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Small preys and plant exploitation by late pleistocene hunter–gatherers. A case study from the Northeast of the Iberian Peninsula

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Abstract The aim of this paper is to explain the subsistence strategies of late hunter–gatherers from the Northeast of the Iberian Peninsula on the basis of zooarchaeological and archaeobotanical records. The study is based on the Molí del Salt archaeological site which has yielded an Upper Palaeolithic and Mesolithic sequence. Each of the disciplines shows us a various type of assemblage to approach the same problem. Archaeobotanical materials, including charcoal and seeds provide data on the strategies related to firewood gathering and vegetal food supply, which was a basic subsistence resource for these groups. The archaeobotanical assemblage is mainly formed by conifers, but other species related to edible plants are also important. Bone assemblage, mainly formed by *Oryctolagus cuniculus*, show how hunting and meat processing is highly related. The environmental constraints as well as mobility are discussed in order to achieve an ampler knowledge on human activities.

Keywords Late hunter–gatherers · Subsistence strategies · Firewood · Diet · Zooarchaeology · Archaeobotany · Spain

Introduction

At the Mediterranean Basin, the Late Upper Palaeolithic represents a change concerning hunting and gathering strategies in relation to animal and plant exploitation (Aura et al. 2002; Mason and Hather 2002; Hockett and Haws 2003; Lovis et al. 2006). In this area, these changes are characterized by the presence of small game animals in the archaeological assemblages, whereas in other regions large mammals or medium game preys are more abundant (Charles 1997; Strauss 2006). Zooarchaeological studies reveal a clear economic change in relation to subsistence that shows its peak during the end of this chronological frame (Aura et al. 2002; Villaverde et al. 1996; Hockett and Haws 2003; Jones 2006). In this sense, some authors consider leporids as an attractive resource for different reasons such as their abundance in the area, their high reproductive capacities and the easy location of the burrows where they live in dense-packed warrens (Adovasio et al. 1997; Hockett and Bicho 2000; Stiner 2001; Hockett and Haws 2002; Stiner and Munro 2002; Lupo and Schmitt 2002; Jones 2006).

Explanations for the inclusion of small game in the diet are diverse, including different factors such as demographic, ecological, nutritional and technological aspects and mobility of hunter–gatherer groups (Flannery 1969; Binford 1968; Pérez-Ripoll and Martínez-Valle 2001; Villaverde 1995; Villaverde et al. 1998; Villaverde 2001; Hockett and Bicho 2000; Stiner 2001; Hockett and Haws 2002; Stiner and Munro 2002, Aura et al. 2002; Vaquero 2004; Jones 2006; Costamagno et al. 2008). None of these explanations seem to exclude the others, nevertheless, there are no doubts that technological innovations of traps and nets permitted exploitation of small game with a higher energetic return (Hockett and Bicho 2000; Stiner 2001; Jones 2006).

Also plant remains from the Upper Palaeolithic are recovered more often, even though they may appear in low quantities, depending on their conservation (Mithen et al. 2001; Mason and Hather 2002; Aura et al. 2005). Archaeobotanical records (charcoal and remains of charred seeds) involve two interpretative perspectives. Firstly they contribute to the

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knowledge of past plant formations, and even if they are remains from human activities their potential for paleoecological interpretation has already been demonstrated (Vernet 1997; Chabal 1997). Secondly, these remains are the product of fire use (combustion) related to different daily activities carried out at the site, referring to different aspects of subsistence such as food processing, diet and firewood gathering. Therefore they contribute to the understanding of hunter–gatherer's behaviour (Mason and Hather 2002; Asouti and Austin 2005; Allué and García Antón 2006).

The advances in the research of different subjects related to behaviour, mobility and subsistence of Palaeolithic hunter–gatherers are mainly based on lithic and bone remains (Strauss 2006; Bicho et al. 2006), and plant remains are approached separately. They are not often analysed jointly. However, both archaeological records outline the components of the main subsistence resources among late hunter–gatherers. The Molí del Salt is an example of this type of assemblage which reflects the main features of hunter–gatherer groups in this area. In this paper, we discuss subsistence strategies from late hunter–gatherers on the basis of bone and plant evidences from a site in the northeastern Iberian Peninsula.

Site description

The Molí del Salt is located at Vimbodí (41°23′44″ North-1° 02′48″ East), 490 m above sea level and 100 m from the river Milans (Figs. 1, 2). The site is located at a transition area between the mountains (*Prades* mountains) and the alluvial plain of the river Francolí. The deposit has yielded a 2.5 m thick sequence with several archaeological layers, most of them corresponding to the Late Upper Palaeolithic, although also a Mesolithic layer (level Sup) has been detected at the top of the sequence. Two main assemblages have been identified in the Upper Palaeolithic sequence according to sedimentological and archaeological criteria. Assemblage A includes the levels Asup, A and A1 and its upper part has been dated by ^{14}C (AMS) at 10,840±50 years BP (Beta-179599) and 10,990±50 years BP (Beta-179598). Assemblage B is made up of levels B1 and B2, respectively, dated at 11,940±100 years BP (GifA-101037) and 12,510±100 years BP (GifA-101038) (Vaquero 2004).

Fig. 1 Location of the Molí del Salt shelter

Fig. 2 General view of the Molí del Salt site

Of the archaeological artefacts, the lithic remains are mostly made of flint, though also some other materials such as limestone, quartz and quartzite are found. Along the sequence there are changes in technological production and raw material source exploitation. Truncatures and end-scrapers are dominant in levels B1 and B2; backed elements are also abundant, but burins are poorly represented. In assemblage A, the percentage of truncatures drops abruptly and endscrapers are clearly dominant. Burins tend to increase in these upper levels and backed elements remain unchanged. Raw material acquisition also shows differences between assemblages A and B. The lithic sources are more local in the upper levels, showing a pattern of less mobility in relation to exploitation of raw materials. The lower levels are characterized by higher percentages of exotic flint. In spite of these differences, all the Upper Palaeolithic levels can be attributed to the Mediterranean Upper Magdalenian (Vaquero 2004; Vaquero et al. 2006). These assemblages have also yielded several large flat schist pebbles presenting zoomorphic engravings (Vaquero 2004; García-Díez and Vaquero 2006).

Materials and methods

Archaeobotany

The archaeobotanical remains are mainly wood charcoal; however, also a few charred seeds have been recovered. These remains are related to human activities involving fire even though hearths are not preserved. Fragments of charcoal are scattered in the layers associated with the rest of the artefacts. The study of plants from archaeological assemblages yields information on environment and human behaviour and is based on a methodological and theoretical framework that permits interpretation by both approaches (Chabal et al. 1999; Asouti and Austin 2005; Allué and García Antón 2006).

Charcoal remains (<4 mm) were pulled out manually; in addition all the sediment was sieved using bucket flotation, by which smaller charcoals and seeds could be recovered. For identification the charcoal remains were fragmented by hand in order to obtain the three wood anatomy sections which permit description of the cell structure. Charcoal fragments were observed through a metallographic microscope under reflected light with dark and light fields, using ×5, ×20 and ×50 magnifications. Charcoal analysis does not always allow identification up to a species level, sometimes only the family, genus or type can be identified. This is due to the low variability of some taxa, to the preservation of the material and to the size of the charcoal fragments. Therefore in this study the results are shown through different identification categories (genus, species, type, e.g.). Quantification is based on the number of fragments, adding up manually recovered and sediment charcoals. Fragments of charred fruits and seeds were observed under a binocular lens up to ×5 magnification. For both charcoal and seeds, a reference collection and reference atlases were used to support the identification (Beijerinck 1947; Schweingruber 1990; Hather 2000).

Zooarchaeology

Zooarchaeological analysis was done on 2,130 remains recovered during 1999 to 2003 field seasons. For all the excavated levels there is a high identification index, between 50% and 75%. Taphonomy, based on observation through a binocular lens, was used for derivation of the origin of the bone accumulation. Two arguments support the theory that hominids were an agent of accumulation of rabbits during the Upper Palaeolithic in Southwest Europe. First, anatomical and age profiles (Cochard and Brugal 2004; Hockett and Bicho 2000; Jones 2006). Secondly, taphonomic aspects: the presence of cut marks associated with skinning, defleshing and dismembering, and standardized patterns in the fracturing of three bone types: humerus, femur and tibia (Hockett 1991; Hockett and Bicho 2000; Hockett and Haws 2003; Pérez-Ripoll 1992, 1993, 2001; Pérez-Ripoll and Martínez-Valle 2001; Callou 2003; Cochard and Brugal 2004).

The marks produced during disarticulation appear as a series of oblique and transverse incisions near the epiphyses of the humerus and tibia, on the coxal acetabulum, on the neck of the scapula, on the condyle of the femur and on the mandible. Less frequently, they are found on the proximal radius and calcaneus. The filleting grooves appear in the form of more or less deep incisions and scrapings. These are often placed longitudinal or obliquely on the diaphysis of bones such as the humerus and femur where carcasses contain a greater volume of flesh mass. Anthropic breakage of the long bones is identified from the recovery of diaphysial cylinders and isolated epiphyses (Hockett 1994; Villaverde et al. 1995; Pérez-Ripoll 2001; Hockett and Haws 2002; Callou 2003; Cochard and Brugal 2004). This activity is mainly recognized on three bone types: humerus, femur and tibia, because these have the largest marrow cavity. The fracturing process takes place through percussion, bending or biting off the epiphyses. Percussion is characterized by the formation of notches, flexion leaves neatly fractured surfaces and bite marks are characterized by the presence of opposing grooves formed by the pressure of premolars. Isolated epiphyses often occur in very low proportions in hominid-produced assemblages, with domination of the most compact ones (distal parts of the humerus and tibia).

The anthropic activity identified on ungulate remains is similar to that on leporids, as it responds to the same objective: to obtain the meat and the marrow of the bones. The predominant macromammal species present during this period at the eastern Iberian Peninsula are *Capra pyrenaica* and *Cervus elaphus*. Generally, the remains of these animals tend to show significant fracturing which in many cases hinders the anatomical and taxonomical identification. Aura et al. (2002) observed that with the emergence of Magdalenian industries the intensive processing of ungulate carcasses increases. Marginal bones such as carpal and tarsal bones and third phalanges are fractured with the aim to consume the marrow. According to the same authors this intensification corresponds with a reduction in residential mobility and the increase in the consumption of small animals.

Anthropic modifications on these animal bones are the same as those on small game bones, but the way in which the carcasses are processed changes significantly due to the variability in the size of the animals. Their anatomical structure and their nutritional composition influence the strategy employed during the processing (Gifford-Gonzalez 1993). All aspects related to macromammal flesh processing have been widely developed and studied by zooarchaeologists, among others Binford (1981); Blumenschine (1988, 1995); Bunn (1981, 1982); Higgins (1999); Potts and Shipman (1981); Villa and Mathieu (1991).

Analogue to small-sized animals, the location and layout of cut marks on the various macromammal elements reflects the specific activity performed. Cut marks produced during skin extraction are usually found on phalanges, metapodials and the skull. Marks produced during breakage are found on the epiphyses and adjacent areas of limb bones, on vertebrae surfaces and on coxal areas. Filleting marks cause parallel cut marks, located on the medial areas of long bones and arranged longitudial or obliquely with respect to the axis of sagittal bones.

Superficial changes produced during the fracturing of bones may also be different. Percussion marks are depressions or collapses associated with microstriation areas, produced when the hammerstone slides on the bone after beating. Microstriations can also be produced when the bone slides on an anvil (Blumenschine and Selvaggio 1988). Percussion marks can be found together with other evidences such as impact marks. These impacts are indentations caused by the collapse of the cortex in the area that has received the maximum intensity of the blow (Capaldo and Blumenshine 1994).

Results

Archaeobotanical results

The study of 903 charcoal fragments from levels Asup, A1, A, B1 and B2 has yielded 9 different taxa (Table 1). In level Asup the most significant taxa are *Juniperus* (juniper), *Prunus* (plum) and *Pinus sylvestris* type (scots pine type). In this layer the scots pine has the lowest percentage of occurrence (17.9%) and juniper the highest (28.1%). There are also a few fragments of *Rhamnus cathartica/saxatilis* (buckthorn), Maloideae (pome), *Quercus* sp. deciduous (deciduous oak) and *Acer* (maple). Levels A and A1 have yielded very few charcoal fragments; identified are among others *P. sylvestris* type, *Prunus*, and *Juniperus*. Level B1 has yielded five taxa from which *P. sylvestris* type is the most important, with high percentages up to 66.6%. Also *Juniperus*, *Prunus*, *Betula* (birch) and *R. cathartica/saxatilis* are present, in lower percentages. Finally, in level B2 the most significant taxon is *P. sylvestris* type, with the highest percentage of the sequence. Also other taxa such as *Prunus*, *Betula*, *Corylus avellana* (hazel), *Juniperus* and *Sambucus* (elder) are present, in low quantities though.

Some specific items show taxonomical variability. This might have implications for the interpretation of the charcoal record. The case of *Prunus* is exemplar; this genus refers to different species including plums, cherries and almonds. The wood anatomy is very similar for all *Prunus* species (Schweingruber 1990; Hather 2000). In charred remains there are few diagnostical characteristics which can be used to distinguish between them and in addition these characteristics are not always well preserved or not even present in the studied fragments. However, sometimes scholars identify them to the species level considering different species or types on the basis of some general characteristics (Bazile-Robert 1980; Heinz and Barbaza 1998). For European woods from the Mediterranean basin the most useful characteristics are the ones established by Heinz and Barbaza (1998). The authors described three different *Prunus* types based on the number of cells in the rays. *Prunus* type 1 contains not more than 2 cells per ray; *Prunus* type 2 contains three to four cells per ray and *Prunus* type 3 more than five cells. Each type would correspond to different species, type 1 to *Prunus avium/padus* (wild cherry/European bird cherry), type 2 *Prunus spinosa/mahaleb* (blackthorn/mahaleb or St. Lucie cherry) and type 3 *P. spinosa/amygdalus* (blackthorn/almond). For this site we have distinguished all three types, the most abundant being type 3, which corresponds to *P. spinosa/amygdalus* (Table 1).

There are six carpological remains, all coming from levels A and Asup. The identified taxa are *P. spinosa* (blackthorn), *Crataegus* (hawthorn) and cf. *Rosa* (cf. rose) (Table 1). Also three undetermined fragments are found. The accuracy of the identification of seed remains is higher if we compare with charcoal. Comparison resulted in the identification of one genus from the Maloideae subfamily, hawthorn, and a concrete species from the *Prunus* genus, blackthorn.

Zooarchaeological results

For all levels *Oryctolagus cuniculus* (rabbit) is the dominant species relative to the number of identified remains (Table 2). Also other macromammals such as *C. pyrenaica* (spanish ibex), *C. elaphus* (deer), *Sus scrofa* (wild boar) and *Lynx pardina* (lynx) have been identified. There are also 12 bird remains, of which eight are Perdicinae.

In the assemblage we have identified all the anatomical segments present in a rabbit skeleton. However, in the anatomical profiles from the Molí del Salt vertebrae and ribs are significantly scarce. In the anthropic assemblages this absence is likely related to grinding activities of these elements to profit their grease content, and even though among product associations of anthropic activities this type of absence is common, there are not always (direct) evidences of grinding (Hockett and Bicho 2001; Hockett and Haws 2003). Tibiae, femurs, coxals and mandibles are more frequently identified elements. According to Cochard and Brugal (2004) this means an accumulation with food purposes. A high number of mandibles and extremities indicates that meat processing and bone discarding were carried out in the same place (Hockett et al. 2002).

Concerning the taphonomical analyses of the record, the identified modifications on the bones have mainly an anthropic origin. The three types of anthropic bone alteration found are: cut marks, presence of diaphysial

Table 1 Results of the archaeobotanical analysis

	Levels							
	Asup		A	A1	B1		B2	
	No.	%	No.	No.	No.	%	No.	%
Wood charcoal								
Acer	1	0.35						
Betula					1	0,4	3	0.7
Corylus avellana							3	0.7
Juniperus	80	28.1			3	1,3	4	1.0
Pinus sylvestris type	51	17.9		2	154	66,6	313	82.5
Pinus	2	0.7			14	6.0	6	1.5
Prunus	20	7.0	2		11	4.7	7	1.8
Prunus type 1	9	3.1			2	0.8		
Prunus type 2	13	4.5			2	0.8	5	1.3
Prunus type 3	15	5.2			7	3.0	9	2.3
Rhamnus cathartica/saxatilis	6	2.1			4	1.7	4	1.0
Rosaceae/Maloideae	4	1.4					2	0.5
Sambucus							1	0.2
cf. *Fraxinus*	1	0.3			1	0.4		
cf. *Prunus*	4	1.4						
cf. *Rhamnus*	3	1.0						
Undetermined angiosperm	23	8.1	1	1	7	3.0	4	1.0
Undetermined conifer	30	10.5	1		15	6.4	14	3.6
Undetermined	22	7.7	2		10	4.3	4	1.0
Total	284		6	3	231		379	
Charred seeds								
Crataegus	1							
Prunus spinosa			1					
cf. Rosa	1							
Undetermined	3							
Total	5		1					

cylinders due to anthropic breakage of femurs, tibiae and humeri, and burnt bones (Table 3). Cut marks of anthropic origin occur isolated or in groups, when grouped they appear as parallel striae on bone areas near the muscular insertions (Fig. 3). The length and orientation of the marks and the anatomical positions correspond to activities related to butchering (Binford 1981; Potts and Shipman 1981; Shipman and Rose 1983; Pérez-Ripoll 1992).

Table 2 Results of the zooarchaeological analysis

TAXA	Levels									
	Asup		A		A1		B1		B2	
	No.	%	No.	%	No.	%	No.	%	No.	%
Oryctolagus cuniculus	85	97.7	86	91.4	36	76.6	210	91.7	844	94.6
Capra pyrenaica	1	1.1	6	6.3	5	10.6	11	4.8	32	3.5
Cervus elaphus			1	1.0	2	4.2	5	2.1	1	0.1
Sus scrofa					2	4.2	1	0.4		0.3
Lynx					2	4.2	1	0.4	3	0.3
Perdicinae			1	1.0			1	0.4	6	0.6
Birds	1	1.1							3	0.3
Total	87		94		47		229		889	

Table 3 Representation of percentages of the taphonomic features of small and big game

Small game						
levels	Sup	Asup	A	A1	B1	B2
Cut marks	0.9	1.4	5.1	2.6	7.1	3.7
Shaft cilinders	22.5	12.6	10.8	36.8	23.8	18.3
Burnt bones	15.3	22.4	21.5	0.0	3.8	8.2
Big game						
levels	Sup	Asup	A	A1	B1	B2
Cut marks	2.1	20.0	8.3	0.00	3.39	4.84
Anthropic breakage	0.0	0.0	0.0	18.8	10.2	9.7
Burnt bones	26.8	100	21.7	18.2	6.1	20.0

In the assemblage we have identified 3.9% of the cut marks on *O. cuniculus* and on bone fragments of undetermined small game animals (Table 3). These marks are related to skinning for flesh extraction. 50% of the marks are related to flesh dismembering. They are located at the areas with the highest flesh content such as the diaphysis of the humerus, femurs, and proximal shafts of tibiae. At the caudal border of the scapula they are positioned obliquely or longitudinally to the sagittal axe of the bone. Cut marks are also present on bones with a low flesh mass such as mandibles, radio-ulnae and distal tibiae. From the situation of these anatomical cut marks the inferred origin is hide extraction, as they are located at the extreme areas of the carcasses where there is little flesh mass and the distance between the skin and bone is smaller.

The cut marks related to dismembering are located at the epiphyses or at the articular zones next to scapulae, ulnas, coxals and femurs. This is the lowest represented activity in the assemblage. The cut marks from both, the hide extraction and the dismembering are placed obliquely or transversal to the longitudinal axe of the bone. The scarceness of cut marks in the whole assemblage is not surprising. The volume of bones with cut marks on these chronological assemblages is highly variable (Pérez-Ripoll 1992). There is less need to use stone tools for getting the meat from small game carcasses compared to carcasses of larger animals. The presence of abundant cut marks can be related to the preparation of the bones for conservation (e.g. dried, smoked, roasted), assuming that intensive processing is not needed for immediate consumption of these animals. However, in the case of the Molí of Salt, the marks are not abundant enough to infer conservation activities.

On the large bones repetition of patterns at tibiae and femurs is observed (Figs. 4, 5). From these elements we have mainly recovered diaphysial cylinders. According to the model these should be complemented by the presence

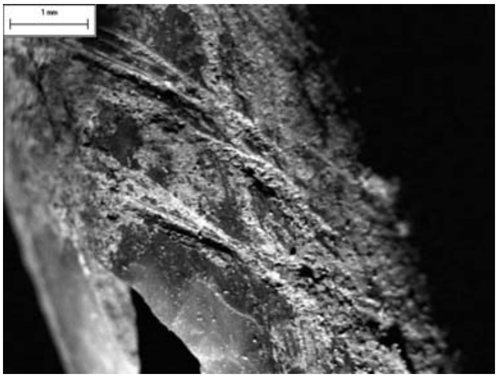

Fig. 3 Cut marks related to butchering activities located on a humerus diaphysis

Fig. 4 Patterns of rabbit bone breakage showing diaphysial cylinders on femur portions

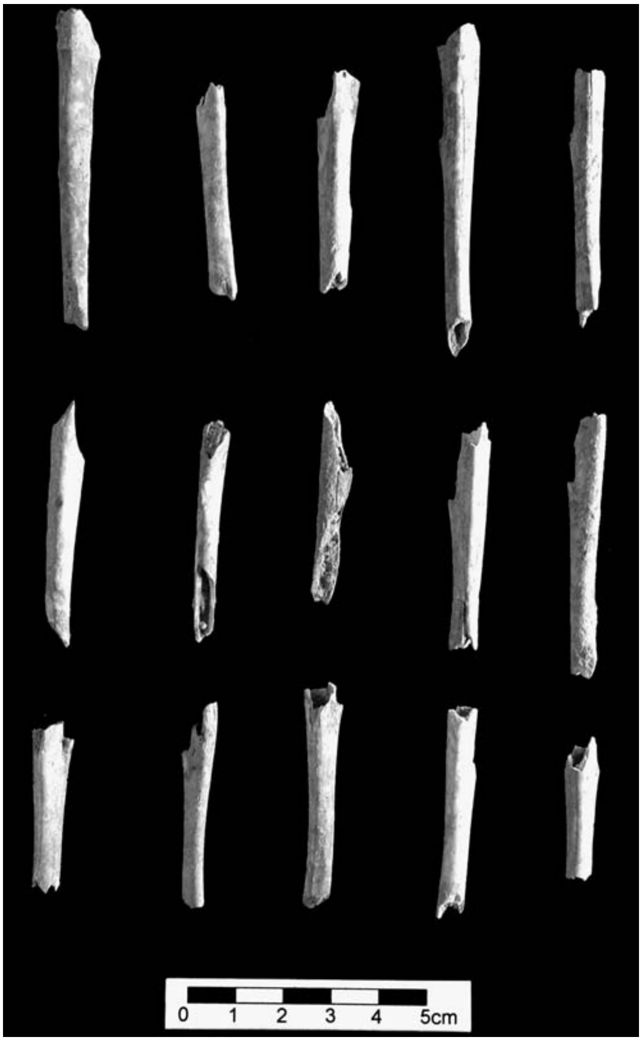

Fig. 5 Patterns of rabbit bone breakage showing diaphysial cylinders on tibia portions

of isolated epiphyses or small parts of the diaphysis, which are very few in this sample. The clear pattern of bone representation as well as the presence of animals of different sizes, weights and ages cannot be explained by differential destruction of the remains. In almost all cases the edges of femur and tibia fractures tend to present a concave morphology and abundant grooves. This morphology results from percussion activities. During these activities the ends of these bones are crushed, hereby disappearing from the record. The humeri display a very similar pattern, although we have also recovered distal epiphyses associated with diaphysial fragments. Here the pattern of fracturing would be produced by striking the medial part of the diaphysis.

The radios and ulnas show a different pattern. In this case, we have recovered abundant epiphyses with part of the diaphysis attached. The edges of these fractured bones, which are more fragile, are upright and net, corresponding to fracturing by bending. The objective of this type of fracture is not to obtain the marrow, very little in these bones, but to reject the most distal extremity (foot).

The small game remains present various degrees of burning; 14.1% of the remains of very small-sized animals (both unidentified and identified bones) are burnt. Regarding cremation of the segments, none of the levels shows clear patterns that could be used to establish a specific pattern of cooking of the carcasses. However, we observed that the remains with a major proportion being burnt are the tibia. In addition, 36.2% (NR=85) of the burnt fragments concerns small portions of unidentified diaphysial fragments. This can respond to the models proposed by Jones (1983) and Hockett (1991) in which the authors state that the heating of tibiae on ember is done to optimize the extraction of marrow from the carcasses of small game, thereby reducing the cost of processing. This technique would produce some of the small unidentifiable fragments found.

The macroremains also have anthropic marks characterized by cut marks and breakages. The macromammals represent only 4.4% of the identified remains. These remains show butchering patterns similar to those of the rabbits. The cut marks that have been located on midshafts of limb bones are in all cases related to filleting. In relation to fracturing 5.5% of the remains shows percussion marks. These are mainly located on *C. pyrenaica* and *C. elaphus* remains. Among these remains we highlight a phalanx of *C. pyrenaica* showing percussion marks with macroscopically visible microstriae (Fig. 6). This element is burnt, showing homogeneous staining at the bottom of the grooves and the rest of surface, indicating that possibly this bone was exposed to fire before fracturing. As in the case of rabbit bones this technique appears to be used to optimize marrow obtainance. Most of the macromammal bones presenting thermo alteration show a black colour. In general they are small undetermined remains. Among these remains, we find 6 elements showing incisions with homogeneous staining between the bottom of the cut marks and the remaining surface. From the obtained data we could not establish whether intentional cremations were produced after deposition of the remains on the substrate. Only for the phalanx

Fig. 6 *Capra pyrenaica* burnt phalanx with percussion stigma on its surface

intentional cremation could be inferred. Only in one other case we can say that cremation occurred after filleting, either postdepositional or for specific purposes such as facilitating the fracturing and to maximize nutrient obtainance.

Discussion

During the Upper Palaeolithic and Mesolithic, changes in human economical behaviour were determined by environmental changes affecting the spreading of certain fruit producing species which might have had an effect on food consumption. At the Iberian Peninsula, these changes also enhanced the proliferation of rabbits which then became an abundant resource for prehistoric hunters (Delibes and Hiraldo 1981; Hockett and Bicho 2000). Some authors claim that the inclusion of small game in diets was produced earlier, during the Lower and Middle Palaeolithic, and that this was related to changes in hunting fast and slow preys (Stiner et al. 1999; Stiner et al. 2000; Stiner 2001; Sanchis-Serra and Fernández-Pérez 2008; Blasco 2008; Blasco and Fernández-Peris 2009). The exploitation of plant resources was also important during earlier periods even though evidences in archaeological records are rather scarce (Lev et al. 2005; Goren-Inbar et al. 2002). In addition, the quantity of archaeobotanical evidence is also related to the use of specific techniques for consumption or storage, such as fire use.

At the Iberian Peninsula these economic changes reached their maximum during the Late Upper Palaeolithic. According to Aura et al. (2002) these changes are due to the long duration of settlements involving lower mobility and maximal exploitation of the nearest resources. However, these changes do not necessarily imply a reduction of mobility, it has been demonstrated that long trips were undertaken to obtain certain non-perishable raw materials (Hockett and Haws 2002).

All these approaches mainly focus on hunting strategies, although the same way the hunting strategies changed, there were also changes in the vegetable diet. These changes were possibly also following the climatic improvement and had the purpose to complete a meat diet based on small preys (Speth and Spielman 1983). The archaeobotanical record has enlightened the importance of vegetal nutrition inputs among the late hunter–gatherers (Mithen et al. 2001; Jäger and Shäfer 1999; Mason and Hather 2002; Aura et al. 2005). Nevertheless there are still only very few remains found and understanding vegetal processing is difficult. Furthermore, we consider wood for firewood to be related to the exploitation of vegetal resources as food and for the manufacturing of wooden objects. The relatively better preservation of firewood remains over other plant remains permits recognition of assemblages of woody taxa, enhancing the understanding of some aspects of gathering strategies.

For this period general and local climate records show changes mostly due to an increase in rainfall and milder temperatures (Huntley 1993; Bergadà 1998; Aura et al. 1998). At the Molí del Salt changes related to Late Pleistocene climatic fluctuations are not reflected very clearly, however, trends in the charcoal sequence indicate changes in vegetation cover (Fig. 7). During the time the site was occupied, conifers dominated the landscape. A more or less open pine forest with some juniper shrubs formed the main landscape cover during the earliest phases (levels B1 and B2). In addition other species were spreading out, among them some that are not well adapted to extreme climatic conditions such as *R. cathartica/saxatilis*, *Acer*, *Quercus* sp. deciduous, *Prunus* and Maloideae. In level Asup, the appearance of *Quercus* sp. deciduous, *Acer* and an increase of other mesophile species indicate that milder conditions are established in the region. Along the sequence we can also observe the increase of *Juniperus* and a decrease of *P. sylvestris* type. As for the faunal assemblage, there are species from different environments, both forests zones and open land. The presence of wild boar, which is increasing through time, implies humid environments. At the moment there is no palynological record to confirm the retreat of the arboreal vegetation cover in relation to expansion of the herbaceous vegetation cover. However, this evolution of the vegetal cover is also detected in other sequences from the Mediterranean Basin (Mir and Freixas 1993; Vernet 1995; Bergadà 1998; Aura et al. 1998; Allué et al. 2007; Allué 2002). For the NE of the Iberian Peninsula anthracological (charcoal) records show that during the earlier stages of the Tardiglacial pine forests dominated the entire territory (Carbonell et al. 1985; Heinz 1990; Galobart et al. 1991; Mir and Freixas 1993; Bergadà 1998; Piqué 1995; Vaquero et al. 2006; Allué et al. 2007). As climatic changes took place, the vegetation cover changed from pine groves to open lands dominated by junipers and/or mesophile taxa, both are considered pioneer species or vegetation. In the southeast of the Peninsula, oaks and Mediterranean pines were widespread in earlier stages due to a milder climate (Aura et al. 1998; Carrión 2005; Aura et al. 2005).

Vegetal resources were rather important for hunter–gatherers, although evidences of organic materials are scarce due to preservation problems. Firewood, which is better conserved as a result of combustion, is the most common plant remain. On the opposite, other archaeobotanical remains such as fruits and seeds are less common in archaeological records. From the Upper Palaeolithic onwards these evidences become more frequent in archaeological sequences (Holden et al. 1995; Buxó 1997; Zapata 2000; Zapata et al. 2002; Mason and Hather 2002; Aura et al. 2005). In the Mediterranean

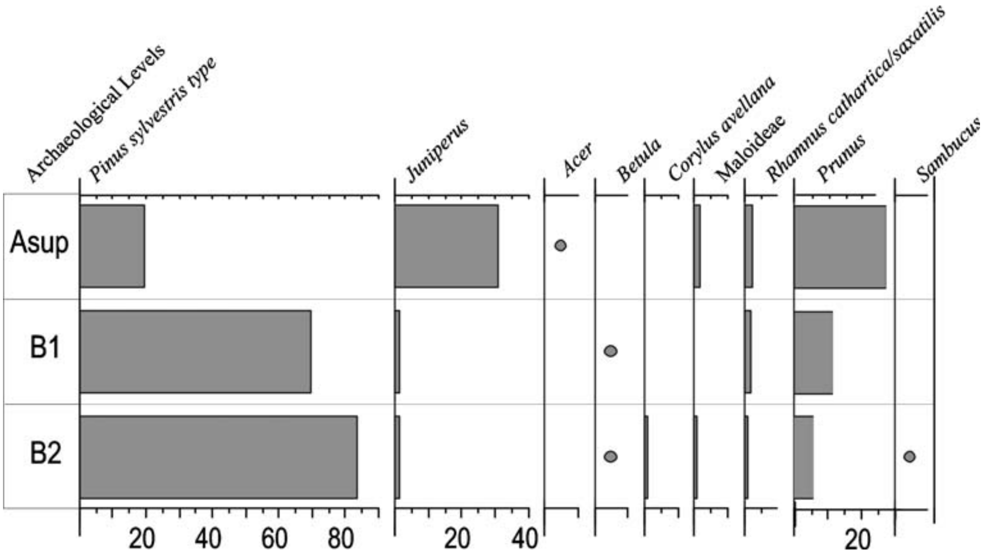

Fig. 7 Charcoal analyses diagram showing relative frequencies

region, this development is related to a higher abundance in the environment caused by climatic improvement, but also to the different acquisition, processing, and preservation techniques and recovery techniques. Generally there are few evidences of vegetal food gathering in early Palaeolithic sequences (see Lev et al. 2005; Goren-Inbar et al. 2002). However at the Iberian Peninsula there are some examples of archaeobotanical records showing that if the environment provides plants suitable for consumption, they are also present in the records. For example, both the Middle and Upper Palaeolithic levels from Gorham's cave (Gale and Carruthers 2000) and the Upper Palaeolithic layers from the Cueva de Nerja (Badal 1998) provide remains of pine nut shells, showing the exploitation of vegetal resources as food. During the Late Upper Palaeolithic and the Mesolithic the exploitation of these resources increases (Holden et al. 1995; Buxó 1997; Mason and Hather 2002; Aura et al. 2005). The increase might be related to improved mobility and exploitation strategies, abundance of edible plants, and developed food preservation techniques.

During the Palaeolithic the most common fuelwood was pinewood in the NE of the Iberian Peninsula. Fuelwood management is based on gathering dead wood from the ground; the selection of specific species (from the total offer) is related to availability and abundance (Allué and García Antón 2006). Among the important species present in archaeobotanical records, pine is the most profitable from all points of view: production of dead wood, caloric conditions and availability or abundance in the environment. Furthermore, any of the species in this genus (*P. sylvestris*, *P. nigra*, *P. pinea*, *P. pinaster*, *P. halepensis*) was widespread at the Iberian Peninsula during the latest Upper Pleistocene phase (Badal and Carrión 2001; Allué 2002).

At the Molí del Salt site we found a change in the principal wood type exploited for firewood over time. In the layers B1 and B2 pine dominates, whereas in layer Asup junipers, plums and low quantities of pine dominate the assemblage. Two hypotheses could apply to these changes: Firstly, a change in the main plant cover at a local scale, and secondly, overexploitation of the local pine forest by humans, causing a decrease of pine wood use and subsequent expansion of other species that were more available at the time. As for hunter-gatherer firewood exploitation strategies it seems clear to us that overexploitation would also involve the cutting of entire trees for timber. We believe that the exploitation of wood according to the archaeological record is mainly related to firewood and this exploitation was based on the collection of branches, mostly pine. The significant climatic change permitted the expansion of species that during cold phases were only growing at refuge niches. The specific properties, related to firewood quality or the production of their edible fruits, of these spreading taxa, e.g. junipers or plums, made them more suitable for their use as fuelwood.

During the Molí del Salt occupations probably all the gathered plants were used as firewood; they could be used as basic firewood, thrown to the fire as waste from other activities, or burnt by chance. In addition there are some which have other properties besides just being good and available fuel. In the Molí del Salt charcoal record, there is an important group of wood types which produce edible fruits or have other useful properties such as *Juniperus*, *Acer*, *Prunus*, Maloideae, *C. avellana*, *Sambucus* and *R. cathartica/saxatilis. R. cathartica* and *Rhamnus saxatilis* fruits have dyeing properties. Immature fruits of *R. cathartica* (buckthorn) produce a yellow dye and the mature ones produce orange or brownish dye (Rivera and Obón 1991). *Acer* wood has very good qualities for woodworking (Abella 1998). The Maloideae group includes a series of species with edible fruits, some of them cultivated at present, such as *Malus* (apple) and *Pyrus* (pear). Others grow in their wild forms, such as *Sorbus* (rowan) and *Crataegus* (hawthorn). Finally, *C. avellana* (hazel) is one of the best preserved pericarps found in archaeological sequences (Buxó 1997; Zapata 2000; Mithen et al. 2001, Mason and Hather 2002).

Hazel, oak and elder charcoal are scarcely present at the Molí del Salt site, but they were widely exploited in Northern Europe areas where they were spreading out (Mason and Hather 2002; Allué et al. 2007). All three species have edible fruits. *Prunus*, which includes various species bearing edible fruits, was probably abundant and also has good qualities as firewood. Several evidences of blackthorn seeds show that *Prunus* was also exploited for its edible fruits. Furthermore the absence of a larger amount of seed remains could be related to the type of food processing, which did not necessarily involve fire use or was done in another area than the excavated area. *Prunus* comprises different species with a mesophile and pioneer character, and it is present in relatively high amounts in 90% of the Mesolithic and Epipalaeolithic sequences from the northeast of the Iberian Peninsula (Allué et al. 2007).

The archaeological layers from the Molí del Salt show an economic pattern of animal consumption, hunting and processing that is typical for the Mediterranean Late Upper Palaeolithic and Mesolithic. In these assemblages a dominance of rabbit is common, being in most of the cases present in values higher than 80% such as in Cueva del Parpalló, Tossal de la Roca, Cueva Matutano, Cueva de les Cendres, Cueva de les Malladetes, Santa Maira (Valencia), Cueva de Nerja (Andalucía) or Picamoixons (Catalunya) (Allué et al. 1992; Davidson 1989; Villaverde 1995; Aura Tortosa et al. 2002; Olària 1999; Pérez-Ripoll 2004). The presence of rabbit is often accompanied by avifauna (Olària 1999; Aura et al. 2002; Pérez-Ripoll 1992, 2001, 2004). The rabbit specimens from the Molí del Salt site and their taphonomic damages show that humans are the rabbit accumulation agent. According to Hockett (1991) some features - presence of diaphysial cylinders, cut marks, burnt bones and high frequencies of adults - are used to establish the identification of anthropic assemblages. At the studied levels the anthropic modifications are relatively abundant and there are no evidences of activities of other predators on the bones. These hunter–gatherers exploited different biota from the nearest environment as well as from further areas. Both mountain and forest environments were exploited as demonstrated by the presence of goat, dear and wild boar remains. The zooarchaeological record in all levels shows intensive exploitation of rabbits with a high degree of fracturing and butchering marks. Rabbit processing is based on butchering, skin extraction, disarticulation and bone fracturing. Consequently evidences of the complete process are present in all levels. The frequencies of rabbit elements with cut marks are highly variable in assemblages from this chronology (Hockett 1994: Hockett and Bicho 2000; Pérez-Ripoll 1992, 1993 and 2001; Quirt-Booth and Cruz-Uribe 1997), a high amount of bones with cut marks is due to filleting of the meat to prepare it for smoking (Pérez-Ripoll 1992). In Santa Maira for example, there are high frequencies of cut marks caused by defleshing, possibly related to meat preparation for conservation. In the Molí del Salt assemblage however the frequency of cut marks is not high enough to suggest this type of processing. A high amount of cut marks is the only empirical signal on the carcasses that might suggest conservation of food. In contrast, the anatomical distribution of burnt bones does not provide a pattern of roasting of entire carcasses or segments of them. Nevertheless, the marks related to the disarticulation of segments suggest preparation of raw carcasses, because once they are cooked this process can easily be done by hand. The high frequency of burnt tibiae could be related to the optimization of marrow extraction, since this bone has the highest marrow content. This burning would take place after defleshing and disarticulation of the carcass, maybe suggesting an immediate consumption of the marrow and preservation of at least muscular packages for later consumption. Furthermore, the smoking of meat as a conservation process is common and has been described by ethnographic sources (Rivera and Obón 1991). The presence of junipers in all levels suggests the possibility of the use of this species for smoking the rabbit meat. Thus the exploitation of this wood might be related to a specific meat processing activity and not to the use as current fuel for heating or lighting.

This assemblage suggests the significance of the exploitation of plant and animal resources in relation to other activities. The importance of plants for hunter–gatherer subsistence implies a growing seasonal dependence of these products and therefore a reduction of mobility. Animal hunting and processing shows recurrent patterns which describe strategies based on a selection of preys, probably depending on the socio-economic behaviour of hunter–gatherer groups. Even if mobility suggests a possible relationship with the sea, marine food resources were not exploited during the occupations at the Molí del Salt, and neither were fluvial resources. The latter, even if it could be an immediate resource of firewood or fish, we have not found any evidence of their exploitation. This socio-economic behaviour related to mobility and resource exploitation is consistent with the exploitation patterns of lithic raw materials (Vaquero 2004).

We believe that animal and plant resources were collected from the most nearby areas, whereas other resources, such as raw materials for lithic production, come from other further areas (Vaquero 2004). The presence of marine shells indicates movements to the sea, which is 40 km away (in a straight line) from the present-day coastline. On the basis of lithic raw material, the data show that there is a decrease in mobility regarding the exploitation of this resource. During the occupation that corresponds to levels B1 and B2 the lithic sources for raw material were located far away, whereas in the upper layers the sources were local. Therefore these data indicate a possible major mobility among the hunter–gatherers from the early phases. A contact with the coast is evident in all levels (Vaquero 2004), however, the development of exploiting more local food and plant resources in the surroundings could have caused a reduction of the group mobility. Seasonal exploitation of certain plant species and the development of preservation techniques of food are elements to take into consideration. Climatic changes and the establishment of seasonality have supposedly caused a greater dependence on seasonal resources. This hypothesis is in accordance with those of other authors working in nearby areas (Aura et al. 2002). The consumption of rabbit meat would have been complemented with vegetal resources introduced into the diet. Rabbits were highly available since they are not seasonal and dispose of various reproductive episodes throughout the year (Hockett and Bicho 2000; Jones 2006). Rabbit mass hunting using traps or snares turns them into a very profitable resource (Jones 2006), and would favor the preservation of meat for differentiated consumption. We should also take into account that the incorporation of rabbits was complementary to a broader diet, since for itself its caloric contribution is low. If there were long term settlements, human groups would profit from all the available resources according to the season, and they would profit maximally during seasons of scarcity. The abiotic and non-perishable resources (lithic materials, shells or wood for manufacturing objects) indicate a high mobility of these groups, decreasing though time from the Magdalenian to the Epipalaeolithic. This dynamic is observed in all the Mediterranean Levant (eastern Iberic Mediterranean) (Aura et al. 2002). The perishable resources (plants and animals) from the Molí del Salt show a high degree of exploitation of resources from the immediate surroundings of the site. This supports the possibility of longer and more sedentary occupations. We do however believe that a high degree of sedentism does not necessarily mean a lower degree of mobility.

Conclusions

In the Upper Palaeolithic and Mesolithic clear subsistence strategies exist based on food processing and immediate food resources. However in the Mediterranean area there are significant elements that suggest that seasonality and mobility patterns change through time. Environmental constraints indicate that better climatic conditions and changes in seasonality could have caused a greater dependence on the more local environment and therefore produce a lower mobility of the human groups. The combination of different resources shows patterns of mobility strategies which suggest an exploitation of the most abundant resources in the vicinity.

From the Molí del Salt record we have been able to demonstrate how complementary data from different archaeological records display similar patterns and can yield further information on cultural behaviour of hunter–gatherer groups. Nevertheless for the full understanding of these processes further excavations of a larger surface of the site are being undertaken which will provide more data in the future.

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