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Europe's First Farmers

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From the Mesolithic to the Neolithic in the Iberian peninsula

Introduction

As exemplified by the open air art and habitation sites of the Douro basin, particularly those recently found in the Côa valley (Zilhão *et al.* 1997), the interior of Iberia knew an important settlement throughout the Upper Palaeolithic. However, after the end of the Ice Age, *c.* 11,400 calendar years ago, it shows no sign of human occupation (with the exception of some areas in the upper Ebro basin) until 5000–4500 BC, when the protagonists of such occupation are already clearly defined agro-pastoral societies. This pattern seems to be a genuine reflection of regional settlement history. Many systematic survey projects in both Portugal and Spain (Iglesias *et al.* 1996, Arias 1997) have consistently identified large numbers of late early Neolithic (epi-Cardial or Impressed Ware) sites all over this vast area, as well as, particularly in Portugal, fair numbers of Upper Palaeolithic sites. None, however, is of Mesolithic age, and there is not a single typical Cardial sherd.

The abandonment of the Iberian interior in the early Holocene may be related to the particular geographic and climatic characteristics of the peninsula. Unlike European areas north of the Pyrenees where Mesolithic occupation of the hinterland is well documented, the Meseta lacks important lakes, and the rivers, even the largest (such as the Douro, the Tagus, and the Guadiana), are susceptible to drying out in the summer. Therefore, aquatic resources, which were critical in known Mesolithic instances of successful settlement of mainland Europe (as along the Danube), may have been subject to periodic failure in interior Iberia. In contrast, last glacial settlement had been possible because, at the time, the main rivers were permanent (melting of the winter snow and of the ice accumulated in the glaciers of surrounding mountain chains kept them running throughout the dry season) and the open steppe landscapes provided year-round pasture for large herds of grazing animals. Once forests covered the land and the

herbivore biomass was drastically reduced, fish and other aquatic foods may not have been there in the amount and with the reliability necessary to compensate for such a decrease.

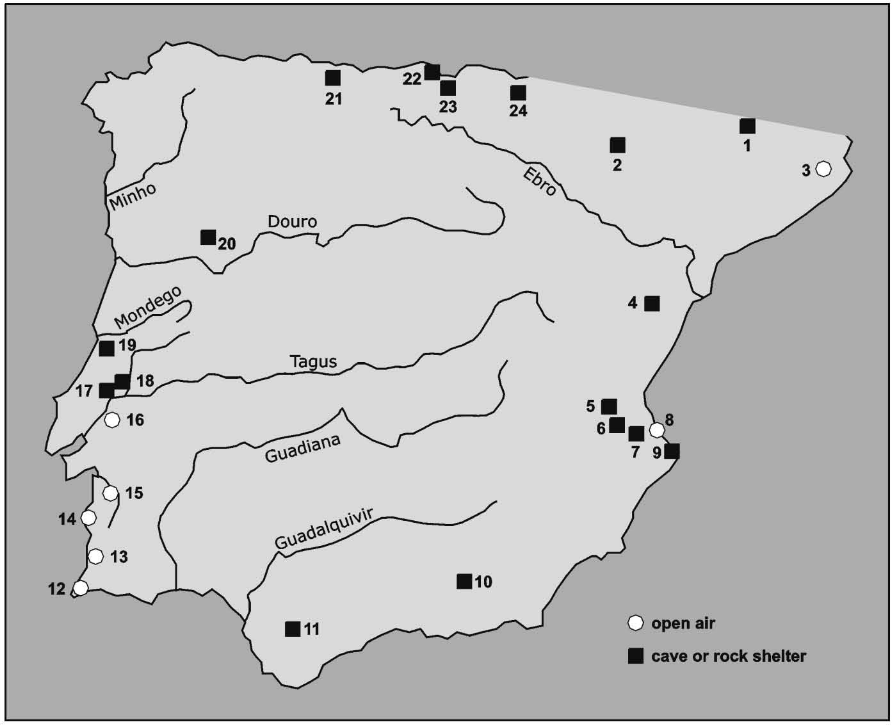
An alternative explanation would be that the absence of Mesolithic sites in the Meseta results from the operation of as yet unidentified biases in preservation or research. It must be noted, however, that the absence of human settlement from vast regions with a very dense tree cover is known in other parts of the world and that, in this regard, the Iberian pattern is not unique and does not necessarily require special qualifications. In fact, a similar situation has been observed in southwest Tasmania, where, after many thousands of years of occupation throughout the last glacial period, its inland valleys were abandoned by humans at the beginning of the Holocene, when they were colonized by a very dense temperate forest, and remained that way until the time of contact (Porch and Allen 1995).

In any case, the implication is that the problems of the transition from early Holocene hunter-gatherer adaptations to food-production economies in the peninsula can only be approached from a perspective based on the archaeology of coastal areas. This chapter will begin with a brief overview of the empirical evidence and conclude with some observations regarding its relevance for the interpretation of the process of agricultural expansion in southern Europe. The location of the primary sites mentioned in the text can be found in Fig. 6.1 and more detailed maps of the cultural geography of Portugal during the transition from the Mesolithic to the Neolithic are given in Fig. 6.3.

North of the Cantabrian mountains

The Mesolithic–Neolithic transition in northern Spain has been recently reviewed by Arias (1991, 1992, 1994a, 1997) and González Morales (1992, 1996). Both agree that the areas defined by the present-day national-administrative boundaries of Asturias, Cantabria, and Euzkadi, which extend southwards into the Douro and the Ebro drainages, are not appropriate units of analysis, and that the process should be considered from the perspective of natural geography. Their analytical framework, therefore, is restricted to the ecologically differentiated, narrow coastal strip and the adjacent northern slopes of the Cantabrian mountains, which isolate the study area from the rest of Iberia.

Pottery is present in this region from *c.* 4900 BC, as demonstrated by an AMS radiocarbon date on charcoal collected in the fabric of a sherd from the cave site of Los Canes (Arias 1992) – 5865 ± 70 BP (AA-5788). From this, Arias argues the presence from that time on of the rest of the Neolithic package as well. He bases this inference on two main arguments: that elsewhere in Iberia pottery and domesticates appear simultaneously; and that



6.1 Location of sites mentioned in the text: 1. Balma Margineda, 2. Chaves, 3. La Draga, 4. Fosca, 5. Cocina, 6. Sarsa, 7. Or, 8. El Collado, 9. Cendres, 10. Cariguela, 11. La Dehesilla, 12. Cabranosa, 13. Fiais, 14. Vale Pincel, 15. Sado shell-middens, 16. Tagus shell-middens, 17. Almonda, 18. Caldeirão, 19. Buraca Grande, 20. Buraco da Pala, 21. Los Canes, 22. Pico Ramos, 23. Arenaza, 24. Marizulo.

pottery and ovicaprids do appear at the same time in the relevant stratigraphic sequences of the region, particularly those excavated at Marizulo and Arenaza.

González Morales (1996), however, has argued that, except for dogs (which are well documented in the local Mesolithic), no evidence for domesticates exists in the area before *c.* 4100 BC, at about the same time construction of megalithic monuments begins. Such concrete evidence is supplied by the burial found in the cave of Marizulo, where a human skeleton was accompanied by sheep and dog bones. Radiocarbon has provided a date for this context of 5285±65 BP (GrN-5992) (Arias 1994a), that is, *c.* 4130 BC. As for Arenaza cave, fair numbers of ovicaprids have indeed been found in level IC2, where domesticates amount to 79% of the faunal remains and are associated with decorated pottery. It is such an association that leads Arias to

compare this occupation with the epi-Cardial contexts dated to before 4500 BC elsewhere in Iberia. So far, however, no absolute chronology has been obtained for that level, so all that can be said with certainty is that it should be older than the overlying level IC1, which dates to 4965±195 BP (I-8630), that is, *c.* 3800 BC. More recently, Arias (1997:375) has also remarked that the decorative styles of the pottery from IC2 are reminiscent of those found in the late Neolithic of the Meseta, which would set them apart from the epi-Cardial tradition and indicate that this level probably is not much older than the overlying level IC1 and, therefore, that its age may be similar to that of Marizulo.

It seems fair to conclude, thus, that no signs of food production in the pottery-bearing contexts of the region can be securely dated to a time period before *c.* 4100 BC. Results from recent work point in the same direction. At Cueva de la Trecha, a sequence of four coherent radiocarbon dates established the accumulation of the shell-midden excavated there, which contained neither pottery nor domesticates, as having taken place between 6300 and 4300 BC (González Morales 1996). Further evidence for the continuation of traditional subsistence patterns until after 4900 BC is reported by Zapata (1994) from the shell-midden in level 4 of Pico Ramos cave, radiocarbon dated to 5860±65 BP (Ua-3051), that is, *c.* 4700 BC: it contained no domestic animals and flotation failed to provide any evidence for domestic plants. In this context, González Morales argues that even if one accepts that the evidence from Los Canes and Arenaza is indeed a genuine reflection of the relatively early introduction in the region of pottery and of other technological aspects of the Neolithic package, the best models for the Mesolithic–Neolithic transition would still be those supplied by other regions of Atlantic Europe with a similar ecology. That is, the archaeological situation in the Cantabrian strip between 4900 and 4100 BC would be best described as an Ertebølle-type pottery Mesolithic, not as an Iberian-type epi-Cardial Neolithic.

In their discussion of the transition in Great Britain and Denmark, Zvelebil and Rowley-Conwy (1986) have shown that the appearance of megalithic monuments post-dates by a few centuries (four, in the Danish case) the first establishment of agro-pastoral economies (although monumental earthen barrows are present from the very beginning of the Neolithic – Price *et al.* 1995). The interpretation of the Cantabrian data in this light would carry the implication that the replacement of hunting by food production as the main subsistence activity would have taken place some time before the accepted dates for the earliest megaliths in the region, that is, some time before 4100 BC, as Arias has claimed on the basis of artifactual evidence. Other regions of Atlantic Europe, however, may resemble Cantabria in that the existence of a pre-megalithic Neolithic is problematic, or altogether unaccepted. Such is the case, for instance, in Galicia and northern Portugal, where no peasant-shepherd groups have been documented before the time of the first megalith builders, whose material culture is, on the other hand, in total discontinuity with that of local Mesolithic hunter-gatherers (Vázquez Varela 1994).

Progress in this debate seems to be possible in two ways only: a reliable direct dating by AMS of the ovicaprids found in level IC2 of Arenaza; and the collection of additional palaeonutritional data by stable isotope analyses of human remains from the critical time period (such as those from the Marizulo burial). However, in spite of the disagreements over chronology, there seems to be a consensus among researchers that, in Cantabria, we are observing an essentially indigenous process. In the view of González Morales (1992), continuity is implicit in the explanation of the introduction of ovicaprid husbandry as possibly caused by a situation of extreme stress brought about by the very high sea levels recorded *c.* 4300 BC, resulting in a mixed forager-herding way of life, with agriculture presumably becoming important only in the later Neolithic and Chalcolithic. In the view of Arias (1992), continuity is explicit in his interpretation of pottery-bearing shell-middens as part of a subsistence system where the novel agro-pastoral resources complemented the exploitation of forest game and of sea foods; the regional early Neolithic would simply represent, therefore, a further broadening of the traditional "broad spectrum" hunter-gatherer economy.

Along the shores of the Mediterranean

As in Mediterranean France (Guilaine 1976; Binder, this volume), the earliest Neolithic of Catalonia, the Ebro basin, Valencia, and Andalucía is defined by the presence of Cardial pottery (Navarrete 1976, Baldellou and Castán 1983, Fortea and Martí 1984–5, Baldellou and Utrilla 1985, Martí *et al.* 1987, Navarrete and Molina 1987, Bernabeu 1989, Martín 1992). In all known deeply stratified cave sequences (such as Chaves, Or, Cendres, or Cariguela), such contexts date to between *c.* 5900 and *c.* 5400 BC and represent the simultaneous first appearance of a series of technological and subsistence innovations in the archaeological record of these regions.

In the realm of subsistence, those innovations include ovicaprids (which make up most of the fauna from the base of the Or sequence) and domestic plants. Wheat and barley, very abundant at Or, have also been recovered in all other cave sites of the Cardial "culture" in Valencia and were present in the Cardial levels of Balma Margineda, in Andorra, as well. In the realm of technology, such innovations include, in addition to pottery, polished stone items and, at least in the case of Valencia, a wide variety of new types of bone tools and a new lithic production system (Fortea *et al.* 1987, Juan-Cabanilles 1992). All microliths are geometrics (almost exclusively trapeze) but use of the microburin technique is not documented; blade debitage probably resulted from pressure flaking and there is evidence of heat pretreatment of the flint; laminary products were systematically shortened through flexure breaking techniques to be used as parts of composite tools, for the most part, as indicated by the numerous specimens bearing the characteristic use wear, as sickle blades; and borers with thick, long points make their first appearance in the regional sequences. This lithic production system is in total discontinuity with the autochthonous Geometric Mesolithic, where triangles and crescents were clearly dominant, produced by the microburin technique, and extensively retouched with *doble bisel*, which is extremely rare in the Cardial sites. The presence of some Cardial pottery sherds in the uppermost levels of the long stratigraphic sequences where the evolution of this Geometric Mesolithic can be followed (such as La Cocina) is interpreted as evidence of interaction between the local hunter-gatherers and the contemporaneous groups of allochthonous farmers established elsewhere at such sites as Sarsa and Or (Juan-Cabanilles 1992).

Traditional research biases explain why most of these contexts have been recovered in caves. That an important open-air late Mesolithic settlement focused on estuarine or lacustrine areas must have characterized the coasts of Mediterranean Spain has been recently demonstrated by the discovery of the El Collado shell-midden which, like its Atlantic counterparts in Portugal and Scandinavia, also contained a cemetery (Aparicio 1988). Unfortunately, the site remains essentially unpublished, although Arias (1994b) refers to the excavation of fourteen burials and two radiocarbon dates on human bone around 6300 BC, at the beginning of the climatic optimum. The nature of the relations that may have existed between this coastal settlement and the cave and rockshelter habitats known in the adjacent limestone mountains (exemplified by La Cocina) remains, however, to be investigated.

That Cardial settlement must also have been largely open air and organized in aggregates of wood huts that can only be described as peasant villages has been recently demonstrated beyond any reasonable doubt by the lakeside site of La Draga (Banyoles, Catalonia). Tarrus *et al.* (1994) describe the finding of posts and planks stuck in the chalk bedrock beneath the archaeological horizon and they report the excavation of three stone paved platforms and thirty-two associated hearths. From the depth attained by the posts they reconstruct wood structures at least 3–4 m high, some of which may have been granaries. Of the animal bone fragments, 93% belong to domesticates (sheep, goats, pigs, and cattle) and enormous amounts of plant remains (mostly wheat, but also barley and some legumes) were recovered in hearths, dumping areas, and large ceramic vessels. Pottery is often decorated with cardial shell impressions and, besides traditional lithic types (blades, borers, trapezes, polished adzes), material culture also included a cylindrical, finely polished marble vessel, a kind of object that, so far, was known only in early Neolithic contexts in eastern Mediterranean areas and in southern Italy. Eight radiocarbon dates on charcoal, cereal grain, animal bone, and wood from oak posts suggest the site was occupied between *c.* 5900 and *c.* 4900 BC.

Based on the marked discontinuity observed at all levels with the material culture of local Mesolithic traditions and on the affinities with the earliest Neolithic to the east, most researchers working in Mediterranean Spain consider this Cardial complex to represent a cultural and demic intrusion, not an essentially local development, as is widely accepted for the areas north of the Cantabrian mountains. Some, however, have taken the opposite view. Acosta and Pellicer (1990), on the basis of data from the Andalucian cave site of La Dehesilla, believe that Neolithization was an ongoing process already by 6900 BC (well before Mediterranean France and Italy), when domestic sheep and rabbits would already be present in the region. Olaria (1988) suggests a similar process in northern Valencia and Catalonia, based on data from Cova Fosca, where goats would have been domesticated from autochthonous ibex populations.

As exhaustively discussed elsewhere (Zilhão 1993), these interpretations are based on seriously disturbed and poorly excavated sites, with highly questionable associations between the radiocarbon dates and the archaeological evidence relating to the Neolithic. At Cova Fosca, for instance, the dates came from samples made up of charcoal collected in badger burrows mistakenly identified as "storage pits." Furthermore, such models are flawed at a very basic level: as demonstrated by genetics and palaeontology, Neolithic sheep and goats are undoubtedly of Near Eastern origin and it was not until very recent times that rabbits were domesticated (Vigne 1989).

The western façade

Tables 6.1 and 6.2 list all radiometric dates available in Portugal for the period between 6000 and 4500 BC. The ranges of occupation for each site derived from the one sigma calibrated radiocarbon ages are given in Fig. 6.2 and their geographical distribution is represented in Fig. 6.3 for three different moments separated by 500 years each: 6000–5750, 5500–5250 and 5000–4750 BC. Only Mesolithic sites are known until 5750 BC and well-defined Cardial Neolithic assemblages are present from *c.* 5500 BC onwards in Estremadura and the Algarve. Remarkable similarities in pottery decoration between the early "baroque" Cardial wares of Cova de l'Or and those from several undated sites in Estremadura, such as Almonda and Eira Pedrinha (Fig. 6.4), suggest contemporaneity. On the Atlantic shores of Iberia, therefore, the Neolithic may be as old as in Mediterranean Spain, that is, its first appearance in Portugal may date precisely to the period between 5750 and 5500 BC not represented in the maps of Fig. 6.3.

Table 6.1 *Chronology of the late Mesolithic in Portugal*[1]

Site	Provenience	Sample[2]	Lab number	Date BP	cal BC 1	cal BC 2
Buraca Grande	Layer 8a	Ch	Gif-9940	7000 ± 60	5944–5753	5964–5702
	Layer 7c	Ch	Sac-1461	6850 ± 210	5943–5525	6112–5336
	Layer 7c	Es	Sac-1459	6940 ± 140	5583–5332	5680–5243
Bocas	Layer 2	Es	ICEN-899	7490 ± 110	6017–5836	6170–5709
Forno da Telha	Layer 2	Es	ICEN-417	7360 ± 90	5947–5710	5981–5632
Cabeço da Arruda	Skeleton III	Hbc	TO-360	6990 ± 110	5980–5730	6090–5640
	Skeleton A	Hbc	TO-354	6970 ± 60	5960–5740	5980–5650
	Skeleton 42	Hbc	TO-359a	6960 ± 60	5960–5734	5980–5640
	Skeleton D	Hbc	TO-355	6780 ± 80	5732–5573	5810–5490
	Skeleton N	Hbc	TO-356	6360 ± 80	5380–5235	5480–5210
Moita do Sebastião	Skeleton 22	Hbc	TO-131	7240 ± 70	6129–5993	6219–5970
	Skeleton 29	Hbc	TO-133	7200 ± 70	6108–5886	6180–5886
	Skeleton 24	Hbc	TO-132	7180 ± 70	6097–5974	6170–5848
	Skeleton 41	Hbc	TO-134	7160 ± 80	6091–5966	6170–5830
	Skeleton CT	Hbc	TO-135	6810 ± 70	5739–5629	5830–5540
Arapouco	Middle level	Es	Q-2492	7420 ± 65	5959–5779	5992–5715
Cabeço do Rebolador		Es	ICEN-277	7140 ± 70	5680–5529	5733–5481
		Es	ICEN-278	7100 ± 60	5627–5526	5693–5448
Várzea da Mó		Es	ICEN-273	7110 ± 50	5628–5528	5687–5488
Poças de São Bento	Lower level	Es	Q-2493	7040 ± 70	5595–5448	5668–5435
	Middle level	Ch	Q-2494	6780 ± 65	5726–5584	5770–5530
	Middle level	Es	Q-2495	6850 ± 70	5443–5313	5566–5259
Cabeço do Pez	Middle level	Es	Q-2497	6730 ± 75	5373–5229	5437–5081
	Middle level	Es	Q-2496	6430 ± 65	5064–4908	5214–4805
Amoreira	Level 2b	Es	Q-(AM85B2b)	6370 ± 70	4946–4787	5064–4715
	Level 2a	Ch	Q-(AM85B2a)	5990 ± 75	4944–4789	5060–4718

Table 6.1 (*cont.*)

Site	Provenience	Sample[2]	Lab number	Date BP	cal BC 1	cal BC 2
Vale de Romeiras	Layer 2	Abc	ICEN-144	7130 ± 110	6043–5854	6175–5723
	Layer 2	Es	ICEN-150	7390 ± 80	5956–5732	5997–5672
	Layer 2	Es	ICEN-146	7350 ± 60	5936–5716	5960–5672
Vale Pincel (hearths)	Levels 2/3	Ch	ICEN-724	6700 ± 60	5601–5525	5668–5448
	Levels 2/3	Ch	ICEN-723	6540 ± 60	5520–5389	5573–5331
Samouqueira I	Level 3	Es	ICEN-729	7520 ± 60	6011–5889	6117–5833
	Level 2	Hbc	TO-130	6370 ± 70	5382–5238	5480–5220
Vidigal	Level 3	Abc	Ly-4695	6640 ± 90	5593–5443	5668–5348
	Level 2	Abc	GX-14557	6030 ± 180	5220–4770	5330–4510
Medo Tojeiro	Level 4?	Es	BM-2275R	6820 ± 140	5448–5256	5590–5067
Fiais	Level 30–35	Es	ICEN-103	7310 ± 80	5924–5679	5960–5597
	Level 30–35	Abc	ICEN-110	6870 ± 220	5953–5526	6156–5336
	Level 20–30	Abc	ICEN-141	6180 ± 110	5252–4946	5321–4836
		Ch	TO-806	7010 ± 70	5973–5750	6075–5668
		Ch	TO-705	6840 ± 70	5725–5609	5807–5582
		Abc	TO-706	6260 ± 80	5270–5076	5333–4990
Montes de Baixo	Layer 4	Es	ICEN-720	7910 ± 60	6419–6230	6461–6183
	Layer 2	Es	ICEN-718	7590 ± 60	6116–5971	6176–5888

Notes:

1 *References:* Buraca Grande – Aubry *et al.* (1997); Bocas – Bicho (1993); Forno da Telha – Araújo (1993); Moita do Sebastião and Cabeço da Arruda – Lubell *et al.* (1994); Amoreira, Arapouco, Cabeço do Pez, Cabeço do Rebolador, Poças de São Bento, Vale de Romeiras – Arnaud (1989, 1997), Soares (1989); Vidigal – Straus and Vierra (1989); Samouqueira and Medo Tojeiro – Lubell and Jackes (1985, 1988), Bowman *et al.* (1990), Soares (1995); Fiais – Lubell and Jackes (1988), González Morales and Arnaud (1990), Soares (1989); Montes de Baixo – Soares (1997).

2 Es – estuarine shells; Hbc – human bone collagen; Ch – charcoal; Abc – animal bone collagen; the dates on estuarine shells were calibrated with the curve for continental samples after subtraction of 380 ± 30 years, apparent age of this material in archaeological sites from this time range (Soares 1993).Page numbers in bold denote illustrations.

Table 6.2 Chronology of the early Neolithic in Portugal[1]

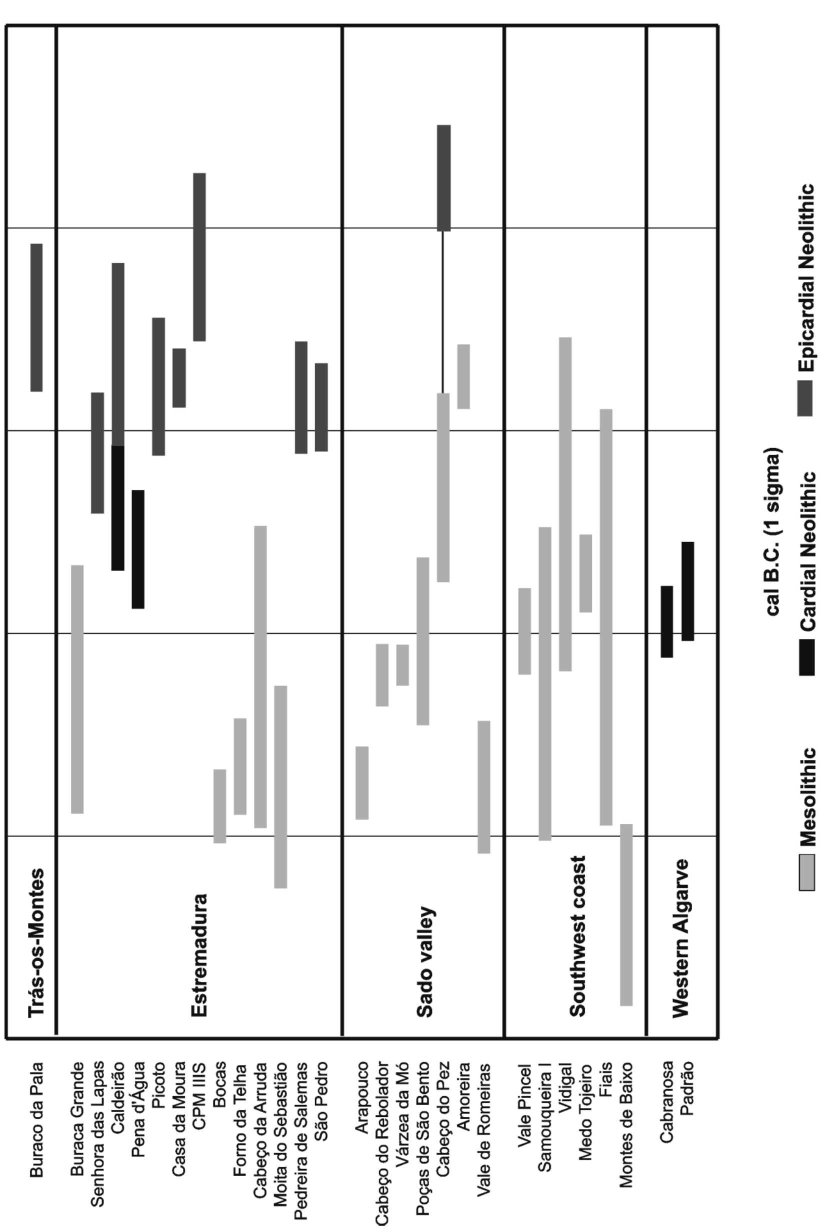
Site	Provenience	Sample[2]	Lab number	Date BP	cal BC 1	cal BC 2
Buraco da Pala	Level IV, base	Ch	ICEN-935	5860 ± 140	4905–4540	5060–4369
	Level IV, base	Ch	GrN-19104	5860 ± 30	4780–4714	4798–4627
Senhora das Lapas	Layer C	Hbc	ICEN-805	6100 ± 70	5206–4908	5230–4847
Caldeirão	Layer Eb	Ch	ICEN-296	6870 ± 210	5970–5570	6120–5370
	Horizon NA2	Abc	OxA-1035	6330 ± 80	5348–5231	5480–5079
	Horizon NA2	Abc	OxA-1034	6230 ± 80	5302–5072	5340–4940
	Horizon NA2	Hbc	OxA-1033	6130 ± 90	5226–4941	5296–4843
	Horizon NA1	Abc	OxA-1037	5970 ± 120	5048–4770	5220–4583
	Horizon NA1	Abc	OxA-1036	5870 ± 80	4894–4685	4941–4540
	Horizon NA1	Hbc	TO-350	5810 ± 70	4782–4588	4895–4510
Pena d'Água	Layer Eb (base)	Ch	ICEN-1146	6390 ± 150	5441–5149	5579–4962
Picoto	Surface	Hbc	ICEN-736	6000 ± 150	5063–4723	5256–4528
Casa da Moura	Level 1a	Hbc	TO-953	5990 ± 60	4944–4800	5192–4780
CPM IIIS[3]	Neolithic hearth	Ch	SMU-2477	5710 ± 155	4780–4366	4938–4245
Pedreira de Salemas		Hbc	ICEN-351	6020 ± 120	5059–4783	5226–4616
São Pedro de Canaferrim	UE-4, 69–73 cm	Ch	ICEN-1151	6020 ± 60	4951–4836	5060–4781
	UE-4, 46–63 cm	Ch	ICEN-1152	6070 ± 60	5055–4908	5202–4830
Cabeço do Pez	Upper level	Abc	Q-2499	5535 ± 130	4510–4247	4720–4043
Cabranosa	Neolithic hearth	Es	Sac-1321	6930 ± 60	5563–5389	5579–5325
Padrão	Neolithic hearth	Es	ICEN-873	6920 ± 60	5521–5386	5577–5318
	Neolithic hearth	Es	ICEN-645	6800 ± 50	5432–5278	5442–5255

Notes:

1 *References:* Buraco da Pala – Sanches *et al.* (1993); Senhora das Lapas – Oosterbeek (1997); Caldeirão, Pena d'Água, and Picoto – Zilhão (1992, 1993), Zilhão and Carvalho (1996); Casa da Moura – Straus (1988); CPM IIIS – Marks *et al.* (1994); São Pedro de Canaferrim – Simões (1996); Pedreira de Salemas and Cabranosa – Cardoso *et al.* (1996); Cabeço do Pez – Arnaud (1989); Padrão – Gomes (1994, n.d.). The dates for the caves of Salemas and Correio-Mor published as early Neolithic (cf. Cardoso *et al.* 1996) were not considered given that there is no secure association between the dated samples and the artifact assemblages.

2 Es – estuarine shells; Hbc – human bone collagen; Ch – charcoal; Abc – animal bone collagen. The dates on shell were calibrated with the curve for continental samples after subtraction of 380 ± 30 years, apparent age of this material in the archaeological sites from this time range (Soares 1993).

3 CPM = Cabeço de Porto Marinho.

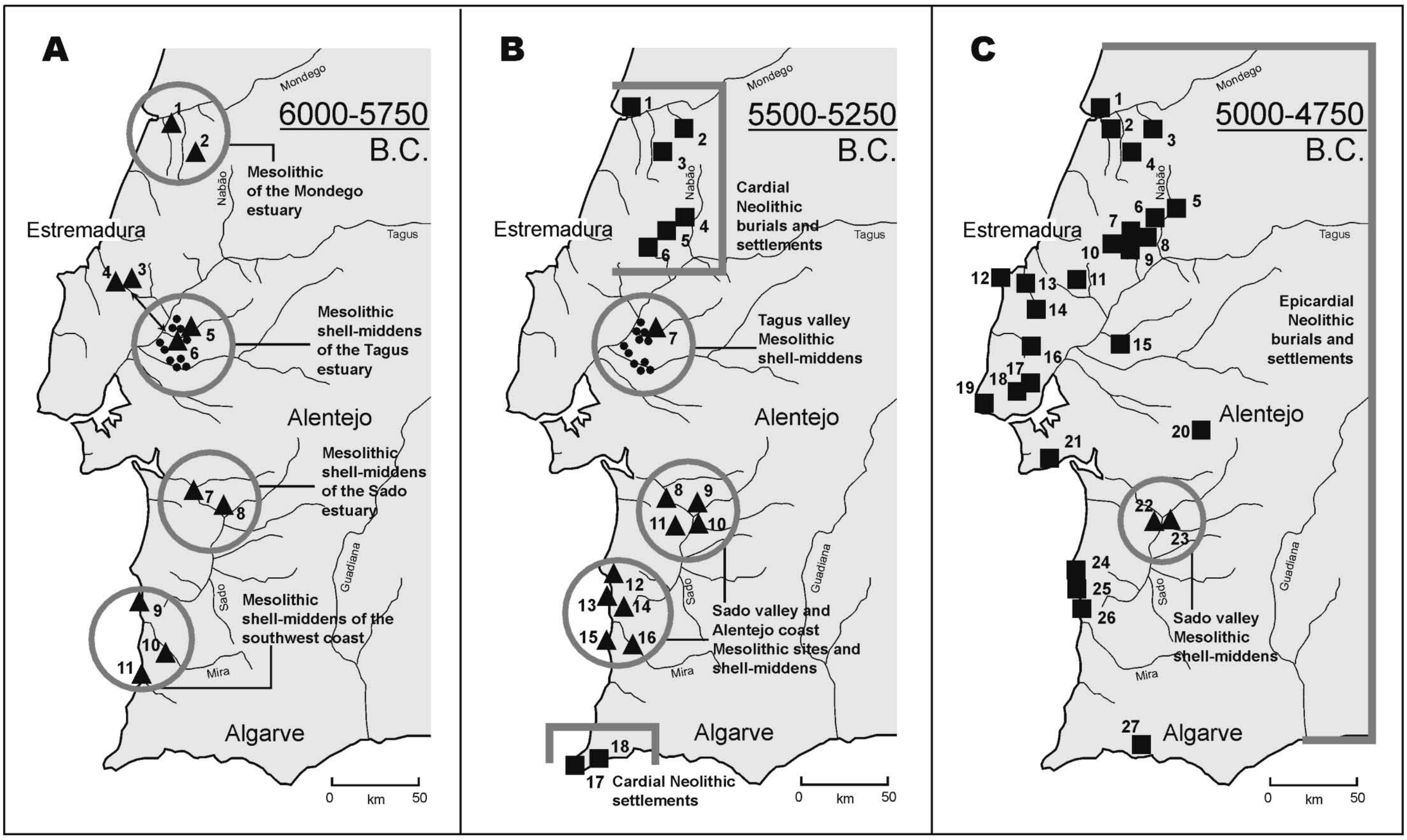


6.2 Calibrated radiocarbon chronology of early Neolithic and late Mesolithic sites known along the western façade of Atlantic Iberia. The bars represent occupation ranges defined with the earliest and the latest limits of all one sigma calibrated intervals derived from the dates obtained for each site or level (cf. Tables 6.1, 6.2).

By comparison with similar western Mediterranean pottery styles, the ceramics found in the Neolithic sites dated to the period between 5500 and 5250 BC can be described as "late Cardial" (Fig. 6.5), in good agreement with their radiometric ages (Zilhão *et al.* 1991, Zilhão 1992, Moura and Aubry 1995, Zilhão and Carvalho 1996, Aubry *et al.* 1997). Accelerator radiocarbon dating of sheep bones from Gruta do Caldeirão has demonstrated that these "late Cardial" contexts are associated with animal domesticates and must be defined as Neolithic not only from the perspective of material culture but also from that of economics (Rowley-Conwy 1992; Zilhão 1992, 1993). Slightly before 5000 BC, impressed or epi-Cardial wares replace Cardial pottery and Neolithic groups begin their expansion toward the interior. The transition is completed by 4750 BC, when Neolithic people reach eastern Trás-os-Montes (Sanches 1996; Sanches *et al.* 1993) and the last Mesolithic hunter-gatherer systems surviving in the Sado valley and the Alentejo coast disappear. Mesolithic–Neolithic cultural interaction in this time range is documented by the *in situ* occurrence of a few decorated sherds in the very late shell-midden of Amoreira, in the Sado valley (Arnaud 1990).

Cardial Neolithic cave sites from Estremadura are located in the interior limestone massifs of the region, which contain many Upper Palaeolithic and some early Mesolithic sites, but where no evidence of a late Mesolithic settlement has so far been recovered (Fig. 6.3). In the several sedimentary sequences bridging the Pleistocene/Holocene boundary that are known in the area, the late Mesolithic is always represented by a hiatus in both sedimentation (no deposits) and occupation (no diagnostic artifacts intrusive in underlying Palaeolithic levels or displaced in overlying Neolithic ones). However, a few late Mesolithic sites radiocarbon dated to between *c.* 6000 and *c.* 5750 BC are known in the periphery of these massifs, at the head of tributaries of the larger rivers of the region: the Mondego, in the case of Buraca Grande (Aubry *et al.* 1997), and the Tagus, in the cases of Forno da Telha (Araújo 1993) and Bocas (Heleno 1956, Zilhão 1992, 1995, Bicho 1993). At these three sites, the late Mesolithic levels could be defined as shell-middens or, at least, as containing large amounts of shells. This suggests that they functioned as logistical outposts of settlement-subsistence systems centered on the exploitation of the very extensive estuaries created in the major rivers of Portugal by the Flandrian transgression.

Thus, on present evidence, it would seem that the onset of the Atlantic period corresponded to a major reorganization of the human settlement of Estremadura (Zilhão 1993): as the limestone massif forests grew denser and less productive, they were gradually abandoned and people concentrated along the margins of estuaries, basing their subsistence strategies on the exploitation of aquatic resources. A similar process seems to have developed in southern Scandinavian, whose interior regions also became largely devoid of human occupation at the time of the mid-Holocene climatic optimum, when "the vast majority of Mesolithic settlement took place along the coasts and at the mouths of river systems . . . as the inland



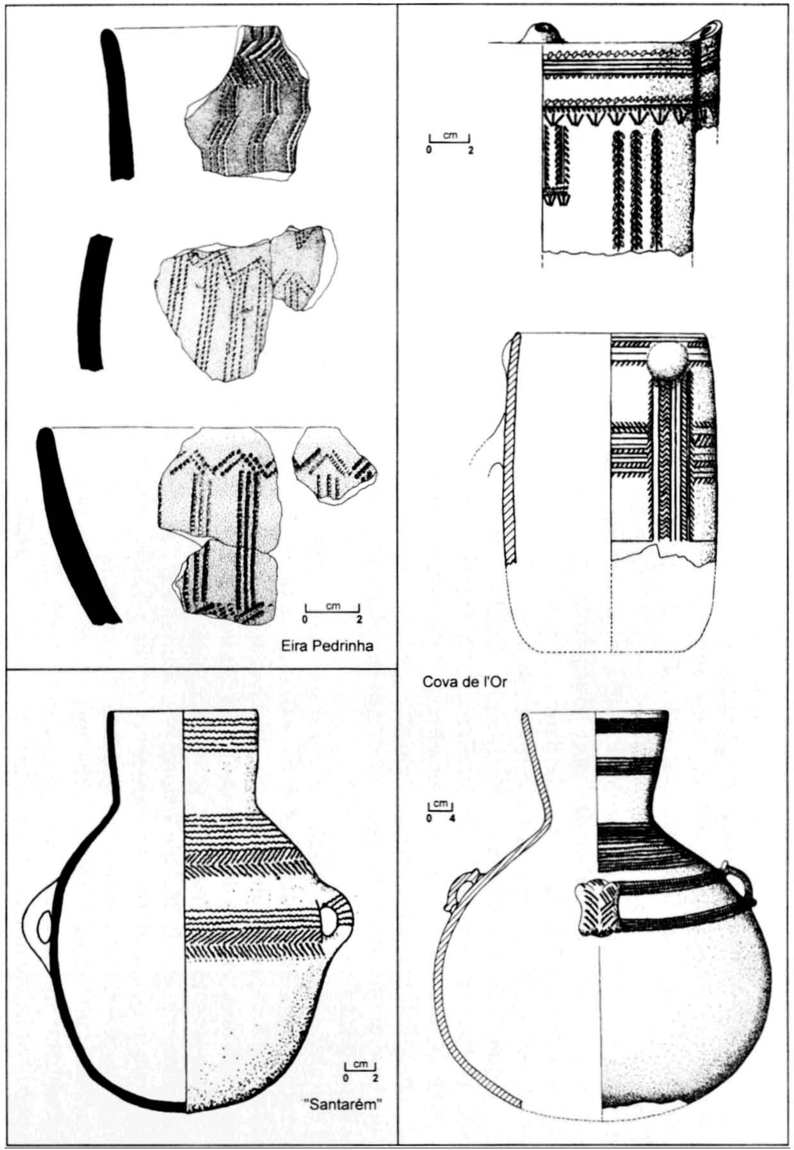
6.3

Caption to Fig. 6.3

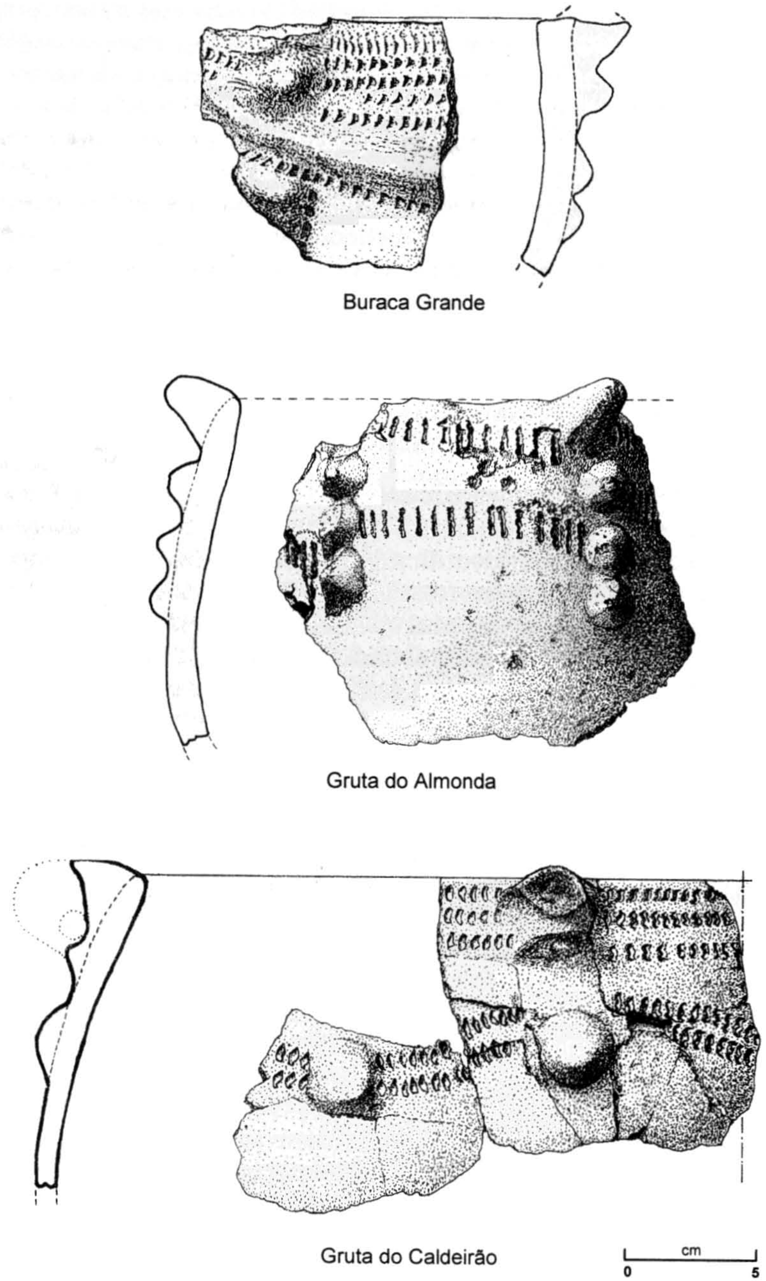
A Geographic and cultural distribution of archaeological sites in southern Portugal *c.* 6000–5750 BC, 1. Forno da Cal, 2. Buraca Grande, 3. Forno da Telha, 4. Bocas, 5. Cabeço da Arruda, 6. Moita do Sebastião, 7. Arapouco, 8. Vale de Romeiras, 9. Samouqueira I, 10. Fiais, 11. Montes de Baixo. Buraca Grande is a cave and Bocas a rockshelter. All the other are open air. The small dots represent numerous undated shell-middens, some already destroyed, known around the Muge and Magos streams, left-bank tributaries of the Tagus; their accumulation may have begun in this time range or slightly earlier, as at Moita do Sebastião.

B Geographic and cultural distribution of archaeological sites in southern Portugal *c.* 5500–5250 BC. Only the Cardial contexts defined by pottery assemblages, radiocarbon dating, or stratigraphic position that can be confidently placed in this age range were considered (neither isolated finds, such as the Santarém vessel, nor the odd sites where a few Cardial sherds have been found but most likely belong to later epi-Cardial contexts, were included). 1. Várzea do Lírio and Junqueira, 2. Eira Pedrinha, 3. Buraca Grande, 4. Caldeirão, 5. Pena d'Água, 6. Almonda, 7. Cabeço da Arruda, 8. Cabeço do Rebolador, 9. Várzea da Mó, 10. Cabeço do Pez, 11. Poças de São Bento, 12. Vale Pincel, 13. Samouqueira I, 14. Vidigal, 15. Medo Tojeiro, 16. Fiais, 17. Cabranosa, 18. Padrão. Sites 2–6 are caves or rockshelters; all the others are open air. The small dots represent the undated Tagus middens, some which may have been contemporary with Cabeço da Arruda. The mutually exclusive distribution of late Mesolithic and Cardial sites and the absence of known late Mesolithic settlement in the areas with the earliest Neolithic suggest that the latter is intrusive.

C Geographic and cultural distribution of archaeological sites in southern Portugal *c.* 5000–4750 BC. 1. Várzea do Lírio and Junqueira, 2. Forno da Cal, 3. Eira Pedrinha, 4. Buraca Grande, 5. Nossa Senhora das Lapas, 6. Caldeirão, 7. Pena d'Água, 8. Picoto, 9. Almonda, 10. Laranjal de Cabeço das Pias and Forno do Terreirinho, 11. Cabeço de Porto Marinho and Bocas, 12. Furninha, 13. Casa da Moura, 14. Lapa do Suão and Gruta das Pulgas, 15. Moita do Sebastião, 16. Cova da Moura, 17. Pedreira de Salemas, 18. Correio-Mor, 19. São Pedro de Canaferrim, 20. Escoural, 21. Lapa do Fumo, 22. Amoreira, 23. Cabeço do Pez, 24. Vale Pincel I, 25. Samouqueira II, 26. Vale Vistoso, 27. Caramujeira. Sites 3–9, 12–14, 16, 18, 20 and 21 are caves, Bocas and Pena d'Água are rockshelters, and all the other are open air. The persistence of Mesolithic groups on the coast of the Alentejo into this time range suggested by radiocarbon (Fig. 6.2) may be an artifact of the large standard deviations of the ICEN-141 and GX-14557 dates for Fiais and Vidigal (Table 6.1). The epi-Cardial ceramics recovered in the Sines area sites suggest that the transition to the Neolithic in this region took place around 5000 BC. The last Mesolithic people in Portugal seem to have been those who persisted in the inner estuary of the Sado until *c.* 4750 BC.



6.4 Cardial vessels from Valencia and from cave sites in the limestone massifs of Portuguese Estremadura with stylistically similar decorative patterns. *Top left:* Sherds from Eira Pedrinha (after Vilaça 1988); identical specimens have been recovered in the 1988–9 excavations at Almonda (Zilhão *et al.* 1991). *Bottom left:* The Santarém vessel (after Guilaine and Ferreira 1970), a ceramic vessel recovered in the nineteenth century from a now unknown location in that district (probably a cave site in the limestone plateau of Santo António, whose southeastern boundary runs only a few kilometers north of that city). *Right:* Ceramic vessels from Cova de l'Or (after Bernabeu 1989).



6.5 "Late Cardial" ceramic vessels from Buraca Grande, Caldeirão, and Almonda. These vessels belong to archaeological contexts radiocarbon dated to *c.* 5300 BC at Pena d'Água and Caldeirão. Although as yet undated, the Cardial vessel recovered at Buraca Grande was found directly atop the latest Mesolithic level.

forests increased in density and decreased in biomass and human population" (Price *et al.* 1995:115). In Portugal, this reorganization coincides in time with a major technological transformation, although no simple relation between the two is easily discernible: flake/bladelet lithic production systems, often based on the debitage of carinated "scrapers" and featuring marginally retouched hypermicroliths ("Areeiro bladelets"), were replaced by blade/bladelet technologies oriented toward the production of geometric armatures, especially trapezes. Technological observation of the Forno da Telha lithics indicates that indirect percussion was used to extract the blade/bladelet blanks found in these later assemblages.

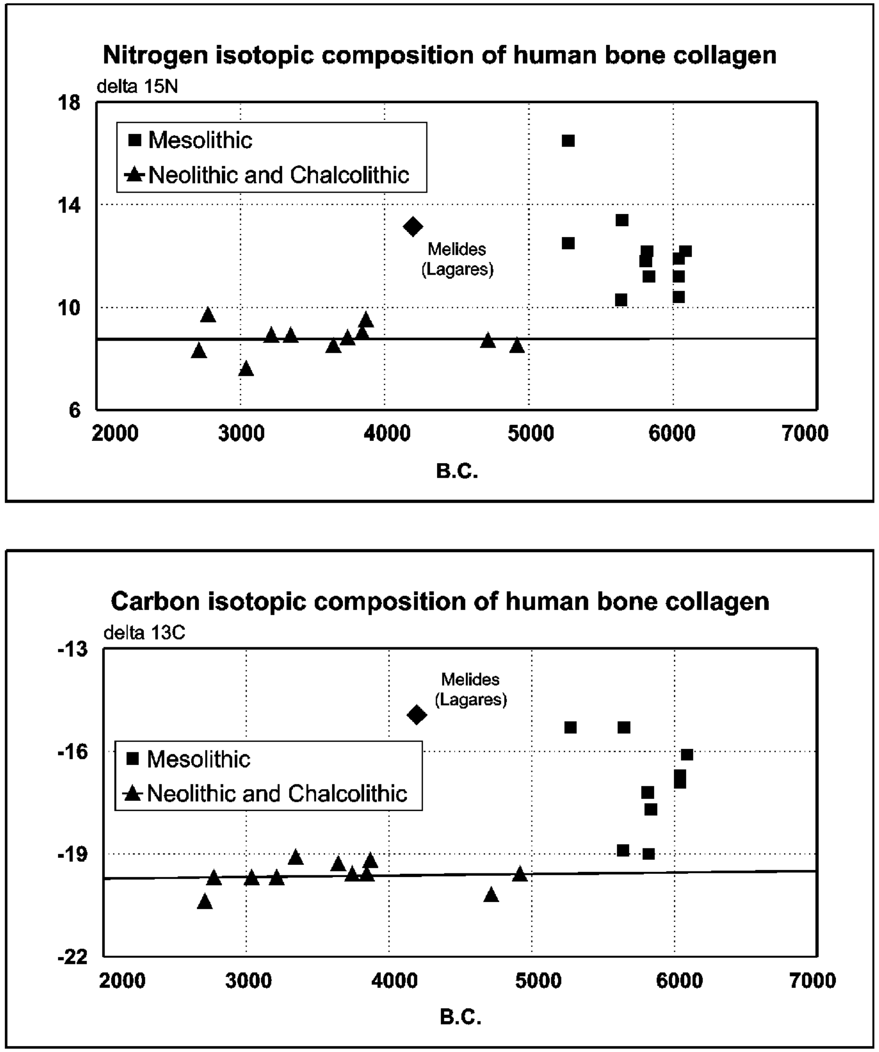
The late Mesolithic settlement-subsistence strategy is well documented by the numerous sites known in the inner parts of the estuaries of the Tagus (particularly the famous shell-middens of Muge, whose excavation began in the mid-nineteenth century), Sado, and Mira rivers (Arnaud 1989, González Morales and Arnaud 1990). Examination of the lithic assemblages recovered in the open-air sites excavated near Figueira da Foz at the turn of the century, traditionally considered to be exclusively early Neolithic, has led to the identification of a late Mesolithic component (Aubry *et al.* 1997). One of these sites, Forno da Cal, was described by the excavator, A. Santos Rocha, as containing a large shell-midden, spreading for more than 40 m and containing abundant remains of estuarine molluscs (Vilaça 1988). In Portugal, however, such extensive accumulations of shells are unknown in both cave and open-air Neolithic sites. It is quite likely, thus, that Forno da Cal actually featured a stratigraphic sequence identical to that found in some of the better-known similar sites of the Tagus and Sado estuaries: an important late Mesolithic shell-midden, overlain by deposits containing scattered remains of the use of the area in late Early Neolithic times. The decoration of the small ceramic assemblage recovered (eight vessels), which is of an epi-Cardial style (Jorge 1979), is compatible with such a model. If confirmed by future research, this would indicate, as was to be expected, that the estuary of the Mondego also witnessed the development of the same kinds of late Mesolithic adaptations that are well known further to the south. Accordingly, Forno da Cal was included in Fig. 6.3 as representing the estuary-focused adaptations of the lower Mondego basin with which the late Mesolithic use of the Buraca Grande cave must have been related.

In the Sado and Mira estuaries, these adaptations persisted until *c.* 5000 BC and were, therefore, fully contemporaneous for at least 500 years with the early Neolithic of the limestone massifs of Estremadura and the Algarve. In the Muge area, the most recent accelerator age obtained for the skeletons dated by Lubell and Jackes (1988) was 6360 ± 80 BP (from skeleton N at Cabeço da Arruda), that is *c.* 5200 BC. However, a charcoal date obtained for the upper part of Cabeço da Amoreira – 6050 ± 300 BP (Sa-194) (Roche 1977) – could be interpreted, despite the large standard deviation, as suggesting a similar late persistence of the Mesolithic. Photographs from the

original excavations show that even the burials located higher up in the stratigraphy were still overlain by at least 1 m of midden fill, suggesting that the accumulation of shells continued well after the most recent skeleton dates. On the other hand, given the stable isotope data for the human bone (Lubell *et al.* 1994), such dates are probably somewhat affected by the reservoir effect, that is, the skeletons are probably at least 100 years younger than indicated by the radiocarbon results (Schwarcz, personal communication). This suggests that the overlap between Cabeço da Arruda, Caldeirão and Pena d'Água shown in Fig. 6.2 is genuine and that the Mesolithic settlement of the estuary of the Tagus did persist for as long as that of the Sado and the Mira.

Stable isotope data (Lubell *et al.* 1994) also show that, although contemporaneous, Cardial pottery sites in the limestone massifs of Estremadura and shell-midden sites in the river estuaries represent separate adaptive systems, not different functional or seasonal poses of a single, highly diversified, system (Zilhão 1992, 1993). The cave site of Caldeirão, located in the valley of the river Nabão, a subtributary of the Tagus, was mainly used, in early Neolithic times, as a cemetery. Accelerator radiocarbon dating of human bone has demonstrated the contemporaneity of the burials with the sheep bones from the same levels (Table 6.2). Stable isotope analysis of those human bones indicated that the people buried at Caldeirão had a terrestrial diet (Fig. 6.6). In contrast, the people buried in the contemporaneous clusters of Mesolithic shell-midden sites located in the Tagus estuary had a diet where the aquatic component amounted to about 50%, as is also indicated by the analysis of faunal remains (Arnaud 1987). Burial practices were also different. The Tagus and Sado Mesolithic shell-middens feature individual burials with very few associated items (mostly shell beads), while Caldeirão represents the beginning of a long tradition of Neolithic collective interment in caves, with ceramic vessels and polished stone tools accompanying the bodies of the deceased.

Although direct evidence of domestic plants remains to be obtained, the fact that the sheep-owning people buried at Caldeirão were able to survive without the aquatic resources upon which their hunter-gatherer contemporaries were so strongly dependent suggests that cereal agriculture must have been the critical element in their successful colonization of the interior limestone massifs. Data from Buraco da Pala, a rock-shelter in Trás-os-Montes, northeastern Portugal, confirm this view. Wheat and barley were recovered from the base of level IV, in association with impressed wares, polished stone tools, and stone mills (Sanches *et al.* 1993; Sanches 1996). In good accord with its archaeological content, the base of the level has yielded two radiocarbon dates placing it in epi-Cardial times (Table 6.2). Buraco da Pala thus physically demonstrates that cereal agriculture existed in the most interior region of Portugal at the end of the early Neolithic. In this context, it seems entirely reasonable that cereal agricul-



6.6 Isotopic composition of human bone collagen from Portuguese Mesolithic, Neolithic and Copper Age sites (after Lubell *et al.* 1994:Table 1). The retrodiction of Neolithic values into Mesolithic times highlights the marked discontinuity in diet at the Mesolithic–Neolithic boundary.

ture was associated with the few centuries earlier Cardial settlement of the coastal regions, as happens in west Mediterranean areas wherever the relevant artifact suites are present.

The contemporaneity, the mutually exclusive geographical distribution, the economic differentiation, the discontinuity in material culture, and the distinctive burial practices that characterize the late

Mesolithic and the earliest Neolithic of Portugal indicate that the latter is intrusive. The only alternative hypothesis admitted by available evidence is that of a precocious adoption of the Neolithic package by hunter-gatherers living in the limestone massifs of Estremadura, while those living along the river estuaries would still have retained the traditional way of life for several hundred years. This hypothesis faces, however, two major problems, one empirical, the other theoretical: first, that no signs of the putative late Mesolithic adopters have been found so far in the limestone massifs before the putative adoption (an absence that persists even after the intensive archaeological surveys carried out over the last fifteen years); second, that an explanation would have to be provided for the reasons why adaptations in the two areas followed such different strategies after the Neolithic "package" became available through the long-distance exchange networks in which all human groups living in coastal Portugal presumably participated.

Alternatively, it could be argued that the Cardial Neolithic of the massifs of Estremadura exemplified by Caldeirão and Pena d'Água originated in Mesolithic people living in the estuary of the Tagus who decided to move on to unsettled land whose exploitation was made possible once new resources (ovicaprids and cereals) were made available through such exchange networks. The cultural and economic differences with the groups that continued to live in the margins of the estuary as fisher-hunter-gatherers, exemplified by Cabeço da Arruda, would have developed very rapidly once those that had left to settle the interior limestone areas successfully adapted to a new environment and a new way of life. This explanation would require, however, that the arrival of ceramics and ovicaprids to the estuarine areas, whence those settlers presumably originated, pre-dated their first occurrence at Caldeirão and Pena d'Água. The opposite is true – no ceramics and no domestic animals have been found in the Muge Mesolithic shell-middens, except for a few sherds in disturbed, surficial deposits from Moita do Sebastião (Ferreira 1974). The latter are of epi-Cardial style, documenting the use of the area by agriculturalists at a time when the middens had ceased to accumulate and the local hunter-gatherer Mesolithic adaptive systems had already gone extinct. Furthermore, there is no evidence, at the critical moment in time (5750–5500 BC), that the late Mesolithic adaptations of the estuarine regions of Portugal were undergoing processes of population pressure or resource depletion that might have originated such a drive toward the settlement of the interior.

The Alentejo coast in close-up view

The dates for the Cardial sites of Cabranosa and Padrão (Gomes 1994, n.d., Cardoso *et al.* 1996) (Table 6.2), in the Algarve, confirm their contemporaneity with those from Estremadura and, therefore, the isolation of the hunter-gatherer adaptive systems that persisted for several hundred years in the coast and estuaries of the geographically intermediate region of Alentejo. Although this further strengthens the mosaic frontier pattern previously described for Portugal and the maritime pioneer colonization model derived from it (Zilhão 1992, 1993), the opposite view has recently been taken by Soares (1992, 1995, 1997). She states that the large majority of the Alentejo sites should be described as Neolithic and that, given the radiocarbon dates obtained for Vale Pincel (Table 6.2), they represent an early, gradual, local transition from fisher-hunter-gatherer to food-production economies. A detailed analysis of the arguments shows, however, that her position is in direct contradiction with the empirical data.

In the time period of relevance, the Alentejo coast features three kinds of sites: (a) large shell-middens with no indisputably Neolithic artifacts (pottery and polished stone tools) and a mammal fauna featuring exclusively wild species, such as Fiais or Samouqueira I; (b) small shell-middens with no domesticates but with a few Neolithic artifacts of questionable association with the midden deposit, such as Medo Tojeiro; (c) large non-midden sites with pottery (and in some instances with hearths and other features as well) but yielding no direct evidence on subsistence (owing to the acidity of the sandy soils, which has precluded the preservation of bone), such as Vale Pincel.

Soares argues that the first kind of site represents Mesolithic base camps but that the other two would belong to a single, logistically organized, Neolithic settlement-subsistence system developed through indigenous integration in the traditional way of life of domesticates and related new kinds of artifacts: the small sites, featuring low artifact densities, where only hunting and gathering activities are represented, would be temporary camps; the large sites, with high artifact densities, would represent the more permanent village settlements related to agricultural activities. At the same time, she argues that this Neolithic settlement of coastal Alentejo was contemporary with the Mesolithic occupation of the inner estuary of the Sado, explaining the presence in shell-middens such as Cabeço do Pez of ceramics and other Neolithic items (stone mills), acquired through contacts with the coastal forager-farmers.

However, with the already mentioned single exception of the very late midden of Amoreira, in the Mesolithic sites of the inner estuary of the Sado ceramics and other Neolithic artifacts, when at all present, only appear in the upper sections of the sequences, above the midden deposits, not inside them (Arnaud 1982, 1987, 1989, 1990); that is, the deposition of such items post-dates the Mesolithic occupations represented by the shell-middens. Similarly, the Medo Tojeiro midden contained no Neolithic artifacts; as the excavators state, "the only artifacts . . . considered to be indisputably Neolithic were found on the deflated surface of the midden, overlain by dune sand" (Lubell, *in litteris*, 9 June 1991). Furthermore, the small-sized assemblage of decorated ceramics recovered at Vale Pincel is of an epi-Cardial style elsewhere dated in Portugal to the period after *c.*5100 BC; it is also strikingly similar to the pottery recovered in the deposits that overlie the Mesolithic middens of the Sado. Thus, both style and stratigraphy indicate that such pottery cannot be older than *c.* 5100 BC and, consequently, that the hearths dated at Vale Pincel cannot possibly be associated with the Neolithic occupation documented by the epi-Cardial ceramics recovered at that site.

Soares's argument is also internally contradictory since radiocarbon indicates that her "Mesolithic base camp" of Samouqueira I would be a few hundred years later than her supposed locally evolved "Neolithic village settlement" of Vale Pincel (Table 6.1, Fig. 6.2). She tries to avoid this contradiction through defining the site of Samouqueira I as "Mesolithic" and the human skeleton from which the date was derived as "Neolithic" (Soares 1997). The implicit assumption is that the site is earlier than that date and the burial intrusive, but the excavators (Lubell and Jackes 1985) mention no archaeological evidence of intrusion and no Neolithic artifacts were associated with the skeleton (in actual fact, none was recovered at the site). Finally, isotopic evidence shows that the individual in question had a marine diet identical to that of the people buried in the Mesolithic shell-middens of Muge (Lubell *et al.* 1994).

The functional differentiation argument is also inconsistent. Medo Tojeiro, the prototype of the "Neolithic temporary camps," had a lithic artifact density of $8/m^3$. Although this is exceedingly low indeed, Vale Pincel, the prototype of the "Neolithic village settlements," is no different – from the data supplied by Silva and Soares (1981), the corresponding value can be calculated to be of $8.5/m^3$ and, in the 40 m^2 excavated at Vale Pincel in 1975, there were only 1.4 lithic artifacts per square meter in levels 2d/3 (the base of the occupation, where the dated hearths and other features described as "hut-floors" were found). Such extremely low lithic artifact densities are incompatible with the definition of Vale Pincel as a permanent village settlement. For comparative purposes, it may be worth noting that the corresponding values obtained at geologically *in situ* sites in this time range were of approximately $520/m^3$ in the epi-Cardial open-air settlement of Laranjal de Cabeço das Pias, Estremadura (Carvalho and Zilhão 1994), and of some $470/m^3$ in the Sado valley Mesolithic shell-midden of Poças de São Bento (modern Arnaud/Larsson excavations) (Araújo 1998); at Mesolithic Samouqueira I, Soares (1997) herself gives values of *c.* $400/m^3$.

In this context, it would seem that the hearths dated at Vale Pincel belong to the Mesolithic occupation previously inferred from stratigraphic and material culture data alone (Zilhão 1993:33–6). In fact, Vale Pincel is a seriously disturbed site, as indicated by the low density of finds, the slope of the sandy deposits containing the Neolithic material, and the presence of obvious erosional features at the interface between levels 2 and 3 – the most striking are the extensive, irregularly shaped pockets and channels excavated in level 3 and filled with darker material wrongly interpreted as "hut-floors" by the excavators (Silva and Soares 1981). Since these hearths (*cuvettes* of hardened, reddish sands containing charcoal and burnt cobbles) are encrusted in level 3 and since their topographical relation with the overlying Neolithic level 2 indicates that they too were affected by the erosional processes ante-dating the accumulation of the latter (the upper part of the *cuvettes* is convex and protuberant, outcropping from the surface of level 3 extant during excavation), their radiocarbon dating to the Mesolithic should come as no surprise. The scant data available on vertical distributions also suggest the presence of a Mesolithic component among the lithics recovered in levels 2d/3.

Similar taphonomic patterns are known from sites in identical geological contexts excavated in Estremadura and in the Algarve. At Ponta da Vigia (Zilhão *et al.* 1987), in coastal Estremadura, several early Mesolithic hearths were identified encrusted on an eroded, deflated surface of hard sands, and the lithics presumably related with this occupation were scattered around at very low densities, as is the case at Vale Pincel. In the 80 m^2 excavated at Padrão, in the Algarve, the surface with the dated hearth and associated Cardial Neolithic material was cut by Roman burials and the negative of the basis of a fallen menhir. It was the discovery of the latter that prompted the excavation and its close proximity to the hearth initially led the excavator to believe that its erection actually dated back to the earliest Neolithic (Gomes 1994). A sequence in unconsolidated sands presenting exactly the same characteristics as those suggested for Vale Pincel (two occupations in direct stratigraphic contact, with material from the later occupation found in discontinuous pockets excavated by erosion in the underlying deposits containing the earlier occupation), but featuring upper Solutrean and final Magdalenian instead of late Mesolithic and early Neolithic, has also been described at Olival da Carneira, in Estremadura (Zilhão 1995).

There is nothing solid in the Alentejo data, therefore, that can be taken to indicate a slow, piecemeal adoption by local hunter-gatherers of the several elements of the Neolithic package starting as early as 5750 BC. Whether the epi-Cardial Neolithic that appears throughout the region around 5000 BC represents an expansion of the farmer groups that previously settled the neighboring regions of Algarve and Estremadura or the adoption by local hunter-gatherers of the new subsistence system remains, however, to be clarified.

Traditional explanatory frameworks and their limitations

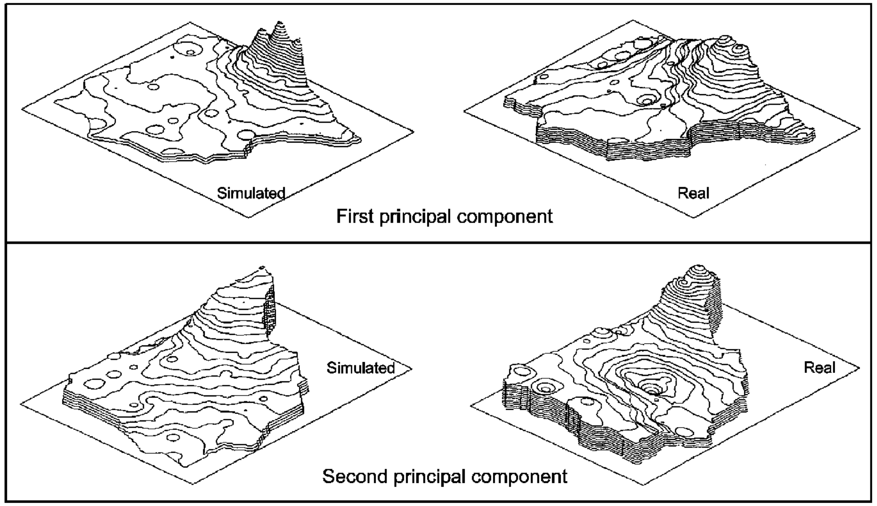
Genetic data indicate that two very different population clusters can be distinguished in Iberia, with the Basque group well isolated from the rest (Calafell and Bertranpetit 1993). These authors interpret such a differentiation in terms of population history. The Basque would represent a pre-Neolithic population that survived in cultural isolation. The pattern of homogeneity revealed by the gene frequencies everywhere else in Iberia

would in turn be the result of the Neolithic expansion of farming populations originating in Catalonia and spreading southwestwards. This process would have led to the assimilation of the autochthonous hunter-gatherers, whose genetic contribution to subsequent populations, given their small numbers, would have been extremely diluted.

These conclusions find some support in the results of a simulation study also carried out by Calafell and Bertranpetit (1993), which was based on the "Wave of Advance" model of Ammerman and Cavalli-Sforza (1984). Mapping of the first principal component of the simulated data (interpreted as pre-Neolithic) shows good accord with the real gene frequencies (Fig. 6.7). The isolation of the Basque shown by this map is also in good accord with linguistic and ethnohistorical data and is compatible with the archaeological evidence. As mentioned above, both Arias (1991, 1992, 1994a) and González Morales (1992, 1996) consider that the Neolithization of the Cantabrian coastal strip is best interpreted as the local acquisition of novel resources by local hunter-gatherers. Mapping of the second principal component (interpreted as indicating the consequences of the Neolithic expansion), however, does not show a similar degree of accordance with the real gene frequencies. Instead of the regular east–west gradient predicted by the simulation, we have a pattern where the highest recorded frequencies outside the presumed area of origin of the expanding populations are to be found in central Portugal, not along the adjacent coasts of Valencia and Andalucía, as it should be expected, given the assumptions of the model (Fig. 6.7).

Other exceptions to the east–west gradient predicted by gradualist demic Wave of Advance models of the expansion of agriculture are given by Jackes *et al.* (1997a, 1997b), who find that the Portuguese cluster with the French instead of with neighboring Spaniards in the analysis of some genes. They quote similar findings when blood groups, red cell enzymes, and serum protein polymorphisms are used. It is possible that these contradictions between genetics and geography result from the impact of recent historic processes such as the medieval Berber invasions or the western Crusades. Since the information on conditions at the time of the Neolithic transition contained in modern samples is necessarily confused by the passage of time and the impact of documented large-scale population movements of the recent past, the only conclusion that can be safely derived from these analyses is that the palaeodemography of the Mesolithic–Neolithic transition should be addressed by looking at the extinct populations themselves. This is all the more so since the interpretation of prehistoric patterns through modern ones is dependent on the conditions at start, when the process of hypothesized Neolithic expansion began.

The shortcomings of the Wave of Advance have the implication that the appearance of agro-pastoral economies in Spain and Portugal cannot be simplistically self-explained as the result of the spread of the populations



6.7 The genetic history of the Iberian peninsula after Calafell and Bertranpetit (1993:Figs. 4–7, modified). The first principal component is interpreted by these authors as representing the pre-Neolithic population background and the second principal component is interpreted as reflecting the consequences of Neolithic demic diffusion. Simulations were based on the assumptions of Ammerman and Cavalli-Sforza's Wave of Advance model for the spread of agro-pastoral economies across Europe. If the historical significance of the second principal component was correctly interpreted, the disagreement between simulated and real gene frequencies constitutes a refutation of the idea that such a spread was a gradual, southwestwards "oil-spill" process.

that practiced them. Alternative explanatory frameworks available in the literature can be grouped in two categories: (a) independent invention and (b) acculturation models. Independent invention in Iberia was favored, among others, by Acosta and Pellicer (1990) and Olaria (1988). As mentioned above, the empirical foundation of their models is seriously faulty and forces us to eliminate them from further consideration. Acculturation models have been put forward by Guilaine (1976) and Lewthwaite (1986a, 1986b) for the western Mediterranean area and, more recently, by Whittle (1996) for Europe as a whole. According to these models, the local hunter-gatherer populations would have been driven to the adoption of agro-pastoral economies by a number of different causes. They would have gradually acquired the different items of the Neolithic package as needed, doing so by means of long-distance exchange routes that were already operative in the Mesolithic. The classic example of such a scenario is southern France. There, according to data from several sites, mainly located in the Languedoc, the process would have begun with the introduction of sheep in

traditional economies. A few hundred years later, pottery would have made its first appearance, to be followed, in the centuries to come, by the other domesticates, such as pigs and cattle. Sedentary villages, however, would not become a feature of the landscape until the Chasséen Middle Neolithic, when cereal agriculture would have become dominant and the region entered the "consolidation phase" of Zvelebil and Rowley-Conwy (1986).

As previously argued, this scenario needs to be submitted to a taphonomic critique (Zilhão 1993). Examination of the published evidence raises serious doubts about the concept of "Mesolithic sheep" put forward by Geddes (1983) (see also Binder, this volume, and Rowley-Conwy 1995). In some cases, such bones are probably intrusive, as was recently demonstrated in the case of Châteauneuf-les-Martigues (Courtin *et al.* 1985). The Languedoc sites (such as Dourgne and Gazel), on the other hand, have high-altitude catchments, which suggests that in many cases we may be dealing with bones of ibex or chamois, particularly since the remains in question tend to be mainly composed of immature animals. In his recent revision of the faunal material from the Mesolithic levels of the Dourgne rockshelter, Geddes (1993) has acknowledged this possibility. As a result, definite ovicaprids dropped to 4% in level 7 and to 3% in level 8 of the total number of identifiable specimens recovered, instead of 29% and 38%, as before. Faced with this evidence, Guilaine (1993) has accepted that the supposedly Mesolithic ovicaprid remains in level 8 are probably intrusive and tentatively reinterpreted the overlying level 7 as a palimpsest of two different occupations, one Mesolithic and one Neolithic, attributing the latter to the first explorations of the Corbières by shepherds coming into the area from coastal villages.

The idea of an early adoption of sheep by the Mesolithic hunter-gatherers of southeastern France is also contradicted by the evidence from Mediterranean Spain reviewed above, which demonstrates that Neolithic innovations appear (for instance at Cova de l'Or) as a "complete package" some time before 5500 BC. Therefore, as suggested by Binder and Courtin (1986) and Binder (this volume), the absence or rarity of cereal remains and of evidence of sedentary agricultural settlement in the Cardial "culture" of southern France may be simply a consequence of differential preservation (or preferential excavation) of site types (caves and rockshelters) that, in the Neolithic, would have been used in a logistic way, for special purposes (herding or hunting). In this perspective, the now submerged, open-air site of Leucate (Guilaine *et al.* 1984) would be the French equivalent of La Draga, that is, an example of the vastly under-represented agricultural villages that would have constituted the sedentary focus of the Cardial Neolithic settlement systems.

The mechanisms suggested for the piecemeal introduction of Neolithic domesticates and items of material culture in the hunter-gatherer economy of west Mediterranean Europe are not exempt from criticism either. Arguments based on sheep (Lewthwaite 1986a, 1986b) or pottery

(Barnett 1990b) as prestige items accumulated in a socially competitive environment have to face the objections that: (1) pottery is not recorded in pure hunter-gatherer contexts such as the Muge shell-middens, in Portugal; (2) pigs do not seem to have been domesticated until the later part of the early Neolithic and sheep are likely to have been an unbearable burden in the framework of a mobile economy based on the resources of the temperate forest (Rowley-Conwy 1986, Helmer 1993); (3) there is no indication in the archaeological record of the existence in the Mesolithic of long-distance exchange networks through which domesticates might have arrived to the shores of Mediterranean France (such as those that were responsible for the presence of Sardinian obsidian at Arene Candide – Ammerman and Polglase 1997, Tykot n.d.); (4) wherever exchange networks across a Mesolithic-Neolithic frontier are documented, as happens in Scandinavia (Price 1991, this volume), it is artifacts, not domesticates, that initially circulated; (5) although Zvelebil (1994b) thinks that burial practices in the Mesolithic of north temperate Europe show "some degree of social hierarchy," Knutsson (1995:204) considers that there are no real clues in the archaeological record of the area, when interpreted in the light of ethnographic evidence, of social inequality and ranking, "with the exception of the somewhat doubtful circumstances at Olenij Ostrov," and Price *et al.* (1995:122) note that "no evidence of elite burial treatment is found in the Ertebølle" (see also Larsson 1990); and (6) even if Zvelebil's interpretation is accepted for the circum-Baltic area, nothing even remotely resembling ranking can be inferred from the interment practices of western Mediterranean Mesolithic hunter-gatherers as exemplified in the hundreds of burials contained in the shell-midden sites of the estuaries of the Tagus and the Sado (Arnaud 1987).

An alternative model: maritime pioneer colonization

The complete absence of serious evidence of independent invention and the problems encountered by models of indigenous adoption when confronted with the empirical data indicate that some form of demic diffusion is still the most powerful explanation for the appearance of Neolithic economies in western Mediterranean Europe and, in particular, in Iberia. However, the above-mentioned contradiction between Calafell and Bertranpetit's simulation and the real genetic data indicates that gradualist "Wave of Advance" models cannot be accepted either. This is also brought forward by the fact that such models predicted that, at the rate of spread calculated by Ammerman and Cavalli-Sforza (1984), agro-pastoral economies would have reached the Pyrenees some time between 4900 and 3800 BC. However, such economies are present in Portugal from at least 5500–5250 BC, as is shown by the accelerator radiocarbon dating of sheep bones from Caldeirão, and probably as early as 5750–5500 BC, as suggested by the typology of some Cardial vessels recovered at other cave sites located in the limestone massifs of Portuguese Estremadura.

Therefore, the spread of the Neolithic package from the Gulf of Lions to the estuary of the Mondego seems to have been, in historical perspective, a punctuated event, rather than a gradual process. Given the littoral orientation of the Neolithic settlement, and the existence of well-documented navigational capabilities in the Mediterranean since at least the early Holocene (recently confirmed by the discovery of ceramic toy boats in the early Neolithic underwater lake site of La Marmotta, near Rome – Fugazzola Delpino and Pessina 1994), it is likely that we are dealing here with leapfrogging colonization by small seafaring groups of agriculturalists, as previously suggested (Zilhão 1993) and as is becoming to be increasingly accepted in the literature (Budja 1996, Harris 1996b, Renfrew 1996).

In the present state of our knowledge, such seems to be the only kind of process capable of explaining both the enclave situation of the earliest Neolithic sites of Portugal and the punctuated, irregular nature of the spread of agro-pastoral economies along the northern shores of the west Mediterranean. Neither of these features can be accounted for in the framework of Wave of Advance or "adoption through prestige exchange in a socially competitive environment" models, since both carry the implication that the spread of food-production economies should proceed at a regular and continuous pace and leaving no "gaps" behind. If early cereal agriculture was economically superior and expanded through the gradual assimilation of neighboring people and neighboring resources into the new system as the latter required more and more land, as assumed by Wave of Advance models, how did it get to Estremadura first, further away from the nearest possible source than the Alentejo, and why did the hunter-gatherer groups of the Alentejo maintain their traditional way of life for at least another 500 years after agriculture was introduced only 150 km to the north? If Mesolithic society was competitive and ranked, and pottery and sheep entered Estremadura in the framework of the accumulation strategies of prestige-seeking leaders or would-be leaders, why did the the latter's Alentejo peers not compete in the same way for the accumulation of the same prestigious items? And, if it is from mortuary data that incipient social ranking is inferred, why are there no signs of those (or any other) prestigious items to be found in the burials of the estuarine food consumers of the Tagus and Sado shell-middens while, in contrast, they are always associated with the human remains of their contemporaneous terrestrial food consumers buried in the cave sites of the limestone massifs of Estremadura?

In a pioneer colonization model, these patterns of the process are easily explained. Early cereal agriculture was not economically superior to European Mesolithic adaptations in terms of work load and long-term stability (Zvelebil and Rowley-Conwy 1986, Gregg 1988), especially when productive and reliable aquatic resources were available, as was the case in coastal Portugal. There would be, therefore, no economic incentive for adoption, and no adoption did in fact occur, even when the new economic system was immediately available as a result of the establishment of farming settlements nearby. Relatively peaceful coexistence between the two systems was made possible by the fact that, at first, farmers only occupied the interstitial areas of the local hunter-gatherer settlement. Peasant economies, however, are more productive, in terms of the amount of people they can feed per area unit of territory. Their specific demographic dynamic would lead, therefore, to a greater population growth among the pioneer groups, resulting in the gradual assimilation, through intermarriage, of neighboring hunter-gatherers, and in the correlative expansion of the new system to all the surrounding areas where it was ecologically viable and socially feasible. Given the discontinuous nature of the distribution of good agricultural land in the broken limestone terrain of the northern shores of the west Mediterranean where the Cardial "culture" developed, this process would require, at a certain point in time, that pioneers would leave to settle in distant areas that might have been previously reconnoitered through the communication and travel routes used by the assimilated local hunter-gatherers. That areas such as the coasts of the Alentejo were "skipped" over may have to do with their different geography, as is indicated by the fact that the expansion of the Cardial "culture" stopped at the mouth of the Mondego, north of which Mediterranean limestone ecosystems no longer exist. In Mediterranean Iberia, the subsequent expansion from the initial enclaves led to the integration of these "skipped" areas, which seems to have been accomplished between 5000 and 4750 BC, at a time when farming had also begun to expand to the interior Meseta, making it possible for pottery to be introduced into the Mesolithic of the Cantabrian strip.

Economic pressure, however, is not necessarily the only reason for the budding off of pioneer groups, as is shown by the archaeological and ethnohistorical data concerning the mechanisms and the motives for the colonization of the Pacific islands, which was initiated by primitive agriculturalists whose technology probably was not more sophisticated than that available to the peoples living around the shores of the Mediterranean in early Holocene times. Such colonization was the result of purposeful and planned navigational enterprises and, often, the movement from one island or archipelago to the next would take place long before any pressure on resources is documented in the archaeological record (Kirch 1984, Irwin 1992). As in the Pacific, social reasons or the prevalence of a "pioneer ethic" enforced by tradition and rooted in the previous history of farming groups may actually account better, therefore, for the apparent swiftness that seems to characterize the spread of the Neolithic package along the shores of west Mediterranean Europe.

Özdogan (1997:16–17) has recently suggested that the initial westwards spread of agriculture out of central Anatolia coincided with the collapse of the Pre-Pottery Neolithic B, for which there are strong indications of a stratified society and a strong impact of cult practices. In contrast, the

succeeding Neolithic societies of western Anatolia and southeastern Europe lack any archaeological evidence of specially built temples and of social ranking in settlement or in burial. Özdogan's hypothesis is that these egalitarian rural societies were originated by the migration of groups carrying to the west "all aspects of their culture except central authority." It may not be too bold to extend this hypothesis a little further and to suggest that the driving force behind the expansion of the Neolithic across the west Mediterranean may have been a social imperative rooted in a tradition going back to the events leading to the collapse of the Pre-Pottery Neolithic B: the imperative to fission before groups get too large and conditions arise for the development of social inequality. In sum, agriculture may have been brought to Europe by pioneers escaping from dominance in ranked societies and striving to maintain egalitarianism through the application of strict controls to group size. Along the shores of the north Mediterranean, this tendency to fission and move on would have been further reinforced because opportunities for settlement and expansion around initial enclaves were limited by physical geography and the presence of local hunter-gatherer groups.

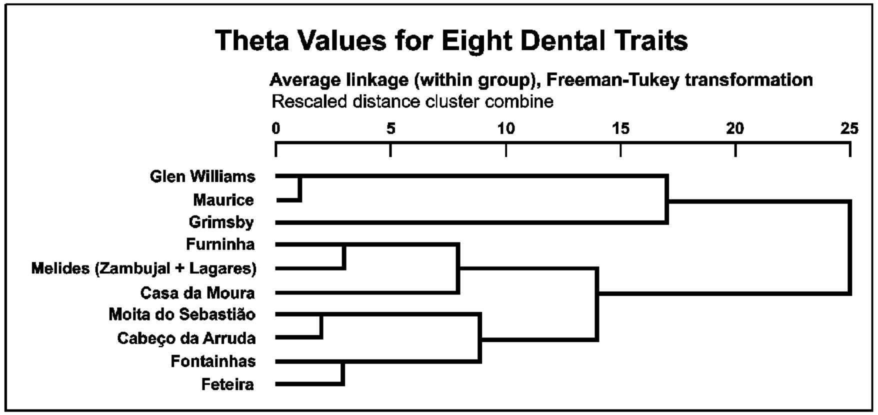
Continuity and discontinuity in physical anthropological data

The comparison of the spread of agriculturalists in the west Mediterranean with the colonization of the Pacific islands must not overlook the major difference that exists between the two: the shores of the Mediterranean were not uninhabited at the time of the postulated farmer maritime dispersals and, therefore, the action of the local Mesolithic populations needs to be considered in the process. If people moved along with domestic resources, it should be possible, using Iberian fossil samples – those farthest away from the presumed origin of European agriculturalists – to establish mtDNA or Y-chromosome lineages extending to the earliest Neolithic of the Fertile Crescent, where wheat, barley, sheep, and goats were first domesticated and from where they spread into the continent. If Iberian early Neolithic people were shown to belong to such lineages and Iberian Mesolithic people were shown to be different in this regard, population movement would be proved, regardless of the extent to which the input of incoming agriculturalists affected the gene pool of succeeding populations.

If the input of external farmer groups was important, as might have been the case if local hunter-gatherers were rapidly absorbed by incoming agriculturalists with higher fertility, one would have considerable changes; for all practical purposes, the end-result would be population replacement, even if local Mesolithic groups participated in the process; the extent, nature, and regional variation of such a participation, in turn, would affect the degree of heterogeneity of succeeding Neolithic populations. If, on the contrary, it had been local hunter-gatherers who rapidly absorbed the newcomers and changed their way of life to become farmers and shepherds, one might have very few changes except as regards those brought about by the new nutritional patterns or by adaptation to different kinds of work patterns and new types of terrain; the end-result would be Neolithic homogeneity or Neolithic heterogeneity depending on which was the situation in the Mesolithic, and the external input, although perhaps visible in fossil samples, might have since vanished, or become of little significance, in modern populations.

Since no fossil DNA data are available at present for this time period, the extent to which local Mesolithic people contributed to the later gene-pool of Iberian populations and, conversely, the impact of agricultural colonists on the demographic patterns extant once the transition to food production was completed, can only be evaluated from physical anthropological evidence. Unfortunately, not enough data are available for late Mesolithic skeletal morphology outside Portugal and the scant data on the osteology of the earliest Neolithic people of the west Mediterranean do not allow, in most cases, significant comparisons. Arguments based on skeletal morphology also have to face the complicating possibility that external farmer groups may not have been significantly different from local Mesolithic people and that, therefore, their impact on the osteological record may be undetectable. In the extreme case, that is, if west Mediterranean Mesolithic groups were morphologically homogeneous and if the northwestwards spread of agriculture from southern Italy was initiated by local Mesolithic people who had become Neolithic through indigenous adoption of novel resources with insignificant external population inputs from areas further to the east, total population replacement could have occurred in spite of apparent continuity in osteology.

Over the past fifteen years, Lubell and Jackes (1985, 1988), Jackes and Lubell (1992, n.d.), Lubell *et al.* (1994) and Jackes *et al.* (1997a, 1997b) have tried to address the issue of population continuity or population replacement in the Mesolithic–Neolithic transition through the analysis of the rich skeletal material available in Portugal. In the non-metrical dental traits dendrogram reproduced in Fig. 6.8, Jackes *et al.* (1997a) show that there is less difference between samples from the late Mesolithic and the late Neolithic of Portugal than there is between southern Ontario proto-historic and historic Iroquois groups belonging to the Huron and Neutral nations. Given that the latter are considered to correspond to populations that are known to have been culturally and biologically homogeneous, these results would indicate genetic continuity across the Mesolithic–Neolithic boundary in Portugal. From the previous discussion it necessarily follows, however, that the biological homogeneity inferred from this dendrogram may exist even if the introduction of agriculture was indeed associated with pioneer colonization, given the demographic features of the model: the small size of the colonist groups and the nature of the process through which local Mesolithic people were assimilated (intermarriage, leading to

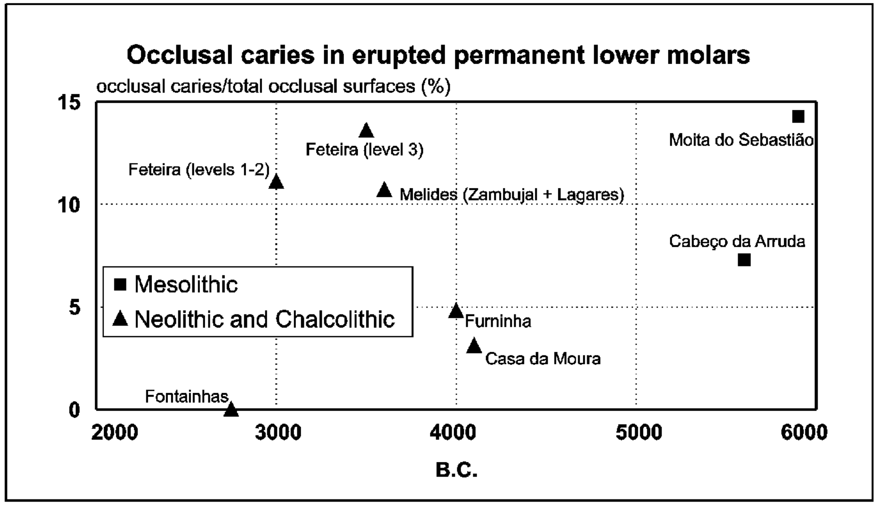


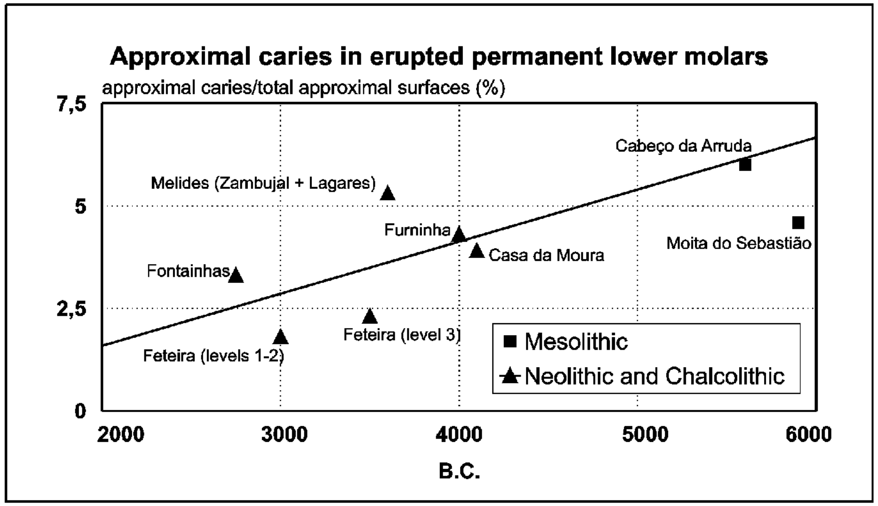
6.8 Results of the cluster analysis of seven Portuguese prehistoric skeletal collections using eight non-metrical traits from dentition and controlling for sample size through the application of the Freeman-Tukey transformation (after Jackes *et al.* 1997a). Moita do Sebastião and Cabeço da Arruda are close-by Mesolithic sites belonging to the Muge cluster of shell-middens. Melides, Furninha, Casa da Moura, Feteira and Fontainhas were used as burial caves mostly in the Late Neolithic and Copper Age periods, between *c.* 4000 and *c.* 5000 BP (the collections from Casa da Moura and Furninha also contain an epi-Cardial human bone component, probably small). The North American samples date to late proto-historic or historic times: Maurice is Iroquois Huron, Glen Williams, 150 km to the south, is Iroquois Neutral, as is Grimsby, located another 50 km further south of Glen Williams, across Lake Ontario.

appropriation by the agriculturalists of the reproductive potential of the local populations and of their genetic heritage – Moore 1985).

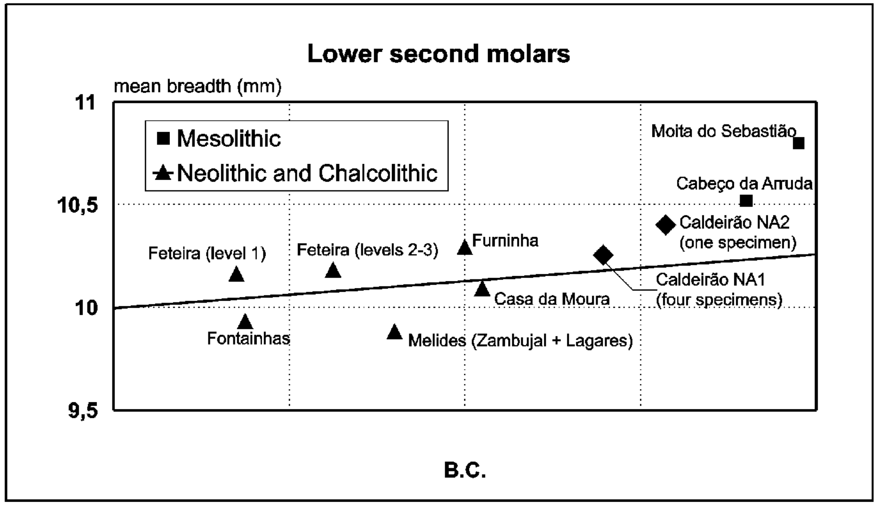
Furthermore, as exhaustively argued elsewhere (Zilhão 1998), the interpretation of the American Indian data provided by Jackes *et al.* (1997a) is questionable. In fact, the collections they analyzed group according to geography and ethnicity, which can be taken as an indication that the Huron and the Neutral may have been biologically more distinct than assumed by the authors. Thus, the comparison would highlight simply that the degree of biological difference between Portuguese Mesolithic and Neolithic people may not have been greater than that between neighboring populations documented ethnohistorically. This is entirely compatible with the maritime pioneer colonization model, which places the presumed origin for the earliest Neolithic Portuguese in the nearby Spanish regions of Andalucía and Valencia, as indicated by the close stylistical similarities between ceramic assemblages from the two regions.

Jackes *et al.* (1997b:884), however, argue against demic mechanisms on the basis that they would require "a massive advantage for the incoming





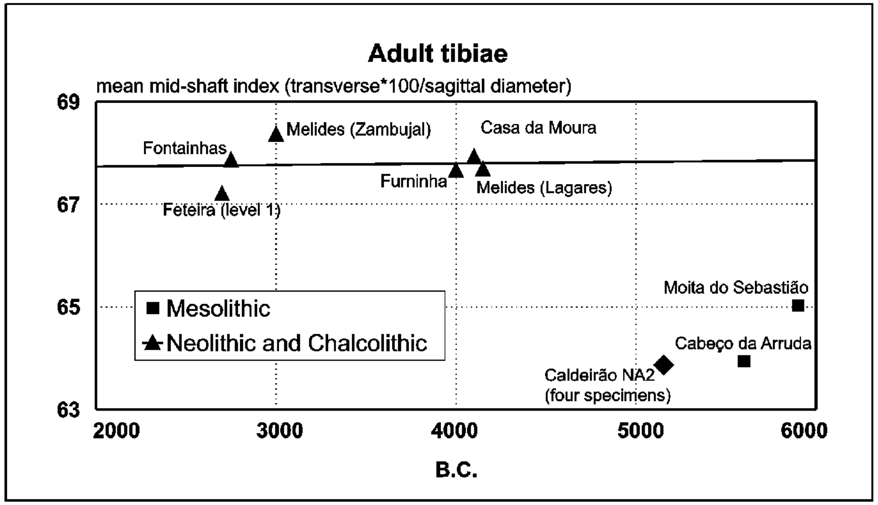
6.9 Dental evidence for the Mesolithic–Neolithic transition in Portugal (after Lubell *et al.* 1994 and Jackes *et al.* 1997a). Late Neolithic–Copper Age values were retrodicted into Mesolithic times but, given the small sample sizes, the trend line was computed without consideration of the early Neolithic material. Caries rates do not show variation through time. The retrodiction of the average bucco-lingual breadth of lower second molars gives results lower than those actually observed and the values for the earliest Neolithic molars are already in the range of those from later periods. The late Neolithic–Copper Age tooth size pattern cannot be considered as the outcome of a gradual trend beginning in the Mesolithic. Instead, it seems to have become established rather abruptly at the Mesolithic–Neolithic boundary.

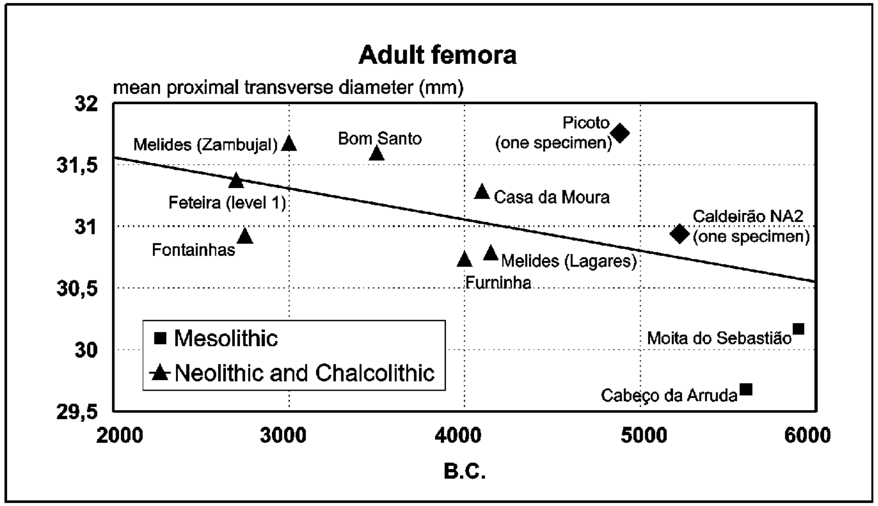


6.9 (*cont.*)

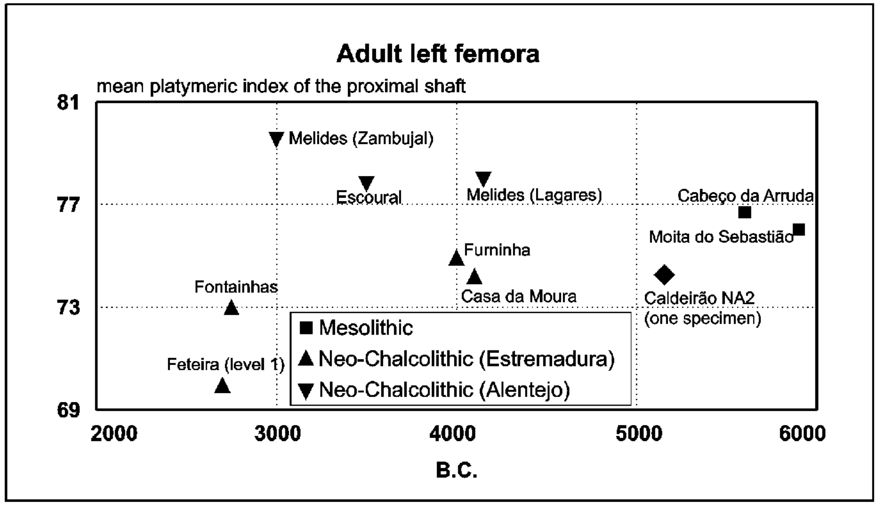
Neolithic population, one that would permit the newcomers an extremely high fertilty rate." The assumption that population replacement can occur only in situations of extreme imbalance is unwarranted. Zubrow (1989), for instance, has demonstrated, in the case of Neanderthal/early modern human interaction, that a difference of no more than 2% in mortality would suffice to bring about the total extinction of the autochthonous European population in thirty generations. Since peasant economies are more productive (the simplification of the ecosystems enables them to feed more people in less space), in situations of initial pioneer settlement they can grow much faster than local hunter-gatherers. As shown by Zubrow's models, this different dynamics would easily result, even if the demographic advantage of pioneer colonists was minor, in the rapid assimilation of neighboring hunter-gatherers, particularly if both groups intermarried. It is interesting to note, in this regard, that elsewhere Jackes *et al.* (1997a:652) state that fertility did increase significantly, by something like 50%, in the Portuguese Neolithic. In fact, on the basis of data from Mesolithic Cabeço da Arruda and late Neolithic Casa da Moura, they estimate that "while Mesolithic women had four children on average, Neolithic women had about six."

Their other results also suggest that, in Portugal, there is a lot more biological discontinuity at the Mesolithic–Neolithic boundary than they are willing to admit (Figs. 6.6, 6.9 and 6.10). Jackes *et al.* (1997b:844) conclude that "the Mesolithic–Neolithic transition period shows a shift in diet and related patterns of dental pathology, but it is neither sudden nor at the boundary . . . instead, it is gradual and continuous across the boundary." In





6.10 Lower limb morphological evidence for the Mesolithic–Neolithic transition in Portugal (after Jackes and Lubell n.d. and Jackes *et al.* 1997a). Late Neolithic–Copper Age values were retrodicted into Mesolithic times but, given the small sample sizes, the trend line was computed without consideration of the early Neolithic material. Mesolithic adult tibiae are sabershinned, while those from the late Neolithic–Copper Age are much rounder in mid-shaft. It is impossible to retrodict the later Neolithic trend and obtain Mesolithic values. The mean proximal transverse diameter of adult femora is consistently larger in the late Neolithic–Copper Age than in the Mesolithic and the odd early Neolithic specimens available for analysis already display the later condition. In late Neolithic collections from the Alentejo, the antero-posterior diameter is also larger and, as a result,



6.10 (*cont.*)
values for the proximal platymeric index of adult left femora are closer to those found in the Mesolithic. If femoral shape is genetically controlled, this might indicate that the contribution of local Mesolithic people to the gene-pool of subsequent populations was more important than in Estremadura.

good accord with the pattern revealed by our Fig. 6.6, however, Lubell *et al.* (1994:213), using the same data, have stated exactly the opposite: "there is stable isotopic evidence for a marked difference in diet between Mesolithic and Neolithic Portuguese human remains. The Mesolithic diet can be characterized as a mixture of terrestrial and marine foods, while the Neolithic population appears to have consumed only terrestrial foods (herbivore flesh and plant foods)." Since this difference is already apparent in early Neolithic samples, the conclusion seems inescapable that the shift was indeed sudden and at the boundary.

Data on molar size and caries (Fig. 6.9) are more ambiguous. Teeth from Cabeço da Arruda fit a trend of gradual decrease from the Mesolithic to the Neolithic in the incidence of approximal caries, but those from Moita do Sebastião do not, and no trend can be established for occlusal caries. Thus, dental pathology does not seem to change across the transition. Tooth size, however, undergoes a marked change at the boundary: retrodicting the values obtained for late Neolithic/Copper Age molar breadth into Mesolithic times would give results lower than those actually observed, and the values for the earliest Neolithic molars are already in the range of those from later periods. As is the case with palaeoisotopic data, the late Neolithic/Copper Age tooth size pattern is not the outcome of a gradual trend beginning in the Mesolithic.

Fig. 6.10 charts the information on limb bone morphology in Table 2 of Jackes and Lubell (n.d.) and in Figs. 5–6 of Jackes *et al.* (1997b). Mesolithic adult tibiae are saber-shinned, while those from the late Neolithic and the Copper Age are much rounder in mid-shaft. It is impossible to retrodict the later Neolithic trend and obtain Mesolithic values although it is not yet clear which was the condition prevalent in the early Neolithic, since the average for Caldeirão has a very large standard deviation (there is no statistically meaningful difference between Caldeirão and Lagares). The mean proximal transverse diameter of adult femora is consistently larger in the late Neolithic/Copper Age than in the Mesolithic and the odd early Neolithic specimens available for analysis already display the later condition: Mesolithic values fall way below the retrodictions of the trend. However, in some Neolithic collections, the antero-posterior diameter is also larger and, as a result, values for the proximal platymeric index of adult left femora are not very different from those found in the Mesolithic.

If these differences in the size of teeth and in the morphology of leg bones are related to changes in nutritional patterns, they are in good accord with the occurrence of the abrupt dietary shift indicated by the palaeoisotopic evidence. The same is true if, as sustained by Jackes *et al.* (1997a), the differences are related to activities, since they would then correlate well with the replacement of the hunter-fisher-gatherer way of life of the local Mesolithic by farming and ovicaprid herding. In fact, such simultaneous shifts in diet and in activities would coincide with the appearance of pottery and sheep in the archaeological record of Portugal *c.* 5500 BC.

American Indian archaeological, historic, and forensic data have led Gilbert and Gill (1990) to suggest that proximal femoral shape is under genetic control rather than environmentally regulated. If so, the patterns in Fig. 6.10 may be interpreted as indicating that the marked discontinuities in material culture, settlement patterns, burial practices, diets, and teeth size are indeed associated with pioneer colonization. In this context, the regional differentiation in late Neolithic/Copper Age proximal femoral platymeria may also indicate that, in the Alentejo, the contribution of local Mesolithic people to the later gene-pool may have been larger than in Estremadura, as previously hypothesized on the basis of archaeological and chronometric data alone (Zilhão 1992, 1993).

Concluding remarks

Inter-regional comparisons, such as those upon which both the Wave of Advance and the maritime pioneer colonization model are based, have to rely heavily on radiocarbon dating. However, even if it is fairly easy to compensate for systematic inter-laboratory differences and even if the use of the appropriate taphonomic filters enables us to eliminate those dates and contexts that are mixed or not related to the Neolithic at all, the impact of other factors in the patterns revealed by the available dates also needs to be evaluated. For instance, differences between bone and charcoal samples suggest that an old-wood effect may be hindering a better understanding of the LBK expansion across the Danubian basin (Whittle 1990a). To what extent this may affect the west Mediterranean patterns is currently unknown, but the fact that, at La Draga, the dates on the oak pillars are some four hundred years earlier than those obtained from seeds or from charcoal collected in the hearths (Tarrus *et al.* 1994) may be an indication that a similar problem does exist in southern Europe and suggests that the issue should be explicitly addressed in the future. To overcome these kinds of problems, a collaborative inter-regional program for the accelerator dating of short-lived samples of materials that can in themselves be taken as proof that domesticates are indeed present at a certain point in time is an obvious necessity and should deserve priority efforts by all researchers concerned.

Such a program should also include stable isotope determinations, aimed at establishing palaeonutrition data for the human populations across the Mesolithic–Neolithic boundary, in order to evaluate the real impact on subsistence of those domesticates that are actually shown to be present. The issue of colonization might also be further clarified by more in-depth comparative studies of anatomical data on bone morphology and of ancient DNA obtained from the different late Mesolithic and early Neolithic regional populations of Mediterranean Europe. In fact, given the shortcomings of historical reconstructions of population movements based on modern genetic information and in light of the limitations of the skeletal material to address issues of colonization involving human groups that, originally, may have been biologically identical and morphologically similar, it would seem that a definitive test of competing explanations for the physical anthropological patterns can only come from direct comparison of genetic material extracted from the prehistoric human remains themselves.

Finally, as Barnett (this volume) points out, radiocarbon dating only allows us to work with time units that, at best, encompass at least as much as five human generations. Thus, although useful in terms of testing processual models, radiocarbon dating does not enable us to address real-time historical events. When we state, for instance, that the Neolithic may have appeared simultaneously in Valencia and in Estremadura, we are actually talking about processes best described as penecontemporaneous and resulting in patterns that subsume a few hundred years of human activity. Even at such a low resolution, however, it would seem that, in Iberia, "indigenous adoption" only operates in the Cantabrian strip, and that the expectations derived from Wave of Advance models that are testable against the archaeological record are not met in Mediterranean Spain and Atlantic Portugal. "Maritime pioneer colonization" seems to fare better in this regard, but still needs to be more thoroughly tested, particularly through simulation studies such as that performed by Gregg (1988) for southern Germany. With the help of biological, ethnographical, and historical data, such studies might provide sophisticated models for the contact and interaction between pioneer colonist farmers and indigenous hunter-gatherers that operate in real human time and with adequate consideration of the reconstructed geographical characteristics and economic potential of the spatial scenario in which the process takes place.

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