POLLEN IN HYENA COPROLITES
FROM GABASA CAVE (NORTHERN SPAIN)

González-Sampériz, P (1); Montes, L. (2) & Utrilla, P. (2)

(1) Instituto Pirenaico de Ecología-CSIC. Campus de Aula Dei, apdo 202, 50.080-Zaragoza (Spain)

pgonzal@posta.unizar.es

(2) Dept. of Antiquity Sciences (Prehistory). Pedro Cerbuna 12, 50.009 University of Zaragoza

(Spain)

lmontes@posta.unizar.es utrilla@posta.unizar.es

Abstract:

Pollen from hyena coprolites are useful to describe palaeovegetation and to infer palaeoclimate conditions. In previous studies, sedimentological and palynological analyses of the Mousterian Gabasa Cave (Pyrenean foothill region, NE Spain) have not been able to provide detailed palaeoenvironmental information. In this paper, coprolites of extinct cavern hyena (*Crocuta crocuta*) from Gabasa Cave were used for pollen analysis with the goal of establishing the regional environmental history between >50.700 and >39.900 yr BP. Eight of the twelve coprolites analysed contained well-preserved and rich pollen assemblages. They indicated the development of a mosaic glacial landscape that included *Pinus* and *Juniperus* woodlands and steppes of *Chenopodiaceae*, *Poaceae*, *Artemisia* and *Asteraceae*. Pollen for mesophilous and thermophilous trees and shrubs are also present, suggesting the location of nearby refugia of temperate and Mediterranean vegetation.

Key words: Coprolites, Hyena, Palaeoecology, Spain, Pleistocene, Palaeolithic, Glacial refugia

1. Introduction

Pollen from peat-bog, lacustrine and fluvial environments, archaeological sites and even stratified slope deposits are usually studied for palaeoenvironmental interpretation (González-Sampériz *et al.*, 2002). The analysis of coprolites may also provide useful information about palaeoclimate, palaeovegetation and even palaeoethnology (Bryant & Holloway, 1983; Davis, 1990; Scott & Cooremans, 1992; Carrión *et al.*, 2000, 2001), especially in arid environments without lakes or swamps. Coprolites can be used to analyse parasites, the main plant taxa of the food and even the season of ingestion. The results are not always as informative as in conventional palynology of lakes and peatbogs sites, but notwithstanding, coprolite palynology has proven its potential in recent studies (Carrión *et al.*, 2000, 2001).

In this paper, eight of a collection of twelve coprolites from a Mousterian site in NE Spain yielded very well preserved pollen. Previous studies have not found a good correlation among the macrofaunal, microfaunal, palynological and sedimentological evidences (Azanza *et al.*, 1988; Hoyos *et al.*, 1992). Besides, pollen percolation in the cave impeded more accurate interpretations (Hoyos *et al.*, 1992). Our results help to clarify uncertainties regarding the plant cover in the vicinity of the Mousterian Gabasa Cave. We selected samples from abundant hyena coprolites in the archaeological excavation (Blasco & Montes, 1997) to perform a palynological analysis in an attempt to provide a complete and coherent picture of past regional environmental and climate change. It is worth stressing that the pollen in hyena coprolites gives a regional perspective of the palaeoenvironment, since these animals travel long distances in search of food (Scott, 1995; Carrión *et al.*, 2001). Hyena coprolites reflect more regional pollen sources than sediment analysis, as demonstrated by Scott and Klein

(1981) and Scott (1987) in the South African hyena sites of Deelpan, Free State and Equus Cave, Kalahari region. The results are especially interesting when compared to pollen analyses of the sedimentary matrices.

2. Physical Setting

The Gabasa Cave (42°00'20''N, 4°06'20''E, 780m a.s.l.) faces south at 150m above the channel in the headwater of the Sosa River -a tributary of the Cinca River- in the Pyrenean foothill region (NE Spain) (Fig.1). The basal lithology is composed of Cretaceous and Palaeocene limestones, resulting in a karstic relief with abundant caves, many of them containing prehistoric artifacts.

The climate of the region is of a mountain continental Mediterranean type. The mean annual temperature is 14°C, with a large range (July 30°C and January –5°C). The mean annual precipitation is about 550mm. Maximum rainfalls occur in spring and autumn (García-Ruiz *et al.*, 2000). Modern vegetation includes a Mediterranean mixed oak forest with *Quercus rotundifolia* and *Quercus faginea*, especially in the shady aspects, accompanied by scrub of *Juniperus communis*, *Juniperus sabina*, *Buxus sempervirens*, *Pistacia lentiscus* and *Rosmarinus officinalis*. The most frequent species of the adjacent riparian communities are *Populus nigra*, *Populus alba*, *Salix alba* and *Ulmus campestris*.

3. Stratigraphy of the cave

The Gabasa cave has two small chambers (around 30m² each one) with human settlement located in the inner room. The stratigraphy (Fig.2) shows eight archaeologically defined beds (Hoyos *et al.*, 1992). Layer “b” is thin, sterile, and

discontinuous. The whole deposit is very homogeneous (except for the layer “h”), which makes it difficult to separate layers based on colour and texture. According to several authors, each layer corresponds to long periods of intermittent occupation as revealed by artefact contents (Montes, 1988; Utrilla & Montes, 1989, 1993; Blasco, 1995; Blasco *et al.*, 1996; Montes *et al.*, 2000).

The chronology and climatic interpretation used in the first sedimentological study of the Gabasa cave (Hoyos *et al.*, 1992) were based on preliminary data. After new radiocarbon dating, Montes *et al.* (2000) has attributed the sediment of the Gabasa cave to the central part of the Ruddiman and McIntyre’s curve (1981) and not to the beginning of the isotopic stage 3. The absolute chronology of the cave sequence (Table 1) is somewhat imprecise (minimum age), since the dates are beyond the ^{14}C time scale (Montes *et al.*, 2000). The Gabasa sequence could be included in the OIS -Marine Isotope Stage- 3 of Ruddiman and McIntyre (1981) but an older age cannot be ruled out. The absence of human structures (except for a fireplace in the “h” layer), the nature of the sediment and the presence of Mousterian lithic tools suggest a sporadic, though persistent use of the cave by one or a few human groups during the Mousterian period. The animal remains suggest that the cave was used for seasonal hunting (Blasco, 1995; Blasco *et al.*, 1996), alternating with use as an animal shelter (hyenas, bears, cavern lions).

4. Hyena coprolites: Description and Methodology

Fifty-four coprolites or fragments were found in the sediment of the Gabasa cave pit (Photo 1). The 12 largest samples were used for pollen analyses. Most coprolites weighed less than 30g (Table 2). Their characteristics and associated skeleton fragments

of at least 13 individuals corresponded with an age distribution that was typical of hyena dens (adults and sub-adults) of *Crocuta crocuta spelaea*, or cavern hyena from the Würm period (Blasco, 1995). This animal was larger than the modern spotted hyena (Kurtén, 1968) and perhaps it was a hunter and not a scavenger. This possibility becomes crucial in the interpretation of the pollen spectra.

Coprolites surfaces were yellowish to pale brown and they were whitish inside. The surfaces formed a dense-hard cortex that presumably preserved pollen. Thus, each coprolite was treated as a whole and was not split (Carrión *et al.*, 2001). In the laboratory, the coprolites were washed with distilled water to minimise contamination from external sources. This method appears valid since we verified the absence of pollen contamination in the first coprolites. The chemical treatment followed the conventional method (Delcourt *et al.*, 1959; Moore *et al.*, 1991; Dupré, 1992): HF, HCl, KOH, concentration with Thoulet – solution with density 2 - and *Lycopodium clavatum* tablets (Stockmarr, 1971) to calculate pollen concentrations.

Hyenas digest enough organic and plant matter, including pollen, that is preserved in their faecal material (Wernet, 1955). In favorable cases, it is possible to compare sediment and coprolite pollen contents from the same locations (southern Spain, Carrión *et al.*, 2001), and even with coprolites of different species (*Canis* and *Capra* in Pre-Roman settlements, González-Sampériz, 2001). This approach provides useful data to test the validity of the results from both types of pollen analyses: sediments and coprolites (González-Sampériz, 2001). The coprolite pollen spectra of herbivorous animals are theoretically influenced by diet regime and plant availability. In archaeological settlements from Mallorca island, coprolite pollen analyses from the endemic goat *Myotragus balearicus* demonstrated that this extinct ruminant had a

monospecific diet based on *Buxus*. Thus, the extinction of *M.balearicus* has been related with the extinction of *Buxus* in the island (Yll *et al.*, 2001). Since hyenas are not herbivorous, the ingestion of pollen and spores might be accidental or indirect through respiration (air) in addition to the oral system (water, ingestion of vegetable matter via the stomach contents of prey) (Carrión *et al.*, 2001). The information obtained from coprolites is not used to describe the diet but to help understand the palaeoenvironment.

The pollen spectra of hyena coprolites in two Palaeolithic settlements in Auvergne - Saint-Hippolyte (Puy-de-Dôme) and Châtelperron (Allier) - in France, also proved to be representative of the pollen rain as they compared well with the pollen spectra of sediment samples (Vivent, 1989). This author observed the absence of pollen contamination during the digestive process in the hyena. Frequently, there is no over or under representation of specific taxa in the spore-pollen contents of coprolites, but there may be a slight enrichment in entomophilous pollen and shrubs (Girard, 1987; Burjachs, 1988).

5. Palynological Results

In general, the pollen spectra in the studied coprolites (Fig.3) indicate a patchy landscape composed of steppe and forest areas distributed according to topography (altitude and aspect, especially) similar to the current landscape foothill of the Pyrenees. The region is transitional between the Ebro Valley and the mountains. The steppes were composed of chenopods, composites, grasses and *Artemisia*, with patches of pines and junipers. Overall, it suggest cold, arid climate, typical of the last glacial period in continental Iberia (Pons & Reille, 1986; Turner & Hannon, 1988; Peñalba, 1989; Montserrat, 1992; Pérez-Obiol & Julià, 1994; Carrión & van Geel, 1999).

Mesophilous vegetation occurred in the pollen catchments. It includes *Betula*, *Corylus*, *Ulmus*, *Fagus*, and the Mediterranean *Quercus ilex-coccifera* type and *Quercus faginea-pubescens* type. The pollen content of the hyena coprolites is probably derived from a complex landscape, including a number of biotopes, and trapped by hyenas while traveling up to 50 km away from their dens and eating a variety of fauna (Mills, 1989). In the same archaeological layer, pollen spectra show a large variability. . Other studies of pollen in spotted hyena coprolites also provide information about a regional, heterogeneous plant composition, as in the Las Ventanas Cave, southern Spain (Carrión *et al.*, 2001), dated at the end of the Pleistocene. This site was characterized by patchy grass vegetation, heliophytic herbaceous plants like *Artemisia* and *Chenopodiaceae*, pine forests and glacial plant refuges. All these features were present in several hyena coprolites from the same layer.

The suggested plant composition varies in all layers at Gabasa, but the climate conditions interpreted were similar. In the top layer (“a” layer), pollen analysis suggests more temperate and humid conditions (Fig.3) instead of arid and cold/cool conditions. The “a” layer had a higher proportion of arboreal pollen, especially *Pinus* (60% of the total pollen content) and *Quercus t.ilex-coccifera* (10%). In Mediterranean Europe, except in the case of glacial refugia situations, the increase of *Quercus t.ilex-coccifera* is usually interpreted as belonging to interglacial or relatively warmer periods (Wijmstra, 1969; Woillard, 1978; Pérez-Obiol, 1987; Dupré, 1988; Burjachs, 1989; Carrión *et al.*, 1993).

It is interesting that the bottom and middle of the sequence had an unusual proportion of *Chenopodiaceae* in the first case, and *Plantago* in the layer “e”. These plants are appreciated by ruminants, particularly *Plantago* because their leaves are very

nutritious. The high percentages of these two taxa in hyena coprolites are interpreted as a result of the consumption of some ruminant stomachs-contents. The Mousterian cavern hyena was larger than modern hyena and, it could have chosen its meat food before other mammals (except felines). These hyenas would have been able to eat more stomach and intestines and, consequently, ingest more pollen grains from these taxa (Kruuk, 1972). On the hand, the prey of the hyena mainly consumed grasses, and grass swards are excellent traps for regional pollen (Gutierrez *et al.*, 1998).

6. Conclusions

Pollen analysis can be performed in many types of sites and materials, including faecal material or coprolites. In this paper, the pollen content of hyena coprolites from the Gabasa Mousterian Cave (northern Spain) provided information about the palaeoenvironment and palaeoclimate, and reinforced previous archaeological, palynological, sedimentological and chronological studies. It also showed the existence of pollen percolation in the stratigraphy of the cave.

Our results are in agreement with the revised chronology (Montes *et al.*, 2000) and the regional environmental and climatic interpretations (Pérez-Obiol, 1987; Dupré, 1988; Burjachs, 1989; Carrión *et al.*, 1993, 2001).

The pollen analysis of hyena coprolites in the Gabasa cave suggested an arid and cold/cool climate except in the upper layer (“a”), which was probably warmer due to the relatively high proportion of *Quercus t.ilex-coccifera*. The rest of the layers show a complex landscape formed by xerophyte-steppe herbaceous plants and forest patches (essentially coniferous). The presence of a proportion of mesophilous vegetation suggests the occurrence of refuges of temperate trees, which were probably related with

favorable topographic conditions in the Ebro valley. The varied composition of regional vegetation is probably reflected in the pollen composition of the hyena coprolites, due to the mobility of these animals. It is clear that hyena coprolites reflect more regional pollen sources than sediment matrix, but very little is known about pollen incorporation and post-depositional processes in hyena coprolites. The pollen analyses presented in this paper are a small new contribution to this debate.

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FIGURES

Fig. 1. Location of the Gabasa Mousterian Cave (northern Spain)

Fig. 2. Stratigraphy of Gabasa cave. Location in layers of the coprolites analysed

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Photo 1. Spotted hyena coprolites of Gabasa Cave

Fig. 1. Location of the Gabasa Mousterian Cave (northern Spain)

Fig. 2. Stratigraphy of Gabasa cave. Location in layers of the coprolites analysed

The stars are the coprolites analysed for layers (one coprolite at **layer a**, no coprolites at **layers b** and **c**, one coprolite at **layer d**, two coprolites at **layer e**, one coprolite at **layer f**, two coprolites at **layer g** and one coprolite at **layer h** or base).

Fig. 3. Pollen diagram of hyena coprolites from Gabasa Cave (northern Spain)

Table 1. Radiocarbon dating of Gabasa Cave

GABASA CAVE	Radiocarbon Dating	COPROLITES
layer a	>39.900 BP	H.A.1.
layer b	>45.900 BP	No coprolite
layer c	>46.900 & >47.800 BP	No coprolite
layer d		H.D.1.
layer e	>45.600 & >51.900 BP	H.E.2., H.E.4.
layer f		H.F.4
layer g	>50.700 BP	H.G.4., H.G.8.
layer h		H.H.2

Table 2. Description and pollen of coprolites analysed

Hyena Coprolites	Weight	Taxa Number	Pollen Concentration	Indetermina
H.A.1	30 gr	30	12.720 grains/gr	6 %
H.D. 1	38 gr	37	1.707 grains/gr	5 %
H.E.2	25 gr	26	3.990 grains/gr	3 %
H.E.4	44 gr	26	1.304 grains/gr	6 %
H.F.4	23 gr	37	4.289 grains/gr	5 %
H.G.4	32 gr	17	3.606 grains/gr	9 %
H.G.8	23 gr	16	12.275 grains/gr	4 %
H.H.2	35 gr	31	3.383 grains/gr	4 %

Photo 1. Spotted hyena coprolites of Gabasa Cave