
MEDITERRANEAN AREA							
Mas D'Is	80205	S *H. vulgare*	Beta-166727	6600 ± 50	7613-7335	5664-5386	1
Mas D'Is	80219	S *H. vulgare*	Beta-162092	6600 ± 50	7613-7335	5664-5386	1
Or	Basal Cardial (1955-58)	S Cereal	KN51	6510 ± 160	7855-6886	5906-4937	2
Or	J4, level 17	S *T. aestivum*	OxA-10192	6310 ± 70	7430-6960	5481-5011	2
Or	J4, level 14	S *T. aestivum*	OxA-10191	6275 ± 70	7425-6937	5476-4988	2
Or	Upper Cardial (1955-58)	S Cereal	H-1754/1208	6265 ± 75	7424-6904	5475-4955	2
Oliva	UE79	B *Ovis aries*	Beta-221431	6510 ± 50	7566-7272	5617-5323	3
Falguera	2051b	S *T. monococcum*	Beta-142289	6510 ± 80	7609-7174	5660-5225	4
Cendres	H16	S *T. dicoccum*	Gif-10136	6490 ± 90	7620-7160	5671-5211	5
Chaves	Ib	F Acorn	GrA-28341	6380 ± 40	7427-7172	5478-5223	6
Chaves	Ia	H *Homo*	GrA-26912	6230 ± 45	7278-6948	5329-4999	6
Can Sadurní	18	S cereal	UBAR-760	6405 ± 55	7460-7167	5511-5218	7
Nerja	NV-2	B *Ovis aries*	Beta-131577	6590 ± 40	7578-7421	5629-5472	8
PORTUGAL							
Almonda	Level 1	P *Cervus elaphus*	OxA-9287	6445 ± 45	7421-6851	5529-5305	2
Almonda	Level 1	Bb –	OxA-9288	6445 ± 45	7315-6675	5529-5305	2
Caldeirão	NA2	B *Ovis aries*	OxA-1035	6330 ± 80	7478-7254	5516-5001	2
Caldeirão	NA2	B *Ovis aries*	OxA-1034	6230 ± 80	7478-7254	5472-4902	2
Caldeirão	NA2	H *Homo*	OxA-1033	6130 ± 90	7465-6950	5366-4726	2
MESETA							
La Paleta	Pit 219	S Cerealia sp.	Beta-223092	6600 ± 60	7622-7322	5673-5373	9
Mirador	Level MIR 23	S *T. dicoccum*	Beta-208134	6300 ± 50	7420-7008	5471-5059	10
Mirador	Level MIR 22	S *T. aestivum/durum*	Beta-208133	6110 ± 40	7167-6797	5218-4848	10
La Vaquera	Level 94	F Acorn	GrA-9226	6440 ± 50	7491-7177	5542-5228	11
La Revilla	E 9	S Cereal	UtC-13347	6313 ± 48	7421-7020	5472-5071	12
La Revilla	E 2	S Cereal	UtC-13269	6250 ± 50	7323-6949	5374-5000	12
La Revilla	E 2	S Cereal	UtC-13350	6210 ± 60	7315-6949	5366-5000	12
La Revilla	Pit 12	S Cereal	UtC-13295	6250 ± 50	7323-6049	5374-5000	12
La Revilla	Pit 12	B Ovicaprid	KIA-21353	6156 ± 33	7243-6946	5294-4997	13
La Revilla	Pit 4	B Ovicaprid	KIA-21356	6355 ± 30	7415-7177	5466-5228	13
La Revilla	Pit 4	B *Sus sp.*	KIA-21359	6245 ± 34	7270-7002	5321-5053	13
La Revilla	Pit 4	S Cereal	UtC-13348	6120 ± 60	7235-6897	5286-4948	13
La Revilla	E 13	B Ovicaprid	KIA-21354	6177 ± 31	7318-6885	5369-4936	13
La Lampara	Pit 1	S *T. monococcum*	UtC-13346	6280 ± 50	7417-6996	5468-5047	13
La Lampara	Pit 1	H *Homo*	KIA-6740	6144 ± 46	7247-6856	5298-4907	14
La Lampara	Pit 1	B *Bos s.p.*	KIA-21348	6125 ± 33	7167-6882	5218-4933	13
CANTABRIA BASIN							
Arenaza	Ic2	B *Bos Taurus*	OxA-7157	6040 ± 75	7241-6640	5292-4691	15
Mirón	303.3	S *T. dicoccum*	GX-30910	5550 ± 44	6467-6216	4518-4267	16
Kobaederra	level 1	S *H. vulgare*	AA-29110	5375 ± 90	6414-5901	4465-3952	17
Pico Ramos	-	S *H. vulgare*	Beta-181689	5370 ± 40	6290-5994	4341-4045	17

Tab. 3. Early Neolithic radiocarbon dates on short lived samples. B = bone; Bb = bone bead; H = human bone; F = fruit; P = pierced canine; S = seed. References. 1. **Bernabeu et al. 2003*; 2.* Zilhão 2001*; 3.* Esquembre et al. 2008*; 4.* Bernabeu 2006*; 5.* Bernabeu et al. 2001*; 6.* Utrilla et al. 2008*; 7.* Blasco et al. 2005*; 8.* Aura et al. 2005*; 9.* Jiménez et al. 2008*; 10.* Vergés et al. 2008*; 10.* Estremera 2003*; 12.* Stika 2005*; 13.* Rojo et al. 2006*; 14.* Rojo and Kunst 1999*; 15.* Arias et al. 1999*; 16.* Peña-Cocarro et al. 2005*; 17.* Zapata et al. 2005.**

banilles and Marti 2002). However, new evidence from the North Meseta show that incursions were not isolated but distributed over a wide area in the hinterland during the same chronological span, *c.* 5300–5200 calBC.

Chaves Cave, a site located in the southern pre-Pyrenean foothills, contains two Neolithic levels (Ia and Ib) with storage pits and hearth structures. The short-lived dated materials, an acorn from level Ib and a human bone from level Ia, have yielded a slightly younger chronology (5300–5200 calBC) than the previous dates based on charcoal samples (*Utrilla et al. 2008*).

In the North Meseta, the first Neolithic occupations occurred almost coevally in different locations where domesticates appear in villages and stabling caves. La Paleta is an open-air site with over 200 hundred pit structures excavated in different chronologies from the Early Neolithic to the Bronze Age. A preliminary paper has published one radiocarbon date from a cerealia sp. seed, which derives from the organic material used as temper in anthropomorphic ware with cardial decoration; this date is statistically similar to the oldest coastal Iberian Neolithic contexts – 5673–5373 calBC – (*Jiménez-Guijarro et al. 2008*). Nevertheless, the presence of such an old occupation associated with cardial pottery should be confirmed and better characterized in future publications.

In the case of La Vaquera Cave (Valladolid), an acorn recovered in level 94 that belongs to the first and most intense occupation of the cave – Phase I – was dated to the second half of the sixth millennium calBC – 5542–5228 cal BC– (*Estremera 2003*). Associated with this material, in the same level, other indirect indicators of farming activity such as wheat seeds and blades with use-wear sickle polish have also been found.

In the Atapuerca chain, the El Mirador Cave stratigraphy recently produced a detailed sequence spanning from the Early Neolithic to the middle/upper Bronze Age. For the purposes of this paper, the earliest acceptable radiocarbon date comes from two cereal seeds found in the lowest levels of the cave (22 and 23) and dated to the beginning of the Neolithic, *i.e.* to *c.* 5400–5200 calBC (*Vergès et al. 2008*).

Finally, in the Ambrona Valley, there is a long series of radiocarbon dates that situate the appearance of the Neolithic at the beginning of the sixth millennium calBC. However, considering only short-lived materials unequivocally identified as domesticates (plants or animals), La Revilla produced dates in the last third of the 6^{th} millennium calBC (*c.* 5472–5071 to *c.* 5374–5000 calBC). Again, a single cereal grain (*Stika 2005*) and one animal bone fragment yielded the oldest Neolithic radiocarbon dates in La Lámpara (*c.* 5400–5200 calBC). Among the archaeological records from both sites, a large number of pit structures have been identified, mainly storage pits in the former, and some pit structures (storage pits, rubbish pits), but also a singular ditched enclosure in the latter. The extended sequence of ^{14}C dates provided by samples coming from the same pit suggests certain problems. Since the same space was continuously reused, materials from different periods have been displaced by post-depositional processes and become part of the filling in some features. That is the case of pit 4 in La Revilla, where three consecutive radiocarbon dates (6355±30 BP, 6245±34 BP, and 6120±60 BP), separated by some centuries when calibrated (Tab. 3), appeared at different depths in a disorderly stratigraphic sequence. Subsequently, the interpretation of the occupation phases of these sites remains controversial, above all regarding the degree of mobility developed by early farmers.

● The later appearance of agriculture and domesticates in the Cantabrian façade. Direct radiocarbon evidence of domesticates in this region displays a significant chronological delay compared to other areas such as North Meseta or the Mediterranean and Portuguese coasts. The chronological frame is variable, depending on whether the radiocarbon samples are from domestic cattle or crops. On the one hand, Arenaza Cave has a 'post-Mesolithic' level (Ic = IC2) with geometric microliths, undecorated ceramics and two bovine remains classified as cattle (*Bos taurus*), the oldest being directly dated to *c.* 5292–4691 calBC (*Arias and Altuna 1999*). Nevertheless, a third cattle jaw bone, supposedly from the same level, yielded an AMS date of 10 860±120 BP. Thus, it seems that the stratigraphy is plagued by uncertainties. On the other hand, the oldest cereal in the Cantabrian area, from El Mirón Cave, has been dated to the second half of the fifth millennium calBC; level 303.3 provided a charred grain identified as Triticum dicoccum (emmer), dated to *c.* 4518–4267 calBC (*Peña-Chocarro et al. 2005*). Lastly, we can mention two dates from barley grains, one associated with a few high-quality combed and digitally impressed ceramics, geometric microliths and marine mollusks in Kobaederra cave (*c.* 4465–3952 calBC) (*Zapata 2002*); and

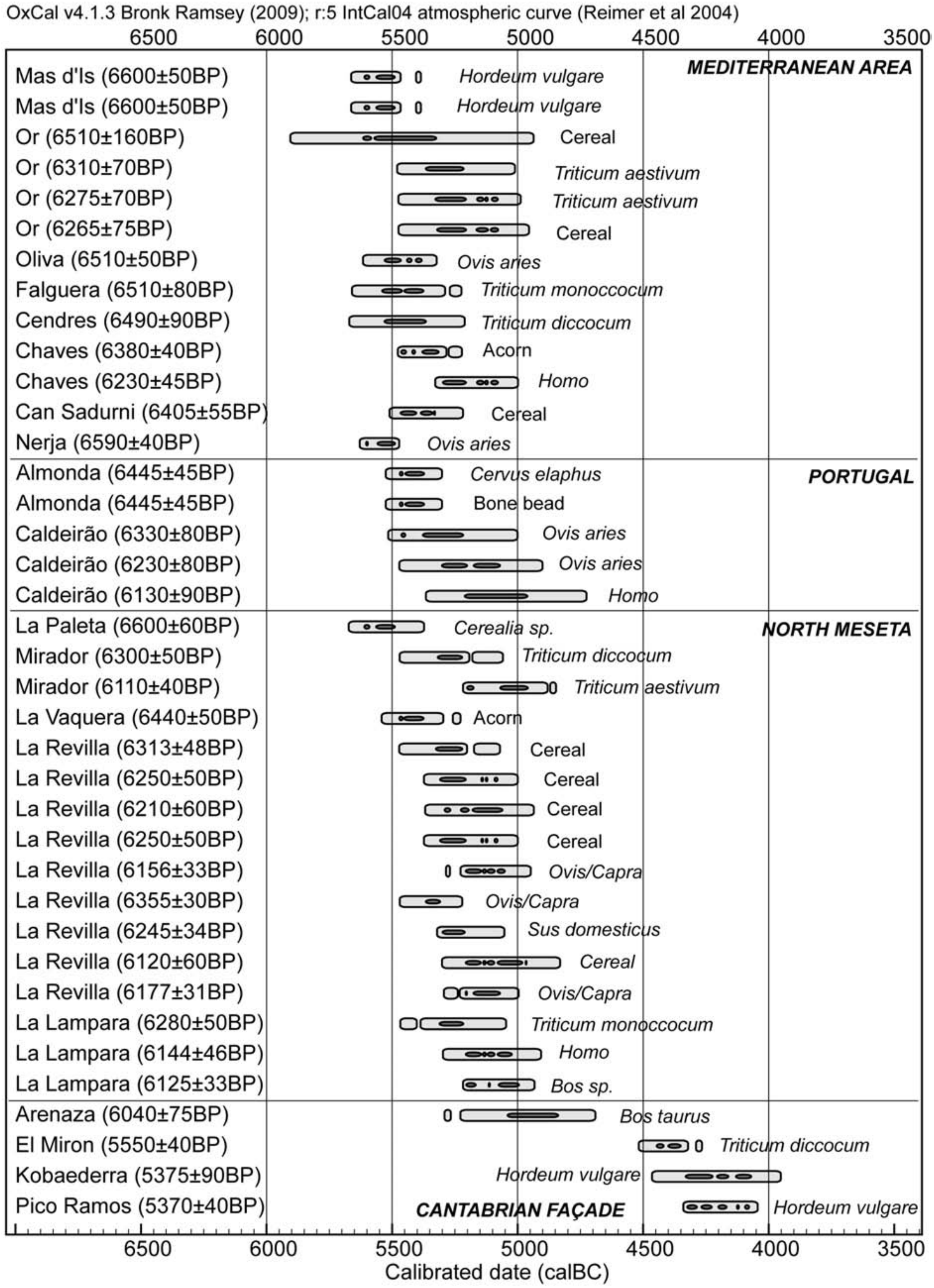


Fig. 4. Chronological framework of farming dispersal in Iberia, with the earliest radiocarbon dates on short lived sample (see Fig. 3).

the second one at the Pico Ramos site (*c.* 4341–4045 calBC), a small cave where cereal was found, but neither ceramics nor domesticated animals (*Zapata 1995*).

Revisting the distribution of farming on the Iberian peninsula: discussion

In the light of new paleo-environmental information and archaeological data on the Late Mesolithic record, and taking into consideration current chronological information and the distribution pattern of the earliest Neolithic contexts on the Iberian Peninsula, we can raise new questions about how farming spread during the Mesolithic-Neolithic transition.

Regarding previous syntheses (*Zilhão, 2001; Juan-Cabanilles and Martí 2002*), the main question still turns on discovering the driving forces behind the rapid Neolithic expansion through the interior Iberian regions. In about 200 years (or nearly 8 generations), all the components of the 'Neolithic package' (domesticates, pottery, village dwellings, houses) simultaneously appear from the oldest coastal enclaves and throughout the interior locations. This phenomenon requires a reformulation of traditional expansion mechanisms previously invoked to explain the early appearance of the Neolithic in the Spanish Meseta (*Rojo et al. 2006.85–86*). Furthermore, a more complex historical rather than contingent (migration vs. adoption) perspective is need to consider both the demographic and cultural factors behind the underlying migration mechanisms.

Bearing in mind the updated chronological overview presented above and the most recent archaeological evidence, we can inquire into the validity of the main farming dispersal models proposed for the Iberian case so far: the cultural diffusion model, maritime pioneer colonization and demic diffusion.

In Iberia, the most elaborated cultural diffusion model is the 'Capillary Model' (*Vicent 1997; Cruz and Vicent 2007*; among others). This model assumes continuity of human occupation between the Mesolithic and Neolithic periods to explain the introduction and spread of pottery and domesticates in hunter-gatherer social networks. Rather than refute its validity here, we wish simply point out that this modality could be considered only in those areas where archaeological evidence of local hunter-gatherers exists; in other words, where Late Mesolithic sites would have been documented. In this sense, this model is not adequate to explain Neolithic distribution in the North Meseta or in Catalonia because of the lack of Late Mesolithic sites in these regions, as shown above. However, it also should be noted that some of the theoretical assumptions of this hypothesis, such as seasonal storage and cycles of delayed return consumption (*Vicent 1997*) are completely absent from the Iberian Late Mesolithic record.

On the other hand, this model requires the documentation of transitional forms, for instance the use of pottery or domesticates in Late Mesolithic contexts, to be correctly contrasted. Still, the identification of this situation in the archaeological record is complex, given the necessary critical evaluation of archaeological formation processes that lead to these kinds of association (*Zilhão 1998; Bernabeu 2002; 2006; Juan-Cabanilles and Martí 2006*). At present, most of the Iberian Late Mesolithic contexts with ceramics are documented in rock-shelters consisting of multi-stratified archaeological deposits with ceramic and preceramic levels represented in the stratigraphy, or even in the same stratigraphic unit. In all these cases, the relationship between cultural remains and the dated material should be regarded with caution, given the taphonomic factors, the sedimentary processes and potential post-depositional disturbance[6]. The Cantabrian coast is the only Iberian region where adoption processes were likely to have occurred, given the long geographic coexistence of foraging groups there with the neighboring North Meseta and High Ebro Valley farming populations during the last

6 During last years, the most debated study case of ceramics found in terminal Mesolithic contexts is represented by Mendandia site, where the oldest ceramics were retrieved from Level III–Sup dated in 7210±80 BP and 7180±45 BP. As A. Alday has pointed out, the typology of the ceramic assemblage of this level is simpler (mainly bowls and 'S' shaped wares) and stylistically different (mainly slight incisions and some plain cords) than the Mediterranean Impressed and Cardial complexes. This author has defended the validity of such chronology invoking for a some kind of parallelism with other Western European Mesolithic cultures, which developed their own ceramic styles such as the Rocadourien, La Hoguette and Limbourg complexes (*Alday 2005.489*). However, even accepting the fact that Mendandia might represent a kind of different ceramic style, there are stratigraphic and archaeological arguments to refuse such old chronology: First, level III whose stratigraphic depth is about 25 cm was arbitrarily divided in two sections, the oldest (III inf) preceramic and the more recent ceramic (III sup). Regarding to this, the nature of radiocarbon samples from level III sup are clusters of bones (250 gr from the excavation unit Z2 and 115 gr from Z3) retrieved at different depths (–120 to –125 cm from excavation unit Z2 and –125 to –130 from excavation unit Z3). This fact implies that each radiocarbon date is composed by aggregates of organic materials from different occupation episodes that were grouped and interpreted as singular occupational events; Second, the chronology of level III sup falls into the chronological limits of Late Mesolithic phase A and

quarter of the sixth and the first half of the fifth millennia calBC.

A second farming dispersal model proposed for the Iberian case is Maritime Pioneer Colonization (MPC) (*Zilhão 1993; 1997; 2001*). According to the most recent radiocarbon evidence, the appearance of the Neolithic in Iberia still fits with the expectations of MPC, as proposed by Zilhão. The earliest data on farming are linked to coastal or neighboring coastal areas on the Mediterranean coast of Spain (Central Catalonia, South Valencia and Malaga) and Portugal (the Algarve and North Estremadura). No evidence or very little evidence of previous Late Mesolithic occupations is known in those areas, suggesting an elusive, non-overlapping strategy for the first Neolithic installations regarding local forager populations. Expansion by sea, which produced long-distance relocation episodes in early Neolithic enclaves, could potentially explain the rapidity of expansion, as well as similarities in material culture (especially in ceramic decoration).

However, the main interpretative challenge for this model still comes from the driving forces that caused this mode of farming dispersal. In this sense, when comparing several Iberian Neolithic enclaves, the archaeological record contains significant differences in terms of material culture (suggesting different cultural affiliations) and settlement data (site densities, rock art, habitat features, etc).

Moreover, the cultural homogeneity of the first ceramic contexts is the subject of recent discussion. Recently, Manen *et al.* (*2007*) and Carvalho (*in press*) have suggested a possible Maroquain origin for the Early Neolithic in South Portugal on the basis of some similarities in ceramics (back-lip shapes and almagra) and lithics (heat treatment, pressure debitage, and dominance of lunates among the microliths). As noted by these authors, these characteristics are not common in traditional Cardial Franco-Iberian archaeological culture.

In addition, Bernabeu (*Bernabeu et al. in press*) has recently identified an early Neolithic context at the El Barranquet site (Oliva, Valencia) dominated by impressed non-Cardial ceramics similar to the Ligurian phacies of Sillon d'Impressions documented in southern France (sites of Peiro Signado and Pont de Roque-Haut) and northern Italy (Arene Candide). Bernabeu goes further suggesting that this ceramic impressed horizon could even be pre-cardial, representing the first Neolithic cultural complex in Iberia before 5500 calBC, and being on the bases of subsequent Cardial culture and the earliest North Meseta Neolithic contexts (*i.e.* La Revilla, La Lámpara sites).

On the other hand, it should be noted that the archaeological record indicates significant differences in complexity (number of sites, density of occupation, rock art and monuments) among the different early Neolithic enclaves. For example, the southern Valencia region displays an Early Neolithic Cardial record of villages, rock art sanctuaries, and monumental enclosures (*Bernabeu et al. 2003*) significantly much more complex than sites in the Algarve or Portuguese Estremadura regions.

To recapitulate, as regards the first farming enclaves, a developing variety and complexity not contemplated by the MPC model assumptions, has been discovered. Placed in the general Iberia context, such differences in complexity and settlement densities might indicate the existence of social presure and attractive factors such as segregation and aggregation processes governed by rank and social competition strategies (*Anthony 1997; Fiedel and Anthony 2003*).

Finally, demic diffusion has also been invoked as an interpretative model to explain the populating of many Iberian regions during the Early Neolithic Epicardial phase (*c.* 5200–4800 calBC) (*Juan-Cabanilles and Martí 2002; Carvalho in press*). The chronological framework and the regional distribution of sites of this chronology attest to a subsequent and gradual expansion process from the Cardial enclaves through neighboring or adjacent areas following fission and short-distance relocation logic (*e.g. Mestres 1992*).

However, the earliest radiocarbon dates provided by the North Meseta sites (*c.* 5400–5300 calBC) cannot be simply explained by this model, because of the geographic discontinuity and distance from the coastal Neolithic enclaves (more than 500km). On the

about 6 centuries older than the first Cardial or Impressed ceramic contexts found in the Iberian coasts dated on the basis of stratigraphic associations with short lived individual samples (see Fig. 4). However the lithic industry, dominated by lunates with bifacial retouch among the geometric microliths is discordant too with the chronology displayed by this type of armatures in Iberia (see *Fernández et al. 2009*). Finally, considering a micro-regional scale validation, the appearance of ceramics at Mendandia is about 700 years older than other neighbor sites such as Zatoya, Atxoste or Aizpea where the first ceramics are found overlying Late Mesolithic contexts (*Alday 2003*). As J. Bernabeu has recently stated (*2006*) it is difficult to accept Mendandia as the only site in the High Ebro Valley where pottery is present during 600–800 years while in other neighbor locations is absent.

one hand, this fact implies a lower rate of spread than MPC (10–20km per year), but higher than demic diffusion (1km per year). In this sense, although the present paleo-anthropological data on the Iberian Peninsula is too limited to provide enough information to test the demographic growth of farming communities (also known as the Neolithic demographic transition) recognized in other European regions (*Bocquet-Appel 2002; 2008*), population growth does not seem to have been the only cause for the rapid dispersal that the radiocarbon dates indicate. Moreover, as Shennan remarks, in Central Europe (*Shennan 2007*) demographic growth would not necessarily have triggered spatial expansion, since settlement data show that new places were colonized before others reached any sort of maximum carrying capacity.

Additionally, this situation would demand alternative farming dispersal models to set off the migration of coastal farming groups to inland regions. For instance, long distance inland colonization as a result of fission and settlement relocation logic driven by household decision-making might be invoked (*Bogucki 2003; Martí 2008*). Similarly, an ideal free distribution pattern as a spatial behavior might have been carried out by farmers, whereby they tended to occupy sites giving the best yields (*Shennan 2007; McClure et al. 2009*).

According to this view, in the very first wave of migration, household decision-making would have consciously evaluated the costs and benefits of farming strategies and settlement relocation according both to the ecological suitability of the territories and dynamic social networks (*Boguki 2003*). In this sense, the spectrum of crops identified at Early Neolithic sites in the northern Meseta and the agrarian practices involved, indicate agricultural activity was well-established and perfectly adapted to the local ecological conditions (*Zapata et al. 2004*). It is likely that crops identified in La Lámpara and La Revilla sites, hulled wheats and barley, might have been selected because they were suited to that area (resistance to poor soil conditions and fungal disease; toleration of drier conditions).

The last issue to be discussed here is how the distribution pattern of both Late Mesolithic and Early Neolithic settlements and the chronological trends in the spread of farming would be reflected in the genetic composition of ancient Iberian populations. The key question, however, is whether the farming transition was a process of cultural and economic change, but not marked gene flow, or if it implied the arrival of genetically distinct populations which replaced the Mesolithic ones; this matter should be addressed in terms of the regional variability of socio-cultural processes.

During the 90's, anthropological studies reached contradictory conclusions on this issue. On the basis of skeletal differences Lalueza-Fox (*1996*) suggested population replacement, while others have observed that there is no evidence of discontinuity in Portuguese dental morphology (*Jackes et al. 1997; 2001*). In the same way, using craniometric data in a broader European context, Pinhasi and Pluciennik see no marked difference between Late Mesolithic and Early Neolithic human remains in the Western Mediterranean region, which might be interpreted as a result of a higher level of biological admixture (*Pinhasi and Pluciennik 2004*, but see also *Zilhão 2004* for comments on biases in the Iberian data set).

From the beginning of the 21st century, this matter has been addressed on the basis of molecular studies of archaeological data. However, in dealing with the genetic issues involved in the Iberian Peninsula Mesolithic-Neolithic transition, two major problems arise:

❶ There is remarkable regional disparity in the relevant data sets to address this question, most of them from Portugal (*Bamforth et al. 2003; Chandler et al. 2005*). Obviously, such regional bias challenges any attempt to reach equivalent conclusions for other Iberian areas whose geographic, environmental and demographic conditions were different. Regarding ancient mtDNA, new sites have been analyzed recently in the Mediterranean region, such as Sant Pau (Catalonia) (*Fernández-Dominguez 2005*) and Can Grau (Catalonia) (*Sampietro et al. 2007*); however the skeletal samples do not date to the Neolithic transition, but to the Post-cardial and Middle Neolithic phases, or to the Chalcolithic period (*Gamba et al. 2008*).

❷ On the other hand, there is no consensus among geneticists regarding the origin of the first European farmers or what one may infer from the geographic distribution of various genetic markers (*e.g. Haak et al. 2005 vs. Ammerman et al. 2006* for Central Europe). For instance, Haplogroup J, widely considered one of the main genetic signatures of Neolithic expansions (*Wells 2007*), is completely absent among the oldest Iberian Neolithic samples, but also lacks for skeletal material analyzed in Syria (Tell Halula and Tell Ramad) dated to the PPNB period (*Fernández-Dominguez 2005*). Consequently, as far as the Iberian material is concerned, the absence of haplogroup J among the Neolithic samples does not necessarily mean the absence of Neolithic expansion.

Bearing in mind the problems mentioned above, the first study published on ancient mtDNA Iberian material, comparing 15 Mesolithic with 13 Neolithic samples, suggests genetic continuity in the female line, given the presence of two individuals from Arruda (Late Mesolithic) and another from Feteira (Neolithic) in haplogroup K (*Bamforth et al. 2003*). Another interesting conclusion of this study was the lack of haplogroup I (predominant in Northern and Eastern Europe) and U6 (of North African origin).

In contrast, a more recent study (*Chandler et al. 2005*) reports genetic discontinuity between the Early Neolithic (the Algar do Bom Santo, Caldeirao and Perdigoes sites) and the Late Mesolithic populations (the Cabeço da Amoreira, Cabeço do Pez, Poças de Sao Bento, Toledo, Fiais, Vale de Romeiras sites) based on significantly different frequencies of common haplogroups between them; however, their relationship is closer to other Iberian than Near Eastern populations. The authors interpret this discontinuity as support for the MPC model. In this sense, the absence of haplogroup J in the Portuguese Neolithic samples was interpreted as a result of the lack contribution of women of Near Eastern origin in the colonization process, considering the uniparental transmission mode (*Zilhão 2004.78*).

Concluding remarks and directions for future research

It was not our intention in this paper to discuss the reasons behind the adoption of farming, or to discuss in detail the broad array of archaeological situations led by the cultural interaction between foragers and farmers in Iberia. We wish simply to stress some structural problems not widely discussed on the Iberian scale, drawing attention to paleo-environmental evolution and population dynamics.

According to the chronological evidence, with the exception of the Northern façade, Iberia witnessed a rapid Neolithic transition process. From the standpoint of evolutionary theories, the spread of farming in Iberia is an example of dispersal opportunities. Early and Middle Holocene environmental changes seem to have affected not only the regional distribution of hunter-gatherer populations, but also the outcomes of such adaptations in terms of subsistence and demography. We have already mentioned that such divergences might have been especially important because of the relationship between coastal and estuarine adaptations, with year-round sedentary or semi-sedentary settlements and potential for demographic growth. For instance, assuming the El Collado data as representative of the central Iberian Mediterranean coast, the last foragers relied less on aquatic resources than their Portuguese counterparts in the Tagus estuary, and were possibly more mobile. Consequently, such a structural constrain might explain the rapid extinction of forager subsistence systems after a short period of cultural contact with the first farming groups.

Thus, farming expanded to other regions, bringing about different migration processes and interaction phenomena. Even though some regional bias in the Late Mesolithic record needs to be corrected (Andalusia), the current evidence indicates broad areas such as Catalonia and North Meseta had no forager population when the first farmers arrived.

In contrast, in those areas where the Late Mesolithic record is present, one could expect a broad range of different cultural contact situations, including small-scale migratory phenomena such as infiltration (*Zvelebil 2000*), as proposed for the Ebro Valley (*Bernabeu 2002*). However, the role of forager populations in farming expansion, whether by means of rapid adoption through exchange or assimilation by direct interaction with farming groups, is not clear in the Ebro Valley archaeological record, concentrating current debates. In the same way, it is unwise to neglect a priori the possible contribution of such populations to farming expansion in the North Meseta.

It is true that many of the migration debates in this paper center on the North Meseta data. Of course, this region raises new questions about the timing of, and specific ways in which the Neolithic reached the deep interior of Iberia, as a counterpart to other traditional research regions. What seems clear, however, is the need to incorporate new models that present farming dispersal migration as a more complex process driven by social factors, and not merely the simple result of aimless demic growth.

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