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## Portuguese Mesolithic-Neolithic subsistence and settlement

(With 2 Tables and 7 Figures)

### Introduction

Over the last four years we have been studying the Mesolithic-Neolithic transition in Portugal, in a project which integrates archaeological and palaeoenvironmental investigations with the analysis of human skeletal collections.

The sites and samples we have worked on come from coastal, estuarine and montane environmental settings in central and southern Portugal (Fig. 1). Some have been excavated by modern methods, either by our team or by Portuguese colleagues; others were excavated in the 19th century but have never been fully published. They cover a calibrated time span from about 8000 to 4000 BP, and include sites and samples assigned on artifact typology to the Mesolithic, the Neolithic and the Chalcolithic. Our overall goal is to see if there are changes in the biology of human populations from these periods which can be explained as due, at least in part, to changing economic practices (see also JACKES, this volume).

Portugal has been well-known since the 1860s for the shell middens on the Tagus estuary near Muge northeast of Lisbon. Two of these, Moita do Sebastião and Cabeço da Arruda, contained numerous human skeletons – the largest such collections in western Europe – but until now their assignment to the Mesolithic was not confirmed (NEWELL et al., 1979). A much smaller sample of human remains were excavated from a third site, Cabeço da Amoreira.

We have obtained a series of AMS radiocarbon dates on human bone collagen from Moita and Arruda. These dates confirm that the human remains excavated in the 19th century date to the Mesolithic occupation of the sites during the early Holocene (Table 1: LUBELL et al., 1986; MEIKLEJOHN et al., 1986). The calibrated weighted average for Moita is 7929 BP while for Arruda it is slightly later at 7604 BP. The dates also suggest that Moita and Arruda were each used for approximately 500 years: Moita from about 8000 to 7500 BP and Arruda from about 7800 to 7200 BP. These new results do not preclude the possibility that the sites may also have been occupied during the Neolithic: ceramics have been identified in 19th century collections from

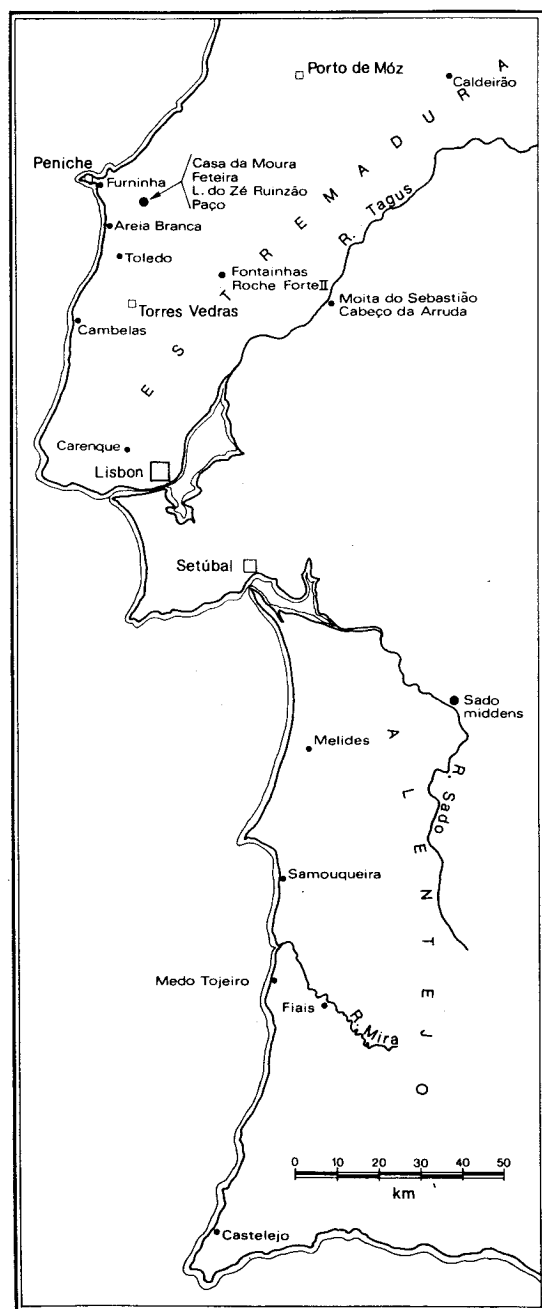


Fig. 1 — Map of Portugal showing locations of archaeological sites and towns discussed.

other Muge middens (VEIGA FERREIRA, 1974), and a charcoal sample from ROCHE's excavations in the upper part of the Arruda sequence was dated to a Neolithic time range.

At all three sites the dead were buried within or immediately beneath midden debris which contained abundant remains of shellfish, land snails, crustaceans, fish, birds and various mammals. Preliminary results of a study of the faunal collections from the Muge middens housed in Lisbon and Porto (LENTACKER, 1986) suggest that some of the collections from the 19th century excavations may be biased in favour of larger animals. For Moita, lagomorphs comprise almost 50% of the identified mammal bones, followed by red deer, wild boar and aurochs. For Arruda, lagomorphs and wild boar are both about 15%, while red deer and aurochs are about 33%. The collections from 20th century excavations at Arruda and Amoreira give a very different picture. In these samples lagomorphs represent over 75% of the identified mammal fragments while red deer are less than 12% and aurochs less than 2%.

We do not yet have data on the Moita sample excavated in the 20th century, but if we can accept the 19th century sample as representative, there may be a differences among the sites. The differences could reflect season of occupation, but as yet, LENTACKER (1986 and pers. comm.) sees no clear evidence for seasonality, although she suspects that there is evidence for season activities (e.g. mullets are the most common fish remains and would have been most easily caught in spring and summer). The overall picture suggests year-round occupation. This interpretation is in reasonable agreement with ROWLEY-CONWY's preliminary reconstructions for the slightly later Mesolithic faunal assemblages from Cabeço do Pez in the Sado valley, and Fiais near Odemira (ARNAUD, 1987; ROWLEY-CONWY n.d. and pers. comm.).

#### Palaeoenvironments and palaeoeconomies

Three palynological studies are available which shed some light on environment conditions during the early and middle Holocene in Portugal.

JANSSEN and WOLDRINGH (1981) analyzed a 5 m core, covering the last 9000 years, from a small depression at about 1600 m elevation in the Serra da Estrela, to the north of Muge. Pine is common at the base of the sequence, but declines rapidly by 8310 bp ( $8310 \pm 160$  bp; GrN 9916) and is replaced by oak and birch. This vegetation community appears to last, with only minor fluctuations, until about 2700 bp ( $2680 \pm 100$  bp; GrN 9915). Following this the influence of cultivation and grazing is clearly seen (see also VAN DEN BRINK and JANSSEN, 1985).

MATEUS (1985), working at Lagoa Travessa on the Atlantic coast near the mouth of the Sado estuary, provides evidence for the existence of closed woodlands from at least 8400 BP ( $7650 \pm 50$  bp) until about 7400 BP ( $6560 \pm 70$  bp), when « dramatic... changes take place... producing a much more open vegetation », and leading eventually to the development of scrub formations.

Table 1 — Radiocarbon dates and stable isotope values for Portuguese samples processed to date by the University of Alberta research project.

SAMPLES	PERIOD	LAB. NO.	MATERIAL	DATE BP	$\delta^{13}C$	$\delta^{15}N$	CAL. VRS. BP(*)
							$-1\sigma$ X $+1\sigma$
Cabeço da Arruda (ossada A)	M	TO-354	Hbc	6970 ± 60	-18.98	12.25	7906 7769 7689
Cabeço da Arruda (ossada D)	M	TO-355	Hbc	6780 ± 80	-18.9	10.3	7681 7590 7522
Cabeço da Arruda (ossada N)	M	TO-356	Hbc	6360 ± 80	-15.3	12.5	7329 7204 7184
Cabeço da Arruda (ossada III)	M	TO-360	Hbc	6990 ± 110	-17.7	11.2	7929 7783 7679
Cabeço da Arruda (ossada 42)	M	TO-359	Hbc	6960 ± 70	-17.22	11.78	7909 7761 7683
Moita do Sebastião (ossada CT)	M	TO-135	Hbc	6810 ± 70	-15.3	13.4	7688 7597 7578
Moita do Sebastião (ossada 22)	M	TO-131	Hbc	7240 ± 70	-16.1	12.2	8078 8037 7942
Moita do Sebastião (ossada 24)	M	TO-132	Hbc	7180 ± 70	-16.8	11.9	8042 7992 7923
Moita do Sebastião (ossada 29)	M	TO-133	Hbc	7200 ± 70	-16.9	10.4	8057 7998 7929
Moita do Sebastião (ossada 41)	M	TO-134	Hbc	7160 ± 80	-16.7	11.2	8040 7986 7915
Samouqueira (Porto Cov. Sines)	M	TO-130	Hbc	6370 ± 70	-15.3	16.5	7331 7200 7187
Samouqueira (Porto Cov. Sines)	M?	Beta-11722	Mbc	5060 ± 130	-17.0		5949 5816 5652
Samouqueira (Porto Cov. Sines)	M	BM-2276	Msh	8040 ± 100			8569 8450 8369
Casteljo (Vila do Bispo. Sagres)	M	Beta-2908	Msh	7450 ± 90			7694 7900 7772
Casteljo (Vila do Bispo. Sagres)	M?	TO-707	Mbc	7800 ± 110			8999 8539 8379
Pandeiro. 1 (Toledo. Estremadura)	M	TO-705	Ch	6840 ± 70			7899 7626 7509
Fiais. 1 (Odemira)	M	TO-706	Mbc	6260 ± 80			7319 7183 6898
Fiais. 2 (Odemira)	M	TO-806	Ch	7010 ± 70			8024 7822 7617
Fiais. 3 (Odemira)	M	TO-953	Hbc	5990 ± 60	-19.6	8.5	6893 6877 6749
Casa da Moura (1987 Straus test)	N	TO-349	Hbc	4940 ± 70	-19.6	8.8	5736 5700 5638
Gruta do Caldeirão (Ea top)	N	TO-350	Hbc	5810 ± 70	-20.2	8.7	6731 6668 6537
Gruta do Caldeirão (Ea base)	N	TO-352	Hbc	4110 ± 60	-20.4	8.3	4822 4638 4532
Gruta da Feteira (1)	N	TO-353	Hbc	4570 ± 70	-19.1	8.9	5322 5297 5058
Gruta da Feteira (2)	N	TO-358	Hbc	4170 ± 60	-19.7	9.7	4838 4725 4571
Gruta da Fontainhas (Montejunto)	N	TO-357	Hbc	4480 ± 60	-19.7	8.9	5288 5191 4988
Roche Fonte II (Montejunto)	N	BM-2275	Msh	6570 ± 120	-23.1		7189 7108 6929
Medo Tojeiro (couche 4)	N	Beta-11723	Ch	5420 ± 160			6406 6222 5989
Medo Tojeiro (couche 4)	N	TO-351	Hbc	1420 ± 50	-19.0	8.8	1350 1313 1292
Gruta do Caldeirão (3)	B	TO-351a	Hbc	1490 ± 70	-16.73	8.87	1491 1370 1312
repeat				4040 ± 220			4849 4529 4239
Praia da Foz (Sines)	G	IRPA-635	Ch				
Praia do Morgavel (Sines)	G	IRPA-636	Ch	19780 ± 300			

PERIOD: M = Mesolithic; N = Neolithic; C = Chalcolithic; B = Bronze Age; G = Geological.  
 MATERIAL: Hbc = Human bone collagen; Mbc = Mammal bone collagen; Msh = Marine shell; Ch = Charcoal.  
 (\*) Calibrations follow conventions established by the 12th International Radiocarbon Conference (STUIVER and KRA, 1986), and were done using CALIB Version 2.0 (STUIVER and REIMER, 1986).

VAN LEEUWAARDEN and JANSSEN (1985) have published a preliminary report on a core taken 10 km from Muge, in the Tagus basin, which covers the period from just before 6500 BP (6445 BP; 5060 ± 110 bp: GrN-11841), when a decrease in arboreal pollen is evident, to about 2700 BP (2590 ± 60 bp: GrN-11838) when the influence of agriculture and grazing are once again clearly seen.

In general, the limited palaeoenvironmental data suggest that localized changes took place in the early and middle Holocene, and that these are reflected, at least to some extent, in the present-day environmental diversity of Portugal. In the south, MATEUS suggests that the onset of the change from woodland to scrub is due to the effects of an early Holocene marine transgression (the « Flandrian ») rather than the activities of man, but that later, progressive change, is a result of human activities. This appears to be in general agreement with the interpretation of the pollen diagrams from the Tagus basin and the Serra da Estrela.

Possible differences in the frequencies of mammalian and non-mammalian species at all the Mesolithic sites are probably therefore related not only to overall environmental changes but also to highly variable local conditions. For example, the calibrated average for two radiocarbon dates for the middle levels at Cabeço do Pez in the Sado Valley is 7124 BP (from data in ARNAUD, 1987). Thus, this site may have been occupied during and after the environmental changes identified by MATEUS. This seems to be confirmed by the predominance of red deer (indicative of deciduous woodland with dense undergrowth), which is much higher than at the Muge sites.

Tentative confirmation comes from another Mesolithic site in the south that we excavated in 1986. Fiais is southwest of Pez near Odemira, on a 100 m terrace of the Rio Mira. The faunal assemblage, dated to 7438 BP (6588.5 ± 52.7 bp, the weighted average of TO-705 and TO-706, see Table 1), has been studied by Dr. P. ROWLEY-CONWAY who reports that it is also dominated by red deer with lesser frequencies of wild pig, roe deer and aurochs with numerous rabbits (ROWLEY-CONWAY, n.d.). Amongst the shellfish, oysters are common. Remains of fish are rare. Preliminary interpretations of the mammalian data suggest two possible models for the occupation: either year-round or during the late spring, summer and autumn, season of the year.

In sum, the available data for the Mesolithic suggest a pattern of localized hunting, fishing and gathering, and some seasonal occupation, during a period which experienced some environmental change. Therefore inter-site differences in faunal assemblages should probably be ascribed to a combination of several factors.

This is also true, to an even greater extent, for variability in the molluscan fauna. All these sites are shell middens, on estuaries. At the Muge sites, close to 90% of the shellfish are *Cardium*. At Fiais, *Ostrea* is far more common than *Cardium*. As a general rule, middens on the coast contain coastal species, those further inland are almost entirely estuarine. At sites like Fiais these is a mixture of coastal and estuarine species.

Variability in faunal assemblages appears to continue beyond the Mesolithic. Evidence for a very similar mixed diet of mammals, fish

and molluscs has been found at Neolithic and Chalcolithic sites as well, and once again it seems local variations may often be ascribed to site location.

At Samouqueira, on the Atlantic coast, we have evidence for at least two occupations: a Mesolithic one dated by human bone collagen to about 7200 BP, and a later one dated to about 5800 BP on non-human bone. The deposits, which were badly disturbed and therefore did not have preserved stratigraphy, contained no remains of domestic fauna: mammalian bone indicates predominance of lagomorphs (54%) followed by wild boar (24%) and red deer (20%). Fish were present, and of the shellfish, *Mytilus* and *Patella* were by far the most common. Stable isotope analysis of the human remains suggests a much greater reliance on marine resources than appears to have been the case for populations located further inland at Muge.

Twenty kilometres south of Samouqueira, also on the coast, is the Early Neolithic midden of Medo Tojeiro. Here, in deposits dated to around 6200 BP, only coastal shellfish and crustaceans were found. This is not an isolated instance. Similiar sites have been found elsewhere along the Portuguese coast. Two of these, one in the extreme south at Castelejo, and the other west of Torres Vedras at Santa Cruz, have much earlier dates: 7900 BP in the south and 8730 ± 110 bp (ICEN-51: ZILHÃO et al., 1987) in the north.

As with the southern sites, we have also found variability in both terrestrial and aquatic faunal remains at midden sites in the region north of Lisbon, both near the coast and further inland.

At Toledo, 5 km from the coast on a small stream, we have tested a large shell midden called Pandeiro, containing an artifact assemblage that could be Mesolithic but might also be Neolithic. An AMS radiocarbon date on mammal bone from test excavations suggests the first (TO-707 in Table 1), but the sample appears to have been associated with ceramics. Further investigations are planned at this site. The shellfish species at Pandeiro are almost entirely estuarine, indicating that, as is the case with the Muge and Sado sites as well as Fiais, saline water penetrated further inland in the past than is the case today.

The only reliable faunal data for Neolithic occupations come from the Caldeirão cave, near Tomar. Preliminary results show a predominantly wild fauna with a few domestic elements (ZILHÃO, 1985) in the early Neolithic levels dated between 6700 and 5700 BP (Table 1).

Two studies of Chalcolithic faunal assemblages are available. At the Zambujal hill fort about 10 km inland from the coast north of Lisbon, von den DREISCH and BOESSNECK (1976) found domesticated and wild suids, together with deer and marine molluscs. The domesticated mammals made up 87% of the identified vertebrate remains. At Rotura, on the coast south of Lisbon, GAUTIER and LENTACKER (1985) have shown that in the Lower and Middle Chalcolithic levels domesticated animals made up only 64% of the recovered mammal and non-mammalian vertebrate assemblage (based on the number of identified fragments), and that marine resources provided a good portion of the diet. These two studies confirm the continuing importance in the Chalcolithic of hunted mammals and gathered marine resources.

Thus, the available faunal evidence suggests that the Mesolithic subsistence pattern, in which fish, shellfish and mammals were combined to provide a varied diet, was maintained into the Neolithic and Chalcolithic. Furthermore, evidence such as that from Medo Tojeiro, where only shellfish and crustaceans were found, suggests that Neolithic subsistence was, in some instances, determined by season and location. We caution, however, that the data from Neolithic habitation sites are still very limited. Most Neolithic sites that have been excavated were special purpose burial sites.

Macrobotanical data on the floral component of prehistoric Portuguese diets are almost non-existent and there are no reliable palynological data from archaeological sites. Samples of charcoal from Samouqueira and Medo Tojeiro (SHAY, personal communication) have been identified as juniper, pistachio, fig and stone pine. Pine was also present during the occupation of the Muge sites (ROCHE, 1977: 357). We do not know if these plants were collected only for fuel, or if their fruits and nuts were also collected for food. If the Mesolithic subsistence pattern recently documented in southern France at the Balma Abeurador (VAQUER et al., 1986) has parallels further south in Iberia, we should eventually find such evidence.

#### Evidence from stable isotopes

An indication of the likelihood of finding such evidence comes from stable isotope analyses of the specimens of human bone dated by our project. The results (Table 1 and Fig. 2), which must be considered preliminary until further controls are undertaken (Dr. H.P. SCHWARCZ, McMaster Univ., pers. comm.), appear to show a difference between Mesolithic and Neolithic specimens. The Mesolithic specimens are distributed closer to the isotopic range of marine herbivores and carnivores, while the Neolithic ones are closer to terrestrial herbivores. On this basis, we can hypothesize that the Mesolithic diet was more-or-less evenly divided between foods of marine and terrestrial origin, while the Neolithic diet was more heavily dependent upon terrestrial resources.

The precise nature of the differences between Neolithic and Mesolithic diets remains to be determined. We suspect, on the evidence already discussed, that these differences may turn out to be of a very local nature. The data now available suggest that when differences occur, they will probably be explained, at least in part, on the basis of the available local resources, and that settlement patterns in the Mesolithic and Neolithic had much to do with local seasonal abundances.

There is a slight difference between Moita and Arruda, whereby most of the Arruda stable isotope values lie between those for Moita and the Neolithic. Taken together with the evidence we have already summarized, there is a fair possibility of some dietary difference between the two Muge sites.

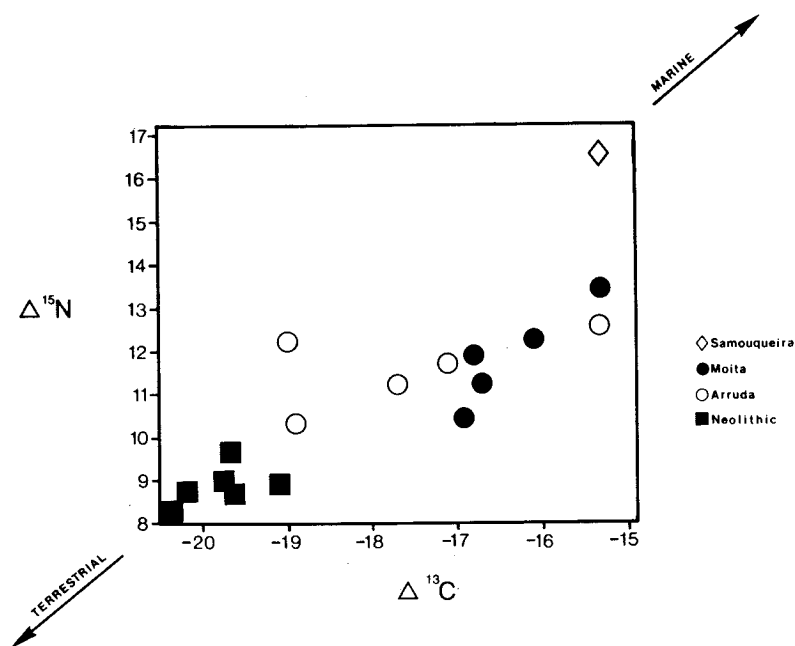


Fig. 2 — The relationship of  $\Delta^{13}\text{C}$  and  $\Delta^{15}\text{N}$  from collagen in samples of human bone for three Mesolithic sites (Samouqueira, Moita do Sebastião and Cabeço da Arruda) and several Neolithic ones. The separation of Mesolithic and Neolithic samples indicates difference in diet.

#### Evidence from teeth

Dental pathology rates are generally thought to be related to diet. We have preliminary data on the rates of caries and pre-mortem tooth loss in the lower molars of individuals 15 years and over (or in the case of loose teeth, those with appropriate root development or attrition).

Our evidence does not show a linear pattern, or support the view that dental pathology increased from the Mesolithic to the Neolithic (Fig. 3 and Table 2). The caries rate for adult lower molars in the Moita sample is 19%; Arruda, the slightly later Mesolithic site, has only 9% carious lower molars; the rate for Casa da Moura, an Early Neolithic ossuary cave which is dated approximately 700 years later, is about 10%. The combined Middle and Late Neolithic samples from the ossuary cave of Feteira have a caries rate of 16%, while the rate for the Middle Neolithic sample from Melides is 19%, equivalent to the rate for Moita.

We appear, then, to have continuity from the Mesolithic to the

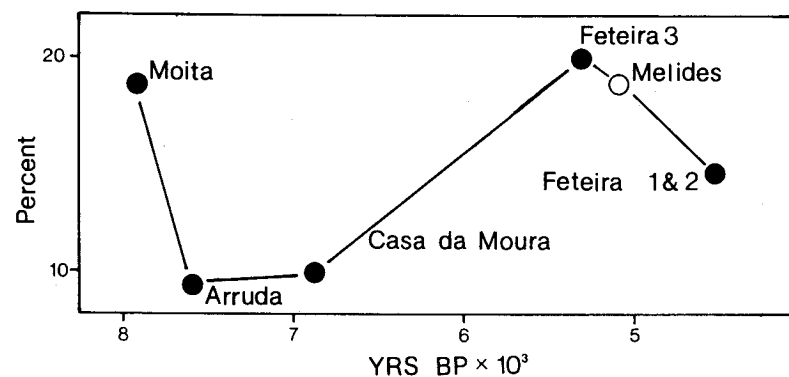


Fig. 3 — The percentage of caries in lower molars for Portuguese Mesolithic and Neolithic samples.

Table 2 — Pathology of lower molars in Portuguese samples.

Sites	Pre-mortem tooth loss plus caries		Intact teeth w/caries			Observed sockets pre-mortem tooth loss		
	n	%	n	n	%	n	n	%
Moita do Sebastião	59/198	29.8	155	29	18.7	198	31	15.7
Cabeço da Arruda	57/297	19.2	225	21	9.3	297	36	12.1
Gruta da Caldeirão								
Layer Ea			7	0		3	0	
Layer Eb			5	1	20.0	0	0	
Casa da Moura								
mandibles	35/163	21.5	117	12	10.3	163	24	14.1
loose molars			963	94	9.8			
Total caries			1080	106	9.8			
Gruta da Feteira								
Layers 1 & 2								
mandibles	6/43	14.0	28	3	10.7	43	3	7.0
loose molars			34	6	17.6			
Layer 3								
mandibles	8/20	40.0	12	4	33.3	20	4	20.0
loose molars			13	1	7.7			
Total caries			87	14	16.1			
Grutas da Melides (Zambujal)	33/124	26.6	75	14	18.7	124	19	15.3

Neolithic with a dip in pathology levels in the later Mesolithic and in the Early Neolithic at Casa da Moura.

Since Moita and Arruda are neighbouring and nearly contemporaneous sites, why is the rate of lower molar pathology for Arruda so much lower than for Moita? Is the difference real or an artifact of sampling? Since pathology is age-dependent to some degree, are we only proving that the Mesolithic sample from Moita consists of more old people?

Unfortunately, the Portuguese Mesolithic and Neolithic skeletal samples are not sufficiently well preserved to permit the use of traditional age indicators such as pubic symphyses. We have instead, over the last four years, tried to use radiographic, bone mineral and microscopic data for accurate age assessment. Our major difficulties are due to diagenetic changes in buried bone over time which make it impossible to observe microstructure and, therefore, to use techniques such as cortical remodelling to derive accurate estimates for age at death. Bone porosity and remodelling rates are also relevant to studies of diet. Thus, diagenetic changes will also limit our abilities to reconstruct diet.

In some cases, calcite crystals fill fractures in the microstructure which is therefore obscured and cannot be read for osteons. Even when there is less destruction - no «exploding» apart of the layers of bone lamellae by calcite crystals - matrix which has been deposited in the bone interferes with the observation of the osteons to the extent that it is impossible to tell if they are forming or resorbing. Regardless of burial conditions or age, such problems are common in the Portuguese bone and cannot be overcome by decalcification or by further grinding of the sections.

Because we cannot apply readily accepted methods of age assessment with confidence, we have instead used seriation of mandibular attrition. This gives relative, not absolute ages and its accuracy is affected by dental pathology rates. More importantly, attrition is affected by exactly those cultural and genetic factors that we are trying to bring to light in our study of the Mesolithic/Neolithic transition.

Using a modified version of Smith's (1984) attrition grading system, we found that the seriated Moita mandibles fell into 11 clear attrition grades (Fig. 4) and that these seem to correlate fairly well with cortical thickness, bone density and porosity.

When the mandibles from Arruda were seriated, and the wear assessed by the same system of 11 grades, we found differences between the two samples. The major difference can be explained in terms of the rates of dental attrition. By the time Moita third molars have come into occlusion, the first molars are already worn to the point at which the fissures have completely disappeared and there are two or more large exposures of dentin. The Arruda first molars have not reached a comparable level of attrition when the third molars come into wear.

Nevertheless, when we can associate a seriated mandible with a cortical thickness estimate for males, and compare the results for Moita and Arruda, there seems to be reason to believe that the attrition grades identified for the two samples are comparable in terms of age (Fig. 5).

We have some confidence then that we have distributed the Arruda mandibles into categories comparable with those for Moita. Figure 6



Fig. 4 — Eleven grades of wear showing the patterns of attrition in the three lower molars.

shows that despite a higher rate of pathology at Moita, the Moita sample is biased in favour of less worn (i.e. generally younger) mandibles. The shaded curves compare the percent distribution of seriated adult mandibles over the 11 attrition grades. The Arruda distribution is fairly even, while Moita is skewed to the left. The dashed line shows the percentage of pathology (caries and tooth loss) for lower molars within each attrition level as running averages. The frequency for Moita pathology is always equal to or higher than for Arruda.

In fact, when age is controlled by using attrition categories, the distribution of Arruda pathology is similar to Casa da Moura and Melides, both Neolithic samples. In Fig. 7 we have collapsed the 11 attrition categories into 4 because of the problems of pushing the smaller seriated Neolithic samples into the Mesolithic attrition grades.

So, it seems clear that, insofar as we can control for age distribu-

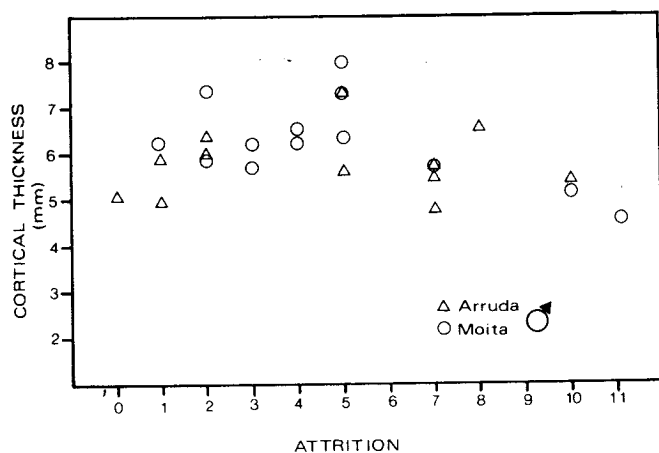


Fig. 5 — Mid-femoral cortical thickness plotted against attrition grades in Portuguese Mesolithic males.

tion differences in the samples, dental pathology rates at Moita were higher than those for the later occupants of Arruda, as well as those represented in the Neolithic ossuary caves.

#### Other Evidence for Dietary Differences between Moita and Arruda

##### a) Demography

The impregnation of bone by minerals derived from the burial environment complicates our analyses of bone porosity, bone density and mineral content, therefore making it difficult to investigate the interrelation of diet and changes due to age. The only possible measure that can be used is cortical thickness, but unfortunately this is a rather imprecise measure and one affected by the method of sampling the bone.

Figure 5 indicates early and drastic loss of cortical bone at both Moita and Arruda, if the 11 attrition grades are given equal 5 year age ranges. While it is unlikely that this would be correct, the figure at least demonstrates that the attrition levels of the two samples are similar enough to allow us to use the attrition grades for rough comparative palaeodemographic analysis.

The age specific probabilities of death (the  $q$  values) suggest that mortality is slightly higher for Moita than for Arruda, most especially in younger adults. Juvenile mortality is a little higher at age 5.

Unfortunately, there is every reason to think that the two samples are incomplete. Probably less than 50% of the Arruda midden has been excavated, while an unknown amount of the Moita midden has been destroyed without observation or excavation by archaeologists. Incomplete excavation can produce a biased sample and therefore make demo-

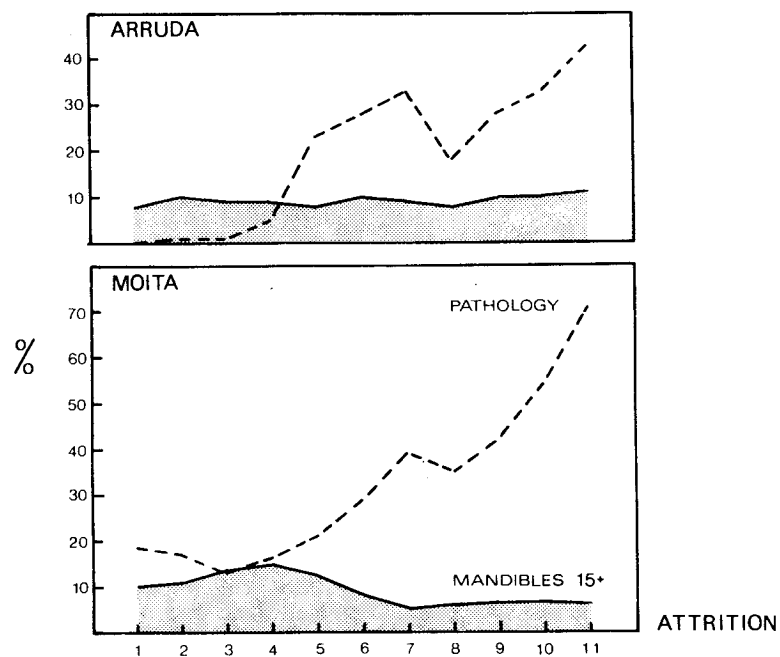


Fig. 6 — Comparison of the pathology (*pre-mortem* tooth loss and caries) rates within each attrition grade for Moita do Sebastião and Cabeço da Arruda. The shaded areas represent the percent distribution of mandibles over 15 years of age across the 11 attrition grades.

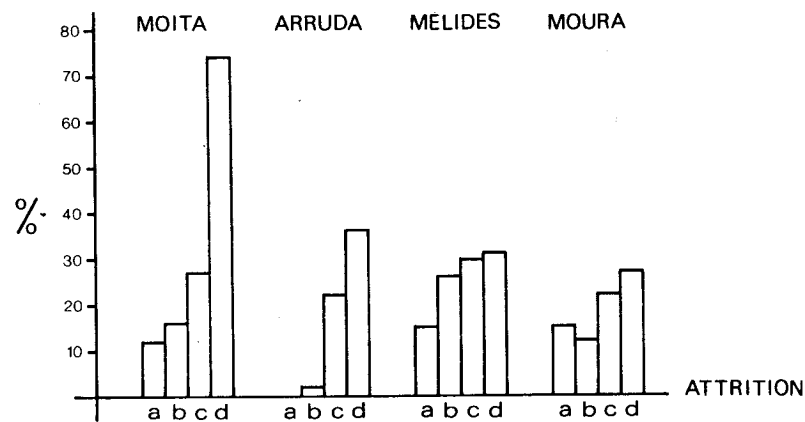


Fig. 7 — Pathology rates (percentage of individuals with *pre-mortem* tooth loss and caries) by broad attrition groupings in Mesolithic and Neolithic samples: a = grades 1,2; b = grades 3,4; c = 5-8; d = 9-11.

graphic statements uncertain. However, according to the methods we have developed for checking sample reliability and estimating demographic parameters from unsatisfactory material (JACKES, this Symposium), both Moita and Arruda do provide biologically possible samples within the context of prehistoric sites. On this basis, we can say that the Moita mortality levels were higher than those at Arruda. The Arruda sample fits within the range of those palaeodemographic samples with relatively low mortality, equivalent to the West 1 schedule of Coale and Demeny. Moita mortality appears to be somewhat higher.

#### b) Tetracycline marking

There is another interesting difference between Moita and Arruda. All the Moita femurs which have been thin sectioned show patterns of clear yellow rings when observed under the fluorescing microscope. These are different from the general auto-fluorescence of bone. So far, we have not found these rings in the Arruda femoral thin sections.

The fluorescent labelling appears similar to tetracycline marking (PALMER, 1987). Tetracycline binds itself to calcium in such a way that it labels areas of active mineralization at the time of ingestion. We would not see this clear ring and line formation if we were observing only the results of *post mortem* fungal or bacterial infestation. BASSETT et al. (1980) and HUMMERT and VAN GERVEN (1982), identified tetracycline labelling in prehistoric and later human remains from Sudanese Nubia, and explained this as due to consumption of grain stored in such a way that the bacterium, *Streptomyces*, was cultured. There is no evidence for grain storage in Portugal at 7000 BP, but there are other ways in which tetracycline might have been ingested. For example, ROCHE (1972: 97) described hollows at Moita, some full of unopened *Scrobicularia plana*, the peppery furrow shellfish so common in all the sites we have excavated or analyzed. Other foods could equally well have been stored, and for longer periods than shellfish: pine nuts, pistachios and acorns are the obvious choices in a Mediterranean woodland (and see CLARK, 1987: 300). Besides this, roots and tubers bearing *Streptomyces* could well have been stored and eaten. Thus the possible identification of tetracycline labelling is simply one more clue to the composition of the Mesolithic diet, and it will be interesting to see if similar patterns are found in human bone from other sites, especially those from later periods.

#### Conclusion

On the basis of stable isotopes and radiocarbon dates we can confirm that both Moita and Arruda should be considered predominantly if not entirely the result of Mesolithic occupations. Yet, the differences in dental pathology between them suggest that the Mesolithic populations buried in the Muge valley were not homogeneous. At this stage in our work it seems unlikely that the differences were genetic. For example, MEIKLEJOHN's cranial non-metrical data give no indication of marked differences, nor do our post-cranial data on stature and body proportions.

It is more likely that dietary differences are at the base of the differences we see in dental attrition rates and in pathology. The slight shift in stable isotope values for Arruda and the possibility of tetracycline labelling at Moita support such an hypothesis.

The Neolithic pattern of attrition and of dental pathology is closer to that first identified at Arruda, but the stable isotope analyses show that there were dietary differences between the Mesolithic and the Neolithic.

Differences in burial patterns highlight a major distinction between the Mesolithic and the Neolithic. Mesolithic burials were primary individual interments at sites also used for occupation. The graves were often dug into the sterile substrate beneath the midden deposits. The Neolithic pattern was very different, being characterised by secondary communal burial in single-purpose ossuary caves.

However, there is some variability, whether temporal or geographical, in the Mesolithic disposition of the dead. Apparently all burials in the Sado middens are flexed, some tightly, others less so (ARNAUD, 1987). This appears to have been the case at Arruda as well – based on our reconstructions – many of the Arruda skeletons were in extreme flexion of thigh on hip. However, for the Moita materials, we have found flexion only at the knees, suggesting that the bodies were buried fully extended, sometimes with raised knees. Thus, one could suggest the existence of an earlier (Moita) and later (Arruda, Sado sites) Mesolithic burial pattern. The extent to which the later Mesolithic pattern can be seen to continue into the Neolithic is highly debateable. The radiocarbon date for Pandeiro should not at this point be considered conclusive evidence. There are ceramics in the upper levels of some of the Sado middens (and this may also have been the case at Muge), but since none of the Sado skeletons has yet been dated it is impossible to say whether any fall within a Neolithic time range. Nor is it possible to confirm absolutely that all Neolithic burials were in ossuaries. Excavations in and around Neolithic occupation sites will be required before this can be resolved.

In conclusion, the data for faunal remains, dental pathology, burial practices and stable isotopes, in some instances argue for continuity between the Mesolithic and the Neolithic, and in other instances for discontinuity. The picture is becoming more complex, and more challenging, for it seems likely that the scenario of a homogeneous Mesolithic and a different but homogeneous Neolithic is over-simplified. One thing has become clear: it is necessary to understand the range of variation in the Mesolithic and Neolithic before we can truly understand the nature of the transition from one to the other.

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Discussion at p. 475.

#### SUMMARY

**Key-Words:** Subsistence patterns, Settlements, Environmental changes, Mesolithic-Neolithic, Portugal.

Excavation of Mesolithic and Neolithic sites in central Portugal in conjunction with a study of human skeletal collections from other sites in the same region (see abstract by M. K. JACKES), provides new information on the nature of the Mesolithic-Neolithic transition and its effect upon human populations.

Geoarchaeological, zooarchaeological and paleobotanical analyses do not suggest environmental change as a major in the transition, and partial reliance on hunted and gathered foods appears to have persisted long after the end of the Mesolithic. There are clear distinctions in the burial practices of Mesolithic and Neolithic populations, new radiocarbon dates show that they do not overlap in time, and osteological data so far available are too limited for assessment of differences or similarities at this time. Radiocarbon dates for recently excavated sites suggest that some Mesolithic and Neolithic occupations were contemporaneous - if the assignment to cultural period is technological rather than on the basis of economic criteria. Stable isotopes ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) in dated human skeletal samples show a trend through time from an earlier heavy dependence on foods of marine origin to an emphasis on foods of terrestrial origin in later samples. Absence of well-excavated Neolithic sites limits our ability to interpret these data, but on present evidence we can suggest that Portugal may have been a region in which indigenous Mesolithic populations lived side by side with non-indigenous Neolithic groups for some time before adopting the new economic practices.

#### RIASSUNTO

**Parole chiave:** Modelli di sussistenza, Insediamenti, Modificazioni dell'ambiente, Mesolitico-Neolitico, Portogallo.

La transizione tra il Mesolitico ed il Neolitico in Portogallo, così come i suoi effetti sulle locali popolazioni umane, sono stati valutati sia attraverso la documentazione archeologica emersa dallo scavo di alcuni siti della regione centrale, sia mediante il parallelo studio di serie scheletriche provenienti da aree limitrofe.

Il complesso dei dati geoarcheologici, zooarcheologici e paleobotanici non suggerisce l'esistenza di rilevanti cambiamenti ambientali avvenuti all'epoca della transizione. Viceversa, un'economia basata ancora sulla caccia e sulla raccolta del cibo sembra essere persistita per lungo tempo dopo la fine del Mesolitico.

Tra i gruppi mesolitici e neolitici, sono state chiaramente evidenziate pratiche funerarie differenziate e le più recenti datazioni, realizzate con il  $\text{C}^{14}$ , permettono generalmente una buona separazione cronologica tra i due periodi. Tuttavia, data la loro incompletezza, le serie scheletriche non consentono ancora una dettagliata valutazione delle principali affinità e differenze tra i diversi gruppi. Inoltre, le datazioni di alcuni siti archeologici scavati più di recente suggeriscono come insediamenti mesolitici e neolitici fossero talvolta contemporanei. Ciò, almeno nel caso in cui l'attribuzione culturale si basi su criteri tecnologici, piuttosto che economici.

L'analisi di alcuni isotopi stabili, realizzata su campioni scheletrici ben datati, ha posto in evidenza il progressivo passaggio da una dipendenza dalle risorse alimentari marine, tipica dei gruppi più antichi, a quella da risorse terrestri, caratterizzante invece i gruppi cronologicamente più recenti.

L'attuale assenza di siti di epoca neolitica scavati in modo approfondito, limita ancora fortemente la possibilità di una corretta interpretazione del complesso di queste informazioni. Tuttavia, sulla base dei dati raccolti fino ad oggi, è possibile suggerire che il Portogallo fu una regione nella quale, prima dell'adozione di nuove forme di economia, le popolazioni indigene mesolitiche vissero per un certo periodo di tempo accanto a gruppi non-indigeni neolitici.

#### RÉSUMÉ

**Mots-clés:** Modèles de subsistance, Établissements, Changements ambiants, Mésolithique-Neolithique, Portugal.

La fouille de sites mésolithiques et néolithiques au centre du Portugal, conjointe à l'étude des collections de squelettes humains provenant d'autres sites de la même région, apporte de nouvelles informations sur la nature de la transition Mésolithique-Neolithique et ses effets sur les populations humaines.

Les analyses géoarchéologiques, zooarchéologiques et paléobotaniques n'évoquent pas de changement environnemental majeur durant la transition, la permanence partielle de la nourriture « chassée et cueillie » a persisté bien après la fin du Mésolithique. Il existe des distinctions claires dans les pratiques funéraires des populations du Mésolithique et du Néolithique. De nouvelles datations radiocarbone montrent qu'elles ne se chevauchent pas dans le temps, et les quelques données ostéologiques disponibles jusqu'à présent, sont trop limitées pour déterminer des différences ou des similarités à cette époque. Les dates radiocarbone pour les sites plus récemment fouillés évoquent la contemporanéité de certaines occupations néolithiques et mésolithiques - si l'attribution à la période culturelle est basée sur le critère technologique plutôt qu'économique. Les isotopes ( $\delta^{13}\text{C}$  et  $\delta^{15}\text{N}$ ) sont stables dans les échantillons de squelette humain mésolithique et ceux de sub-recents à chasseurs/cueilleurs récents.

Finalement la variation dans les dimensions des dents et la morphologie dentaire sera mentionnée et reliée aux problèmes « ethniques ».

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