Chapter 13
Bone Grease Rendering in Mousterian Contexts: The Case of Noisetier Cave (Fréchet-Aure, Hautes-Pyrénées, France)

Sandrine Costamagno

Fat is an essential element of the diet of human groups living in subarctic regions (Binford 1978; Saint-Germain 1997, 2005; Outram and Mulville 2005; Karlin and Tchesnokov 2007; Costamagno and David 2009). In addition to contributing vitamins, the consumption of grease can be of crucial importance during certain periods of the year for groups with very high protein diets with a limited carbohydrate content (Binford 1978; Speth and Spielmann 1983; Abe 2005). At the end of winter and beginning of spring, herbivores are generally in poor physical condition. The sequence of fat loss begins with subcutaneous fat depletion, followed by muscular, organ and then marrow depletion. The lower extremities (metapodials and phalanges), mandible and brain retain fat the longest (Speth 1983; Stiner 1991). In environments lacking exploitable vegetal resources during these periods, the ingestion of lean meat with no supplementary lipid source can lead to serious dietary deficiencies, sometimes resulting in death (Speth and Spielmann 1983).

Hunter-gatherers can compensate for these deficiencies by eating carbohydrates, especially dried fruits or nuts. They may also hunt the animals most rich in fat, use fat reserves constituted during other seasons and/or extract greater quantities of grease from the available carcasses (Speth and Spielmann 1983; Saint-Germain 2005). Extracting the fat contained in bone tissues is one of the methods that could have been used to increase the lipid portion of the diet. Boiling is the method often used to render bone grease: the bones are submerged in water and then heated over a slow fire for a varying amount of time (Saint-Germain 1997). Bone grease rendering was commonly practiced by forager groups living in very diverse environments (cold tundra, boreal forest, plains, high desert, etc.) (Denys 1672; Leechman 1951; Vehik 1977; Binford 1978; Grønnow et al. 1983; Brink 1997; Morrison 1998; Abe 2005; Saint-Germain 2005; Costamagno and David 2009). Though it is frequent, this food preparation technique is not systematically observed among modern hunter-gatherers (e.g. Hadza: Bunn et al. 1988; O'Connell et al. 1988; Dassanetch: Gifford-Gonzalez 1989).

The bones used to obtain fat are very diverse, including long bones, carpal bones, tarsal bones, vertebrae, and ribs. The Nunamiut (Binford 1978) were very selective, favoring long bone extremities and sometimes a few carpal and tarsal bones. The same is true of the Hidatsa (Wilson 1924 cited in Logan 1998), who preferred the bones of limb extremities. Nunamiut groups often used the fat of vertebrae and ribs to fabricate a sort of candle, while the skull, antlers and scapulae were never processed for bone grease (Binford 1978). Binford argued that the proportion of mono-unsaturated oleic acid was responsible for the Nunamiut's preference for lower limb fats. According to Brink (1997), grease weight is the most important variable underlying the Nunamiut selection. This debate was recently renewed by Morin (2007) who showed that parts rich in oleic acid would have been selected more often than expected based on grease weight alone. Morin (2007: 81) argued that "(…) taste, texture, time of consumption, sequence of fat mobilization, and ease of extraction are all potentially contributing to the bias favoring the selection of skeletal parts rich in unsaturated fatty acids". This fat preference is not universal among forager groups, however. The Cree (Calling Lake Alberta), the Copper Inuit and the Omaha used the articular extremities of long bones, the coxal bones (except the acetabulum), the glenoid cavity of the scapula, the vertebrae and the ribs (Bonnichsen 1973; Jenness, 1922 cited in Morrison 1998; Dorsey, 1884 cited in Vehik 1977). Some Siberian groups who practice reindeer herding still extract fat from a highly variable range of bones (Evenki: Abe 2005; Koriak: Karlin and Tchesnokov 2007). In all of these examples, with the exception of the Koriak, who

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S. Costamagno (✉)
TRACES-UMR 5608, CNRS, PRES Toulouse, Université
Toulouse 2 – Le Mirail, 5 Allées A. Machado,
31058 Toulouse Cedex 9, France
e-mail: costamag@univ-tlse2.fr

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sometimes used shaft fragments (Karlin, personal communication), only cancellous portions are processed for bone grease rendering. However, Delpech and Rigaud (1974) also note the use of long bone shafts by Nunamiut groups; these fragments were submerged in water to make a beverage that was consumed as is.

Few data describe the procedure used to obtain the articular extremities of long bones. When processing marrow bones in their residential camps, the Nunamiut strike long bones as close as possible to the extremities in order to detach the articular portions with as few remaining shaft portions as possible (Binford 1981: 158); the Cree, on the other hand (Bonnichsen 1973), place the articular extremities of long bones on stones and then strike them one or two times in the middle of the shaft. The marrow is thus collected and the shaft fragments attached to the articular extremities are fractured. In all of the recorded cases, the bones used for fat extraction are intensively fragmented through the use of an anvil and percussor: Abe (2005) speaks of fragments that are 1 cm in length, Leechman (1951) of pieces the size of a fingernail, Delpech and Rigaud (1974) of small fragments of epiphyses with an average length of 2 cm, Karlin and Tchesnokov (2007) of a high degree of crushing, and Denys (1672) of a reduction into powder. Higher fragmentation rates, created by increasing the bone surface exposed to boiling water, could result in a more rapid release of grease in a shorter amount of time (Lupo and Schmitt 1997; Saint-Germain 1997). Based on long bone boiling experiments, Church and Lyman (2003) argued that small fragments are in fact not necessary for efficient grease extraction. Nonetheless, the proportion of grease extracted after one hour of boiling is the greatest for the smallest fragments: after one hour, 4 cm long pieces had released 41 % of their fat, while pieces 1 cm long had released 63 %.

Contrary to marrow extraction, bone fat rendering is particularly difficult to detect in archaeological faunal assemblages. Roberts and collaborators (2002) showed that the physicochemical characteristics of bone are not modified (loss of collagen, increased porosity, increased crystallinity) until the bones have been boiled for at least ten hours, which is much longer than the time generally recorded in the ethnographic examples. According to Koon and collaborators (2003), collagen alteration induced by heating at low temperatures can be observed using Transmission Electron Microscopy (TEM). Koon and collaborators (2010) argue that this visualization technique allows us to discriminate between cooked and uncooked bones in recent archaeological contexts. The efficacy of this technique for older sites and on cancellous specimens has not yet been tested, however. For the Paleolithic, due to the lack of durable vessels that can be directly exposed to flames, many researchers have proposed that hot rocks were dropped in a skin or gut container filled with water (Frison 1978; Stiner 2003; Karlin and Tchesnokov 2007). Examples of hot-rock boiling are widely recorded in the ethnographic record (e.g. Ryder 1966, 1969; Vehik 1977; Binford 1978). According to Stiner (2003), three criteria are necessary to identify bone grease rendering at prehistoric sites: (1) intensively fragmented bones; (2) large quantities of heated rocks; (3) anvils with use traces. Few sites have yielded all of these three factors in combination. In the Gravettian at Vale Boi (Portugal), Stiner (2003) noted the presence of fire-cracked rocks and stone anvils with large depressions associated with an intensive fragmentation of cancellous bones. In level 7 of Le Flageolet, the presence of heated rocks and extremely fragmented articular ends, which were concentrated in well delimited zones, led Delpech and Rigaud (1974) to propose that the Gravettian occupants of this site made a fat bouillon. In level IV0 of Pincevent, Julien and Beyries (in Bodu et al. 2006: 83) noted the presence of three sandstone rocks with impact traces that could have "served to fracture bones to collect the marrow or to crush them to extract the fat", while heated limestone pieces could have been used to boil horse bones (March et al. in Bodu et al. 2006: 116). At sites with bison in North America, pits in the ground have been interpreted as evidence of this activity (Logan 1998). Few sites display this type of structure, however, and it is often based on bone residue analysis that bone fat extraction is proposed (Davis and Fisher 1990; Outram 1999; Costamagno and Fano Martínez 2005; Munro and Bar-Oz 2005; Prince 2007).

Few ethnohistoric sources specify the parts and dimensions of the bones that were crushed but most of the examples cited show an intensive crushing of bones before they are dropped in water and boiled, as well as a preferential use of cancellous portions. Shaft fragments were rarely used for bone grease extraction. However, many different taphonomic processes can lead to the fragmentation of cancellous bones and it is very difficult to distinguish post-depositional taphonomic processes from bone grease rendering techniques. For this reason, the comparison of the percentage of preserved cancellous parts with their fragmentation rate (NISP/MNE) proposed by Munro and Bar-Oz (2005) seems of little use as long as we lack a reference base that would enable us to distinguish fresh from post-depositional breakage of cancellous elements. Conversely, the intensive fragmentation of cancellous parts can lead to a problem of differential determination (Lyman and O'Brien 1987; Outram 1999) and result in an under-representation of some skeletal parts. The identification of long bone articular ends may therefore be influenced by this processing technique. An under-representation of long bone epiphyses relative to shaft portions may thus provide an archaeological signature for bone grease rendering. However, numerous other taphonomic processes can also lead to a scarcity of epiphyses, including post-depositional processes (Brain 1969; Behrensmeyer 1975), carnivore gnawing (Brain 1981; Haynes 1983; Hudson 1993), or the use of bone as fuel (Théry-Parisot et al. 2004; Costamagno et al. 2005). It is thus essential to identify the causes of bone preservation/fragmentation to resolve the problems of equifinality (Outram 2001, 2004). Carnivore actions and bone use as fuel are relatively easy to distinguish (e.g. Richardson 1980; Binford 1981; Lyman 1994; Fisher 1995; Costamagno et al. 1998, 2008b). For density-mediated destruction, this distinction is far more problematic, however. As shown by Lyman (1984) and Morin (2010), a very strong negative correlation exists between long bone density and the percentage of fat. Among artiodactyls, bone density is largely correlated with fat content. Therefore, differential preservation linked with density-mediated destruction may mimic a bone grease rendering pattern. The appearance of the bones, the presence of fetal bones or divergent skeletal representations depending on the species, can thus be used to discriminate the taphonomic processes that may have contributed. The bone assemblage of Noisetier Cave enables us to avoid the problems created by the equifinality of these different processes.

Site Presentation

The Mousterian site of Noisetier Cave was first noted by Viré in 1898. Allard finally excavated test pits there in the late 1980s (Allard 1993). Since 2004, Mourre and Thiébaut have been conducting a full research excavation of this site. Noisetier Cave is a small cavity located in the Pyrenees Mountains. It is situated within a limestone cliff at an altitude of 825 m above sea level. The excavations by Allard mainly concerned the central part of the cave. The current excavations, extending over approximately 30 m^2 (Fig. 13.1), have revealed a relatively complex stratigraphic sequence approximately 3 m thick (Fig. 13.2). All of the levels of this sequence have yielded a Mousterian industry characterized by an association of discoid and Levallois debitage, and some Neanderthal human remains (Mourre et al. 2008). Radiocarbon dates have been obtained from wood charcoal fragments originating from an in situ hearth and bone remains from the US0 and levels 1 and 3 (Table 13.1). These dates must be considered with caution, however, as they are at the limit of the radiocarbon method. Based on the abundant microfauna assemblage, all of the levels can nonetheless be attributed to Isotope Stage 3 (Jeannet 2001). The identified animal species (rodents and large mammals) indicate that the deposits were formed during a relatively temperate climatic period (Mourre et al. 2008).

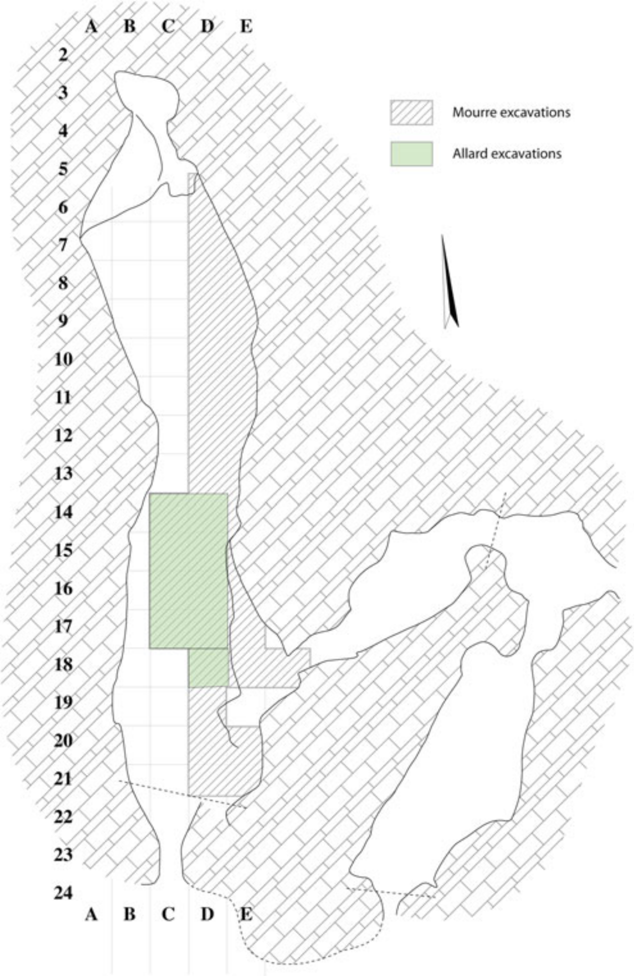

Fig. 13.1 Noisetier cave: zones excavated since 1987 (Mourre *in* Mourre et al. 2010)

The Cartesian coordinates of the archaeological remains collected during both excavations were recorded using the grid installed by Allard. In comparison to the methods employed by Allard, the artifacts recovered during the current excavation are more systematically recorded and the sediments more meticulously sieved. When possible, all of the identifiable bone remains, and all other pieces over 3 cm long, are systematically recorded in three dimensions. All of the sediments are water-sieved through a mesh of 1.6 mm. Once dry, these sieved sediments are sorted to extract the lithic, faunal, microfaunal, malacofaunal and human remains.

Taphonomic analyses have shown that a large portion of the bone assemblage has a non-human origin: the chamois remains (*Rupicapra rupicapra*) are mostly natural, the red deer remains (*Cervus elaphus*) are anthropogenic, and the ibex remains (*Capra ibex* cf. *pyrenaica*) are of a mixed origin (Costamagno et al. 2008a; Mallye et al. 2010).

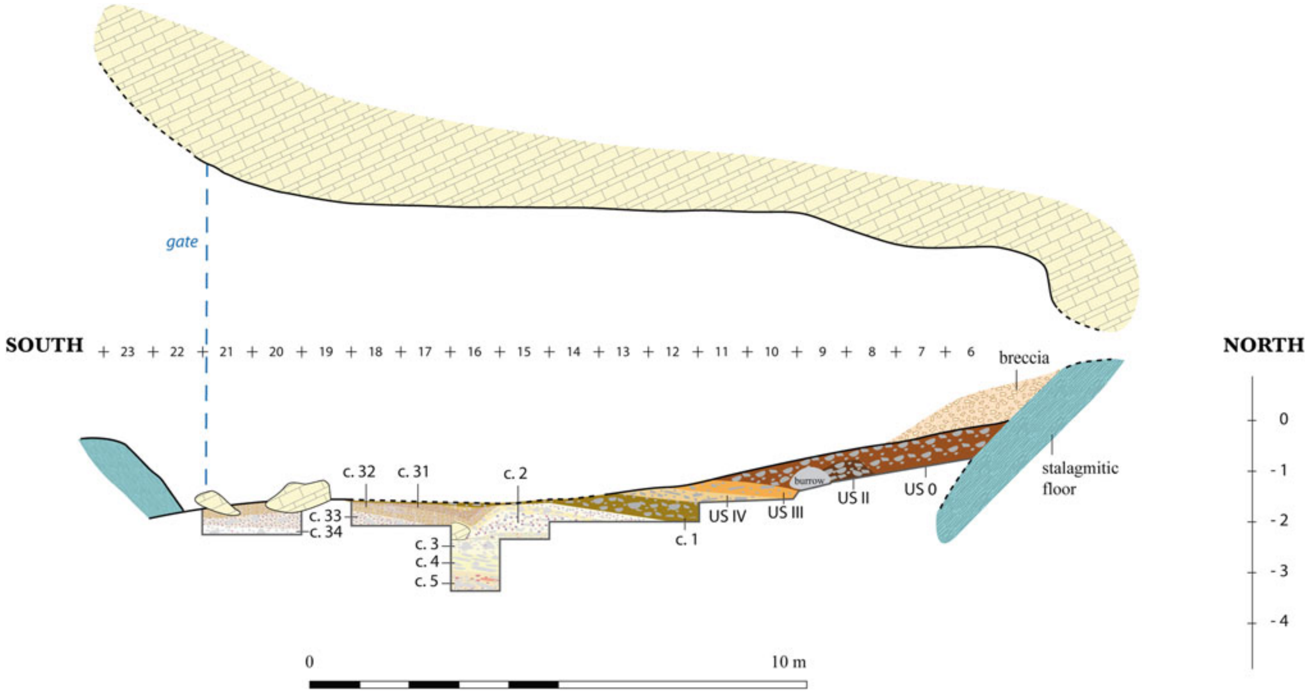

Fig. 13.2 Noisetier cave: stratigraphic sequence (Mourre *in* Mourre et al. 2010)

Table 13.1 Noisetier cave: radiocarbon dates

Layer	Nature	Laboratory number	^{14}C age in years BP	Collagen yield (%)	References
US0	Bone	Poz-14257	29,500 ± 300	4.8	Mourre et al. (2008)
1	Charcoal	Poz-13720	33,700 ± 500	–	Mourre et al. (2008)
1	Charcoal	Poz-13757	31,500 ± 600	–	Mourre et al. (2008)
1	Bone	GIF-7997	42,000 ± 3,100	–	Allard (1993)
3	Bone	Poz-14255	47,000 ± 2,000	0.6	Mourre et al. (2008)

The discovery of dhole[1] (*Cuon alpinicus*) deciduous teeth led us to propose the hypothesis of a cuon den alternating with human occupations (Mallye et al. 2010). This carnivore, rather than the bearded vulture (*Gypaetus barbatus*), as was previously proposed (Costamagno et al. 2008a), would have accumulated the majority of the chamois remains (Mallye et al. 2010). Based on their taphonomic characteristics, these chamois remains could have originated from feces accumulated in the latrine zones, since cuons very rarely bring carcasses into their dens (Fox 1984).

Materials and Methods

Due to a less exhaustive recovery of bone remains, the assemblages originating from the excavations by Allard were not included in this study. The upper levels found in the back of the cave (US0 to US IV) were also excluded due to the abundance of cave bear remains (Fig. 13.3). In the test pit, the lower levels (starting with level 4) show a low degree of anthropogenic modification and were thus not included in this analysis. As the other levels displayed clear taphonomic and taxonomic similarities (Costamagno et al. 2010), the bone remains were analyzed with no distinctions between the levels in order to benefit from a sufficiently large sample of red deer.

The assemblage studied in detail is composed of 3,123 remains corresponding to all of the bone remains recorded between 2004 and 2008 (1,558 specimens) and all the taxonomically and anatomically identifiable remains (1,565 specimens[2]) recovered from the sediments sieved during this same period. To make taphonomic and zooarchaeological observations, all the bone surfaces were examined under a low-angled light using a hand lens (magnification: 12×). The criteria used to identify these traces are those

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[1] Determination by Boudadi Maligne.

[2] 76 % of these remains are less than 2 cm long.

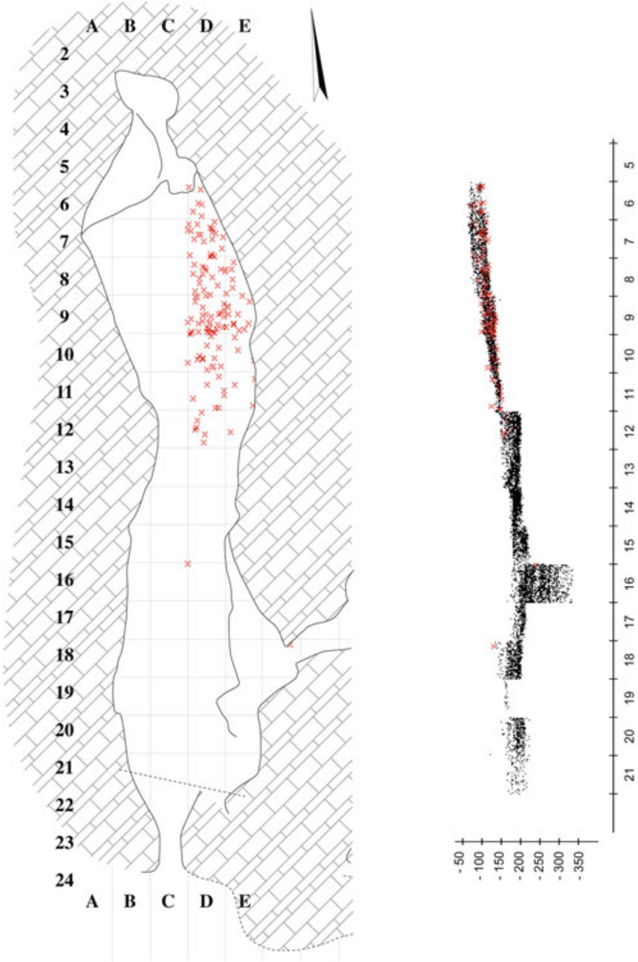

Fig. 13.3 Noisetier cave: spatial distribution of bear remains (*Ursus spelaeus*) (Thiébaut *in* Mourre et al. 2010)

listed by Blumenschine et al. (1996). For the remainder of the sieved materials (i.e. unidentifiable remains), we studied a sample of 20,000 remains. These pieces, nearly 97 % of which are less than 2 cm long, were not subject to a detailed taphonomic analysis. The unidentified bones collected through sieving (20,015 pieces) were sorted into four categories: dental fragments, compact tissue fragments, compact tissue fragments with spongiosa and cancellous bone fragments. The length of these pieces and the presence of burning traces were also recorded. Among the ungulates present, only chamois and red deer are presented in detail in this paper. Ibex, the third most frequent species, was not included in this study due to its mixed origin.

To evaluate the influence of carnivores on the bone assemblage, the percentage of fragments with tooth marks among the recorded remains (number of bone remains with tooth marks/number of bone remains[3] × 100) and the mean percentage of shaft fragments with tooth marks were calculated. The cut marks (number of bone remains with cut marks/number of observable bone remains × 100) and percussion traces (number of bone remains with percussion marks/number of bone remains[4] × 100) present on the recorded remains were also studied. For digestive attacks, all remains were taken into account. To determine whether the fragmentation of long bones occurred on fresh or dry bone, the method defined by Villa and Mahieu (1991) was used. Since burned bones are most abundant among small remains (Stiner et al. 1995; Costamagno et al. 2005), their proportion was estimated based on all the bone specimens (including the fine sieving fraction). The percentage of burned bones (number of burned bones/total number of bone remains × 100) and the percentage of burned cancellous remains (number of burned cancellous remains/number of burned remains × 100) were calculated. To evaluate the relative abundance of skeletal elements or portions rich in cancellous material, the %NNISP,[5] which gives results comparable to the %MAU (Grayson and Frey 2004), was used. I considered only the articular portions of long bones because the discard of vertebrae at a butchery site and their disappearance in association with problems of determination and/or preservation is extremely difficult to distinguish (Marean and Frey 1997; Costamagno 2004; Costamagno and Fano 2005). These skeletal part profiles were subsequently analyzed using bone mineral densities calculated by Computed Tomography (Lam et al. 1999). The correlation coefficients calculated are Spearman's correlation coefficients.

Results

The faunal assemblage of Noisetier Cave is largely dominated by chamois (65.2 %), followed by red deer (12.3 %) and ibex (9 %). Carnivores represent 4.3 % of the assemblage (Table 13.2). The faunal remains are generally very well preserved. Tooth marks are present on 3 % of the remains, and cut marks are present on 11 %. Digestion stigmata were observed on 40 % of the bone remains (Table 13.3). With regards to taphonomic and zooarchaeological observations, there is a clear difference between red deer and chamois. The red deer remains are characterized by a large number of cut marks and low number of digestion

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[3] Tooth fragments excluded.

[4] Tooth fragments excluded.

[5] The Normed NISPs (NNISP) represent "the skeletal part NISP values divided by the number of times the relevant part occurs in the skeleton of the animal involved" (Grayson and Frey 2004, p. 31). For %NNISP, the highest NNISP is set to 100 % and the rest of the NNISP values are scaled to that figure.

Table 13.2 Noisetier cave: taxonomic abundance

Taxa	NISP	%NISP
Ursus spelaeus	5	0.3
Panthera pardus	3	0.2
Canis lupus	5	0.3
Cuon alpinus	12	0.7
Vulpes vulpes	33	1.8
Canidae	17	0.9
Putorius putorius	1	0.1
Bovinae	28	1.6
Capra ibex cf. *pyrenaica*	162	9.0
Rupicapra rupicapra	1,170	65.2
Caprinae	32	1.8
Cervus elaphus	221	12.3
Capreolus capreolus	1	0.1
Cervidae	4	0.2
Equus caballus	2	0.1
Lepus sp.	20	1.1
Marmota marmota	78	4.3

marks (Tables 13.3 and 13.4). More than 73 % of the chamois remains, on the other hand, are digested and few display evidence of human activities (2.7 %). Among the chamois middle shaft long bones, 19.6 % have cut marks and 17 % are digested. For chamois, the epiphyses are characterized by a digestion rate varying between 74 and 100 % (Fig. 13.4). Among the long bones, between 6 and 40 % of the middle shaft bones are digested. Table 13.5 shows the percentage of digested bones by size class for chamois and red deer. Even among the small fragments, the red deer bones rarely display traces of digestion.

Carnivore tooth marks are relatively rare on both of these species (Tables 13.3 and 13.4). For red deer, they were recorded on 13 bone specimens mostly composed of rib and middle shaft fragments. Only 1.9 % of the middle shaft bones of red deer, and none of the epiphyses, have tooth marks. For Chamois, the percentages are respectively 5.7 and 2 %. These light bite marks occur in the form of pitting or scoring. No whole red deer or chamois long bones were found and nearly 90 % of the fracture edges indicate the fracturing of fresh bone.

The skeletal profiles of these two species also show clear differences. Fragments of vertebrae, girdles and phalanges are much more numerous for chamois than for red deer (Fig. 13.5). The same is true for compact bone (carpals, patella, tarsals and sesamoids). Along with the phalanges, these pieces represent 46 % of the chamois remains versus 8 % for red deer. For chamois, these pieces nearly always display digestion marks (compact bone: 88 %, phalanges: 83 %). Other than the femur and tibia, both species are characterized by relatively similar frequencies of long bones. Significant differences are nonetheless observable in the skeletal portions (Fig. 13.6). For red deer, regardless of the long bone considered, epiphysis fragments are scarce (depending on the bone, this frequency varies between 2 and 16 %) and are never digested (Fig. 13.6a). For chamois, on the other hand, all the long bones are mostly represented by epiphysis fragments (Fig. 13.6b), 80 % of which display digestion marks (Fig. 13.4). Bone density has been used as a proxy measure of resistance to destructive processes. For red deer, the scatterplot shows a positive and statistically significant relationship between the relative abundance of skeletal portions and their density ($r_s = 0.720$, $p < 0.01$) (Fig. 13.7). The relative abundance of chamois long bone portions, however, is not linked to their density, as is shown by the Spearman correlation coefficient ($r_s = 0.009$) (Fig. 13.8). The spatial analysis of the bone remains recorded during excavation shows an identical spatial dispersion for red deer and chamois (Fig. 13.9).

Among the specimens collected through sieving, compact bones, with or without cancellous tissue, are dominant (90.4 %); cancellous fragments represent less than 9.3 % of the remains and tooth fragments are extremely rare (0.2 %). Less than 8 % of the bone remains are burned and only 7.7 % correspond to cancellous bone fragments (Fig. 13.10).

Table 13.3 Noisetier cave: frequency of tooth-marked, cut-marked, percussion-marked and digested bones

	Tooth-marked		Digested		Cut-marked		Percussion-marked	
Red deer	2.9	(6/210)	3.2	(7/221)	40.6	(76/187)	13.8	(29/210)
Chamois	1.2	(14/1126)	73.2	(857/1,170)	2.7	(14/524)	0.5	(6/1126)

Table 13.4 Noisetier cave: frequency of tooth-marked, cut-marked, percussion-marked and digested bones on red deer and chamois middle shaft fragments

	Tooth-marked		Digested		Cut-marked		Percussion-marked	
Red deer	1.9	(2/105)	0	(49/95)	51.6	(49/95)	20.9	(22/105)
Chamois	5.7	(3/53)	17.0	(9/53)	19.6	(9/46)	9.4	(5/53)

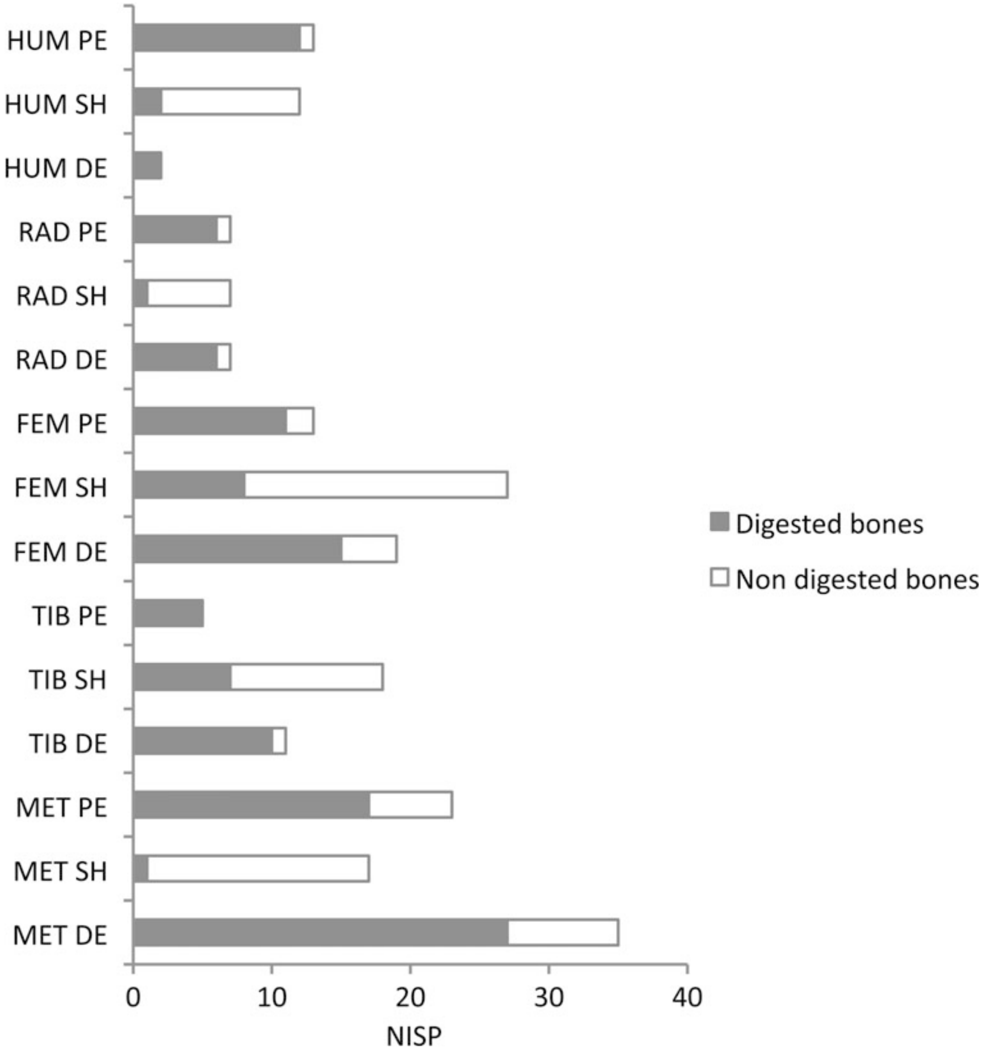


Fig. 13.4 Noisetier cave chamois: digested and non digested bones per long bone portions

Table 13.5 Noisetier cave red deer and chamois: digestion frequency per bone fragment size (length in cm)

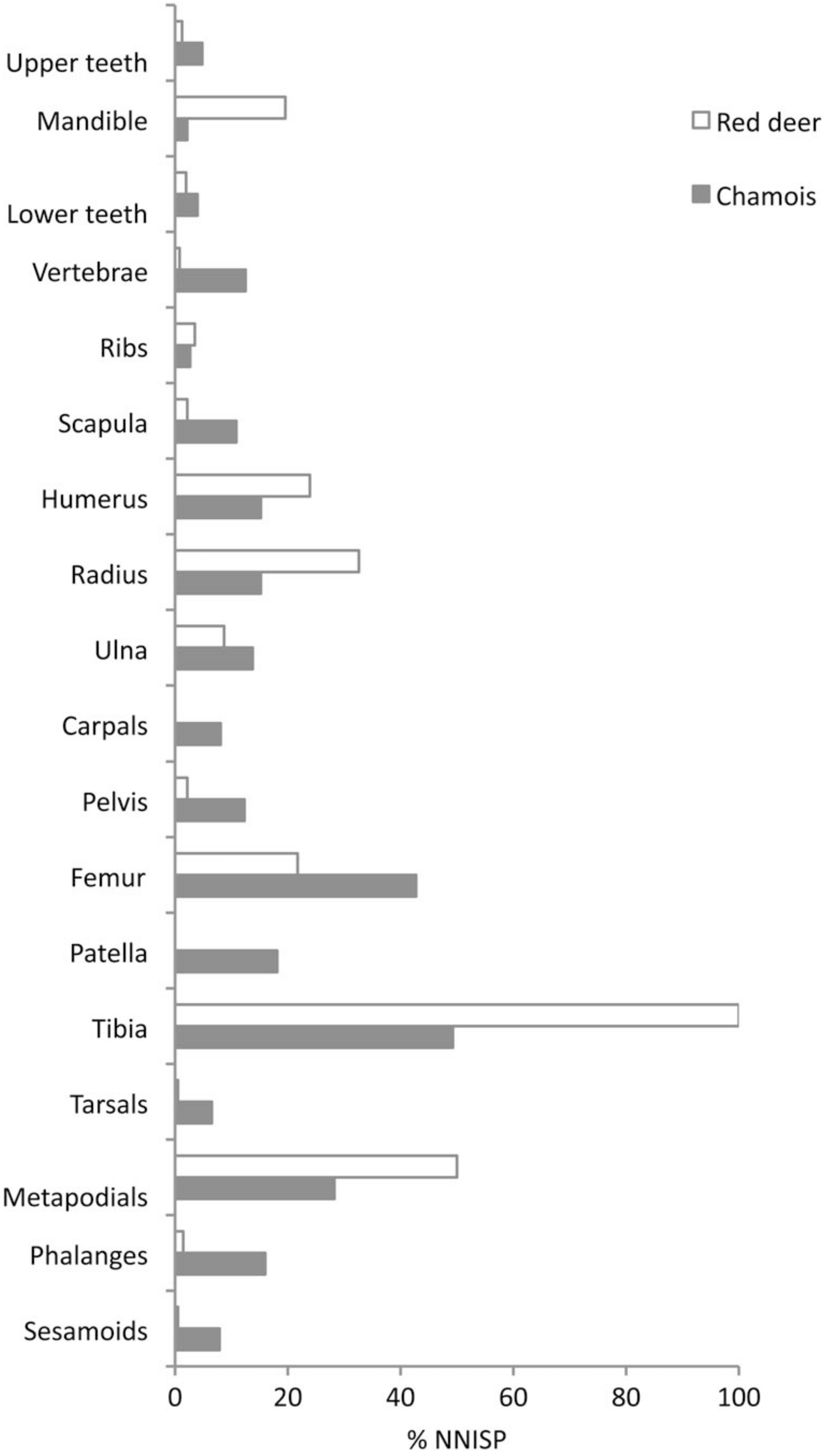
	Chamois			Red deer		
	Digested bones	Non digested bones	Digested (%)	Digested bones	Non digested bones	Digested (%)
0–1	90	21	81.1	0	0	0
1–2	598	163	75.6	2	7	22.2
2–3	148	67	68.8	3	16	15.8
3–4	20	21	48.8	2	23	8.0
4–5	1	15	6.3	0	31	0
>5	0	24	0	0	137	0

Discussion

Based on the abundance of cut marks on red deer bones and the high percentage of digested chamois bones, Costamagno et al. (2008a) and Mallye et al. (2010) argued that the red deer specimens were accumulated by humans, whereas most of the chamois specimens were accumulated by the actions of a non human predator.

The scarcity of some skeletal parts suggests that the red deer were hunted by Neanderthals who brought them into the cave in portions, which they then defleshed, as is indicated by the abundance of cut marks. The absence of complete long bones, the presence of impact points on the shaft fragments, and the fracture edges indicating that mostly fresh bone was fractured, are all evidence that long bones were fragmented to extract their marrow. The red

Fig. 13.5 Noisetier cave red deer and chamois: scaled normed NISP (%NNISP) per skeletal part



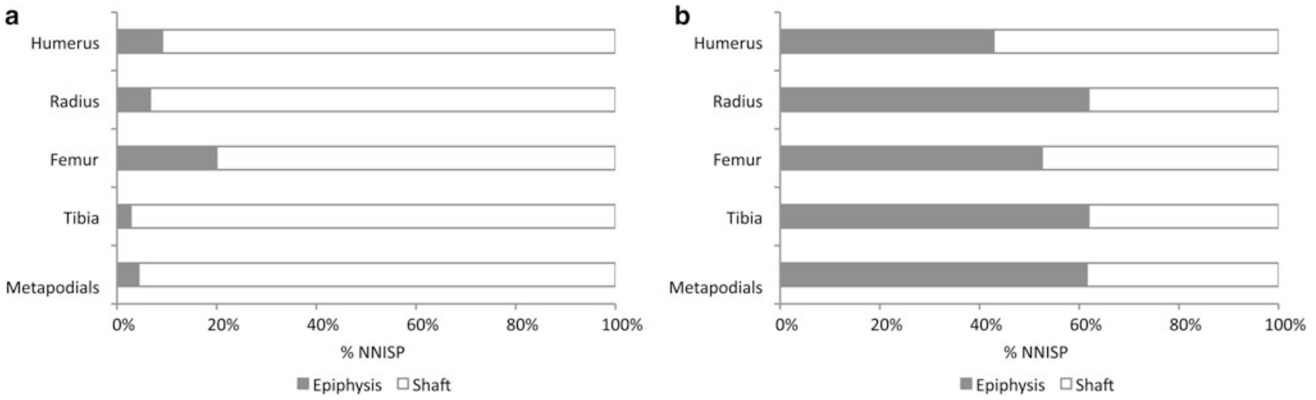


Fig. 13.6 Noisetier cave: relative abundance of epiphysis and shaft fragments per long bone. **a** Red deer. **b** Chamois

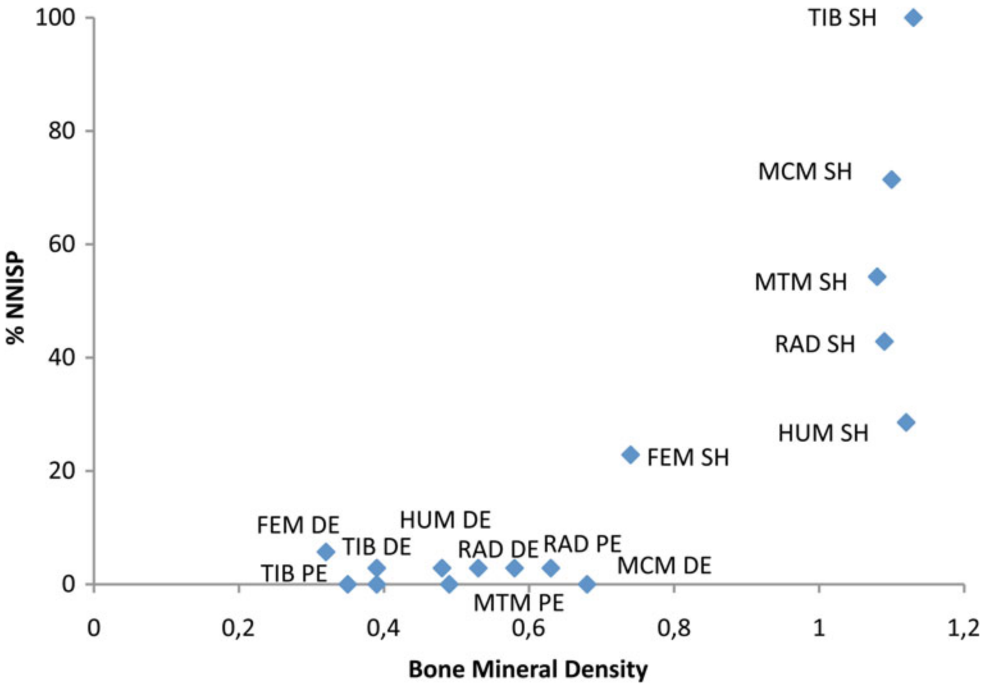


Fig. 13.7 Noisetier cave red deer: relationship between %NNISP and bone mineral density (Lam et al. 1999) (*FEM* femur, *HUM* humerus, *MCM* metacarpal, *MTM* metatarsal, *RAD* radius, *TIB* tibia, *DE* distal epiphysis fragment, *SH* shaft fragment, *PE* proximal epiphysis fragment)

deer remains are also characterized by a clear under-representation of epiphysis portions relative to long bone shafts.

The comparisons made by Mallye et al. (2010) show numerous similarities between the chamois bones accumulated in Noisetier Cave and bones originating from canid scat (Barja Nuñez and Corona-M. 2007; Esteban-Nadal et al. 2010; Mallye et al. unpublished). The percentage of digested bones provides a strong argument for a coprocoenosis. The small size of the bones (97 % of the chamois remains are less than 4 cm long), the low percentage of tooth marks and the identified skeletal elements are also characteristic of bones originating from scat (see Mallye et al. 2010 for a detailed discussion).

Conversely, the hypothesis that the chamois carcasses were scavenged after being processed by Neanderthals is difficult to support based on the available data. If we take into account the remains under 4 cm long—the maximum size of bones generally ingested by canids (Esteban-Nadal 2010)—a clear dichotomy in terms of digestion is still evident between chamois (75.9 %) and red deer (13.2 %) (Table 13.5). In addition, while the under-representation of digested red deer phalanges could be explained by differential transport, the absence of digested red deer long bones indicates clear differences between the skeletal profiles of red deer and chamois. From both a taphonomic and skeletal point of view, the two species show distinct patterns that allow us to exclude the hypothesis of an identical

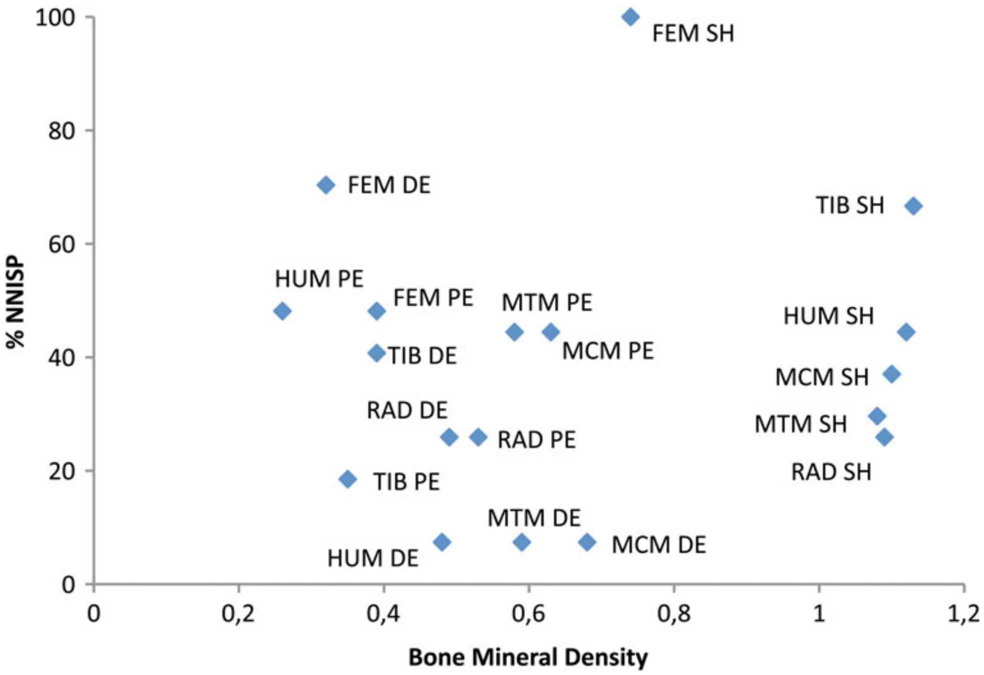


Fig. 13.8 Noisetier cave chamois: relationship between %NNISP and density (Lam et al. 1999) (*FEM* femur, *HUM* humerus, *MCM* metacarpal, *MTM* metatarsal, *RAD* radius, *TIB* tibia, *DE* distal epiphysis fragment, *SH* shaft fragment, *PE* proximal epiphysis fragment)

taphonomic history. A few chamois remains with characteristics similar to those of the red deer remains (mainly shaft fragments with or without traces) appear nonetheless to have an anthropogenic origin. The extreme rarity of red deer epiphyses raises interesting questions. Numerous studies have shown that when carnivores had access to carcasses already exploited by humans, they preferentially consumed the epiphyseal fragments due to their high fat content (Blumenschine 1988; Marean and Spencer 1991; Marean et al. 1992; Blumenschine and Marean 1993; Faith et al. 2007). These fragments are therefore often underrepresented in bone assemblages scavenged by carnivores (Marean and Kim 1998; Bartram and Marean 1999; Marean et al. 2000).

Most of the experiments simulating dual-patterned archaeofaunal assemblages (carcass processing by humans followed by scavenging by carnivores) have been conducted on hyenas (Blumenschine 1988; Marean et al. 1992; Capaldo 1998; Domínguez-Rodrigo 1997). Lacking a reference base on canids, I used the data available for hyenas to evaluate the pre-depositional ravaging of red deer bones by carnivores. At Noisetier Cave, tooth marks are present on less than 3 % of the red deer remains. This percentage is well below the values recorded for modern reference collections of carcasses exploited by humans and then scavenged by carnivores (Blumenschine 1988 (tooth-marked on long bones: 15 %); Capaldo 1998 (tooth-marked: 23.2 %)). If we consider the mid-shaft fragments, this percentage (1.9 %) is still very low compared to that recorded for assemblages secondarily scavenged by carnivores, which varies between 6.4 and 15.4 % (Blumenschine 1995; Capaldo 1998; Marean et al. 2000; Lupo and O'Connell 2002). The epiphyseal to shaft fragment ratio of red deer at Noisetier Cave is very low (0.07), corresponding to experiments in which epiphyseal loss is the highest (Seregeti fat-rich experiments, Blumenschine and Marean 1993). At these simulation sites, the proportion of tooth marks on mid-shaft fragments is significantly higher (10 %) than on the

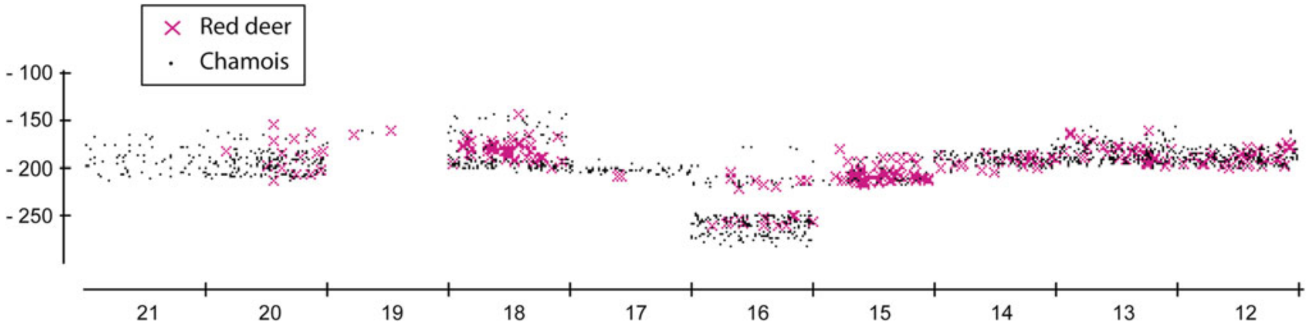


Fig. 13.9 Spatial distribution of red deer and chamois

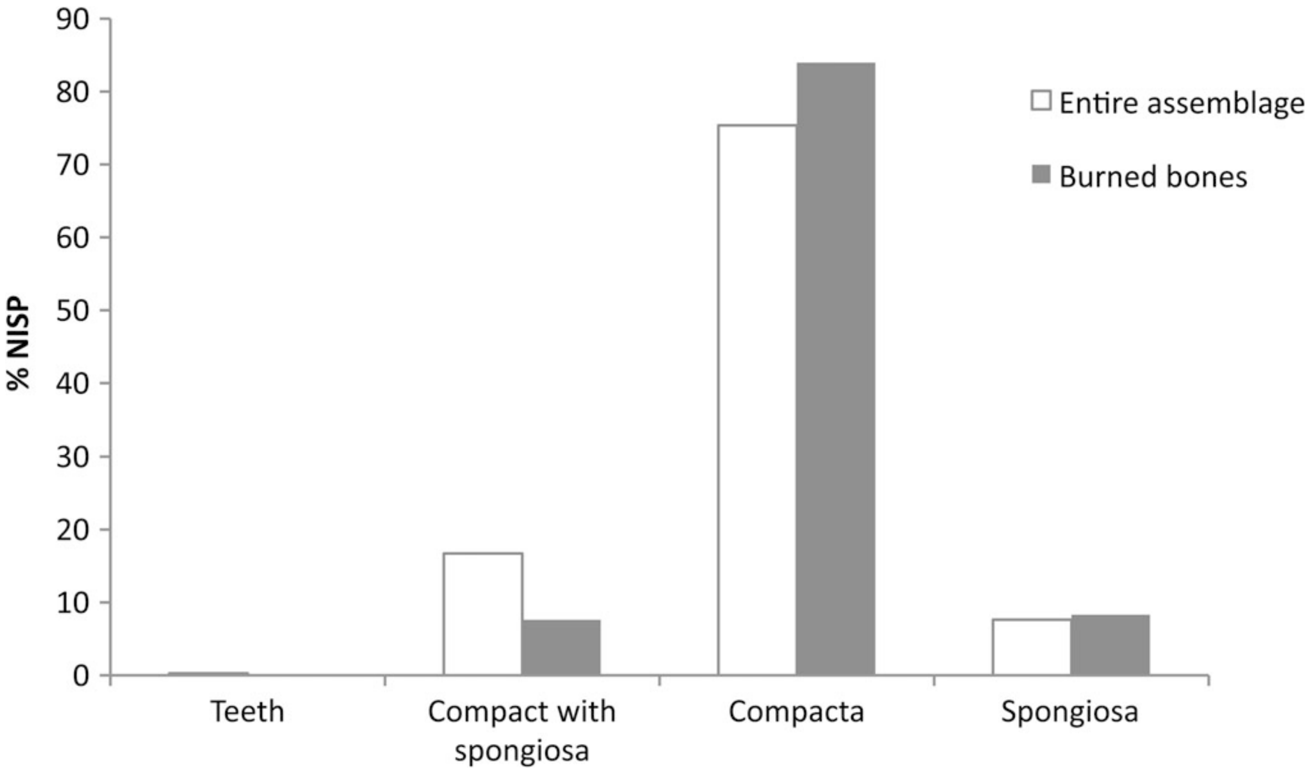


Fig. 13.10 Noisetier cave: relative proportions of bone tissue types for the entire bone assemblage and for the burned bones

red deer bones from Noisetier Cave. In destroying epiphyses, carnivores produce tooth-marked near-epiphyseal fragments in high frequencies (Blumenschine and Marean 1993). In Serengeti fat-rich assemblages, 60 % of the epiphyseal fragments are tooth marked, while at Noisetier Cave less than 5 % display tooth marks. Finally, in actualistic studies, though most of the epiphyses are swallowed by carnivores, the remaining epiphyses are commonly tooth marked, at a rate ranging from 40 to 100 % (Blumenschine and Marean 1993). At Noisetier Cave, none of the recovered red deer epiphyses have such marks. A reference base concerning canid scavenging of human-butchered assemblages would be useful from a comparative point of view, but based on the epiphyseal to shaft fragment ratio, the degree of involvement of canids should have been high for the red deer bones at Noisetier Cave. Even if we can imagine that tooth mark frequencies would be lower in assemblages scavenged by canids, it seems highly unlikely that frequencies this low could result in such a high intensity of epiphyses destruction. The hypothesis that the epiphyseal fragments are due only to ravaging by carnivore scavenging is thus difficult to support.

The use of bone as fuel is another possible cause. Several experiments have shown that: (1) the elements rich in cancellous tissue constitute effective combustion materials, in contrast to the portions composed of compact tissue[6] (Costamagno et al. 1998, 2008b; Villa et al. 2002; Théry-Parisot and Costamagno 2005; Théry-Parisot et al. 2005); and (2) the bone residues originating from intentional burning are always characterized by intensive fragmentation (Théry-Parisot et al. 2004; Costamagno et al. 2005, 2010). Consequently, a preferential use of epiphyses for burning can lead to a bias of long bone portions in favor of shafts (Lyman and O'Brien 1987). At Noisetier Cave, burned bones constitute only a very small proportion of the bone remains. In addition, among the burned bones, there are very few cancellous fragments and their relative abundance per tissue type attests to an accidental burning of remains in contact with fire (Fig. 13.10) (Costamagno et al. 2008b). The hypothesis that an intentional use of bone as fuel is the cause of the under-representation of long bone epiphyses is thus not validated.

Among the other factors that can lead to an under-representation of epiphyses, climatic-edaphic factors (i.e. duration of exposure of the bones before burial, acidity of the surrounding sedimentary matrix or water circulation) must not be neglected (Behrensmeyer 1978; Lyman 1984, 1994; Andrews 1995). As they are difficult to quantify, their

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[6] When the marrow is extracted.

action is often supposed when a positive and statistically significant relationship is revealed between the relative abundance of bones and their density. At Noisetier Cave, this type of correlation is observable for the red deer long bones (Fig. 13.7). Nonetheless, if we take the chamois bones into account, it appears that density-mediated destruction played only a minor role in the formation of the bone assemblage. Though the red deer and chamois remains were accumulated within the same sedimentary matrix, and were thus subjected to identical climatic and diagenetic agents, the epiphyses of red deer long bones are nearly absent, while they are clearly dominant among the chamois remains, and there is thus no correlation between the relative abundance of the portions and their density. The over-representation of chamois proximal and distal femur articular extremities is thus significant since these portions are among of the least dense parts of the long bones. It is therefore more probable that the scarcity of red deer long bone epiphyses is attributable to human butchery processes than to density-mediated destruction. Bone grease rendering then becomes the only process that can explain the described pattern.

The Mousterian site of Les Pradelles shows the same pattern as that of Noisetier Cave. Excavated from 1967 to 1980 by Vandermeersch, and since 2001 by Maureille and Mann, Les Pradelles (Marillac-le-Franc, Charente) is a collapsed gallery within a karstic system (Maureille et al. 2007). Its deposits yielded a Quina industry contemporaneous with the last glaciation cycle (Meignen et al. 2007). In the lowest levels, Facies 2, the faunal spectrum is largely dominated by reindeer and has an exclusively anthropogenic origin (Costamagno et al. 2006; Rendu et al. 2012). The analysis of the skeletal part representation shows a high frequency of long bone fragments, which does not seem to be associated with taphonomic problems as the bones are well preserved and the frequency of carnivore modifications is extremely low (2.7 %). The carcasses were thus introduced into the site as incomplete portions, with a preference for marrow-rich long bones (Costamagno et al. 2006; Rendu et al. 2012). As at Noisetier Cave, long bone epiphyses are poorly represented. Shaft fragments represent 95 % of the long bone sample and epiphysis fragments are on average less than 2 cm long (Fig. 13.11). The under-representation of long bone epiphyses cannot be linked to carnivore actions or to density-mediated destruction since the bones are very well preserved. No burned bones have been found at Les Pradelles. Therefore, as at Noisetier Cave, the under-representation of reindeer epiphyses may be attributable to bone grease rendering.

Noisetier Cave and Les Pradelles are not the only Mousterian sites that display this pattern. For level II of Roc de Marsal I, excavated by Dibble and Turq since 2004 (tooth-marked: 0.3 %, no burned bones), Soulier (2007) proposed bone grease rendering to explain the scarcity of reindeer long bone epiphysis (i.e. 4.6 %). Castel personal communication also observed this pattern in the lower levels of this site. According to Deaujard (2008), the red deer in level 7 of Saint-Marcel[7] (i.e. 7.1 %) and Ibex in levels b and c–d of Les Peyrards[8] (i.e. 18.7 and 15.4 %) may have been processed in the same way. All of these assemblages are characterized by a relatively low ratio of long bone epiphyses. Not all Mousterian sites are characterized by this pattern, however, as is shown at the site of Payre, level Fa, which has a high ratio of long bone epiphyses (i.e. 49.2 %).

The data presented in this paper are based on the NISP since the MNE has not yet been calculated for Noisetier Cave and Les Pradelles. One could therefore object that the high frequency of shaft fragments could be associated with marrow extraction. In the context of this activity, long bone diaphyses indeed yield many more fragments than long bone epiphyses. To test this assumption for the available sites, the percentage of epiphyses based on the NISP was compared to the percentage of epiphyses based on the MNE. The scatterplot shows a strong positive correlation between both quantitative units (Fig. 13.12). Sites where epiphysis fragments are scarce are also characterized by an under-representation of MNE epiphyses. The quantitative unit used for the analyses has no influence on the observed pattern.

No fire-cracked rocks have been found at any of the Mousterian sites discussed in this paper. Given the early date of the excavations at La Baume des Peyrards and Saint-Marcel, this absence could be linked to the excavation methods employed. At Les Pradelles, Noisetier Cave and Roc-de-Marsal, on the other hand, this is not the case. It is thus difficult to consider the possibility of hot-rock bone-boiling technologies at these three sites. Ethnological studies have shown that some hunter-gatherers chew long bone ends after marrow extraction (Schaefer and Steckle 1980; Oliver 1993). This activity produces tooth marks, but the epiphyses are not destroyed. Grinding the bones of small prey to ease consumption has also been recorded (Yohe et al. 1991; Reinhard et al. 2007; Sobolik 2008). According to Brugal (personal communication), Maasai peoples may entirely consume smashed bones. Given the need for fat in cold temperate, subarctic, and arctic environments, Marean (2005) proposed the hypothesis that Neanderthals lacking a hot-rock technology swallowed crushed cancellous bones. At Noisetier Cave, cobbles with percussion traces could be evidence of the crushing of cancellous portions. Could the ingestion of fragments of crushed cancellous bones by Neanderthals explain the scarcity of long bone epiphyses at

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[7] Excavated by Gilles from 1977 to 1988.

[8] Excavated by de Lumley from 1955 to 1969.

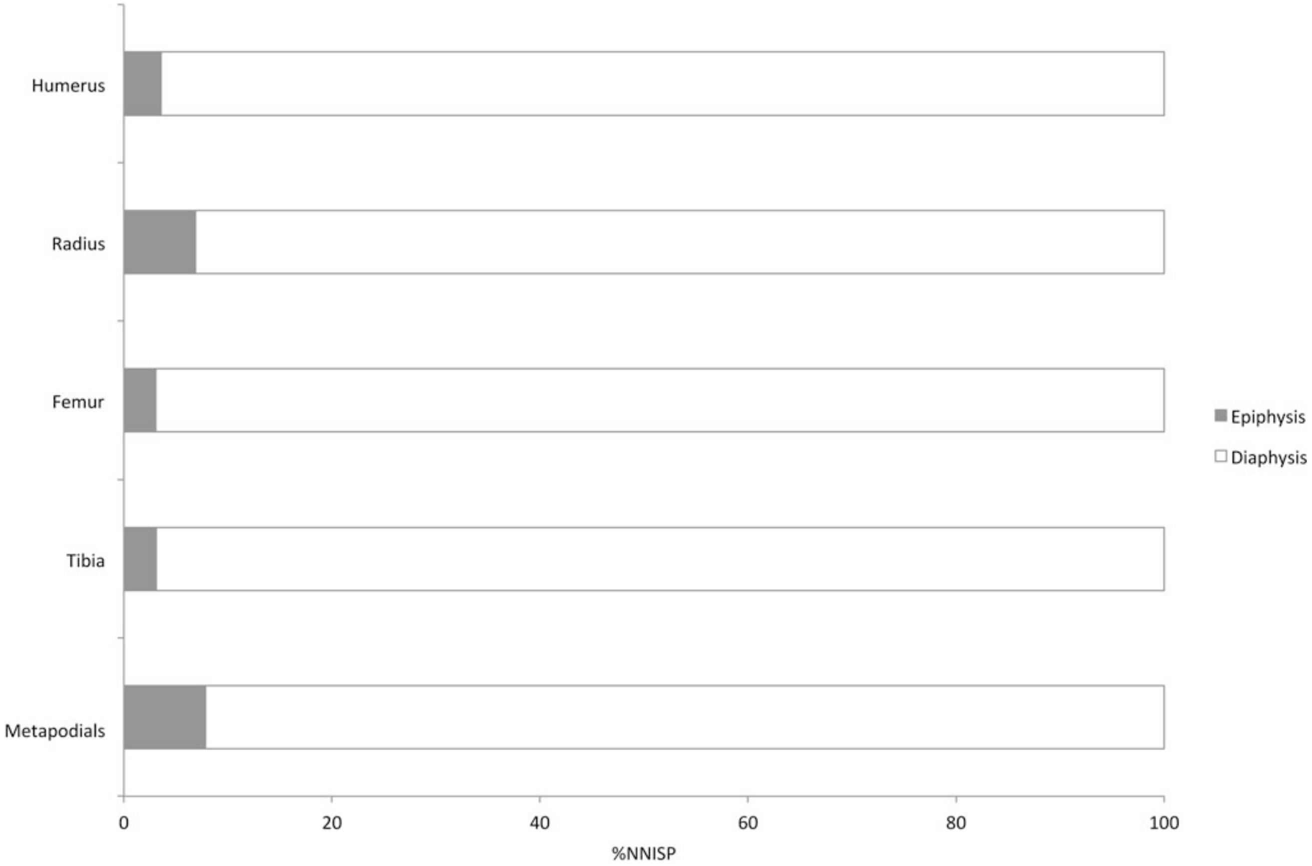

Fig. 13.11 Les Pradelles. Relative abundance of epiphysis and shaft fragments per long bone

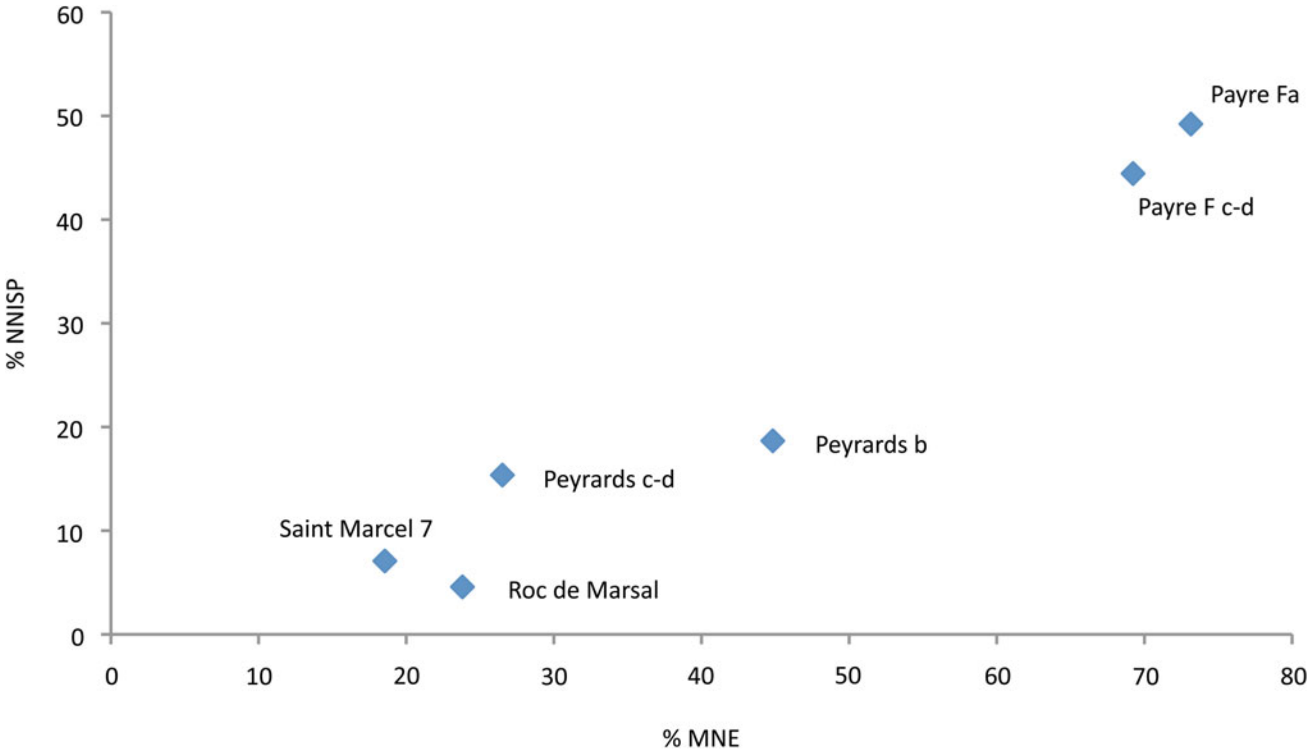

Fig. 13.12 The relationhip between %NNISP and %MNE for the ratio epiphyses/diaphyses (data from Soulier 2007 and Daujeard 2008)

some Mousterian sites? Did the resulting "bony paste" have the same capacities for storage as the bone grease rendered by boiling? Without nutritional studies, it is difficult to draw any firm conclusions. Moreover, we cannot reduce bone grease rendering to seasonal stress or resource intensification. Ethnological data on subarctic hunter-gatherers show that there are complex relationships between humans and animal fat: fat is valuable not just for food, but also for technical purposes such as skin processing, or ritual practices (Karlin and Tchesnokov 2007). It is therefore possible that Neanderthals used this substance for technical, or even cultural, purposes.

Conclusions

Taphonomic studies of the bone remains at Noisetier Cave support the hypothesis that Neanderthals extracted the fat contained within cancellous tissues. This study thus appears to indicate that as early as MIS 3, Neanderthals used technical procedures that enabled them to exploit this substance, whose extraction is known to be difficult. However, since numerous taphonomic processes can result in an under-representation of cancellous elements and/or portions, detailed taphonomic analyses must be made of each site before conclusions can be made concerning this type of exploitation.

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