The mammals and birds from the Gruta do Caldeirão, Portugal

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A B S T R A C T   Caldeirão cave is 140 km north east of Lisbon near the town of Tomar. João Zilhão, of the University of Lisbon, excavated Caldeirão between 1979 and 1988. It contains a sequence of levels with associated cultural remains belonging to the Mousterian, Early Upper Palaeolithic, Solutrean, Magdalenian and Neolithic. Faunal remains from a wide spectrum of species were recovered by sieving. The most common large mammals include red deer, equids, goat, chamois, aurochs, and wild boar. Large carnivores, especially hyaena, were common in the older levels, and became scarcer or disappeared in the course of the cave's occupation. Other carnivores include four species of felids, wolf, fox, bear and badger. Rabbit, hare and beaver were also present.

Caldeirão provides us with an interesting zoo-archaeological puzzle. Did the cave function more as a hyaena den, at least in its early periods of occupation? The main indicators of hyaena activity include the presence of Crocuta remains, coprolites, and "semi-digested" bones. All these are most common in Mousterian and EUP levels. Burn marks are scarce in the Mousterian and EUP levels, but abundant in subsequent levels. The lithics to bone ratios are low in the Mousterian and EUP, but high in the Solutrean. Most remains of the equids and red deer are juvenile in the early levels and adult in the later ones — a possible reflection of hyaenas' inability to hunt and/or bring back to the cave adults of these species.

It is proposed that the cave functioned more as a hyaena den in the early levels and that subsequently hyaenas disappeared as people used the cave more intensively. This decrease in hyaena activity in the course of time at Caldeirão is apparently common in Iberian sites, and suggests that in the Mousterian and EUP human populations were sparse. The rabbit to ungulate ratio also increases with time — another possible indicator of increasing intensity of human exploitation of the environment.

R E S U M O   A Gruta do Caldeirão está situada na região centro de Portugal, perto da cidade de Tomar. Entre 1979 e 1988 foi escavada por João Zilhão da Universidade de Lisboa e revelou uma sequência de níveis com vestígios culturais pertencentes ao Moustierense, Paleolítico Superior antigo, Solutrense, Magdalenense e Neolítico. Durante as operações de crivagem foram recuperados restos faunísticos de uma grande variedade de vertebrados. As espécies mais abundantes são o veado, equídeos, cabra, camurça, auroques e javali. Os grandes carnívoros, sobretudo a hiena, são frequentes nos níveis mais antigos, tornando-se mais

escassos ou desaparecendo no decurso da ocupação da gruta. Regista-se igualmente a presença de lobo, raposa, urso, texugo e quatro espécies de felídeos. O coelho, a lebre e o castor também estão presentes.

O estudo zoo-arqueológico da Gruta do Caldeirão suscita uma problemática de difícil resposta: quem ocupou aquele espaço durante os períodos mais antigos — o Homem ou as hienas? Os principais indicadores da actividade destas últimas são a presença de restos (ossos e dentes) de Crocuta, coprólitos, e ossos parcialmente digeridos. Estes vestígios são mais frequentes nos níveis do Moustierense e do Paleolítico Superior antigo. Ossos queimados são raros durante estes períodos mas tornam-se mais frequentes nos níveis posteriores. A proporção entre material lítico e ossos é baixa durante o Moustierense e o Paleolítico Superior antigo, aumentando no Solutrense. A maior parte dos restos de equídeos e veados pertencem a animais jovens nos níveis mais antigos e pertencem a adultos nos mais recentes , sendo este talvez um indicador da incapacidade das hienas de caçar ou transportar para a gruta indivíduos adultos destes animais.

Neste artigo, propõe-se que a gruta terá funcionado mais como um covil de hienas nos períodos mais recuados, diminuindo a sua presença à medida que se intensificou a ocupação humana daquele espaço. Situações semelhantes são aparentemente conhecidas noutras jazidas Ibéricas podendo indicar a escassez de grupos humanos durante o Moustierense e o Paleolítico Superior antigo. A proporção entre coelhos e ungulados também aumenta ao longo do tempo, sendo este um outro indicador do possível acentuar da exploração humana dos recursos ambientais.

"... the occasional occurrence, in various parts of Europe, of the bones of man or the works of his hands, in cave-breccias and stalactites, associated with the remains of the extinct hyæna, bear, elephant, or rhinoceros, has given rise to a suspicion that the date of man must be carried further back than we had heretofore imagined."

CHARLES LYELL, 1863
The geological evidences of the antiquity
of man with remarks on theories of the
origin of species by variation.
London, John Murray (p.1)

Introduction

The zoo-archaeology of caves first contribution to science, as suggested by the above quotation, was to provide evidence for the antiquity of man. People were making tools and hunting now extinct animals long before 4004 BC — the supposed date of the creation. Edouard Lartet (1801-71) who studied bones in caves found changes in the species composition in different strata and recognised different periods according to their associated animals. Since those pioneering days, faunal studies have become an integral part of archaeology. Animal bones help us to understand a site's use, climate change, the evolution of species, and, of course, the nature of the relation between people and their environment. It is my hope that this report on the mammals and birds from Caldeirão cave will contribute to our understanding of the prehistory of Portugal. Caldeirão, in the Vale do Nabão, central Portugal, is some 140 km north east of Lisbon near Tomar. At an altitude of 120 metres it is situated at latitude 39º 38' 54"N and longitude 8º 24' 54"W (Fig. 1). The cave, in a limestone region, faces south and provides access to a corridor, which terminates in a room approximately 14 m² whose end is some 20 m from the

entrance (Zilhão, 1997a). João Zilhão, who excavated Caldeirão between 1979 and 1988, uncovered levels to a depth of 6.2 m with remains belonging to the Neolithic, Magdalenian, Solutrean, Early Upper Palaeolithic and Mousterian cultures (Zilhão, 1997a; see table below). Today the vegetation in this "Atlantic-Mediterranean" region includes various species of oak, and on the overlying plateau, fig and olive are cultivated. Annual rainfall is around 1000 mm.

Póvoas (1991), and Póvoas et al. (1991) described the Mousterian to Magdalenian rodents, and Rowley-Conwy (1992) the Neolithic large mammals of Caldeirão. Antunes (1989) described five beaver teeth from the Mousterian and Magdalenian. This report describes the large mammal and bird remains. John Stewart studied the bird remains and Sally Newton is studying the rabbit bones. A summary of her findings is included here. Although the Caldeirão faunal collection is small by Franco-Cantabrian standards, it is the largest in Portugal and the only one encompassing such a time depth and stratigraphic resolution. It adds to a growing number of studies of Portuguese Upper Pleistocene faunal assemblages (see for example two recent syntheses, one by Cardoso, 1993 and the other by Antunes, 2000 and a recently completed study of Upper Palaeolithic bones

Fig. 1 Map of Portugal to show the location of Caldeirão cave.

from Pego do Diabo by Valente, 2000). I make various hypotheses, mainly about who used the cave, which should become testable when further excavations provide more material for study.

Remains of animals from late Pleistocene deposits may provide the kinds of information mentioned above. However, caves often present the zoo-archaeologist with another problem. Other bone-collecting carnivores besides man are known to have inhabited the region. We need then to understand who was using the cave. To what extent were the animal remains collected by people and to what extent did carnivores accumulate them? Our conclusion is that in the earlier periods, Mousterian and Early Upper Palaeolithic, the cave of Caldeirão functioned largely as a carnivore feeding den, while in subsequent Solutrean and Magdalenian periods humans were its main occupants. If this was indeed the case, we would like to understand to what *degree* were carnivores and humans respectively responsible for accumulating the bones in each level.

Recovery, preservation and sample-size

All earth was routinely dry-sieved through a mesh of 2 mm aperture. A sample (10-20%) was transported to the Natural History Museum in Lisbon and wet-sieved using a 0,5 or 0,6 mm mesh. The latter provided Póvoas with her samples of microfauna. The bones are well preserved and there do not appear to have been great changes in this with time. Many had a calcareous encrustation ('calcrete'), which could be removed with dental tools or by immersion in dilute acetic acid. Although it is a small collection in total, it is worth noting that for example for the
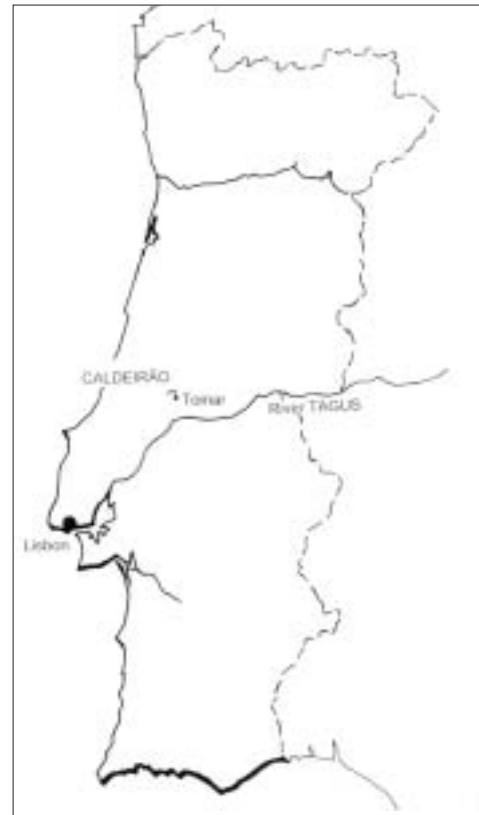
Solutrean red deer (Table 3) the MNI estimates are as high for the phalanges (obtained by dividing the counts of each phalanx by 8) as for other parts of the skeleton, such as humerus (obtained by dividing by 2). This is unusual and presumably reflects the great care taken in excavation and recovery of the bones from this site, as well as (perhaps) their state of preservation.

The animal bone assemblage from Caldeirão is sufficiently large to estimate:

a) The frequencies of different taxa in each of the five periods,
b) The proportions of juvenile and adult red deer and equids in the four late Pleistocene periods,
c) The representation of different parts of the red deer and equid skeleton in the late Pleistocene,
d) Some very tentative indications concerning the size of some of the species, and
e) By analysing the pattern of damage on bones and their fragments, an idea of carnivore versus human involvement in each level.

The animal bones from Caldeirão are stored in the Museum of Archaeology, Belém, Lisbon.

Stratigraphy and pooling of the faunal remains

With around 900 recorded bones and teeth, observations on the faunal remains have been pooled into five main cultural units (with their strata and dates) as follows:

LAYERS	PERIOD	DATE BP
Ea	Neolithic*	6400 - 5700
Eb	Magdalenian**	16 000 – 10 000
Fa, Fb, Fc, H, I	Solutrean	22 000 – 18 000
Ja, Jb	Early Upper Palaeolithic	27 000 – 22 000
K, L, M, N	Mousterian	> 27 000

  * includes Neolithic material intrusive in Eb and excludes Palaeolithic material derived from Eb
** excludes Neolithic material intrusive in Eb and includes Palaeolithic material displaced in Ea

Animal burrowing in Magdalenian times, probably by lynx or badger, affected the integrity of the deposits in some parts of the cave, particularly in the corridor area, where some large burrows traversed the Solutrean levels down to the interface with the EUP deposits. Although great care was placed in isolating these disturbed areas, such activity, as well as other processes of post-depositional disturbance that are a natural feature of most cave deposits, mean that significant amounts of Magdalenian bones (especially rabbits) may be intrusive in the Solutrean (this is clearly the case in the uppermost Solutrean levels of squares O-P/13-14, for instance). Conversely, in the corridor area, diagnostic Solutrean lithic artefacts were found scattered in the Magdalenian levels, which, therefore, can be expected to be similarly "contaminated" to a small extent by upwardly displaced Solutrean material (Zilhão 1992, 1997a, personal communication). Small-scale displacements must have occurred throughout the succession, as indicated by artefact refitting and the radiocarbon dating of individual bone samples' and are duly considered below whenever vertical distribution patterns are discussed.

Methods

All bones and teeth were examined, but only certain regions of some of the bones were recorded in detail. What follows is a description of the criteria applied when deciding whether or not to record a particular fragment of bone or tooth, and how bones and teeth were counted, so that data from Caldeirão can be easily interpreted and used by other zoo-archaeologists working on the same material (Davis, 1992).

The parts of the skeleton counted

These regions are similar to Watson's (1979) "diagnostic zones". For example the medial half of the articulation of the distal tibia is counted, but none of the following parts of a tibia would be counted: the lateral half of the distal articulation, diaphysis, and proximal end. These "counted parts of the skeleton" include the mandibular cheek teeth, and articular ends/epiphyses of girdle, limb and feet bones. They are the units used to calculate the frequencies of different parts of the skeleton and proportions of young (epiphysis unfused) versus adult (epiphysis fused) animals. When other parts of the skeleton such as antlers, horn cores or maxillary teeth are the only evidence for the presence of a species, these **non-countable specimens** are recorded and their presence denoted by a + sign, but not included in the total counts of species found. The reasons for selecting these particular parts are as follows: a) they are relatively easy to identify to species; b) some, such as the distal metacarpal in some species of artiodactyls, when in sufficient quantity, can provide information about the sex ratio; c) many include a separate centre of ossification, or epiphysis, which fuses to the rest of the bone at a particular age and so, in sufficient quantity, provide a ratio of juveniles to adults; d) many provide useful measurements; and e) they come from most regions of the mammalian skeleton (head, girdles, limbs and feet) and their relative abundance indicates possible preferences for different parts of the body such as non-meat-bearing versus meat-bearing or fore-quarters versus hind-quarters.

Detailed descriptions of parts of the ungulate skeleton counted.

Isolated cheek teeth – deciduous premolar (dP_2, dP_3, dP_4) or pre-molar (P_2, P_3, P_4) first, second and third molar teeth (M_1, M_2 and M_3)
When more than half is present.

Scapula
If *more than half the glenoid articulation* is present. A glenoid articulation from a very young animal to which the coracoid had not been fused is recorded (as 'scapula U'). The state of fusion of the coracoid cannot be ascertained for a glenoid from which the area adjacent to the coracoid (or fusion surface with the coracoid) is missing, and is therefore recorded as 'Scapula - Coracoid?'.

Distal humerus
The *medial half of the trochlea* including enough bone adjacent to the shaft to identify the state of fusion of the distal epiphysis. The lateral half of a broken/chopped trochlea would not be counted.

Distal radius

The *medial half of the articular surface* including enough bone adjacent to the shaft to identify the state of fusion of the distal epiphysis.

Distal metacarpal

The *condyles* plus at least a small part of the region of fusion of the epiphysis (i.e. enough of the distal end to identify the state of fusion of the epiphysis.) Artiodactyl distal metacarpals comprise two condyles, which often break apart. A single artiodactyl condyle is counted as a '1/2'. At least half of a single condyle should be present. Each of the two central suid metacarpals (Mc 3 and 4) are counted as halves. Suid lateral metacarpal condyles (Mc 2 and 5) are not counted. Some poorly preserved metapodials, and broken suid axial metapodials, cannot be identified as metacarpals or metatarsals. These are counted as 'metapodials'.

Ischium of the pelvic girdle

That part of the *acetabulum rim which is formed by the ischium*. At least half should be present.

Distal femur

More than half of the *lateral condyle* including enough bone adjacent to the shaft to identify the state of fusion of the distal epiphysis.

Distal tibia

Medial part of the articulation provided this consists of half or more of the total articular surface and including enough bone adjacent to the shaft to identify the state of fusion of the distal epiphysis.

Astragalus

Half or more of the *lateral surface*.

Calcaneum

All of the sustentaculum plus half or more of the adjacent surface that articulates with the astragalus. This is essentially the central part of the calcaneum and if the ascending ramus is missing the state of fusion of the *tuber calcis* cannot be ascertained. Calcanea without ascending rami are therefore recorded as 'Calcaneum - tuber calcis ?'.

Distal metatarsal

See distal metacarpal.

Proximal first and second phalanx

Half or more of the *articular surface* including enough bone adjacent to the shaft to identify the state of fusion of the epiphysis.

Third (terminal) phalanx

The *articular surface* if half or more is present.

This method was devised for dealing with assemblages that are comprised in the main part of ungulate bones. Caldeirão is rather different in containing many carnivore remains whose metapodials and phalanges are difficult to assign to their position within the hand and foot. Here, all these bones are counted so the total numbers of carnivore bones is slightly inflated – as carnivores have many more of these bones than do ungulates.

Fragments

In addition to recording these identifiable bones, a very large number of unidentifiable fragments and chips of large mammal bones (most are presumed to have belonged to ungulates) were also studied. Their numbers, as well as certain characters that they show such as burn, cut, acid-corrosion, and gnawing marks were recorded.

Recording of age-at-death

There are two osteological methods of determining the "age-at-death" of a mammal. One method considers the proportion of unfused limb-bone epiphyses. The growing ends or epiphyses of long bones do not fuse to their respective shafts (diaphyses) until the end of their growing period. The state of fusion of epiphyses is recorded as follows. "F" = fused (adult) and "UE" = unfused (juvenile) epiphysis and "UM" the unfused metaphysis – the end of the shaft to which the epiphysis would have been attached in life. An epiphysis is described as "fused" once spicules of bone have formed across the epiphysial plate joining diaphysis to epiphysis.

The other method considers tooth eruption and wear. Growing mammals replace their milk teeth at well-defined ages. Mandibles may therefore contain deciduous (milk) premolars (dP_2, dP_3 and dP_4) or their replacement teeth (P_2, P_3 and P_4). Like many herbivores, bovids have high crowned teeth to counteract the wear induced by their abrasive diet of grass and the inevitable sand and grit particles. Their crowns gradually wear down. As they do so, the enamel fold pattern on their occlusal (biting) surface changes. These patterns form the basis of a series of age-related "wear stages" which have been described by various investigators. Here, caprine and *Rupicapra* teeth were assigned to the eruption and wear stages of Payne (1973 and 1987), *Sus* and *Bos* teeth were assigned to the eruption and wear stages of Grant (1982).

Epiphysial fusion, and "milk versus permanent" dental data provide an estimate of the proportion of juveniles for a particular epiphysis and for the dentition respectively. More detailed sub-divisions into smaller age classes are provided by the different wear-stages of individual teeth.

Measurements

Measurements were taken with vernier callipers to the nearest 0.1 mm in the manner suggested by von den Driesch (1976) and as shown in Fig. 1 in Davis (1996). Equid mandibular teeth were measured as in Fig. 2.
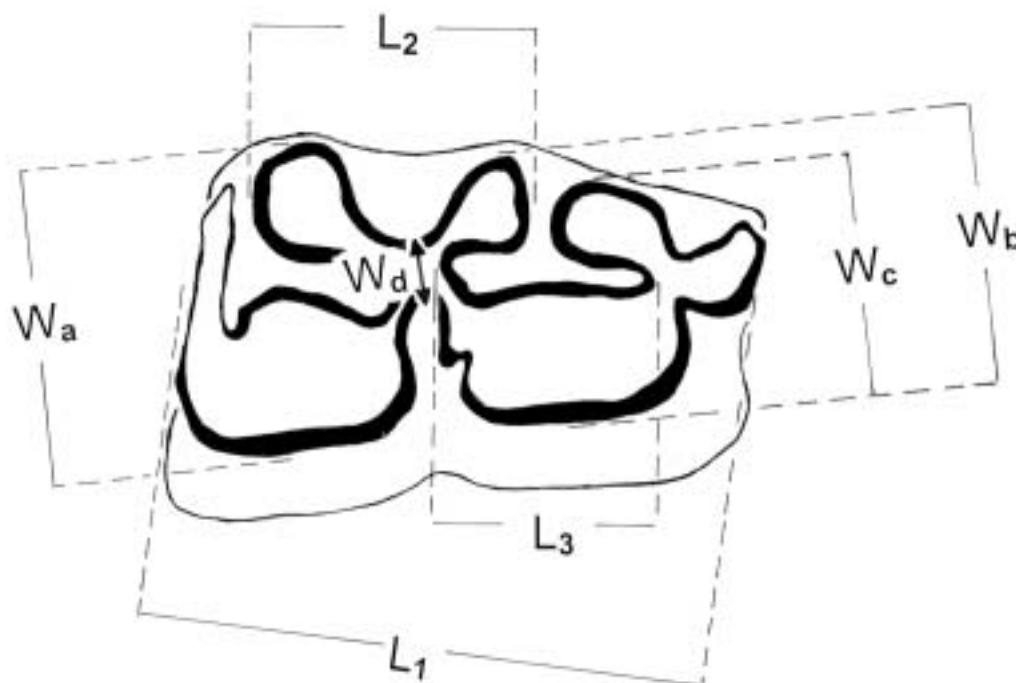
Fig. 2 An equid mandibular tooth in occlusal view, with the enamel folds drawn in black, to illustrate how measurements are taken.

Identifications

I used the reference collection here in the IPA. Specimens thought to belong to rare animals like bear, hyaena, large felids, and chamois were verified at the Musée d'Histoire naturelle in Paris. Photographs of many bones of these are included. (I am not certain that all identifications are correct and would appreciate comments from colleagues.) Similarly, bird bones were identified at the Laboratorio de Arqueozoologia, Universidad Autónoma de Madrid. John Stewart, using the Natural History Museum collection in Tring, Hertfordshire, England has also checked our identifications and has written the section on birds.

Modifications

Cut and gnaw marks as well as burns are recorded, although these often proved difficult to see due to the calcareous concretions. Counts of such marks are therefore underestimated. Other post-mortem changes to bone were also noted such as acid corrosion.

Species found and some metric considerations (Tables 1 to 6 and appendix)

The taxonomy of extant species follows Mitchell-Jones et al. (1999). The Caldeirão mammal fauna includes at least eight species of ungulates and eight species of carnivores as well as an abundant small mammal and avian fauna. The most common large mammal is red deer, followed by equids and goat. Their frequencies are discussed later.

Tables 1 to 5

Numbers of teeth and bones from the Mousterian, Early Upper Palaeolithic, Solutrean, Magdalenian and Neolithic of Caldeirão cave. Some caprine/rupicaprine bones could not be identified to species and their numbers are given in the column "RCO" (i.e. *Rupicapra/Capra/Ovis*). Cat = *Felis silvestris*. Other taxa are abbreviated as follows: Bos = aurochs/cattle, Cap = goat, Rupi = chamois, Cerv = red deer, Sus = wild boar/pig, Equu = equid, Badg = badger and Hyen = hyaena. UM = unfused metaphysis, UE = unfused epiphysis, F = fused end. For some calcanea and scapulae the state of fusion of their epiphyses (tuber calcis and coracoid) could not be ascertained due to poor preservation/breakage, they are counted under "?". Bones marked with an "*" are uncertain identifications. Each mandibular tooth, whether isolated or within a mandible, is counted separately, ("dP-" teeth are milk teeth). In the Solutrean, 15 first and 5 second red deer perforated phalanges are listed separately as "+x" and in view of their possible cultural origin are not included in the counts.

Table 1. Mousterian														
		Bos	**Cap**	**RCO**	**Rupi**	**Cerv**	**Sus**	**Equu**	**Badg**	**Hyen**	**Bear**	**Lynx**	**Wolf**	**Fox**	**Others**
Teeth	dP_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(mandibular)	P_2	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	dP_3	-	-	-	1	1	-	-	-	-	-	-	-	-	-
	P_3	-	-	-	-	2	1	-	-	1	-	1	-	-	-
	dP_3/dP_4	-	-	-	-	-	-	7	-	-	-	-	-	-	-
	dP_4	1	-	-	1	1	-	-	-	-	-	-	-	-	-
	P_4	-	-	1	-	2	1	-	-	1	-	-	-	-	-
	P_3/P_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M_1	-	-	-	-	1	-	-	-	1	-	-	-	-	1 Leopard
	M_1/M_2	-	1	-	-	1	-	1	-	-	-	-	-	-	-
	M_2	-	-	-	-	1	-	-	-	1	-	-	-	-	-
	M_3	-	-	1	-	3	-	-	-	-	-	-	-	-	-
	PM/M	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Scapula	U	-	-	-	-	-	-	1	-	-	-	-	-	-	-
(glenoid)	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal	UM	-	-	1	-	-	-	-	-	-	-	-	-	-	-
humerus	UE	-	-	-	-	1*	-	-	-	-	-	-	-	-	-
	F	-	1	-	-	-	-	1	-	-	-	-	-	-	1 Roe deer
Distal **radius**	UM	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal	UM	-	-	-	-	2	-	-	-	-	-	-	-	-	-
metacarpal	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	1	1	-	-
Ischium		-	1*	-	-	-	-	-	-	-	-	1*	-	-	-
(acetabulum)															
Distal **femur**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **tibia**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	F	-*	-	-	-	1	-	-	-	-	-	-	-	-	-
Calcaneum	U	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	1	-	-	-	-	-	1	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Astragalus		-	3	-	-	5	-	-	-	-	-	1	-	1	-
Distal	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
metatarsal	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-
Phalanx 1	UM	-	-	-	-	5	-	3	-	-	-	-	-	-	-
proximal	UE	-	-	-	-	3	-	2	-	-	-	-	-	-	-
	F	-	2	-	-	1	-	-	-	-	1	4	2*	-	-
Phalanx 2	UM	-	-	-	-	2	-	2	-	-	-	-	-	-	-
proximal	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	1*	-	-	1	-	-	-	-	-	-	-	-	-
Phalanx 3		-	2	-	2*	10	-	1	-	2	-	2	-	-	-
Distal	UM	-	-	-	-	0.5*	-	-	-	-	-	-	-	-	-
metapodial	UE	-	-	-	-	1	-	1	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other bones															2 Amphib.longbones
															2 tortoise osteoderm
															9 Bird bones

Table 2. Early Upper Palaeolithic														
		Bos	Cap	RCO	Rupi	Cerv	Sus	Equu	Badg	Hyen	Bear	Lynx	Wolf	Fox	Others
Teeth (mandibular)	dP_2	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	P_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP_3	-	-	-	-	2	-	3	-	-	-	-	-	-	-
	P_3	-	1	-	-	-	-	-	-	1	-	-	-	1	-
	dP_3/dP_4	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	dP_4	-	-	-	-	5	-	1	-	-	-	-	-	-	-
	P_4	-	3	2	-	-	-	-	-	-	-	-	-	-	-
	P_3/P_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M_1	-	1	-	-	1	-	-	-	1	2	-	-	-	-
	M_1/M_2	-	2	1	-	-	-	-	-	-	-	-	-	-	-
	M_2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	M_3	-	3	2	-	-	-	-	-	-	-	-	-	-	-
	PM/M	-	-	-	-	-	-	3	-	-	-	-	-	-	-
Scapula (glenoid)	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **humerus**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Distal **radius**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **metacarpal**	UM	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-
	F	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Ischium (acetabulum)		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **femur**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **tibia**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	1*	-	-	-	-	-	-	-	-	-
Calcaneum	U	-	-	-	-	-	-	1	-	-	-	-	1	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	2*	-	-	-	-	-	-	-	-	-
Astragalus		-	1	-	-	1	-	1	-	-	-	-	-	-	-
Distal **metatarsal**	UM	-	-	-	-	3	-	2	-	-	-	-	-	-	-
	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	1	-	-	-	-	1	-	-	-	-
Phalanx 1 proximal	UM	-	-	-	-	5	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	F	-	1	1	3	1	-	-	-	-	4	2	1*	-	1 Lion, 1 Hare
Phalanx 2 proximal	UM	-	-	-		3	-	1	-	-	-	-	-	-	-
	UE	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	F	-	4	1	-	2	-	-	-	-	-	-	3*	-	-
Phalanx 3		-	3	1	1*	5	-	1	-	2*	-	1*	-	-	1 Roe deer
Distal **metapodial**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	0.5	-	-	-	-	-	-	-	2	-	1*	-	1 Hare, 1* Lion
Other bones															10 Bird bones 1 tortoise osteoderm

Table 3. Solutrean		Bos	Cap	RCO	Rupi	Cerv	Sus	Equu	Badg	Hyen	Bear	Lynx	Wolf	Fox	Others
Teeth (mandibular)	dP_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP_3	-	-	1	-	2	-	-	-	-	-	-	-	-	-
	P_3	-	-	4	-	2	-	-	1	-	-	1	-	-	-
	dP_3/dP_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP_4	-	-	-	-	8	-	-	-	-	-	-	-	-	-
	P_4	-	-	2	-	5	-	-	1	-	-	-	-	-	1* Leopard
	P_3/P_4	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	M_1	-	-	-	2	2	-	-	1	-	-	2	-	1	-
	M_1/M_2	-	3	2	1	4	-	1	2	-	-	-	-	-	-
	M_2	-	-	-	2	2	-	-	1	-	-	-	-	-	-
	M_3	-	1	1	4	5	-	1	-	-	-	-	-	-	-
	PM/M	-	-	-	-	2	-	2	-	-	-	-	-	-	-
Scapula (glenoid)	U	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	F	-	1	-	1	-	-	-	-	-	-	1*	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **humerus**	UM	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	UE	-	1*	1	-	1*	-	-	-	-	-	-	-	-	-
	F	-	1	1	-	-	-	1	-	-	-	2	-	-	-
Distal **radius**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Distal **metacarpal**	UM	-	-	-	-	1	-	-	-	-	-	-	-	-	1 Roe deer
	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	2	-	-	3	-	1	-	-	-	-	-	-	-
Ischium (acetabulum)		-	1*	1	1*	-	-	-	-	-	-	-	-	-	-
Distal **femur**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **tibia**	UM	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	1*	-	-	-	2	-	-	-	-	-	-	-	-	1 Leopard
Calcaneum	U	-	-	-	-	4	-	-	-	-	-	-	-	-	-
	F	-	3	-	-	-	-	-	1	-	-	-	-	-	-
	?	-	-	-	-	1*	-	-	-	-	-	-	-	-	-
Astragalus		-	1*	-	1*	7	-	-	-	-	-	3	-	-	1 Cat
Distal **metatarsal**	UM	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	2	-	1	-	-	-	-	-	-	-
	F	-	1*	-	-	3	0.5	-	-	-	-	-	-	-	-
Phalanx 1 proximal	UM	-	-	-	-	7 (+2)	-	2	-	-	-	-	-	-	1* Roe deer
	UE	-	1*	-	-	8	-	-	-	-	-	-	-	-	-
	F	-	3	-	-	18 (+13)	-	-	-	-	-	5*	1*	-	1 Cat, 1 Leopard
Phalanx 2 proximal	UM	-	1	-	-	9	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	1	-	1	-	-	-	-	-	-	-
	F	-	2	-	2*	23 (+5)	-	-	-	-	1	5*	-	-	-
Phalanx 3		1	1	-	-	25	-	1	-	-	-	1	-	-	-
Distal **metapodial**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	2*	-	-	-
Other bones															10 Amphib. longbones 36 Bird bones

		Bos	Cap	RCO	Rupi	Cerv	Sus	Equu	Badg	Hyen	Bear	Lynx	Wolf	Fox	Others
Teeth	dP$_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(mandibular)	P$_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP$_3$	-	-	-	-	1	2	-	-	-	-	-	-	-	-
	P$_3$	-	-	-	-	2	-	-	1	-	-	-	-	-	1 Cat
	dP$_3$/dP$_4$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP$_4$	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	P$_4$	-	-	-	-	3	-	1	1	-	-	1	-	-	1 Cat
	P$_3$/P$_4$	-	-	-	-	-	-	-	-	-	-	1	-	-	-
	M$_1$	-	-	-	-	-	-	-	2	-	-	-	-	-	1 Cat
	M$_1$/M$_2$	-	-	-	-	2	-	2	-	-	-	-	-	-	-
	M$_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M$_3$	1	-	-	-	1	-	-	-	-	-	-	-	-	1 Beaver
	PM/M	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Scapula	U	-	-	-	-	1*	-	-	-	-	-	-	-	-	-
(glenoid)	F	-	-	-	-	1	-	-	1	-	-	1*	-	1	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Hare
humerus	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	1*	-	-	-	-	-	3	-	1	2 Hare, 1 Cat
Distal	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
radius	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Distal	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
metacarpal	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	2	-	-	-	-	-	2	-	1	-
Ischium	-	-	-	-	-	-	-	-	-	-	-	1*	-	1	2 Hare
(acetabulum)															
Distal **femur**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	1*	-	-	-	-	-	-	-	-	-	-	-	1	-
Distal **tibia**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-*	-	-	1	2	-	1	1	-	-	1	-	-	-
Calcaneum	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	2	-	-	2	-	-	6 Hare
	?	-	-	-	-	1	-	-	-	-	-	-	-	-	1 Hare
Astragalus		-	2*	-	-	4	-	-	-	-	-	3	-	1	1 Roe deer
Distal	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
metatarsal	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5 Roe deer
	F	-	-	-	-	3	-	-	-	-	-	4	-	-	-
Phalanx 1	UM	-	-	-	-	1	-	-	-	-	-	-	-	-	-
proximal	UE	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	9	2	-	5	-	-	2*	-	2	1 Hare, 1 Roe deer, 2* Leopard
Phalanx 2	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
proximal	UE	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	1	-	2	-	8	1	-	-	-	-	2	-	1	-
Phalanx 3		-	-	-	-	15	2	-	3	-	-	5	-	-	-
Distal	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
metapodial	UE	-	-	-	-	-	2	-	-	-	-	-	-	-	-
	F	-	-	-	-	1	1	2	2	-	-	2	-	-	1 Cat, 1* Leopard
Other bones															10 Amphib.longbones 28 Bird bones 1 trout vertebra

Table 4. Magdalenian

Table 5. Neolithic														
		Bos	**Cap**	**RCO**	**Rupi**	**Cerv**	**Sus**	**Equu**	**Badg**	**Hyen**	**Bear**	**Lynx**	**Wolf**	**Fox**	**Others**
Teeth (mandibular)	dP_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP_3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
	P_3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP_3/dP_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	dP_4	-	-	-	-	-	4	-	-	-	-	-	-	-	-
	P_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P_3/P_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M_1	-	-	-	-	-	2	-	-	-	-	-	-	2	-
	M_1/M_2	2	-	1	-	-	-	-	-	-	-	-	-	-	-
	M_2	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	M_3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PM/M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapula (glenoid)	U	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **humerus**	UM	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Distal **radius**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **metacarpal**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ischium (acetabulum)		-	-	1	-	-	-	-	-	-	-	-	-	-	-
Distal **femur**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distal **tibia**	UM	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	UE	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	F	-*	-	-	-	-	-	-	1	-	-	-	-	-	-
Calcaneum	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	?	-	-	1	-	-	1	-	-	-	-	-	-	-	-
Astragalus		2	-	-	-	-	1	-	-	-	-	-	-	-	1 Cat, 2* Sheep
Distal **metatarsal**	UM	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	UE	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanx 1 proximal	UM	-	-	1	-	-	6	-	-	-	-	-	-	-	1* Sheep
	UE	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	F	-	1*	-	-	1	2	-	-	-	-	-	-	1	-
Phalanx 2 proximal	UM	1	-	1 -		-	-	-	-	-	-	-	-	-	-
	UE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	4	-	-	-	-	5	-	-	-	-	-	-	3	3 Cat, 1* Sheep
Phalanx 3		-	-	-	-	-	2	-	-	-	-	-	-	-	-
Distal **metapodial**	UM	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
	UE	0.5	-	0.5	-	-	2.5	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other bones															2 Amphib. longbones 5 Bird bones

Table 6. Counts and percentages of the mammal, bird and fish bones in the five main layers at Caldeirão cave.										
	Mousterian		**EUP**		**Solutrean**		**Magdalenian**		**Neolithic**	
	n	%	n	%	n	%	n	%	n	%
Aurochs/cattle	1	**1**	-	-	1	+	3	**1**	10.5	**13**
Goat	12	**9**	23.5	**18**	24	**7**	2	**1**	1	**1**
Goat/Chamois/Sheep	3	**2**	8	**7**	14	**5**	3	**1**	8	**10**
Chamois	5	**4**	4	**3**	14	**4**	1	+	-	-
Sheep	-	-	-	-	-	-	-	-	4	**5**
Red deer	50	**39**	40.5	**33**	150.5	**52**	65	**32**	1	**1**
Roe deer	1	**1**	1	**1**	1	**1**	2.5	**1**	-	-
Wild boar/pig	3	**2**	-	-	0.5	+	10	**5**	34	**43**
Equids	24	**19**	17	**14**	25	**9**	6	**3**	1	**1**
Hare	-	-	2	**2**	-	-	17	**8**	-	-
Rabbit	806		1551		9406		5248			
Beaver	+	+	-	-	-	-	1	+	-	-
Hyaena	6	**5**	4	**3**	-	-	-	-	-	-
Bear	1	**1**	9	**7**	1	+	-	-	-	-
Badger	-	-	-	-	5	**2**	19	**9**	1	**1**
Lion	-	-	2	**2**	1*	+*	-	-	-	-
Leopard	1	**1**	-	-	3	**1**	3	**1**	-	-
Lynx	11	**9**	4	**3**	22	**8**	30	**15**	1	**1**
Wildcat	-	-	-	-	2	**1**	5	**2**	4	**5**
Wolf	3	**2**	-	-	1	+	-	-	-	-
Fox	1	**1**	1	**1**	1	+	9	**4**	8	**10**
BIRDS	9	-	10	-	36	-	28	-	5	-
FISH	-	-	-	-	-	-	1	-	-	-
Large carnivores %	(10)		(14)		(3)		(3)		(0)	
Rabbits : ungulates	8		17		42		57			
TOTAL (excluding rabbits)	131		126		303		205.5		78.5	

The "large carnivore %" is calculated by dividing the number of hyaena+bear+lion+leopard+wolf bones by the total number of mammalian herbivore and large carnivore bones. A "+" in the numbers columns signifies the presence of a bone not included in the list of parts of the skeleton counted (see "methods"). The Solutrean perforated red deer phalanges are not included in these counts.

Mammals

Aurochs/cattle – *Bos primigenius/B. taurus*

Most Pleistocene levels of Caldeirão contain a few bones and teeth of a large species of bovid. Aurochs (ancestor of our modern domestic cattle) bones are difficult to distinguish from those of bison — another species of large bovid once quite common in Europe. In order to make a distinction certain bones such as horn cores, complete metapodials and distal humeri are necessary (Auguste and Patou-Mathis, 1994). But, in the absence of these bones at Caldeirão, it is not possible to determine whether bison was present. In the Côa valley, northern Portugal, numerous late Pleistocene rock engravings include depictions of large bovids. All appear to represent aurochs rather than bison (Zilhão, 1997b). Estévez and Saña (1999) suggest that bison was absent from the central and southern parts of Iberia. According to Cardoso (1993, p. 208) the presence of bison has not been demonstrated in the Portuguese Pleistocene. I therefore tentatively refer to the large bovid of Caldeirão as *Bos primigenius.*

The aurochs was considerably larger than its domesticated descendant, cattle. Driesch and Boessneck (1976) have produced a useful synthesis of measurements of aurochs and cattle bones from Holocene sites in Portugal. It includes a scatter diagram (their Fig. 1) of astragalus lateral

length versus distal width, which shows two clearly distinct clusters. Specimens with widths (Bd) under 48 mm are interpreted as belonging to domestic cattle and specimens larger than this are aurochs. An astragalus (with Bd = 45,6 mm) and a distal humerus (HTC = 33,6 mm) from the Neolithic at Caldeirão are both fairly small and are similar in size to archaeological remains of domestic cattle suggesting that these two bones belonged to domestic rather than wild cattle. Indeed, the Caldeirão astragalus clearly falls within the range of Driesch and Boessneck's "domestic" cluster. Rowley-Conwy (1992) also described a fragmentary *Bos* astragalus similar in size to the one mentioned above (presumably the same specimen) and a damaged distal humerus (with an estimated BT of 70,5 mm). He came to the same conclusion as to the domestic status of these two specimens. Is there any other hint as to the wild or domestic status of the Neolithic *Bos* at Caldeirão? Large bovid (presumed to be aurochs) is very scarce in earlier levels (see below), and appears to have become abundant in the Neolithic. This diachronic increase in frequency argues also for its domestic status in the Neolithic in the same way that a shift from wild animals to species known to be domesticable occurred in many regions.

Chamois, goat, sheep – Rupicapra, Capra, Ovis

Many of the bones of these three animals are difficult to identify to species level, and they therefore pose a problem for the zoo-archaeologist. Both wild-goat (the Spanish ibex, *Capra pyrenaica*), and chamois (*Rupicapra pyrenaica*), still survive in Spain and, until recently, in Portugal too.

Fig. 3 Goat mandible with P_3 – M_3 in internal, occlusal and external views. P12 382 Jb J5 Early Upper Palaeolithic.

Fig. 4 Goat distal humerus anterior view. P12 697 K K4 toca Mousterian.

The former, for example, became extinct in 1892 (Mitchell-Jones, et al. 1999). Sheep (*Ovis*), an important domestic animal in the present-day economy, only appear in the archaeological record of Europe in the Neolithic — an appearance generally taken to signify its introduction as a domestic animal. Some small artiodactyl bones and teeth from Caldeirão could not be assigned with certainty to any of these three species and are referred to under the heading "RCO" (i.e. *Rupicapra/Capra/Ovis*). However, some have definite goat characters and are referred to this species (Figs. 3 and 4). One certain example is a well-preserved metacarpal from the Solutrean (M14 sc 450; Fig. 5). Note in particular the shape of the condyles in plantar view. Goat metacarpal condyles are characterised by being wide and having trochleas that become constricted towards the verticillus of the condyle, and with condyle widths *versus* trochlea depths of 18,6 *versus* 15,3 and 18,5 *versus* 13,9, this specimen is clearly not sheep. Moreover, with this degree of constriction, identification as chamois can also be ruled out. The other striking feature of this bone is its large size and robustness. In many parts of the world wild mammals were considerably larger in the Pleistocene than they are today (see for example, Harris and Mundel, 1974 for North America;

Fig. 5 Goat metacarpal in anterior, lateral and plantar views, M14 sc 450 Fc F7 Solutrean

Fig. 6 Chamois horn core P14 201 Jb Early Upper Palaeolithic

Fig. 7 Chamois complete metacarpal, superior, anterior, medial, posterior, lateral and plantar views. P12, 643, Jb, J8, Early Upper Palaeolithic.

Fig. 8 ?Chamois distal humerus in anterior and medial views O13 331 Ja I3 Early Upper Palaeolithic alongside a modern chamois (adult female) from the Asturias, Spain (CIPA Reference Collection # 884).

Kurtén, 1965 and 1974 for the Near East; and Klein, 1976 for South Africa). This specimen may also typify late Pleistocene large size. Its robustness also suggests it belonged to a male since female metapodials tend to be more slender (personal observation). Few bones could be identified with certainty as chamois. Two exceptions are a horn core (P14 201; Early Upper Palaeolithic; Fig. 6) and a metacarpal (P12 643; EUP; Fig. 7). The horn core is slender and circular in cross section. Both these characters are typical of chamois horn cores rather than goat whose horn cores are elliptical in cross section. The metacarpal is superficially similar to sheep, but lacks the pointed protuberances at the lower posterior-lateral side of the shaft, typical of sheep. Cardoso and Antunes (1989) identified chamois in the Upper Pleistocene (probably Solutrean) of Portugal at Salemas cave, Loures, and Valente (2000) also found it at Pego do Diabo (Upper Palaeolithic) also in the Loures district (near Lisbon). Geraads (1997) found this animal in the Mousterian at Zafarraya in Andalusia, and he suggests that this marks its southernmost extension in the Iberian Upper Pleistocene. The humerus shown in Fig. 8 is also identified as 'probable' chamois.

Red deer – Cervus elaphus

Abundant remains of both teeth and limb-bones of a large cervid without doubt belonged to red deer (Figs. 9 and 10). Morphologically, these remains are little different from modern skeletons of this species from France, England and Spain. There is little evidence for any change in the size of the red deer during the course of Caldeirão's Mousterian to Magdalenian occupation as is suggested by the few astragali and measurements of the terminal phalanges (Fig. 11). But samples are very small, so this conclusion must be treated with great caution. Klein and Cruz-Uribe (1994) and Mariezkurrena and Altuna (1983) have summarised the size variation of this animal in Late Pleistocene and Holocene Spain. They note that red deer were considerably larger in former times as in other parts of Europe (see for example Walvius, 1961). Size variation among modern populations of this animal is thought to be mainly a function of forage quality and population density, so that changes in the past may reflect vegetation change. The five Solutrean red deer metapodials from Caldeirão (3 metatarsals and 2 metacarpals, see appendix) are little different in size from the Spanish Mousterian to Magdalenian specimens, but larger than modern Spanish red deer (see Fig. 5 in Klein and Cruz-Uribe, 1994).

Fig. 9 Red deer mandible with P_2 – M_3 teeth in internal, occlusal and external views. P13 485 K K5 Mousterian
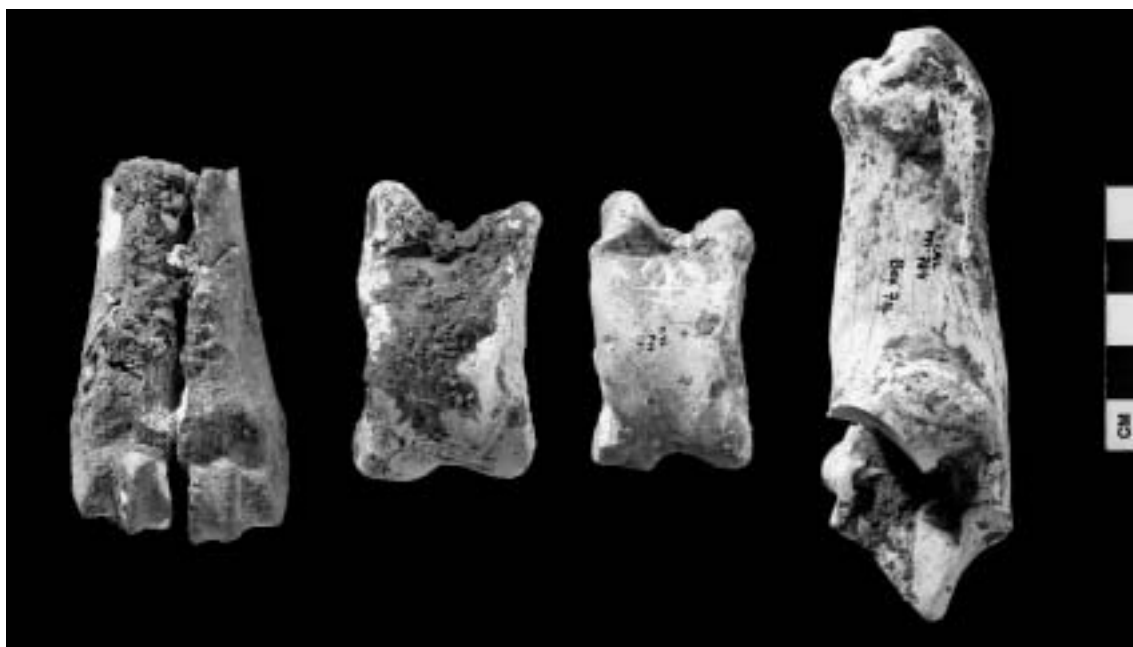
Fig. 10 Red deer, various bones of the hind foot. Distal metatarsal, anterior view L16 129 Fa F1 Solutrean; Astragalus, plantar view P11 537 H I1, Solutrean; Astragalus, plantar view P11 734 H corte, Solutrean; Calcaneum, medial view P11 784 K K3 Mousterian.
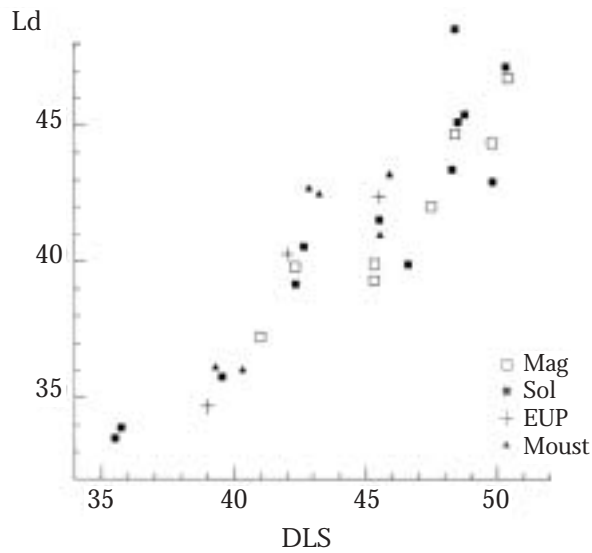
Fig. 11 Red deer terminal (hoof) phalanges
– variation through time. A plot of the
length of the dorsal surface (Ld) versus the
greatest diagonal length of the sole (DLS).
Measurements are in tenths of a
millimetre. There does not appear
to have been any change of red deer size
from Mousterian to Magdalenian times.
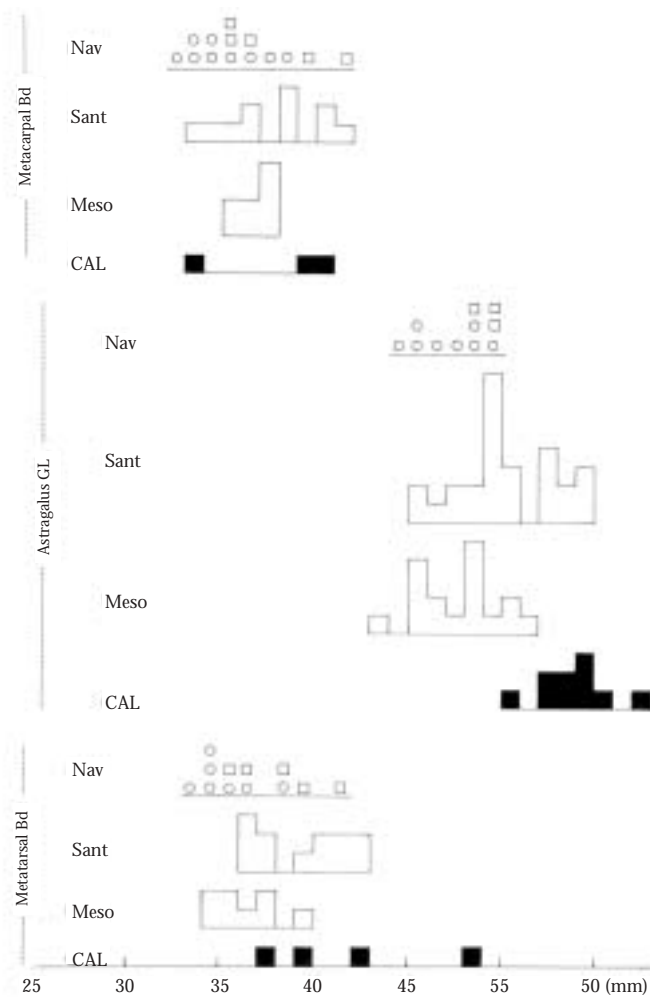
Fig. 12 Size variation of late Pleistocene and
Holocene Red deer in Iberia. Measurements
in millimetres of Red deer metacarpals,
astragali and metatarsals from Caldeirão
("CAL"), Mesolithic Portugal ("Meso";
most are from Cabeço do Pez in the Sado
Estuary), Iron Age
to Moslem from Alcáçova de Santarém
("Sant") and recent Red deer from Navarra,
Spain ("Nav"; data from Mariezkurrena
and Altuna, 1983).
Males are shown as squares and females as
circles. Note, at least for the astragali, there
was a size decrease between late Pleistocene
and Holocene times.
This size decrease was probably real rather
than due to any biased selection
of one sex as the measurements of the
modern deer from Navarra indicate a small
degree of sexual size dimorphism.
The measurements of metapodials do not
show the same trend though this may
simply be due to insufficient data.

The measurements of astragali from Caldeirão are clearly larger than Mesolithic to recent ones from Spain and Portugal (Fig. 12). Mariezkurrena and Altuna's (1983) measurements of recent red deer from Navarra show that there is considerable overlap of the sexes, which makes a sexual selection explanation unlikely. It does then appear that red deer were larger in the late Pleistocene and this may well argue for relatively high quality forage there at that time. Clearly more metric data from Portuguese sites for this rather variable animal are needed.

In the Solutrean level there are 15 first and 5 second red deer perforated phalanges (Table 3 and Fig. 13). Most are perforated on both sides of the shaft, ie the lateral and medial sides, while two have this pattern of damage on the lateral and posterior sides. It is unclear whether these perforations are man-made or the result of carnivore gnawing. Several also have rodent gnaw marks. Their presence in the Solutrean when many of the large carnivores such as hyaenas are absent/rare is also enigmatic. Carnivores may have perforated them, as Chase (1990) also has suggested for the perforated cervid phalanges in the French Middle Palaeolithic. However, the Caldeirão specimens feature a unique damage pattern for which no modern or fossil analogue could be found. This, plus the fact that, as argued by Zilhão 1997a, these perforations affect exclusively the deer phalanges, not the ibex/chamois ones, that they are found only in the Solutrean levels, and that none are recorded in the EUP and Mousterian, where, as opposed to the Solutrean, significant carnivore activity is documented, means that an anthropic origin cannot be ruled out. Therefore, these 20 phalanges are listed separately in Table 3 and are not included in the counts of Solutrean bones.

Fig. 13 Three of the 20 Solutrean perforated red deer first and second phalanges. The majority have holes in both sides of the shafts while two have a hole in one side and another in the posterior side of the shaft. Were these man-made or are they simply the result of carnivore activity?

A few bones and teeth of a small cervid are identified as roe deer, *Capreolus capreolus*. This animal is still common in Portugal. In Europe, roe deer bones and teeth are generally much smaller than those of fallow deer, though certain roe bones are difficult to distinguish from those of sheep and chamois.

Wild boar/pig – Sus scrofa/ S. domestica

Suine bones are easily distinguished from other artiodactyl bones and there is no doubt about the identity of the *Sus* from Caldeirão. The sample of *Sus* bones from pre-Neolithic levels is too small and there are too few measurements to enable a comparison with bones of domestic pig. Like cattle and several other domestic animals and their wild ancestors, domestic *Sus* (pig) is generally distinguished from its ancestor the wild boar (*Sus scrofa*) on the basis of size — pigs are smaller. According to Rowley-Conwy (1995), early Neolithic *Sus* remains from Iberia were still wild. Measurements of the few *Sus* teeth from the Neolithic at Caldeirão are compared with modern wild boar from Portugal (Table 7). The samples are small, and only two of the three dimensions (width posterior dP_4 and width anterior M_1) provide a statistically meaningful separation between wild and domestic. These two dimensions indicate that the Caldeirão specimens are too small to be Portuguese wild boar. They are therefore assumed very tentatively to have belonged to pigs. Rowley-Conwy (1992) was unsure of the status of the Caldeirão Neolithic *Sus* remains, although he suggested that while their dimensions were too small to be from the wild animal, he pointed out that the bones were from juvenile animals whose ossification was incomplete, and preferred to identify them as wild individuals with incompletely grown bones. Due to the problems of incomplete growth, tooth widths are used. These are age-independent, and it is concluded that the Caldeirão *Sus* was domestic. A biometric survey of Portuguese wild boars and pigs is clearly needed to aid in the distinction between wild and domestic pigs.

Table 7. Identity of the Caldeirão Neolithic pigs.			
	n	**mean**	**S.E.**
width posterior dP_4			
Portuguese wild boar (males and females)	5	90.0	1.79
Muge Mesolithic	6	87.8	0.91
Caldeirão		88 and 84	
Launceston medieval pigs	20	83.4	0.96
width anterior M_1			
Portuguese wild boar (males and females)	5	104.8	3.44
Muge Mesolithic	10	100.5	1.19
Caldeirão		95 and 95	
Launceston medieval pigs	114	99.8	0.59
width posterior M_1			
Portuguese wild boar (males and females)	5	106.8	3.56
Muge Mesolithic	12	108.2	1.04
Caldeirão		106 and 108	
Launceston medieval pigs	107	104.7	0.65

Measurements in tenths of a millimetre of Caldeirão mandibular teeth compared with statistics (the mean and its standard error) of modern Portuguese wild boar, Mesolithic *Sus* from the sites of Moita do Sebastião and Cabeço da Arruda at Muge (some 45 km north-east of Lisbon), and pigs from the medieval levels at Launceston Castle in England (from Albarella and Davis, 1996). Two of the three measurements, width dP_4 and width anterior M_1, indicate that the Caldeirão specimens probably belonged to domestic animals, while the third measurement, width posterior M_1, does not appear to provide any discrimination between wild and domestic animals.

Equids

Most of the equid remains at Caldeirão are identified as horse – *Equus caballus* (see for example Fig. 14). Wild horses were once common throughout Europe and Asia, but only survived until recent times in central Asia. Equid species may often be identified on the basis of the pattern of the enamel folds on the biting surfaces of adult cheek teeth in full wear (Eisenmann, 1981). The Caldeirão equid lower molar teeth (Fig. 15) have "U" shaped lingual folds and their buccal folds partially penetrate between the flexids. Both are caballine characters. Southern Europe was once inhabited by a small species of equid, the so-called Otrantine ass, *Equus hydruntinus,* first described by Regalia in 1907 from a cave in Apulia, southern Italy (see also Stehlin and Graziosi, 1935). *Equus hydruntinus* had characteristic zebra-like teeth in which the lingual folds are "V" shaped and their buccal folds in the molars penetrate completely between the flexids often touching the lingual fold. Cardoso (1995) describes two upper molar teeth from Pedreira das Salemas (Loures, near Lisbon) dating to the "late Würm", which, on the basis of their small size, he identifies as *E. hydruntinus.* This species of equid is also reported from three sites in Spain (Geraards, 1997). Unfortunately no complete teeth that can be assigned to this small equid were found at Caldeirão. However, the occlusal surface of a partially digested lower cheek tooth (Mousterian, see Fig. 26) shows clear penetration between the two flexids of the buccal fold. It may have belonged to *Equus hydruntinus. E. hydruntinus* limb-bones however tend to be slender and its terminal phalanges are pointed. Two poorly preserved equid terminal phalanges from Caldeirão are illustrated in Fig. 16. Note the great size difference between these two specimens. This degree of difference is too great to be accommodated biometrically within one species. They undoubtedly belong to two different species of equids. The pointed anterior "edge" of the smaller one makes it quite likely to have belonged to *E. hydruntinus.*
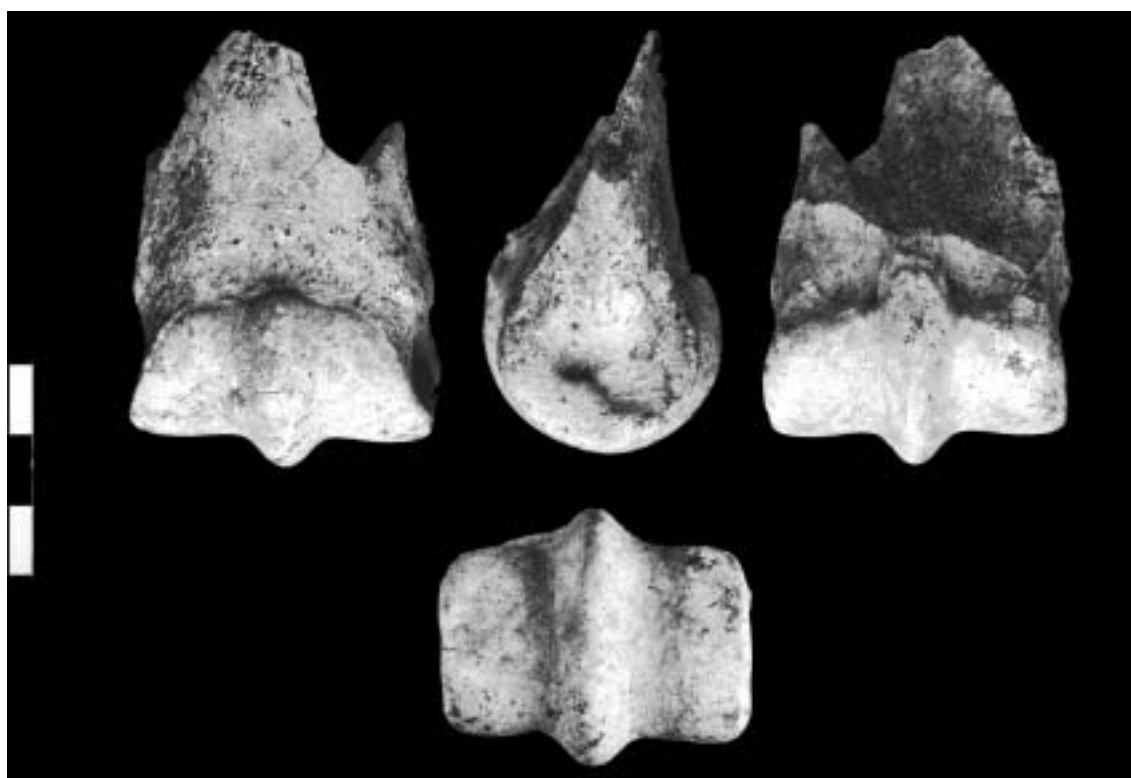
Fig. 14 Anterior, lateral, posterior and plantar views of a horse distal metapodial fragment. L16 124 Eb E3 Magdalenian.
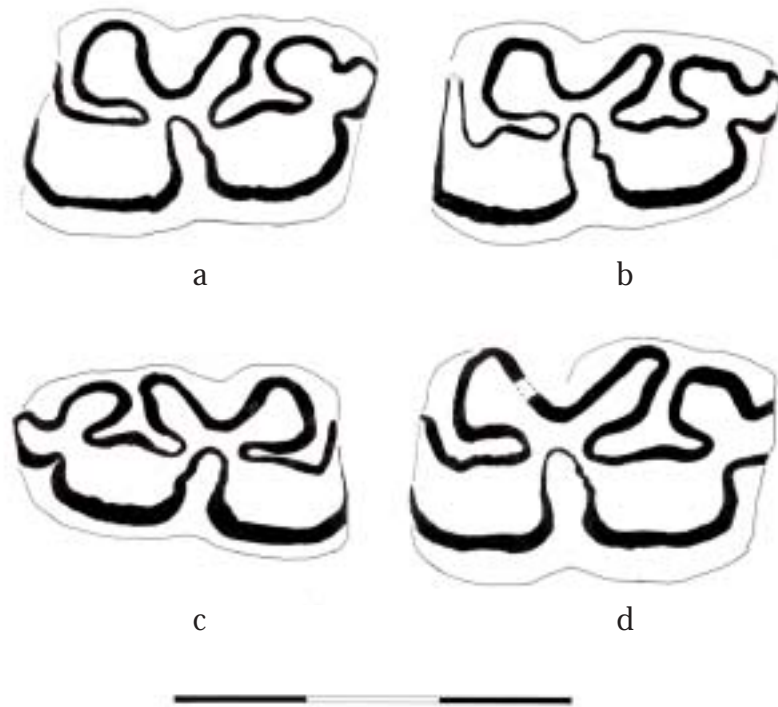
Fig. 15 Four horse mandibular teeth in occlusal view with their enamel folds drawn in black. The scale bar is 3 cms.
a. $M_{1/2}$ or P_4 from N14 sc 138 Eb topo E1 toca (Magdalenian) – b. $M_{1/2}$ from P11 608 Fc 17W (Solutrean) – c. $M_{1/2}$ from O13 241 Fa F6 (Solutrean) – d. $P_{3/4}$ from P11 208 Fa (Solutrean)

O12 138 K1
(Mousterian)

M14 sc 383 F_3 toca
(Solutrean)
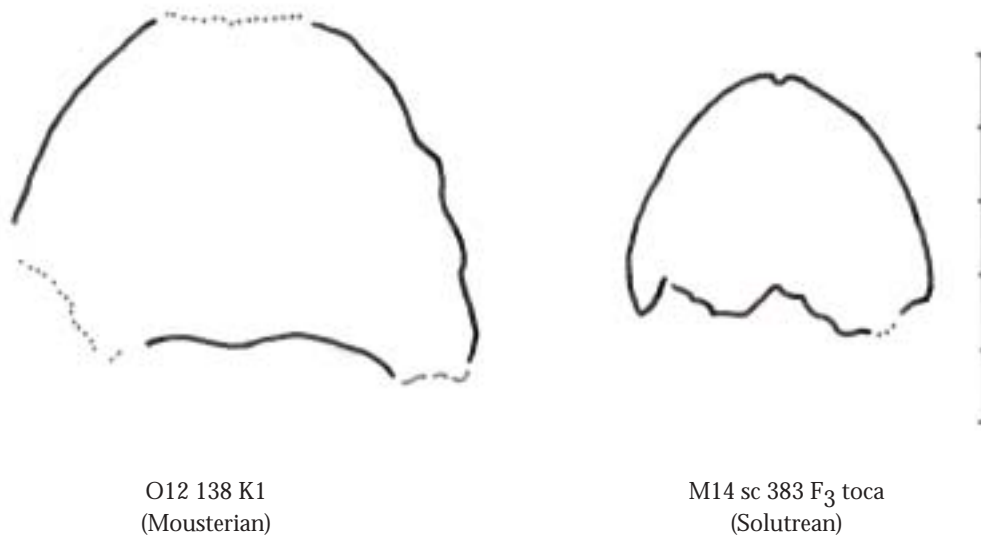
Fig. 16 Sketched outlines of the plantar surfaces of two equid terminal (hoof) phalanges from Caldeirão. One is from the Mousterian, and the other from the Solutrean. These two specimens are quite different in both shape and size, and they therefore belonged to two different species. The larger is probably a horse, *Equus caballus* and the smaller more pointed one, the so-called Otrantine ass, *E. hydruntinus*.

Badger – Meles meles

20 badger bones and teeth were recovered (see Fig. 17). Many are from the Magdalenian. It is interesting that the two Magdalenian and one Solutrean badger carnassial teeth (Fig. 18), plot out among the larger modern Portuguese and English badger teeth. According to this Fig., badgers in England and Portugal are larger than their relatives further south. It is well known that many mammals display a geographical size cline with larger individuals found in colder regions (Mayr, 1963). When more data are available, it should be possible to discover whether a modern size cline of badgers correlated with environmental temperatures is reflected in the Pleistocene-Holocene as has been demonstrated in the Near East for example (Kurtén, 1965; Davis, 1981), which will enable use of badger teeth as "palaeo-thermometers" indicating cold or warm conditions in the late Pleistocene of Portugal.

Fig. 17 Badger mandible with C, P_3 – M_2 in internal, occlusal and external views. P12 194 Fa F6 Solutrean.
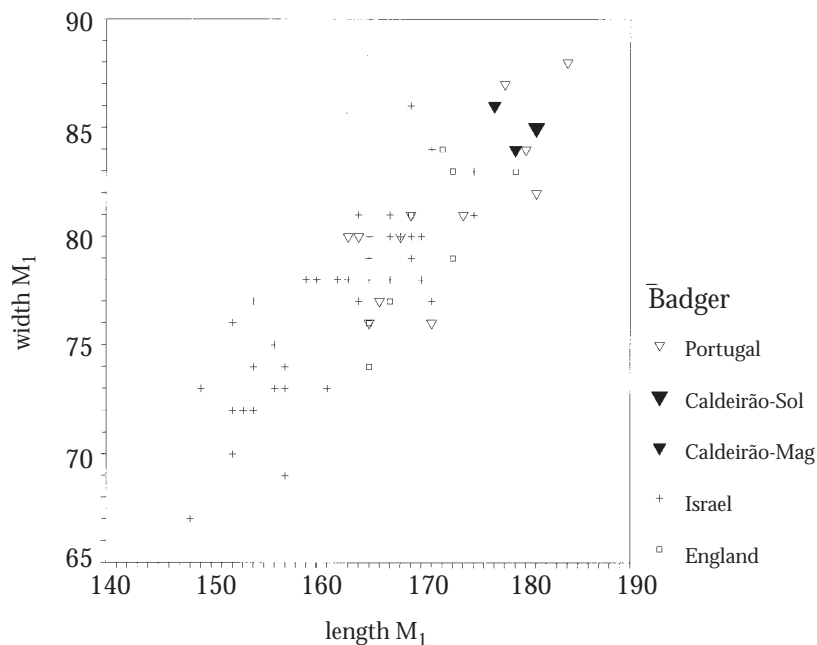
Fig. 18 Badgers – Caldeirão versus modern Portuguese, English and Israeli specimens. Plot of length versus width of the lower carnassial tooth, M_1. Measurements are in tenths of a millimetre. Note that Israeli badgers are smaller than their relatives to the north, and the Caldeirão specimens plot among the larger English and Portuguese specimens. Were badgers in Portugal larger in the late Pleistocene?

Hyaena – Crocuta crocuta/spelaea

During the Upper Pleistocene Europe was inhabited by two species of hyaena, the striped hyaena, *Hyaena hyaena*, and the spotted hyaena, *Crocuta crocuta.* The latter increased in size to become the true "cave hyaena" (*Crocuta spelaea*) whose large size is clearly visible in Fig. 19, where this species is plotted separately (as "+"), and modern African spotted hyaenas are plotted as circles. In Europe, the spotted hyaena became extinct at the end of the last Ice Age (i.e. around 12 000 years ago; Kurtén, 1968; Bonifay, 1971). According to Fernández Rodríguez et al. (1995) hyaenas are only poorly documented in archaeological sites in Iberia and they "disappeared almost completely in the latter phases" of the Upper Palaeolithic. Altuna and Mariezkurrena (1988) found that *Crocuta* in northern Spain did not survive after the Solutrean.
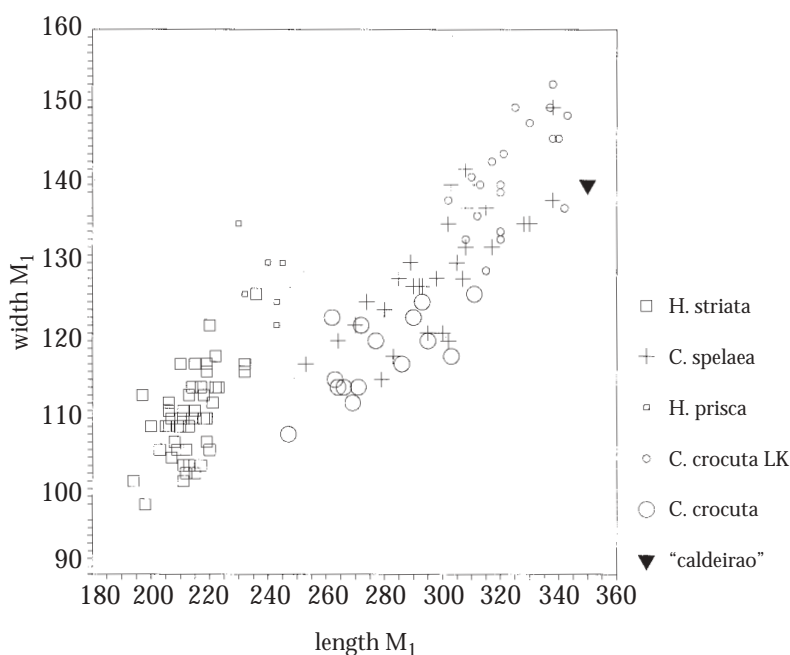
Fig. 19 Hyaena identification. Plot of lower carnassial tooth length versus width showing a separation of striped from spotted hyaena groups as proposed by Bonifay (1971). Measurements are in tenths of a millimetre.
Key:
□ = modern *Hyaena striata* from Israel and Africa
□ = *H. prisca* from the Mindel and Mindel-Riss of Provence, France (Bonifay, 1971),
○ = modern *Crocuta crocuta* from Africa
○ = *C. crocuta* from the Mousterian – Aurignacian of Labeko Koba, northern Spain (from Altuna and Mariezkurrena, 2000)
+ = *C. spelaea* from the Würm and Mindel-Riss in Provence, France (Bonifay, 1971)
▼ = the Mousterian specimen from Caldeirão (P11 865 K corte).

The striped hyaenas tend to have shorter and wider carnassials. The Caldeirão specimen clearly belongs to the spotted group, and falls among the very large late Pleistocene *Crocuta* from Labeko Koba.

Both spotted and striped species are reported from Gruta Nova de Columbeira near Bombarral (Roche, 1971). Cardoso (1993) mentions striped hyaena in the Early Würm at the Gruta de Furninha, near Peniche, although most of the hyaenid remains from the Upper Pleistocene of Portugal are identified as *Crocuta* (Cardoso, 1996).

The mandibular teeth of *H. hyaena* and *C. crocuta* are easily distinguished in various ways, which take into consideration the relative sizes of their carnassials and premolars. For example the carnassial tooth (M_1) of *Crocuta* is long and narrow while that of *Hyaena* is much shorter - a difference which Bonifay (1971) used in her Fig. 34, and here shown as Fig. 19. There are other biometrical differences as in Fig. 20, which shows how the length of P_4 compared to M_1 is much greater in *Hyaena* than in *Crocuta*.
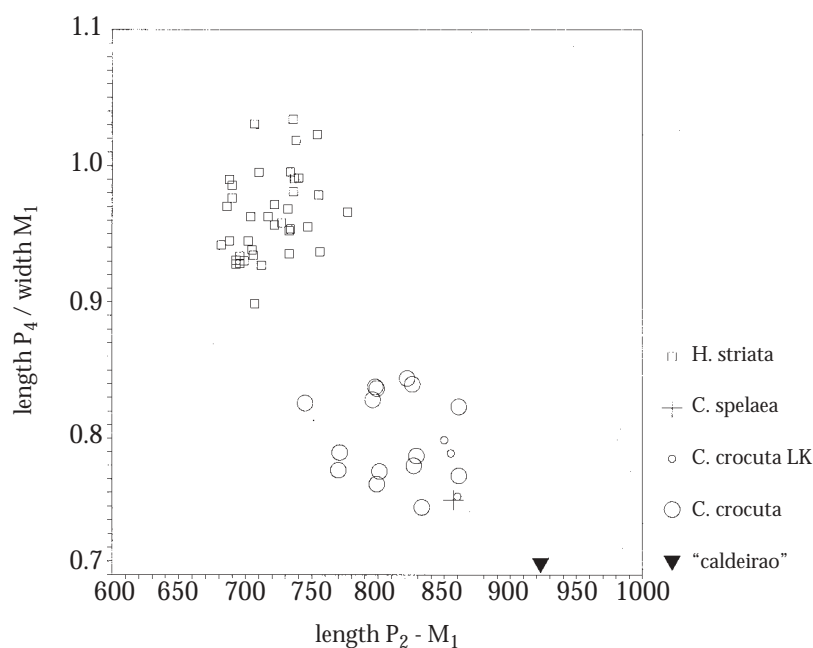
Fig. 20 Hyaena identification. Plot of the 'lower P_4 length divided by M_1 length' versus the 'tooth row length' to show the difference between striped and spotted hyaenas.

Key:

□ = modern *Hyaena striata* from Israel and Africa

◯ = modern *Crocuta crocuta* from Africa

○ = *C. crocuta* from the Mousterian – Aurignacian of Labeko Koba, northern Spain (from Altuna and Mariezkurrena, 2000)

+ = *H. spelaea* from France

▼ = the Mousterian specimen from Caldeirão (P11 865 K corte).

The striped hyaenas have relatively large P_4s and short tooth row length. The Caldeirão specimen clearly belongs to the spotted hyaena group.

The Caldeirão collection includes several small bones of hyaena such as phalanges, but most useful for identification purposes is a well-preserved mandible (Fig. 21). Figs. 19 and 20 show that the Caldeirão specimen is undoubtedly *Crocuta.* It appears to be closest to *Crocuta spelaea*. However, the possibility of striped hyaena also has to be considered. With little comparative skeletal material it has proved difficult to identify the postcranial bones to species. All hyaena bones and teeth at Caldeirão are from the Mousterian and Early Upper Palaeolithic levels.

Further evidence for the presence of hyaenas comes in the form of coprolites (Fig. 22) and see below). Many are broken segments, many are very large — too large to have belonged to wolf. 40 were found in Mousterian levels and another 3 in Solutrean levels. It is not altogether clear

Fig. 21 Hyaena (*Crocuta*) mandible from Caldeirão, external, occlusal and internal views, P11 865 K Mousterian.

Fig. 22 Coprolites from Caldeirão (P11 sc 907; layer M M1; Mousterian). In view of their large size these are probably derived from hyaena.
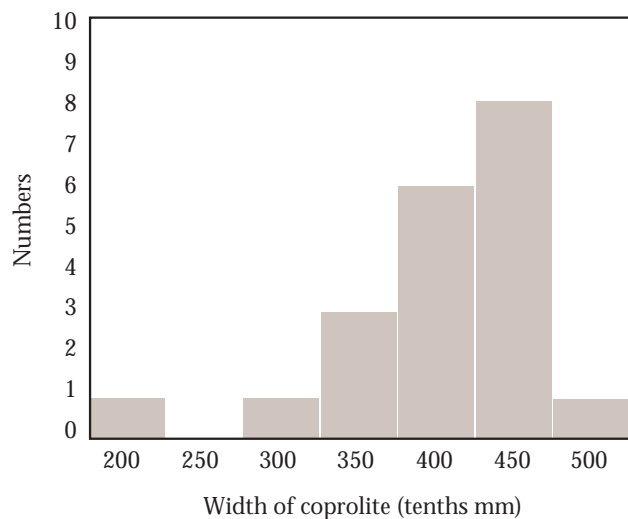

Fig. 23 Mousterian coprolite widths in tenths of a millimetre. The average width (measured across the widest axis) is 40 mm and modal width is 45 mm. These measurements associate at least the larger coprolites to hyaena.

who their original owner was. They are yellow, with smooth surfaces and the ends are either pointed or with a central depression, similar to those described by Fernández Rodríguez, et al. (1995) from La Valiña in northwest Spain (dated to 35 000 BP), which they identify as spotted hyaena coprolites. The average width (see appendix and Fig. 23) of the coprolites is 40 mm. This closely matches the 12 coprolites from La Valiña. The description that Owen (1846, p. 146) gives of the fossilised faeces of spotted hyaena, once known as *album graecum* from a site in England could equally apply to the Caldeirão specimens:

"its external form is that of a sphere irregularly compressed as in the faeces of sheep, and varying from half an inch to an inch and half in diameter; its colour is yellowish white; its fracture is usually earthy and compact, resembling steatite, and sometimes granular; when compact, it is interspersed with small cellular cavities, and, in some of the balls, there are undigested minute fragments of the enamel of teeth."

The three coprolites found in the Solutrean are all small (see appendix) and so not necessarily from hyaena.

Table 8. Man versus carnivore activity at Caldeirão.					
	Mousterian	**EUP**	**Solutrean**	**Magdalenian**	**Neolithic**
IDENTIFIED BONES					
Ungulate bones & teeth	98	93	229	93	60
Rabbit bones	806	1551	9406	5248	
Felids bones & teeth	12	6	28	38	5
Canids bones & teeth	4	1	2	9	8
Badger bones & teeth	0	0	5	19	1
Bear bones & teeth	1	9	1	0	0
Hyaena bones	**1+?1**	**2?**	**0**	**0**	**0**
Hyaena teeth	**4**	**2**	**0**	**0**	**0**
Coprolites	**40**	**0**	**3**	**0**	**0**
Semi-digested bones	**11**	**3**	**0**	**0**	**0**
Gnawed bones	**0**	**0**	**0**	**1**	**1**
Burnt bones	**0**	**0**	**4**	**3**	**2**
UNIDENTIFIED CHIPS					
Total Number	**648**	**780**	**2288**	**2071**	
Number gnawed	**6**	**4**	**7**	**2**	
Number with cut marks	**2**	**0**	**4**	**5**	
Number burnt	**11**	**14**	**177**	**183**	
Number semi-digested	**108**	**53**	**17**	**8**	
% gnawed	**0.9**	**0.5**	**0.3**	**0.1**	
% cut	**0.3**	**0**	**0.3**	**0.2**	
% burnt	**1.7**	**1.8**	**7.7**	**8.8**	
% semi-digested	**16.7**	**6.8**	**0.7**	**0.4**	
Ratio chips to identified	**7**	**9**	**10**	**22**	
Average faunal density (g/m²/millennium)*	**440**	**225**	**470**	**?**	
Average lithic density (g/m²/millennium)*	**175**	**76**	**91**	**?**	
Ratio fauna to lithics*	**2.5**	**3.0**	**5.2**	**?**	
Presence of scavenging birds	+	+	+	-	-

This table provides various counts that indicate the relative activity of man and carnivores, presumably hyaena, at different times. Above are counts made of identified bones and teeth, coprolites and observations made on the recorded bones (see methods). Below are observations on the unidentified bone fragments and chips. Both identified and unidentified bones appear to show the same trends. Hyaenas were clearly present in the Mousterian and Early Upper Palaeolithic as evidenced by their bones and teeth. The coprolites too are *assumed* to have belonged to this animal. Other evidence for carnivore activity, presumably hyaena but possibly other species too, includes semi-digested bone, and the low ratio "chips to identified bones" (chips may have become completely digested by large carnivores such as hyaenas). Direct evidence for human activity takes the form of tools and burnt bones. Viewed together, these data suggest the cave was predominantly a large carnivore den in the Mousterian but subsequently humans exploited the cave more intensively and presumably caused the demise of hyaenas and the other large carnivores before or during the Solutrean. The increased human activity, at least in the Solutrean, is also indicated by the high ratio of fauna to lithics. Faunal and lithic density data are from Zilhão (1997 vol. 2; table 9.2 on page 114). * Note: for the Mousterian, the faunal and lithic density data are for layer K only; and for the Solutrean these data are for layer I only. Lithic density data are not yet available for levels above I, but Zilhão's faunal density values in levels H, Fc, Fb and Fa are: 420, 1385, 1784 and 2045 respectively.

Fig. 24 Two semi-digested fragments of large mammal bone alongside 11 ordinary fragments from P11 L1 sc 894 (Mousterian). The two semi-digested fragments are shown enlarged below — note their shiny surfaces and sharp broken edges.
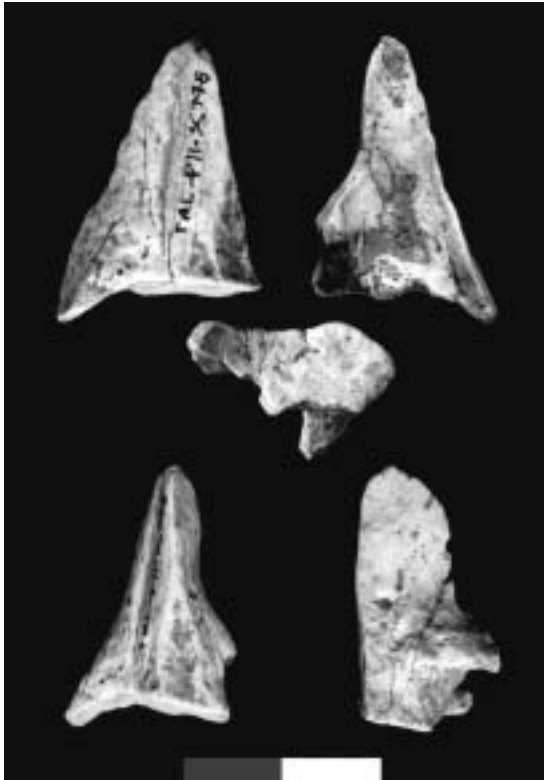
Fig. 25 Five views of a partially digested bone, perhaps a calcaneum (?red deer), P11 778 Jb K3 Early Upper Palaeolithic
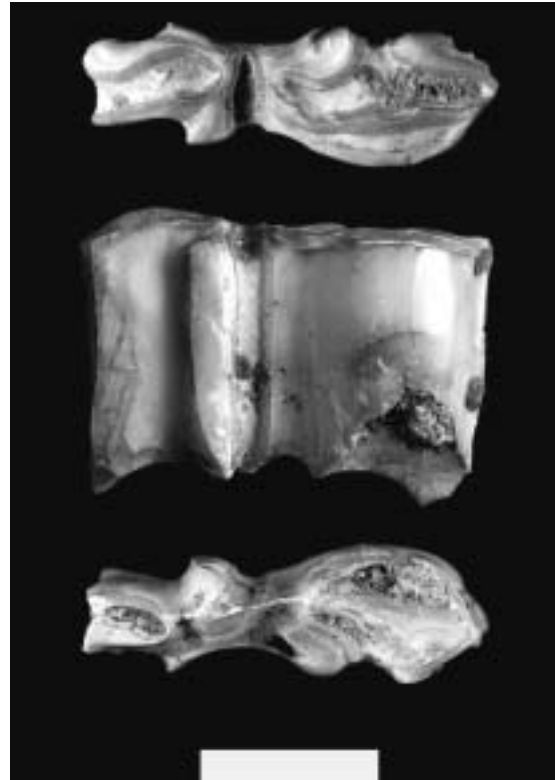

Fig. 26 Semi-digested equid cheek tooth, occlusal, external and inferior views, P12 sc 717 K K8-K9

Fig. 27 The same tooth as in figure 26 shown below a modern (undigested) horse second molar to show the extent of gastric erosion.

So much for bones, teeth and coprolites: let us turn now to a consideration of the large amounts of small chips and fragments of bone found throughout the Caldeirão sequence. These include many corroded fragments. The pattern of corrosion is similar to that produced by immersion in acid, which suggests they had been partially digested (Figs. 24-27 and Table 8). The degree of destruction is illustrated in Fig. 27 in which the partially digested lower molar tooth in Fig. 26 is shown alongside a modern undamaged horse molar. Partially digested bones are most abundant in the Mousterian and Early Upper Palaeolithic layers. Hyaenas are known to regurgitate the indigestible residues of their meals (Brain, 1981; Klein et al. 1999) and it is suggested that these "semi-digested" bones are further evidence for the presence at Caldeirão of hyaena. The problem of presence/absence of hyaenas in the Caldeirão succession is discussed later.
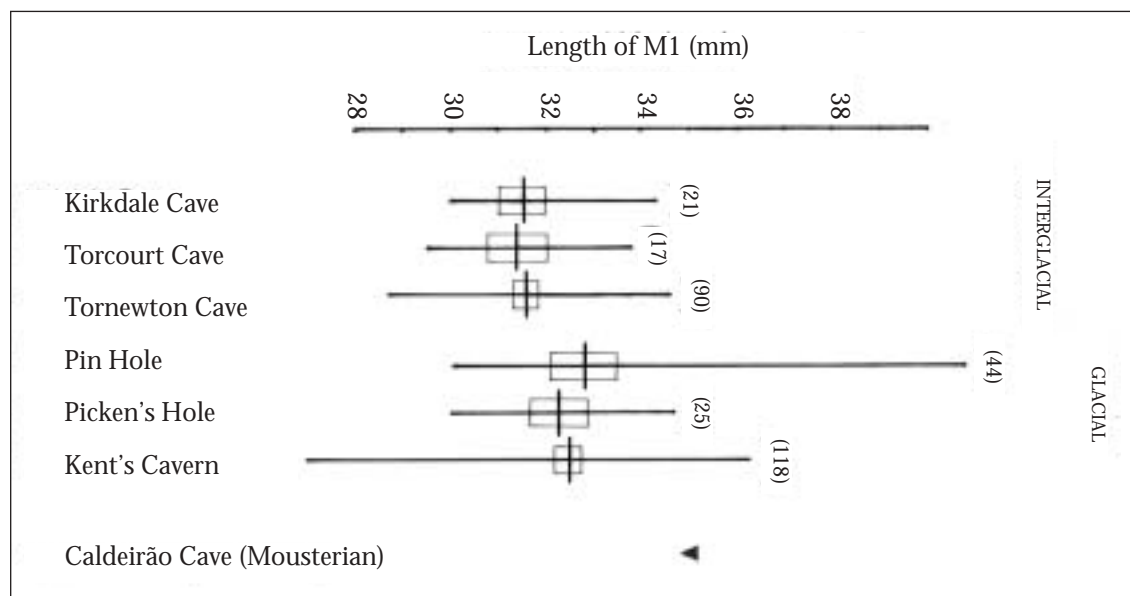
Fig. 28 The Caldeirão Mousterian Spotted hyaena mandible in biometric perspective. The *Crocuta* from Caldeirão (P11 865 K Corte) compared to Glacial and Interglacial samples from English cave sites (data from Klein and Scott, 1989; table 1). The plots are of the antero-posterior length of the carnassial tooth (M_1). For each of six large samples studied by Klein and Scott, the mean is shown as a vertical line, the observed range by a horizontal line, and the 95% confidence limits of the mean by a rectangle. Sample sizes are given in parentheses. Klein and Scott suggest that the three "Interglacial" samples being smaller than the three "Glacial" ones are consistent with Bergmann's rule, which correlates low environmental temperature with greater body size in warm-blooded animals. Note the very large size of the Caldeirão carnassial – was it very cold in Portugal during the Mousterian?

Let us briefly return to the question of size. Klein and Scott (1989), who studied hyaena remains from caves in Britain as well as modern hyaena from Africa, noted firstly that in Britain late Pleistocene *Crocuta* were larger during glacial maximum times than in inter-glacial times, and secondly, that today this animal's carnassial length increases with latitude in Africa. Both these trends, they suggest, exemplify the inverse relation between body-size and temperature predicted by Bergmann's rule. Although there is only a single specimen of a carnassial tooth (M1) from the Mousterian at Caldeirão (Fig. 28), its extremely large size (length = 35,0 mm) would, according to Klein and Scott, indicate very cold conditions, although, as Klein has also pointed out (pers. comm.) it may be even larger than Bergmann's rule would predict due to reduced competition with man.

Bear – Ursus arctos

Several teeth are identified as bear (Fig. 29). Note for example the typical bunodont cusps on a first upper molar, which was probably unerupted. Two of the three identified bear teeth are clearly from very senile animals — most of their crowns had been worn away, while the upper molar, with its incompletely formed roots, must have belonged to a juvenile animal. In many cases of cave bears from the Pleistocene of Europe, the bulk of the remains derive from juveniles and older adults. This kind of age structure is generally regarded as being a clear indication that the bears died during hibernation (see for example, Kurtén, 1958; Straus, 1992; Weinstock, 2000). Perhaps, if only for a brief period, Caldeirão served as a den for hibernating bears. The bear is also represented by a number of phalanges and metapodials (Figs. 30 - 32). A "Solutrean" sec-
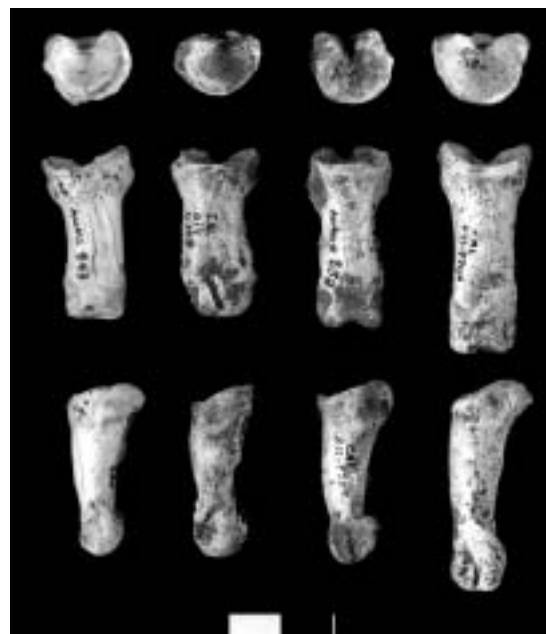
Fig. 30 Bear first metatarsal, lateral and anterior views, P11 666 Jb J8E Early Upper Palaeolithic

Fig. 29 Bear teeth from top to bottom:
M^2 of a young animal, inferior, lateral and occlusal views
P11 sc 886 K K5 Mousterian
M_1 of a senile animal, lateral and occlusal views, P11 725 Jb
Early Upper Palaeolithic
M_1 of a senile animal, lateral and occlusal views P11 714 Jb
Early Upper Palaeolithic
Incisor, of a senile animal, lateral and occlusal views:
P11 620

Fig. 31 Bear first phalanges, superior, anterior and lateral views, from left to right:
P11 699 Jb Early Upper Palaeolithic
O14 sc 358 Jb J3 Early Upper Palaeolithic
P11 755 K K3 Mousterian
P11 776 Jb K3 Early Upper Palaeolithic

ond phalanx (Fig. 32) was found in the corridor, in square N14, spit I2, at the interface between levels I (Proto-Solutrean) and Ja (EUP). Since all other bear material comes from the underlying EUP levels Ja and Jb, or from the Mousterian levels further down in the succession, it is quite possible that this isolated "Solutrean" bear find is in fact a displaced EUP specimen (Zilhão, personal communication). Given the ^{14}C age of level I (Zilhão, 1997a), it would appear that Pleistocene bear became rare or even extinct in the Caldeirão area after ca. 23 000 BP. [Bear is documented, historically, in the Tomar area in the Middle Ages, and a bear bone was found in a 13th century AD level at Alcáçova de Santarém.]
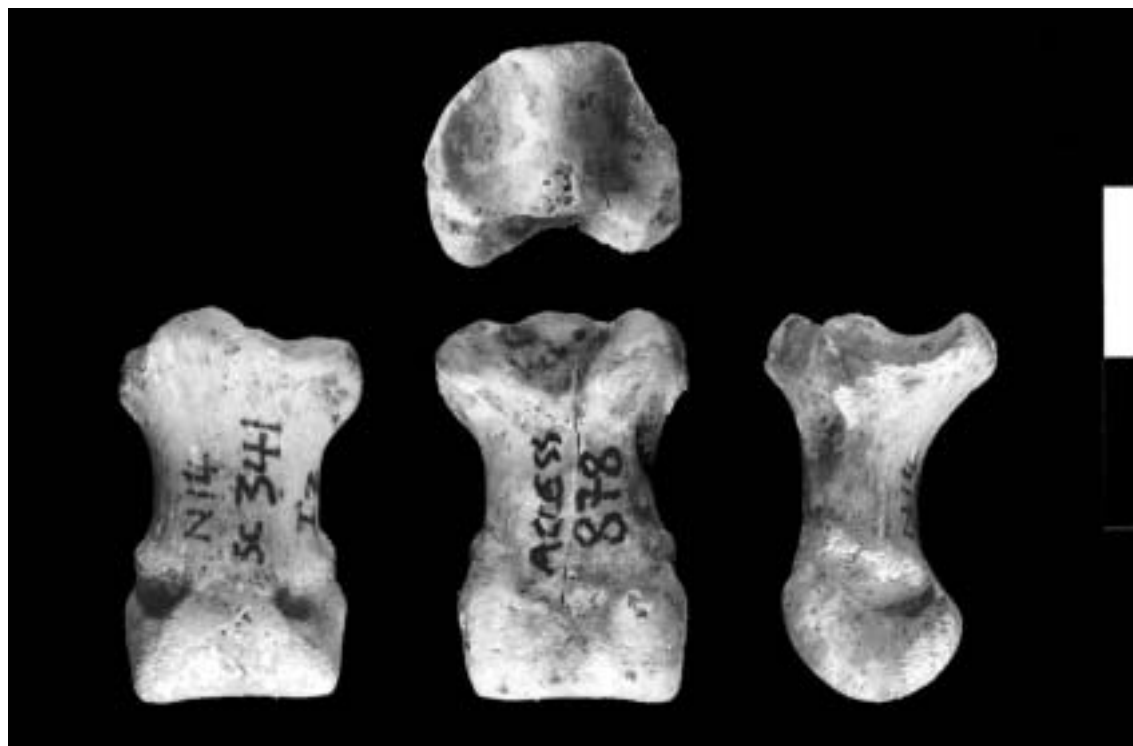
Fig. 32 Bear second phalanx, superior, anterior, posterior and lateral views, N14 sc 341 I I2 Solutrean

Felids

Cats are osteologically rather similar to one another. Apart from its great size, a lion skeleton is little different from that of a domestic cat. Indeed, most Old World cats have the same number of chromosomes (Kitchener, 1991). In general then, zoo-archaeologists have to rely on size differences in order to distinguish between different felids. At Caldeirão, plots of length versus width of lower carnassial felid teeth (Fig. 33) indicate the presence of three species of felids, and a very large thumb-bone from the EUP (Fig. 34) indicates a fourth and larger felid, similar in size to lion (see below). Today the wildcat, *Felis silvestris*, ancestor of our domestic cat, survives in Spain and Portugal. The smaller felid bones and teeth from Caldeirão are referred to this species. A plot (Fig. 35) of the dimensions of modern carnassial teeth of *Felis silvestris* from various parts of Europe, the Maghreb and the Near East indicates little geographical variation in the teeth of this animal today. Note that the lower carnassial tooth (see Fig. 36) from Caldeirão falls among these modern wildcats. Lynx is the next largest cat, which still survives in Portugal and elsewhere in Europe. The species found in Spain and Portugal is *Lynx pardinus*. At Caldeirão there are abundant remains of this medium-sized felid (see Figs. 37-39), and it is still present in the Neolithic. In addition to wildcat and lynx, a single lower carnassial tooth from the Mousterian at Caldeirão (Fig. 40) indicates the presence of a larger species. Its dimensions are similar to those of modern leopards, *Panthera pardus*, and leopards from the late Quaternary of southeast France measured by Bonifay (1971, p. 303). There is abundant evidence for this animal in the Upper Pleistocene of Portugal (Cardoso, 1997) and in northern Spain leopards survived into the early Magdalenian — longer than in the rest of Western Europe (Altuna and Mariezkurrena, 1988). In southern France the leopard had become rare by the early part of the last Ice Age, and
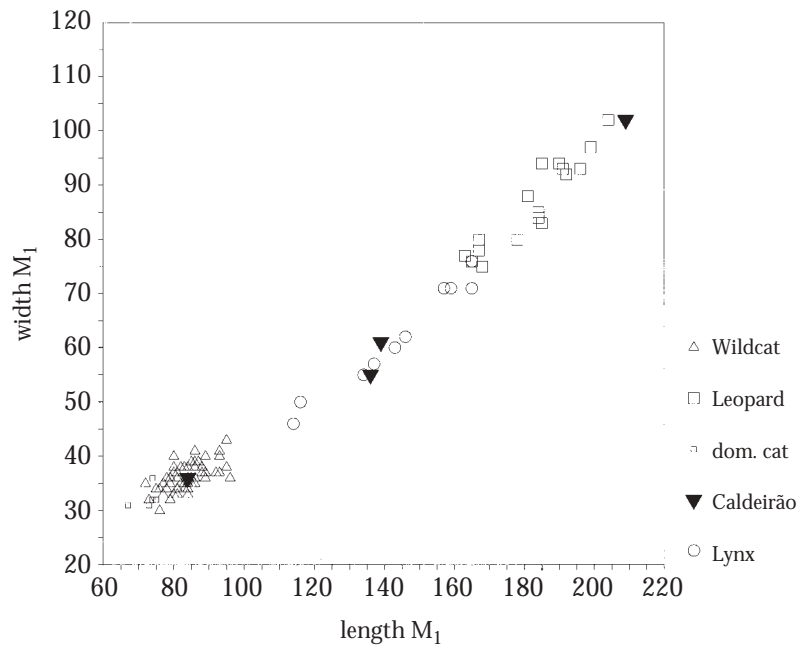
Fig. 33 Felid teeth from Caldeirão – their identification. Plot of length versus width of the lower carnassial tooth, M_1. Measurements are in tenths of a millimetre. At Caldeirão there were clearly, on the basis of dental measurements, three felid species.

probably became extinct in the Aurignacian (Bonifay, 1971, p. 304). Another felid bone identified as definite leopard comes from the Solutrean. Three "Magdalenian" probable leopard bones may well be displaced specimens from the Solutrean (Zilhão, pers. comm.). One, Q12-150, is a fossilized specimen found in a clearly displaced stratigraphic position in early Neolithic level Ea; the other two (O11sc78 and O11sc244) come from the lowermost Magdalenian spits in a square where the Magdalenian/Solutrean contact was not clear cut and where those same spits also contained a few displaced Solutrean lithics. If these specimens are indeed of leopard (as opposed to, for instance, a large lynx), their Magdalenian age cannot be ascertained. Leopards are known to accumulate bones in caves (Ruiter and Berger, 1999) and may have played an important role

Fig. 34 Lion first thumb phalanx, superior, anterior and lateral views, P11 715 Jb Early Upper Palaeolithic

in this respect at Caldeirão (see below). While there are no teeth belonging to any larger felid, a proximal thumb-phalanx probably belonged to a larger cat (Early Upper Palaeolithic; Fig. 34). It is too large to have belonged to leopard and is therefore tentatively identified as lion. Its surface is somewhat abraded and it may be partially digested. It is similar in size (and shape) to the thumb first phalanx from the Périgordian of Abri du Roc de Combe in south west France illus-
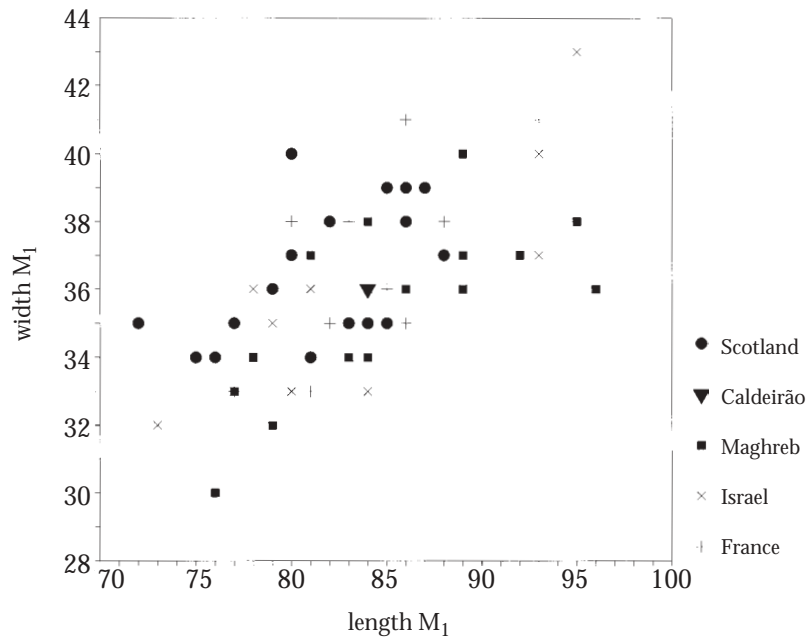
Fig. 35 The Caldeirão wildcat, *Felis silvestris*, compared with several populations of modern wildcats. Plot of length versus width of the lower carnassial tooth. Measurements are in tenths of a millimetre. The Caldeirão specimen is similar in size to other modern wildcats.

trated by Delpech (1983, Plate 6) which she identified as cave lion. Two other bones are tentatively identified as lion, one from the EUP and the other Solutrean. The latter is an uncoordinated specimen (P12sc541) from the basal Solutrean and it cannot be excluded that it too is in fact of EUP age (Zilhão, pers. comm.). The lion was once widely distributed in the Old World — and even survived into historic times in parts of Europe — the Persians, for example, were greatly inconvenienced by this animal when they invaded Greece. In Cantabria, Northern Spain, the lion survived until the Magdalenian, later than the rest of Western Europe. Lions here were similar in size to modern lions (Altuna, 1986; Altuna and Mariezkurrena, 1988).

Fig. 36 Wildcat mandible with C - M_1 teeth in internal, occlusal and external views. Q12 215 Eb E7 Magdalenian.

Fig. 37 Lynx distal humerus, anterior and medial views, L15 154 Eb base E2 toca Magdalenian.
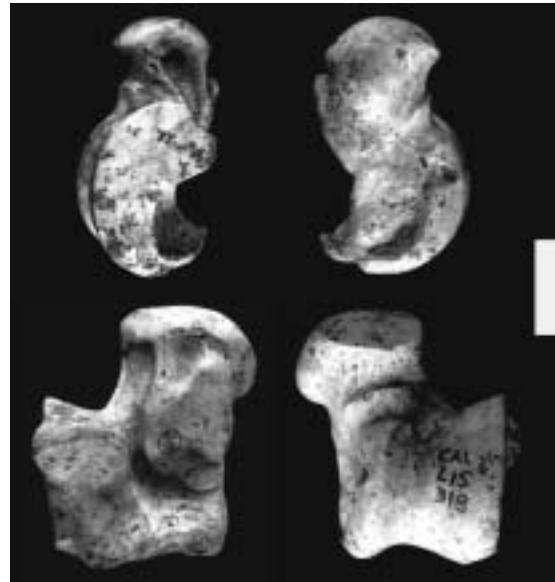

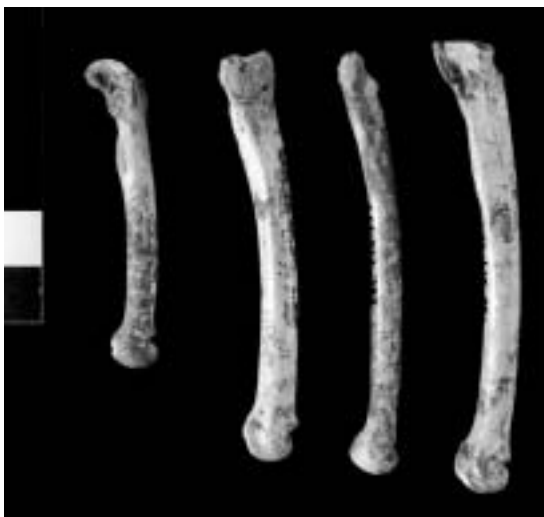**Fig. 38** Lynx astragalus, four views, L15 318 Fc F6 Solutrean.

Fig. 39 Lynx metapodials, lateral views, all Magdalenian from left to right:
  metacarpal L15 sc 264 Eb E3
  metatarsal L15 sc 215 Eb E2
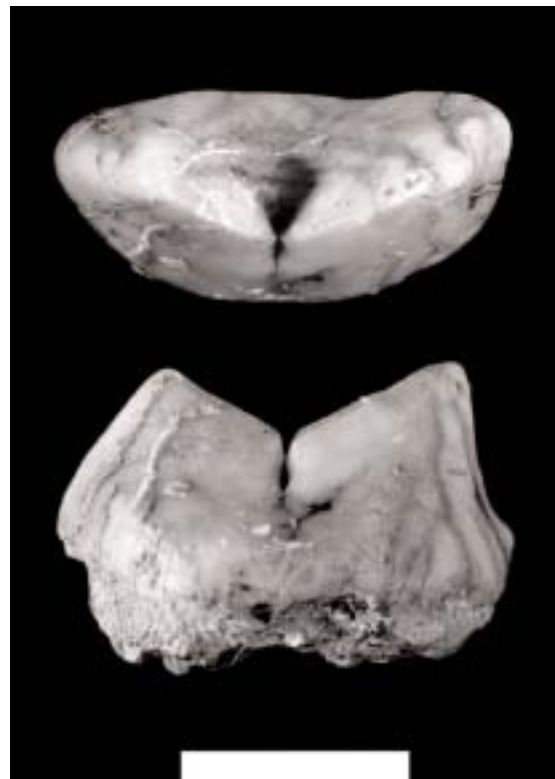 metatarsal L15 196 Eb
  metatarsal L15 197 Eb.

Fig. 40 Leopard carnassial tooth (M_1), occlusal and external views, P11 sc 838 K K4 Mousterian.

Wolf – Canis lupus

A number of what are clearly large canid phalanges and metapodials are identified as wolf, an animal that is still found in northern Portugal (Figs. 41-43).

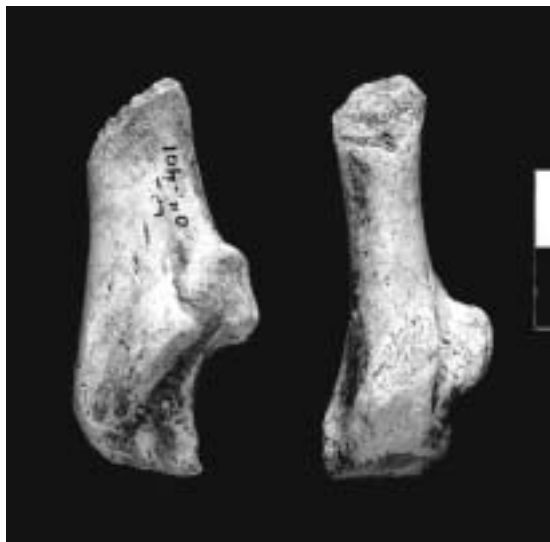**Fig. 41** Wolf (juvenile) calcaneum, medial and posterior views, O14 401 Jb J3 Early Upper Palaeolithic.
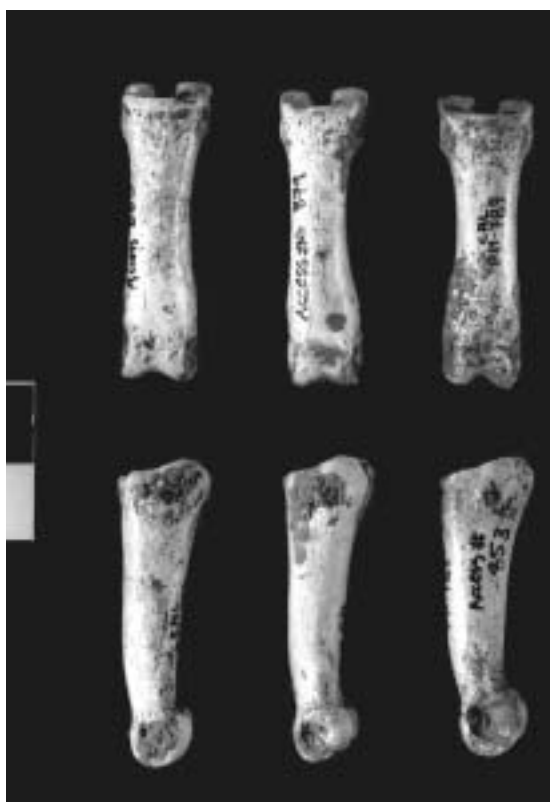

Fig. 42 Wolf metacarpal, superior, anterior, posterior and plantar views, P14 218 K K1 Mousterian.

Fig. 43 Probable wolf first phalanges, anterior and lateral views from left to right:
  P12 708 K K6 Mousterian
  O13 355 K J6 Early Upper Palaeolithic
  P11 789 K K3 Mousterian.

Fox – Vulpes vulpes

Several small canid bones are identified as fox. As elsewhere in Europe, foxes are still very common in Iberia. Foxes appear more frequently in the later periods (see below). Straus (1992) who has summarised the faunal finds from Upper Pleistocene sites in Cantabria, northern Spain, notes a relative increase of small carnivores, especially fox, with time. He suggests that people hunted them for pelts and that they became more abundant as the large carnivores, especially hyaenas, became scarce. At Caldeirão too, in the Magdalenian and Neolithic the percentage of small carnivores, especially fox, is high. Perhaps foxes were somewhat intimidated in the early levels of Caldeirão by the presence of large carnivores like hyaena (see below).

Beaver – Castor fiber

Several beaver teeth from Caldeirão were identified and are fully described by Antunes (1989). One is from the Mousterian and four are from Magdalenian levels. Beaver were common throughout Europe but had become scarce by the 20th century. Antunes (1989) suggested that beavers once inhabited west central and northwest Portugal but probably became extinct here during the 15th century.

Rabbit – Oryctolagus cuniculus (Sally Newton)

Most of the abundant rabbit bones are in excellent condition. Sally Newton is preparing a detailed study of the rabbit remains from Caldeirão. Her findings are summarised in the following. She observed that evidence for human predation is plausible throughout the succession as a low but consistent degree of burning. Magdalenian Layer E and Layer J (Early Upper Palaeolithic) have the highest incidence of burning and Layer K (Mousterian) the lowest but burning evidence *is* present throughout, and oscillations are not drastic. Burnt patches were frequently at the articular ends of long bones or at extremities such as phalanges, suggesting rabbit carcases were roasted whole or in joints.

Evidence of gnawing was surprisingly sparse given the presence of hyaenas within the cave. A rabbit carcass gnawed and digested by a hyaena is not likely to enter the archaeological record in an identifiable state and we can surmise by the general completeness of the specimens, and lack of erosion to the bone surface, that hyaenas were not the main predators of the rabbits. Even the unidentifiable component did not exhibit noticeable evidence of digestive erosion. Aside from the very small sample from Layer L, Layer K has the highest incidence of gnawing damage to rabbit bone, at 3,8%.

Perhaps most interesting are the counts of rabbit bones when compared to ungulate bones (Table 6 and Fig. 44). The ratio of rabbit to ungulate is lowest in the Mousterian, low in the EUP and progressively higher in the Solutrean and Magdalenian. In other words relatively more rabbit remains became incorporated into the cave as time progressed. This relative increase in the rabbit will be discussed below.
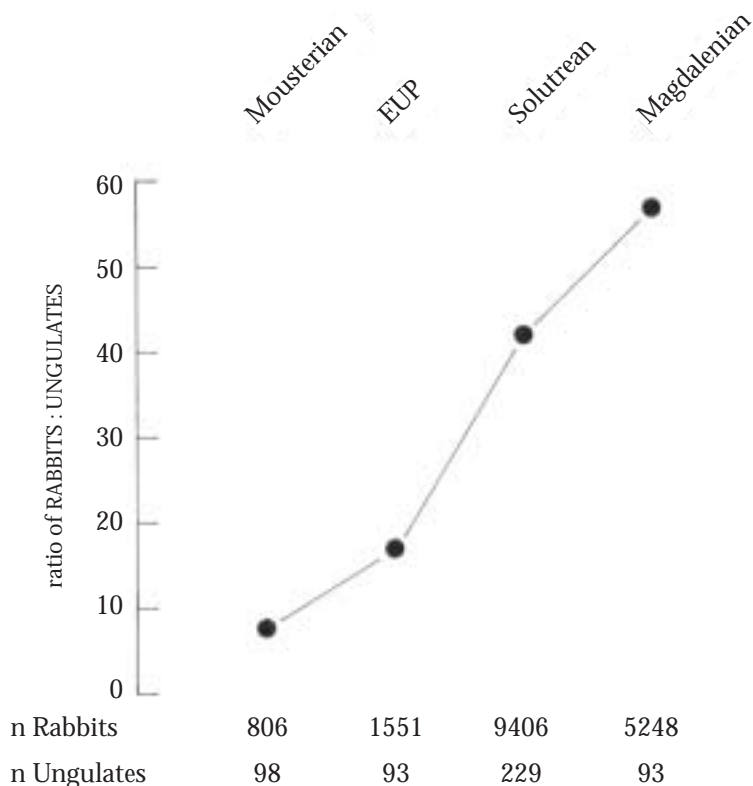
Fig. 44 Ratio of rabbit to ungulate bones at Caldeirão cave. Counts of rabbit bones are preliminary and are from Newton (pers. comm.). Note the relative increase of rabbits in the course of time.

Fish

Salmonid ?trout

Andrew Jones (University of Bradford, England) has identified the single fish vertebra (from M14 sc 180 spit 10; Magdalenian) as salmonid — probably a trout. The antero-posterior length of the centrum is 6,1 mm and the centrum diameters are 7,5 x 6,7 mm. The river Nabão was probably once a good source of these fish.

Birds (John Stewart) see also Table 9.

Ducks – Anatidae

A carpometacarpal (L15 sc 135 Eb topo Magdalenian) and coracoid fragment (scapular end) (sc 225, Ebase-Eb/Fa) were identified. These could not belong to the same individual or even the same species, as they are too dissimilar in size. The smaller coracoid probably belonged to a medium sized duck such as a Shoveler (*Anas clypeata*), while the carpometacarpal is similar in size to a larger duck like the mallard.

Taxon	Mousterian	EUP	Solutrean	Magdalenian	Neolithic
Table 9. Caldeirão birds. The bird remains from the five main levels grouped by species above, and by behavioural/ecological group below.					
Unidentified birds	1	1	6	11	2
Chough *Pyrrhocorax pyrrhocorax*	1	3	11	-	-
Chough?	2	3	9	5	-
Alpine chough *P. graculus*	-	1	2	-	-
Magpie *Pica pica*	-	-	-	1	-
Unid. Corvid	-	1	2	-	-
Raven *Corvus corax*	-	-	1	-	-
Black-winged stilt *Himantopus himantopus*	-	-	1	-	-
Duck	1	-	-	-	-
Pigeon *Columba palumbus*	-	-	-	1	1
Partridge *Alectoris* sp.	1	-	2	9	2
Little owl *Athene noctua*	-	-	-	1	-
Eagle owl *Bubo bubo*	1	-	-	-	-
Griffon vulture *Gyps fulvus*	-	-	1	-	-
Black vulture *Aegypius monachus*	-	-	1	-	-
Black vulture?	2	1	-	-	-
Total birds	**9**	**10**	**36**	**28**	**5**
(Birds/Mammals)%	**6**	**7**	**11**	**12**	**6**
	Mousterian	**EUP**	**Solutrean**	**Magdalenian**	**Neolithic**
Corvids	3	8	25	6	-
Scavengers	2	1	2	-	-
Owls	1	-	-	1	-
Water birds	1	-	1	-	-
Partridges	1	-	2	9	2
Pigeons	-	-	-	1	1

Birds of prey - Accipitriformes

SD and Marta Moreno García (MMG) identified both Griffon Vulture *Gyps fulvus* and Black Vulture *Aegypius monachus* (Fig. 45). JS has not restudied these specimens.
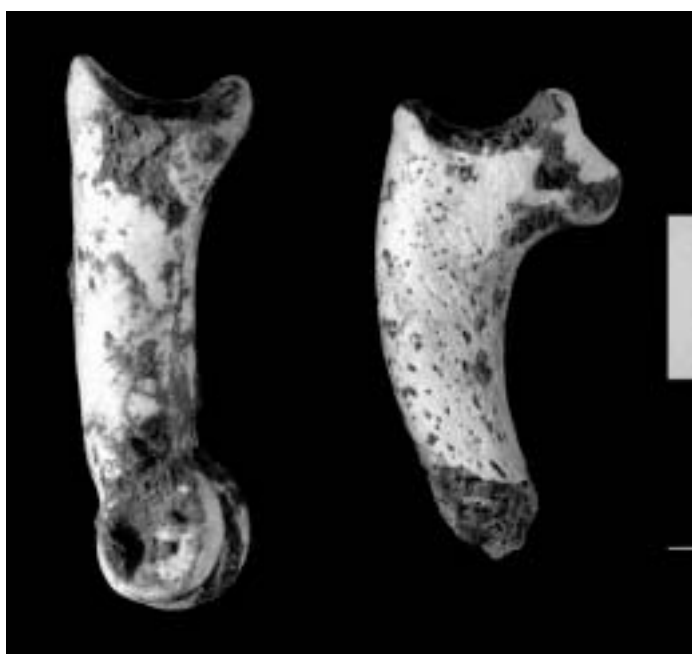

Fig. 45 ?Black vulture ?*Aegypius monachus* phalanges, lateral views, both Mousterian
Second phalanx: P13 sc 486 K K5
Terminal phalanx: P13 497 K.

Partridges and pheasants - Phasianidae

Alectoris sp.

A tarsometatarsal (Fig. 46; M14 sc 279 Eb Magdalenian) is clearly that of a galliform due to its overall form that is distinct from all other European birds. There are no clear characters distinguishing phasianids from tetraonids although its greatest length exceeds that of all smaller European tetraonid (*Lagopus* spp. and *Tetrastes bonasia*). The distinction between the tarsometatarsal of members of the genus *Perdix* and that of the genus *Alectoris* is the relative breadth of their midshaft as can be seen in Table 10.

Further distinction of *Alectoris* tarsometatarsals to species level is probably not possible due to the overlap in their metric and discrete morphological characters. Therefore species such the red-legged partridge *Alectoris rufa*, chukar partridge *A. chukar*, barbary partridge *A. barbara*, rock partridge *A. graeca* are all possible candidates.

Fig. 46 Partridge (*Alectoris cf rufa)*, tarsometatarsal, anterior view, M14 sc 279 Eb11 Magdalenian.

Table 10. Measurements of the Caldeirão Phasianid tarsometatarsal alongside measurements of extant European phasianid species from Kraft (1972).					
	GL	**BP**	**KB**	**BD**	**DD**
CAL M14 sc279 Eb Magd	42.3	8.3	3.9	8.7	8.3
Perdix perdix (n= 48)	38.3 – 43.9	7.1 – 7.8	3.0 – 3.6	6.9 – 8.5	7.2 – 8.2
Alectoris rufa (n= 21)	41.2 – 48.0	7.5 – 9.0	3.4 – 4.3	7.7 – 9.0	7.9 – 9.2
Alectoris graeca (n= 18 - 19)	42.4 – 49.5	7.8 – 10.0	3.6 – 4.7	7.5 – 10.0	8.2 – 10.2

Cf. *Alectoris*

Several distal tarsometatarsals (Q15 sc41 E2); (O13 sc184 E1); (Q13 sc199 E4); (P12 sc689 K4 Mousterian); (P12 587 H Solutrean); and a distal humerus (O11 sc229 E3) are all clearly partridge bones but have not been identified confidently beyond that, as they are incomplete. They are likely to belong to the genus *Alectoris* though.

Waders - Charadriiformes

MMG and SD identified a Stilt *Himantopus himantopus* (Fig. 47) from L14 sc 153 Fa F1 (Solutrean).

Fig. 47 Black-winged stilt (*Himantopus himantopus*), tarsometatarsal distal part, anterior and posterior views, L14 sc 153 Fa F1 Solutrean.

Pigeons and doves - Columbidae

Rock dove/Stock dove? *Columba* cf. *livia*/*oenas*
There are two distal tarsometatarsals, both from Magdalenian levels. One (R11 sc182 Eb) has a shaft and the other (P13 sc347 E2) does not.

Table 11. Measurements of the Caldeirão Columbid tarsometatarsal and modern European *Columba* species from Fick (1974).		
	BD	**KC**
CAL P13 sc347 E2 Magdalenian	6.18 + (damaged)	-
CAL R11 sc182 Eb Magdalenian	6.7	3.1
Columba palumbus (n= 21)	7.7 – 9.0	3.2 – 3.8
Columba livia (n= 8)	6.9 – 8.2	2.8 – 3.0
Columba oenas (n= 18)	6.6 – 7.6	2.6 – 3.3

The shaft breadth (KC) measurement (see Table 11) of the tarsometatarsal (R11 sc182) indicates that it falls in the range of the measurements recorded by Fick (1974) for the stock dove (*Columba oenas*) or the rock dove (*C. livia*). The distal breadth (BD), on the other hand, falls within the range given by Fick (1974) for the stock dove and outside that for the rock dove. The latter may be influenced by the small sample size of specimens measured by Fick as only 8 specimens were available and the BD of specimen R11 sc182 is only just outside the range. The other tarsometatarsal is damaged and hence cannot be compared reliably with Fick's (1974) data. Visual comparison would seem to indicate that it is also in the size range of the two aforementioned *Columba* species and is hence referred to them. A slight note of caution is necessary as neither specimen has been compared with any of the sand grouse species (*Pterocles*) known in southern Europe in the Late Pleistocene and today (Cassoli, 1972; and Harrison, 1982).

Columba sp.
A damaged distal humerus (N10 sc111 Ea E1toca Neolithic); distal humerus (P14 sc111 E3 Neolithic) and a distal humerus (P14 sc129 EbE4 Magdalenian) are all proportionately larger than the tarsometatatarsals, which may mean that they belong to the Wood Pigeon *Columba palumbus*. However, this is questionable because it would seem unlikely that all the tarsometatarsals belonged to one species while all the humeri to the other. Further work is needed to resolve this problem.
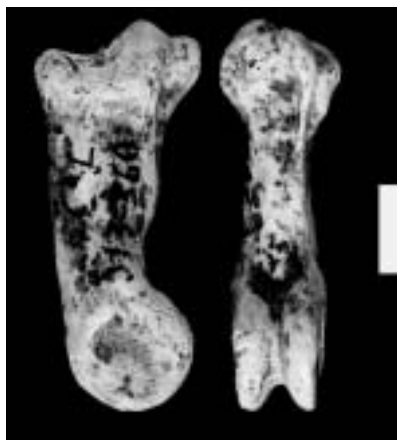
Owls - Strigiformes

MMG and SD identified both Eagle Owl *Bubo bubo* (Fig. 48) and Little Owl *Athene noctua.*

Fig. 48 Eagle owl (*Bubo bubo)*, proximal phalanx, lateral and posterior views, O13 360 K K1 Mousterian.

Crows - Corvidae

Raven, *Corvus corax*

A distal tibiotarsal (O13 sc168 FaF2 Solutrean); and a distal humerus fragment (P11 sc 225 E base-Eb/Fa) are clearly from a very large corvid and due to the absence in Europe today of any other species besides the raven this would seem to be the most likely candidate. The bivariate graph in Fig. 49 is a plot of various modern and fossil raven tibiotarsals. This shows that the present specimen from Caldeirão Cave is rather small in keeping with other late Pleistocene ravens from the Iberia such as that from Ibex Cave, Gibraltar and the Grotte d'Isturitz in the Pyrenees. The specimen is also similar size to the extinct species *Corvus antecorax* named from the Rissian site La Fage in France. However, the ravens in Iberia today, *Corvus corax hispanus*, are also relatively small compared to those in northern Europe. Stewart (1999) has shown that *Corvus antecorax* may be a synonym of *C. corax* as it was named with an insufficient knowledge of the variation of the modern raven. Therefore, it is best to consider the present specimen as *Corvus corax.*
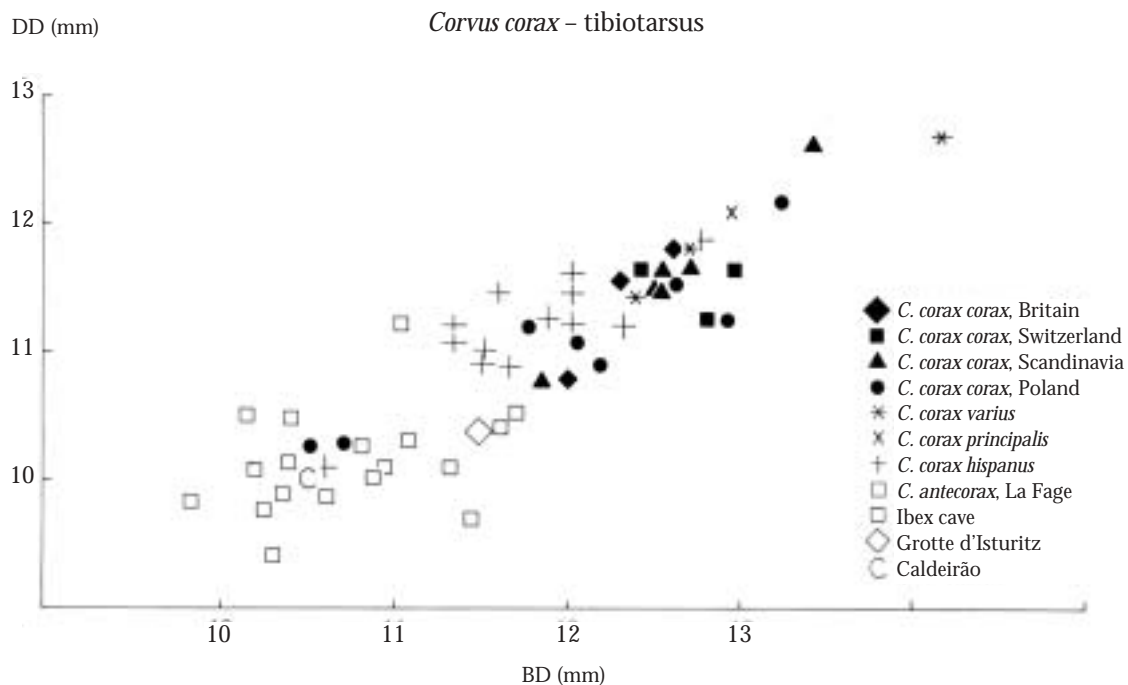
Fig. 49 Raven tibiotarsals. Measurements of the Caldeirão *Corvus corax* compared to modern and fossil raven tibiotarsal measurements from various parts of Europe. A plot of the distal depth (DD) versus the distal breadth (BD). Comparative data are from Tomek and Bochenski (2000) and Stewart (1999). Measurements are in millimetres.

Common chough, *Pyrrhocorax pyrrhocorax*

A complete humerus (Fig. 50; M15 sc 290 Fa F3 Solutrean) is clearly that of a large passerine due to the presence of a dorsal supracondylar process and because it differs markedly from that of a Charadriiform. The specimen's size (the largest of the three specimens from Caldeirão plotted in Fig. 51) appears to indicate that it belongs to a Common Chough. Those diagnostic characters published by Tomek and Bochenski (2000) did not invalidate this conclusion. Fig. 52 shows a complete common chough tarsometatarsal from the Solutrean.

Alpine chough, *Pyrrhocorax graculus*

Two humeri (O12 sc 185 Ja J0 EUP and L15 sc 330 Fa F2 toca Solutrean), the two smaller specimens from Caldeirão plotted in Fig. 51, would appear to coincide with the modern size and proportions of the Alpine Chough. The greater degree of uncertainty given to these specimens is due to the overlap between the scatters of the Alpine Chough and Jackdaw (*Corvus monedula*) in this Fig.

Fig. 50 Three chough humeri from left to right:
Large: Chough (*Pyrrhocorax pyrrhocorax*) M15 sc 290 Fa F3 Solutrean
Small: Alpine chough (*Pyrrhocorax graculus*) O12 sc 185 Ja J0 Early Upper Palaeolithic
Small: Alpine chough (*Pyrrhocorax graculus*) L15 sc 330 Fa F2 Solutrean.

Fig. 52 Chough (*Pyrrhocorax pyrrhocorax*), tarsometatarsal, anterior view, L15 sc 331 Fa Solutrean.

SC (mm)

European corvid humeri

Legend:
◇ *Corvus monedula*
■ *Pyrrhocorax pyrrhocorax*
△ *Pyrrhocorax graculus*
✕ *Pica pica*
✳ *Garrulus glandarius*
○ *Nucifraga caryocatactes*
+ *Cyanopica cyanus*
⊕ *Perisoreus infaustus*
C Caldeirão

GL (mm)

Fig. 51 Corvid humeri. A plot of measurements of the shaft width (SC) versus the greatest length (GL) of corvid humeri from Europe and the three specimens from Caldeirão cave. Comparative data are from Tomek and Bochenski (2000) and Stewart (1999). Measurements are in millimetres.

Undetermined Corvidae

All the remainder of the corvid specimens including the one previously identified as Magpie (*Pica pica*) (ie most of the avian remains from Caldeirão Cave) could be confirmed as corvid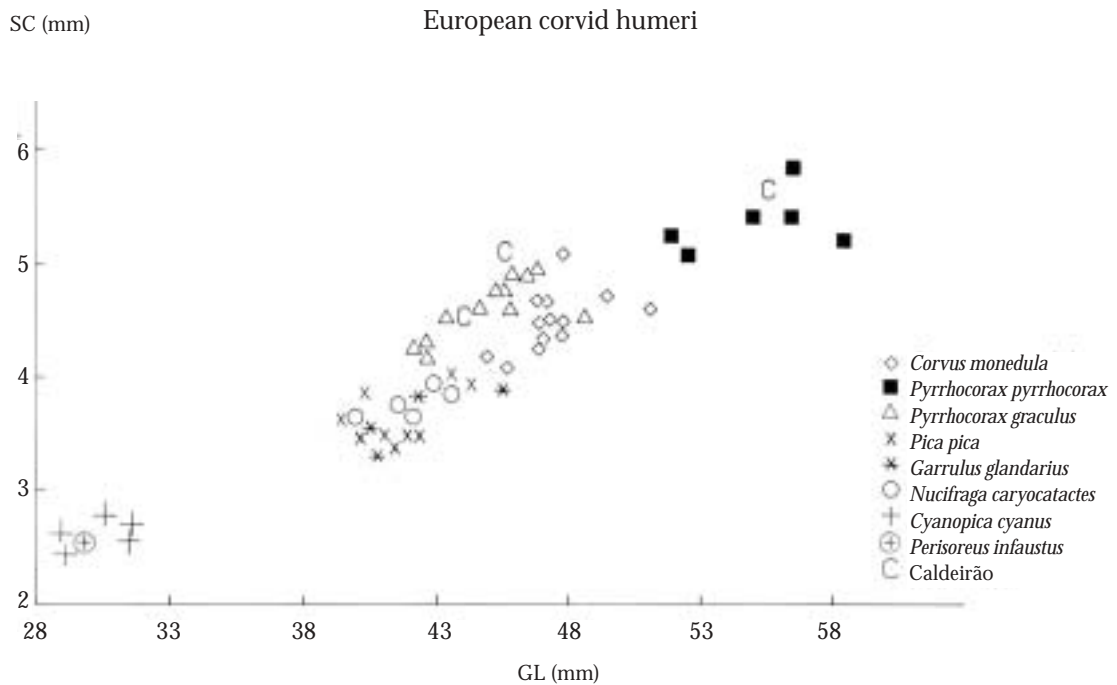 but due to the overlap in measurements between Alpine Chough and Jackdaw on the one hand and Magpie, Nutcracker and Jay on the other and the closeness of these two groups it is best to consider them undetermined corvids.

The Caldeirão assemblage consists of the usual categories of bird remains often found in cave assemblages (Table 8). These are birds that live (breed and/or roost) in or around the cave (the corvids, pigeons, owls and vultures and ones that formed prey items of some of those same birds (partridge, duck and wader). The palaeoecological indications of this fauna are therefore steep rocky country with crevices for nesting for the former category which is hardly surprising, open to scrubby country for the partridge and water body for the duck which would have to be relatively shallow in parts for the wader.

No indications of human interference are visible on any of the bones.

The finds of scavenging birds such as vulture and Black vulture is interesting and is discussed below. They appear in the three earlier levels of the cave.

Age-at-death of the large mammals (see Tables 1 to 5, Table 12 and appendix)

The juvenile to adult ratios of the equids and red deer show an interesting pattern in the Caldeirão sequence. This is discussed below. There are too few ungulate teeth to enable any further resolution to finer age classes via dental wear patterns. The few data that were collected are given in the appendix.

			MOUSTERIAN		EUP		SOLUTREAN		MAGDALENIAN		NEOLITHIC
Taxon	Teeth/bones	Juv/adult	n	% juv	n	% juv	n	% juv	n	% juv	n
Red deer	teeth	dP_4	1		5		8		2		0
Red deer	teeth	P4	2		0		5		3		0
Red deer	bones	UE	9		6.5		13.5		5		0
Red deer	bones	UM	9.5		11		23		2		0
Red deer	bones	F	4.5		5		49		27		1
				68		69		32		16	
Equids	teeth	dP	7		6		0		0		0
Equids	teeth	P+M	5		3		16		3		0
				58		67		0			
Equids	bones	UE	3		2		2		0		0
Equids	bones	UM	7		4		3		0		1
Equids	bones	F	1		0		3		3		0
				88		100		50			

Table 12. Caldeirão cave red deer and equids – juveniles versus adults.

This table provides separate counts of teeth and bones from young and adult animals, and the percentages of juveniles calculated separately from teeth and bones (very small samples are excluded). For teeth of red deer, the numbers of deciduous and adult fourth premolars (dP_4 and P_4 respectively) are given. Since equid P_3s and P_4s, and M_1s and M_2s are difficult to distinguish, equid teeth counts are pooled as deciduous premolars ($dP_2 + dP_3 + dP_4$) and adult premolars + molars (P + M). For bones of both taxa, UE and UM are the unfused epiphyses and unfused metaphyses respectively of the following bones: scapula, distal humerus, distal radius, distal metapodials, distal femur, distal tibia, calcaneum, proximal first phalanx, and proximal second phalanx. Unfused scapulae and unfused calcanea are counted as "UM". In order to compute the percentage of juveniles via the limb bones, the higher of the UM or UE counts was used in the numerator. These figures indicate that in the Mousterian and Early Upper Palaeolithic most of the red deer and equids brought into the cave were juveniles. Subsequently the percentages of juveniles were much lower.

Discussion

Presence and absence of carnivores at Caldeirão (Table 13)

Table 13. Survival and extinction of carnivores at Caldeirão – a working hypothesis.					
	Moust	*EUP*	*Sol*	*Magd*	*Neol*
Bear	+	+			
Lion	+	+			
Hyaena	+	+			
Leopard	+	+	+		
Wolf	+	+	+		
Lynx	+	+	+	+	+
Fox	+	+	+	+	+
Wild cat			+	+	+
Badger			+	+	+
Nº of carnivore taxa	7	7	6	4	4

Before trying to answer the question of who collected the bones at Caldeirão it is important to consider which carnivores, especially which large carnivores, were actually present. As mentioned above, there are several anomalous or stratigraphically questionable finds such as a Solutrean lion phalanx that is probably EUP, two leopard phalanges and a leopard metapodial which are most probably Solutrean rather than Magdalenian, and a Solutrean bear phalanx which is probably EUP. Table 13 disregards these specimens with dubious stratigraphic provenience, and proposes as a working hypothesis a scheme for the survival/extinction of carnivores in the Caldeirão region. Thus the Mousterian and EUP saw the cave inhabited by seven carnivores — lion, bear, hyaena, leopard, wolf, lynx and fox. Hyaena, lion and bear then became extinct or at least were ousted from the cave by man. Six carnivores therefore survived into the Solutrean. And leopard and wolf suffered the same fate as the lion, hyaena and bear but during the Solutrean so that by Magdalenian and Neolithic times only four species of carnivores survived — lynx, wildcat, fox and badger.

Who collected the large animal bones? (Tables 8 and 13 and Fig. 53)

In general animal bones found associated with cultural remains in an archaeological site are presumed to have been accumulated by people, an assumption often reinforced by the findings of cut and burn marks on the bones. It is also usually assumed that most archaeological animal bones derive from meals eaten in the past. Small mammal and bird bones may also accumulate in caves and probably derive from roosting owls. Some burrowing animals may even "incorporate themselves" into an assemblage. It is also important to remember that people were not the only living being capable of hunting large animals and transporting their carcasses back to their living area! Hyaenas, and several other species of large carnivores are known to do the same. Hyaena inhabited Portugal and the rest of Iberia during much of the Pleistocene and therefore this animal has to be considered as an alternative or additional factor. Hyaena, leopard, and other large carnivores, as mentioned above, were found in Mousterian and Early Upper Palaeolithic layers but not in any of the subsequent levels (Table 6). Since these large carnivores are well-known accumulators of animal bones — even bones of other carnivore species including their own — one is at first tempted to infer that in Mousterian and Early Upper Palaeolithic times, Caldeirão was a carnivore den. This would mean that people had lit-
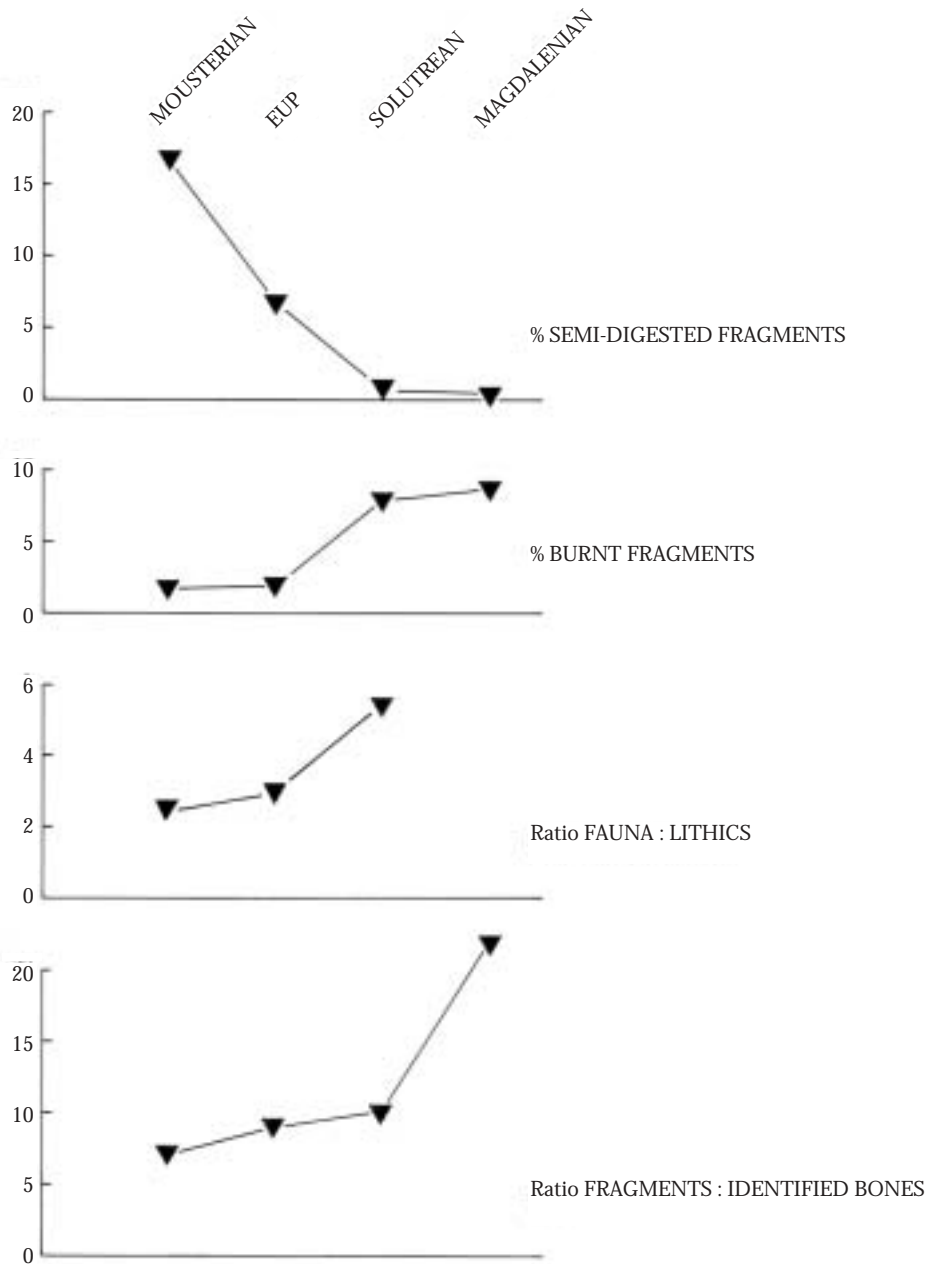
Fig. 53 Carnivores versus humans as bone accumulators. Plots to show a change in the pattern of occupation of Caldeirão cave in the course of time. Data are in table 8. Note the decrease of *partially-digested bones* and increase of *burnt bones, fauna versus stone tools* (from Zilhão, 1997 vol. 2; 114), and *unidentified versus identified bones* in the course of the succession. These changes may reflect a decrease in the use of the cave by carnivores, especially hyaenas, and its increasingly intense use by humans.

tle or no impact on the assemblage of bones that had accumulated during thousands of years in the cave. This is probably an extreme interpretation, as there are cultural remains too in these same levels. But how important was the presence of carnivores? Clearly both people and carnivores used the cave, perhaps simultaneously — hyaenas, for example, will tolerate the presence of other species such as warthogs in their dens (Brain, 1981). However a mutual avoidance seems more probable (see Klein and Cruz-Uribe, 1984). It is most likely that people used the cave for some years or even decades and then carnivores used it. Alternate use of the cave by people and carnivores would be difficult to observe archaeologically. Can we determine the extent of carnivore versus human responsibility for the bones? Besides the presence/absence of large carnivore bones and teeth, several other characteristics of the faunal remains in different levels at Caldeirão are considered.

They are as follows:

- The presence/absence of coprolites, presumed to be from hyaenas
- The presence/absence of partially digested bones
- Fauna to lithics ratios
- Juvenile to adult ratios of the red deer and equid remains
- Carnivore to ungulate ratios
- Body-part frequencies
- Cut and burn marks
- The ratio of small unidentified fragments to identified bone

Some of these indicate little carnivore influence; others indicate considerable carnivore influence, while some indicate clear human occupation of the cave. In sum the picture that emerges is not clear-cut, and the results are presented in the hope that future excavations will provide more data to solve the question *who collected the bones*? At this stage however, it is suggested that large carnivores, whose bones and teeth are only found in the Mousterian and Early Upper Palaeolithic, were only using Caldeirão in those two earlier levels, and that they either avoided the cave in Solutrean and Magdalenian times or that they had become locally extinct in these later times.

Coprolites, presumed to have belonged to hyaenas (described above), were, like hyaena bones and teeth, observed in the Mousterian (Table 8). The few small ones found in the Solutrean are a possible indication of a lingering presence of hyaena after the Early Upper Palaeolithic, though being small these may have belonged to a smaller carnivore.

Partially digested bones (Table 8). Many carnivorous mammals swallow complete bones, or parts of bones. These may be subsequently regurgitated or survive passage through the gut (see for example Payne and Munson, 1986). Spotted hyaenas regularly regurgitate indigestible residues of their recent meals (Brain, 1981, p. 63). Kruuk (1972, p. 244) spent several years observing spotted hyaenas in East Africa. He writes (Kruuk, 1972, p. 244): "Adults do regurgitate near the den, but what comes out is almost invariably a large slimy ball of hair and bone slivers …". These bones may survive their stay in the stomach, but suffer varying degrees of digestive alteration, and present a characteristic eroded appearance. Etched surfaces of partially digested bones are often shiny, and any broken edges wafer-thin and sharp. The absence of this sort of corrosion on larger bones rules out the possibility that soil acids

were responsible. Dogs for example will not swallow fragments whose diameter exceeds c. 2,5 cm; soil corrosion will affect small and large fragments alike (Payne and Munson, 1986). Two examples from Caldeirão are a fragment of red deer calcaneum and an equid tooth fragment (see Figs. 25 and 26). These and numerous other partially digested bones and chips of bones were found mainly in Mousterian and Early Upper Palaeolithic levels. This confirms the presence of a bone-eating carnivore in the earlier two periods at Caldeirão, while other carnivores such as wolves may also have been responsible. Hence we can explain the presence of semi-digested bones in the Solutrean and Magdalenian.

Fauna to stone tools ratio. Zilhão (1997a) made various quantitative studies of the deposits at Caldeirão. Among these are the densities of fauna and lithics (Table 8). The low bone to lithics ratio in the Mousterian and EUP suggests that people used the cave intermittently. But the faunal density and ratio of fauna to lithics is greater in the Solutrean. His conclusion is that this change indicates an intensification of human activity in the Solutrean. In other words, while hyaenas were significant bone accumulators in the Mousterian and Early Upper Palaeolithic, their role declined subsequently when people occupied the cave more intensively.

Juvenile to adult ratios of the red deer and equids. Zoo-archaeologists generally deduce the age-at-death of the animals represented in an archaeological assemblage of animal bones. An estimate of the mortality pattern of animals culled in antiquity can reveal important information about man-animal relations. At Caldeirão (Table 12) most of the Mousterian and Early Upper Palaeolithic red deer and equids were juveniles, while in the subsequent Solutrean and Magdalenian periods, more or most of these animals were adult. (At Pego do Diabo, which also functioned as both human and carnivore den, the percentage of juvenile red deer was also high at 49%, though the percentage for equids was lower at 37%; Valente, 2000). One could argue that people were improving their hunting capabilities in the course of time and that it was not until the later periods that he was able to cull the adult (larger) horses and red deer. An alternative explanation for this change in the pattern of mortality, and the one I prefer, is quite simply that the majority of the equids and red deer in the Mousterian and Early Upper Palaeolithic were not hunted by people but by carnivores such as hyaenas and leopards. Hyaenas are by no means the largest and most efficient of predators and were perhaps unable to take the faster and more ferocious adult horses and adult red deer. This may be further evidence for a change of predator between Early Upper Palaeolithic and Solutrean times. Kruuk (1972) notes that the three species of large mammals most commonly hunted by spotted hyaenas are wildebeest, zebra and Thompson's gazelle. He recorded the ages of over 100 wildebeest killed by hyaenas. His data (Kruuk, 1972, p. 94) are as follows: 36% 0-12 months old, 14% 13-24 months old and 50% over 24 months at Serengeti, and 60% 0-12 months old, 2% 13-24 months old and 38% over 24 months at Ngorongoro. He also indicates (Kruuk, 1972, p. 98) that 48% of the 46 zebras killed were up to 4 years old, and of the 98 gazelles he found killed by hyaenas, 43% were fawns, probably all less than three weeks old. He also suggests that his counts of young animals killed are underestimated due to the hyaena's often rapid and complete consumption of their carcasses. This preference for young animals is quite different from what lions and wild dogs prefer to kill today in East Africa (Kruuk, 1972). These two carnivores take a much smaller proportion of young prey. The age-at-death data for leopard kills of large

mammals in the Kruger National Park in South Africa in 1966-1968 given by Pienaar (1969; cited by Ruiter and Berger, 1999) are also interesting. Pienaar noted that of 733 impala (average weight c. 45 kilos) killed by leopards 82% were adults, 10% juveniles and 8% infants. However, of 20 waterbok (average weight c. 260 kilos) the percentages were respectively 10, 55 and 35 and all 4 burchell's zebras (average weight 315 kilos) were infants. The small amount of data in Fig. 12 does then seem to implicate leopards and hyaenas rather than man or lion!

Let us return to the Iberian Pleistocene. At Cova Negra (Valencia), Villaverde et al. (1996) noticed that levels with a predominance of carnivore marks on the bones, show a greater representation of infant as well as old cervids. It is unclear to me at present why there are few "old" cervid remains at Caldeirão in the early levels, though it may simply be a matter of sampling and that future excavations will reveal some of the "old" cervids at Caldeirão. Altuna and Mariezkurrena studied the animal remains from a pit in Labeko Koba, an Upper Palaeolithic cave in the Basque region of Spain (Arrizabalaga et al., 2000), where they found abundant *Crocuta* remains (30% of the animal bones were of this taxon) as well as numerous coprolites. They suggest that their preferred prey at that time were horses, **most of which were juveniles**. These hyaenas also took red deer and large bovids **" ... entre estos últimos abundan los restos de animales jóvenes."** However in their full description of the animal remains from this cave, Altuna and Mariezkurrena's (2000) tables do not appear to support this suggestion in the levels with *Crocuta* remains. While in levels IX and VII 50% and 57% respectively of the red deer were juvenile, for equids the percentages of juveniles are rather lower ranging between 25% and 44%.

Carnivore to ungulate ratio Klein (1975) suggested that human food remains could be distinguished from those of carnivores by the proportion of carnivore remains. This is because carnivores like hyaenas have a tendency to feed on the carcasses of other carnivores, even of their own species, and to an extent greater than people did. Using this argument, Brain (1981) concluded that large carnivores collected many of the accumulated animal and hominid bones in South African caves — hominids were hunted rather than hunters. Geraads (1997) found high carnivore to ungulate ratios at Zafarraya cave in Andalusia and argued that there too hyaenas had been the main accumulators of the animal bones. At Caldeirão it is quite clear that the percentage of large carnivores, ie those carnivores that would be expected to have competed with people for use of the cave, such as hyaena, bear, lion, leopard and wolf, decreases quite drastically after the Early Upper Palaeolithic (Table 6). Thus in the Mousterian and EUP the percentages of large carnivores are 10 and 14. In the Solutrean, Magdalenian and Neolithic the percentages of large carnivores decrease to 3, 3 and even 0 in the Neolithic. From this change it is inferred that large carnivores were more frequent users of the cave in early times but were scarce after the Early Upper Palaeolithic.

Body parts. Zoo-archaeologists identify and record many or even most of the different bones of an animal's skeleton such as teeth, leg bones, feet bones, and phalanges. Their frequencies in an archaeological site may reveal information about where the animals were slaughtered and what happened to their skeletons after death. However, the main factor causing discrepancies, as Brain (1967) pointed out, is differential *post-mortem* destruction. Some bones are more fragile than others and so in adverse conditions, suffer greater *post-*

mortem loss. The hyaena with its powerful jaws and teeth is capable of causing great destruction to the bones of a mammal carcass. A study of this destruction in relation to different parts of the skeleton and the size of the animal in question reveals that hyaenas will destroy all the limb bones of mammals the size of a goat, but tend to leave the teeth. However, in the case of larger animals, not only are the teeth left intact but so too are many of the limb-bones (Skinner et al. 1980). The mammal fauna of Caldeirão includes both smaller animals like goat and large ones like red deer and equids. If *Crocuta* had a major impact on the Caldeirão assemblage, we would expect the large animals to be represented by both teeth and bones and the smaller ones by teeth only. And this discrepancy should disappear in the more recent levels from which hyaenas were absent. With so few remains it is difficult to see whether any particular part of the animal skeleton was preferred, though there is nothing in the bone counts (Tables 1 to 5) to indicate any particular discrepancies. It appears likely that all parts of the skeleton of the larger herbivores were introduced into the cave. Table 14 pools the different parts of the skeleton in several ways. The tooth-to-bone ratios show little overall variation between large and small animals and between early and later levels. A more detailed breakdown of the different parts of the skeleton in the lower part of this table similarly shows few differences between animals and between layers. It is difficult to find any explanation for the lack of any discrepancy.

Table 14. Body-part counts of the common large and medium-size mammals at Caldeirão.						
	Mousterian + EUP			*Solutrean + Magdalenian*		
	Equids	*Red deer*	*RC*	*Equids*	*Red deer*	*RC*
Teeth	21	22	21	19	43	24
Bones	20	68.5	34.5	12	172.5	33
	Mousterian + EUP			*Solutrean + Magdalenian*		
	Equids	*Red deer*	*RC*	*Equids*	*Red deer*	*RC*
Teeth	21	22	21	19	43	24
Long-bones	5	18.5	6.5	7	25.5	9
Tarsals	2	9	5	0	17	7
Phalanges	12	40	22	4	127	12

The purpose of this table is to try and see whether the presence or absence of hyaena has had any effect on the parts of the skeleton present. The Mousterian and Early Upper Palaeolithic layers in which bones of hyaena were found are compared to Solutrean and Magdalenian layers which have little or no evidence for hyaena. Data are from tables 1 to 5. "RC" includes both goat and chamois. "Bones" is the count of all girdle (scapulae and pelves), limb and foot bones. "Long bones" is the count of the main limb-bones, excluding scapulae and pelves. "Tarsals" includes both astragali and calcanea. (The Solutrean perforated red deer phalanges are omitted.) The presence or absence of hyaena does not appear to have had any overall impact on the tooth to bone ratio or other body-part frequencies. The high proportion of red deer phalanges in the Solutrean + Magdalenian (which becomes even higher if the perforated ones were to be included) is worth noting but difficult to explain.

Cut and burn marks. The presence of cut marks on bones is conclusive evidence of an association between people and the animal in question. Cut marks were observed on a small number of the bones in all levels (Table 8). We can therefore conclude that people accumulated some of the faunal remains in all periods. Burning of bones is evidence for man's presence in the cave. Burn marks are relatively scarce in the earlier levels, and common in the more recent ones — almost one in ten bone fragments in the Magdalenian show signs of burning. The fourfold increase of burnt bones between Early Upper Palaeolithic and Solutrean confirms the notion of large carnivores being replaced by people as the main occupants of the cave.

'Unidentified to identified' bone ratio. By the Magdalenian period, the numbers of unidentified fragments increased relative to the numbers of identified bones. Does this reflect reduced scavenger activity in the cave? People were, as always, breaking the bones into fragments for marrow extraction, but in the absence of hyaenas, these fragments remained unconsumed.

Newton's study of the rabbit bones shows a similar picture to that shown by the large mammals. Thus (see above under "rabbit") many of the Mousterian rabbit bones show acid etching and puncturing. Approximately 4% of the Mousterian rabbit bones show signs of gnawing, and this percentage decreases in the subsequent levels. It is more probable that the carnivore responsible here was the lynx.

In sum it is difficult to understand to what extent *Crocuta* (and perhaps the other large carnivores such as wolves, leopard and lion) played a bone-accumulating role at Caldeirão during the Upper Pleistocene. We can, however, be fairly certain that a substantial proportion of the larger mammals in the Mousterian and Early Upper Palaeolithic *were* collected by carnivores, and that their activity declined to insignificance in the subsequent Solutrean and Magdalenian. Valente (2000), in her study of mammalian bones from the Upper Palaeolithic cave Pego do Diabo, also describes hyaena remains as well as coprolites and semi-digested bones. She comes to a similar conclusion as here — that the cave also functioned as both carnivore den and human shelter. Some of the Early Last Glacial caves in Cantabria were also major dens of large carnivores and their use by humans was, according to Straus (1992, p. 54), "relatively modest". Altuna (1994) notes the absence of *Crocuta* from all 13 Solutrean sites in northern Spain, and at Labeko Koba *Crocuta* disappears from the sequence during or after the Aurignacian (Altuna and Mariezkurrena, 2000).

If therefore, the macro-fauna of Caldeirão was collected by both large carnivores and people in the early part of the sequence, but predominantly by people alone in the later part of the sequence, we cannot consider the Mousterian to Magdalenian sequence to draw inferences about Upper Pleistocene climate and vegetation change. This is because the agent(s) responsible for its collection changed in the course of time. And it is quite probable that different agents had different species preferences. Nonetheless, some attempt is made to view the presence and absence of species there alongside other early Portuguese sites, and consider the Solutrean, Magdalenian and Neolithic — those assemblages for which people were the primary agent — in order to try and make inferences about the environment and man-animal relations.

Species presence/absence at Caldeirão and other sites in Portugal

In terms of species present, the Caldeirão fauna is a fairly typical Portuguese Upper Pleistocene assemblage (Tables 15 and 16). However, Caldeirão lacks several species of very large animals such as rhinoceros, hippopotamus, and mammoth all present elsewhere in the Mousterian period. One possibility is that these taxa had become extinct before the Caldeirão Mousterian, though perhaps the more likely explanation is that Caldeirão, situated in a narrow valley in steep rocky terrain, was too far from open plains, the habitat normally associated with these very large herbivores. This topographic explanation may also account for the scarcity of aurochs (see Table 6).

At Pego do Diabo (Valente, 2000) the list of species and their counts are rather similar to the ones for the Early Upper Palaeolithic of Caldeirão.

	G da FB	G da C	Caldeirão Mousterian
Aurochs	75	15	1
Goat	101	22	12
Chamois	-	-	5
Red deer	116	151	50
Roe deer	-	1	1
Wild boar	7	-	3
Horse/equid	28	16	24
Rhinoceros	14	15	-
Dolphin	6	-	-
Ringed seal	1	-	-
Mammoth	10	-	-
Hyaena	25	24	6
Bear	31	1	-
Badger	-	-	-
Lion	1	-	-
Leopard	7	-	1
Lynx	-	7	11
Wildcat	2	1	-
Wolf	1	2	3
Fox	8	-	1

Table 15. The Mousterian mammalian assemblage at Caldeirão compared to two Mousterian assemblages in central Portugal: Gruta da Figueira Brava ("G da FB", Serra da Arrábida, near Setúbal) and Gruta da Columbeira ("G da C", Serra da Cesareda, near Bombarral) in Antunes, 2000.

Table 16. Caldeirão in context. Large mammals from 28 Portuguese Pleistocene sites (simplified from table 1 in Cardoso, 1997), alongside the data from Caldeirão.

	Min	Ris	R/W	E-W	L-W	Caldeirão Mou	EUP	Sol	Mag
Sus scrofa	.	.	.	.	+	+	.	+	+
Hippopotamus	+	+	.	.	.	.	.	.	.
Cervus elaphus	.	+	.	+	+	+	+	+	+
Dama dama	.	.	.	.	+	.	.	.	.
Capreolus capreolus	.	.	.	.	+	+	+	+	+
Bos primigenius	.	+	.	+	+	+	.	+	+
Capra	.	.	.	.	.	+	+	+	+
Rupricapra	.	.	.	.	+	+	+	+	+
Equus caballus	.	+	.	+	+	+	+	+	+
Equus hydruntinus	.	.	.	.	+	.	.	?+	.
Dicerorhinus	.	.	.	+	+	.	.	.	.
Elephas antiquus	+	+	+	+	+	.	.	.	.
Cf Mammuthus primigenius	.	.	.	.	+	.	.	.	.
Canis lupus	.	.	.	+	+	+	.	+	.
Vulpes vulpes	.	.	.	+	+	+	+	+	+
Cuon alpinus	.	.	.	?+	.	.	.	.	.
Ursos arctos	.	.	.	+	+	+	+	?+	.
Hyaena hyaena	.	.	.	+	.	.	.	.	.
Crocuta crocuta	.	.	.	+	+	+	+	.	.
Homotherium latidens	.	+	.	.	.	.	.	.	.
Panthera pardus	.	.	.	+	+	+	+	+	.
Panthera leo	.	.	.	+	+	+	+	?+	.
Lynx pardina	.	.	.	+	+	+	+	+	+
Felis silvestris	.	.	.	+	+	.	.	+	+

Min = Mindel; Ris = Riss; R/W = Riss-Würm; E-W = early Würm; L-W = late Würm; Mou = Mousterian; EUP = Early Upper Palaeolithic; Sol = Solutrean. "+" = presence and "." = absence. Note that most of the Portuguese Pleistocene sites are "late Würm" hence the scarcity of records from Mindel – early Würm times.

Species' frequencies in the Caldeirão succession and the environment

Table 17. Percentages of large herbivores at Caldeirão cave. Taxa present in small numbers are shown as "+".					
	Moust	*EUP*	*Sol*	*Magd*	*Neol*
Aurochs/cattle	1	-	+	3	18
Chamois/sheep/goat	20	38	21	6	22
Red deer	51	44	66	70	2
Roe deer	1	1	1	3	-
Wild boar/pig	3	-	+	11	57
Equids	24	18	11	6	2
Total numbers of teeth and bones	98	93	229	93	60
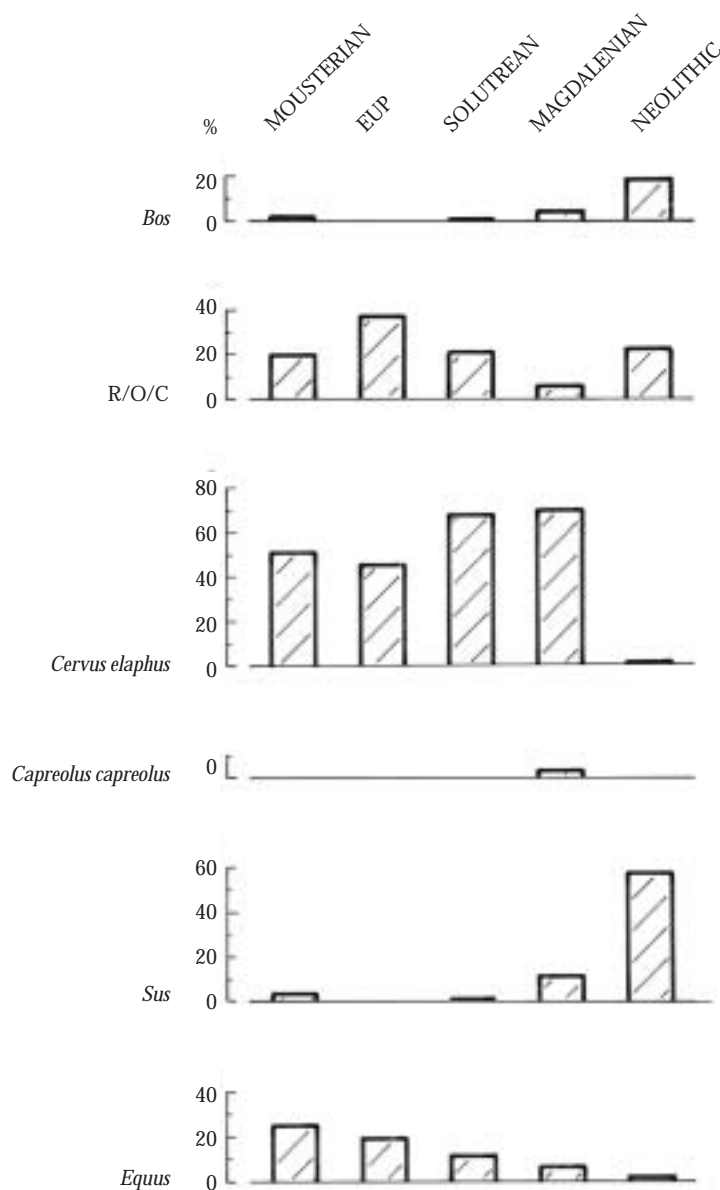
Fig. 54 Percentages of ungulates at Caldeirão cave. 'R/O/C' includes *Rupicapra*, *Capra* and *Ovis*, many of whose bones are difficult to identify to species, but most are *Capra* up to and including the Magdalenian, and most are *Ovis* and *Capra* in the Neolithic.

Table 17 and Fig. 54 summarise the percentages of large herbivores and show some variation in the faunal succession at Caldeirão. Between the Mousterian and the Early Upper Palaeolithic there appears to be little change in the herbivore frequencies. Note however, that between the EUP and Solutrean equids decrease and red deer increase. If indeed the Mousterian and EUP bones were largely collected by large carnivores then the EUP to Solutrean change could be a reflection of differences in preferences or predation abilities between carnivores and man, as we are assuming that people hunted most, if not all, the Solutrean and Magdalenian fauna. Hence, differences between Solutrean and Magdalenian assemblages should either reflect cultural changes or a change of the faunal composition of the Caldeirão region in turn due to vegetation change. Between Solutrean and Magdalenian there are two changes worth noting: the goat and equids decreased while wild boar and red deer increased. Although only in small numbers, roe deer are also present in the Magdalenian. These changes may reflect an increase of forest cover during the Magdalenian — both goats and equids are grazers preferring open rocky escarpments and grasslands, while wild boar and deer prefer woodland. Roe deer and wild boar are generally common in the early Holocene of Cantabria — presumably reflecting increased deciduous forest after the Pleistocene (see Altuna, 1992; Klein and Cruz-Uribe, 1994). The palaeoclimatic inferences drawn from the large mammal fauna of Caldeirão do not match those made by Póvoas (1991) in her study of the rodents of Caldeirão (Table 18). She suggested that the Magdalenian was characterised by drier conditions than earlier periods. Given the much larger sample sizes of the rodents, greater weight should be attached to Póvoas' conclusions.

Table 18. The percentages of rodents in Caldeirão. Adapted from table 1 in Póvoas (1991).				
	Moust	*EUP*	*Sol*	*Magd*
Apodemus sylvaticus	31	35	38	31
Allocricetus bursae	10	-	-	-
Eliomys quercinus	14	9	10	7
Microtus arvalis/agrestis	28	20	9	8
Microtus brecciensis/cabrerae	3	2	2	+
Chionomys nivalis	-	1	+	+
Terricola duodecimcostatus/lusitanicus	14	33	41	53
Arvicola cf. sapidus	-	-	-	+
Total Min. Nº of Individuals	29	113	413	814

In northern Spain Altuna and Mariezkurrena (1988) observed that pre-Magdalenian assemblages comprised a mix of various ungulates reflecting what they term "opportunistic hunting". However, Magdalenian faunal assemblages are distinguished by being dominated by a single species only — red deer if the region is flat, or wild goat if rocky — which they suggest reflects "specialised hunting". It is difficult (Table 17, Fig. 54) to detect a similar specialisation at Caldeirão, though we need to remember that humans were not the only predator collecting the assemblage there. It is asked whether *Crocuta* did not play an important 'bone collecting' role in many of the sites that Altuna and Mariezkurrena discuss, and if so, to what extent the "hunting specialisation" is not due to a bias caused by the disappearance of this animal in the course of time.

It is interesting to note the presence of fish (admittedly only a single bone) in the Magdalenian, as well as the increased proportion of rabbit with time from the Mousterian to Magdalenian (see Table 6 and Fig. 44). This may have some economic significance. In many areas in southern Europe and the Near East it is now clear that during the few millennia which preceded the Neolithic, people began to expand their resource base. This included many smaller species of animals whose capture must have required a higher expenditure of energy per unit of flesh obtained. Let us quote four examples: Lentacker (1986) noted the huge numbers of marine ani-
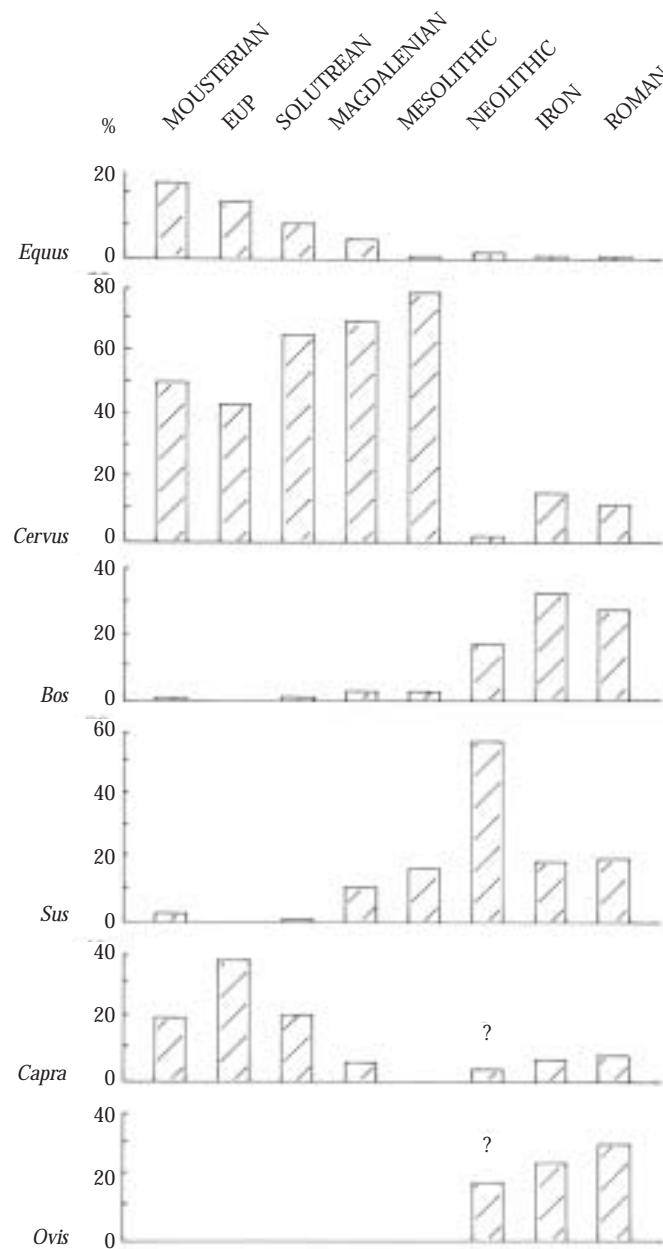
Fig. 55 Percentages of ungulates at Caldeirão in a wider context. This graph shows the faunal succession at Caldeirão as well as the percentages of ungulates from a Mesolithic site (Cabeço do Pez in the Sado estuary, near Alcácer do Sal) and the Iron Age and Roman assemblages (Alcáçova de Santarém, on the Tagus river). Given the difficulties in distinguishing between sheep and goat bones, the percentages of these two species in the Neolithic of Caldeirão should be regarded as 'guesstimates'. Note the decline of red deer after the Mesolithic and the increased importance of bovids (especially *Bos* and sheep/goat) in the Neolithic and subsequent periods. This shift may be a reflection of a change from hunting to husbanding, and if so, the *Bos* in the Neolithic may have been domesticated. The status of the *Sus*, as well as the *Capra* in the Neolithic is uncertain. Biometric analyses of Neolithic *Sus* and *Capra* may help to elucidate the status of these two species at that time in Portugal.

mals, birds and other small vertebrates at the Mesolithic sites near Muge, (Portugal); Morales et al. (1998) noted the appearance of fish bones in the Magdalenian at Nerja in Andalusia, (Spain); Payne (1975) noted the sudden appearance of large fish bones in the Mesolithic at Franchthi cave (Greece); and Davis et al. (1994) noted the huge increase of fish, as well as birds, and small mammals in the Natufian to PPNA sequence at Hatoula (Israel). (The increase of fish may to some extent reflect the encroachment of the seashore as sea levels rose after the Pleistocene.)

One possible explanation for this widening of the resource base, or, as Flannery (1969) called it, "the broad spectrum revolution", is simply that there were more people to feed, the traditional sources of protein such as big game were now too scarce and alternatives had to be sought. The continuation of this demographic pressure may explain why people had to largely abandon the hunting way of life and begin husbanding animals.

The other and more recent faunal change at Caldeirão occurred between the Magdalenian and the Neolithic. Fig. 55 puts the Caldeirão faunal assemblage in a wider context as it includes Mesolithic, Iron Age and Roman faunal assemblages from two other sites in central Portugal. It is clear that up to and including the Mesolithic, red deer, goat, equids and some *Sus* dominated these faunal assemblages. Neolithic, Iron Age and Roman assemblages however are dominated by cattle, *Sus*, and a species new to Iberia — sheep (only tentatively identified by me in the Neolithic of Caldeirão, although according to Rowley-Conwy, 1992, sheep was definitely present in the Neolithic of Caldeirão). *Sus*, sheep and cattle are all well known as domestic animals while red deer is not domesticable. This shift then must be due to the change from hunting to husbanding. Similar shifts from wild animals to domesticated species are documented in other regions with a long well documented late Pleistocene-Holocene faunal sequences. This switch from red deer to bovids undoubtedly represents a change from hunting to domesticating large mammals. It is therefore concluded (if somewhat tentatively due to the small size of the Neolithic faunal assemblage at Caldeirão) that at least the cattle were domestic at Neolithic Caldeirão.

Summary and Conclusions

1. A wide range of animals, especially carnivores, once inhabited the region around Caldeirão. However, towards the end of the Pleistocene several species disappeared — presumably a sad testimony to the ever-increasing rate of destruction that people wrought upon the environment.

2. Subsequently in the Neolithic, a clear shift to pigs, sheep and cattle is to be observed. These were undoubtedly being husbanded by then – a shift that reflects the change from hunting to herding.

3. Unlike the rodents, the large herbivores indicate more humid conditions in the Magdalenian compared to the preceding Solutrean. I prefer not to include the earlier levels (Mousterian and Early Upper Palaeolithic) in drawing inferences about climate change since people probably played a relatively minor role as bone accumulator in these earlier levels.

4. The frequencies of small carnivores, especially fox, increased during Magdalenian times. This probably reflects increased use of these animals for their pelts, a trend noted elsewhere in the Iberian Peninsula.

5. The hyaena and badger at Caldeirão were large. Since these species are larger in colder regions or during colder periods, their large size at Caldeirão may signify colder conditions there in the Upper Pleistocene. However, samples are too small to draw definite conclusions.

6. The ratio of rabbit remains to ungulate remains increased from the Mousterian to Magdalenian. This may reflect a gradual increase of hunting pressure on the environment – perhaps due to increased human population. As the numbers of people increased, so they were forced to exploit less "profitable" sources of meat.

7. Caldeirão has provided us with an interesting zoo-archaeological puzzle. Did the cave (at least in its early periods of occupation) function as a large carnivore den all or some of the time? The main indicators of large carnivore (such as hyaena) presence or absence are:

a) The actual presence of *Crocuta* and other large carnivore bones and teeth in the early layers and their subsequence disappearance from the Caldeirão sequence.

b) The finds of coprolites in the Mousterian, although several specimens in the Solutrean could signify a lingering presence of *Crocuta*.

c) The finds of "semi-digested" bones, most common in Mousterian and Early Upper Palaeolithic levels.

d) The scarcity of burn marks in the Mousterian and Early Upper Palaeolithic levels and their abundance in subsequent levels.

e) Low lithics to bone ratios in the Mousterian and UP, and high lithics to bone ratios in the Solutrean.

f) Most remains of the equids and red deer are juvenile (milk teeth for example) in the early levels and adults in the later ones. It is likely that the carnivores at Caldeirão were less able than people to hunt and/or bring back to the cave adult horses and red deer.

These are speculations, especially in view of the small samples, but on balance, it does seem likely that the cave functioned more as a carnivore den in the early levels and that subsequently carnivores disappeared or became extinct as people used the cave more intensively. A decrease in hyaena activity in the course of time at Caldeirão is apparently common in Iberian sites, and suggests that in the Mousterian and Early Upper Palaeolithic human populations were sparse (Klein, pers. comm.) or, as Villaverde et al. (1996) suggest for the Spanish Mediterranean, human presence was "scarce and diversified". Although only a small assemblage of animal bones has so far been uncovered at Caldeirão, it has many characteristics in common with successions from other parts of the Old World. Increasing demographic pressure "caused" the ousting of hyaenas and other large carnivores from caves and ultimately their extinction. Other large animals too became extinct and the ever-increasing numbers of human mouths requiring food meant people had to turn to alternative environments for sustenance such as the waters for fish. Ultimately people had to change from hunting to herding.

Acknowledgements

Apendix A

Measurements in tenths of a millimetre of mammal bones and teeth from Caldeirão, arranged by period, part of skeleton and taxon.

Measurements taken are as in von den Driesch (1976), Payne and Bull (1988) for pig teeth, and Davis (1992 and 1996) for artiodactyl metapodials. For equid teeth, see Fig. 2. Columns provide the following information: Box, Square (sq), whether with or without field coordinates and number (num), layer, spit, taxon (tax), period (Moust – Mousterian, EUP – Early Upper Palaeolithic, Sol – Solutrean, Mag – Magdalenian, Neol – Neolithic), complement (comp; for teeth, this indicates which teeth were recorded or were present in the mandible), then follow the measurements. Approximate measurements are either noted in the "notes" column or are in parentheses. "ACH" refers to the Anatomical Crown Height measured for third milk and third permanent molars up the buccal side of the central pillar from the crown-root junction to the occlusal surface.

KEY					
Bones are coded as follows:					
HU	humerus	**CA**	calcaneum	**P1**	proximal (first) phalanx
MC (MC1 or MC2)	metacarpal	**AS**	astragalus	**P3**	terminal (third) phalanx
FE	femur	**MT (MT1 or MT2)**	metatarsal		
TI	tibia	**MP (MP1 or MP2)**	metapodial		
Tax					
B	Aurochs/cattle	**FES**	Wildcat	**RC**	Chamois/goat
CAC	Roe Deer	**LE**	Hare	**RO**	Chamois/sheep
CAP	Capra	**LYP**	Lynx	**RUR**	Chamois
CAL	Wolf	**H**	Crocuta	**S**	Wild boar/pig
CEE	Red deer	**MEM**	Badger	**URA**	Bear
EQ	Equid	**LION**	Lion	**VUV**	Fox
EQC	Horse	**OVA**	Sheep		
ERE	Hedgehog	**PAP**	Leopard		
Fus. The state of fusion of the epiphysis is coded as follows:					
F	fused	**UE**	epiphysis unfused		

Carnivore mandibular teeth														
box	square		num	lay	spit	tax	per	**P₃** l	w	**P₄** l	w	**M₁** l	w	ramus Ht behind M₁	other msmnts

box	square		num	lay	spit	tax	per	P_3 l	w	P_4 l	w	M_1 l	w	ramus Ht behind M_1	other msmnts
912	Q12		215	Eb	E7	FES	Mag	56	28	74	32	84	36		l.P3-M1 = 208
39	K15	sc	156	Fb	F4 toca	LYP	Sol					136	55		
58	P11	sc	578	H	I2	LYP	Sol					139	61		
78	P11	sc	838	K	K4	PAP	Moust					209	102		
87	P11		865	K	corte	H	Moust	241	171	248	(165)	350	140		w.P2 = 121
53	O14		143	Fa	F1	MEM	Mag					(177)	86	203	
912	Q13	sc	237	Eb	E5	MEM	Mag					179	84		
57	P12		194	Fa	F6	MEM	Sol					181	85	202	
950	P11		714	Jb		URA	EUP					(279)	140		
904	Q14		11	Eb	E2	VUV	Neol					161	63		
63	N14		283	I	I2	VUV	Sol					176	66		

Equid mandibular teeth															
box	square		num	layer	spit	tax	per	tooth	L_1	L_2	L_3	W_a	W_b	W_c	W_d
41	P11		517	Fc	H2	EQ	Sol	P2	316	148	129	110	112	152	62
19	L15		223	Eb-base	E3 toca	EQC	Mag	M1/2	-	128	-	115	-	-	22
950	P11		608	Fc	17W	EQ	Sol	M1/2	251	128	70	147	75	114	20
950	P11		208	Fa		EQC	Sol	P3/4	281	174	96	164	161	143	38
950	O13		241	Fa	F6	EQC	Sol	M1/2	257	133	81	136	123	110	25
950	P11		783	K	K3	EQC	Moust	M1/2	248	160	60	149	151	143	33

Pig mandibular teeth													
box	square		num	layer	spit	per	dP_4 l	dP_4 w	M_1 l	M_1 wa	M_1 wb	$M_{1/2}$ l	$M_{1/2}$ wa	$M_{1/2}$ wb
904	O14		66	Ea	E1	Neol	208							
904	Q13		75	Ea	E3	Neol	183	88	164	95	108			
906	Q12		212	Eb	E7toca	Neo	-	84	165	95	106			
906	O10	sc	291	Eb	E7	Neol						216	128	138

| | | | | | | | | Teeth | | | | | | | | |
box	sq	num	layer	spit	per	tax	comp	dP$_4$l	dP$_4$w	M$_1$l	M$_1$wa	M$_2$l	M$_2$wa	M$_3$l	M$_3$wa	notes
30	K16	71	Eb-base	E2	Mag	CEE	dP4	260	115							ACH = 86 dP$_4$l = approx
17	L15 sc	240	Eb-base	E2toca	Mag	CEE	dP4	271	121							ACH = 101
25	M14 sc	248	Eb	11	Mag	CEE	M3							348	160	wa = approx ACH = 102
951	O12 sc	95	Eb	E4	Mag	ERE	M1			65	45					very large!
951	O10 sc	258	Eb	E9	Mag	ERE	M2					56	39			
58	O12	95	H	H2	Sol	CAP	M3							297	424	
48	N14 sc	199	Fa	F1toca	Sol	CEE	dP4		117							ACH = 95
48	N14	207	Fa	F3toca	Sol	CEE	dP4	281	127							ACH = 155
62	P12	553	I	H5	Sol	CEE	dP4	285	112							ACH = 143
41	P11	402	Fc	F9	Sol	CEE	M3								151	ACH = 149
57	P11	330	Fa	Corte	Sol	CEE	M3							298	136	ACH = 183
61	N14	300	I	I3toca	Sol	CEE	M3							348	152	ACH = 258
61	N14	269	I	I2	Sol	CEE	P4-M3							327	142	M$_3$ ACH = 216
43	M14 sc	355	Fa	F3toca	Sol	RCO	M3							199	76	
952	M14 sc	353	Fa-Fe	F3toca	Sol	RUR	M3							197	75	
45	M14 sc	487	Fa	F7toca	Sol	RUR?	M3							200	77	
82	P12	616	Jb	J5	EUP	CAP	M3							282	104	
70	O14	391	Ja	I3	EUP	CAP?	M3								97	length = c.290-300 ACH = 392 Wa = approx
85	P13	396	Jb	J5	EUP	CEE	dP3-M1	272	118							dP$_4$ ACH = 130
68	N14 sc	355	Ja	J2	EUP	CEE	dP4	279	132							
69	O14	399	Ja	J2	EUP	CEE	dP4	296	125							Wa = approx ACH = 161
71	P11	744	Ja	Corte	EUP	CEE	dP4		110							ACH = 136
82	P12	648	Jb	K1	EUP	CEE	dP4	274	114							ACH = 130
69	O14 sc	344	Ja	J1	EUP	RCO	M3							268	102	ACH = 306
69	O14	398	Ja	J1	EUP	RCO	M3							205	76	ACH = 248
950	P11	807	K	K4toca	Moust	CEE	dP3-M1	272								
78	P12	695	K	K4	Moust	CEE	M3							328	154	ACH = 93
79	P12	749	K	L2	Moust	CEE	M3							340	145	ACH = 261 length = approx
76	P13	485	K	K5	Moust	CEE	P2-M3							356	142	M$_3$ ACH = 235 M$_3$wa = approx
78	P11 sc	872	K	K5	Moust	RCO	M3							262	101	ACH = 372 M$_3$w = approx

| | | | | | | | | | Bones | | | | | | | | | | | | |
box	sq	num	layer	spit	per	bone	tax	fus	GL	Bd	Dd	BT	HTC	Ld	DLS	WCM	WCL	DEM	DEL	SLC	notes
903	R13	3	Ea	E2	Neol	AS	B			456											Bd = approx
904	O14 sc	110	Ea	E1	Neol	AS	FES		181												
907	O11	102	Eb	E6	Neol	AS	OVA?		288	173											juv
903	O10	67	Ea	E5toca	Neol	AS	OVA?		274	177	137										
904	L15 sc	136	Eb-topo E1		Neol	AS	S		286												v. juv GL = approx
907	Q12 sc	321	Eb	E6	Neol	CA	VUV	F	281												
903	Q15	3	Ea	E1	Neol	HU	B	F					338								
907	R12	44	Eb	E10	Neol	HU	LYP	F		313		182	89								
903	O10 sc	225	Ea	E2	Neol	MC2	RO	UE								124		114			
904	P14	39	Ea	E1	Neol	P3	S							308	320						
904	Q15	6	Ea	E2	Neol	P3	S							257	270						
904	P12	74	Ea	E1	Neol	TI	MEM	F		185											
911	P14	28	Ea	E1	Mag	AS	CAC		290		165										?juv
17	L15	187	Eb-base E2		Mag	AS	CAP?		354		185										
15	M17	71	Eb-topo E1toca		Mag	AS	CAP?		330		188										GL and Dd = approx
30	K16	108	Eb-base E2		Mag	AS	CEE		534	327	283										GL = approx
10	M15	109	Eb-topo E1		Mag	AS	CEE		530	336	280										
14	L14	54	Eb-base E2		Mag	AS	CEE		507	314	274										
31	L16	88	Eb-topo E2		Mag	AS	CEE		543	348	303										
912	P14	36	Ea	E1toca	Mag	AS	LYP		242												
14	L14	57	Eb-base E2		Mag	AS	LYP		254												
53	O14	201	Fa	F3	Mag	AS	LYP?		256												
910	P14	38	Ea	E1	Mag	AS	VUV		204												
905	Q11 sc	526	Eb	G	Mag	CA	LE	F	278												
910	P12 sc	664	Ea	E4	Mag	CA	LE	F	301												
912	O10 sc	319	Eb	E9	Mag	CA	LE	F	297												
64	N10 sc	160	Eb	E3	Mag	CA	LE	F	300												
12	O13 sc	187	Eb	E6	Mag	CA	LE	F	296												
17	L15 sc	212	Eb-base E2toca		Mag	CA	LYP	F	493												
12	O14	104	Eb	E4	Mag	CA	LYP	F	484												
912	Q12	209	Eb	E7	Mag	CA	MEM	F	317												
912	O11 sc	232	Eb	E4	Mag	CA	MEM	F	320												
17	L15	174	Eb-base E2toca		Mag	HU	CEE	F				467	271								BT = approx
12	O13 sc	212	Eb	E8	Mag	HU	FES	F				152	69								
910	P15 sc	97	Eb	E2	Mag	HU	LE	F		113			60								
910	P11 sc	700	Eb	1b	Mag	HU	LE	F		107			57								

Bones (cont.)

box	sq		num	layer	spit	per	bone	tax	fus	GL	Bd	Dd	BT	HTC	Ld	DLS	WCM	WCL	DEM	DEL	SLC	notes
0	M14	sc	432	Eb	11	Mag	HU	LYP	F		322		223	104								LYP as id in MNHN, Paris
17	L15		154	Eb-base	E2toca	Mag	HU	LYP	F		311		216	97								
912	Q14	sc	29	Eb	E3	Mag	HU	LYP	F				212	102								
23	M14		63	Eb	11	Mag	MC1	CEE?	F		333											Bd = approx Dd = c 230-240 badly abraded
912	O11	sc	78	Eb	E6	Mag	MP	PAP?	F		84											
32	L16		124	Eb-base	E3	Mag	MP1	EQ	F		442	366										
33	K17		67	Eb-base	E2	Mag	MP2	S	F		186											DV = 197
30	K16		65	Eb-base	E2toca	Mag	MP2	S	F		145											
14	L14	sc	130	Eb	E2	Mag	MT	LYP?	F	807	96											
22	N13		32	Eb-base	E2	Mag	MT1	CEE	F		375	274										Bd = approx
912	R12	sc	87	Eb	E8	Mag	P1	LYP?	F	233												
910	Q12		150	Ea	E2	Mag	P1	PAP?	F	320												
912	O11	sc	244	Eb	E9	Mag	P1	PAP?	F	259												
17	L15		159	Eb-base	E2toca	Mag	P3	CEE							447	484						
12	O14	sc	239	Eb	E6	Mag	P3	CEE							468	504						
19	L15		230	Eb-base	E3toca	Mag	P3	CEE							421	475						
19	L15		212	Eb-base	E3toca	Mag	P3	CEE							444	498						
1	N14		180	Eb-base	E2toca	Mag	P3	CEE							464							
19	L15	sc	269	Eb	E3toca	Mag	P3	CEE								447						
23	M14	sc	313	Eb	11	Mag	P3	CEE							399	453						
26	K15		26	E		Mag	P3	CEE							398	423						
26	M13	sc	84	Eb	11	Mag	P3	CEE								446						
25	M14		72	Eb	11	Mag	P3	CEE							393	453						
909	Q11	sc	81	Eb	E	Mag	P3	CEE							372	410						Ld & DLS = approx
7	M15	sc	224	Eb-base	E4toca	Mag	P3	S							290	294						Ld & DLS = approx
912	O11	sc	81	Eb	E6	Mag	RA	MEM	F	866												
1	N14		45	Eb-base	E2	Mag	TI	CEE	F		483											
17	L15	sc	220	Eb	E2toca	Mag	TI	LYP	F		234											
905	P11	sc	189	Eab	E	Mag	TI	MEM	F		226											
18	L15	sc	139	Eb-topo	E1	Mag	TI	RUR?	F		229											
56	L16		118	Fa	F1	Sol	AS	CAP?		323	208	181										CAP Bd = approx
58	P11		734	H	Corte	Sol	AS	CEE		543	312	293										
58	P11		537	H	I1	Sol	AS	CEE		577	354	312										Bd = approx
39	L15		307	Fb	F4	Sol	AS	CEE			293	293										
62	P12		479	I	F17	Sol	AS	CEE		529	321	286										

Bones (cont.)

box	sq	num	layer	spit	per	bone	tax	fus	GL	Bd	Dd	BT	HTC	Ld	DLS	WCM	WCL	DEM	DEL	SLC	notes
51	L17	132	Fa	F1	Sol	AS	CEE			318											
56	L16	176	Fa	F2	Sol	AS	CEE		527	316	280										
39	O12	59	Fb	F3	Sol	AS	FES		173												small cat
42	L15	318	Fc	F6	Sol	AS	LYP		279												
51	K16 sc	149	Fa	F4	Sol	AS	LYP		267												
56	L16	203	Fa		Sol	AS	LYP?		261												
41	P11	584	Fc	I6	Sol	AS	RUR?		363	222	193										Dd = approx. prob. RUR rather than CAP
45	M14 sc	473	Fa	F7toca	Sol	CA	CAP	F	718												Definite CAP
55	P14	123	Fa	F5	Sol	CA	MEM	F	334												GL = approx
47	L14	76	Fa	F1toca	Sol	HU	CAP	F				386	188								BT = approx
52	O13	236	Fa	F6	Sol	HU	EQ	F				586	291								BT = approx
48	N14 sc	220	Fa	F1toca	Sol	HU	LYP	F					100								
40	O14	344	Fc	F11	Sol	HU	LYP?	F		324		222	100								probable LYP
950	M14 sc	415	Fa	F3toca	Sol	HU	RC	F				293	152								
42	M14 sc	450	Fc	F7	Sol	MC1	CAP	F	1613	406	235				186	185	153	139			SD=235 DVM=235 DIM=195 DVL=226 DIL=190
51	M16	30	Fa	F2	Sol	MC1	CEE	F		406	276				176	172	201	198			
54	K15	62	Fa		Sol	MC1	CEE	F		394	265				179	176	192	186			DVM = 265 DVL = 265
54	N14	162	Fa	F1	Sol	MC1	EQ	F		416	354										Bd = approx
44	L14	78	Fa	F1toca	Sol	MC2	CAP	F							160		130				
44	L14	84	Fa	F1toca	Sol	MC2	CAP	F								156		125			Bd = c. 335 Dd = 215
42	N14	236	Fc	F8toca	Sol	MT1	CAP?	F		328	211										
56	L16	129	Fa	F1	Sol	MT1	CEE	F		423	270										
48	N14	94	Fa	Ftoca	Sol	MT1	CEE	F		480	304										
39	P14	142	Fb	F8	Sol	MT1	CEE	F		392	266										Bd = approx
54	K15	71	Fa		Sol	MT1	EQ	UE		452	355										
950	M14 sc	381	Fa	F3toca	Sol	P1	CAL?	F	364												Bp = 124
39	O13	288	Fb	F9	Sol	P1	LYP	F	315												
48	N14	203	Fa	F3toca	Sol	P1	LYP?	F	261												
0	P12 sc	431	Fc-H	F16	Sol	P1	LYP?	F	239												Bp = 76
55	M15 sc	260	Fa	F1	Sol	P1	LYP?	F	291												
52	O13	242	Fa	F6	Sol	P1	PAP?	F	311												Bp = 104 probably PAP
62	P11 sc	755	I	Corte	Sol	P3	CAP							290	400						
39	O13	267	Fb	F8	Sol	P3	CEE							472	503						
40	O13	311	Fc	F10	Sol	P3	CEE							485	483						

Bones (cont.)

box	sq	num	layer	spit	per	bone	tax	fus	GL	Bd	Dd	BT	HTC	Ld	DLS	WCM	WCL	DEM	DEL	SLC	notes
63	N14	262	I	I1	Sol	P3	CEE							358	395						
45	M14 sc	464	Fa	F7toca	Sol	P3	CEE							339	357						
48	N14	179	Fa	F2toca	Sol	P3	CEE							454	487						
59	P13	278	H	F10	Sol	P3	CEE							430	498						Ld & DLS = approx
951	P11	623	I	J3W	Sol	P3	CEE							433							SAMPLE 13
51	K16	172	Fa	F2	Sol	P3	CEE							392	423						
50	L15	263	Fa	F1	Sol	P3	CEE							406	426						
91	P13 sc	302	Fbc	F8	Sol	P3	CEE							399	466						
60	O14	381	H	H1	Sol	P3	CEE							452	486						
40	O13	310	Fc	F10	Sol	P3	CEE								472						
56	L16	197	Fa	F3	Sol	P3	CEE								502						
52	O13	255	Fa	F7	Sol	P3	CEE							434	483						
50	L15	309	Fa	F4	Sol	P3	CEE							336	356						
56	L16	142	Fa	F1	Sol	RA	EQ	F		754											BFd = 605
62	O12	110	I	I2	Sol	SC	LYP?	F												206	
63	O13	327	I	I2	Sol	TI	CAP	?		325											
58	P11	733	H	Corte	Sol	TI	CEE	F		476											Bd = approx
39	P14	154	Fb	F9	Sol	TI	CEE	F		453											
84	P14 sc	280	Jb	J9	EUP	AS	CAP		386	262	217										
84	P14	212	Jb	J7	EUP	AS	CEE		553	345	296										
70	O14	393	Ja	K1	EUP	HU	CEE	UE					272								
70	O13	331	Ja	I3	EUP	HU	RUR	F				302	154								
952	P12	643	Jb	J8	EUP	MC1	RUR	F	1573	277	167					125	125	106	104		SD = c.153
71	P12 sc	501	Ja	Corte	EUP	MP	CAL?	F		114	137										
950	P12	628	Jb	J6	EUP	MP	URA	F		170	178										probable URA
950	P11	705	Jb		EUP	MP	URA	F		158											Bd = approx
950	P11	666	Jb	J8E	EUP	MT1	URA	F	665												MT 1 SD = 106
950	O13	355	K	J6	EUP	P1	CAL?	F	393												Bp = 116
83	P14	204	Jb	J5	EUP	P1	FELID	F	263												Bp = 84 This must (via msmmts) be LYP
950	P11	715	Jb		EUP	P1	LION	F	308	178											left thumb phal 1 Bp=c.205 GL&Bd=approx
950	P11	776	Jb	K3	EUP	P1	URA	F	414												Bp = 179
950	P11	699	Jb		EUP	P1	URA	F	332												Bp = 171
68	N14 sc	358	Ja	J2	EUP	P2	CAL?	F	271												Bp = 106
83	P13 sc	408	Jb	J4	EUP	P3	CAC							267	265						

Bones (cont.)

box	sq	num	layer	spit	per	bone	tax	fus	GL	Bd	Dd	BT	HTC	Ld	DLS	WCM	WCL	DEM	DEL	SLC	notes
84P13		395	Jb	J5	EUP	P3	CAP								495						
69	O13 sc	322	Ja	J2	EUP	P3	CAP							300	436						
914	P12 SN		I-Ja	I2	EUP	P3	CEE							403	420						
82	P12	595	Jb	J4	EUP	P3	CEE							347	390						
70	P13	345	Ja	I3	EUP	P3	CEE?							424	455						
69	O13	350	Ja	Corte	EUP	P3	RUR?							252	326						Ld = approx
76	P13	433	K	K2	Moust	AS	CAP		356	245	198										
75	P11	866	K	Corte	Moust	AS	CAP		323	214	187										
74	P11	828	K	Corte	Moust	AS	CAP		372	235	196										
79	P12	721	K	K7	Moust	AS	CEE		547	331	297										
950	P11	773	K	K3	Moust	AS	LYP		243												?Articulates with CA in P11 757
75	P11 sc	957	K	Corte	Moust	AS	VUV		210												
74	P11	784	K	K3	Moust	CA	CEE	F	1154												?Articulates with AS in P11 773
950	P11	757	K	K3	Moust	CA	LYP	F	457												
86	P11	842	M	M1	Moust	HU	CAC	F					157								BT = c. 250
74	P12	697	K	K4toca	Moust	HU	CAP	F				423	187								
81	P13	418	K	J7	Moust	HU	EQ	F					361								HT = 471 HTC = approx
79	O14 sc	399	K	K1	Moust	MP1	EQ	UE		442	354										
950	P12	708	K	K6	Moust	P1	CAL?	F	396												Bp = 116
950	P11	789	K	K3	Moust	P1	CAL?	F	382												Bp = 122 felid? URA?
79	P12	704	K	K5	Moust	P1	EQ	UM		394											probable EQC SD=284
950	P11 SN	751	Jb/K	K1E	Moust	P1	LYP	F	246												Bp = 86
950	P11	751	K	Corte	Moust	P1	LYP	F	292												Bp = 89
950	P11	755	K	K3	Moust	P1	URA	F	356												Bp = 158
74	P11 sc	875	K	K5	Moust	P3	CAP?							276	383						Both msmnts are approx
79	P12	723	K	K7	Moust	P3	CEE							425	432						
79	O13 sc	331	K	K1	Moust	P3	CEE							360	403						?juvenile
79	O14 sc	393	K	I3	Moust	P3	CEE							361	393						?juvenile
81	O14	423	K	J6	Moust	P3	CEE							427	428						
72	P12	696	K	K4	Moust	P3	CEE							410	455						
0	P11	764	K		Moust	P3	CEE							432	459						
72	P12	649	K	K1	Moust	TI	CEE	UE		407											
950	P12 SN	518	I-Ja	I1	Sol/EUP	P1	LYP	F	289												
0	P12 sc	518	HIJ	H5	Sol/EUP	P3	CAP							328	455						Bp = 89

Appendix B

Measurements in millimetres of the coprolites from Caldeirão, arranged by period.

box	square	num	spit	per	length	width
41	P12	449	F16	Sol	-	19,0
36	P11	360	F6	Sol	-	18,2
72	P11	sc893	K5	Moust	-	21,1
86	P11	sc907	M1-17	Moust	45,7	35,5
"	"	"	"	Moust	-	38,5
"	"	"	"	Moust	-	52,1
"	"	"	"	Moust	-	46,9
"	"	"	"	Moust	51,1	33,2
"	"	"	"	Moust		43,8
"	"	"	"	Moust	-	36,1
"	"	"	"	Moust	-	42,0
"	"	"	"	Moust	-	42,2
"	"	"	"	Moust	49,0	39,5
"	"	"	"	Moust	-	43,0
"	"	"	"	Moust	-	44,0
"	"	"	"	Moust	32,9	40,6
87	P12	sc727	L2	Moust	33,6	29,1
"	P11	sc899	L2	Moust	-	45,8
"	P11	sc899	L2	Moust	29,5	44,4
"	P11	sc896	L1	Moust	34,3	43,8
"	P12	sc736	L4	Moust	33,0	38,4
"	P12	sc736	L4	Moust	28,8	43,8

Apendix C

Age-at-death of the artiodactyls at Caldeirão.
Mandibular tooth wear stages arranged by period and taxon.

Columns provide the following information: Box, Square (sq), whether with or without field coordinates, number (num), layer, spit, period (per, coded as for the measurements section of the appendix), taxon (tax, coded as for the measurements section of the appendix), the teeth present in the mandible or as an isolated tooth (comp), then follow the dental eruption and wear data. Eruption and wear stages for the "RCO" group (*Rupicapra*, *Capra* and *Ovis*) follow Payne (1987). *Sus* and *Bos* teeth are assigned to the eruption and wear stages of Grant (1982). "ACH" is the anatomical crown height measured up the buccal side of the central pillar from the crown/root junction to the occlusal surface of the goat/chamois/sheep third molars. For "ACH" measurements (in tenths of a millimetre) of the red deer dP_4s and M_3s, see the appendix table of tooth measurements. "P" = present.

box	sq		num	layer	spit	per	tax	comp	dP_4	P_4	M_1	M_2	M_3	$M_{1/2}$	notes
903	O10		55	Ea	E3	Neol	B	$M_{1/2}$						b	
903	R13		6	Ea	E2	Neol	B	$M_{1/2}$						b	
903	Q13	sc	201	Ea	D3	Neol	RCO	$M_{1/2}$						9	
904	O14		51	Ea	E1	Neol	S	dP_3-dP_4	b						
904	O14		66	Ea	E1	Neol	S	dP_4	e						
904	Q13		75	Ea	E3	Neol	S	dP_4-M_1	f		c				
906	Q12		212	Eb	E7toca	Neol	S	dP_4-M_2	e		a	U			
906	O10	sc	291	Eb	E7	Neol	S	$M_{1/2}$						a	
53	O14		207	Fa	F3toca	Mag	B	M_3					P		wear stage = k/l/m
914	P11	SN		H-Ja	I8	Sol	CAP	$M_{1/2}$						9	
952	M14	sc	490	Fa-Fe	F7toca	Sol	CAP	$M_{1/2}$						9	
952	M14	sc	362	Fa-Fe	F3toca	Sol	CAP	$M_{1/2}$						9	
952	M14	sc	490	Fa-Fe	7toca	Sol	CAP	$M_{1/2}$						9	
952	M14	sc	362	Fa-Fe	F3toca	Sol	CAP	$M_{1/2}$						9	
58	O12		95	H	H2	Sol	CAP	M_3					9		
43	M14	sc	357	Fa	F3toca	Sol	RCO	$M_{1/2}$						9	
39	M15	sc	318	Fb	F5	Sol	RCO	$M_{1/2}$						9	
43	M14	sc	355	Fa	F3toca	Sol	RCO	M_3					11		
950	M14	sc	411	Fa	F3toca	Sol	RCO	P_2-P_4		0					just erupted
950	M14	sc	411	Fa	F3toca	Sol	RCO	P_2-P_4		0					just erupted
952	M14	sc	363	Fa-Fe	F3toca	Sol	RUR	$M_{1/2}$						9	
952	M14	sc	363	Fa-Fe	F3toca	Sol	RUR	$M_{1/2}$						9	
950	N14		302	I	I3	Sol	RUR	M_1-M_3			10	9	11		
950	N14		302	I	I3	Sol	RUR	M_1-M_3			10	9	11		
952	M14	sc	353	Fa-Fe	F3toca	Sol	RUR	M_3					0		probably erupting
952	M14	sc	353	Fa-Fe	F3toca	Sol	RUR	M_3					0		probably erupting
45	M14	sc	487	Fa	F7toca	Sol	RUR?	M_3					11		
82	P12		616	Jb	J5	EUP	CAP	M_3					11		
85	P12		382	Jb	J5	EUP	CAP	P_3-M_3		12	12	9	10		
39	P11		672	Ja	J8W	EUP	CAP	P_4		12					
68	N14		344	Ja	J2	EUP	CAP?	$M_{1/2}$						6	prob CAP given its large size
70	O14		391	Ja	I3	EUP	CAP?	M_3					8?		ACH = 392
85	P12		656	Jb	K2	EUP	CAP?	P_4		12					CAP or RUR
69	O13		338	Ja	J1	EUP	RCO	$M_{1/2}$						9	
69	O14	sc	344	Ja	J1	EUP	RCO	M_3					10		ACH = 306
69	O14		398	Ja	J1	EUP	RCO	M_3					10		ACH = 248
70	O13		333	Ja	I3	EUP	RCO	P_4		12					
69	O13	sc	302	Ja	J1	EUP	RCO	P_4		9					
950	P12		651	K	K1	Moust	CAP?	$M_{1/2}$						9	
78	P11	sc	872	K	K5	Moust	RCO	M_3					8		ACH = 372
79	P12	sc	739	K	Corte	Moust	RCO	P_4		14					
75	P11		859	K	Corte	Moust	RUR	dP_2-dP_4	11						
950	P12		747	L	L1	Moust	S	P_4		b					

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