Stéphane Péan & Marylène Patou-Mathis
Muséum National d'Histoire Naturelle, Paris

Taphonomy of mammoth sites

Péan, S. & Patou-Mathis M., 2003 - Taphonomy of mammoth sites - in: Reumer, J.W.F., De Vos, J. & Mol, D. (eds.) - ADVANCES IN MAMMOTH RESEARCH (Proceedings of the Second International Mammoth Conference, Rotterdam, May 16-20 1999) - DEINSEA 9: 331-346 [ISSN 0923-9308] Published 24 May 2003

In order to answer questions about the setting of faunal assemblages with mammoth remains, pertinent taphonomic criteria are proposed in a methodological way. All factors that lead to an accumulation of mammoth bones must be taken into account from the beginning of the study. Biological or non-biological hypotheses should be tested. Among the predatory agents, anthropic factors should be distinguished from carnivorous ones. If man is responsible for the accumulation, differences should be detectable between hunting and scavenging activities. The collecting strategy might have been quick (fast access to the carcass) or slow, depending on the people's needs (food or other utilisation). In order to organize this methodology, references are taken through the zooarcheological study of two open air Elephantoidea sites, En Péjouan in France (a Miocene mastodont site) and Milovice in the Czech Republic (a Late Pleistocene mammoth site), leading to a discussion about the understanding of mammoth site genesis.

Afin d'apporter des éléments de réponse quant à la mise en place d'assemblages osseux à mammouth, des critères taphonomiques pertinents sont rassemblés ici dans une perspective méthodologique. Il est nécessaire de prendre en compte tous les facteurs susceptibles de participer à une accumulation d'os de mammouth, en testant les hypothèses biologiques et non-biologiques. Parmi les agents prédateurs, il faudrait distinguer les facteurs anthropiques des interventions des carnivores. Dans les cas où l'homme est responsable de l'accumulation osseuse, des différences devraient apparaître entre les activités de chasse et de charognage. Quant à la collecte d'ossements, elle peut avoir été effectuée rapidement (accès rapide à la carcasse), ou lentement, en fonction des besoins humains (nourriture ou autre utilisation). La structuration de cette méthodologie se fera à travers l'étude archéozoologique de deux sites de plein air à Elephantoidea, En Péjouan en France (site à mastodontes du Miocène) et Milovice en République Tchèque (site à mammouths du Pléistocène supérieur), amenant alors une discussion sur la mise en place des sites à mammouth.

Correspondence: Stéphane Péan & Marylène Patou-Mathis, Muséum National d'Histoire Naturelle, Laboratoire de Préhistoire, Institut de Paléontologie Humaine, Paris, 1 rue René Panhard, 75013 Paris, France; e-mail: stpean@mnhn.fr; patmath@mnhn.fr

Keywords: mammoth, taphonomy, zooarcheology, paleolithic

INTRODUCTION

Our studies deal with mammoth-man relationships, given the fact that mammoth bones are found in different proportions in most Late Pleistocene cave and open-air sites. The finding in cave sites of mammoth molars, which must have been brought in by people, refers to human activity outside the cave, in open-air sites. Hence the study of open-air sites will shed new light on the setting of the cave sites. The impact of Paleolithic people on mammoths has very often been evocated by prehistorians under the very popular image of 'mammoth hunters'. As a result of zooarcheological studies for several decades, it is known nowadays that the presence of large mammal remains in a Paleolithic site does not mean that this animal either has been hunted or even eaten by humans. Many taphonomical agents, responsible for bone accumulations, have already been identified and described in literature (synthetic books, e.g.: Lyman 1994, Patou-Mathis [ed.] 1994). The questions about subsistence practices of Paleolithic people are not clear yet regarding the techniques that humans used to acquire remains of the biggest herbivores, notably mammoths or rhinos (Auguste *et al.* 1998). In order to determine the human impact on the setting of mammoth bone accumulations in open-air sites, a taphonomic methodology will be proposed here. It has been built by looking for pertinent field data that can be linked to hypotheses given by present observations, i.e. observations such as eco-ethological features of modern elephants (*cf.* Haynes 1991), and, if available, ethnoarcheological experiments. It will be shown how further data about bone heaps of other fossil *Elephantoidea*, like mastodonts, can also be very informative.

SETTING A METHODOLOGY

The methodology about the setting of a mammoth bone assemblage is shown in a synthetic diagram (Fig. 1). Different specific data are proposed for each possibility of death cause. Four types of information have to be considered together.

Paleo-environmental data: geomorphological studies, landscape reconstruction, impact of altitude; plant cover (open or wooded) after palynological diagrams and plant macro-remains, faunal associations (rodents, large mammals, molluscs); climate; sediment (nature, structure, and chemical properties); presence of water (river, swamp, etc.).

Archeological data: precise stratigraphy to answer the question of single-event/multi-event/time-average recording; lithic and bone artefacts (density, typology, technology); art items; hearths; spatial organization (of lithic tools and bones).

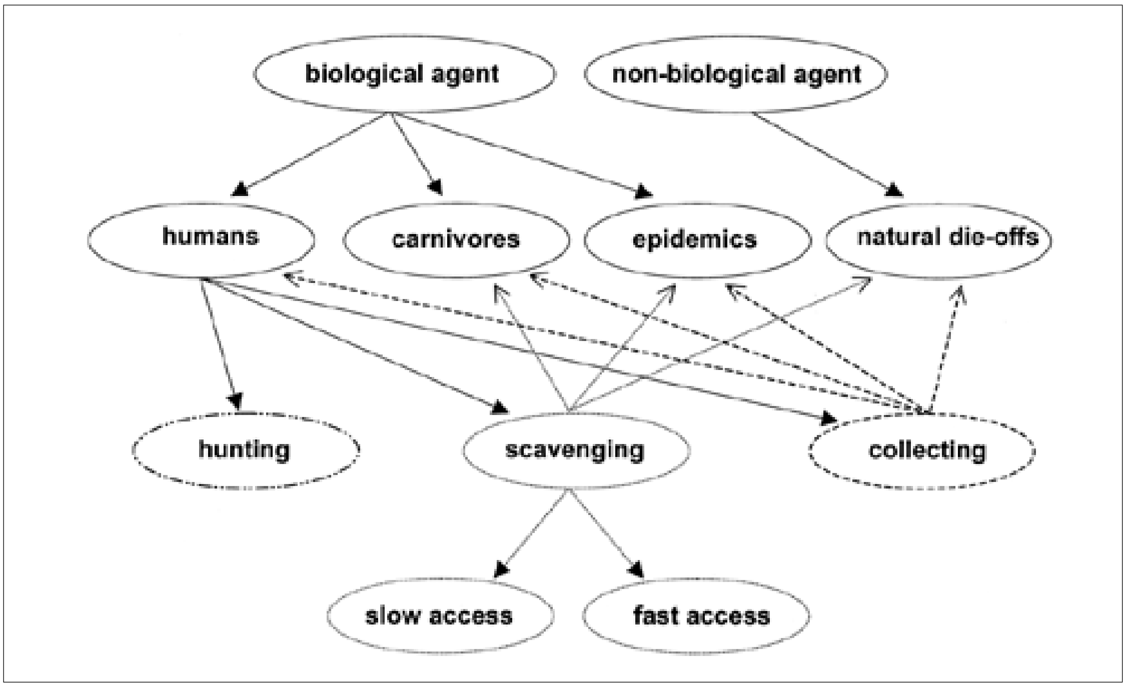

Figure 1 Setting of a mammoth bones assemblage: methodological diagram showing the different factors which can interfere in the accumulating process.

Taphonomical data: climatic and edaphic modification (weathering), notably still questionable under periglacial climate; exfoliation due to freezing/thawing; water modifications (abrasion, transport); gnawing by carnivores, rodents and herbivores; breakage pattern; plant root marks; striations (carriage, butchery); chemical processes.

Zooarcheological data: mammoth age profile (determined from stage of molar wear or stage of epiphyses fusion); sex distribution; paleopathology; bone representation presented in terms of identified specimens, anatomical elements, and preserved parts for each skeleton element; remains of taxa other than Proboscideans.

Death by a natural non-biological event

Sinkholes act as natural traps for large mammals such as proboscideans. They can be present in a swampy environment. Under a periglacial climate, potholes are known to appear at the end of the cold season, when the upper soil (mollisol) thaws. Other natural traps are crevasses into which mammoths can fall. In such a natural mammoth site a few lithic artefacts, though not diversified, may be present. We would speak in this case of a secondary human influence. In case of a fluviatile environment, linked to a swampy area, modifications caused by the water should be observed on the faunal material, such as rounded bones. If the environment is fluviatile, we should observe a specific sorting of anatomical elements (Voorhies 1969). On the contrary, (a) whole skeleton(s) should be found if the animal(s) has(have) been trapped in a hole. As for the age profile, it should show an attritional distribution, typical of a living population.

Death by big carnivores

Large predators such as cave lions and hyaenas are present in many Pleistocene environments. Especially hyaenas provoke large accumulations of bones in caves, as is known from recent observations of hyaena dens (e.g. Sutcliffe 1970; Villa & Bartram 1996). Their predatory activity obviously begins outside the cave. Even big carnivores cannot be responsible for killing a whole herd of proboscideans, but they can attack young and single individuals. In order to apply such behaviour to mammoths, we must assume that ancient Elephantidae had a social behaviour similar to modern elephants. That means that they lived in herds, except for young male adults or very old individuals that lived as singles. Young individuals, whether trapped or in time of environmental stress, must have been a good prey. These specific age classes should then appear in the mammoth age profile. Again, a secondary human influence may be noted, in the form of few, not diversified, lithic artefacts. Carnivores leave very specific marks on bones: gnawed off epiphysis, pits due to the canine teeth, fresh bone breaking patterns (long bones modified into shaft cylinders). The bones represented should indicate a lack of rich meaty parts.

Kill and butchery site

According to the site function different types of Paleolithic settlements have been defined on zooarcheological studies (Patou-Mathis 1994). First, we present features linked to kill and butchery sites. This type of deposit should be linked to specific environments showing trapping opportunities. Traps cannot have been made by humans in periglacial environments due to the difficulty of digging into permafrost. This situation occured in most European areas (except the Mediterranean) during the glacial periods. Natural traps must have been used instead, such as swamps during thawing times in spring, or cliffs or crevasses. A close relationship between the stone tools and the bones should be noted from the spatial distribution of the archeological artefacts.

On a kill site, hunting projectiles should be found, unless entirely wooden weapons were used. Examples are known in some North American Clovis sites showing stone points closely associated with mammoth remains. Uncertainties remain so far about possible weapons used to kill mammoths.

Butchering is expected to start on the death site. So it may appear difficult to distinguish kill sites from butchering sites. Finding butchering tools clearly shows anthropic activity on a deposit. Referring to studies about butchery of modern elephants in Africa, cut-marks may be present but not necessarily so. Flesh can be so thick that tools have been noted not to reach the skeletal elements, thus leaving no cut-mark on the bones. However, features of striking impacts should be seen on long bone diaphyses, associated with breaking pattern of fresh bones (spiral fractures). The bone representation should be characterised by a lack of meat-rich parts. Young individuals should be predominant in the age profile.

Camp site

This type of deposit is archeologically well determined. Many data such as the number and diversity of tools, the presence of hearths, areas of different activities as shown by the spatial distribution, characterise a human settlement. Worked bones and tusks are interesting (used to make tools and furniture). Then comes the major question: do the mammoth remains originate from hunting or scavenging, or have they only been collected?

Hunting or scavenging?

First it must be told that it is still difficult to differentiate between hunting and fast access scavenging. In both cases, the same taphonomical modifications can be seen: cut-marks and striking impacts on fresh bones. However, two main types of bone representation can appear: either a selection of meat/rich parts, which indicates hunting or fast access scavenging, or a predominance of parts poor in meat, which shows late access scavenging, i.e. after predators have taken the best parts. The age profile can be very diverse. In case of hunting or scavenging from a carnivore kill, the population of mammoth should be composed of young individuals. Scavenging from a natural die-off should lead to a living population profile (attritional). If the site corresponds to a long or seasonal settlement, the age profile should be time-averaged.

Collecting

Collected bones should show features characteristic for a long stay on the soil surface or subsurface, such as plant root marks, different stages of weathering, gnawing marks, and possibly water modifications. The breaking pattern should mostly be typical for dry skeletal elements (irregular breaking lines). The bones present should be tusks, linked to art items, or large flat and limb bones used as raw material to build huts. The predominant age class should be big adults, adapted to the supposed expected size of the raw material.

METHODS AND QUANTITATIVE CONVENTIONS

As zooarcheologists and paleontologists do not always use quantitative faunal indices in a similar manner, we will precise how we counted the material. Only identified bone specimens will be taken into account (NISP), leading to a Minimum Number of anatomical Elements (MNE). The combined Minimum Number of Individuals (cMNI) is determined for each anatomical element, by combining information such as left/right side ('latéralité'), age, size, and reassembling ('remontage') (Poplin 1983). The calculation of relative Minimum Animal Unit (MAU), i.e. elementMAU/maxMAU, follows Binford (1978): MNE/Qsp. This specific ratio (Qsp) is equal to the total number of each anatomical element within one species.

Another index, Survival Percentage (Ps, 'Pourcentage de survie'), takes into account the precision of MAU calculation, relative to the maximum combined Minimum Number of Individuals (Ps = elementMAU / max cMNI). As the number of molars evolves during Elephantid life, the calculation of MAU (and Ps 'a fortiori') for this anatomical element has no meaning. However, this element, considered both the molars embedded in mandible or maxilla and the isolated ones, gives the maximum value of cMNI in the studied samples. It should be precised that, in Elephantids, the mandible is considered a unit (Qsp = 1) due to the early fusion of the mandibular symphysis, whereas maxillae are counted by halves (Qsp = 2).

A MIOCENE EXAMPLE: EN PEJOUAN

Environment

En Péjouan is a Middle Miocene site located in the South Aquitaine Basin (France). It was excavated by L. Ginsburg, C. de Muizon and P. Tassy (Ginsburg *et al.* 1975). The faunal remains are dominated by one mastodont species: *Gomphotherium angustidens*. Studying the taphonomy of this Neogene site is particularly interesting for the obvious lack of human impact (Péan *et al.* 1998). This open-air site lies in clastic sediments, linked to a changing water stream paleoenvironment with a warm to subtropical climate, in wooded savannah.

Taphonomy

The bones do not show clear carnivore activity. A few rodent marks have been noticed however. A strong weathering process has modified bones. 'In' and 'out' transport by water is evidenced by the sorting of the skeletal elements. Water streaming has been also noticed. Large flat bones, such as innominates, have been found with a mosaic breaking pattern, indicating trampling and/or sediment packing. Root marks have been also observed.

Faunal data

The predominating gomphotheres are represented by 30 individuals (cMNI), out of a total fauna of 70 large mammal individuals (Fig. 2). The proboscidean age profile shows a distribution in almost every age class, with notably a rather high number of old individuals (Fig. 3), based on dental criteria defined by Tassy (1985 *in* Tassy 1996). The bones were found without any anatomical connection. The small bones (hand/foot, axial skeleton) are clearly missing (Fig. 4).

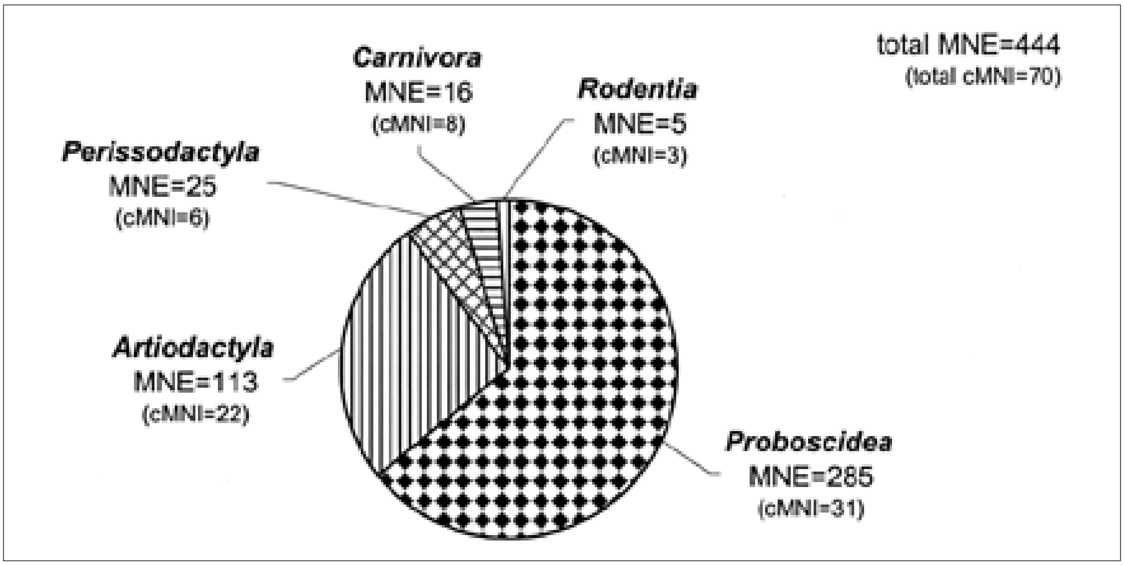

Figure 2 Fauna at En Péjouan (South Aquitaine Basin - Miocene). Proportion in Minimum Number of Elements (and indication of combined Minimum Number of Individuals). Proboscidea: *Gomphotherium angustidens*; (*Archaeobelodon filholi*: 1 milk tooth).

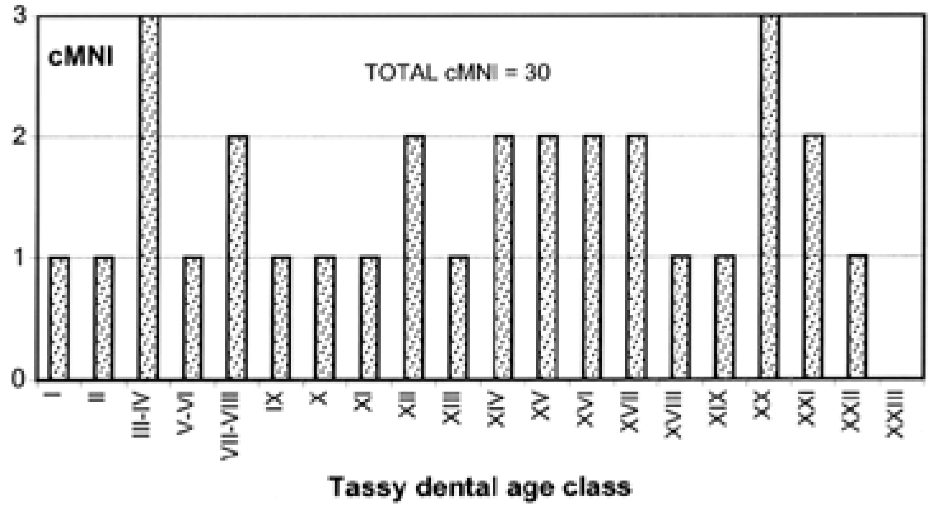

Figure 3 Gomphothere "age profile" at En Péjouan (South Aquitaine Basin - Miocene). **cMNI** = combined Minimum Number of Individuals.

AN UPPER PALEOLITHIC EXAMPLE: MILOVICE - SECTOR G

Environment

Milovice is located in South Moravia (Czech Republic). The field works were conducted by Oliva (1988). This fauna dates from the last Interpleniglacial of the Late Pleistocene (late OIS 3) and is dominated by *Mammuthus primigenius*. It lies on a slope, in a small dry blind valley, in loessic sediments. The paleo-environment was an open coniferous wood-land.

Archeology

The site consists mostly of a thick Gravettian layer (Upper Paleolithic). Most archeological finds come from sector G: lithic tools, one hearth, one circular structure made of mammoth bones. Oliva (1988) described this bone circle, surrounding an area with a lower density of stone tools than outside, as a hut. The lithic implements (Oliva 1999) are mainly composed of small debitage, among which retouched tools (10% of the total inventory) are dominated by backed points (gravettes, microgravettes), with a frequently added ventral flat retouch, some *fléchettes* and shouldered points. Almost no core has been found. The site has been interpreted as a place to produce and resharpen tools, based on the study of the lithic artefacts. Only a few hollowed reindeer antlers, sometimes incised, have been found as worked bones. There is no worked ivory.

Taphonomy

A zooarcheological study has been carried on the faunal material from sector G (Péan & Oliva 1998). Nearly all material (97%) shows a high stage of weathering. Many plant root marks have modified the bone surfaces. The distal epicondylian crest of seven mammoth humerus shafts, plus one humerus distal end, have been gnawed by big carnivores. There is no water modification.

Zooarcheology

In sector G, 21 mammoth individuals (cMNI) have been identified among a total fauna of 40 large mammal individuals (Fig. 5). Other fauna includes reindeer, horse, wolf, cave lion, wolverine and fox. Based on dental criteria defined by Laws (1966), the mammoth population appears dominated by young mammoths, mainly juveniles and subadults (Fig. 6). The mammoth bones do not show any anatomical connection. There is a low

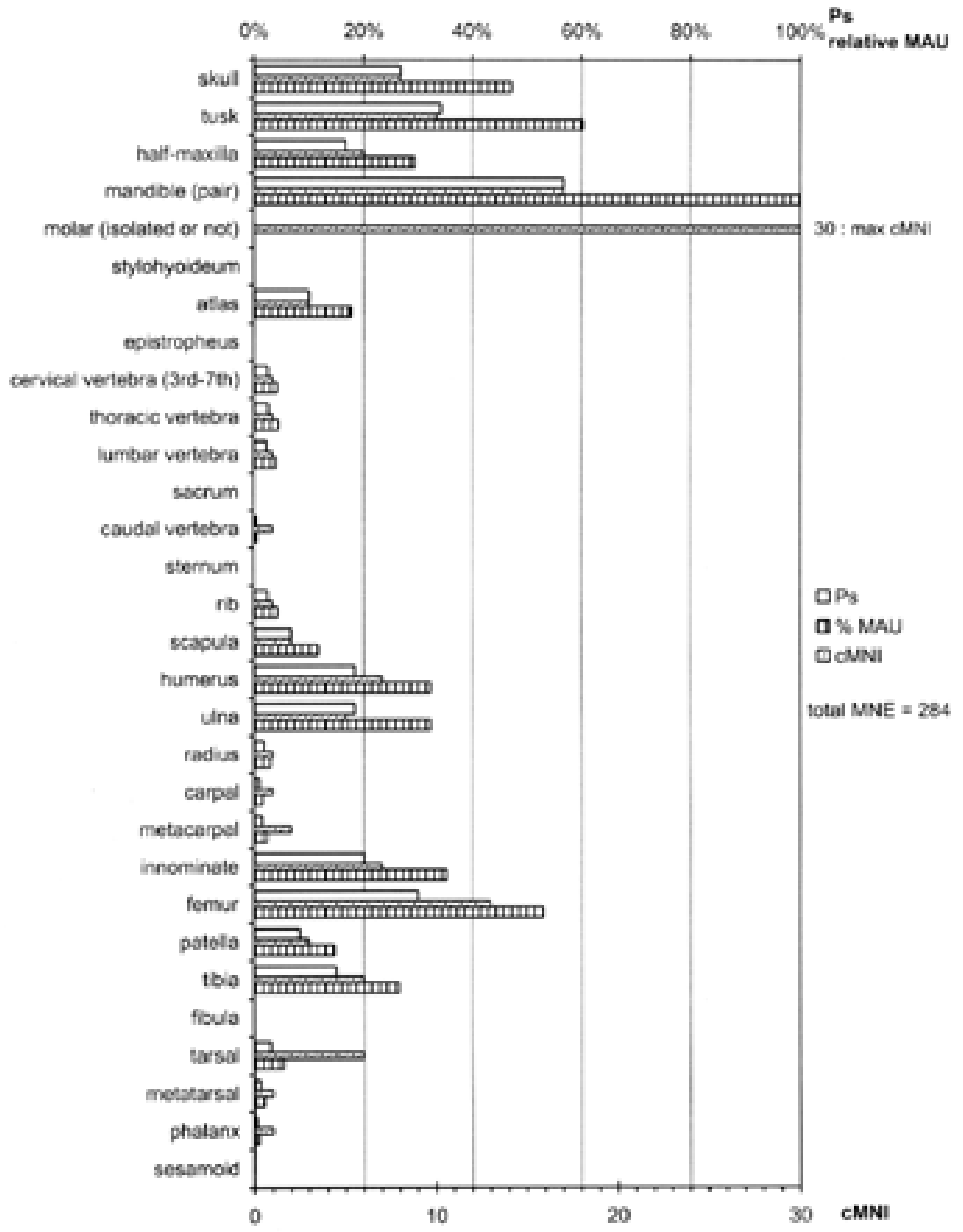

Figure 4 Gomphothere bone distribution at En Péjouan (South Aquitaine Basin - Miocene). **Ps** = survival Percentage; **MAU** = Minimum Animal Unit; **cMNI** = combined Minimum Number of Individuals.

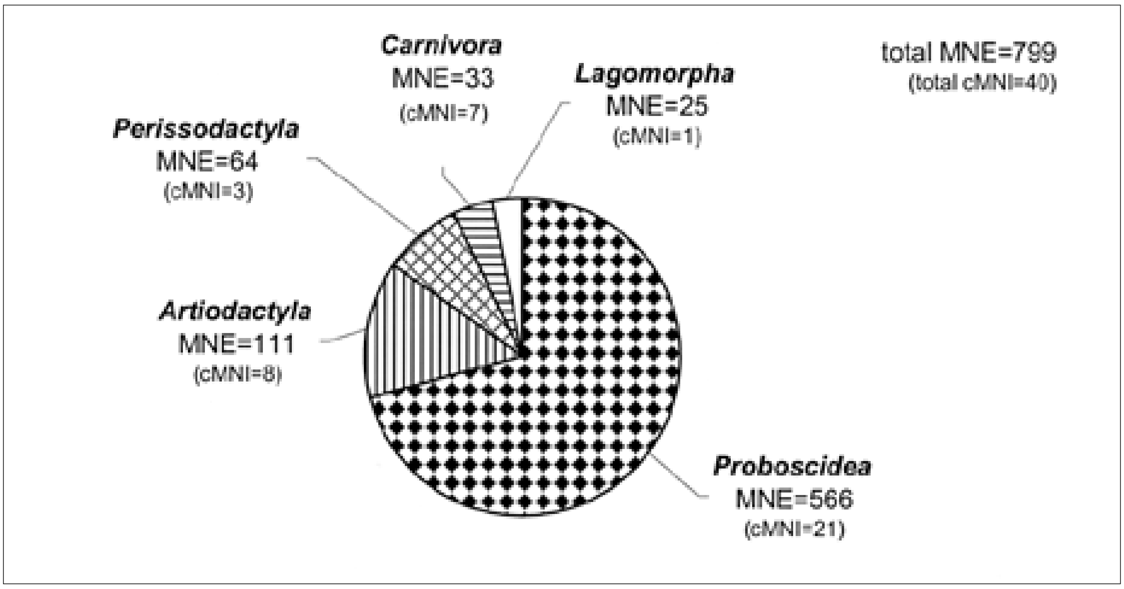

Figure 5 Fauna at Milovice-G (South Moravia - Late Pleistocene - Upper Palaeolithic). Proportion in Minimum Number of Elements (and indication of combined Minimum Number of Individuals). Proboscidea : *Mammuthus primigenius*.

proportion of distal limb bones, especially foot bones and vertebrae, but almost every anatomical part is present (exept caudal vertebrae) (Fig. 7). It proves that the mammoths died *in situ*. Trampling breakage patterns have been also noted. The reindeer antlers (five quite small shed antlers, one full-grown antler from a slaughtered male individual) and one decidual horse tooth seem to indicate an early summer season of settlement.

DISCUSSION, CONCLUSION AND PERSPECTIVES

Yet another mammoth site from the literature will be taken into account in this chapter: la Cotte Saint Brelade. This famous site, located

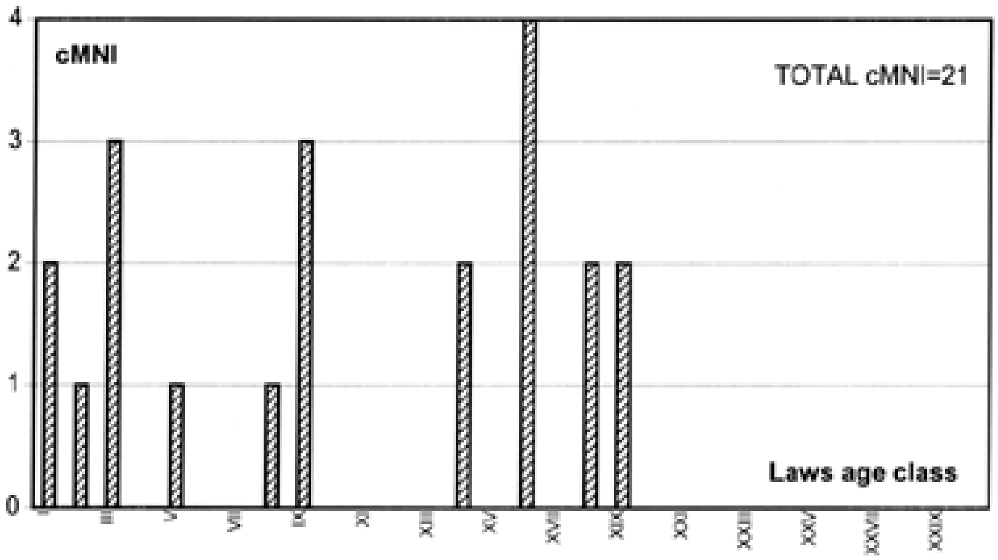

Figure 6 Mammoth 'age profile' at Milovice G (South Moravia - Late Pleistocene). cMNI = combined Minimum Number of Individuals.

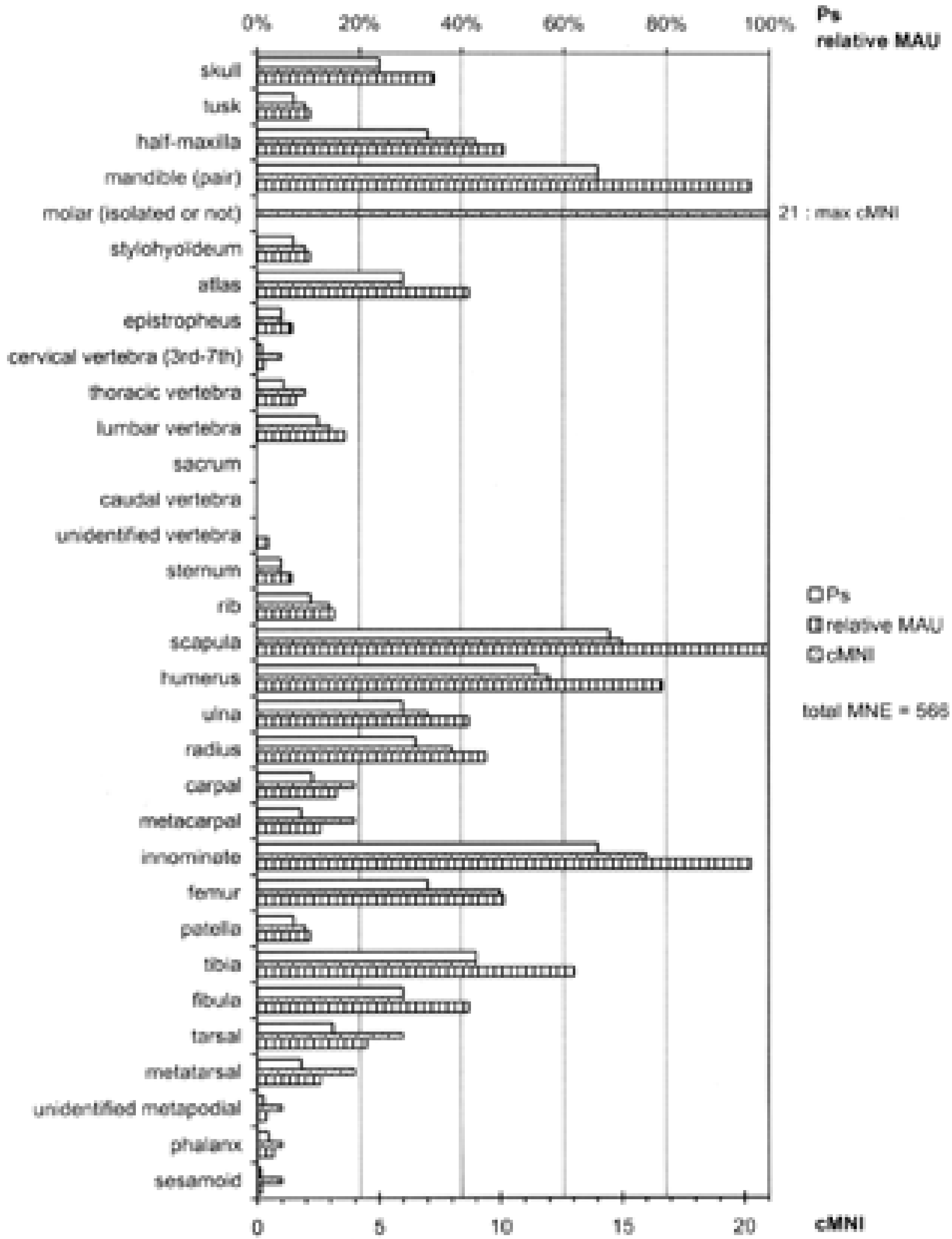

Figure 7 Mammoth bone distribution at Milovice G (south Moravia - Upper Pleistocene - Upper Paleolithic). **Ps** = survival percentage; **MAU** = Minimum Animal Unit; **cMNI** = combined Minimum Number of Individuals.

in Jersey (Channel Islands) and dated to the Middle Pleistocene (OIS 6), is known for its accumulation of mammoth (*Mammuthus primigenius*) and woolly rhino (*Coelodonta antiquitatis*) remains, and Middle Paleolithic implements (Callow & Cornford 1986). Here we will compare the different types of data, as defined in our methodology, between the three sites, to show how the bone deposits have formed. Climatic and geomorphological backgrounds are different. En Péjouan and Milovice are two open air sites, but the former was deposited during a warm climate and in a fluviatile environment, whereas the latter formed during glacial times and in an arid region judging by the loessic sediments. Milovice is specifically located on a gentle slope of a secondary small blind valley, among the Pavlov hills which overlie an alluvial plain. La Cotte Saint Brelade is a cave or partly-roofed shelter, presently at the bottom of a sheer cliff on the south-west coast of Jersey Island. During Middle Pleistocene times it overlaid a broad coastal plain at the end of a steep-sided grassy highland when under glacial climate. No water-caused modification of this bone deposit is observed.

As a Miocene site, En Péjouan obviously lacks anthropic disturbance. For Milovice, the zooarcheological study presented here concerns one sector (G) of the site only. This is *a priori* the most interesting one for paleoethnographic research, because most of the archeological remains of the site (lithic tools, hearths, and a spatial circular structure interpreted by the finder as a hut) are found there. Among the predominant small debitage material, the main retouched tools present a backed shape and may have been used as projectiles. However, in our opinion the small size of these possible weapons may not have been sufficient to kill mammoths. As for the clean circular area surrounded by mammoth bones, we propose that it could result from a butchering process. In La Cotte Saint Brelade (Scott 1989), each of the two different levels with piles of mammoth bones (layer 3 and 6) repectively lies above cultural layers with Middle Paleolithic lithic implements. Retouched tools represent 25-30% of the total inventory. Stratigraphical uncertainty remains for the stone artefacts at the interface between cultural and pile levels.

En Péjouan gives data about mainly climato-edaphic taphonomic modifications, as carnivore activities seem not to be well developed. Fluviatile clastic sediments have abraded (or even broken) the bone surface. The observation of serialised process show how the site has been set up diachronically. The loessic sediments in Milovice-G, lacking any trace of water, have well preserved the bone. However, the emphasized weathering modifications indicate a slow burial, although many questions remain about the periglacial weathering process. A low impact of carnivore activity is clearer in the faunal material of Milovice G. This must have disturbed at least the spatial distribution of the bones. According to the zooarcheological study (Scott 1989), mammoth bone surfaces remained well protected from weathering at the time of field works observations in La Cotte Saint Brelade. There are no carnivore gnawing marks on the surface of a certain number of bones that were not chemically damaged by the process of removing the bone from the matrix. Unfused epiphyses have not been found.

The age profiles of the En Péjouan gomphotheres (Fig. 3) and the Milovice-G mammoths (Fig. 6), are presented in a synthetic comparative diagram (Fig. 8). Dental age classes are gathered into 5 groups, which we name: juveniles, young adults, adults 1, adults 2, and old adults. This method, defined by Haynes (1987, 1991) for modern African elephants and fossil proboscideans, is based on observations of dental criteria and of the physiological development. Considering a life span of about 60 years (noted AEY=African Elephants Years), ages are gathered in 12-year-intervals. Table 1 presents our attempt to establish parallel development stages, based on lower cheekteeth wearing patterns, between *Mammuthus primigenius* and *Gomphotherium angustidens*:

data come from: (1) the 30 (XXX) age classes defined by Laws (1966) for *Loxodonta africana*, which can be used for *Mammuthus primigenius*, (2) the corresponding ages in AEY according to Haynes (1991), and (3) the 23(XXIII) age classes defined by Tassy (1985 in Tassy 1996) for *Gomphotherium angustidens*. The definition of the oldest group in *G. angustidens* remains questionable: the lack of upper wear stage, beyond the XXIIIrd one, seems to indicate a lack of senile individuals in the En Péjouan sample, but it could also mean that gomphotheres had a slower teeth wearing tempo than elephantids. However, these uncertainties do not basically change the following interpretations about general age profiles.

The gomphothere age profile at En-Péjouan shows an attritional pattern with middle-aged adults poorly represented. En Péjouan is a good illustration of a natural (non-biological) die-off, probably due to environmental stress, possibly a drought. The mammoth age profile at Milovice-G, showing a predominance of juveniles and other classes in decreasing proportions (Haynes' type A), represents a catastrophic mortality, without selection (adults are less under-represented compared to young individuals). In La Cotte Saint Brelade, the mammoths are dominated by young individuals, from juveniles (2 years old) to middle-aged adults (25 years old). It could be due to a selective mortality process, but also to non-selective death events following previous selecting dying processes (Haynes 1991).

The comparison of bone preservation between the En Péjouan gomphotheres (Fig. 4) and the Milovice-G mammoths (Fig. 7) is summarised in Figure 9, which presents relative survival for different anatomical parts. It shows a low proportion of bone remains when compared to teeth, especially for the gomphotheres (maximal Ps=19%), but also for the mammoths (maximal Ps=46%). In both sites, there is a parallel low representation of axial bones (vertebra and rib) and distal limb bones (radius, ulna, carpals, tibia, fibula, tarsals, metapodials, and phalanges) compared to cranial bones and proximal limb bones (scapula, humerus, innominate and femur). The low presence of small bones (hand/foot and vertebrae) in En Péjouan is explained by the fluvial paleo-environment, which is not the case in Milovice-G loess sediments. There, small bones have probably partly suffered a natural differential preservation among anatomical elements (*cf.* 'conservation théorique' by Bouchud 1975), but have

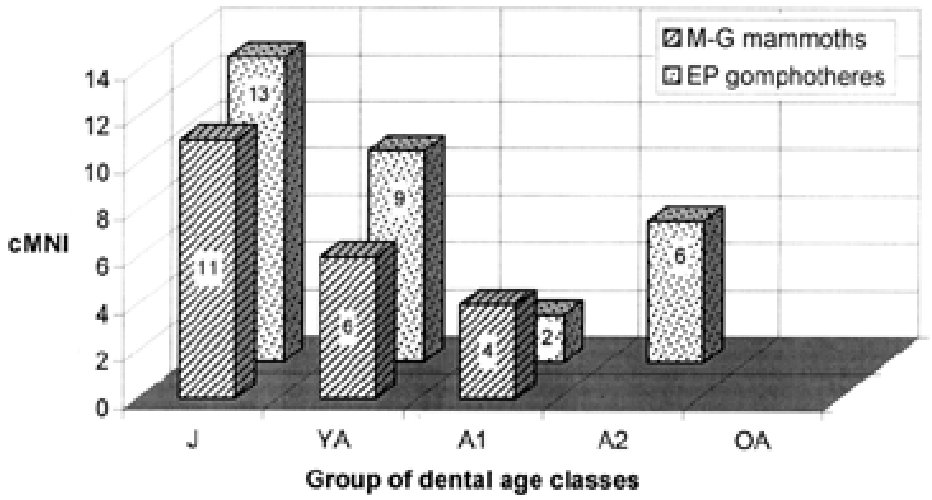

Figure 8 Compared Proboscidean 'age profile' at Milovice-G (**M-G**) and En Péjouan (**EP**). **cMNI** = combined Minimum Number of Individuals.

also been taken away by predators, notably humans (for food?). In La Cotte St Brelade distal limb bones are poorly represented as well, perhaps carried away by predators (humans or large carnivores; Scott 1989). It appears that water on the one hand and predator activity on the other, lead to a similar distribution of anatomical elements in these proboscidean bone deposits.

The preservation of ribs is difficult to interpret, because of the under-counting of this element among the bone materials. The great preservation of scapula and innominate as well as limb long bones in Milovice-G is particularly impressing. It indicates that human people did not use the mammoth bodies to the very limit of subsistence and raw material resource. Compared to En Péjouan, it seems to be linked to a lesser impact of other breaking agents, such as trampling or sediment packing. This taphonomical feature is in agreement with the proposal of a one-event recording in Milovice, as observed during the field works. The better preservation of tusk in Milovice-G is noticeable (the additional lower pair of incisors in *Gomphotherium angustidens*, in comparison to mammoths, has been taken into account in the quantification). This might perhaps be due to the impact of Gravettian people collecting raw material for ivory working. No ivory item has been found in Milovice, but two famous Gravettian sites, Pavlov and Dolní Věstonice, contain such items and are located just a few kilometers away (Absolon 1938; Klíma 1954, 1995; Svoboda [ed.] 1994).

In comparison to the distribution of anatomical elements in En Péjouan, we assume that mammoths in Milovice-G have died *in situ*, and then skeletal parts were moved out of the site (Fig. 9). It validates the hypothesis of a kill site or a quick access scavenge site. Some breaking features in La Cotte mammoth bones seem to occur several times, and are partly attributed to people (Scott 1989). No cut mark has been observed, except on two tusks. Human activity appears more convincing in the stacking of mammoth scapulae and skulls. In the case La Cotte St Brelade, the anthropic influence on the accumulation

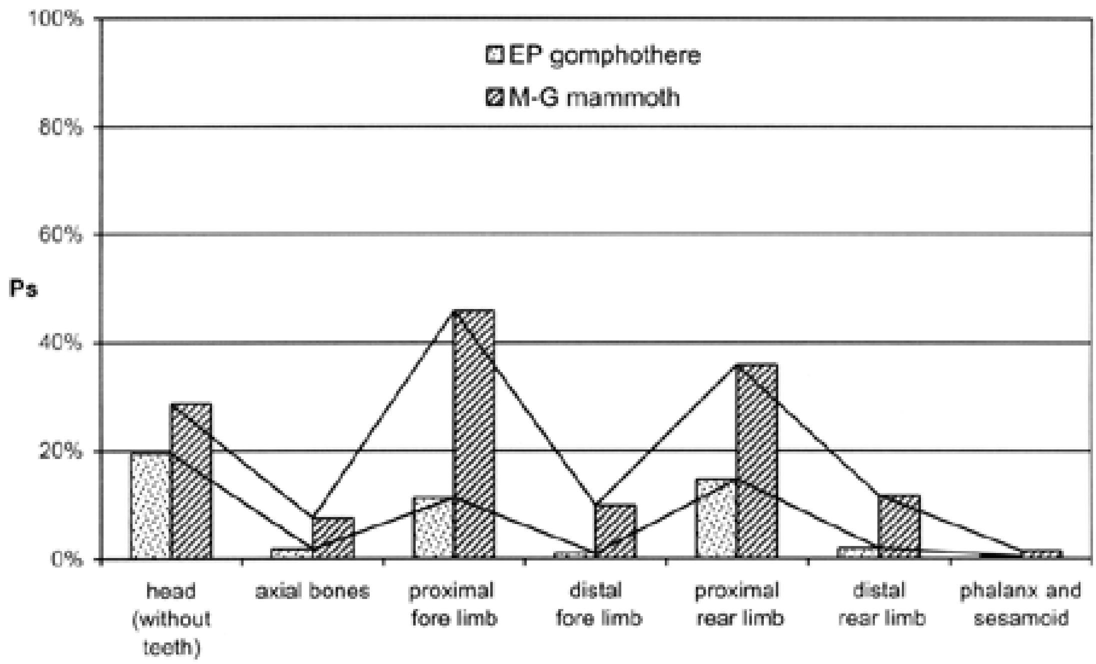

Figure 9 Compared bone preservation between En Péjouan (**E P**) gomphotheres and Milovice-G (**M-G**) mammoths. **Ps** = survival Percentage

Table 1 Attempted relationships between Laws age classes for *L. africana*, equivalent African Elephant Years according to Haynes, and Tassy age classes for *G. angustidens*.

name used in this study	Haynes group	Laws age class	Laws definition	Haynes AEY	Tassy age class	Tassy definition
	Loxodonta africana				*Gomphotherium angustidens*	
J: juveniles	0-12 AEY	I	dp/2: unworn	0,3	I	dp/2: unworn dp/3: unworn
		X	dp/4: smooth M/1: 75% worn	~9-10	XII	P/3: wear figures (coalescent) P/4: wear facets (figures) M/1: 75% worn
YA: young adults	13-24 AEY	XI	dp/4: gone M/1: 100% worn	~10-14	XIII	P/3: coalescent wear figures P/4: wear figures M/1: 100% worn
		XVII	M/2: 100% worn M/3: lamellae unfused	~23	XVII	M/2: 100% worn M/3: unworn
A1: adults	25-36 AEY	XVIII	M/2: 100-50% left M/3: lamellae fused	~24-27	XVIII	M/2: 100% worn M/3: 20-40% worn
		XXI	M/2: 30% left M/3: 50% worn	~33-35	XIX	M/2: 100% worn M/3: 40% worn
A2: adults	37-48 AEY	XXII	M/2: 20-25% left M/3: 65% worn	~36-38	XX	M/2: 100% worn (gone) M/3: 80% worn
		XXV	M/3: 100% worn, front smoothing	~47-48	XXII	M/3: 100% worn
OA: old adults	49-60 AEY	XXVI	M/3: 65% left	~50	XXIII	M/3: 100% worn
		XXX	M/3: nearly smooth	~60	> XXIII ?	? (unknown)

may be restricted to butchery processes. In both archeological deposits with mammoth remains, Milovice-G and La Cotte Saint Brelade, the anthropic influence is restricted to butchering activities. In both examples, Paleolithic people seem to have trapped herds of mammoths (without old individuals) in specific natural areas before they killed them. People may also have contributed in having mammoths trapped into natural chasms of the surroundings of La Cotte St Brelade, or they may have just used an opportunity to scavenge proboscideans accidentally fallen down the cliffs. The paleo-geomorphological background of Milovice is not so explicit for natural trapping, except the half-closed feature of the small valley. Did a stressed mammoth herd get trapped during an unusual climatic event (which would have left no sedimentological trace) into the place of Milovice where they did not normally go? And did the Gravettian people use this exceptional situation for capturing the stuck and weakened animals? Whether or not mammoths were not led by humans towards trapping zones, it shows how perfectly those people used the environment for their subsistence practices, by probably developing intermediate strategies of meat acquisition, mixing hunting and scavenging techniques.

In the wider perspective of understanding the human impact in the setting of mammoth bone accumulations, the proposed methodology will be applied to numerous Paleolithic sites with such a faunal pattern. The North American mammoth sites associated with the Clovis culture show interesting features interpreted as hunting and butchering activities (Hannus 1990; Saunders 1980). Most of the European mammoth sites have so far mainly been studied through the strict archeological artefacts. Questions have been asked about the acquisition of the bone remains in the famous East-european sites of the Russian plain (Soffer 1985). Zooarcheological analyses considering the environmental backgrounds, the other game of the Paleolithic people and the tool/bone interactions are in progress.

ACKNOWLEDGEMENTS

We would like to acknowledge the organizers of the 2nd International Mammoth Conference in Rotterdam, the CNRS Unit UMR 6569 for the financial support, Martin Oliva for allowing the examination of the Milovice material, and Pascal Tassy for his advise about Elephantoidea development stages.

REFERENCES

Absolon, K., 1938 - Die Erforschung der diluvialen Mammutjägerstation von Unter-Wisternitz an den Pollauer Bergen in Mähren - Arbeitsbericht über das erste Grabungsjahr 1924, Polygrafia, Brünn, 52 pp.

Auguste, P., Moncel, M.-H. & Patou-Mathis, M., 1998 - Chasse ou 'charognage': acquisition et traitement des rhinocéros au Paléolithique moyen en Europe occidentale - in: Économie préhistorique: les comportements de subsistance au Paléolithique - Actes des XVIIIe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes, 23-25 octobre 1997, pp. 133-151, Editions APDCA, Sophia-Antipolis

Binford, L.R., 1978 - Nunamiut Ethnoarchaeology - Academic Press, New York, 504 pp.

Bouchud, J., 1975 - La conservation différentielle des os et le problème des mesures biométriques - in: Colloque international C.N.R.S. n° 218, "Problèmes actuels de Paléontologie - Evolution des Vertébrés", Paris, 4-9 juin 1973 : 861-871

Callow, P. & Cornford, J.M., 1986 - La Cotte de St. Brelade 1961-1978: excavations by C.B.M. McBurney - Firefly Books, Norwich (U.K.), 433 pp.

Ginburg, L., Muizon, C. de, & Tassy, P., 1975 - Découverte d'un important gisement à Mastodontes dans le Miocène moyen de Simorre (Gers) - Comptes Rendus de l'Académie des Sciences, Paris, Série D, 280: 1547-1549

Hannus, L.A., 1990 - Mammoth hunting in the New World - in: Davis, L.B., & Reeves, B.O.K. (eds.) - Hunters of the recent Past - Unwin Hyman, London: 47-67

Haynes, G., 1987 - Proboscidean Die-offs and Die-outs: Age Profiles in Fossil Collections - Journal of Archaeological Science 14 (6): 659-668

Haynes, G., 1991 - Mammoths, Mastodonts, and Elephants: biology, behaviour, and the fossil record - Cambridge University Press, Cambridge, 413 pp.

Klíma, B., 1954 - Pavlov, nové paleolitické sídliště na jižní Moravě - Archeologické rozhledy 6: 137-142

Klíma, B., 1995 - Dolní Věstonice II: ein Mammutjägerplatz und seine Bestattungen - The Dolní Věstonice Studies, Volume 3, ERAUL 73, Université de Liège, Liège, 188 pp.

Laws, R.M., 1966 - Age criteria for the African elephant *Loxodonta a. africana* - East African Wildlife Journal 4: 1-37

Lyman, R.L., 1994 - Vertebrate taphonomy - Cambridge University Press, Cambridge, 524 pp.

Oliva, M., 1988 - Discovery of a Gravettian mammoth bone hut at Milovice (Moravia, Czechoslovakia) - Journal of Human Evolution 17: 787-790

Oliva, M., 1999 - L'industrie lithique du secteur G à Milovice (Moravie du Sud) et le faciès "méridional" du Gravettien morave - in: Sacchi, D. (ed.) - Les faciès leptolithiques du nord-ouest méditerranéen : milieux naturels et culturels - Actes du XXIVe Congrès Préhistorique de France, Carcassonne (France), 26-30 septembre 1994, SPF, Paris: 139-150

Patou-Mathis, M., 1994 - Actions anthropiques sur les assemblages osseux et sur les ossements du Paléolithique : état des recherches - in: Patou-Mathis, M. (ed.) - Taphonomie/Bone Modification - Outillage peu élaboré en os et en bois de Cervidés IV, 6e Table Ronde du Groupe de Travail n° 1 de la Commission de Nomenclature sur l'Industrie de l'Os préhistorique (UISPP) - Editions du CEDARC, Treignes - Artefacts 9: 133-142

Patou-Mathis, M. (ed.) 1994 - Taphonomie/Bone Modification - Outillage peu élaboré en os et en bois de Cervidés IV – 6e Table Ronde du Groupe de Travail n° 1 de la Commission de Nomenclature sur l'Industrie de l'Os préhistorique (UISPP), 11-13 septembre 1991, Paris –Éditions du CEDARC, Treignes - Artefacts 9, 232 pp.

Péan, S. & Oliva, M., 1998 - Mammoth and man, 25000 years ago, at Milovice (South Moravia, Czech Republic): First results of a zooarchaeological study in sector G - Communication at the International Conference on Mammoth Site Studies, University of Kansas, Lawrence (Kansas), 11-13 March 1998

Péan, S., Patou-Mathis, M. & Tassy, P., 1998 - Agents climatiques et édaphiques intervenant dans la mise en place d'un assemblage osseux : taphonomie d'un gisement à mastodontes du Miocène (En Péjouan, bassin d'Aquitaine, France) - in: XIII[th] UISPP Congress Proceedings, Forlì (Italy), 8-14 September 1996 - Vol. 6, Tome I, Workshop 4: 201-208

Poplin, F., 1983 - Essai d'ostéologie quantitative sur l'estimation du nombre d'individus - Kölner Jahrbuch für Ur- und Frühgeschichte 16: 153-164

Saunders, J.J., 1980 - A Model for Man-Mammoth Relationships in Late Pleistocene North America - Canadian Journal of Anthropology/Revue Canadienne d'Anthropologie 1(1): 87-98

Scott, K., 1989 - Mammoth Bones Modified by Humans: Evidence from La Cotte De St. Brelade, Jersey, Channel Islands - in: Bonnichsen, R., & Sorg, M.H. (eds.) - Bone modification, University of Maine, Orono: 335-346

Soffer, O., 1985 - The Upper Palaeolithic of central Russian Plain, Academic Press, Orlando, 539 pp.

Svoboda, J. (ed.) 1994 - Pavlov I. Excavations 1952-1953 - The Dolní Věstonice Studies, Volume 2, ERAUL 66, Université de Liège

Sutcliffe, A.J., 1970 - Spotted Hyaena: Crusher, Gnawer, Digester and Collector of Bones - Nature 227: 1110-1113

Tassy, P., 1996 - Growth and sexual dimorphism among Miocene elephantoids: the example of *Gomphotherium angustidens* - in: Shoshani, J., & Tassy, P. (eds) - The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives, Oxford University Press, New York: 92-100

Villa, P., 1996 - Torralba et Aridos : chasse, charognage et depeçage d'éléphants au Pléistocène moyen en Espagne - in: L'Acheuléen dans l'Ouest de l'Europe, Actes du colloque de Saint-Riquier, 1989, Publications du CERP n°4, Université des Sciences et Technologies de Lille: 61-71

Villa, P. & Bartram, L., 1996 - Flaked bone from a Hyena den - Paleo 8: 143-159

Voorhies, M.R., 1969 - Taphonomy and population dynamics of an early Pliocene vertebrate fauna, Knox County, Nebraska - Contributions to Geology, Special Paper 1 (University of Wyoming): 1-69

received 6 July 2000

DEINSEA - ANNUAL OF THE NATURAL HISTORY MUSEUM ROTTERDAM
P.O.Box 23452, NL-3001 KL Rotterdam The Netherlands