

Fred Spoor
University College London

The human fossils from Corbeddu Cave, Sardinia: a reappraisal

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The morphology of a human maxilla and a temporal bone found in pre-Neolithic layers of Corbeddu Cave on the Mediterranean island of Sardinia is re-evaluated. The one unusual aspect of these remains is the aberrant alveolar process of the maxilla, and it is concluded that this morphology is unlikely to have resulted from any pathological process. However, there is insufficient ground for previous claims that the alveolar morphology is indicative of molars that were unusually large for *Homo sapiens*, and that this morphology represents evidence of endemism, the result of genetic isolation of the pre-Neolithic Sardinian population.

Correspondence: Fred Spoor, Dept. of Anatomy and Developmental Biology, University College London, Rockefeller Building, University Street, London WC1E 6JJ, U.K. e-mail f.spoor@ucl.ac.uk

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INTRODUCTION

Long term excavations at Corbeddu Cave on the Mediterranean island of Sardinia under the direction of Paul Sondaar led to the discovery of three human fossils of pre-Neolithic age (Klein Hofmeijer *et al.* 1987, Sondaar *et al.* 1984, 1986, 1991, 1995, Sondaar & Spoor 1989). A right temporal bone and a left maxilla were found *in situ* in the cave's second hall in 1983 and 1985, respectively (Spoor & Sondaar 1986). The two specimens were associated with the endemic Pleistocene island fauna of Sardinia, which is dominated by the cervid *Megaloceros cazioti* and the ochotonid *Prolagus sardus* and predates the influx of Holocene mainland species in the Neolithic. Radiocarbon dating of bone from the layer in which both human remains were found yielded an age of 8750 ± 140 yBP (Klein Hofmeijer *et al.* 1987). In 1993 a partial first

human phalanx was found in a deeper layer dated to approximately 20,000 yBP (Sondaar *et al.* 1995). In addition to these three specimens Klein Hofmeijer *et al.* (1987) and Sondaar *et al.* (1995) refer to the discovery of a human ulna in Corbeddu Cave's first hall, but this specimen lacks stratigraphic context and its morphology has not been described.

Traditionally Sardinia was thought to be colonized in the Neolithic and before the Corbeddu Cave finds were made the oldest known human remains were those from the Middle Neolithic of Grotto Rifugio (Germanà 1981). The direct evidence of the Corbeddu Cave human fossils thus pushes back the time of the earliest occupation of Sardinia well into the Late Pleistocene. In addition, claims have been made for Middle Pleistocene presence of hominids on the island on the basis

of archaeological evidence (Arca *et al.* 1982a, 1982b, Martini & Pitzalis 1982). The arrival of humans on the islands of the Mediterranean is usually associated with the rapid extinction of the endemic fauna (see e.g. Sondaar 1977, 1986), but the findings in Corbeddu Cave clearly suggest that on Sardinia long-term co-existence did occur. Spoor & Sondaar (1986) identified morphological aspects of both the Corbeddu Cave temporal bone and the maxilla which they did not observe in either contemporary mainland populations, or the subsequent Neolithic population of Sardinia (Spoor & Germanà 1987). Given that biological and cultural isolation is indicated by the paleontological and archaeological context of the human fossils Spoor & Sondaar (1986) concluded that the specific morphology could point at endemism, the result of isolation of the pre-Neolithic human population on Sardinia. Moreover, they suggested that the characters should be seen as an adaptive functional complex related to heavy use of the masticatory apparatus. This paper re-evaluates those aspects of the morphology of the human maxilla and temporal bone that were previously interpreted as evidence for endemism. The 1993 partial phalanx is too fragmentary to provide any useful evidence in this context and thus the specimen is not discussed here.

METHODS

The morphology of the Corbeddu Cave maxilla and temporal bone was reassessed by comparing detailed casts and photographs with modern human specimens in the large osteological and odontological collections of the Department of Anatomy and Developmental Biology of University College London. This material has been collected in the course of this century, is of mixed sex and has a predominantly white English ethnic affiliation. In addition to comparisons with the morphological variation shown by the modern sample, the Corbeddu Cave specimens were examined for any manifestations of palaeopathology. The internal morphology

was assessed on the basis of dental radiographs of the maxilla, and computed tomography (CT) scans of both the maxilla and the temporal bone. The CT scans were made in the sagittal and transverse planes with the Philips Tomoscan 350 of the Utrecht University Hospital using a slice thickness of 1.5 mm. Moreover, detailed impressions previously taken from the maxilla with dental casting material were used to investigate the shape and surface structure of the molar alveoli.

DESCRIPTIONS AND COMPARISONS

The temporal bone (CB 83.1096) shows some post-mortem damage in the mastoid region and on the endocranial aspect of the petrous pyramid, but there is no evidence for pathological processes. Its morphology is typical for that of modern humans and lacks any of the external or internal traits which characterise more archaic populations such as Neanderthals (Santa Luca 1978, Condemi 1988, Hublin *et al.* 1996). The one structure that was singled out by Spoor & Sondaar (1986) as being outside modern human variation is the articular eminence of the temporomandibular joint. It is mediolaterally flat instead of the concave shape most frequently seen in modern humans. However, both the glenoid fossa and the articular eminence are extremely variable in modern humans and several specimens in the comparative sample show a morphology closely resembling that of CB 83.1096 (Fig. 1).

The maxilla (CB 85.3013) exhibits postmortem damage to the zygomatic and alveolar processes and the frontal process is broken off completely. The root of the canine and the lingual root of the first premolar are present, but no tooth crowns are preserved. The aspect of the specimen that stands out and was the focus of previous analyses (Spoor & Sondaar 1986, Spoor & Germanà 1987) is the unusual morphology of the alveolar process. Its anterior part, associated with the incisors and the canine, is similar in size and shape to that in

modern humans. However, at the level of the first and second molars the process is remarkably wide buccolingually, both relative to overall maxillary size, and to the size of the anterior part (Fig. 2). The posterior end of the alveolar process shows major postmortem damage, but the strongly tapering outline suggests that the third molar must have been absent or dysplastic. When compared with modern human morphology the greater width of the alveolar process in the molar region appears to follow from medial expansion, and this is associated with a narrow palate rather than with a maxillary shape that is unusually broad externally. Similar to the findings of Spoor & Sondaar (1986) and Spoor & Germanà (1987) no modern human specimens with a similar morphology could be found in the current comparative sample. Crucial questions that follow from this observation are whether the unusual alveolar proportions could result from any kind of pathological process, and whether the alveolar dimensions can provide a reliable indication of the crown size of the associated teeth, as has been suggested by Spoor & Sondaar (1986).

The maxilla shows some evidence of pathology. This is confined to possible traces of api-

cal inflammation of the premolars and some of the molar roots, resulting in local destruction of the interalveolar bone septa. Moreover, the alveolus of the first molar is notable more shallow than those of the adjacent elements, which could indicate that this molar was overerupted as a response to the absence of its mandibular counterpart. On the other hand, the radiographs and CT scans do not give any evidence for pathology associated with the preserved roots of the canine and the first premolar. Most importantly, all alveolar margins that are preserved are sharp and not affected by chronic inflammation. Where parts of the alveolar wall are missing this clearly concerns postmortem damage. In all, it is unlikely that the overall shape of the alveolar process has been remodelled as the result of major pathology.

Having ruled out a likely pathological origin of the large buccolingual width of the molar alveoli, the question remains whether this morphology implies that the Corbeddu Cave individual had unusually large molars. Such a link between alveolar and crown size was made by Spoor & Sondaar (1986), but this assumption was not underpinned by an essential correlation analysis covering a large sample of modern specimens. Doing such an

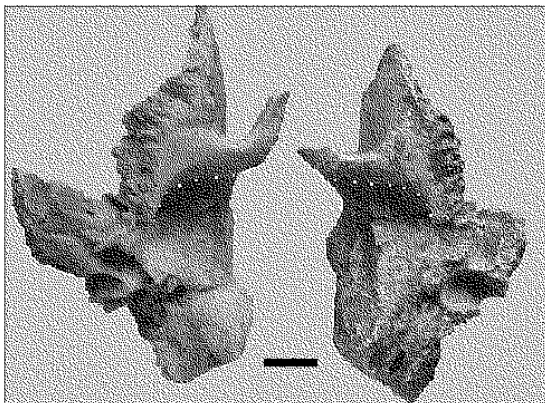


Figure 1 Inferior aspect of the Corbeddu Cave temporal bone CB 83.1096 (right) and a specimen from the modern human comparative sample (left) with a similarly shaped articular eminence. The white dots mark the relatively flat eminence outlines. Scale bar is 10 mm.

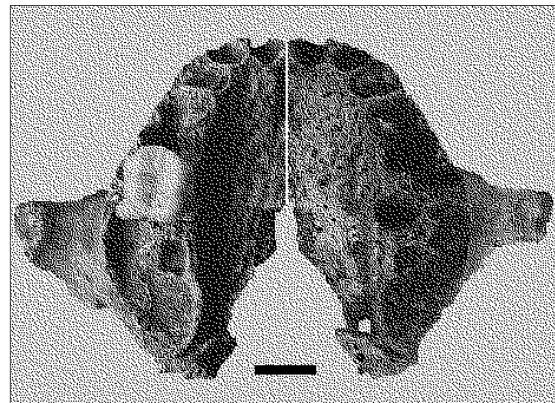


Figure 2 Occlusal view of the Corbeddu Cave maxilla CB 85.3013 (right), combined with a mirror-imaged cast of the specimen (left) with a first molar from the modern human comparative sample mounted in the socket. The buccolingual crown diameter of the molar is 12.0 mm. Scale bar is 10 mm.

analysis is outside of the scope of this paper and here a purely empirical approach was taken by attempting to match isolated first molars with the alveolus of the Corbeddu Cave maxilla. This exercise produced several molars with moderate crown sizes which show a reasonable fit in the alveolus (Fig. 2). All molars thus selected show a certain degree of spreading of the roots, a morphology that is not clearly reflected in the alveolus because of its shallow depth. Hence, even though there may be a broad correlation between alveolar size and crown size, the Corbeddu Cave maxilla provides insufficient evidence to make any inferences about the specimen's dental size.

DISCUSSION AND CONCLUSIONS

This re-evaluation of the morphology of the Corbeddu Cave human remains recognizes the unusual nature of the alveolar proportions of the maxilla as observed by Spoor & Sondaar (1986), and concludes that this morphology is unlikely to have resulted from any chronic pathological process. However, the conclusion of these authors that the alveoli are indicative of molars that were unusually large for *Homo sapiens* and would be part of a functional complex related to heavy use of the masticatory apparatus is clearly premature and without sufficient foundation. Moreover, unlike claims by Spoor & Sondaar (1986), all aspects of the temporal bone morphology can be accommodated within the normal variation seen in modern human populations.

Do the Corbeddu Cave human remains provide any morphological evidence to suggest that the Sardinian pre-Neolithic population showed signs of endemism, the result of genetic isolation from mainland populations for a period going back perhaps as far as the Middle Pleistocene? The one unusual aspect of these remains, the aberrant alveolar process of the maxilla, is clearly insufficient to reach such far-reaching conclusions. It is a relatively minor feature and the evidence for its occurrence is restricted to one body side

of a single individual only. Moreover, it concerns the one morphological region of the human skeleton that is perhaps the most susceptible to biomechanical and developmental influences during life, which renders it particularly unsuitable for assessing genetic isolation. In the absence of any traits shared with more archaic European hominids there is currently no morphological indication for a Middle Pleistocene root of the humans represented in Corbeddu Cave and an origin from modern Late Pleistocene mainland populations seems most likely. That the morphological evidence for their biological isolation is rather weak obviously does not exclude the possibility of cultural isolation, a phenomenon suggested by the archaeology and by taphonomic analysis of associated deer fossils (Klein Hofmeijer *et al.* 1989, Klein Hofmeijer 1996, Sondaar *et al.* 1991). Also, it is interesting to note that genetic evidence based on modern samples does suggest a somewhat independent evolutionary history of the Sardinian population (Barbujani *et al.* 1995).

In conclusion, the most parsimonious scenario suggested by the Corbeddu Cave remains seems to be that modern humans, present on the mainland from about 40,000 years ago, reached Sardinia earlier than was thought previously. If the archaeological evidence for a Middle Pleistocene occupation is correct these colonizers may have encountered and replaced the descendants of more archaic hominids. It is likely that there was little contact with mainland populations until the Neolithic, but to assess whether this degree of isolation did result in any form of morphological endemism additional human specimens will need to be discovered. That the Sardinian endemic fauna did not go extinct following hominid colonization may be related to the combination of low population levels of the Palaeolithic hominids, the relatively large size of Sardinia and the abundant presence of a rapidly reproducing food source, the rabbit-like ochotonid *Prolagus*

(Sondaar *et al.* 1986). It is thus only with the arrival of more advanced Neolithic cultures and populations that most of the endemic fauna disappeared, perhaps as much through competition with imported mainland species as through hunting pressures. The detailed excavations of Corbeddu Cave under the inspiring and sometimes provocative direction of Paul Sondaar have demonstrated that this site offers the unique opportunity to study this complex process of multiple migrations of humans and other mammals. With the latest published evidence indicating human presence in the cave at least 20,000 years ago, it can only be hoped that this work can and will continue in the future.

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NOTE ADDED TO PROOFS

Scenarios of multiple hominid migrations into Sardinia during the Middle and Late Pleistocene have been proposed previously (Martini 1992; Sondaar in press). In this context it is worth noting that if the mainland ancestors of the humans represented at Corbeddu Cave were north African rather than southern European a time of migration considerably earlier than 40.000 years ago could be compatible with the modern human morphology of the Corbeddu Cave fossils.

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F.S.