UDK 903(46)"633/6343"
Poročilo o raziskovanju paleolitika, neolitika in eneolitika v Sloveniji XXIV, Ljubljana 1997

Maritime pioneer colonisation in the Early Neolithic of the west Mediterranean. Testing the model against the evidence

João Zilhão
Instituto Português de Arqueologia, Lisboa

The model of the neolithization of the western Mediterranean as a process of maritime pioneer colonisation was initially presented in the framework of the monographic publication of the Neolithic levels of the Portuguese cave site of Gruta do Caldeirão (*Zilhão 1992a; 1993*). Largely based on the Portuguese evidence, it tried to provide a solution for the growing inadequacy of the competing explanatory frameworks for the advent of agro-pastoral economies, which were developed in the 1970's and the 1980's:

- slow, gradual east-west wave of advance spread of the Neolithic package across Europe, as a result of the demographic expansion of agriculturalist groups (*Ammerman and Cavalli-Sforza 1973; 1984; Renfrew 1987);*

- acculturation of local hunter-gatherers, who would have gradually adopted the different elements of the Neolithic package, once they were available. This would have been for social or economic reasons and would have taken place in a piecemeal process, dictated by internal rhythms (*Guilaine 1976; Lewthwaite 1986a; 1986b; Zvelebil 1986*).

The wave of advance was refuted by accumulating radiocarbon evidence, which demonstrated that the spread of agro-pastoral economies along the northern Mediterranean shores had been much faster than predicted. At the rate of spread calculated by Ammerman and Cavalli-Sforza (*1984*), agro-pastoral economies would have reached the Pyrenees some time between 5000 and 6000 BP. However, such economies were present in Portugal from at least 6300 BP. This is shown by the accelerator radiocarbon dating of sheep bones from Caldeirão (*Rowley-Conwy 1992*). They may be as early as 6700 BP, as suggested by the typology of some Cardial vessels, recovered at other cave sites located in the limestone massifs of Portuguese Estremadura (Fig. 1). Data from this European Far West thus suggested an almost simultaneous (at the available chronometric resolution) advent of the Neolithic in all the regions located between the Languedoc and the mouth of the river Mondego.

A simulation study published in the early 1990's further suggested that the wave of advance failed to explain observed demographic patterns. Modern genetic data indicated to Calafell and Bertranpetit (*1993*) that two very different population clusters can be distinguished in Iberia. The Basque group is well separated from the rest and possibly represents the survival of a pre-Neolithic population. The pattern of homogeneity revealed by the gene frequencies in the rest of Iberia would in turn be the result of the Neolithic expansion of farming populations, originating in Catalonia and spreading southwards and westwards. The simulation produced a map of the first principal component of the gene frequencies (interpreted as pre-Neolithic), which accorded with the real data and was compatible with the archaeological evidence. Arias (*1991; 1992; 1994*) 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. The simulated distribution of

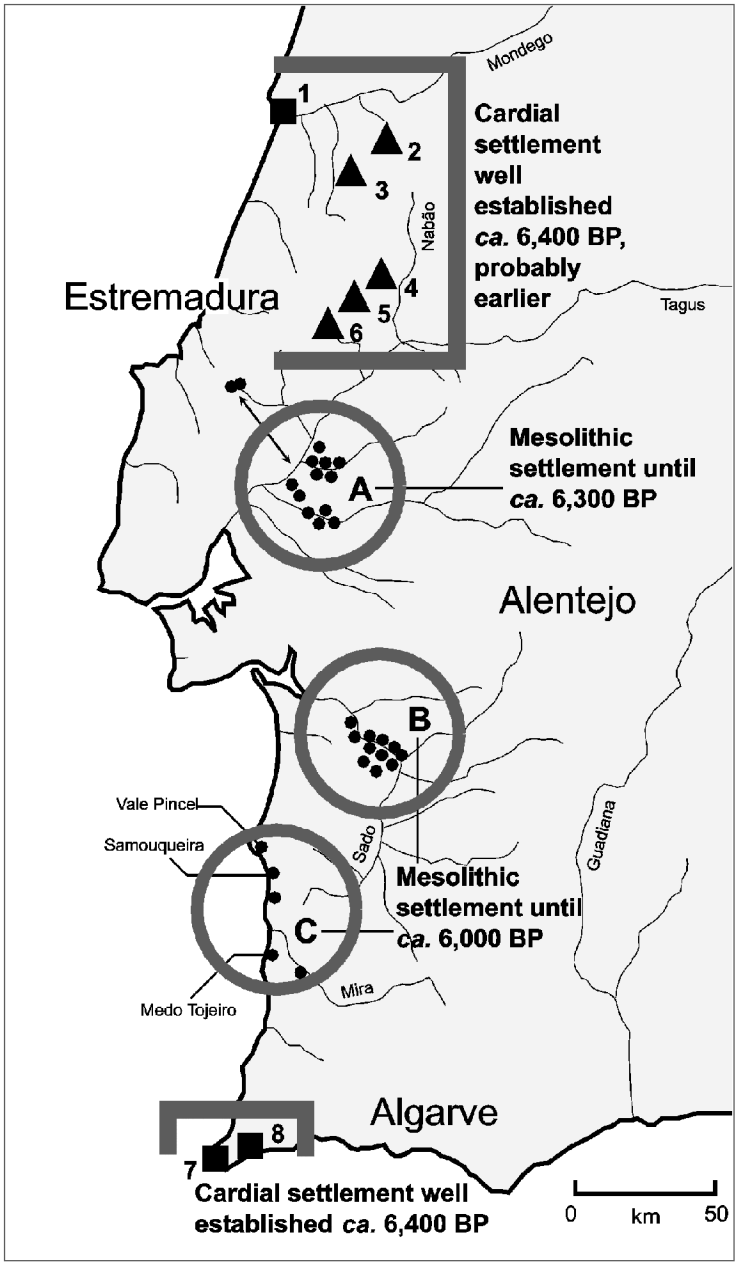

Fig. 1. Location of Portuguese Early Neolithic sites with Cardial contexts dated by pottery assemblages, radiocarbon dating or stratigraphic position whose age is greater than ca. 6300 BP (neither isolated finds, such as the Santarém vessel, nor the odd sites where a few untypical cardial sherds have been found but most likely belong to later epicardial contexts were included). Open air sites: 1. Várzea do Lírio and Junqueira (Figueira da Foz); 7. Cabranosa (Ponta de Sagres); 8. Padrão (Vila do Bispo). Cave and rock shelter sites: 2. Eira Pedrinha; 3. Buraca Grande; 4. Caldeirão; 5. Pena d'Água; 6. Almonda. Late Mesolithic sites (occupied until 6000-6300 BP) are also shown. A - Tagus shell-middens (the outlier dots represent Bocas and Forno da Telha, occupied around 7000 BP, probably as logistic sites used in the framework of a settlement-subsistence system centred on the estuary); B - Sado shell-middens; C - coastal Alentejo shell-middens, with individually labelling of those considered by Soares (1992; 1995; 1997) to be Neolithic. The mutually exclusive distribution of late Mesolithic and Cardial sites, their contemporaneity and the absence of known late Mesolithic settlement in the areas of first Neolithic establishment suggest that the latter is intrusive.

the second principal component (interpreted as indicating the consequences of the Neolithic expansion), however, did not show a similar degree of accordance with the real gene frequencies. Instead of the regular NE-SW gradient predicted by the model, the highest frequencies recorded outside Catalonia were found in central Portugal, not along the adjacent coasts of Valencia and Andalucía (Fig. 2).

Alternative acculturation models derived their rationale from the acceptance of stratigraphic and radiometric data, which, although not exempt of potential criticism, seemed to indicate that the Neolithic had not spread as a "package", as assumed by proponents of the wave of advance. My own evaluation of such models had two relatively independent components. First, the empirical evidence was submitted to the appropriate taphonomic filters. As a result, several instances of radiocarbon ages and archaeological associations from sites in southern France, southern Spain and Portugal were shown to be an artefact of post-depositional disturbance or of the use of poor excavation techniques. In particular, the supposed pre-Cardial Neolithic from Andalucía and Catalonia featuring non-Cardial impressed or undecorated ceramics was shown to be an artificial construct, derived from mixed archaeostratigraphical contexts, where the samples dated were contaminated by Palaeolithic or Mesolithic material from disturbed underlying levels. Thus, acculturation models seemed to correspond to explanations of processes that had never happened.

With this in mind, data patterns previously unobserved or unrecognised were established and described. The main elements of the new understanding of the empirical evidence arising out of the taphonomic critique of sites, stratigraphies and dates were the following:

- the Neolithic had indeed appeared throughout the west Mediterranean, from the Gulf of Lions to the mouth of the Mondego, as a complete package, including pottery, polished stone tools, domesticates (wheat, barley, sheep and goats) and a village based way of life;

- the earliest Neolithic settlements in the Languedoc and westwards (in Catalonia, Valencia, Andalucía and Portugal) were always defined by the presence of broadly similar Cardial pottery styles later replaced by distinctive regional epicardial varieties;

- at the level of resolution allowed by radiocarbon dating, this spread of Cardial farmers and shepherds could be described as a punctuated event, not the outcome of a slow, regular, east-west spread from one contiguous area to the next;

- chronometric data combined with the distribution of settlements indicated that, in the west coast of Portugal, the earliest Neolithic and the latest Mesolithic, although contemporary, were geographically segregated, the former being concentrated in the interior limestone massifs, where no signs of putative late Mesolithic ancestor groups were known, and the latter around the large estuaries of the Tagus, the Sado and the Mira rivers (Fig. 1).

In spite of the problems encountered by the wave of advance when confronted with the empirical evidence, these patterns suggested that mechanisms which postulated some kind of demic diffusion were still the most capable of providing a historical and processual framework to explain what had been going on in those early days of European prehistory. Thus, based on an explicit parallel with the agricultural colonisation of the Pacific islands (*Kirch 1984; Irwin 1992*), I formulated a maritime pioneer colonisation model, which assumed that the spread of the Neolithic around the northern coasts of the Mediterranean had not just involved the circulation of ideas, artefacts and resources, but also that of people. In fact, the coastal orientation of Cardial settlement,

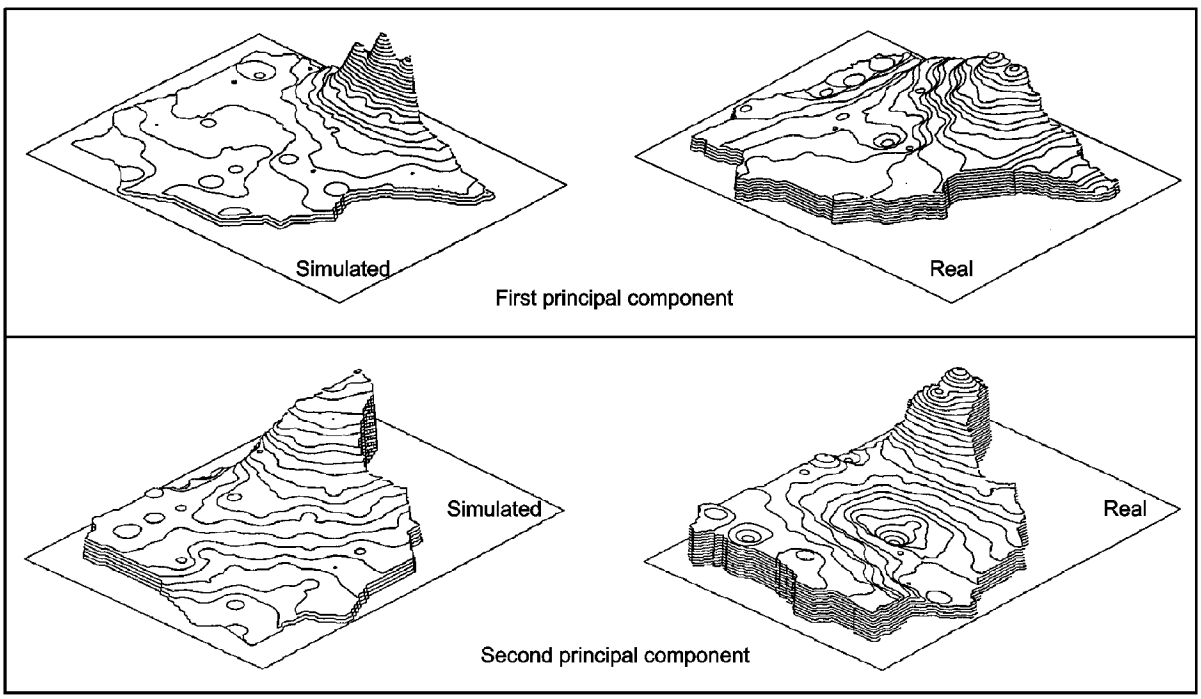

Fig. 2. The genetic history of the Iberian Peninsula after Calafell and Bertranpetit (1993, Figs. 4-7, modified). The first principal component is interpreted by these authors as representing the pre-Neolithic population background and the second principal component is interpreted as reflecting the consequences 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, south-westwards "oil-spill" process.

the physical geography of the regions concerned, the rapidity with which the far-western end of the Cardial range was attained, the enclave nature of the earliest Neolithic of Portuguese Estremadura, and the stylistical diversification in pottery decoration that began to develop not much long after initial settlement suggested:

- that such a circulation had followed maritime routes;
- that it had involved small leapfrogging pioneer groups, which soon became isolated from each other;
- that situations of mosaic frontier with local hunter-gatherers characterised the initial settlement and must have entailed forms of interaction between the two;
- that the outcome of such interactions had been the more or less delayed assimilation of such local hunter-gatherer groups, due to the superior demographic potential of agricultural societies, which, at the cost of simplifying the ecosystems, were able to feed a lot more people per area unit of territory than their Mesolithic neighbours.

Since its formulation, this model has been discussed and criticised by different authors, particularly by proponents or adherents to the acculturation hypothesis. Such criticisms, formally published, orally presented at conferences or manifested in correspondence to me, have been focused around a limited number of points:

- how to interpret patterns of presence and absence and how this affects our reading of data on subsistence and settlement;
- to what extent the evidence from Portuguese Estremadura, showing a geographical segregation of late Mesolithic and early Neolithic sites, can be interpreted as evidence for the occupation of the area by two different populations with different economic systems or, instead, as evidence for seasonal variability in the framework of a single settlement/subsistence strategy (*Whittle 1996.304*);
- how to reconcile the notion of an early Neolithic colonisation of littoral Portugal with the osteological evidence for biological continuity across the Mesolithic/Neolithic boundary (*Jackes et al. 1997*).

Meanwhile, new empirical data have also been published that can be confronted with the predictions derived from the model. In the following sections, I will reply to criticisms and show how the evidence accumulated since my original formulation is in good accord with such predictions (see also Zilhão n.d.a; n.d.b).

THE TAPHONOMIC FILTER

This aspect of the model has proved to be the least controversial. No reply to my demonstration of the more than inadequate nature of the data that had been used to substantiate the concept of a piecemeal adoption, beginning as early as 8000 BP, of the different elements of the Neolithic package has yet been offered. Reviews of my argument by different authors have also been largely supportive.

An example of this is Whittle (*1996.291*), although this author clearly would have preferred to stick to the old version of the facts. Accordingly, he considers the school of thought expressed in my paper and those by, among others, D. Binder (*in press*), as "revisionist", and continues to accept at face value the sequences which I had criticised as firm evidence that "in upland rock-shelters like the Grotte Gazel and the Abri de Dourgne in Languedoc ... pots appeared later in the sequences than sheep and goats" (*Whittle 1996.308*).

Rowley-Conwy (*1995*) fully accepted the case made for a beginning of the Neolithic in west Mediterranean areas no earlier than *ca.* 6800 BP, as a complete package, and with Cardial decorated pottery as its most emblematic feature. In this paper, Rowley-Conwy goes on to extend the application of the taphonomic filter approach to the palynological and archaeological record of Scandinavia and the British Isles, showing that much the same problems apply to finds and contexts traditionally interpreted as indicating a precocious introduction of agriculture in largely hunting and gathering economic systems.

Budja (*1996.71*) and Harris (*1996.559-560, 569-570*) have also stood for the validity of the results derived from the application of a taphonomic filter to the Mediterranean evidence. A further point of agreement with Harris regards the mechanism I had suggested of early Neolithic expansion through the establishment of enclaves in areas that were marginal to the local Mesolithic hunter-gatherers. He hypothesises that the same may apply to other parts

of Europe – and, actually, Binder (*in press*) suggests that a similar settlement dichotomy characterised the initial Impresso Neolithic settlement of Liguria and Provence, which is confined to territories without known Castelnovian occupation. In his concluding remarks, Harris also states his support of the view that the expansion of agro-pastoral economies from the Balkans to central and western Europe was a two-step punctuated process, as I had argued (*Zilhão 1993.52*). A similar agreement is manifested in the same volume by Renfrew (*1996.82*), who reproduces one of my maps to illustrate the point.

More important, however, is that, in spite of Whittle's reluctance, the stratigraphic and definitional problems that I had presented as objections to the concept of "Mesolithic sheep" (*see also Binder, in press*) are now being recognised by the authors who first elaborated it (*Guilaine 1976; Geddes 1981; 1983*). In the monographic publication of the Dourgne rock-shelter, Guilaine (*1993.456-458*) discusses the confused nature of the data reported until then in relation to the earliest manifestations of the Neolithic in the west Mediterranean and admits that the sheep remains found in the Mesolithic levels of the site may be related either to post-depositional disturbance – as regards those from level 8 – or to the palimpsest nature of the deposits – as regards those from level 7. His preferred interpretation for the sheep bones found in the latter would be that level 7 contains the remains of two consecutive occupations too close in time for a clear stratigraphic separation to have developed and to have been visible during excavation. Thus, with an archaeological content for the most part fully Mesolithic, level 7 would also contain remains (the sheep bones) from the slightly later explorations of this mountainous regions by the first farmers of the Languedoc.

The application of a similar taphonomic approach to the concept of Mesolithic horticulture also undermines dramatically the empirical basis of explanations of the spread of the Neolithic as purely a process of acculturation without demic diffusion. The large amounts of seeds recovered at the southern French cave sites of Abeurador and Fontbrégoua suggested to some that the pre-Neolithic inhabitants of the Mediterranean shores were heavily dependent on plant gathering and, as such, pre-adapted to agriculture. Therefore, they were ready to adopt it at their own initiative as soon as it became available through long distance exchange systems. However, as Binder (*1989; in press*) has shown, humans were not responsible for those seed accumulations. Instead, as proved by analyses of soil micromorphology carried by J. Wattez, the seeds, which for the most part belonged to inedible or toxic species, were contained in phosphate rich, culturally sterile, lenticular deposits made up of the faeces of granivora birds, mostly pigeon, whose bone remains also abounded in those deposits.

ABSENCE OF EVIDENCE AND EVIDENCE OF ABSENCE

Although no direct evidence of agriculture (such as charred cereal grains) dated to the earliest Neolithic has yet been found in Portugal, my model assumes that the people who lived in the interior limestone massif of Estremadura and buried their dead in caves, associated with Cardial pottery and sheep bones, were agriculturalists. The model also assumes that these first agriculturalists would have lived in open air settlements around the Mediterranean, in spite of the fact that the large majority of known early Neolithic sites are caves or rock-shelters, with villages becoming the norm only from the middle Neolithic onwards. Thus, the absence of evidence in these two cases was not considered to be a genuine reflection of the past, but, instead, to be related to the incomplete nature of the archaeological record. At the same time, however, my model is based on the consideration as genuine of two other absences: that of late Mesolithic sites that could represent the local ancestors of the Cardial settlement of the interior limestone regions of Estremadura and that of any archaeological sites dated to the period between 10 000 and 6000 BP in the Iberian hinterland (the Spanish Meseta and adjacent regions of Portugal).

It could be argued, therefore, that the model is crippled by a logical inconsistency: the biased interpretation of the patterns of presence/absence – accepted when they favour the argument, absences are rejected when they contradict it. This is an important methodological issue, so I will discuss at some length why this "double standard", this "trying to have it both ways", so to speak, is entirely legitimate.

At the heart of this problem lies the empirical fact that the archaeological record is always incomplete and what is recorded from a given period or culture varies according to activities, preservation, etc. Thus, archaeologists are permanently faced with the need to interpret the absence of certain categories of data from a given site of a given culture/period. Let us suppose, for the sake of the argument, that,

when digging a medieval English settlement, we find no direct evidence of agriculture (i.e., cereal seeds). What interpretation would be more legitimate: that the absence was due to preservation or some other factor, such as, for instance, the site being a military outpost where soldiers lived for a few months from hunting and acorn collection; or that the absence was due to the fact that medieval England lacked agriculture?

I would be surprised if any educated person would even hesitate in the answer to such a question. How then does this example translate into the Portuguese early Neolithic situation? Clearly, in this case, the answer should vary according to what are considered to be legitimate expectations in the face of our current knowledge of the time period and the region under consideration. Given that the earliest Neolithic package contains cereal agriculture everywhere in the west Mediterranean, it would seem that the most legitimate expectation is that cereal agriculture was also present in Portugal, but that wheat and barley seeds have not yet been recovered in the earliest Neolithic. This is a result of the very small number of sites known, their nature (mostly cave burials), the preservation biases (open air sites on acid sand dunes) and the poor way most of them were excavated. This is the answer I prefer, although I am aware of the fact that this answer assumes a certain number of definitions as to what the Cardial phenomenon represents.

In any scientific discipline that deals with the past, interpretation/modelling/explanation requires the making of precisely these kinds of choices, based on expectations derived from the current knowledge of that past: in some situations, absences must be considered as genuine and historically significant and, in other, as apparent and related to the operation of some kind of bias. Distinguishing between the two will always be the bread and butter of archaeology, palaeontology, astronomy, etc., fields in which the familiar motto "absence of evidence is not evidence of absence" needs appropriate qualifications. For a simple example, consider the following statement, of a kind very commonly found in popular creationist literature: "the fact that trilobites are unknown in post-Palaeozoic beds and dinosaurs in pre-Mesozoic ones does not mean that their remains will not eventually be found in such deposits" [after all, absence of evidence is not evidence of absence!].

The fact, however, is that scientists, unlike creationists, developed a methodology that deals with the issues regarding patterns of presence and absence in terms of probability statements. For instance, given our present data base of Palaeozoic and Mesozoic deposits, the probability that trilobites and dinosaurs were actually contemporary is so small that, for all practical purposes, the *in situ* finding of their remains in the same geological bed can be assessed as an impossibility. Or, for an archaeological example, the absence of cereal remains or of ceramic vessels in the hundreds of Solutrean sites known does mean that agriculture and pottery did not exist in the Solutrean and that it can be predicted with 100% certainty that such items will not be found in the Solutrean contexts eventually found and excavated in the future.

In this regard, how do we evaluate the absence of Mesolithic and Cardial sites from interior Portugal and from the Spanish Meseta? The first question is whether anybody has been looking for them and the answer is yes. Many systematic survey projects in both Portugal and Spain (*e. g. Iglesias et al. 1996*), have consistently identified large numbers of late early Neolithic (epicardial or impressed ware) sites all over this vast area, as well as, particularly in Portugal, fair numbers of Upper Palaeolithic sites. However, no sites of Mesolithic age, and not a single typical Cardial sherd have been found.

I have been personally involved in one of these projects, that relating to the establishment of the archaeological context of the Côa valley rock art (*Zilhão et al. 1997*). When the discovery of the art was announced, in November 1994, some expressed the view that it was not Upper Palaeolithic and could not be, as shown, in particular, by the absence of sites from that period in interior Iberia (*e. g. Bednarik 1995*). I immediately replied, following a line of reasoning previously laid down in published form (*Zilhão 1992b*): that this absence was only due to the fact that no one had looked for them; and that such Upper Palaeolithic settlements did exist and would be found if an adequate survey project was set up to that effect.

As it happened, I was challenged to do exactly that and so found the first Upper Palaeolithic site in the Côa valley after only twenty minutes of the first day of field survey. Since then, the number of Upper Palaeolithic settlement sites in the valley has risen to ten, and many more Neolithic and Copper Age sites have also been located. In spite of the fact that a professional team of archaeologists has been systematically combing the region for sites on a daily

basis for the last two and half years, none were found, however, that could be attributed to the Mesolithic or to the Cardial Neolithic. I cannot think of any bias (formation, preservation, survey strategy) that might explain such a repeated failure to find in these interior regions any site dating to the period between 10000 and 6000 BP. Probability strongly suggests, therefore, that they are not being found simply because they are not there, much as we are not finding dinosaur fossils in Cambrian deposits simply because dinosaurs did not exist that long ago. Thus, in these cases, "absence of evidence" should be considered, indeed, as "evidence of absence".

Can a similar statement be made about the absence of late Mesolithic sites in the central limestone massif of Estremadura? In this case as well, such absence cannot be attributed to a lack of survey. Between 1988 and 1995, I directed a project aimed at systematically surveying the massif for prehistoric sites. A few hundred new ones were located, some in caves, most in the open, from many different time periods, including some (e.g. middle and late Neolithic settlements, periods that until then were only represented by burial sites) that were not known in the previously available sample. One period, however, continues to be missing: the late Mesolithic. All sites from this period known are located either around the main estuaries or, in two cases (Bocas and Forno da Telha), in the border of the Massif, at the head of a small tributary of the Tagus. None were found in the interior of the Massif, which, however, was shown to have been settled in the Acheulian, the Middle Palaeolithic, the Upper Palaeolithic, the early Mesolithic, all of the Neolithic and the Copper, Bronze and Iron Ages. Again, it seems reasonable to accept that, in this case, "absence of evidence" must indeed be considered as "evidence of absence".

Why do I take the opposite view regarding the absence of cereal remains in the few Portuguese Cardial sites so far known and the scarcity of village sites in the early Neolithic of the west Mediterranean? As regards the latter, and although such scarcity was seen by some as another indication of continuity with the Mesolithic and a further example of the piecemeal adoption of the Neolithic package by the acculturated hunter-gatherers of the region, the discovery of the submerged site of Leucate-Corrège (*Guilaine et al. 1984*) suggested a different possibility: that this situation should instead be largely attributed to differential preservation (flooding of the coastal plains by the Flandrian transgression must have obliterated most such sites) and preferential excavation (karstic deposits being also hugely over-represented in the Palaeolithic and the Mesolithic). If these biases were accounted for, it would seem logical to admit as likely the hypothesis that Cardial dwellings had been largely open air and organised as aggregates of wood huts that could only be described as peasant villages, as documented in the LBK cultures of Central Europe.

That, in all likelihood, such was indeed the case, has been recently demonstrated by the now underwater lakeside site of La Draga (Banyoles, Catalonia). Tarrus *et al.* (*1994*) describe the discovery of posts and planks stuck in the chalk bedrock beneath the archaeological horizon and they report the excavation of three stone paved platforms and 32 associated hearths. From the depth attained by the posts they reconstruct wood structures at least 3 to 4 m high, some of which may have been granaries. 93% of the animal bone fragments belong to domesticates 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 impressions and, besides traditional lithic types (blades, borers, trapeze, 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 *ca.* 7000 and *ca.* 6000 BP.

What about cereal remains? Cereal remains in Neolithic sites are always rare. One could calculate, as an exercise, from the number of Cardial Neolithic sites in France and the percentage that have yielded wheat or barley, the probability that cereal remains will be found at any given Cardial Neolithic site. I am sure that the application of that probability to the very small-sized Portuguese sample would result in predicting that a zero number of sites with such kinds of remains would have been found, as is the case. Thus, so far, the absence is statistically normal and does not place the Portuguese sample outside the range of variability of the other west Mediterranean Cardial sites. Therefore, the only legitimate interpretation of this absence is that it results from our incomplete knowledge of the past, not that it is a feature of that past; put another way, that, in this case, "absence of evidence" is not "evidence of absence". If, as the number of sites increases, the ab-

sence continues to persist, then a problem exists and our attitude towards what qualifies as a legitimate expectation may have to change. For the moment, however, I find the prediction that, in littoral Portugal, cereal remains will eventually be found in association with Cardial pottery, as soon as the appropriate kind of site is found and properly excavated, much less riskier than the opposite prediction that such remains will never be found.

Recent reports from the Buraco da Pala, a rock-shelter in Trás-os-Montes, north-eastern Portugal, have confirmed this view. Wheat and barley were recovered from the base of level IV, in association with impressed wares, polished stone tools and stone querns. The level has yielded two radiocarbon dates, which are in accord with its archaeological content (*Sanches et al. 1993; Sanches 1996*): 5860±30 BP (GrN-19104) and 5840±140 BP (ICEN-935). Buraco da Pala, thus, physically demonstrates that cereal agriculture existed in the most interior region of Portugal in later early Neolithic times. In this context, my assumption that cereal agriculture was associated with the few centuries earlier Cardial settlement of the coastal regions, as it happens wherever the relevant artefact suites are present elsewhere in the west Mediterranean, seems entirely reasonable.

Explaining why, in pure logical terms, the "absence of evidence" should be considered genuine in some instances and apparent in other does not exempt us from the obligation to provide good explanations for the historical reasons that may lie behind the absences which we believe to be genuine. For instance, in the Portuguese argument, why would interior Iberia have been abandoned in the early Holocene and why would late Mesolithic people have similarly abandoned the central limestone massif of Estremadura? A good answer for the second question remains to be found, although it can at least be said that the pattern has archaeological parallels elsewhere in Europe, particularly at the time of the mid-Holocene climatic optimum, when, in southern Scandinavia, "the vast majority of Mesolithic settlement took place along the coasts and at the mouths of river systems (...) as the inland forests increased in density and decreased in biomass and human population" (*Price et al. 1995.115*).

As regards the early Holocene abandonment of the Meseta and adjacent regions, a parallel also exists, this time on the other side of the world: after many thousands of years of occupation throughout the last glacial period, the inland valleys of Southwest Tasmania were abandoned by humans in the early Holocene, when those areas were colonised by a very dense temperate forest (*Porch and Allen 1995*), and remained that way until the time of contact. In Iberia, such an abandonment may be related to the particular geographic and climatic characteristics of the Peninsula. Unlike European areas north of the Pyrenees where the Mesolithic occupation of the hinterland is well documented, the Iberian interior lacks important lakes and the rivers, even the largest (such as the Douro, the Tagus and the Guadiana), tend to dry out in the summer. Therefore, aquatic resources, which were critical in known Mesolithic instances of successful settlement of mainland Europe (as along the Danube), were subject to periodic failure in interior Iberia. In contrast, settlement before 10000 BP had been possible because, then, the main rivers that drain the Meseta 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. So, it may well be that, once forests covered the land and the herbivore biomass was drastically reduced, fish and other aquatic foods were not there in the amount and with the reliability necessary to compensate for such a decrease.

DIFFERENT PEOPLE OR THE SAME PEOPLE IN DIFFERENT PLACES AT DIFFERENT TIMES?

Whittle (*1996.304*) recognises that, in Portugal, the cave of Caldeirão represents a new kind of occupation. However, he finds the interpretation that its cardial burials represent "very occasional visits inland by the people of an indigenous system changing and expanding with the uptake of new opportunities" more likely than the interpretation that "this intake of the interior uplands was associated with the arrival of people other than those of the estuaries, perhaps from southern Spain". This seems to indicate that Whittle believes in one or the other of the two following scenarios:

- instead of a separate cultural group practising a different subsistence economy, the Caldeirão people would actually be Muge people that happened to die in territories exploited occasionally, perhaps seasonally; the produce of those territories would have played a complementary role in a subsistence system otherwise based in the exploitation of the down river estuarine areas;

- although having become a separate cultural group, the Caldeirão people originated in Muge people who, having obtained ovicaprids, decided to move on to hitherto unsettled lands whose exploitation was now made possible by the availability of that newly acquired resource.

The first hypothesis, however, faces two very serious problems:

- why, in spite of being part of the same group, would those people that happened to be buried at Caldeirão have a terrestrial diet, while those that happened to be buried at Muge had an aquatic one, as shown beyond any reasonable doubt by paleodietary evidence (*Lubell et al. 1994*)?

- why, in spite of being part of the same group, would those people that happened to be buried at Caldeirão have proximally flat femora, while those that happened to be buried at Muge had round ones, as shown by osteological evidence (*Jackes et al. 1997*)?

Since the people whose skeletal remains were found at Caldeirão and at the partly contemporary Muge shell-midden site of Cabeço da Arruda had different diets and different femoral shapes, as well as different subsistence and burial practices and a material culture featuring different kinds of artefacts, both in style and in function (*Zilhão 1992a; 1993*), the hypothesis that the two sites represent distinct structural poses of the same adaptive system is simply untenable. The second hypothesis might circumvent these problems by postulating (1) that limb bones are very plastic and that their shape is determined by activities and not by genes (*as argued by Jackes et al. 1997*) and (2) that the cultural and osteological differences between Cabeço da Arruda and Caldeirão would have developed very rapidly once the groups that had left to settle the interior limestone massif successfully adapted to a new environment and a new way of life. This would require, however, that the arrival of ceramics and ovicaprids to the Muge area, whence those settlers presumably originated, pre-dated their first occurrence at Caldeirão. 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 deposits (*Ferreira 1974*). The latter are of epicardial 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 become extinct.

Since the people buried at Caldeirão and those whose remains have been found at other cave sites in the interior limestone massif of Estremadura (such as Almonda) do not seem to have had local ancestors, cannot have been part of the contemporary estuarine hunter-gatherer adaptive systems, and are not offshoots from the latter, the inescapable conclusion is that they must have had an extra-regional origin. Which? The most parsimonious explanation is that they came from the not very distant areas to the east where Neolithic groups with a similar material culture are known to be contemporary or earlier, such as the regions of Valencia and Andalucía, in Mediterranean Spain.

Thus, the only alternative scenarios hitherto suggested for my interpretation of the Caldeirão data are directly contradicted by the empirical evidence available. These scenarios also face serious theoretical difficulties. The first, is that, as convincingly shown by several authors (*e.g. Zvelebil and Rowley-Conwy 1986; Gregg 1988*), early cereal agriculture was not economically superior to European Mesolithic adaptations in terms of work load and long term stability, especially when productive and reliable aquatic resources were available, as was the case in coastal Portugal. It is difficult to see, therefore, what might have been the economic incentives that would have lead the Muge Mesolithic people to adopt ovicaprids as a supplement to their traditional hunter-fisher-gatherer economy.

It could be argued, however, that, in light of the explanation given above for the abandonment of interior Iberia in the early Holocene, ovicaprids might have been critical in at last making possible settlement of those regions, which lacked reliable aquatic resources. Such an argument would have to overcome two major hurdles. The first is that, in the late Mesolithic of the estuarine regions of Portugal, there is no evidence of the population pressure or the resource depletion that might have initiated such a drive towards the settlement of the interior. The second is that hunting and gathering in the forest is ecologically and economically incompatible with maintaining domestic animals, as Rowley-Conwy (*1986*) convincingly argued for the case of pigs. An even stronger case can be made in the case of sheep, since these are animals that feed on grass, a resource that does not exist in Mediterranean woodlands: in this part of the world, if you want grass, you have to burn the trees.

If one wanted to press the case for the Mesolithic adoption of sheep really hard, one might hypothesi-

se that forest management practices such as those that created the parklands of sweet acorn-producing oaks (known, in Portugal, as *montado*) which, in the recent past, covered significant portions of the Iberian hinterland, dated back to those times. Their ultimate origin would lie in the introduction of ovicaprids into otherwise strictly hunting-gathering economies, in the framework of which the new source of food – later to be seconded by cereal agriculture – played the role of providing the staple resource that made it possible to accommodate population growth and to expand into new areas.

Both the historical and the ethnographic records do document the human consumption of sweet acorns and, today, it is true that, in Portugal, cattle and sheep graze in the pasture that grows between the *montado* trees. However, traditionally, this landscape was developed essentially as a system to turn acorns into pork and, in Europe, pigs were not domesticated until the end of the early Neolithic, as shown by Helmer (*1993*) and Rowley-Conwy (*1997*). Harrison (*1996*) mentions palynological data suggesting that these human-created landscapes may go back to prehistoric times, possibly to the Neolithic, in Southwest Andalucía. Palynological evidence from the coastal Alentejo region of Portugal (*Mateus and Queirós 1993.126 127),* where, today, the *montado* is still very extensive, shows the first indications of a human impact on the climacic oak forests coinciding with the onset of the regional Neolithic, around 6000 BP. However:

- there is no evidence of the kinds of massive transformations necessary to produce the *montado* before *ca.* 5400-5000 BP, that is, before the middle Neolithic, when the pine and heath lands that covered the interfluvial sandy soils undergo significant modification;

- "selective deforestation with protection of the cork-oak and the wild olive tree", the mechanism that created the *montado* productive system, did not become a feature of regional landscapes before the late Bronze Age.

Simple consideration of the ecology of temperate Mediterranean forests forces us to exclude, therefore, the hypothesis of a hunter-shepherd-gatherer subsistence system as an explanation for Caldeirão and similar sites in the central limestone massif of Portuguese Estremadura. In this part of the world, it is either sheep and cereals or hunting and plant collecting: in this case, yes, theory alone predicts that you cannot have it both ways. As we have seen, this theoretical prediction is matched by the empirical data available, further reinforcing the idea that it would be completely wrong to interpret as "evidence of absence" "the absence of evidence" for cereal agriculture in the few Portuguese Cardial sites so far known.

CONTINUITY AND DISCONTINUITY IN THE OSTEOLOGICAL RECORD

Jackes *et al.* (*1997.647, 654*) recognise that, in Portugal, "there are archaeological distinctions between Mesolithic and Neolithic artefact assemblages, burial customs and settlement patterns" but "find no evidence for biological discontinuity amongst human groups in Portugal across the Mesolithic-Neolithic transition". In summary, while they "would not deny the possibility of sporadic transcoastal incursions from any direction around the Iberian Peninsula", they think that there is "no evidence for immigration at the levels required to alter the gene pool". Their arguments rest on three kinds of results:

- analysis of non-metrical traits in dentition (mandibular and maxillary molars) would show that there is more difference between four historical Iroquois collections from southern Ontario then there is between Mesolithic and Neolithic Portuguese (Fig. 3); since the American Indian samples comprise populations that are known to have been culturally and biologically homogeneous, these results would indicate genetic continuity;

- teeth decrease in size, as shown for second lower molars (O.c. 648), but this "was not caused by the subsistence shift; it was the continuation of a trend which began much earlier and which was not the result of decreased body size (though there was probably a concomitant shortening of the dental arcade)" (O.c. 654);

- analysis of limb bone morphology shows clear differences in the sizes and in the cross-sectional shapes of both tibiae and femora; the authors, however, consider that "long bones are so clearly plastic that they may alter in shape without genetic change" (O.c. 649); therefore, they consider that these differences are related to activities, not to population replacement at the onset of the Neolithic.

Patterning of non-metrical traits

If one accepts Jackes *et al.*'s view of the southern Ontario data, total population replacement at the

Mesolithic/Neolithic interface would be out of the question. These data, therefore, might be used to refute models of the transition in Mediterranean Europe as correlated with a massive input of biologically distinct, external populations accompanied by extinction without descent of autochtonous Mesolithic groups. I do not think that even the most extreme partisans of the wave of advance explanation of the advent of the Neolithic are suggesting processes of that kind. In any case, as far as I am concerned, and in order to avoid unnecessary confusion, let me reiterate that I do not believe that we are dealing here with Phoenician or Greek-style processes, but with the kinds of small scale population movements documented in small scale prehistoric and ethnohistoric societies. Thus, nothing in the argument put forward by Jackes *et al.* contradicts maritime pioneer colonisation. Continuity at the level implied by the patterns evidenced by them is a feature of this model, since it postulates a proximate origin for the colonists and the subsequent mixture of the newcomers with local Mesolithic groups.

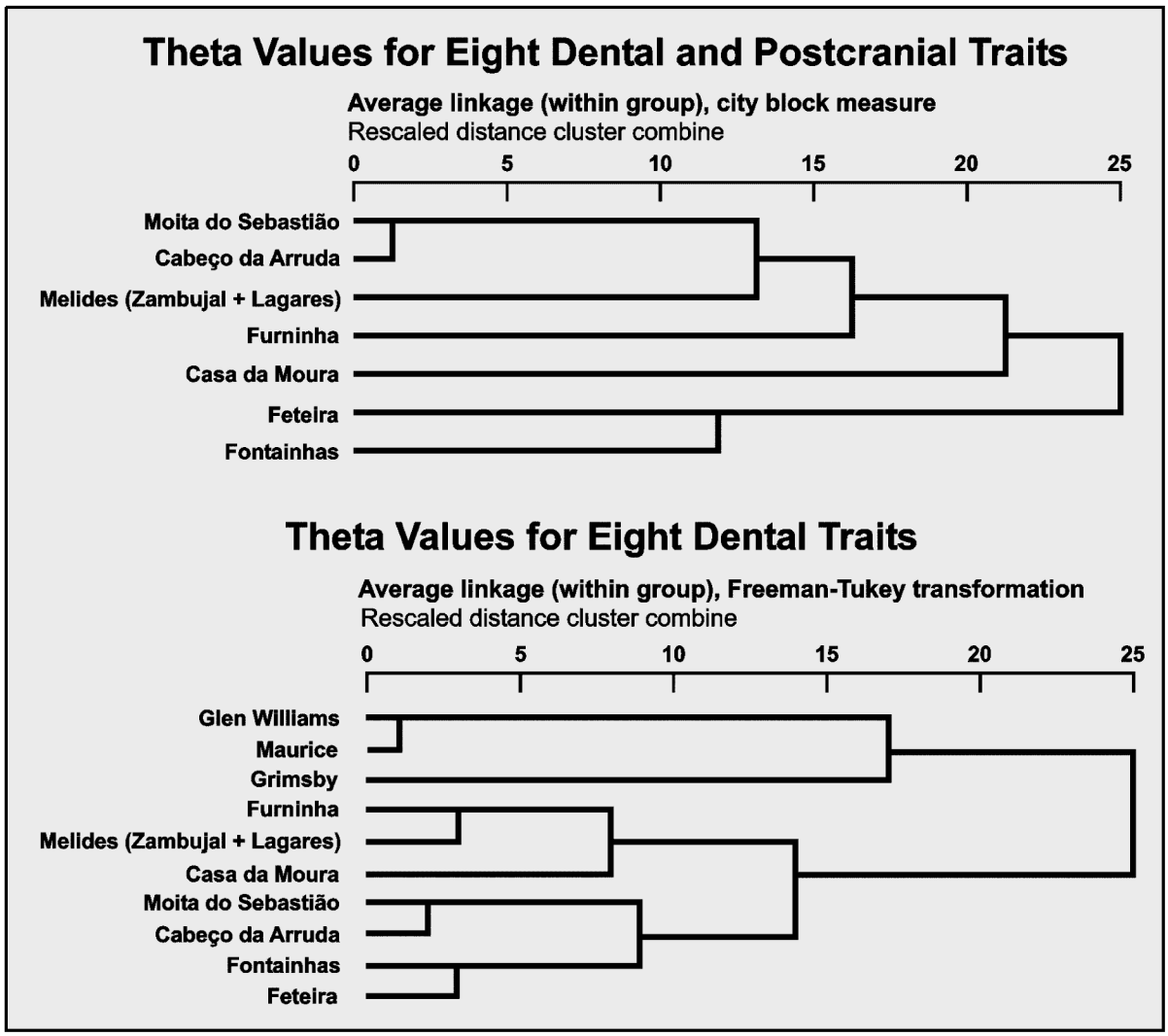

Fig. 3. Results of the cluster analysis of seven Portuguese prehistoric skeletal collections: above, using eight non-metrical traits from dentition and limb bones and controlling for sample size through the application of the city block measure (after Jackes and Lubell n.d.); below, also using eight non-metrical traits but all from dentition and controlling for sample size through the application of the Freeman-Tukey transformation (after Jackes et al. 1997). Moita do Sebastião and Cabeço da Arruda are close-by Mesolithic sites belonging to the Muge cluster of shell-middens, located on a left bank tributary of the Tagus. Melides, Furninha, Casa da Moura, Feteira and Fontainhas were used as burial caves mostly in the Late Neolithic and Copper Age periods, between ca. 4000 and ca. 5000 BP (the collections from Casa da Moura and Furninha also contain an epicardial 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.

In order to make this clearer, let us consider a couple of thought experiments with the southern Ontario data. The dendrograms in Fig. 3 of Jackes et al. (*1997*) group the collections according to their geographic location (*Jackes 1996, Fig. 1*): Grimsby, the southernmost site, is always separate; in Fig. 3A, Glen Williams, 50 km north of Grimsby, clusters with Maurice, another 150 km further north; in Fig. 3B, Glen Williams clusters with nearby Kleinburg. Let us now suppose that a group of Grimsby people (Neutral Iroquois) had moved to the Maurice area (Huron Iroquois), settling there and subsequently mixing with the new neighbours. A few centuries later, if the degree of biological difference between both groups at start is considered not significant, how would one identify such a "pioneer colonisation" in the osteological record, all the more so since the mixing of the two populations would have not increased, but reduced, the difference between them? Instead of a local mixture with Neutral pioneer settlers, one can also hypothesise a quick war followed by genocide, causing the almost complete replacement of the local Huron by the Neutral invaders. Even in that extreme case, it might not be possible to identify the replacement in the osteological record, given the biological similarity between the two. As a result, some students of the past might argue that no population movements had actually taken place and that in the time range of relevance the historical trajectory of the Maurice area could only be described in terms of total biological continuity. We would know, however, that such would not have been the case at all.

In historic times, Iroquois groups spread for some 800 km along a Northwest-Southeast axis (*Fagan 1995*). The distances involved in the west Mediterranean process are not significantly larger. Therefore, if the differences between Grimsby Neutral and Maurice Huron are non-significant in genetic terms, and if the degree of difference between any two Iroquois-speaking groups of North America is found not to be significantly higher than in this example, why should we expect the situation to be different in the prehistoric west Mediterranean? Clearly, if the degree of biological heterogeneity in the late Mesolithic groups of the region was not higher than among historical Iroquois, then the chances are that no osteologically meaningful differences would exist between Mesolithic and Neolithic Portuguese populations, even if the introduction of agriculture was indeed associated with population dispersals, provided that such dispersals originated inside, not outside, the west Mediterranean. At this level of expectation, thus, the kind of "continuity" shown by the data of Jackes *et al.* would be the predictable result if the earliest Neolithic settlement of these regions had been the outcome of pioneer colonisation, as I suggest.

Careful analysis of the argument put forward by Jackes *et al.*, however, makes it quite clear that, in Portugal, there is a lot more biological discontinuity across the Mesolithic/Neolithic boundary than they are willing to admit:

- the first problem with their case lies in the significance of the non-metrical traits analysed; the fact that they do not discriminate between Mesolithic and Neolithic may be due simply to the fact that, at least in this instance, those traits are not good discriminators; although Jackes *et al.* mention that the kind of analysis they performed is commonly used by zoologists when studying intra-specific relationships, they do not inform us of the relevance for that purpose of the specific traits they selected in this case;

- the second problem lies in the composite nature of the Portuguese collections described as "Neolithic"; in actual fact, Furninha and Casa da Moura were used as burials from the late early Neolithic onwards and contain artefact assemblages indicating that they were still in use as burial sites in the Copper and Bronze Ages; the human bone assemblages from the two sites are mixed and it is anybody's guess which percentage of those assemblages is early Neolithic, which is late Neolithic and which is Copper Age or later; my own opinion, based on the relative importance of the artefact suites that can be attributed to the different time periods on typological grounds, is that the late Neolithic component is more important than the others and, thus, I accept that, for broad scale comparisons, the two skeletal assemblages can be considered, on average, as dating from that time period; as for Fontainhas and Feteira, both are late Neolithic to Copper Age and one piece of human bone from Melides (Zambujal) was dated in the Copper Age; therefore, the comparison is at best a comparison between Mesolithic and late Neolithic/Copper Age assemblages, not between Mesolithic and early Neolithic or, at least, pure Neolithic;

- the third problem lies in the extent to which the Iroquois samples are as close as postulated, since the statistics separated Grimsby from Maurice; based on the assumption that, slightly before and at

the time of contact, there was a "gene flow maintained by constant trading", Jackes *et al.* have no doubt that the two belonged to a biologically homogeneous population; they also state, however, that the extent to which the two different nations represented (Huron and Neutral) were as culturally homogeneous as Europeans perceived them is a debated matter; in this context, one would expect the osteological analysis to work as an independent check on the assumption of biological homogeneity; instead, biological homogeneity is assumed and the degree of difference found is deemed biologically non-significant, a conclusion that was already contained in the premises; thus, their argument is circular and can easily be reversed – given that the differences between Grimsby Neutral and Maurice Huron, separated by less than 200 km and less than 100 years, are larger than those documented between the Portuguese collections of Moita (Mesolithic) and Casa da Moura (late Neolithic/Copper Age), separated by less than a third of that amount of space but twenty times as much time, is it not possible that such differences indicate that these two southern Ontario groups may have been biologically more distinct than hitherto suspected?

- the fourth problem lies in the extent to which the statistics are adequate and the resulting graph has any meaning in terms of the real past; Jackes and Lubell (*in press*) used the same technique – the average linkage (within group) dendrogram – to analyse the clustering of the same Portuguese collections according to five of the teeth traits plus three other traits from the limb bones (humerus, talus and calacaneus); the results are totally different (Fig. 3); in Jackes and Lubell (*in press*), Melides is closer to the Muge sites of Moita and Arruda than to any late Neolithic site and the late Neolithic/Copper Age pair of Fontainhas-Feteira is the most separate from the two Mesolithic sites; in Jackes *et al.* (*1997*), however, the pair Fontainhas-Feteira is found to be the closest to Muge, while Melides clusters with Furninha and then Casa da Moura to form a higher level group, well separated from the other collections.

Given the extent to which the degree of biological affinity between the Portuguese collections is affected by the concrete mix of traits analysed and by the statistical manipulations to which the data are submitted, it seems legitimate to state that the conclusion of Jackes *et al.* that biological continuity across the Mesolithic/Neolithic boundary is proved and that external population inputs did not take place at the level required to alter the local gene pools is not at all warranted. Apparently, the only conclusion that can be safely extracted from these data is that Mesolithic groups seem to have been morphologically more homogeneous than those from later times. To what extent the homogeneity of the former can be extended to all coastal Mesolithic groups of Iberia and whether the heterogeneity of the latter is a simple artefact of the composite nature of the samples analysed (namely as regards a weight larger than assumed of the Copper Age and later material), or reflects some real pattern from the past, is something that, for the moment, cannot be securely evaluated. It does not seem too controversial, however, to state that this late Neolithic increase in heterogeneity is exactly what should be expected as the outcome of the interaction processes suggested in the framework of the maritime pioneer colonisation model.

Measurable changes in size and shape

The first problem that has to be addressed in the discussion of Jackes *et al.*'s interpretation of the changes in teeth, femora and tibiae is that of how they occur in time. Their point of view can only be sustained if it is shown that the temporally intermediate early Neolithic represents a morphologically transitional stage from the Mesolithic condition to the late Neolithic/Copper Age condition. Although a superficial reading of some of their graphs might suggest that such was indeed the case, a more careful analysis would show that impression to be the result of an inadequate and misleading presentation of the data. Jackes *et al.* chart bone and tooth dimensions on the y-axis against time in the x-axis. The x-axis, however, is not scaled. This gives the impression that their samples are evenly spaced in time and that they represent a continuum substantiating the view of the changes as the outcome of a long trend. That is absolutely not the case, however. Between their latest Muge sample and their earliest Neolithic sample there are 1500 mostly empty years, corresponding to the early and the middle Neolithic, which are represented only by isolated specimens or very small-sized collections.

What happens in this hiatus is crucial for the argument. Unfortunately, the scarcity of the data does not allow significant quantitative comparisons with those from earlier and later time periods. The mean adult tibial mid-shaft index of the Cardial Cadeirão people (archaeological horizon NA2, there are no data for the subsequent epicardial burials), for in-

stance, has too large standard deviation. Whatever is known regarding the other osteological indices analysed, however, suggests that, contrary to Jackes *et al.*'s interpretation, the late Neolithic/Copper Age morphologies are not the outcome of a trend beginning in the Mesolithic, since the early Neolithic condition, instead of being intermediate, is already identical to that found in subsequent agricultural populations:

- the average bucco-lingual breadth of the lower second molars of the epicardial people buried at Caldeirão (archaeological horizon NA1, the earlier cardial burials contained a single measurable specimen) is in the size range of the late Neolithic/Copper Age and, in actual fact, is even lower than at Furninha (Fig. 4);

- the platymeric index of the proximal shaft of adult left femora shows that the single cardial specimen from Caldeirão has a value in the range of those from the later Neolithic of the same region, clearly lower than in the Mesolithic (Fig. 5).

The importance of these facts is further highlighted by the fact that, as shown by radiocarbon, the cardial people buried at Caldeirão were contemporary with the latest Muge people (Fig. 1). Therefore, if further research confirms that the late Neolithic/Copper Age pattern was already established in those earliest Neolithic populations, then the differences between Muge and Caldeirão cannot be considered to represent the outcome of a long trend, but, instead, have to be considered as representing the sudden appearance in the osteological record of a series of unprecedented features, occurring in the some places and at the same time as the similarly unprecedented irruption in the archaeological record of pottery, sheep and polished stone tools.

This simple fact, in turn, refutes the interpretation of the advent of the Neolithic in Portugal as a gradual process not only at the biological level, but also at the economic level. Even if we admit that, as claimed by Jackes *et al.*, the differences in the size and the shape of the lower limb bones are solely due to activities, then the daily life and, hence, the subsistence practices of the Caldeirão and Muge people must have been quite different. If cereal agriculture did not develop in Portugal before the late Neolithic and the life styles of the first pottery-bearing groups were so similar to those of the Mesolithic, with hunting supplemented by sheep herding and vegetal foods obtained only through wild plant collection,

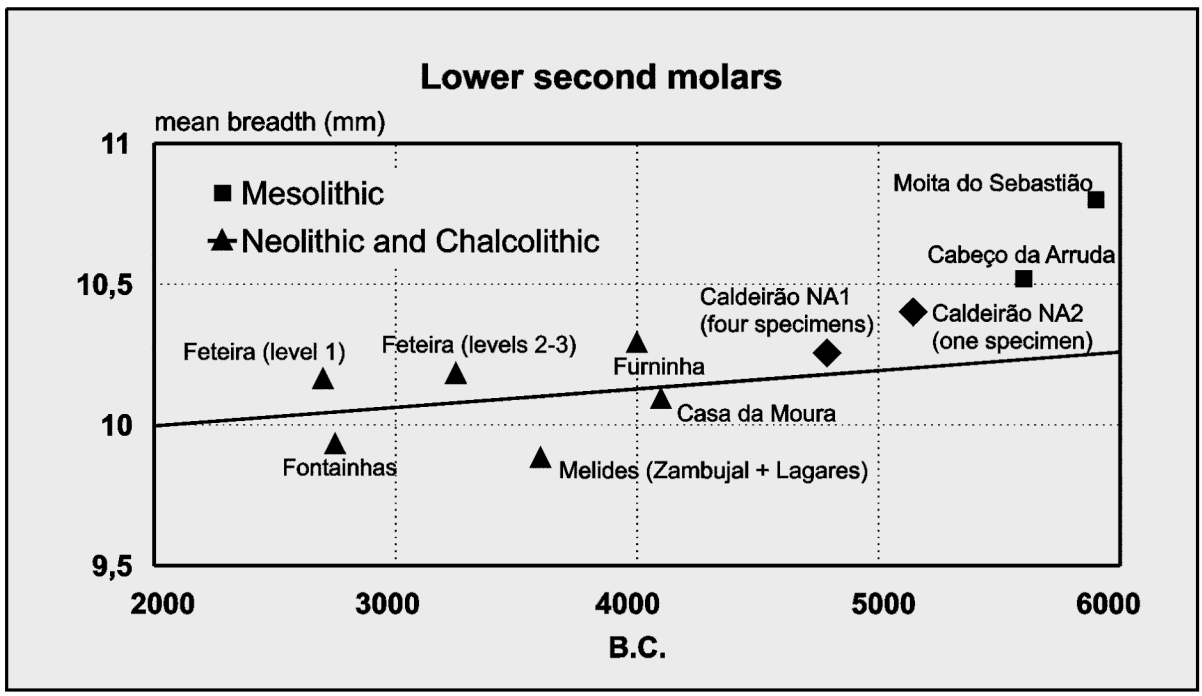

Fig. 4. Average bucco-lingual breadth of the lower second molars of late Neolithic/Copper Age and Mesolithic samples from Portugal (after Jackes at al. 1997). Retrodicting the values obtained for late Neolithic/Copper Age collections into Mesolithic times would give results lower than those actually observed. The values for the earliest Neolithic molars are already in the range of those from later periods. Thus, the late Neolithic/Copper Age tooth size pattern is not the outcome of a gradual trend beginning in the Mesolithic. Instead, it becomes established abruptly at the Mesolithic-Neolithic boundary.

as some have argued, how did such similar activities generate such different bone morphologies? Thus, the conclusion seems inescapable that late Mesolithic and early Neolithic groups of Portuguese Estremadura were indeed culturally distinct entities with distinct life styles, which, given their contemporaneity and spatial segregation, argues in favour of the pioneer colonisation model, not in favour of an entirely local, gradual transition.

Furthermore, if brought about by changes in activities and in the environment, as postulated by Jackes *et al.*, then changes in femoral size and shape across the Mesolithic/Neolithic boundary must have been, in Darwinian terms, a result of the "survival of the fittest". The genes of those who by chance had teeth that equipped them to make the best of the new food resources and limb bone morphologies that enabled them to perform better in forest clearance, in the heavier work load of agricultural life, or in the rougher terrain of the limestone interior, would have had a better chance of making it into the next generations. Ultimately, thus, the new morphologies would have become dominant in the whole population. However, as thoroughly and elegantly shown by Dawkins (*1991*), natural selection needs time and, given the chronometric data available, not enough time existed in Portugal for such a process to take place. As shown above, available data suggest that early Neolithic people were identical to those from later periods instead of having the intermediate shape between Mesolithic and late Neolithic/Copper Age required by a Darwinian explanation of the latter as the result of a trend determined by adaptation to new activities and a new environment.

Thus, even if we accept the explanation provided by Jackes *et al.* for the changes in limb bone morphology as unrelated to genetics and exclusively caused by changes in activity patterns, an external population input has to be postulated. Otherwise, the change cannot be interpreted as a process driven by natural selection. In order to clarify this point, let us assume, for the sake of the argument, that the people buried at Muge and Caldeirão derive from the same close ancestor population. The latter, as suggested by Whittle (*1996*), might correspond to Muge people who, having obtained ovicaprids, decided to move on to lands hitherto unsettled. What was the biological mechanism involved in the acquisition by those Caldeirão people of the new limb bone mor-

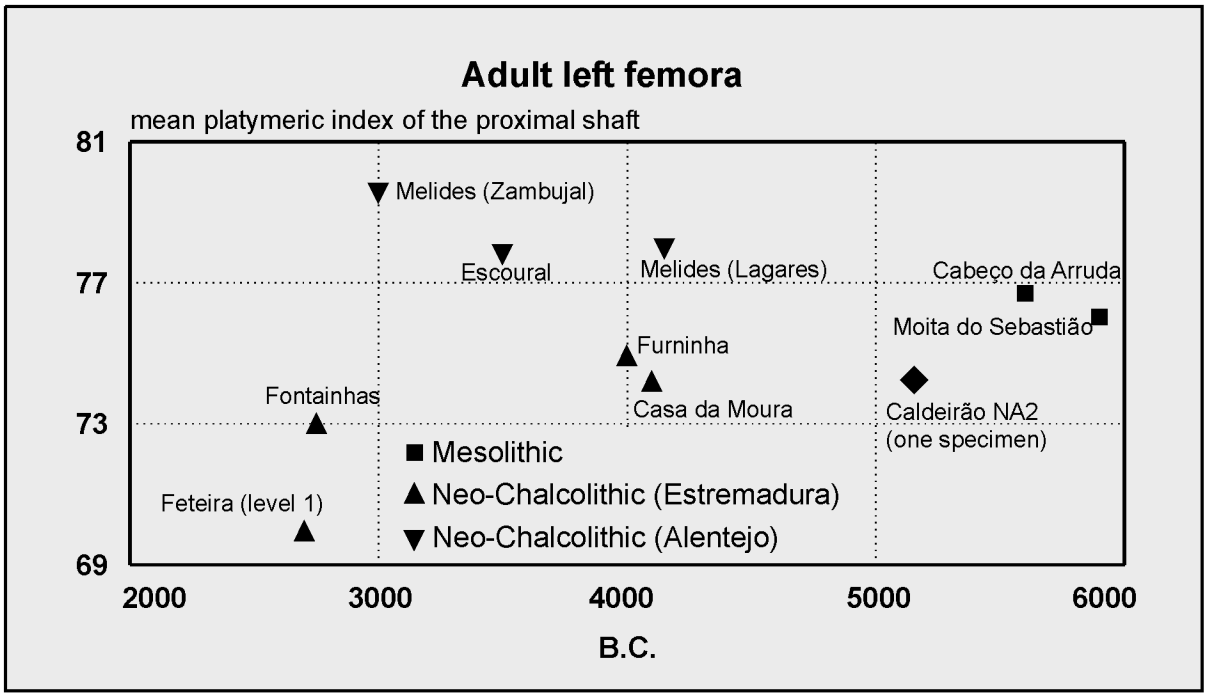

Fig. 5. Mean platymeric index of the proximal shaft of adult left femora of late Neolithic/Copper Age and Mesolithic samples from Portugal (after Jackes at al. 1997). The single Cardial specimen from Caldeirão has a value in the range of those from the later Neolithic of the same region, clearly lower than in the Mesolithic. There seems to be a marked variation, dictated by region of provenience, in late Neolithic/ Copper Age collections: samples from Estremadura have lower indices than those from Alentejo. This may indicate that, in the latter region, the contribution of local Mesolithic people to the gene pool of subsequent populations was more important than in Estremadura.

phology, particularly as regards their larger and flatter femora? Given that its apparently sudden irruption in the bioarchaeological record does not leave enough time for the operation of Darwinian processes and that Jackes *et al.* believe that "long bones are so clearly plastic they may alter in shape without genetic change", one can conceive of three possible alternatives to natural selection that might have brought about the changes in the very short time required (a few generations at most):

- the larger and flatter femora of the earliest Neolithic people (as well as their smaller teeth) may have developed solely as a result of changes in nutrition, particularly if these people grew wheat and barley, as well as herding sheep and goats;

- the femora of the first settlers changed during their life time as a result of adaptation to different environments and activities and their children were already born with bigger and flatter femora due to a Lamarckian transmission of acquired traits;

- the shape of femora is not determined at birth, but, instead, is susceptible of ontogenetical development towards round femora in some situations and towards flat femora in other, the latter being the case with the particular combination of environment and activities that existed at Caldeirão.

The nutritional hypothesis is rejected altogether by Jackes *et al.* (*1997.649*) themselves. They invoke North American studies of the transition to agriculture where genetic continuity was not in question and which attributed observed changes in femoral mid-shaft and subtrochanteric dimensions to altered mechanical stresses, not to nutrition. They also reject (p. 651) that the sabre-shinned tibiae of the Muge people may have been a result of protein deficiency, given the archaeological evidence that their diet was protein-rich.

Regardless of how one evaluates the merits of Lamarckism, the hereditary transmission of acquired femoral shape is empirically contradicted by the American evidence provided by Gilbert and Gill (*1990*). They observe that the proximal femoral shafts of Indians are flatter than those of European colonists and that this applies both to Plains hunters and to Post-Classic Maya farmers. This observation illustrates, in the first place, why biomechanical processes alone do not suffice to explain differences in femoral shape: the femora of Indian hunters are identical to those of Indian farmers and different from those of White pioneers with a similar life style based on hunting. Forensic Indian data provided by the same authors also show that femoral shape is not acquired through a simple change in activities and then transmitted to subsequent generations: "though their environment was essentially that of modern White society, the [forensic] femora continued to display a morphology like that of ancient Indians rather than Whites".

The inadequacy of explanations postulating that femora acquire their adult shape as a result of biomechanical processes occurring during ontogenesis is confirmed by the empirical data supplied by Jackes *et al.* (*1997*). In that case, one would predict different femoral shapes for males and females, caused by the sexual division of labour, as suggested by the analysis they quote of the osteological correlates of the transition to agriculture in Alabama, which showed a differential increase in the robusticity of the long bone diaphyses of males. Although no data on gender differences were available for the femora of the late Neolithic/Copper Age samples, due to the nature of ossuaries, the issue could be addressed for the Mesolithic examples with the following result: "we can discern no significant gender-based difference in the proximal femoral index in the Mesolithic material" (*Jackes et al. 1997.649*).

An ontogenetic mechanism might also be envisaged in Jackes *et al.*'s interpretation of the side differences in femoral shape, identified in the Portuguese material: "the left proximal femur of Portuguese Mesolithic and Neolithic adults has a significantly lower platymeric index than the right", suggesting that "biomechanical factors, activity and terrain, but not genetics, must be considered important to platymeria". Since the authors interpret higher platymeric indexes as indicating less robusticity and lower platymeria as indicating more robusticity, their data would show that Portuguese Mesolithic and Neolithic people would have left sides stronger than right ones, if platymeria is a direct function of activities; that is, a majority of the population would then be made up of left-handed persons!

Since this is highly unlikely, it seems more parsimonious to admit that, whatever the cause may be for the side differences, it most certainly is not related to a differential, activity-induced and ontegenetically-developed robusticity of the limbs. This conclusion is further strengthened by the fact that the sta-

tement of Jackes *et al.* (*1997*) that, in Portugal, "the less rugged the terrain, the higher the [femoral platymeric] index", is refuted by the way the different collections pattern in Fig. 5. Contrary to their interpretation, there is a marked variation in proximal femoral shape in the late Neolithic/Copper Age collections dictated by region of provenience, not by nature of the terrain. Samples from Estremadura (Furninha, Casa da Moura, Fontainhas, Feteira) have low indices (the highest mean value is 74.89), while those from the Alentejo have high indices (the lowest mean value is 77.89). The latter include both littoral (the two Melides collections) and interior (Escoural cave) sites, that is, low sandy coasts as well as hilly limestone topographies similar to those from Estremadura.

That there is no simple, direct causal relation between femoral shape, robusticity and activities and that femoral shape appears to be under genetic control rather than environmentally regulated, as Gilbert and Gill (*1990*) have shown with historical and forensic American information, is also quite clear from due consideration of the data on archaic and early modern humans supplied by Trinkaus (*1997*). The subcircular mid-femoral shape of archaic humans remained stable world-wide for 1.8 million years and, while it is archaic humans that are generally considered to have been more robust, it is the early moderns, not them, who have flat femora and, therefore, low platymeric indexes. Furthermore, Neanderthals and contemporary early modern humans had different femora in spite of having similar life styles. Presumably, part of the explanation for this difference must relate to the fact that they were genetically different groups largely isolated from each other, as shown by recent fossil DNA analysis (*Krings et al. 1997*).

Thus, if further work confirms that, in Estremadura, the late Neolithic/Copper Age femoral morphology was already present in Cardial times, then the simplest explanation, and the only that is compatible with Darwinian biology, is that an external population with a limb morphology different from that of the indigenous Mesolithic groups entered the scene. The particular femoral morphology of this external population would have developed elsewhere, for one reason or the other, but surely in a situation where enough time had existed for that condition to become dominant, either because it was adaptive or because it was indirectly induced by changes in nutrition related to an agricultural way of life. Or, more simply, that condition may have been dominant in such external founder populations perhaps because that was already the case among more remote ancestral groups in the areas where agriculture first appeared and from where it subsequently spread.

Furthermore, although, given the problems with the samples, it may be premature to take for granted the regional differentiation in the proximal morphology of Portuguese femora apparent in Fig. 5, such a differentiation would represent an extremely powerful argument in support of such an external population input to have occurred and to have occurred precisely in the way predicted by the pioneer colonisation model. As I have previously discussed at length (*Zilhão 1992a; 1993*), I believe that the first Neolithic enclaves created by pioneer groups originating in southern Spain were located in Algarve and Estremadura and that the Alentejo coast was skipped. It would have been only subsequently, in epicardial times, around 6000 BP, after the new economic system had become established throughout most of central and southern Portugal, that the hunter-gatherer groups surviving along the Alentejo coast were assimilated into it, perhaps through indigenous adoption. Thus, the model predicts that the contribution of local Mesolithic people to the gene pool of subsequent Neolithic populations would have been larger in Alentejo than in Estremadura. That might explain why, although their size increased everywhere, the morphology of femora in the late Neolithic/Copper Age remained closer to the Muge Mesolithic pattern in Alentejo than in Estremadura.

The establishment of a connection between the femoral shape of the earliest Neolithic people of Estremadura and an external population input would benefit from the acquisition of the relevant data regarding neighbouring areas of Mediterranean Spain. If a similar situation is shown to occur there, this interpretation of the evidence would be considerably strengthened. For the moment, at least, it would seem that this explanation is the most consistent with the empirical archaeological and osteological data, as well as with a view of human evolution as driven by Darwinian natural selection.

MESOLITHIC AND NEOLITHIC IN COASTAL ALENTEJO

The significance of Cardial pottery as a proxy for the first introduction of the Neolithic package in the Mediterranean areas west of the Languedoc has recei-

ved recent confirmation, in Portugal, thanks to the radiocarbon dating of two contexts in the western Algarve:

- Cabranosa, an open air settlement (*Zbyszewski et al. 1981*), was dated to 6880±60 BP (Sac-1321) on a shell sample (*Cardoso et al. 1996*), which, after correction for the reservoir effect (which gives shell dates in this time range an excess age of 380±30 years – Soares 1993), translates into 6500±70 BP;

- Padrão, another open air settlement with Cardial pottery (*Gomes 1994a; 1994b*), was dated on shell samples to 6800±50 BP (ICEN-645) and to 6920±60 BP (ICEN-873), which, after correction for the reservoir effect, translate, respectively, into 6420±60 BP and 6540±70 BP.

These dates suggest that the limestone country of the Algarve was settled by farmers at the same time as the geologically and environmentally similar areas of Estremadura to the north, thus confirming the pattern of contemporaneity between this early Cardial settlement and the Mesolithic hunter-gatherer adaptations of the coast and estuaries of the geographically intermediate region of Alentejo, which survived until *ca.* 6000 BP. Although this further strengthens the mosaic frontier pattern previously described for Portugal (*Zilhão 1992a; 1993*) and, therefore, the maritime pioneer colonisation model, it should be borne in mind that the interpretation given by Soares (*1997*) for the dates she recently published for the Alentejo site of Vale Pincel is in contradiction with the model. However, that interpretation is ill-founded.

In the time period of relevance for the analysis of the Mesolithic-Neolithic transition in Portugal (7000-6000 BP), the Alentejo coast features three kinds of sites:

- large shell-middens with no indisputably Neolithic artefacts (pottery and polished stone tools) and a mammal fauna featuring exclusively wild species, such as Fiais or Samouqueira;

- small shell-middens with no domesticates but with a few Neolithic artefacts of questionable association with the midden deposit, such as Medo Tojeiro;

- large non-midden sites (in some instances with hearths and other features) with pottery but yielding no direct evidence on subsistence (due to the acidity of the sandy soils, which precluded the preservation of bone), such as Vale Pincel.

Soares (*1992; 1995; 1997*) has argued that the first kind of site represents Mesolithic base camps. The other two would belong to a single, logistically organised, Neolithic settlement-subsistence system developed through indigenous integration in the traditional way of life of the new resources and related kinds of new artefacts: the small sites, featuring low artefact densities, where only hunting and gathering activities are represented, would be temporary camps; the large sites, with high artefact 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 querns), acquired through contacts with the coastal farmers.

This view of the evidence is totally inconsistent with the empirical data:

- as shown by Arnaud (*1982; 1987; 1989; 1990*), in the Mesolithic sites of the inner estuary of the Sado ceramics and other Neolithic artefacts, when at all present, only appear in the upper sections of the sequences, above the midden deposits, not inside them; with one exception, Amoreira, where the midden level in question (radiocarbon dated to *ca.* 6000 BP) was very late, the deposition of such items post-dates the Mesolithic occupations represented by the shell-middens, which begin around 7500 BP;

- similarly, the Medo Tojeiro midden contained no Neolithic artefacts; as the excavators state, "the only artefacts ... considered to be indisputably Neolithic were found on the deflated surface of the midden, overlain by dune sand" (*Lubell, in litteris, 9 June 1991*);

- the small sized assemblage of decorated ceramics recovered at Vale Pincel is of an epicardial style elsewhere dated in Portugal to the period between *ca.* 6000 and *ca.* 5700 BP; it is also strikingly similar to the pottery recovered in the deposits that overlie the Mesolithic middens of the Sado; given available dates, that pottery cannot be older than *ca.* 6000 BP; thus, the hearths dated at Vale

Pincel cannot possibly be associated with the Neolithic occupation documented by the epicardial ceramics recovered there;

- the supposed "Mesolithic base camps", such as Samouqueira, would be later than the supposed locally evolved "Neolithic village settlements", such as Vale Pincel; Samouqueira is dated at 6370 ± 70 BP (TO - 130) (*Lubell and Jackes 1988*), while the two dates published by Soares (*1997*) for Vale Pincel are 6700 ± 60 BP (ICEN-724) and 6540 ± 60 BP (ICEN-723);

- Soares (*1997*) avoids the contradiction above through defining the site of Samouqueira as "Mesolithic" and the human skeleton from which the date was derived as "Neolithic"; she implicitly assumes, therefore, that the site is earlier and the burial intrusive; however, the excavators (*Lubell and Jackes 1985*) mention no archaeological evidence of intrusion, no Neolithic artefacts were associated with the skeleton (in actual fact, none were recovered at the site) and 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*);

- Medo Tojeiro, the prototype of Soares's "Neolithic temporary camps" had a lithic artefact density of 8/m^3; although this is exceedingly low indeed, Vale Pincel, the prototype of her "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 artefacts per square meter in levels 2d/3 (the base of the archaeological level, where the dated hearths and other features described as "hut-floors" were found);

- such extremely low lithic artefact 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 epicardial 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 1997*); at Mesolithic Samouqueira, Soares (*1997*) gives herself values of *ca.* 400/m^3.

My alternative view of the Alentejo data (*Zilhão 1992a;1993*) is that:

- the shell-middens of the inner estuary of the Sado and the Mira are indeed contemporary with those from the coast, which accumulated between *ca.* 7000 and *ca.* 6000 BP; all of which (Medo Tojeiro, Vidigal and Samouqueira), however, are Mesolithic in material culture as well as in subsistence;

- the first Neolithic occupation of these areas dates to around 6000 BP and is characterised by ceramics of epicardial style such as those that have been recovered in the upper part of the Sado sequences and at Vale Pincel.

The contradiction between this view and the radiocarbon dates reported by Soares (*1997*) for Vale Pincel is only apparent. As I have previously argued (*Zilhão 1993*), this is a disturbed, multi-component site that in all likelihood was also occupied in the Mesolithic. The new dates confirm such an earlier occupation. In fact, when the evidence is seen through the appropriate taphonomic filters, it becomes clear that:

- Vale Pincel is seriously disturbed, as indicated by the low density of finds, the slope of the sandy deposits containing the Neolithic material (level 2) 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*);

- the hearths (*cuvettes* of hardened, reddish sands containing charcoal and burnt cobbles) encrusted in level 3 must be related to a pre-Neolithic occupation, since their topographical relation with the overlying Neolithic deposit indicates that they too were affected by the erosional processes ante-dating its accumulation (the upper part of the cuvettes is convex and protuberant, outcropping from the surface of level 3 extant during excavation); it was in such combustion features that the samples dated were collected; thus, the radiocarbon ages obtained, falling in the time range of the local Mesolithic, are in good agreement with the site stratigraphy;

- the scant data available on the vertical distribution of artefacts indicates that units 2d/3 of the excavators do contain a bladelet/segment lithic

component identical to that from the Sado middens and independently suggesting a Mesolithic use of the area; that these units also contain Neolithic ceramics is not surprising given that they include the material collected in the "hut-floors", where the erosion processes that affected the Mesolithic surface mixed the Mesolithic material with that deposited during the first Neolithic use of the area;

- the presence of distinct cultural components is hardly surprising given the huge area covered by the site (some 10 ha); at nearby Samouqueira, in a much smaller area, two different *loci* were identified – Samouqueira I, the Mesolithic site discussed above, and Samouqueira II, where, on the basis of surface collection, Silva and Soares (*1981*) identified both Mesolithic and early Neolithic occupations.

Similar taphonomic patterns are known from sites in similar geological contexts in Estremadura and in the Algarve. At Ponta da Vigia (*Zilhão et al. 1986*), 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 I believe to be 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 base of a fallen menhir; it was the discovery of the latter that prompted the excavation. Its close proximity to the hearth initially led the excavator to believe that its erection actually dated back to early Neolithic times (*Gomes 1994a*). A sequence in unconsolidated sands presenting exactly the same characteristics as those I suggest for Vale Pincel (occupations in direct stratigraphic contact, with material from the later occupation found in dense pockets excavated by erosion in the underlying deposits containing the earlier occupation), but featuring Upper Solutrean and Terminal 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, gradual, piecemeal adoption by local hunter-gatherers of the several elements of the Neolithic package, starting as early as 6700 BP. Whether the epicardial Neolithic that appears throughout the region around 6000 radiocarbon years ago represents an expansion of the farmer groups that previously settled the neighbouring regions of Algarve and Estremadura or the final "surrender" of local hunter-gatherers to the new subsistence system remains to be clarified. As argued above, the late Neolithic osteological data from cave ossuaries in Alentejo can be interpreted in favour of the latter, that is, in favour of local hunter-gatherers having indeed made an important contribution to the gene pool of subsequent populations. Only when comparable data from the Sado middens and the regional early Neolithic are obtained will we be able to evaluate this possibility with more consistent data.

CONCLUSION

The above review of the archaeological evidence shows an overwhelming support for the pioneer colonisation model. Osteological data are more ambiguous and have warranted different interpretations but it seems fair to infer from the discussion of the data supplied by Jackes *et al.* (*1997*) that some discontinuities do exist and that their appearance in the record, coinciding with that of the Neolithic package, signals the kind of limited external population input postulated by the model.

A definitive test of competing explanations can be obtained through comparison of genetic material extracted from the prehistoric human remains themselves. If people moved along with domestic resources, it would be possible to establish mitochondrial DNA 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 Europe. If the Caldeirão people were shown to belong to such maternal lineages and the Muge and Sado 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 did or did not affect the skeletal morphology of succeeding populations.

If the skeletal morphology of the hypothesised pioneer groups was significantly different and if its input was important, as might have been the case if local hunter-gatherers were rapidly absorbed by agriculturalist groups with higher reproductive rates, one would have considerable changes. 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 adaptation to different kinds of work patterns and new types of terrain; in the words of Jackes *et al.*, immigration would have taken place but not at the levels necessary to alter the gene pool.

Current research, in association with a team of the University of Barcelona under the direction of Daniel Turbón, is addressing exactly this issue through the comparison of fossil genetic material extracted from the Caldeirão and Muge burials. Its results will hopefully shed some definitive light on the role played by demic diffusion in the emergence of Neolithic subsistence economies in west Mediterranean Europe.

∴

REFERENCES

AMMERMAN A. J., CAVALISFORZA L. L. 1973. A population model for the diffusion of early farming in Europe, in RENFREW C. (ed.), *The Explanation of Culture Change. Models in Prehistory*: 343-357, London, Duckworth.

1984. The Neolithic Transition and the Genetics of Population in Europe, Princeton, Princeton University Press.

ARAÚJO A. C. 1997. O concheiro mesolítico de Poças de São Bento, vale do Sado. Unpublished manuscript.

ARIAS P. 1991. De cazadores a campesinos. La transición al neolítico en la región cantábrica, Santander, Universidad de Cantabria - Asamblea Regional de Cantabria.

1992. Estrategias económicas de las poblaciones del Epipaleolítico avanzado y el Neolítico en la región cantábrica, in MOURE A. (ed.), *Elefantes, ciervos y ovicaprinos. Economía y aprovechamiento del medio en la Prehistoria de España y Portugal*: 163-184, Santander, Universidad de Cantabria.

1994. El Neolitico de la región cantábrica. Nuevas perspectivas. Trabalhos de Antropologia e Etnologia 34 (1-2): 93-118.

ARNAUD J. M. 1982. Néolithique ancien et processus de néolithisation dans le sud du Portugal. Archéologie en Languedoc, no. spécial (Actes du Colloque International de Préhistoire): 29-48.

1987. Os concheiros mesolíticos dos vales do Tejo e do Sado: semelhanças e diferenças. Arqueologia 15: 53-64.

1989. The Mesolithic Communities of the Sado Valley, Portugal, in their Ecological Setting. In C. BONSALL (ed.), *The Mesolithic in Europe*: 614-631, Edinburgh, John Donald.

1990. Le substrat mésolithique et le processus de néolithisation dans le sud du Portugal, in CAHEN D., OTTE M. (eds.), *Rubané et Cardial*, E.R.A.U.L., Liège 39: 437-446.

BEDNARIK R. G. 1995. The Côa petroglyphs: an obituary to the stylistic dating of Palaeolithic rock art. Antiquity 69: 877-882.

BINDER D. 1989. Aspects de la néolithisation dans les aires padane, provençale et ligure, in AURENCHE O., CAUVIN J. (eds.), *Néolithisations*, Oxford, British Archaeological Reports International Series 516: 199-226.

(in press). Mesolithic and Neolithic interaction in southern France and northern Italy: current research and hypotheses, in PRICE T. D. (ed.), *Europe's First Farmers*, Cambridge, Cambridge University Press.

BUDJA M. 1996. Neolithization in the Caput Adriae region: between Herodotus and Cavalli-Sforza. Poročilo o raziskovanju paleolitika, neolitika in eneolitika v Sloveniji XXIII: 69-76.

CALAFELL F., BERTRANPETIT J. 1993. The genetic history of the Iberian Peninsula: a simulation. Current Anthropology 34 (5): 735-745.

CARDOSO J. L., CARREIRA J. R., FERREIRA O. V. 1996. Novos elementos para o estudo do Neolítico antigo

da região de Lisboa. Estudos Arqueológicos de Oeiras 6: 9-26.

CARVALHO A. F., ZILHÃO J. 1994. O povoado neolítico do Laranjal de Cabeço das Pias (Torres Novas), in Actas das V Jornadas Arqueológicas (Lisboa, 1993), 2: 53-67, Lisboa, Associação dos Arqueólogos Portugueses.

DAWKINS R. 1991. The Blind Watchmaker, Harmondsworth, Penguin Books.

FAGAN B. 1995. Ancient North America. The archaeology of a continent, 2nd edition, London, Thames and Hudson.

FERREIRA O. V. 1974. Acerca das cerâmicas neolíticas encontradas na parte superior dos concheiros da região de Muge. Comunicações dos Serviços Geológicos de Portugal 57: 191-197.

GEDDES D. 1981. Les débuts de l'élevage dans la vallée de l'Aude. Bulletin de la Société Préhistorique Française 78: 370-378.

1983. Neolithic transhumance in the Mediterranean Pyrenees. World Archaeology 15 (1): 51 - 66.

GILBERT R., GILL G. W. 1990. A metric technique for identifying American Indian femora. In GILL G. W., RHINE S. (eds.), *Skeletal attribution of race*: 97-99, New Mexico, Maxwell Museum of Anthropology.

GOMES M. V. 1994a. Menires e cromeleques no complexo cultural megalítico português – trabalhos recentes e estado da questão. In *O Megalitismo no Centro de Portugal. Actas do Seminário (Mangualde, Novembro de 1992)*: 317-342, Viseu.

1994b. Escavações arqueológicas em Padrão 1 - Vila do Bispo. Relatório da campanha de 1994. Unpublished manuscript.

GONZÁLEZ MORALES M. 1992. Mesolíticos y Megalíticos: la evidencia arqueologica de los cambios en las formas productivas en el paso al megalistismo en la Costa Cantábrica. In MOURE A. (ed.), *Elefantes, ciervos y ovicaprinos. Economía y aprovechamiento del medio en la Prehistoria de España y Portugal*: 185-202, Santander, Universidad de Cantabria.

1996. La transición al Neolítico en la Costa Cantábrica: la evidencia arqueológica, in *Actes. I Congrés del Neolític a la Península Ibérica*, Gavà, Museu de Gavà 2: 879-885.

GREGG S. A. 1988. Foragers and farmers. Population Interaction and Agricultural Expansion in Prehistoric Europe, Chicago, The University of Chicago Press.

GUILAINE J. 1976. Premiers bergers et paysans de l'Occident méditerranéen, Paris, Mouton.

1993. Questions ouvertes sur la néolithisation de la haute vallée de l'Aude. In GUILAINE J., BARBAZA M., GASCO J., GEDDES D., COULAROU J., VAQUER J., BROCHIER J-E., BRIOIS F., ANDRÉ J., JALUT G., VERNET J.-L. *Dourgne. Derniers chasseurs-collecteurs et premiers éleveurs de la Haute-Vallée de l'Aude*: 443-476, Toulouse/Carcassonne, Centre d'Anthropologie des Sociétés Rurales/Archéologie en Terre d'Aude.

GUILAINE J., FREISES A., MONTJARDIN R. (eds.) 1984. Leucate-Corrège. *Habitat noyé du Néolithique cardial, Toulouse/Sète*, Centre d'Anthropologie des Sociétés Rurales/Musée Paul Valéry.

HARRIS D. H. 1996. The Origins and Spread of Agriculture and Pastoralism in Eurasia: an overview. In HARRIS D. H. (ed.), *The Origins and Spread of Agriculture and Pastoralism in Eurasia*: 552-573, London, Routledge.

HARRISON R. A. 1996. Arboriculture in Southwest Europe: dehesas as managed woodlands. In HARRIS D. H. (ed.), *The Origins and Spread of Agriculture and Pastoralism in Eurasia*: 363-367, London, Routledge.

HELMER D. 1993. Les suidés du Cardial: sngliers ou cochons? In GUILAINE J., ROUDIL J.-L., VERNET J.-L. (eds.), *Premières communautés paysannes en Méditerranée Occidentale*: 215-220, Paris, Centre National de la Recherche Scientifique.

IGLESIAS J. C., ROJO M. A., ALVAREZ V. 1996. Estado de la cuestión sobre el Neolítico en la Submeseta Norte. In *Actes I. Congrés del Neolític a la Península Ibérica*, Gavà, Museu de Gavà 2: 721-734.

IRWIN G. 1992. The prehistoric exploration and colonisation of the Pacific, Cambridge, Cambridge University Press.

JACKES M. 1996. Complexity in Seventeenth Century Southern Ontario Burial Practices, in MEYER D. A.,

DAWSON P. C., HANNA D. T. (eds.) – *Debating Complexity. Proceedings of the 26th Annual Chacmool Conference*: 127-140, Calgary, The Archaeological Association of the University of Calgary.

JACKES M., LUBELL D. (in press). Human skeletal biology and the Mesolithic-Neolithic in Portugal. In BINTZ P. (ed.), *Epipaléolithique et Mésolithique en Europe: peuplements, systèmes culturels et paléo-environnements*, Grenoble.

JACKES M., LUBELL D., MEIKLEJOHN C. 1997. Healthy but mortal: human biology and the first farmers of western Europe. Antiquity 71: 639-658.

KIRCH P. V. 1984. The evolution of the Polynesian chiefdoms, Cambridge, Cambridge University Press.

KRINGS M., STONE A., SCHMITZ R. W., KRAINITZKI H., STONEKING M., PÄÄBO S. 1997. Neandertal DNA Sequences and the Origin of Modern Humans. Cell 90: 19-30.

LEWTHWAITE J. 1986a. From Menton to the Mondego in three steps: application of the availability model to the transition to food production in Occitania, Mediterranean Spain and Southern Portugal. Arqueologia 13: 95-112.

1986b. The transition to food production: a Mediterranean perspective. In ZVELEBIL M. (ed.), *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming*: 53-66, Cambridge, Cambridge University Press.

LUBELL D., JACKES M. 1985. Mesolithic-Neolithic continuity: evidence from chronology and human biology. In I Reunião do Quaternário Ibérico. Actas 2: 113-133, Lisboa.

1988. Portuguese Mesolithic-Neolithic subsistence and settlement. Rivista di Antropologia, Supplemento del Vol. LXVI: 231-248.

LUBELL D., JACKES M., SCHWARCZ H., KNYF M., MEIKLEJOHN C. 1994. The Mesolithic-Neolithic Transition in Portugal: Isotopic and Dental Evidence of Diet. Journal of Archaeological Science 21: 201206.

MATEUS J., QUEIRÓS P. 1993. Os estudos de vegetação quaternária em Portugal: contextos, balanço de resultados, perspectivas. In ASSOCIAÇÃO PORTUGUESA PARA O ESTUDO DO QUATERNÁRIO. *O Quaternário em Portugal. Balanço e Perspectivas*: 105-131, Lisboa, Colibri.

PORCH N., ALLEN J. 1995. Tasmania: archaeological and palaeo-ecological perspectives. Antiquity 69: 714-732.

PRICE T. D., GEBAUER A. N., KEELEY L. H. 1995. The spread of farming into Europe north of the Alps. In PRICE T. D., GEBAUER A. N. (eds.), *Last Hunters - First Farmers. New Perspectives on the Prehistoric Transition to Agriculture*: 95-126, Santa Fe, School of American Research Press.

RENFREW C. 1987. Archaeology and Language, the puzzle of Indo-European origins, London, Jonathan Cape.

1996. Language families and the spread of farming. In HARRIS D. H. (ed.). *The Origins and Spread of Agriculture and Pastoralism in Eurasia*: 70-92, London, Routledge.

ROWLEY-CONWY P. 1986. Between cave painters and crop planters: aspects of the temperate European Mesolithic. In ZVELEBIL M. (ed.), *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming*: 17-32, Cambridge, Cambridge University Press.

1992. The Early Neolithic animal bones from Gruta do Caldeirão. In ZILHÃO J., *Gruta do Caldeirão. O Neolítico Antigo*: 231-257, Lisboa, Instituto Português do Património Arquitectónico e Arqueológico.

1995. Making first farmers younger: the West European evidence. Current Anthropology 36 (2): 346-353.

1997. The animal bones from Arene Candide (Holocene sequence): Final Report, in MAGGI Roberto (ed.), *Arene Candide: a functional and environmental assessment of the Holocene sequence (excavations Bernabo' Brea-Cardini 1940-50)*: 153-277, Istituto Italiano di Paleontologia Umana, Roma.

SANCHES M. J. 1996. Ocupação pré-histórica do Nordeste de Portugal, Zamora, Fundación Rei Afonso Henriques.

SANCHES M. J., SOARES A. M., ALONSO F. M. 1993. Buraco da Pala (Mirandela): datas de carbono 14 ca-

libradas e seu poder de resolução. Algumas reflexões. Trabalhos de Antropologia e Etnologia 33 (1-2): 223-243.

SILVA C. T., SOARES J. 1981. Pré-história da área de Sines, Lisboa, Gabinete da Área de Sines.

SOARES A. M. 1993. The 14C content of marine shells: evidence for variability in coastal upwelling off Portugal during the Holocene. Isotope Techniques in the Study of Past and Current Environmental Changes in the Hydrosphere and the Atmosphere, Viena, International Atomic Energy Agency: 471-485.

SOARES J. 1992. Les territorialités produites sur le littoral centre-sud du Portugal au cours du processus de néolithisation. Setúbal Arqueológica 9-10: 17-35.

1995. Mesolítico-Neolítico na costa sudoeste: transformações e permanências. Trabalhos de Antropologia e Etnologia 35 (2): 27-54.

1997. A transição para as formações sociais neolíticas na costa sudoeste portuguesa. In RODRÍGUEZ CASAL A. A. (ed.), *O Neolítico atlántico e as orixes do megalitismo*, Santiago de Compostela, Universidade de Santiago de Compostela.

TARRUS J., CHINCHILLA J., BOSCH A. 1994. La Draga (Banyoles): un site lacustre du Néolithique ancien cardial en Catalogne. Bulletin de la Société Préhistorique Française 91 (6): 449-456.

TRINKAUS E. 1997. Appendicular robusticity and the paleobiology of modern human emergence. Proceedings of the National Academy of Sciences 94: 13367-13373.

WHITTLE A. 1996. Europe in the Neolithic. The creation of new worlds, Cambridge, Cambridge University Press.

ZBYSZEWSKI G., FERREIRA O. V., LEITÃO M.; NORTH C. T.; NORTON J. 1981. Nouvelles données sur le Néolithique Ancien de la station à céramique cardiale de Sagres (Algarve). Comunicações dos Serviços Geológicos de Portugal 67: 301-311.

ZILHÃO J. 1992a. Gruta do Caldeirão. O Neolítico Antigo, Trabalhos de Arqueologia 6, Lisboa, Instituto Português do Património Arquitectónico e Arqueológico.

1992b. Estratégias de povoamento e subsistência no Paleolítico e no Mesolítico de Portugal. In MOURE ROMANILLO A. (ed.), *Elefantes, ciervos y ovicaprinos. Economía y aprovechamiento del medio en la Prehistoria de España y Portugal*: 149-162, Santander, Universidad de Cantabria.

1993. The spread of agro-pastoral economies across Mediterranean Europe: A view from the Far West. Journal of Mediterranean Archaeology 6 (1): 5-63.

1995. O Paleolítico Superior da Estremadura portuguesa. Doctoral dissertation, Lisboa, Universidade de Lisboa 1997, Lisboa, Colibri.

(n.d.a) – From the Mesolithic to the Neolithic in the Iberian Peninsula. In PRICE T. D. (ed.), *Europe's First Farmers*, Cambridge, Cambridge University Press (in press).

(n.d.b) – On Logical and Empirical Aspects of the Mesolithic-Neolithic Transition in the Iberian Peninsula. Current Anthropology (submitted).

ZILHÃO J., AUBRY Th., CARVALHO A. F., BAPTISTA A. M., GOMES M. V., MEIRELES J. 1997. The Rock Art of the Côa Valley (Portugal) and its Archaeological Context. Journal of European Archaeology 5 (1): 7-49.

ZILHÃO J., CARVALHO E., ARAÚJO A. C. 1987. A estação epipaleolítica da Ponta da Vigia (Torres Vedras). Arqueologia 16: 8-18.

ZVELEBIL M. 1986. Mesolithic societies and the transition to farming. In M. ZVELEBIL (ed.), *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming*: 167-188, Cambridge, Cambridge University Press.

ZVELEBIL M., ROWLEY-CONWY P. 1986. Foragers and farmers in Atlantic Europe. In M. ZVELEBIL (ed.), *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming*: 67-94, Cambridge, Cambridge University Press.