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The End of the Paleolithic and the Mesolithic in Portugal[1]

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Traditionally, Portuguese Late Pleistocene and Early Holocene prehistory has been influenced by two factors: the well-developed French scheme organized by Henri Breuil in the beginning of this century (Breuil 1912), from which Upper Paleolithic "cultures" (i.e., Aurignacian, Gravettian, Solutrean, and Magdalenian) have been imposed on the Portuguese archaeological record, and the inordinate attention paid to the rich and easily accessible Mesolithic shell middens of the Flandrian estuaries of the Tagus and Sado Rivers. Because of these biases, far less is known of the period between the Upper Paleolithic and the Mesolithic and of the areas between the Flandrian estuaries and the Portuguese Estremadura, where most sites are located. Moreover, our interpretations of the Paleolithic are necessarily skewed by efforts to subsume them under categories from distant France, and therefore little is known of the transition that took place in Portugal between Paleolithic and Mesolithic times. In recent years, however, this crucial gap has become the focus of research. On the basis of data from sites recently excavated as well as from earlier excavations (table 1), it is here suggested that the technology and diet of prehistoric hunter-gatherers remained basically the same from 16,000 to 8,500–8,000 b.p., when a more sedentary settlement pattern was introduced and the importance of estuarine species in the human diet increased, a process that reached its peak between 7,000 and 6,000 b.p.

This model, however, creates some terminological problems. Traditionally, one cannot call a site "Paleolithic" when it dates to after 10,000 b.p. At the same time, some Portuguese sites, although dated to between ca. 10,000 b.p. and 8,000 b.p., have technological, economic, and dietary characteristics identical to those of Paleolithic sites (Bicho 1993*a*, Raposo and da Silva 1993, Straus n.d.). Thus, three different terms will be used here: "Paleolithic" for sites of Pleistocene age, "Epipaleolithic" for sites of Holocene age with Paleolithic characteristics, and "Mesolithic" for sites dating to the Atlantic period, which indicate a life system independent of and very different from that of the Paleolithic.

PALEOENVIRONMENT

Northern Portugal is approximately at the latitude (42° N) of the maximum extent of the polar front around 20,000 years ago (CLIMAP 1976, McIntyre and Kipp 1976, Ruddiman and McIntyre 1981). Heavily influenced by the polar front during Solutrean times, Portugal saw

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TABLE 1
Late Quaternary Chronostratigraphy

Oxygen Isotope Stage	General Glacial Division	European Pollen Zone	Date b.p.
		Subboreal	5,000–3,000
		Atlantic	8,000–5,000
1	Postglacial	Boreal	9,000–8,000
		Preboreal	10,000–9,000
		Dryas III	
	Tardiglacial	Alleröd	11,800–10,800
	(ca. 13,000–10,000 b.p.)	Dryas II	
		Bölling	13,000–12,400
	Upper Pleniglacial	Dryas Ic	
		Prebölling	14,500–14,000
		Dryas Ib	
		Angles	15,500–15,000
		Dryas Ia	
2	Last Glacial Maximum at	Lascaux	18,000–16,500
	ca. 19,000–18,000 b.p.	Laugerie	20,000–19,000

SOURCE: Straus 1991*a*:190.

a rapid climatic amelioration after the Last Glacial Maximum (LGM). This climatic change was probably more intense in central and southern Portugal as a consequence of the north-south temperature gradient of 5 to 10°C still present today (Straus 1991*a*, Turner and Hannon 1988). The environment during this period was one of tireless tundra in the northern mountains of Cabreira, Estrela, Gerês, and Peneda, all above 700 m a.s.l. (Daveau 1971, 1973, 1980, 1986), open pine and alder forests, thicker in the river valleys, at lower altitudes, and extensive sand dunes, deposited by strong, cold salty winds coming from the north and west, along the coast as far south as the Tagus estuary (Zilhão 1987, 1990).

With the regression of the polar front after ca. 17,000 b.p., Atlantic species were fast replaced by Mediterranean ones. At Caldeirão Cave (fig. 1, table 2), a Magdalenian level (Eb) dated to between ca. 15,000 and 10,000 b.p. shows a sharp decrease of *Microtus agrestis*, a cold-adapted species, and high frequencies of *Apodemus sylvaticus, Eliomys quercinus,* and *Terricola duodecimostatus,* adapted to warmer environments (Póvoas et al. 1992). Cold-adapted ungulate species such as ibex (*Capra pyrenaica*) and chamois (*Rupicapra rupicapra*)—the main components of the earlier Solutrean levels—were replaced by, among others, red deer (*Cervus elaphus*), horse (*Equus*), and wild boar (*Sus scrofa*) (Póvoas et al. 1992, Zilhão 1991). These species are also present in paleontological sites such as Algar de Cascais, dated to 16,620 ± 980, and Algar João Ramos, dated to 14,170 ± 380 (Antunes et al. 1989, Cardoso 1992). The cold-adapted plant species contracted northward and upward into the mountains, while animal communities slowly desegregated, with ibex and chamois moving to higher and hillier areas and red deer, roe deer, wild boar, horse, and aurochs sharing the forested and more open lowland areas.

Wood charcoal from one of the Magdalenian levels of Cabeço do Porto Marinho dated to ca. 11,200 b.p. clearly indicates a mixed assemblage of Mediterranean and Atlantic species with pine ((*Pinus pinea* and *Pinus pinaster*), evergreen and deciduous oaks (*Quercus ilex/suber*), birch (*Fraxinus angustifolia*), wild strawberry tree (*Arbutus unedo*), and olive (*Olea europaea/sylvestris*) (Figueiral n.d.). Fauna from three levels of the Bocas rock-shelter and from Casal Papagaio Cave, both dated to ca. 10,000 b.p., indicate the same pattern seen before 12,000 b.p., with red deer, roe deer, aurochs, horse, and wild boar. The presence of *Rupicapra* around 10,000 b.p., although in extremely low frequencies in both Bocas (Bicho 1993*a*) and Caldeirão (Póvoas et al. 1992), suggests that the cold snap of Dryas III had some impact in Portugal. This impact is also corroborated by the presence of cold-water molluscs, *Littorina littorea,* at Pedra do Patacho (Soares and da Silva 1993) and Magoito (Arnaud 1986, 1993; Morales and Arnaud 1990). One possible scenario for Portugal during late Dryas III, then, is that the vegetation was a mix of Mediterranean and Atlantic species, with a stronger influence of the latter. *Capra* and *Rupicapra* expanded their ranges slightly to the south in central Portugal, where they could be found in hilly areas at a few hundred meters' elevation, the altitude of such sites as Caldeirão and Bocas. This was likely a period of species aggregation in a strip of central Portugal. With the extension of the polar front to more southern latitudes, seasonal cold-water currents reached the Portuguese coast as far south as the Algarve, creating

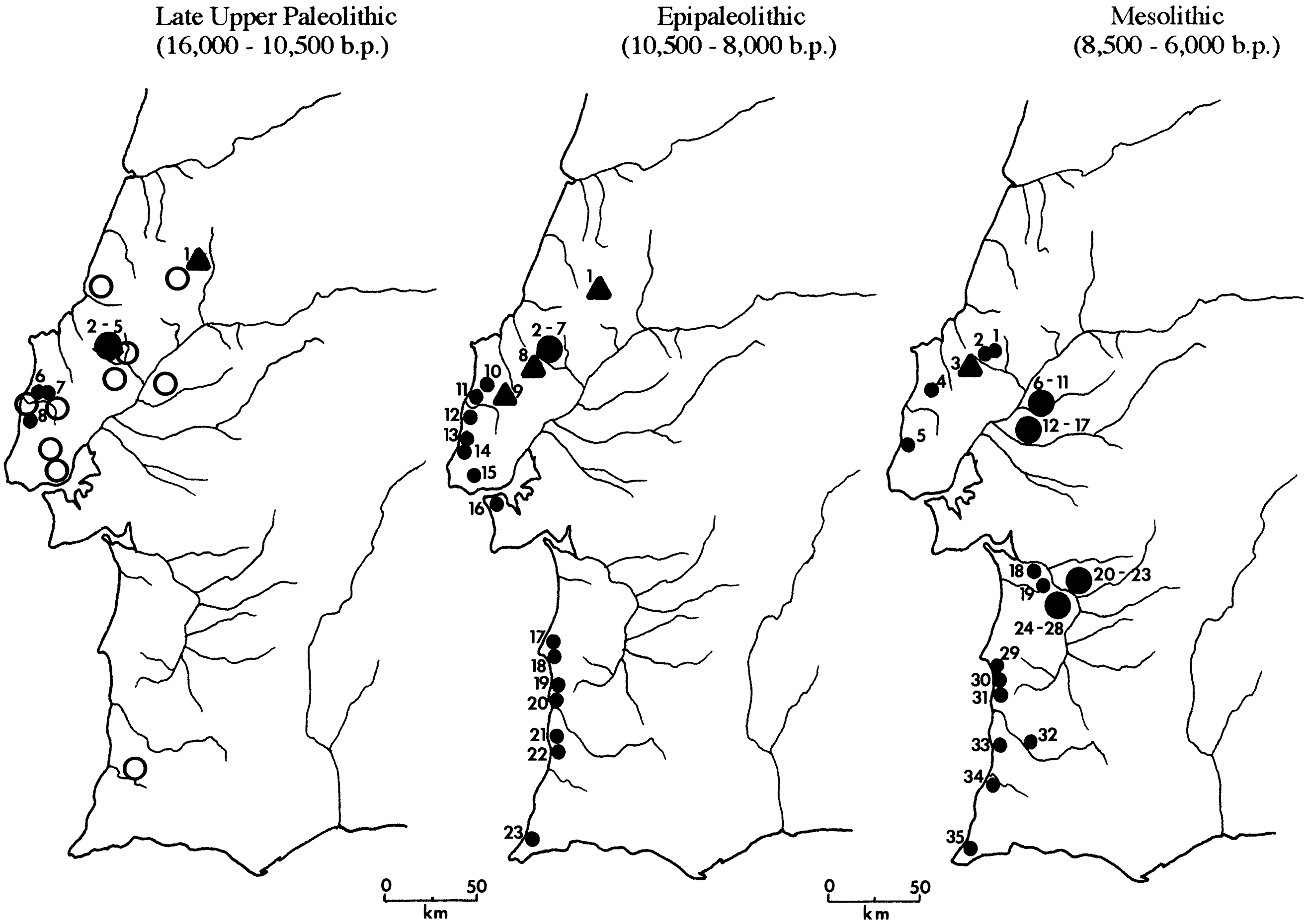

FIG. 1. *Upper Paleolithic and Mesolithic sites in Portugal.* Open circles, *chert sources;* triangles, *caves and rock-shelters;* black circles, *open-air sites. Late Upper Paleolithic:* 1, *Caldeirão Cave;* 2, *Cabeço do Porto Marinho (ten levels);* 3, *Areeiro I;* 4, *Pinhal da Carneira;* 5, *Vascas;* 6, *Rossio do Cabo;* 7, *Cerrado Novo;* 8, *Vale de Mata. Epipaleolithic:* 1, *Casal Papagaio Cave;* 2, *Cabeço do Porto Marinho (three levels);* 3, *Carneira;* 4, *Carneira II;* 5, *Carneira III;* 6, *Olival da Carneira;* 7, *Areeiro III;* 8, *Bocas rock-shelter (three levels);* 9, *Suão Cave;* 10, *Toledo;* 11, *Ponta da Vigia;* 12, *Cabeço do Curral Velho;* 13, *S. Julião (two areas);* 14, *Magoito;* 15, *Penha Verde;* 16, *Ponta do Cabedelo;* 17, *Praia do Norte;* 18, *Cabo de Sines;* 19, *Milfontes Norte;* 20, *Pedra do Patacho;* 21, *Palheirões do Alegra;* 22, *Zambujeira;* 23, *Castelejo. Mesolithic:* 1, *Fonte Pinheiro;* 2, *Forno da Telha;* 3, *Bocas rock-shelter;* 4, *Toledo;* 5, *S. Julião;* 6, *Fonte de Moça;* 7, *Fonte do Padre Pedro;* 8, *Flor da Beira;* 9, *Cabeço da Arruda;* 10, *Moita do Sebastião;* 11, *Cabeço da Amoreira;* 12, *Cabeço dos Ossos;* 13, *Cova da Onça;* 14, *Arneiro do Roquete;* 15, *Magos de Baixo;* 16, *Magos de Cima;* 17, *Cabeço da Barragem;* 18, *Arapouco;* 19, *Cabeço do Rebolador;* 20, *Barrada das Vieiras;* 21, *Amoreiras;* 22, *Vale de Romeiras;* 23, *Cabeço do Pez;* 24, *Várzea da Mó;* 25, *Barrada do Grilo;* 26, *Fonte da Mina;* 27, *Poças de S. Bento;* 28, *Barranco da Moura;* 29, *Vale Marim;* 30, *Samouqueira;* 31, *Vidigal;* 32, *Fiais;* 33, *Medo Tojeiro;* 34, *Montes de Baixo,* 35, *Castelejo.*

conditions for the occurrence of *Littorina littorea* along the Alentejo coast.

These climatic conditions were short-lived, however, since by 9,500 b.p., at Fernão Ferro, some 20 km south of Lisbon, pollen indicates the presence of a plant community very similar to that present in Rio Maior at around 11,000 b.p., before Dryas III. The short lacustrine core shows the presence of various types of pines (*P. pinaster, P. pinea*), oaks (*Q. faginea, Q. suber*), olive (*O. europaea/sylvestris*), and wild strawberry tree (*A. unedo*) (Mateus and Queiroz 1991), suggesting at least a mild climate probably very similar to that of today. Another pollen sequence dated to ca. 9,200 b.p. is from Lagoa Comprida in Serra da Estrela. Although the lagoon is located at 1,600 m a.s.l., it is still marked by the presence, in low frequency, of olive (*Olea*), while the main element is pine (*P. sylvestris*) with some *Quercus* and rarer *Betula* (Janssen 1985, Janssen and Woldringh 1981). After 9,000 b.p. the frequency of pine begins to decrease. Oak is the main tree species present, although there is a constant increase of birch (*Betula*) until the end of the Atlantic, when *Pinus* and *Betula* forests become very

TABLE 2
Late Upper Paleolithic and Mesolithic Radiocarbon Dates

Site	Level	Phase	Facies	Date b.p.	Lab. No.	Material
Cabeço do Porto Marinho	area I/Lower	Lower Magdalenian	Rio Maior	16,340 ± 420	SMU-2015	charcoal
				15,820 ± 400	ICEN-542	
	area VI/Lower	Lower Magdalenian	Rio Maior	15,420 ± 180	SMU-2634	charcoal
	area II/Middle	Lower Magdalenian	Rio Maior	15,410 ± 195	SMU-2476	charcoal
	area IIIS/QLower	Middle Magdalenian	Rio Maior	14,050 ± 850	SMU-2668	charcoal
Caldeirão	Eb base	Magdalenian		14,450 ± 890	ICEN-70	bone
Cabeço do Porto Marinho	top			10,700 ± 380	ICEN-72	bone
	area I/Upper	Late Magdalenian	Rio Maior	12,220 ± 110	ICEN-687	charcoal
				11,680 ± 60	SMU-2011	charcoal
	area IIIS/Upper	Late Magdalenian	Rio Maior	11,810 ± 110	ICEN-689	charcoal
	area III/Upper	Late Magdalenian	Rio Maior	11,160 ± 280	ICEN-545	charcoal
	area II/Upper	Late Magdalenian	Rio Maior	11,110 ± 130	SMU-2637	charcoal
	area III Trench	Late Magdalenian	Rio Maior	10,940 ± 210	ICEN-690	charcoal
Carneira	Pinhal	Late Magdalenian	Carinated	10,880 ± 90	SMU-2635	charcoal
Pedra do Patacho		Mirian		10,740 ± 60	ICEN-207	shell
				10,450 ± 60	ICEN-267	shell
				10,400 ± 90	ICEN-748	shell[a]
				10,380 ± 100	ICEN-266	shell
Cabeço do Porto Marinho	area VI/Upper	Late Magdalenian	Rio Maior	10,160 ± 130	SMU-2637	charcoal
Bocas I	Fundo	Terminal Magdalenian	Rio Maior	10,110 ± 90	ICEN-901	bone
	0	Terminal Magdalenian	Rio Maior	9,880 ± 220	ICEN-900	bone
	1/2	Terminal Magdalenian	Rio Maior	9,900 ± 70	ICEN-903	shell[a]
Casal Papagaio	base	Epipaleolithic		9,710 ± 70	ICEN-369	charcoal
				9,270 ± 90	ICEN-372	shell
				8,870 ± 105	Hv-1351	shell
Magoito		Epipaleolithic		9,970 ± 70	ICEN-80	shell
				9,910 ± 100	ICEN-82	shell
				9,790 ± 120	ICEN-81	shell
				9,580 ± 100	GrN-11229	charcoal
				9,490 ± 60	ICEN-52	charcoal
Cabeço do Porto Marinho	IIISW/Upper	Terminal Magdalenian	Rio Maior ?	9,270 ± 170	SMU-2666	charcoal
Cabeço do Porto Marinho	area V/Lower	Terminal Magdalenian	Rio Maior	9,100 ± 160	ICEN-688	charcoal
S. Julião	area A	Epipaleolithic		8,800–7,500	?	?
Areeiro III	Test VIb	Epipaleolithic	Carinated	8,860 ± 80	ICEN-547	charcoal
	area 1/hearth 2			8,850 ± 50	ICEN-494	charcoal
	area 1/hearth 1			8,570 ± 130	ICEN-546	charcoal
	area 2			8,380 ± 90	ICEN-688	charcoal
Palheirões do Alegra	flint hearth	Mirian		8,400 ± 70	ICEN-136	charcoal
				8,800 ± 100	GX-16414	charcoal
Castelejo		Mirian		>7,600	?	
Ponta da Vigia	hearth	Epipaleolithic		8,730 ± 110	ICEN-51	charcoal
Curral Velho		Epipaleolithic		8,040 ± 70	ICEN-270	shell[a]
				8,050 ± 100	ICEN-269	shell[a]
S. Julião	area B	Epipaleolithic		8,250–7,900	?	?
Fonte Pinheiro		Mesolithic	geometric	8,450 ± 190	ICEN-973	charcoal
Castelejo		Mesolithic		7,620 ± 100	Beta-2276	shell
				7,450 ± 90	Beta-2908	charcoal
Montes de Baixo	4B	Mesolithic		7,550 ± 70	ICEN-720	shell[a]
	2			7,230 ± 70	ICEN-718	shell[a]
Arapouco	middle	Mesolithic	geometric	7,420 ± 65	Q-2492	shell[a]
Forno da Telha	2	Mesolithic	geometric	7,360 ± 90	ICEN-417	shell[a]
	2			7,320 ± 60	ICEN-416	shell[a]
Moita do Sebastião	Skeleton 22	Mesolithic	geometric	7,240 ± 70	TO-131	bone
	Skeleton 29			7,200 ± 70	TO-133	bone
	Skeleton 24			7,180 ± 70	TO-132	bone
	Skeleton 41			7,160 ± 80	TO-134	bone
	Skeleton CT			6,810 ± 70	TO-135	bone
Bocas	1/2	Mesolithic	geometric	7,130 ± 120	ICEN-899	shell[a]
Poças de S. Bento	lower	Mesolithic	geometric	7,040 ± 70	Q-2493	shell[a]
	middle			6,850 ± 70	Q-2495	shell[a]
	middle			6,780 ± 65	Q-2494	charcoal
Fiais		Mesolithic	geometric	7,010 ± 70	TO-806	charcoal
				6,840 ± 70	TO-705	bone
				6,260 ± 80	TO-807	bone
				6,180 ± 110	ICEN-141	bone

TABLE 2
(Continued)

Site	Level	Phase	Facies	Date B.P.	Lab. No.	Material
Cabeço da Arruda	Skeleton III	Mesolithic	geometric	6,990 ± 110	TO-360	bone
	Skeleton A			6,970 ± 60	TO-354	bone
	Skeleton 42			6,960 ± 60	TO-359a	bone
	Skeleton D			6,780 ± 80	TO-355	bone
	Skeleton N			6,360 ± 80	TO-356	bone
Medo Tojeiro		Mesolithic		6,820 ± 140	BM-2275R	shell[a]
				6,150 ± 120	BM-2275	shell
Cabeço do Pez	middle	Mesolithic	geometric	6,730 ± 75	Q-2497	shell[a]
	middle			6,430 ± 65	Q-2496	shell[a]
	upper	Meso?/Neo?		5,535 ± 130	Q-2499	bone
Vidigal	3	Mesolithic	geometric	6,640 ± 90	Ly-4695	bone
	2			6,030 ± 80	GX-14557	bone
Samouqueira		Mesolithic	geometric	7,160 ± 70	?	shell[a]
				6,370 ± 70	TO-130	bone

SOURCES: Araújo (1993, n.d.), Arnaud (1986, 1987, 1989, 1993), Arnaud and Bento (1988), Bicho (1991, 1992, 1993*a*), Daveau, Pereira, and Zbyszewski (1982), Lubell and Jackes (1985), Marks et al. (1993), Morales and Arnaud (1990), Raposo (1993*b*, *c*; n.d.), Raposo and da Silva (1993), Raposo, Penalva, and Pereira (1989), da Silva and Soares (1991), Soares and da Silva (1993), Vierra (1992), Zilhão (1987, 1991, 1993*a*), Zilhão, Carvalho, and Aráujo (1987).
[a]Dates corrected by the subtraction of 360 ± 35 years, the apparent age of estuarine shells accumulated in the Sado shell middens according to Soares (1989) and Soares and Cabral (1989).

rare (Janssen 1985). This deforestation is probably a result of agricultural and herding activities (Chester and James 1991, Van der Brink and Janssen 1985). This same general trend can be seen at a coastal lagoon, Lagoa Travessa, located some 70 km south of Lisbon and dated between 7,600 b.p. and the present (Mateus 1985). After a mixed community of eu-mediterranean evergreen forest (*Olea-Ceratonion*), humid mediterranean deciduous forest (*Quercion faginea*), and littoral mediterranean pine forest dated between 7,500 b.p. and 6,500 b.p., there is a sharp decrease in the pinewoods and an increase in oak and alder and in coastal scrub and salt marsh species (Mateus 1985:240). This phase is probably a consequence of the combination of Flandrian marine transgression and human action.

Mesolithic faunal assemblages do not show any particular change from those dated to the Pleistocene-Holocene boundary except for the absence of *Capra* and *Rupicapra.* Aurochs, red deer, and horse seem to occur in all assemblages, and rabbit and hare are present in high frequencies in all Magdalenian faunal collections (Straus n.d., Zilhão 1992*b*). On the southern coast *Littorina littorea* is replaced by *Monodonta lineata,* present at sites such as Castelejo, Samouqueira, and Montes de Baixo (Lubell and Jackes 1985, da Silva and Soares 1991). The presence of the cold-adapted species *Littorina* between 8,800 and 7,500 B.P. in the shell midden of S. Julião north of Lisbon clearly creates problems for this scenario. It is possible that S. Julião was under the influence of cold seawater currents coming from the north, but by that time this species had disappeared from the Gulf of Biscay (Deith and Shackelton 1986, Ortea 1986). Soares and da Silva (1993) have some reservations about the presence of *Littorina* at both S. Julião and Magoito, since they were unable to find any evidence of it during a local site survey. Clearly, a final report on the faunal material from those sites is needed to clarify the situation.

Regional geomorphology, following the slow transformations during the end of the Pleistocene, changed dramatically during the Atlantic period, with cut, fill, and meandering of rivers as a result of the Flandrian transgression. These cut-and-fill episodes opened new areas in the river valleys and facilitated eolian movement of sands—which was also occurring in the coastal areas. The impact of the sea transgression can best be seen in the estuaries of the main rivers, such as the Tagus, the Sado, and the Mira. In the case of the Tagus the estuary retreated about 40 km upriver to near the Muge area, creating large lacustrine-type environments and greatly impacting the human populations living in the area.

SUBSISTENCE

Dietary information for the Portuguese Paleolithic is still very scarce. The few data on the Final Upper Paleolithic and Epipaleolithic are mainly in short publications or preliminary reports (Araújo 1993, n.d.; Arnaud 1986, 1993; Arnaud and Bento 1988; Bicho 1993*b*; Morales and Arnaud 1990; Póvoas et al. 1992; Roche 1964, 1979, 1982; Zilhão 1987, 1991, 1992*a*, *b*) and have only very recently been summarized (Bicho 1993*a*). In the case of the Mesolithic shell middens, there are some extensive reports and syntheses (Arnaud 1987, 1989, 1990, 1993; LeGall et al. 1992; Lentacker 1986; Lubell and Jackes 1985; Lubell, Jackes, and Meiklejohn 1989; Roche 1972; Straus 1991*b*, n.d.; Straus, Altuna, and Vierra 1990; Zilhão 1993*a*).

At 11,000 b.p. the diet certainly emphasized terrestrial mammals. Red deer, aurochs, wild boar, and horse were the dominant species in the hunter-gatherer diet, although roe deer was also hunted (Straus n.d.). Other animal species that seem to have been of considerable importance, at least in the inland hill country, were rabbit and hare (Zilhão 1987, 1991, 1992*b*). Nuts, berries, and fruits, if not part of the diet, were certainly available, as is shown by the tree species present at Cabeço do Porto Marinho (Figueiral n.d., Zilhão et al. n.d.) and suggested by the presence of grinding stones from various sites dated to this phase (Bicho 1993*a*).

Between 11,000 b.p. and ca. 8,000 b.p. the main game species were similar to those hunted before, with the occasional inclusion of ibex and, more rarely, of chamois. Molluscs are abundant in both inland and coastal sites. The main species are the common cockle (*Cerastoderma edule*), oyster (*Ostrea edule*) clam (*Ruditapes decussata, Venerupis decussata,* and *Scrobicularia plana*), mussel (*Mytilus*), limpet (*Patella*), periwinkle (*Littorina littorea*), and top shell (*Monodonta lineata*), indicating the use of estuarine and littoral rocky shores. All the mollusc species except for the cold-water-adapted periwinkle, *Littorina littorea,* are also found in sites dating to the Atlantic. Unidentified fish species are present at Lapa do Suão (fig. 1 [Roche 1982]), while an estuarine/coastal species, gilthead (*Sparus aurata*), is present at Caldeirão (Zilhão 1992*a*), as well as at other sites dated to Atlantic times (Toledo, Samouqueira, and Arapouco [Arnaud 1986]). Other fishes such as large meagre (*Argyrosomos regius*) and ray and shark are also present in these shell middens.

Among the birds found in the Mesolithic sites of Muge, some, such as duck, pigeon, and partridge (Arnaud 1993), were likely part of the diet. During the Atlantic period, the main large animals hunted were red deer, wild boar, and aurochs and, more rarely, horse and roe deer.

In summary, the available data seem to indicate a pattern similar to that of Cantabrian Spain described by Straus (1991*a*:195; n.d.), with a trend, which probably began during Solutrean times, towards subsistence intensification through both specialization (in central Portugal aurochs and red deer were probably hunted through drives and surrounds [Bicho 1993*a*]) and diversification including the utilization of aquatic resources such as estuarine and coastal shellfish, birds, and marine fish (Clark and Straus 1986). This trend culminated during Mesolithic times, with a very wide range of animal species present in the shell middens: large game such as red deer, aurochs, roe deer, boar, and horse, small species such as rabbit and hare, birds, shellfish, both estuarine and open-sea, crustaceans, urchins, estuarine and open-sea fish, and sea mammals such as otter. Plant materials are also present at some sites, such as Medo Tojeiro and Samouqueira (Lubell and Jackes 1985), including *Pinus* and *Pistacia.* The stable isotope analysis of several human skeletons from Muge has confirmed a balanced diet of terrestrial and aquatic resources (Lubell and Jackes 1985, 1988).

TECHNOLOGY

During the ten millennia in question, some very important technological changes occurred in Portugal (Raposo 1993*b, c*). There was a clear break between the LGM technology (i.e., the Solutrean) and the Magdalenian. The bifacial technology characteristic of the Solutrean for the production of weaponry such as "laurel leaves," shouldered points, and tanged Parpalló points disappeared completely in Portugal by 17,000 b.p. at the latest. These projectile tools were replaced by other tip forms, much lighter and smaller, suggesting not only a more economical use of the raw material but also different types of shafts, hunting techniques, and possibly different patterns of mobility related to seasonal movements of population and to specialized hunting expeditions. These tips of various types had bladelets as blanks and tended to become smaller over time, probably as a result of the introduction of bow-and-arrow technology[2] and a change from simple tipped tools to composite tools mimicking the bone harpoons of Magdalenian and Azilian northern Spain and France. Bone harpoons seem to be completely absent from Portuguese faunal assemblages from this period. It might be argued that this absence is due to sample size (both the number of collections and their NISP), but this does not seem likely; there are various sites (Caldeirão, Bocas, Casal Papagaio, Lapa do Suão) where bone material is abundant and well preserved and bone points are rare (see Bicho 1993*a*). It is therefore likely that in Portugal bone harpoons were not part of the hunting tool kit but similar throwing implements made of wood (shafts) with composite lithic barbs were used in very much the same manner.

These tips are characterized by a very deep and steep retouch commonly known as backing. Double backing is frequent (e.g., Sauveterre and Istres points), giving the projectile a relatively balanced, symmetrical form as well as facilitating its hafting. Double backing must also have reduced the chances of impact fractures, making these points thicker and narrower and thus more resistant to impact. They are therefore likely to have been the tips used for arrows.

Two different types of reduction sequences produced these projectile tips. The more frequent had several stages basically producing parallel-sided flat bladelets, often naturally pointed, from pyramidal or prismatic cores. The other, technically simpler, produced very small, thin, twisted and pointed bladelets from a carinated core that would ordinarily be identified as a carinated endscraper or a carinated burin. These bladelets were then retouched on the proximal end with a light, semisteep retouch, frequently inverse, sometimes bilateral (i.e., Dufour bladelets). These two technological facies may represent two distinct regional bands, both using bow and arrow and wood/lithic harpoons but one

2. This idea was suggested to me by Lawrence Straus in a conversation in 1992 during the annual meeting of the Society for American Archaeology.

using Dufour bladelets while the other used geometric microliths.

The microburin technique and the production of geometrics were introduced after the Last Glacial Maximum. Absent from the Solutrean lithic assemblages, they are present, always in very low frequencies but increasingly through time, in Magdalenian and Epipaleolithic sites dated to between 16,000 b.p. (Cabeço do Porto Marinho areas I and II and Areeiro I) and ca. 9,000 b.p. (Cabeço do Porto Marinho, area V). During Mesolithic times they became very important, constituting a large part of the retouched tool assemblage in shell middens dated to after 7,500 b.p., such as those from the Muge and Sado areas, Rio Maior, and the southern coast of Alentejo. The oldest site characterized by this type of lithic assemblage is Fonte Pinheiro, near Rio Maior, dated to ca. 8,400 b.p. Fauna was not preserved and the site has been largely destroyed, making it impossible to identify the type of occupation. The lithic assemblage, however, indicates an intermediate stage between the Paleolithic/Epipaleolithic and the Mesolithic technological system. The microburin technique and the production of geometrics are fairly common, but bladelet production still clearly follows the Magdalenian reduction sequences.

In summary, it can be argued that the technological facies called the Rio Maior (Bicho 1992, 1993*a*), dated to between 16,000 b.p. and 9,000 b.p., rarely used the microburin technique and produced only scarce geometrics. By the end of Boreal times, microburin and geometric technology had gradually become the most common for barb or arrow tip production, a situation that lasted through Mesolithic times and into the Neolithic period. Between ca. 12,000 and 8,400 b.p., as documented by the sites of Pinhal da Carneira and Areeiro III (Bicho 1991, 1992, 1993*a*; Marks et al. 1994; Zilhão et al. n.d.), a different regional band used carinated cores to produce Dufour bladelets for barbs, but this technique seems to have disappeared completely before the beginning of the Atlantic period.

On the southern coast, however, there seem to have been different technological adaptations. The microburin technique and geometrics were used only during the Atlantic period (e.g., at Samouqueira, Medo Tojeiro, and Fiais). During Pre-Boreal and Boreal times the carinated technology was apparently absent, while the production of bladelets seen in the Rio Maior facies occurred only as a minor component of the lithic assemblages commonly referred to as Mirian. The Mirian, radiocarbon-dated to between ca. 9,000 and 8,000 b.p., is characterized by the extensive use of macrolithic tools such as picks made of the local greywacke (Penalva and Raposo 1987, Raposo 1993*a*, Raposo and Penalva 1987). Similar to the Asturian of northern Spain (Clark 1976, Straus 1979), it was initially identified by Breuil, Ribeiro, and Zbyszewski (1943) through a particular tool, the Mirian axe, still considered a true type-fossil (Penalva and Raposo 1987:185). This stone tool is produced using a bifacial technology similar to that of an Acheulian handaxe (Pereira and Bicho n.d.). A similar macrolithic component, labeled Languedocian, has been reported from inland sites (e.g., Xerez de Baixo [Raposo and da Silva 1984]) near the Portuguese/Spanish border of Alentejo. These lithic assemblages, however, lack absolute dating as well as Mirian axes. Recently da Silva (1993) has advanced the hypothesis of a later, possibly Chalcolithic date for these industries.

Other technological features during these times, considered by Straus (1991*a*) to be Solutrean innovations, were nets, weirs, and traps, which likely account for the frequency of rabbit and hare bones at Caldeirão. These techniques clearly improved through time, as may be inferred from the increasing abundance of bird and fish remains in the Mesolithic shell middens dating to the Atlantic period. The presence of dog in some Mesolithic sites (e.g., Cabeço do Pez, Amoreiras, and Samouqueira) likely indicates important cooperation between humans and dog that would have improved the output of hunting expeditions.

ART

Art seems to have been rare in Portugal during the ten millennia discussed here. The largest and most important site of Paleolithic rock art, the cave of Santiago do Escoural in Alentejo, is said by Santos and Gomes (1981) to have been a sacred space during Magdalenian times. The cave walls are covered with both paintings and engravings composed of animalistic figures and geometric symbols and other abstract designs. There are, however, no absolute dates for these artistic representations, and the few Upper Paleolithic materials found in the cave are Aurignacian and Solutrean (Zilhão 1993*b*). The art is therefore likely the result of Aurignacian and/or Solutrean occupations. The only other center of Paleolithic rock art in Portugal is at Mazouco (Jorge et al. 1981). A Magdalenian chronology was attributed to this site on the basis of stylistic characteristics alone, since Mazouco is an open-air locale with no lithic assemblages.

Portable art objects are also very rare, although they are documented at Bocas by engraved *sagaies* (Bicho 1993*a*), at Casal Papagaio by shell beads (Arnaud and Bento 1988), and at Caldeirão possibly by an engraved plaquette of uncertain date (Zilhão 1993*b*). It is likely that more art was produced in Portugal but of perishable material that did not become part of the archaeological record.

SETTLEMENT SYSTEM AND LAND USE

The settlement system and land use can be divided into three phases corresponding essentially to the Paleolithic (before ca. 10,000 b.p.). Epipaleolithic (between 10,000 b.p. and 8,500 b.p.), and Mesolithic (after 8,500 b.p.). The location of sites dated to before ca. 10,000 b.p. indicates a simpler settlement pattern than that seen during Solutrean times. Between 16,500 and 10,500 b.p. there were two main areas of human occupation: one inland, around Rio Maior, where there are four open-air sites known with a total of ten different archaeological levels, and the other in a coastal area near Torres Vedras, where only three sites, all of them open-air, are known (fig. 1). The only cave site known for this period, Caldeirão, is located north of Rio Maior and, curiously, is the only isolated site. While this pattern is to some extent a result of the lack of systematic survey in other areas, it probably reflects the distribution of chert. This pattern is also confirmed by the negative evidence found by Straus in Algarve (1988), where no sites dated to this period were found.

Central Portugal is and certainly was then a very complex mosaic of biotic communities, and any large game or plant food would have been basically ubiquitous. This was not, however, the case for chert, a very important raw material for weaponry as well as for ordinary stone tools. Rio Maior is one of the main sources of chert in the country; in the 18th and 19th centuries the men of this area did not perform mandatory military service but instead stayed home to produce gunflints. Torres Vedras, while less important, certainly had easy access to various chert sources. Caldeirão had none nearby, but chert cobbles and pebbles occasionally occur in the riverbeds of the gorge in which it is located (Zilhão n.d.)

The presence in Caldeirão Cave of fish bones and marine shell ornaments indicates inland-coastal movement. This movement intensified around 10,000 b.p., as is indicated by the presence of large quantities of estuarine and marine shells at Bocas (Rio Maior) and Casal Papagaio (Fátima). However, the fact that estuarine molluscs are present at sites today located ca. 50 km inland poses some problems, as Arnaud (1993:177) has pointed out. Sea level at the time is estimated to have been ca. 60 m lower than today and at a distance of at least 10 km from the present coast (Dias 1985). If this estimation is correct, two explanations are possible: regional tectonic movements sharply altering the distances to the paleo-coast and a more likely scenario of very complex, frequent, possibly seasonal inland-coastal movement, with utilization of resources from the inland plain and mountain zones as well as coastal and estuarine areas.

After 10,500 b.p., the increase in the number of sites and the use of new areas such as the southern coast of Alentejo and the Guadiana Valley seem to indicate a demographic explosion that necessarily produced a more complex settlement system. During this period of ca. 2,500 years, the number of sites (a total of more than 30) doubled (fig. 1). One of the two main centers of occupation was still Rio Maior. The southern Alentejo coast was the other, with population concentrated around the Mira estuary and using both estuarine and open-sea resources. The location of these sites is highly patterned; all of them are within 100 m of the present coast, which is formed by a sinuous line of high cliffs (Raposo n.d.). Greywacke, the local rock, was used extensively, but only a little chert from various still unidentified sources (Raposo 1993*a*, Vierra 1992) is present. Since some chert is known to be located some 50 km southeast of the Mira area, it is likely that the same inland-coastal movement existed on the southern coast, although sites to support this model have yet to be found. Very little is known about the Guadiana Valley sites except that they used the local raw material, quartzite, and that sites were limited to river valleys.

After Boreal times, there was possibly a second demographic explosion; site volume increased from 200 m^3 to 20,000 m^3. The settlement system changed radically, with concentration of population in two areas not previously occupied, the estuaries of the Tagus and Sado Rivers, along with four other areas of minor importance (fig. 1). The Flandrian transgression seems to have created a set of new ecological conditions that strongly impacted the life systems of human groups. Isotope analysis of human skeletons from shell middens in the Tagus Valley indicates that aquatic resources were very important in the human diet, although terrestrial resources such as large game, birds, and rabbits made up about half of it. According to Lubell and Jackes (1988), seasonal activities are documented in these shell middens, although the general trend is toward year-round occupation. The very large size of some of these middens, sometimes over 100 m in diameter, seems to indicate long-term occupation. This model is supported by the discovery of residential features such as postholes and pits and numerous burials in these middens.

The Sado shell middens have a similar pattern of year-round occupation while showing some variability in terms of fauna, size, and location (Arnaud 1987, 1989). Sites close to the mouth of the river had high frequencies of fish remains, while those farther upriver were characterized by rare fish bones and large collections of bones of large mammals such as red deer and wild boar. Oxygen isotope analysis of the shells indicated fall and winter resources at all sites (Arnaud 1990), while the fish seem to represent spring and summer use (Arnaud 1987). Arnaud (1987, 1989) has interpreted the data as indicating a complex settlement system with year-round residential sites supported seasonally by specialized camps. The fact that, as at the Muge sites, these shell middens were used as burial grounds seems to support the idea of long-term occupation. According to Zilhão (1993*a*), the southern concentration around the Mira estuary and the isolated sites of Castelejo and Montes de Baixo farther south may be a continuation of the pre-Atlantic settlement system of coastal sites. There was also possibly seasonal inland movement for specialized tasks such as procurement of chert, as is suggested by Lubell and Jackes (1985) for Medo Tojeiro and Samouqueira.

The last small concentration of sites, Fonte Pinheiro, Forno da Telha, and Bocas, is located west of the city of Rio Maior. The first two sites are about 100 m apart, while Fonte Pinheiro is only about 1 km east of them. Again, following Zilhãos's model, Forno da Telha could have been a specialized camp of Muge Mesolithic people, seasonally occupied for the exploitation of interior resources such as chert and forest foods including large game. While Bocas could certainly represent the same situation, since the dates around 7,000 b.p. are very similar to those of Forno da Telha and the Muge shell middens, Fonte Pinheiro is dated to 1,000 years earlier than any occupation of the Tagus shell middens. It most likely represents the advent of Mesolithic technology. The Mesolithic settlement system had, however, not yet been adopted, since the necessary ecological conditions (the large estuaries of the Tagus and the Sado) were not yet present.

CONCLUSIONS

The stable and long-lasting Final Paleolithic technology and settlement system, starting sometime during "Magdalenian" times, was probably a consequence of the mild to warm climate, very rich in both animal and plant species characteristic of a semi-Mediterranean climate. This climate developed faster in central and southern Portugal (and probably southern Spain) than in the rest of Western Europe. During the Final Paleolithic and the Mesolithic there was punctuated human demographic expansion in two phases: the first around 10,000 b.p., as documented by the doubling of the number of sites from previous millennia and the occupation of new areas, and the second between 8,000 and 7,500 b.p., with major concentrations of people in year-round settlements in the Tagus and Sado Valleys. Settlement locations before 8,000 b.p. seem to have been mostly conditioned by the presence of rock sources, primarily chert. The reason for this determinism is that all other economic resources (e.g., large game, plant foods, and water) were most likely ubiquitous in the landscape while high-quality knapping stones were not. This system changed, however, once year-round occupation of estuarine sites became possible. The change in settlement system was apparently preceded by a change in technology: microliths became the most common stone tools, while the microburin technique was rapidly and intensively used. This technological change certainly had important repercussions on the shape of arrow shafts, probably in use since the Final Upper Paleolithic. The technological changes, as well as the new set of ecological conditions, allowed a new, more sedentary economic and social system of hunter-gatherers that culminated between 7,000 and 6,000 b.p. in the Sado and Tagus Valleys.

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A Geological Explanation for the Berekhat Ram Figurine[1]

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A scoria pebble excavated at Berekhat Ram has been dated to roughly 230,000 B.P. and is claimed to be the earliest figurine depicting human form (Goren-Inbar 1986; see also Chase and Dibble 1987, Schepartz 1993). Such a claim has extended the debate for the origins of art to the Lower Paleolothic and thereby increased the chasm between those who see this figurine as the earliest representation of human form and those who recognize no symbolic art prior to the Upper Paleolithic (see Chase and Dibble 1992; Bednarik 1989, 1992; Davidson and Noble 1989; Davidson 1990; Schepartz 1993). In attempting to determine the validity of the interpretation of this object, it is important to draw attention to the geologic processes that produce scoria, the postulated hominid modifications of the pebble, and its geologic provenance.

FIG. 1. *A scoria pebble from Hawaii (Geology Department, University of Pennsylvania), showing natural groove and* (lower right) *twisting of the grooved surface.*

Scoria is a general geological term for the pyroclastic material ejected from a volcano. In general, pyroclastic material is classified in terms of average diameter; fragments with a diameter of 4–32 mm, such as the figurine (which measures 35 × 25 × 21 mm), are classified as lapilli and can take many different forms, often given such descriptive names as Pele's Tears, Ribbons, and Cowdung Bombs. The size and shape of the figurine are consistent with those of a teardrop or spherical lapillus. The surfaces of lapilli are often cracked or fissured because the skin that forms around the molten mass as it flies through the air cracks upon impact (figs. 1, 2). Depending on how the rock was ejected from the volcano, it may have a smooth side (stoss) and an irregular side (lee). "Often the skin of the bomb is drawn into crudely developed thin ridges or wrinkles along the edge of the stoss side, projecting toward the lee side" (MacDonald 1967:49).

From the illustration published by Goren-Inbar (1986: pl. 1) it would appear that the front of the figurine is the lee side of the scoria pebble and the grooves delineating the arms are the result of the contraction and folding of the cooling scoria skin while in the air. The groove delineating the head could have been formed either in the air or upon impact with the ground. While such interpretations could only be made upon examination of the piece itself, the geological literature supports such a conclusion. Goren-Inbar (1986:11) agrees that the protrusions of the scoria pebble were formed by the natural