Humans and Hyenas in the Middle Paleolithic of Gruta da Oliveira (Almonda karstic system, Torres Novas, Portugal)

JOÃO ZILHÃO

Resumen

En el periodo entre ~42500 y ~50000 años de calendario antes del presente, representado en la arqueoestratigrafía de Gruta da Oliveira por los niveles 9-14, las ocupaciones del Paleolítico Medio se situaron en un área por detrás de un bloque de más de 20 toneladas desplomado en la entrada de la cueva. En este área también había coprolitos de hiena, especialmente en los niveles 10-13, en los que puntos específicos del espacio fueron utilizados como letrinas de forma recurrente, y pequeños fragmentos de coprolitos degradados y hueso digerido se encuentran de forma generalizada en las láminas delgadas micromorfológicas. El polen de los coprolitos indica que las hienas ocuparon la cueva en épocas donde el paisaje exterior correspondía a un bosque templado, mientras que en el carbón domina el pino silvestre, un indicador de clima frío. Estos resultados sugieren una utilización alternada de la cueva, a donde las hienas vendrían en periodos interestadiales a carroñear huesos acumulados por el hombre en la fase fría precedente. La escasez de restos óseos de hienas y la inexistencia de restos de hiénidos juveniles indican que el sitio no se ha utilizado como cubil.

Palabras clave: Hiena, Coprolito, Neandertal, Paleolítico Medio, Portugal.

Abstract

In the period between ~42500 and ~50000 calendar years ago, represented in the Gruta da Oliveira archeostratigraphy by layers 9-14, Middle Paleolithic humans took shelter in an area of the site located behind a >20 ton boulder fallen at the entrance. Hyena coprolites were also recovered in this area, especially in layers 10-13, where specific spots were recurrently used as latrines, and small fragments of degraded coprolites and digested bone are ubiquitous in micromorphological thin sections. The pollen in the coprolites suggests that hyenas used the site at times when a temperate forest developed outside, while the charcoal, dominated by Scots pine, gives a cold climate signal. Combined, these data suggest a pattern of alternating use of the cave, with interstadial hyena scavenging of bones accumulated by humans during preceding stadials. However, the near-absence of skeletal remains and the lack of juveniles indicate that the site never functioned as a hyena den.

Keywords*: Hyena, Coprolite, Neandertal, Middle Paleolithic, Portugal.*

Humans and Hyenas in the Middle Paleolithic of Gruta da Oliveira (Almonda karstic system, Torres Novas, Portugal)

João Zilhão[1], Diego E. Angelucci[2], Jacqueline Argant[3], Jean-Philip Brugal[4], José S. Carrión[5], Rui Carvalho[6], Noemi Fuentes[7] & Mariana Nabais[8]

The site

The Gruta da Oliveira (39° 30' 23" N; 008° 36' 49" W; elevation ~115 m) is one of the collapsed cave entrances located in the escarpment rising above the karstic spring of the Almonda River, a tributary of the Tagus (Fig. 1). Under excavation since 1989, it contains a Middle Paleolithic archeostratigraphy already recognized over a thickness of >6 m, spanning the interval between ~35000 (calibrated ^{14}C; Weninger *et alii*, 2007; Weninger and Jöris, 2008) and ~70000 (U-Th) BP (Zilhão *et alii*, 1991, 1993; Zilhão and Mckinney, 1995; Zilhão, 2000, 2006; Marks *et alii*, 2001; Angelucci and Zilhão, 2009). The base of the sequence (the Mousterian Cone) is ~2 m beyond the present bottom of the excavation, which, in a 2006 test trench, reached the base of layer 19.

A major unconformity separates the surface of layer 19 from the overlying sequence. Above the unconformity, layers 15-18 (~50-60 ka BP) formed primarily through run-off, with slope processes leading to the syn- or post-depositional redeposition in the Access Corridor of material originally accumulated at the extant cave mouth (now the "Exterior" area; Fig. 2). After the deposition of layer 15, the collapse of the porch's roof obstructed the gallery, separating the henceforth exposed Exterior from the inner cave space located behind the fallen boulders. Layers 9-14 (~40-50 ka BP) accumulated in the depression between those boulders and the cave wall at the back, extending into the "Side Passage" and the "27-S Chamber". A direct link with the outside was re-established with the build-up of layer 8 (~38-35 ka cal BP), at which time the interior had become too shallow for humans, who then settled the "rockshelter" space atop and outward of the buried boulders. The sequence was capped by a thick flowstone formed over layer 7, which eventually became sealed under variably indurated colmatation deposits that completely filled the cave outward from row 18 of the grid.

Over time, these changes in the spatial configuration of the site caused correlative changes in the type, intensity and emplacement of human activities, with implications for the mode of accumulation of the animal bones. The graph in Fig. 3 illustrates this process using a lithics:bones ratio. The low values of the index in layers 15-19 reflect the position of the excavated area (marginal to the extant human habitat), while the peak values reached in layers 13-14 reflect the *in situ* character of the occupation remains, further confirmed by the preservation of a clear hearth feature in layer 14base (Angelucci and Zilhão, 2009) (Fig. 4A). In

1. Department of Archaeology and Anthropology, University of Bristol, 43 Woodland Road, Bristol BS8 1UU, United Kingdom
Joao.Zilhao@bristol.ac.uk
2. Laboratorio di Preistoria B. Bagolini, Dipartimento di Filosofia, Storia e Beni Culturali, Università degli Studi di Trento, Piazza Venezia 41, 38122 Trento, Italy
diego.angelucci@unitn.it
3. UMR 6636 du CNRS, Maison Méditerranéenne des Sciences de l'Homme BP 647, 5 rue du Château de l'Horloge, 13094 Aix-en-Provence Cedex 2, France
j.argant@wanadoo.fr
4. UMR 6636 du CNRS, Maison Méditerranéenne des Sciences de l'Homme BP 647, 5 rue du Château de l'Horloge, 13094 Aix-en-Provence Cedex 2, France & UNIARQ, Centro de Arqueologia da Universidade de Lisboa, Faculdade de Letras, Campo Grande, 1699 Lisboa Codex, Portugal
brugal@mmsh.univ-aix.fr
5. Departamento de Biología Vegetal, Facultad de Biología, Universidad de Murcia, Campus Universitario de Espinardo, 30100 Murcia, Spain
carrion@um.es
6. Centro de Arqueologia da Universidade de Lisboa, Faculdade de Letras, Campo Grande, 1699 Lisboa Codex, Portugal
ruivcarvalho@yahoo.com
7. Departamento de Biología Vegetal, Facultad de Biología, Universidad de Murcia, Campus Universitario de Espinardo, 30100 Murcia, Spain
e-mail: nfuentes@um.es
8. Centro de Arqueologia da Universidade de Lisboa, Faculdade de Letras, Campo Grande, 1699 Lisboa Codex, Portugal
mariananabais@hotmail.com

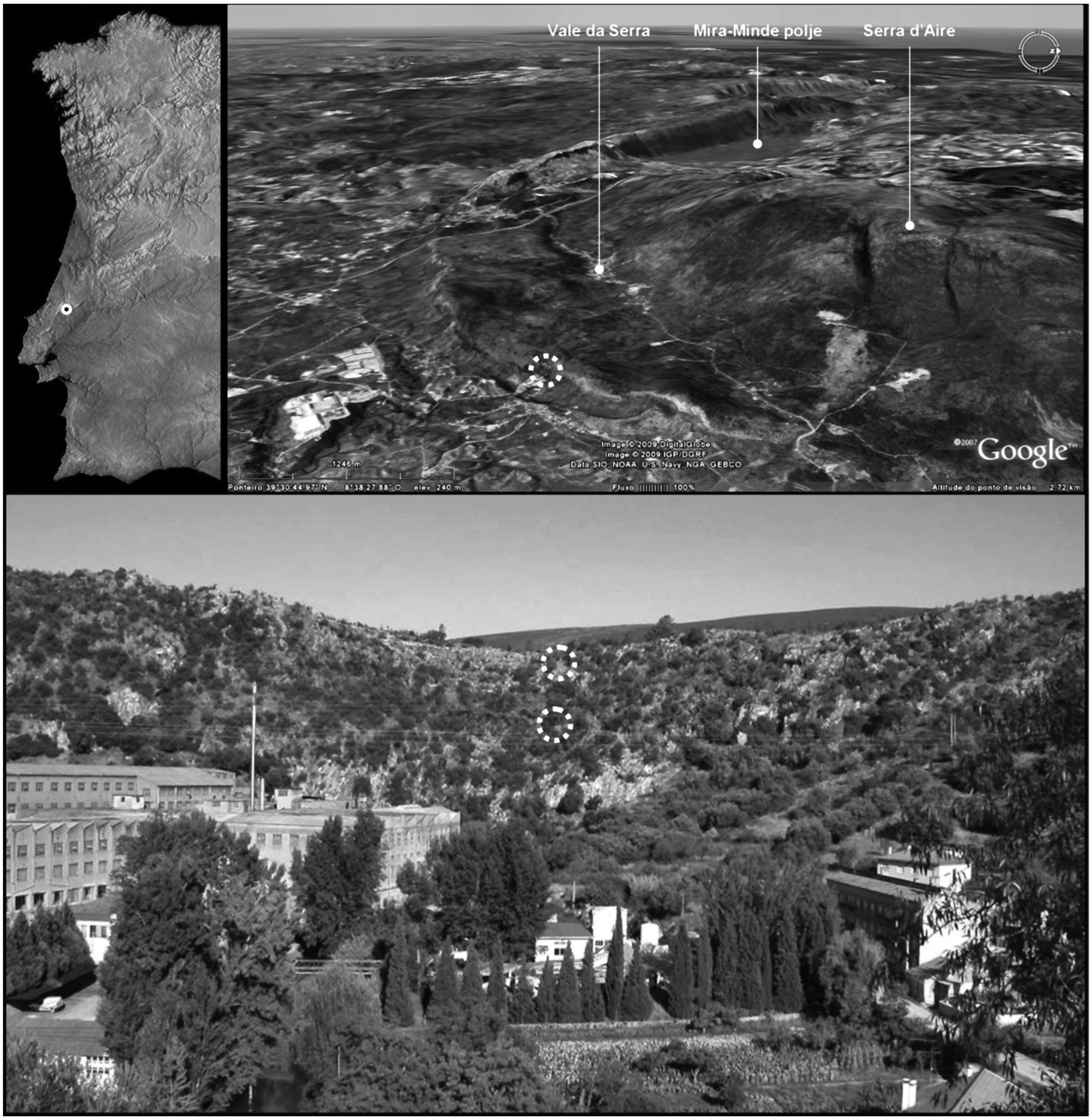

Fig. 1. Top left: location of the Gruta da Oliveira in western Iberia. Top right: the Almonda escarpment in the southern edge of the Estremadura Limestone Massif (elevation 1.5x). Bottom: the Almonda escarpment from the South; the circles indicate the Gruta da Aroeira/Galerias Pesadas (top) and the Gruta da Oliveira (middle).

layer 8 (layer 7 contained virtually no lithics), the index is down to values identical to those for layers 15-19, in this case reflecting the ephemeral, low intensity use of the space available at a time when, as a result of the fill-up of the cave interior, the site provided very little in the way of shelter.

During the accumulation of layers 9-13bis, humans continued to occupy the interior area behind the collapsed boulders but, because of the progressively more restricted space available, these occupations were less intensive than at the time of layers 13-14. The change is well apparent in Fig. 3: above layer 13, none of the layers represents >9% of the overall stone tool inventory, as opposed to 29% for layer 14 and 20% for layer 13. Why the trend is not apparent in the lithics:bones ratio, which shows only a very slight decrease across the transition from layer 13 to layer 10, relates to the higher attrition rates pertaining in layers 9-13bis. As apparent in the macroscopic observation of stratigraphic profiles and décapage surfaces, and confirmed in micromorphological thin sections, small fragments of bone are ubiquitous in the Oliveira deposits, but degraded coprolites, digested bone and fragments of amorphous phosphate resulting from the decay of bone are most abundant in layers 9-13bis, especially in the area of the O-R/17-19 grid units. Thus, in these layers, as a result of the differential loss of bone, the lithics:bones ratio overestimates the original weight of the artifactual component.

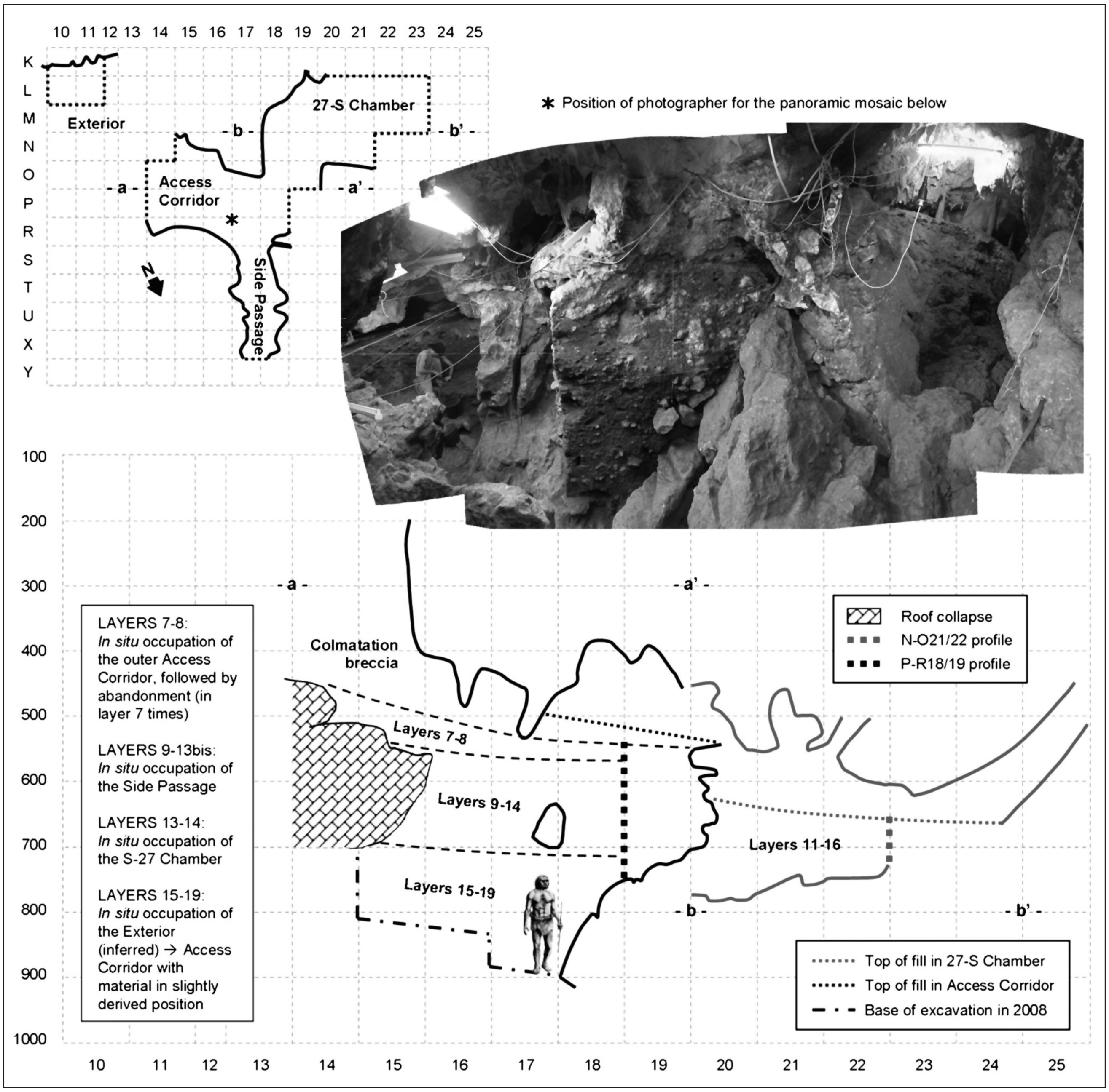

Fig. 2. Gruta da Oliveira. Top left: excavation grid and designation of the different areas. Top right: interior view (2006 field season) over the P-R18/19 profile (center), the 27-S Chamber (left) and the Side Passage (right). Bottom: schematic profile with indication of the main stratigraphic blocks.

The spatial distribution patterns in layers 9-13bis are consistent with higher attrition rates. The comparison of the plots in Figs. 4B and 4C shows that, as the 27-S Chamber filled-up, human occupation moved outward and, by layer 11 times, concentrated in the Side Passage and the back end of the Access Corridor, with a peripheral scatter extending into rows 18-20 of the 27-S Chamber. Given the constraints imposed by the surrounding topography, this peripheral scatter must be post-depositional. Its relation to the layer 11 occupations—*i.e.*, the proof that it relates to horizontal displacements across the entire site, not to post-depositional upward migration of material from underlying layers 13-14—is given by lithic refits such as those plotted in Fig. 4D.

The faunal assemblage

Preliminary counts of the Gruta da Oliveira fauna are available for layers 7-13, spanning the latest three periods of the history of the site as discussed above (Table 1). Red deer is always the most abundant taxon, while ibex, horse and rhino, whose presence is residual in layers 7-10, become more important towards the bottom. Carnivores are represented, including large ones (hyena, bear, wolf, lion), and their taxonomic diversity (eight species) is in fact higher than that of the ungulates (six species). The presence of carnivore remains, including hyena coprolites, thus raises the question of who accumulated the Oliveira bones: humans, carnivores, or both in different (which?) proportions?

In order to address this question, we considered a number of the criteria originally put forth by Klein and Cruz-Uribe (1984) (Table 2). Large carnivores comprise only 4% of the assemblage NISP, which brings the Oliveira fauna in line with the primarily human-accumulated animal bones from the Solutrean levels of the reference sequence of Gruta do Caldeirão (Davis, 2002; Davis *et alii*, 2007). Most bear remains come from layers 7-11, and may reflect hibernation deaths in post-layer 11 times, when human occupation became ever more ephemeral, as indicated by the sharp decrease in the lithics:bones ratio. Except for the bear, the carnivore remains do not include juveniles, which is especially significant for the interpretation of the role of the major bone-accumulator carnivore in the sample, the hyena. As dens are defined as a centre of social attraction for a hyenid clan where cubs are also provisioned and protected (Mills, 1983; Cooper, 1993), this absence suggests that the site was not a hyena den, at least not in the excavated areas. Denning further inside cannot be excluded, but no carnivore bones were visible on the exposed Pleistocene surface of

TAXA (a)	LAYERS							TOTAL NISP	% NISP
	7	8	9	10	11	12+13bis	13		
Cervus	++	++	++	++	++	++	++	643	51
Capra			+	+	+	+	++	227	18
Equus		(+)	(+)	+	+	+	+	65	5
Bos					+		+	4	0
Dicerorhinus		(+)	(+)	+	+	+	+	88	7
Sus		+					+	2	0
Crocuta					+	+		2	0
Ursus	+	+	+	+	+	+	+	29	2
Canis			+		+	+	+	12	1
Vulpes	+	+	+	+	+	+	+	24	2
Lynx	+	+	+	+	+		+	24	2
Felis	+							9	1
Panthera sp.							+	1	0
Martes		+						1	0
Testudo	+	+	+	+	+	+	+	128	10
Castor							+	3	0
GRAND TOTALS									
NISP (b)	66	68	145	100	290	181	572	1422	
NR (b)	227	466	1088	864	1788	1534	4154	10,121	

(a) Preliminary counts (January 2009); ++ abundant; + present; (+) uncertain presence (enamel fragment).
(b) Includes coprolites.

Table 1. Gruta da Oliveira animal bones.

TAPHONOMIC PARAMETER	CALDEIRÃO (a)			OLIVEIRA (b)
	K-P (Mousterian)	Ja-Jb (EUP)	Fa-I (Solutrean)	7-13 (Mousterian)
Large carnivores (% of NISP)	10%	14%	3%	4%
Cutmarked:gnawed (ratio)	0.33	0.00	0.57	0.30
Juveniles of red deer (% of species' bones)	68%	69%	32%	More juveniles than adults
Juveniles of horse (% of species' bones)	88%	100%	50%	Young adults mainly

(a) After Davis (2002): "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".
(b) At Oliveira, extensive carbonate coating prevents accurate assessment of bone surfaces and, consequently, the cutmarked:gnawed ratio may be a gross approximation only.

Table 2. Gruta da Oliveira vs. Gruta do Caldeirão. Taphonomic indicators of the identity of the bone accumulators

the fill of the labyrinthic network of galleries surveyed over hundreds of meters beyond the collapsed cave entrance.

The cutmarked: gnawed ratio is in line with the values for the Caldeirão Mousterian, where the faunal remains are primarily carnivore-accumulated. However, the extensive carbonate coating of the Oliveira remains discriminates against the recognition of the fainter human-inflicted marks,

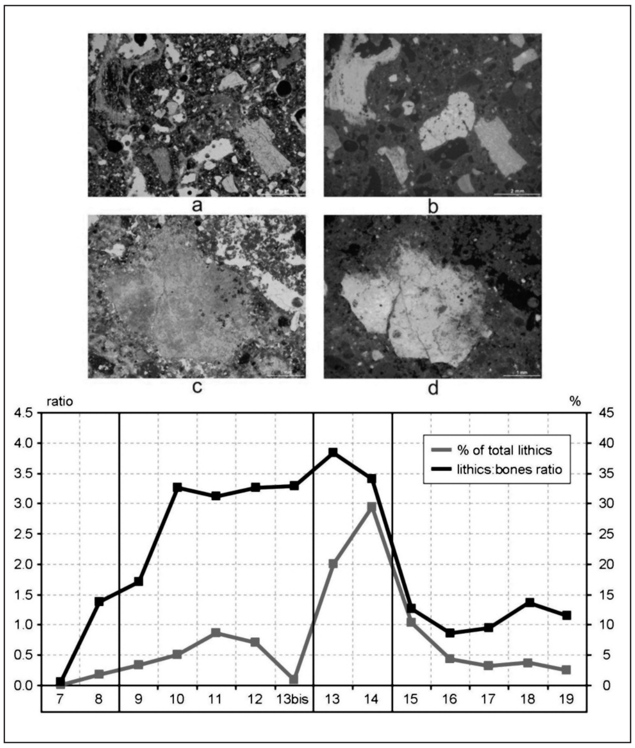

Fig. 3. Gruta da Oliveira. Top: micromorphological thin sections (a) groundmass of unit 13 (note the large quantity of bone fragments, some of them affected by alteration, post-depositional phosphatization and displacement—a "rolling pedofeatures" is visible around the bone fragment at bottom centre), plane-polarized light; (b) same but fluorescence blue wideband (blue-violet); (c) fragment of amorphous phosphate from unit 11, plane-polarized light; (d) same but fluorescence blue wideband (blue-violet). Bottom: stratigraphic variation of the lithics:bones ratio and of the relative weight of each layer in the overall stone tool inventory (piece-plotted items only).

so this index is difficult to interpret (and all the more so as carnivore ravaging of human-accumulated bone assemblages can result in carnivore marks outnumbering anthropogenic ones anyway). In the percentage of ungulate juveniles, Oliveira is again closer to the pattern seen in the Caldeirão human-accumulated faunas, especially where horse is concerned, as remains of this species are mainly of young adults, while, in the carnivore-accumulated EUP and Mousterian faunas from Caldeirão, 100% and 88%, respectively, of the horses, are juvenile.

A primary role for humans in the accumulation of the Oliveira fauna is consistent with the abundance of burnt bone (Fig. 5), especially in layer 14, where its distribution clusters around the hearth excavated in grid units L-M/20-22 (Fig. 4A) (Nabais, 2008). In the layers under consideration here, both the burning stage (mostly brown and black bones) and the ranges of species and skeletal parts represented suggest use as fuel, with accidental burning of minor bones that were natural components of the deposit (e.g., bats and rodents). In earlier periods (layers 15-19), burned-white, cremated fragments of tortoise shell are frequent, and often occur in tightly clustered concentrations, suggesting that the animals were roasted whole, in the shell, directly over a fire (*e.g.* Speth and Tchernov, 2002.).

The only skeletal remains of hyenas are two worn teeth found in adjacent layers and probably coming from a single, aged individual (Table 3; Fig. 6). This is also consistent with the notion that humans, not carnivores, were primarily responsible for the accumulation of the Oliveira fauna. However, although virtually absent further down in the stratigraphy (five in layer 14, six in layer 15, one in layer 16), coprolites were abundant in layers 8-13 and, in proportion to the total number of remains, with little inter-layer variation. In size, the Oliveira coprolites are identical to those from the Mousterian of Caldeirão, where they have been assigned to *Crocuta crocuta* on the basis of their association with a diagnostic mandible (Davis, 2002, this volume;

LAYERS	7	8	9	10	11	12+13bis	13
Teeth (a)	–	–	–	–	1	1	–
Coprolites (b)	–	13	10	14	33	27	55
Coprolite : NR ratio	0.000	0.028	0.009	0.016	0.022	0.018	0.013

(a) T17-130 (layer 11), mesial lobe of lower right P2, and P17-91 (layer 12), upper right P3; probably from a single old individual.

(b) Includes fragments.

Table 3. Gruta da Oliveira. The hyena remains.

Brugal, this volume). This species was thus involved in the Oliveira story throughout. But in which capacity?

The role of hyenas

When evidence of the activity of humans and large carnivores coexists in any given deposit, it is clear that we are dealing with palimpsests generated by an alternating pattern of site use. The question that needs to be addressed is therefore one of wavelength. Did the alternation occur at the scale of the season, the year, the decade, or the epoch, and was it determined by patterns of cyclicity in human settlement-subsistence

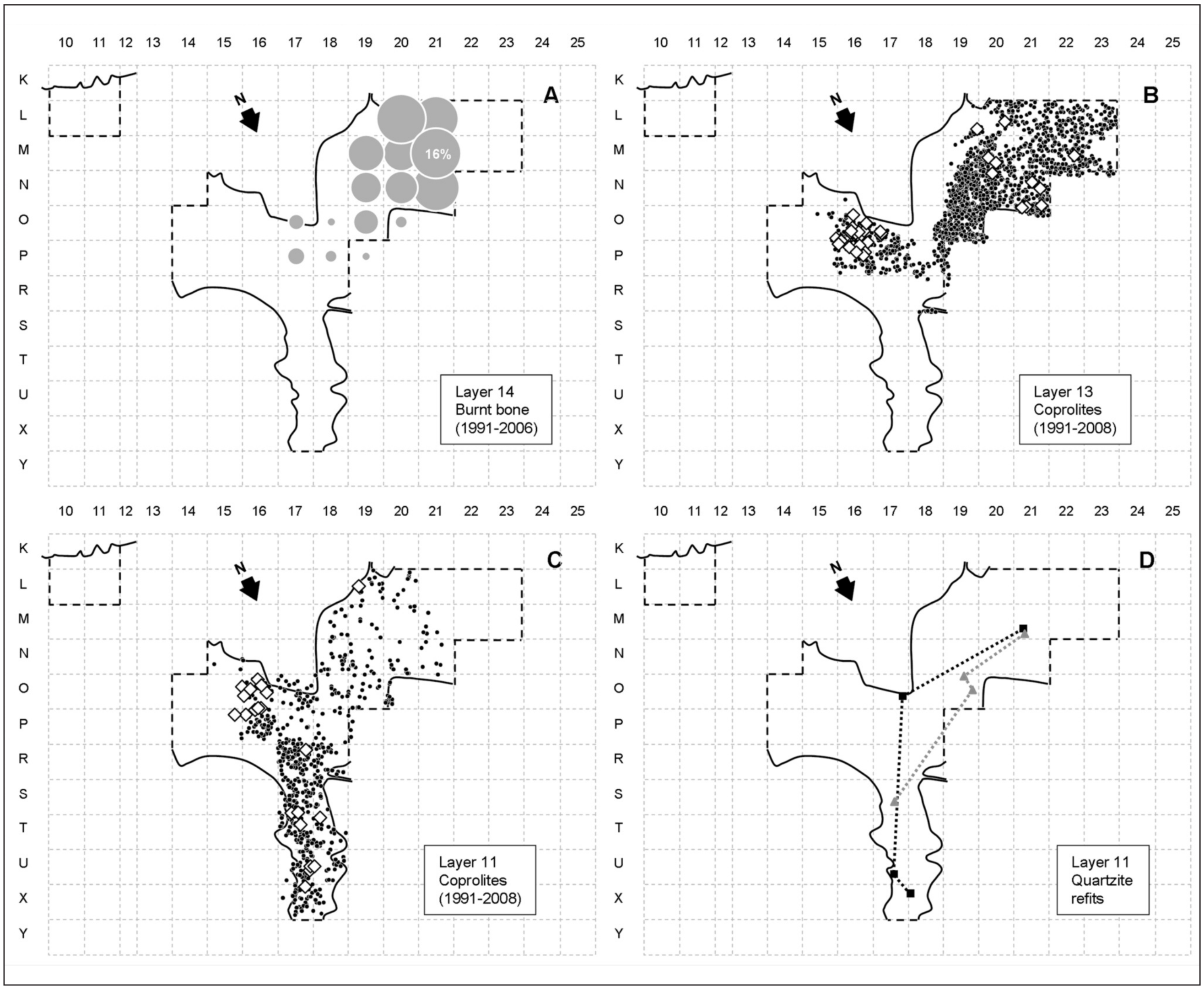

Fig. 4. Gruta da Oliveira distributions. A. Layer 14 burnt bones (percentage per square, both piece-plotted and sieved) up to the end of the 2006 field season. B. Layer 13 piece-plotted coprolites (white diamonds) and lithics (black dots). C. Layer 11 piece-plotted coprolites (white diamonds) and lithics (black dots). D. Horizontal dispersion of two layer 11 refits (grey triangles, refit 84; black squares, refit 141).

systems, or by patterns of long term climatic and environmental change?

The results reported in Table 4 provide some answers. Whenever the deposits contained determinable charcoal, the species found were invariably *Pinus sylvestris* and *Erica arborea*, reflecting a pattern of immediate availability of wood indicative of a landscape of open Scots pine and heathland that, in the Upper Pleistocene of Portugal, is typical of the cold phases, namely the LGM (Queiroz *et alii*, 2002; Queiroz, 2005). Conversely, in the few instances where the analyzed coprolites contained pollen, mesothermophile taxa indicative of a temperate climate (*e.g.*, deciduous and evergreen *Quercus*, *Corylus, Alnus, Tilia, Betula, Salix, Fagus, Ulmus, Myrica, Buxus*) were always found; and, in the more complete samples, *Quercus suber* and *Olea* were also identified, while *Ericaceae*, although present, were residual (0.2% in layer 9, 0.9% in layer 11). Although issues of taphonomy and selection mean that these spectra are biased and distant reflections of the past landscapes to which they refer, the sharpness of the contrast nonetheless implies that different environments are represented in the samples.

The evidence from layer 14, the only stratigraphic unit where information could be gleaned from both types of archives, shows that the contrast between coprolite pollen and wood charcoal does not simply reflect changing condi-

LAYER	POLLEN IN COPROLITES				WOOD CHARCOAL IN SEDIMENTS (a)
	Taxa >1%	%	# of taxa	Pollen count	
9 (U18, spit A6) (b)	*Pinus,*	29.2	29	655	–
	Juniperus	1.3			
	Quercus ind.	15.2			
	Quercus evergreen	3.7			
	Quercus deciduous	20.5			
	Corylus avellana	4.5			
	Alnus glutinosa	9.8			
	Poaceae	2.5			
10	–	–	–	–	*Pinus sylvestris*
11 (U17-58, spit A4) (b)	*Pinus*	15.7	14	302	–
	Quercus ind.	23.5			
	Quercus evergreen	6.5			
	Quercus deciduous	33.6			
	Corylus avellana	2.8			
	Fagus sylvatica	2.8			
	Betula	3.2			
	Ranunculaceae	1.4			
	Plantago	1.4			
12	–	–	–	–	*Pinus* sp.
13	–	–	–	–	*Pinus sylvestris* *Erica* cf. *E. arborea*
14 (O17-155, spit A14) (c)	*Pinus* *Quercus* *Corylus* *Tilia*	–	4	6	*Pinus sylvestris* *Pinus* sp.
15	–	–	–	–	*Pinus sylvestris*
16	–	–	–	–	*Pinus sylvestris*

(a) After Queiroz, 2005.
(b) Pollen analysis by JSC and NF (only these out of 55 samples analyzed were fertile).
(c) Pollen analysis by JA.

Table 4. Gruta da Oliveira. Paleobotanical evidence.

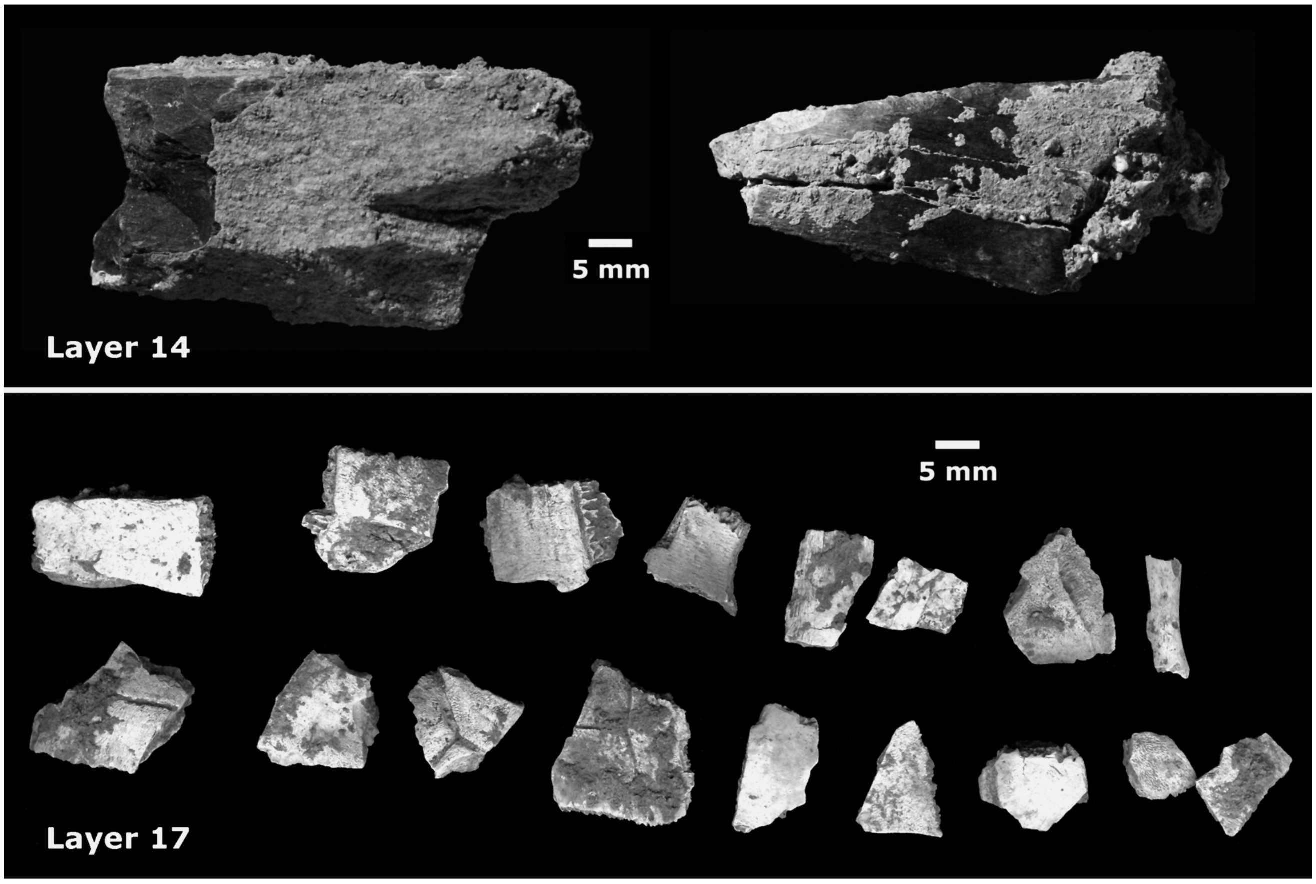

Fig. 5. Gruta da Oliveira burnt bones. Top: burned-to-black ungulate shaft fragments from layer 14. Bottom: cremated-to-white tortoise shell fragments from layer 17.

tions from one layer to the other. One possibility is that the two kinds of landscapes (the closed, humid-subhumid oak and pine woodland indicated by the pollen, and the open, cold oceanic pine and heathland indicated by the charcoal) existed in the immediate vicinity of the cave, and that the contrast relates to human choices in the provisioning of fuel, dictated by the functional requirements of the hearths lit in the cave. More likely, the pattern reflects instead the fact that each of the recognized stratigraphic units contains remains accumulated over the duration of an entire Dansgaard/Oeschger cycle (~2500 years). In the stadial phases of the successive cycles, humans used the cave as shelter, discarding animal bones and stone tools that became buried as sediments accumulated inside as a result of the erosion of the largely denudated surrounding slopes. In the interstadial phases, climate ameliorated, tree cover expanded and the mesothermophile tree taxa returned, fixing soils and originating sedimentation hiatuses during which the previously accumulated deposits became variably covered by thin stalagmitic crusts and were disturbed and intruded as a result of the activity of new users of the now human-abandoned cave.

Under this model, the hyenas were, primarily, interstadial scavengers of the bone abandoned in the cave in the framework of human occupations that took place during the preceding stadial, although we cannot exclude that they also introduced bones to some extent. The distribution of coprolites (Figs. 4B-4C) in layers 11 and 13 suggests that, throughout the interval of alternation, hyenas maintained a certain regularity in their own uses of the interior space. A major concentration in layer 13 indicates that a latrine existed at that time in the area of grid unit O16, and a smaller concentration in grid unit N21 possibly denotes a second latrine. The fact that coprolites feature a more scattered distribution in layer 11 reflects the general pattern of higher post-depositional attrition and more horizontal displacement valid for layers 9-13bis in general, which makes it all the more significant that continued use as a latrine of that O16 area during layer 11 times is nonetheless apparent.

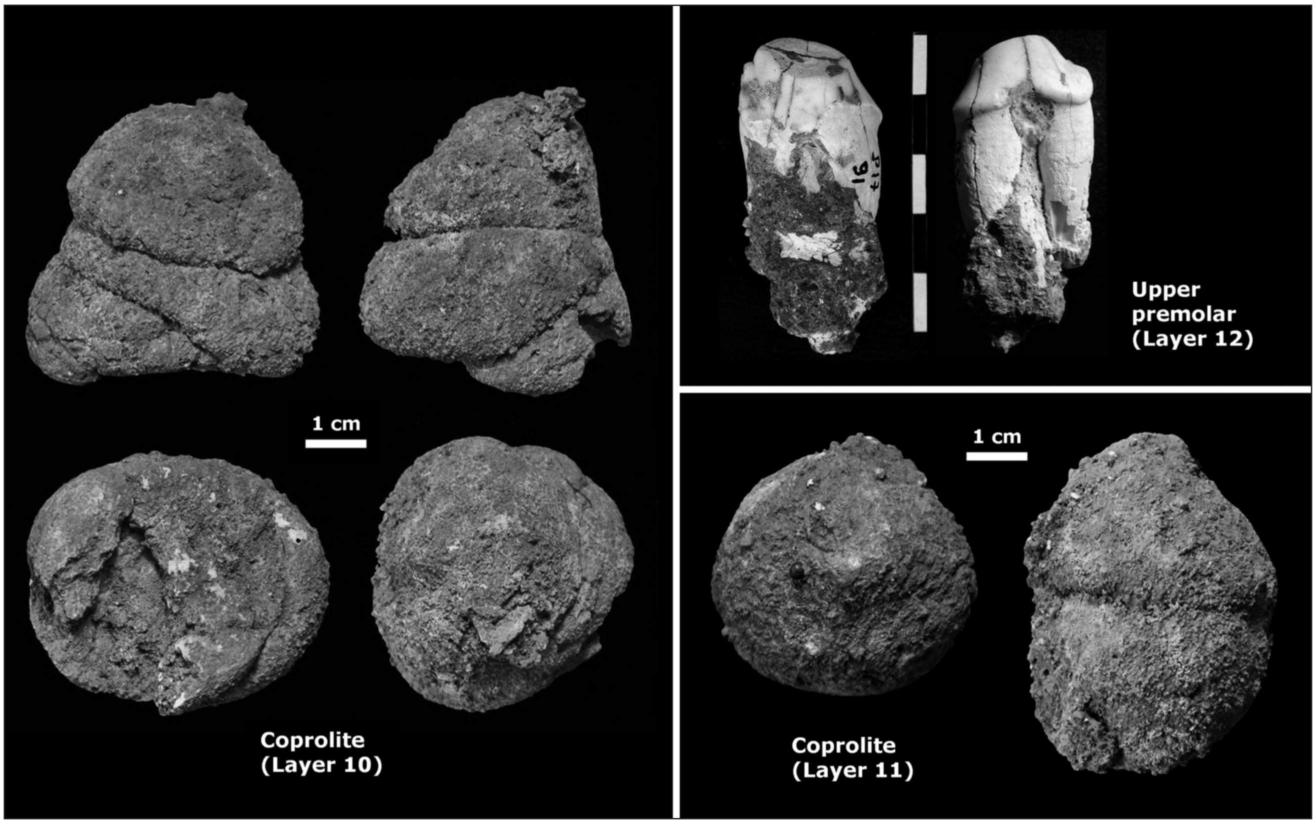

Fig. 6. Gruta da Oliveira hyena remains. Coprolites and the P17-91 tooth (layer 12), an upper right third premolar from an aged individual

When the different lines of evidence (vertical variation in coprolite numbers, in the amounts of burnt bone, in the lithics: bones ratios, and in the relative size of the stone tool inventories) are combined, it becomes clear that the interface between layers 13 and 12 marks a watershed in the use of the site. Under the alternation model proposed above, the coprolites in layer 13 mark an interstadial that closed a period of intensive human use and inaugurated one when people's visits became more infrequent and ephemeral, while hyena incursions became more regular. As a consequence, the level of attrition of the bone component of the deposit increased markedly, and the faunal inventories that survived became a significantly smaller proportion of those originally accumulated than in preceding times.

Pending further study (*e.g.*, analyses of the patterns of superimposition between gnawing marks and cutmarks), the evidence indicates that, during the period represented by layers 9-14, the role played by carnivores in the formation of the Gruta da Oliveira bone assemblage (a) related to modification rather than accumulation, and (b) was especially felt in post-layer 13 times, namely where hyenas are concerned. The data also suggest that, despite the presence of two isolated teeth from an old individual, possibly reflecting an on-site death, hyenas used the cave for feeding but not for denning.

Bibliografía

ANGELUCCI, D. E.; ZILHÃO, J. (2009): "Stratigraphy and Formation Processes of the Upper Pleistocene Deposit at Gruta da Oliveira (Almonda Karstic System, Torres Novas, Portugal)". *Geoarchaeology*: 277-310.

COOPER, S. M. (1993): "Denning behavior of spotted hyaenas (*Crocuta crocuta*) in Botswana". *African Journal of Ecology*, 31: 178-180.

DAVIS, S. J. M. (2002): "The mammals and birds from the Gruta do Caldeirão, Portugal". *Revista Portuguesa de Arqueologia*, 5 (2): 29-98.

-; ROBERT, I. and ZILHÃO, J. (2007): "Caldeirão cave (Central Portugal) – whose home? Hyaena, man, bearded vulture…" *Courier Forschungsinstitut Senckenberg*, 259: 213-226.

KLEIN, R. AND CRUZ URIBE, K. (1984): *The analysis of animal bones from archaeological sites.* Chicago University Press. Chicago.

MARKS, A.; MONIGAL, K. AND ZILHÃO, J. (2001): "The lithic assemblages of the Late Mousterian at Gruta da Oliveira, Almonda, Portugal". In J. Zilhão, Th. Aubry and A. F. Carvalho (eds.): *Les premiers hommes modernes de la Péninsule Ibérique. Actes du Colloque de la Comission VIII de l'UISPP, Vila Nova de Foz Côa, Octobre 1998*. Trabalhos de Arqueologia, 17: 145-154. Instituto Português de Arqueologia.

MILLS, M. G. L. (1983): "Mating and denning behaviour of the brown hyaenas *Hyaena brunnea* and comparisons with other hyeanidae". *Zeitschrift fur Tierpsychologie*, 63: 331-342.

NABAIS, M. (2008): *A Gruta da Oliveira, Rede Cársica da Nascente do Almonda, Torres Novas, Portugal. A ocupação neandertal da camada 14 a partir do estudo dos ossos queimados*. Unpublished undergraduate dissertation. University of Lisbon.

QUEIROZ, P. (2005): *Identificação de um conjunto de carvões de madeira provenientes da Gruta da Oliveira, Almonda*, Trabalhos do CIPA 90, Lisboa (unpublished report).

-; MATEUS, J. AND VAN LEEUWAARDEN, W. (2002): "The Paleovegetational Context". In J. Zilhão and E. Trinkaus (eds.): *Portrait of the Artist as a Child. The Gravettian Human Skeleton from the Abrigo do Lagar Velho and its Archeological Context*. Trabalhos de Arqueologia, 22: 92-111. Instituto Português de Arqueologia.

SPETH, J. D.; TCHERNOV, E. (2002): "Middle Paleolithic tortoise use at Kebara Cave (Israel)". *Journal of Archaeological Science*, 29: 471-483.

WENINGER, B. AND JÖRIS, O. (2008): "A ^{14}C age calibration curve for the last 60 ka: the Greenland-Hulu U/Th timescale and its impact on understanding the Middle to Upper Paleolithic transition in Western Eurasia". *Journal of Human Evolution*, 55: 772-781.

-; -; AND DANZEGLOCKE, U. (2007): *CalPal-2007. Cologne Radiocarbon Calibration & Palaeoclimate Research Package*. http://www.calpal.de/

ZILHÃO , J. (2000): "The Ebro frontier: a model for the late extinction of Iberian Neanderthals". In C. Stringer, R. N. E. Barton and C. Finlayson (eds.): *Neanderthals on the edge: 150th anniversary conference of the Forbes' Quarry discovery, Gibraltar*: 111-121. Oxbow Books, Oxford.

- (2006): "Chronostratigraphy of the Middle-to-Upper Paleolithic Transition in the Iberian Peninsula". *Pyrenae,* 37: 7-84.

-; MAURICIO, J. AND SOUTO, P. (1991): "A Arqueologia da Gruta do Almonda. Resultados das escavações de 1988-89". *Actas das IV Jornadas Arqueológicas (Lisboa, 1990)*: 161-171. Lisboa.

-; -; -; (1993): Jazidas arqueológicas do sistema cársico da nascente do Almonda. *Nova Augusta*, 7: 35-54.

-; AND MCKINNEY, C. (1995): Uranium Thorium dating of Lower and Middle Paleolithic sites in the Almonda karstic system (Torres Novas, Portugal). *Actas da 3ª Reunião do Quaternário Ibérico (Coimbra, 1995)*. Coimbra.