On Logical and Empirical Aspects of the Mesolithic-Neolithic Transition in the Iberian Peninsula[1]

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Jackes, Lubell, and Meiklejohn (CA 38:839–46) criticize Lalueza Fox (CA 37:689–95) and Calafell and Bertranpetit (CA 34:735–45) on population replacement at the advent of the Neolithic in Iberia. They conclude that, as regards the physical anthropological aspects of the process, "there is no evidence for local discontinuity" and that, on the contrary, "data from central Portugal, the source of the core Mesolithic data, show clear continuity" (p. 844). These data are also discussed by Jackes, Lubell, and Meiklejohn in *Antiquity* (1997*b*). Here I will focus first on assumptions and show that their conclusions cannot be supported from a logical point of view even if their reading of the empirical patterns is accepted. Then I will present a different interpretation of the physical anthropological information, which, in my view, shows marked discontinuity at the time of the transition to agriculture. A corresponding discontinuity is evident in the material cultural record, suggesting that the advent of the Neolithic was associated with population input from outside and may be modeled as a process of maritime pioneer colonization (Zilhão 1992, 1993, n.d. *a, b*). Throughout the text I will use dates B.C. derived from calibrated radiocarbon ages.

Homogeneity, heterogeneity, and population replacement. Jackes et al. report that the Portuguese cluster with the French instead of with neighboring Spaniards in the analysis of some genes and cite similar findings when blood groups, red cell enzymes, and serum protein polymorphisms are used. From this they conclude that Iberians are not as homogeneous as Lalueza Fox believes and that the modern population of the peninsula cannot be "solely the result of a Neolithic population replacement" (p. 841). A contradiction between genetics and geography is also apparent in the study by Calafell and Bertranpetit: contrary to the predictions of a simulation assuming demic diffusion from the east coinciding with the advent of the Neolithic, the real gene frequencies of their second principal component are higher in Portugal than in Mediterranean Spain. The first principal component, however, separates the Basques from the rest of the Iberians, which at this level of analysis form a homogeneous group.

The extent to which differences among modern non-Basque Iberians are related to prehistoric patterns is currently unknown. In fact, the heterogeneity identified by Jackes et al. may well be related instead to the differential geographical impact of demic movements known to have occurred in historic times. North African immigration after the Berber invasion of Iberia in the 8th century A.D., which affected Andalucía more than the rest of Iberia, may contribute to the explanation of modern genetic patterns. Another possible source of historical variation is the western Crusades, in the framework of which people from France settled in Portuguese territory. These historically documented demographic processes may well have operated against a background of homogeneity created by population replacement at the time of the transition to agriculture.

More important, however, the hypothesis that demic expansion is associated with the transition to farming in West Mediterranean Europe does not require homogeneous populations as the end result of the process. If people moved along with domestic resources, it should be possible, using Iberian fossil samples, to establish mtDNA or Y-chromosome lineages extending to the earliest Neolithic of the Fertile Crescent, where wheat, barley, sheep, and goats were first domesticated and from where they spread into Europe. If Iberian Early Neolithic people were shown to belong to such lineages and Iberian Mesolithic people were shown to be different in this regard, population movement would be proved, regardless of the extent to which the input of incoming agriculturalists affected the gene pool of succeeding populations.

If the input of outsider farming groups was important, as it might have been if local hunter-gatherers were rapidly absorbed by incoming agriculturalists with higher fertility, for all practical purposes the end result would have been population replacement even though local Mesolithic groups had participated in the process; the extent, nature, and regional variation of their participation, in turn, would have affected the degree of heterogeneity in succeeding Neolithic populations.

If, on the contrary, it was the local hunter-gatherers who rapidly absorbed the newcomers and changed their way of life, becoming farmers and shepherds, there might have been very few changes except for those brought about by the new nutritional patterns or by adaptation to different kinds of work patterns and new types of terrain. The end result would have been Neolithic homogeneity or Neolithic heterogeneity depending on which was the situation in the Mesolithic, and the external input, although perhaps visible in fossil samples, might have since vanished or become of little significance in modern populations.

These are two extreme theoretical scenarios, and past historical situations may have mixed different elements of each even in restricted areas. As I have argued else-

1. Over the past 15 years, Chris Meiklejohn, David Lubell, and Mary Jackes have conducted valuable research on the Mesolithic-Neolithic transition in Portugal. In spite of our current disagreements on interpretation, I wish to stress that but for their work it would have been almost impossible to address many of the issues raised in this paper. Chris Meiklejohn, Cidália Duarte, Daniel Turbón, Erik Trinkaus, and Mary Jackes contributed valuable comments on earlier drafts of this paper and were useful sources of various information. Any errors or omissions are my own.

where (Zilhão n.d. *a*), the Cantabrian data suggest patterns closer to the second scenario (which may help to explain the individuality of modern Basques evident in the first principal component of the study by Calafell and Bertranpetit), while those from Portugal and Mediterranean Spain seem to indicate that the first is closer to what really happened.

Population replacement in the osteological record. As regards skeletal morphology, there is a complicating possibility: if the outsider farmer groups were not significantly different from local Mesolithic groups in this regard, their contribution to the osteological record might be undetectable. In the extreme case, total population replacement could have occurred in spite of apparent continuity in osteology. In order to make this clearer, I will bring into the discussion the Iroquois skeletal data used by Jackes et al. (1997*b:* fig. 3) to frame their evaluation of the Portuguese material. Their dendrograms of nonmetrical traits of the dentition show that there is more difference between four protohistorical and historical collections from southern Ontario than between the Mesolithic and Neolithic Portuguese samples that they analyzed. Since they have no doubt that the American Indian collections belonged to a biologically homogeneous population, Jackes et al. conclude that there was genetic continuity across the transition from the Mesolithic to the Neolithic in Portugal.

Two ethnic groups are represented in the American material: the Neutral and the Huron. The Grimsby site, on the southern bank of Lake Ontario, was Neutral, and the Maurice site, 200 km to the north, was Huron. With this in mind, let us conduct a thought experiment by supposing that a group of Grimsby Neutral people moved to the Maurice Huron area. A few centuries later, if the degree of biological difference between the two groups at the start is considered to have been insignificant, how would one identify such a "colonization" in the osteological record—especially since the mixing of the two populations would not have increased but reduced the difference between them? And, if the outcome of the process had been the extinction of the local Huron and their total replacement by the Neutral colonists, how would one identify this replacement? Osteological data alone would suggest that no population movements had actually taken place and that in the time-range of relevance the historical trajectory of the Maurice area had been characterized by total biological continuity. We would know, however, that this had not been the case at all.

In historical times, Iroquois groups extended for some 800 km along a northwest-southeast axis (Fagan 1995). The distances involved in the West Mediterranean process are not much greater. Therefore, if the differences between Grimsby Neutral and Maurice Huron are nonsignificant in genetic terms and if the degree of difference between any two Iroquois-speaking groups of North America is not significantly greater than in this example, why should we expect the situation to have been different in the prehistoric Western Mediterranean? If the degree of biological heterogeneity in the late Mesolithic groups of the region was no greater than among historical Iroquois, chances are that there would be no osteologically meaningful differences between Mesolithic and Neolithic Portuguese populations even if the introduction of agriculture was indeed associated with population dispersals. At this level of expectation, the continuity that Jackes et al. derive from their dendrograms would be the predictable result even if the earliest Neolithic of Iberia was associated with colonization processes ultimately originating in southern Italy.

The dendrograms also show, however, that the Iroquois collections group according to geography and, to a lesser extent, ethnicity: the Neutral material from Grimsby and the Huron material from Maurice fall into separate clusters. This suggests that the Huron and the Neutral may have been biologically more distinct than is acknowledged by Jackes et al. and, consequently, that Neolithic and Mesolithic Portuguese people may also have been biologically distinct, although the difference between them may not have been greater than that between ethnohistorical neighboring populations. This is entirely compatible with a maritime pioneer colonization model for the earliest Neolithic of Portugal, since the model places the presumed origin of the pioneer groups in the nearby Spanish regions of Andalucía and Valencia, as indicated by close stylistic similarities between ceramic assemblages from the two regions (such as those from Cova de l'Or, Valencia, and Almonda, Estremadura [Zilhão n.d. *a*]).

Comparing modern and fossil populations. Lalueza Fox substantiated his case with a cluster analysis of craniometric data. Jackes et al. performed a similar analysis with further data, and where Lalueza Fox had discerned dramatic discontinuity they concluded that "more complete data remove any evidence of discontinuity" (p. 844). This conclusion is based on the finding that Melides, a Portuguese Late Neolithic sample, clusters with Moita and Arruda, the Portuguese Mesolithic samples, and not with the modern, historical, and protohistorical collections submitted to the same analysis.

The first thing to note in this regard is that the cranial material from Muge underwent significant deformation, and therefore the reliability of any morphometric results derived from its study is open to question. More important, however, is that Jackes et al. seem to assume that, if population replacement occurred at the time of the transition, Neolithic people should be closer to later and modern populations than to the local Mesolithic groups. In light of the arguments presented above, it should be clear, however, that this assumption is unwarranted, since it requires postulating that the replacing and the replaced are significantly different, which need not be the case. If Portuguese Late Mesolithic crania were not very different from those of the hypothetical Early Neolithic colonists to begin with, it should come as no surprise that the sample closest in space and time to the transition is also its closest in morphology. Melides is 1,500 years later than Arruda, and the oldest other samples are from the Bronze Age, some 3,500 years later than Melides and, besides, are from Mediterranean Spain (Granada and Catalonya) rather than from Portugal. Thus, Early Neolithic homogeneity as a result of population replacement is not necessarily contradicted by these patterns: genetic drift alone might suffice to explain why, although originating in a hypothetical common background, Bronze Age Spaniards should have become more different from Melides than Melides is from Moita and Arruda.

This highlights the dangers inherent in any direct comparison between modern and fossil populations. Given that the interpretation of prehistoric patterns through modern ones is dependent on the conditions at the start, when the process of hypothesized Neolithic expansion began, the only conclusion that can safely be extracted from the contradictory results arrived at by Lalueza Fox and Jackes et al. is that the issue has to be addressed by looking at the extinct populations themselves. Unfortunately, not enough data are available on Late Mesolithic skeletal morphology outside Portugal, and the scant data on the osteology of the earliest Neolithic people of the Western Mediterranean generally preclude significant comparisons. Yet it is exactly such data that are needed, since the information on conditions at the time of the Neolithic transition contained in modern, historical, and protohistorical samples is necessarily confused by the passage of time and the impact of documented large-scale population movements.

Neolithic fertility. Jackes et al. argue that demic diffusion would require "a massive advantage for the incoming Neolithic population, one that would permit the newcomers an extremely high fertility rate," but no such advantage is apparent in the subsistence and demographic data (p. 844). The assumption that population replacement can occur only in situations of extreme imbalance is unwarranted. Zubrow (1989), for instance, has demonstrated, in the case of the Neanderthal/early modern human interaction, that a difference of no more than 2% in mortality would suffice to bring about the total extinction of the autochthonous European population in 30 generations.

Most researchers agree that early cereal agriculture was not economically superior to European Mesolithic adaptations in terms of workload and long-term stability, especially when productive and reliable aquatic resources were available as was the case in coastal Portugal (Zvelebil and Rowley-Conwy 1986, Gregg 1988). It is undeniable, however, that peasant economies are more productive: through the simplification of ecosystems they are capable of feeding more people per area unit of territory and therefore, in situations of initial pioneer settlement, can support much more rapid population growth than local hunter-gatherer economies. As is shown by Zubrow's models, this different dynamics would easily result, even if the demographic advantage of pioneer colonists was minor, in the rapid assimilation of neighboring hunter-gatherers, particularly if the two groups intermarried. It is interesting in this regard that Jackes et al. (1997*b*:652) believe that fertility did increase significantly, by some 50%, in the Portuguese Neolithic. In fact, on the basis of data from Mesolithic Arruda and Late Neolithic Casa da Moura, they estimate that "while Mesolithic women had four children on average, Neolithic women had about six."

The significance of differences between Mesolithic samples. Jackes et al. (1997*b*) reason that the differences between the Mesolithic human skeletal assemblages of Moita and Arruda indicate that physical anthropology was undergoing a marked change in the late Mesolithic—that is, that the differences between Moita and Arruda were the outcome of a temporal trend. There are three basic problems with this approach:

1. By definition, the two points that define a line are located on that line; thus, one can only speak of a gradual trend between one moment in time and another if there are intermediate points that fall on that line; otherwise, it is possible that the two moments represent temporal extremes of a range of variability, particularly when they are as close in time as Moita and Arruda (on average, Arruda is 300 years younger than Moita); speaking of a trend between Moita and Arruda when there are no other contemporary or temporally intermediate collections is logically untenable to begin with.

2. In many instances, the differences observed between Moita and Arruda are the opposite of what one would expect if there had been such a trend. Diets change from having an important marine component to being purely terrestrial from the Mesolithic to the Neolithic, but among the Mesolithic individuals analyzed for stable-isotope composition three of the four with the youngest radiocarbon dates (Ossada N from Arruda, Ossada CT from Moita, and Samouqueira) display the values closest to a pure marine diet (fig. 1); the percentage of approximal caries decreases from the Mesolithic to the Neolithic but increases from Moita to Arruda (fig. 2), and the mean mid-shaft index of tibiae increases from the Mesolithic to the Neolithic but decreases from Moita to Arruda (fig. 3).

3. The ten skeleton dates obtained for Moita and Arruda form four chronological groups mixing individuals from the two sites (fig. 1); the first, around 6040 B.C., contains four Moita skeletons; the second is 200 years later (ca. 5850 B.C.) and contains three Arruda skeletons; the third is another 200 years later (ca. 5660 B.C.) and contains one Moita and one Arruda skeleton; and the last is another 300 years later (ca. 5350 B.C.) and contains one individual from Arruda. Thus it is clear that Moita and Arruda overlap and therefore cannot be used as representatives of separate moments in time, the differences between them being the outcome of a temporal trend. It would seem more appropriate to consider the two sites as representing a single ancestral population and to interpret the differences between them as evidence of the variability that existed in that population.

Continuity and discontinuity in diet and skeletal morphology. From the discussion of the available evidence on the dentition, Jackes et al. conclude that "the Mesolithic-Neolithic transition period shows a shift in diet and related patterns of dental pathology, but it is neither sudden nor at the boundary . . . instead, it is

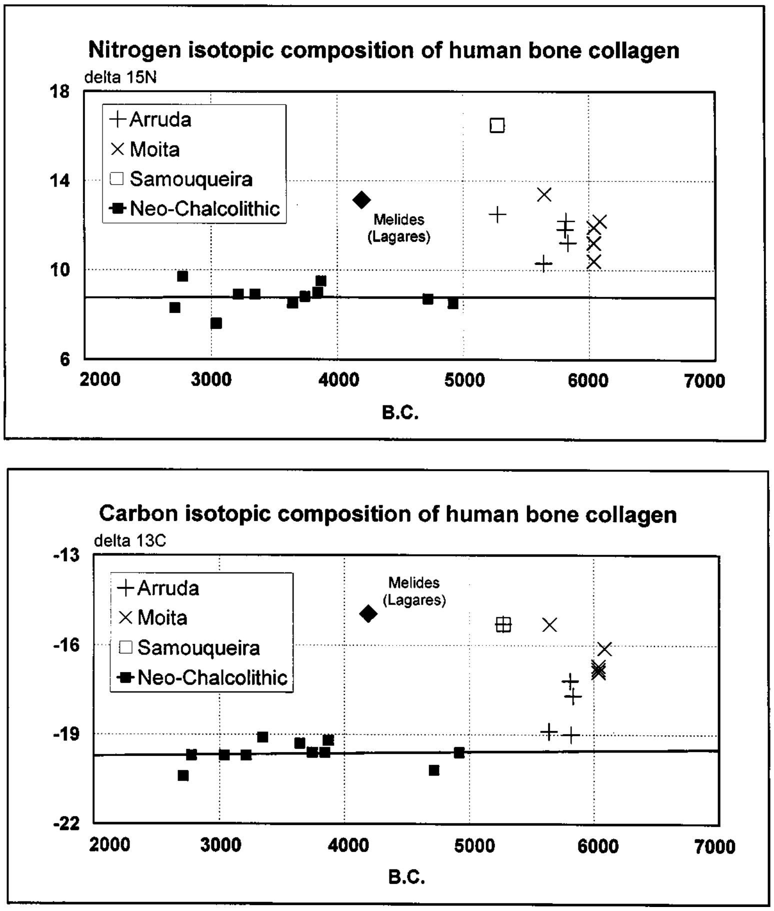

FIG. 1. *Isotopic composition of human bone collagen from Portuguese Mesolithic (Moita, Arruda, and Samouqueira) and Neolithic–Copper Age sites (after Lubell et al. 1994:table 1), highlighting the marked discontinuity in diet at the Mesolithic-Neolithic boundary.*

gradual and continuous across the boundary'' (p. 844). Due consideration of the data supplied by Lubell et al. (1994) and Jackes et al. (1997*b*), however, shows the opposite to be true.

In figures 1–3 the Late Neolithic–Copper Age values have been projected back to Mesolithic times by linear regression. For the sake of simplicity, figures 2 and 3 use averages only, and in order to avoid distortions due to small sample sizes the Early Neolithic data were plotted but not considered in the regressions. Including them would further reinforce the pattern of marked discontinuity at the Mesolithic-Neolithic boundary displayed by the graphs. In figure 2 it was assumed that the absence of dental material in the collections from the Melides cave of Lagares resulted from their accidental inclusion in the collections from the nearby cave of Zambujal. Accordingly, the dental collection labeled ''Melides'' was assumed to represent both sites and was assigned an age corresponding to the average of the dates available for each.

Figure 1 charts the paleoisotopic information in table 1 of Lubell et al. (1994). With a single outlier, the Late Neolithic individual from Lagares, the differences between Mesolithic and Neolithic are obvious: ''there is stable isotopic evidence for a marked difference in diet between Mesolithic and Neolithic Portuguese human remains. The Mesolithic diet can be characterized as a mixture of terrestrial and marine foods, while the Neolithic population appears to have consumed only terrestrial foods (herbivore flesh and plant foods)'' (p. 213). Projecting the Neolithic pattern back to Mesolithic times would give $\delta^{13}C$ and $\delta^{15}N$ values far below those actually encountered. Thus, the Late Neolithic pattern is not the outcome of a gradual trend beginning in the Mesolithic and is already present in the earliest Neolithic specimens analyzed.

Figure 2 charts the caries information in table 2 of Lubell et al. and the mean breadth of second lower molars used in figure 4 of Jackes et al. (1997*b*). Arruda fits a trend of gradual decrease from the Mesolithic to the Neolithic in the incidence of approximal caries, but Moita does not, and no trend can be established for occlusal caries. Thus, dental pathology does not seem to change significantly across the transition. Tooth size, however, undergoes a marked change at the boundary: projecting the values obtained for Late Neolithic–Cop-

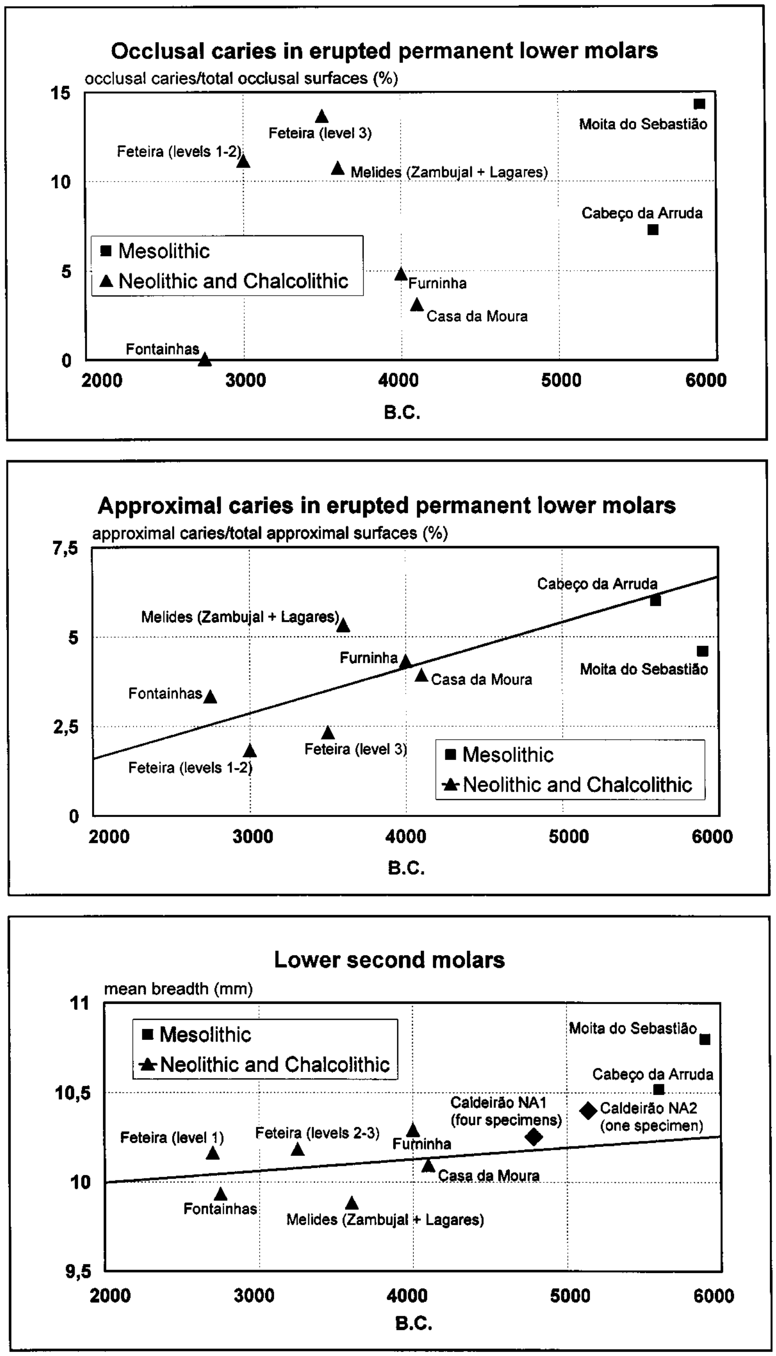

FIG. 2. *Dental evidence for the Mesolithic-Neolithic transition in Portugal (after Lubell et al. 1994 and Jackes et al. 1997b). Caries rates show no variation through time. The backward projection of the average bucco-lingual breadth of lower second molars gives results lower than those actually observed, and the values for the earliest Neolithic molars are already within the range of those from later periods.*

per Age molar breadth back into Mesolithic times would give results lower than those actually observed, and the values for the earliest Neolithic molars are already in the range of those from later periods. As is the case with paleoisotopic data, the Late Neolithic–Copper Age tooth-size pattern is not the outcome of a gradual trend beginning in the Mesolithic.

Figure 3 charts the information on limb bone morphology in table 2 of Jackes and Lubell (n.d.) and in figures 5 and 6 of Jackes et al. (1997*b*). Mesolithic adult tibiae are saber-shinned, while those from the Late Neolithic–Copper Age are much rounder in mid-shaft. It is impossible to project the later Neolithic trend back and obtain Mesolithic values. However, it is not clear which

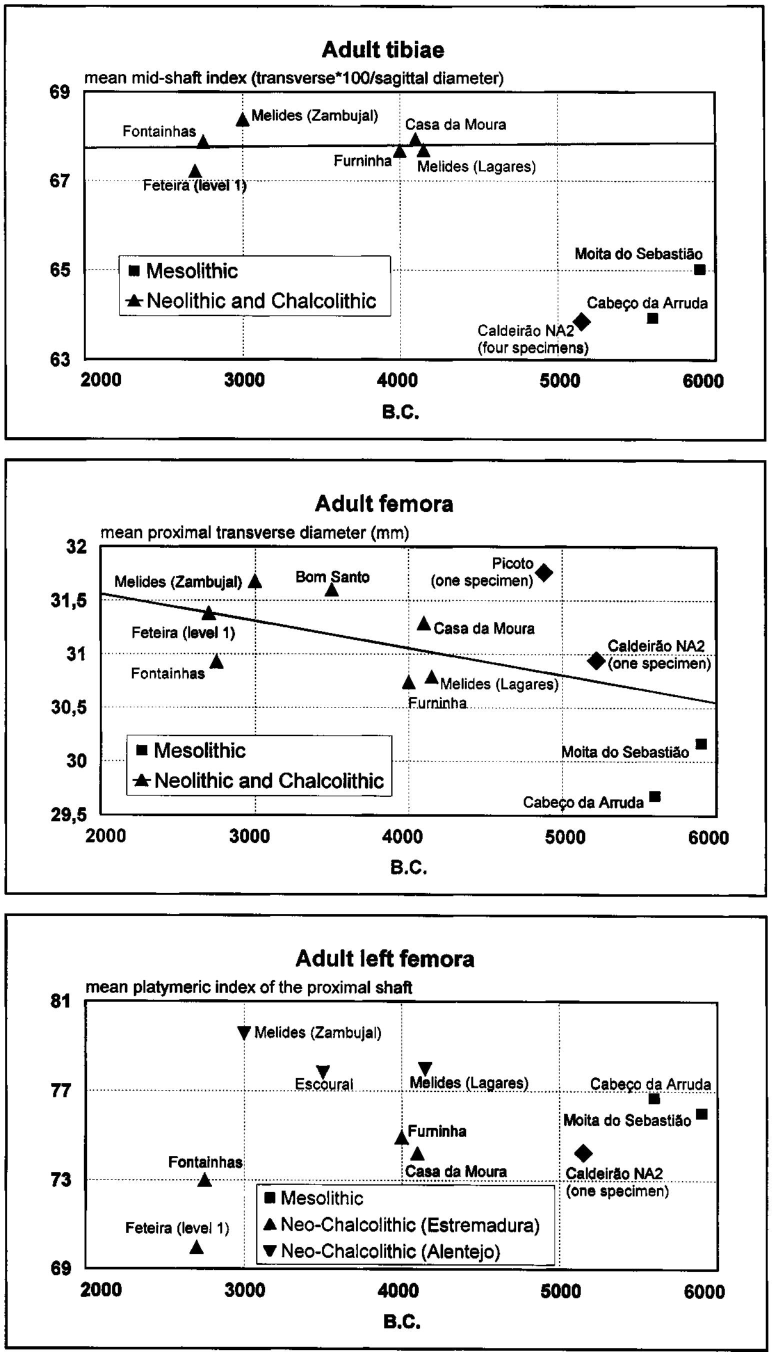

FIG. 3. *Lower limb morphological evidence for the Mesolithic-Neolithic transition in Portugal (after Jackes and Lubell n.d. and Jackes et al. 1997a). Mesolithic adult tibiae are saber-shinned, while those from the Late Neolithic–Copper Age are much rounder in mid-shaft. The mean proximal transverse diameter of adult femora is consistently larger in the Late Neolithic–Copper Age than in the Mesolithic, and the odd Early Neolithic specimens available for analysis already display the later condition. In Late Neolithic collections from the Alentejo the antero-posterior diameter is also larger, and, as a result, values for the proximal platymeric index of adult left femora are closer to those found in the Mesolithic. If proximal femoral shape is genetically controlled, this might indicate that the contribution of local Mesolithic people to the gene pool of subsequent populations was more important in Alentejo than in Estremadura.*

was the prevailing condition in the Early Neolithic, since the average for Caldeirão has a very large standard deviation (according to Jackes et al. there is no statistically significant difference between Caldeirão and Lagares). The mean proximal transverse diameter of adult femora is consistently larger in the Late Neolithic–Copper Age than in the Mesolithic, the few Early Neolithic specimens available for analysis already display the later condition, and the Mesolithic values fall far below the projected trend. However, in some Neolithic collections the antero-posterior diameter is also larger, and, as a result, values for the proximal platymeric index of adult left femora are no different from those found in the Mesolithic.

Conclusion. In good accord with the archaeological record and the paleoisotopic evidence, some physical anthropological indicators display a marked discontinuity at the Mesolithic-Neolithic boundary. In Portugal the transition seems to have been sudden rather than gradual. That it may be associated with population input from outside is also indicated by the pattern of contemporaneity with spatial segregation of the latest Mesolithic and the earliest Neolithic. The former is found only in coastal and estuarine areas (such as the estuaries of the Mondego, Tagus, Sado, and Mira Rivers), while the latter is located in and around the central limestone massif of Estremadura (uninhabited in the late Mesolithic and therefore constituting an empty area available for pioneer Neolithic settlement) and in the Algarve (for the chronological and spatial features of the transition, see Araújo (1993), Arnaud (1989, 1997), Aubry, Fontugne, and Moura (1997), Bicho (1993), Bowman, Ambers, and Leese (1990), Cardoso et al. (1996), Gomes (1994, 1995), González Morales and Arnaud (1990), Lubell and Jackes (1985, 1988), Lubell et al. (1994), Marks et al. (1994), Oosterbeek (1997), Sanches, Soares, and Alonso (1993), Simões (1996), Soares, A. M. (1993), Soares, J. (1995, 1997), Straus (1988, 1991), Zilhão (1992, 1993), Zilhão and Carvalho (1996).

The enclave nature of the earliest Neolithic settlement of Estremadura (which, given the presence at some sites of stylistically early, extensively decorated Cardial wares, may have begun around 5750 B.C. and is in any case well documented from 5500 B.C. on) suggests that we are dealing with a cultural intrusion. Differences in diet, material culture, and burial practices invalidate the hypothesis that these sites represent seasonal components of the estuarine adaptations of the Mondego and Tagus Rivers. The hypothesis that the Cardial occupation of the massifs of Estremadura originated in estuarine Mesolithic people who decided to move onto previously uninhabited land the exploitation of which was made possible once new resources were available requires that the arrival of ceramics and ovicaprids in the estuarine areas predate their first occurrence at the massif cave sites. The opposite, however, is true—no ceramics and no domestic animals have been found in the Muge Mesolithic shell middens, except for a few Epicardial sherds in disturbed surficial deposits which document 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.

If the difference in the size of teeth and in the morphology of leg bones are related to changes in nutritional patterns, they are consistent with the occurrence of the abrupt dietary shift indicated by the paleoisotopic evidence. The same is true if, as is argued by Jackes et al. (1997*b*), the differences are related to activities, since they would then correlate well with the replacement of the hunter-fisher-gatherer way of life of the local Mesolithic by farming and ovicaprid herding. In fact, such simultaneous shifts in diet and in activities would coincide with the appearance of pottery and sheep in the archaeological record of Portugal (Zilhão 1993, n.d. *a, b*).

American Indian archaeological, historical, and forensic data have led Gilbert and Gill (1990) to suggest that proximal femoral shape is under genetic control rather than environmentally regulated. Recent work by various researchers has stressed the plasticity of long bones and illustrated how their morphology may develop ontogenetically as a result of biomechanical stress (see Larsen 1997). As regards femora, however, all such evidence relates to the morphology of the mid-shaft. In fact, Ruff (1987), quoted by Meiklejohn et al. (n.d.), states that subtrochanteric femoral shape "does not display a consistent patterning according to subsistence or activity pattern." Trinkaus et al. (1998), also citing work by Ruff, argue in turn that the difference in subtrochanteric femoral morphology between Neanderthals and early modern humans is determined by genetics, not by activities, because the body and hip proportions that directly affect it tend to be quite stable for any given population.

Since no data on body size and body proportions exist for the Portuguese Mesolithic and Neolithic, the hypothesis that the observed differences in proximal femoral shape may be influenced by genetics cannot be tested at present. It is clear, however, that it is not in contradiction with the available evidence on the plasticity of human bone. If the hypothesis were eventually to be confirmed, the patterns in figure 3 might be interpreted as indicating (1) that the marked discontinuities in material culture, settlement patterns, burial practices, diets, and tooth sizes are indeed associated with pioneer colonization and (2) that the regional differentiation in Late Neolithic–Copper Age proximal femoral platymeria may result from the fact that, in the Alentejo, where Mesolithic adaptations survived for several hundred years after the advent of the Neolithic to the north, the contribution of local hunter-gatherers to the later gene pool may have been greater than in Estremadura.

In light of the above discussion of the limitations of modern material, it would seem that a definitive test of competing explanations for the physical anthropological patterns can come only from direct comparison of genetic material extracted from the prehistoric human remains themselves. Future research should be headed in this direction and would benefit from the abandonment by all those involved of a tendency to use the empirical data as illustrations of assumed models of change in the prehistoric past. Our aim as investigators of that past should be reconstructing the various concrete historical trajectories rather than reducing them to case studies of the action of single universal mechanisms.

References Cited

araújo, ana cristina. 1993. A estação mesolítica do Forno da Telha. *Trabalhos de Antropologia e Etnologia* 33:15–45.

arnaud, josé morais. 1989. "The Mesolithic communities of the Sado Valley, Portugal, in their ecological setting," in *The Mesolithic in Europe.* Edited by C. Bonsall, pp. 614–31. Edinburgh: John Donald.

———. 1997. Mesolithic land-use in the Portuguese territory. Paper presented at the 3d annual meeting of the European Association of Archaeologists, Section 1.3, "The Rise and Fall of Post-Pleistocene Adaptations: New Perspectives on Early Holocene Hunter-Gatherers in Europe," Ravenna, September 24–28.

aubry, thierry, michel fontugne, and maria helena moura. 1997. Les occupations de la grotte de Buraca Grande depuis le Paléolithique supérieur et les apports de la séquence holocène à l'étude de la transition Mésolithique/Néolithique au Portugal. *Bulletin de la Société Préhistorique Française* 94:182–90.

bicho, nuno f. 1993. Late Glacial prehistory of central and southern Portugal. *Antiquity* 67:761–75.

bowman, sheridan g. e., j. c. ambers, and m. n. leese. 1990. Re-evaluation of British Museum radiocarbon dates issued between 1980 and 1984. *Radiocarbon* 32:59–79.

calafell, francesc, and jaume bertranpetit. 1993. The genetic history of the Iberian Peninsula: A simulation. current anthropology 34:735–45.

cardoso, joão luís, júlio r. carreira, and o. da veiga ferreira. 1996. Novos elementos para o estudo do Neolítico antigo da região de Lisboa. *Estudos Arqueológicos de Oeiras* 6:9–26.

fagan, brian. 1995. 2d edition. *Ancient North America: The archaeology of a continent.* London: Thames and Hudson.

gilbert, r., and g. w. gill. 1990. "A metric technique for identifying American Indian femora," in *Skeletal attribution of race.* Edited by G. W. Gill and S. Rhine, pp. 97–99. Albuquerque: Maxwell Museum of Anthropology.

gomes, mário varela. 1994. "Menires e cromeleques no complexo cultural megalítico português: Trabalhos recentes a estado da questão." *O megalitismo no centro de Portugal: Actas do Seminário (Mangualde, Novembro de 1992),* pp. 317–42. Viseu: Centro de Estudos Pré-Históricos da Beira Alta.

———. 1995. Escavações arqueológicas em Padrão 1—Vila do Bispo: Relatório da campanha de 1994. MS.

gonzález morales, manuel, and josé morais arnaud. 1990. "Recent research on the Mesolithic of the Iberian Peninsula," in *Contributions to the Mesolithic in Europe.* Edited by P. Vermeersch and P. Van Peer, pp. 451–61. Leuven: Leuven University Press.

gregg, susan a. 1988. *Foragers and farmers: Population interaction and agricultural expansion in prehistoric Europe.* Chicago: University of Chicago Press.

jackes, mary, and david lubell. n.d. "Human skeletal biology and the Mesolithic-Neolithic in Portugal," in *Epipaléolithique et Mésolithique en Europe: Peuplements, systèmes culturels et paléoenvironnement.* Edited by P. Bintz. Grenoble: Institut Dolomieu.

jackes, mary, david lubell, and chris meiklejohn. 1997*a.* On physical anthropological aspects of the Mesolithic-Neolithic transition in the Iberian Peninsula. current anthropology 38:839–46.

———. 1997*b.* Healthy but mortal: Human biology and the first farmers of western Europe. *Antiquity* 71:639–58.

lalueza fox, c. 1996. Physical anthropological aspects of the Mesolithic-Neolithic transition in the Iberian Peninsula. current anthropology 37:689–95.

larsen, clark spencer. 1997. *Bioarchaeology: Interpreting behavior from the human skeleton.* Cambridge: Cambridge University Press.

lubell, david, and mary jackes. 1985. "Mesolithic-Neolithic continuity: Evidence from chronology and human biology." *Actas da I Reunião do Quaternário Ibérico,* vol. 2, pp. 113–33. Lisboa: Grupo de Trabalho Português para o Estudo do Quaternário.

———. 1988. Portuguese Mesolithic-Neolithic subsistence and settlement. *Rivista di Antropologia* 66 suppl.: 231–48.

lubell, david, mary jackes, henry schwarcz, martin knyf, and chris meiklejohn. 1994. The Mesolithic-Neolithic transition in Portugal: Isotopic and dental evidence of diet. *Journal of Archaeological Science* 21: 201–6.

marks, anthony e., nuno f. bicho, joão zilhão, and c. reid ferring. 1994. Upper Pleistocene prehistory in Portuguese Estremadura: Results of preliminary research. *Journal of Field Archaeology* 21:53–68.

meiklejohn, chris, brett waddell, isabelle trudel, denis michaud, and philip hodge. n.d. "Identification of a missing person using biomechanical analysis: A case study," in *Forensic osteological analysis.* Edited by Scott I. Fairgrieve. Springfield: Charles C Thomas.

oosterbeek, luís. 1997. *Echoes from the East: Late prehistory of the North Ribatejo.* Tomar: CEIPHAR.

ruff, christopher. 1987. Sexual dimorphism in human lower limb bone structure: Relationship to subsistence strategy and sexual division of labor. *Journal of Human Evolution* 16: 391–416.

sanches, maria de jesus, a. monge soares, and fernan m. alonso. 1993. Buraco da Pala (Mirandela): Datas de carbono 14 calibradas e seu poder de resolução, algumas reflexões. *Trabalhos de Antropologia e Etnologia* 33: 223–43.

simões, teresa. 1996. "O sítio neolítico de São Pedro de Canaferrim (Sintra)." *Actes, I Congrés del Neolític a la Peninsula Ibérica,* vol. 1, pp. 329–36. Gavà: Museu de Gavà.

soares, a. monge. 1993. "The ^{14}C content of marine shells: Evidence for variability in coastal upwelling off Portugal during the Holocene," in *Isotope techniques in the study of past and current environmental changes in the hydrosphere and the atmosphere,* pp. 471–85. Vienna: International Atomic Energy Agency.

soares, joaquina. 1995. Mesolítico-Neolítico na costa sudoeste: Transformações e permanências. *Trabalhos de Antropologia e Etnologia* 35:27–54.

———. 1997. "A transição para as formações sociais neolíticas na costa sudoeste portuguesa," in *O Neolítico atlántico e as orixes do megalitismo.* Edited by A. A. Rodríguez Casal, pp. 587–608. Santiago de Compostela: Universidade de Santiago de Compostela.

straus, lawrence g. 1988. Archaeological surveys and excavations in southern Portugal. *Old World Archaeology Newsletter* 12:13–17.

———. 1991. The Mesolithic-Neolithic transition in Portugal: A view from Vidigal. *Antiquity* 65:899–903.

trinkaus, erik, christofer b. ruff, steven e. churchill, and bernard vandermeersch. 1998. Locomotion and body proportions of the Saint-Césaire 1 Châtelperronian Neandertal. *Proceedings of the National Academy of Sciences, U.S.A.* 95:5836–40.

zilhão, joão. 1992. *Gruta do Caldeirão: O Neolítico antigo.* Instituto Português do Património Arquitectónico e Arqueológico, Trabalhos de Arqueologia 6.

———. 1993. The spread of agro-pastoral economies across Medi-

terranean Europe: A view from the Far-West. *Journal of Mediterranean Archaeology* 6:5–63.
———. n.d. *a.* ''From the Mesolithic to the Neolithic in the Iberian Peninsula,'' in *Europe's first farmers.* Edited by T. Douglas Price. Cambridge: Cambridge University Press. In press.
———. n.d. *b.* Maritime pioneer colonisation in the early Neolithic of the west Mediterranean: Testing the model against the evidence. *Porocilo o rziskovanju paleolitika, neolitika in eneolitika v Slovejini* 24. In press.
ZILHÃO, JOÃO, AND A. FAUSTINO DE CARVALHO. 1996. ''O Neolítico do Maciço Calcário Estremenho: Crono-estratigrafia e povoamento.'' *Actes, I Congrés del Neolític a la Península Ibérica,* vol. 2, pp. 659–71. Gavà: Museu de Gavà.
ZUBROW, EZRA. 1989. ''The demographic modelling of Neanderthal extinction,'' in *The human revolution.* Edited by Paul Mellars and Chris Stringer, pp. 212–31. Edinburgh: Edinburgh University Press.
ZVELEBIL, MAREK, AND PETER ROWLEY-CONWY. 1986. ''Foragers and farmers in Atlantic Europe,'' in *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming.* Edited by Marek Zvelebil, pp. 67–94. Cambridge: Cambridge University Press.