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Mammoth bone deposits and subsistence practices during Mid-Upper Palaeolithic in Central Europe: three cases from Moravia and Poland

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Abstract

The lowlands of Lower Austria–Moravia–South Poland form an important natural corridor in Central Europe, allowing migrations of both animals and humans between the Danube valley and the North European Plain. The paper examines the relationship between mammoth bone deposits and Gravettian settlements along this corridor, basing on contextual archaeological evidence in general, and on zooarchaeological analyses of the individual sites: Dolní Věstonice I–II, Milovice G, and Kraków Spadzista Street (B).

Mammoth bone accumulations from these areas can be interpreted as butchery places on the death locations (as in Milovice G) and as butchery places on death/hunting site (as in Kraków Spadzista Street (B)). At these sites, Gravettian people may have seasonally gathered, taking advantage of landscape geomorphology and marshy conditions to organize collective mammoth hunts. The long-term occupations, as recorded at the Moravian sites with their exceptional archaeological evidence, support this idea. The mammoth-dominated sites probably result from specialized mammoth hunts as well as from other means of exploitation of these animals during peculiar environmental stresses, both seasonal (e.g., the palaeoecological changes during the end spring thawing period), and long-term in nature (the declining features of the mammoth population, as shown in Kraków Spadzista Street (B)).

1. Introduction

This paper centers on zooarchaeological and archaeological evidence from the central European lowlands, attached to the Middle Danube River and continuing through the Lower Austria–Moravia–South Poland corridor further to the North European Plain. Since the 19th century, large hunters' settlements are continuously being excavated in these regions, beginning at Předmostí (Moravia) and Willendorf (Austria), continuing at Dolní Véstonice and Pavlov (both Moravia), and, during the last decades, also at Kraków-Spadzista (Poland) and Milovice (Moravia). A typical pattern at these sites is a more or less direct spatial association between the remains of intensive Upper Palaeolithic (Gravettian) settlement and accumulation of mammoth bone remains.

Interpretation of this association varied through time. The extreme viewpoints are either that the mammoth bone dumps represent the result of specialized human hunting, as performed by the habitants of these settlements, or that these are natural deposits that were only secondarily exploited by humans as a source of bone, ivory, or frozen meat. However, a variety of scenarios combining the natural and intentional impacts is also being proposed.

A way to solve this dilemma is detailed zooarchaeological analysis of the mammoth bone deposits themselves. First efforts in this direction were presented for Dolní Věstonice I and II by Klíma (1969) and West (2001), for Kraków Spadzista (B) by Wojtal (1996), for Milovice G by Péan (2001a, b) and for Krems-Wachtberg by Fladerer (2001). These should be compared with analyses of the more variable fauna recovered from the associated settlement sites (Musil, 1994, 1997; West, 2001; Nývltová-Fišáková, 2001). This paper reviews the evidence from the mammoth bone deposits at Dolní Věstonice, develops

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the zooarchaeological results about Kraków Spadzista and Milovice, and discusses the issue in a comparative regional context.

2. Environmental and cultural context

The Mid-Upper Palaeolithic, or later Interpleniglacial and early Upper Pleniglacial (terminal isotopic stage 3 and early stage 2), was a period of global climatic instability (Guthrie and Kolfschoten, 2000), as is also visible in the loess stratigraphic record of Central Europe (Haesaerts et al., 1996). The macrochronological studies demonstrate that the large Gravettian sites were settled repeatedly during longer time-spans, be it millennia, centuries, or seasons of the year. The rough occupation dynamics is being derived from the Gravettian chronological system, starting with the Early Pavlovian (30–27 ky), culminating in the Evolved Pavlovian (27–25 ky, with a strong majority of all Gravettian ^{14}C dates), and transforming into the Willendorf–Kostenkian, or shouldered-point horizon (25–21 ky; all based on uncalibrated ^{14}C dates).

The pollen and charcoal analyses from the related archaeological layers show that the landscape was partly covered by wooded areas (arboreal pollen usually exceeds 50%), with dominating conifers and accompanying deciduous trees, including some warm species (oak, beech, yew; Rybníčková and Rybníček, 1991; Svobodová, 1991; Opravil, 1994; Mason et al., 1994). Frost features studies (Czudek, 1994), supported by malacology, in contrast, suggests markedly colder environmental conditions than do the plants: a kind of cold subarctic tundra (Kovanda, 1991). Synecological analyses of large mammal associations from Central European Gravettian sites show open and arid palaeoecological contexts, with wooded areas, probably forest-galleries along the valleys (Péan, 2001a), as for the mammoth steppe model (Guthrie, 1982). On the basis of discussion of this complex evidence, Musil (2002) reconstructs a variable steppe-and-shrubs landscape as a favourable habitat for large mammals.

The so-called geomorphological "gates" played a strategic role in this landscape, places where the river valleys or dry valleys become narrow and the slopes steep. In the southwest, a typical example is the Wachau Gate on the middle Danube River, joining Upper and Lower Austria (with sites of Willendorf, Aggsbach and others). In the northeast, another case is the Moravian Gate on the Bečva and Odra rivers, connecting Moravia with south Poland. Narrow valleys also occur in central Moravia, as the Napajedla Gate and the adjacent valley of middle Morava River (with sites of Jarošov, Boršice, and Napajedla).

The individual hunter–gatherer populations used these natural predispositions and advantages in different ways (Svoboda et al., 1996). One of the possible adaptations is reflected by the "Gravettian landscape" hypothesis (cf. Otte, 1981, Fig. 5; Kozłowski, 1986; Svoboda et al., 1996: Fig. 6.1; Valoch, 1996: carte 6; Oliva, 1998). The Gravettian site distribution copies the axial shape of the territory, from the southwest to the northeast, along the main rivers of Lower Austria, Moravia and South Poland: Danube, Morava, Dyje, Bečva, Odra and Vistula. The hunters' settlements lie in lower altitudes (200–300 m a.s.l.), compared to the Aurignacian or Magdalenian sites, on mid-slopes, not too high but still controlling the river valleys, or at junctions of a main valley with short, steeply sloping side gullies. Such places were probably also meaningful as areas of human aggregation and communication, with a stimulative affect on technological growth (Soffer, 2000) and symbolism (Klíma, 1989; Svoboda, 1997; Verpoorte, 2001).

This pattern of site location seems to be related to the exploitation of large mammals (the mammoths) following the river valleys, and this presupposition is also supported by the mammoth bone deposits, located either inside the settlements or in the adjacent side gullies, or, as individual pieces, scattered in the river floodplain. The largest dumps were found at Předmostí, Dolní Věstonice, Milovice and Kraków Spadzista (B). Smaller mammoth bone deposits are recorded from Krems Wachtberg in Austria (Fladerer, 2001), and Boršice, Jarošov and Spytihněv in Moravia (Svoboda, 2001c).

As another case, there are natural deposits of mammoth bones, located independently of the human habitation. An example may be the natural "trap" near mineral water sources at Linhartice, deep in the Bohemian Massiv (Nývltová-Fišáková, in preparation). Unfortunately, this important palaeontological site was only partly rescued and lacks good quality documentation.

3. The problem, its history, and the various hypotheses

While interpreting the vertebrate faunal assemblages, the major question is recognizing or refuting the patterns of human selection and/or processing. The earliest finds of huge mammoth bone concentrations were generally classified as "Mammoth age" and interpreted as remains of hunting (Wankel, 1884). At Předmostí, Wankel (1884) explored accumulations of mammoth bones accompanied by artefacts, and observed that some sorts were selected at one spot: the group of molars (50 specimens together), or of tusks. However, the authority of a visiting Danish scholar, Steenstrup (1890), finally convinced Wankel that man was not contemporaneous with mammoths, as could be apparently deduced from the contexts. In his later works, Wankel (1890) accepted the view of Steenstrup that, in fact, later hunters of the ‘‘Reindeer Age’’ would have come to the site to explore bones from earlier natural mammoth death sites.

During excavation of further mammoth bone clusters at the same site, Maška (1886) found all parts of mammoth skeletons in one layer, but also groups of selected tusks (up to 13 pieces at one spot) or of skulls (four pieces together). As well, Maška recorded bones of wolf, polar fox, reindeer, hare, red fox, bear, lion, rhinoceros, aurochs, muskox, etc.

During the large-scale excavations by Absolon (1938) and Absolon and Klíma (1977) at Dolní Věstonice and Předmostí, the man–mammoth relationship pattern appeared so clearly that no more doubts about the intentionality of mammoth hunting for subsistence purposes arose. The term ‘‘mammoth hunters’’ was widely adopted in both scientific and popular literature. One of the objections is that if this was the case, mammoth remains should be found mixed with the other faunal remains (Escutenaire et al., 1999, p. 18).

In a more recent perspective, Soffer (1985, p. 281) suggested that Upper Palaeolithic cultures from the Russian (Ukrainian) Plain focused on other Pleistocene mammal species than woolly mammoth as a food resource. Haynes (1989), too, points out that Palaeolithic hunters from northern Eurasia very probably did not specialize in mammoth hunting. He suggests that increase in human utilization of mammoths was an opportunistic response to heightened mammoth vulnerability. This vulnerability was possibly due to greater seasonal differences of weather, severe cold, or dying trends.

Soffer (1993, p. 40), based on comparisons with African elephant die-offs showing prevalence of young individuals and females, suggests that the Central European sites may also be places of seasonal animal mortality. The same author raised doubts about human capacity to hunt animals as big as the mammoths. These doubts are refuted (1) by hunts of African elephants with spears done by (sub-)extant hunter-gatherers (e.g. Marks, 1976) and (2) by experimental evidence of the efficiency of Palaeo-Indian projectile points to inflict crippling and/or lethal wounds on elephant individuals (Frison, 1989). Oliva (1997), based on the presumption about prevalence of large and almost no meat-bearing bones in these deposits, suggests that the reason for the accumulation was deliberate human decision with symbolic, ritual and prestigious significance.

Svoboda (2001b, pp. 159–160) raised three arguments in favour of the intentional mammoth hunting, underlining, however, that all of them are interpreted from the context and as such, are hypothetical:

1. Spatial relationship of the Gravettian settlements and mammoth bone deposits in the larger river valleys, in lower altitudes but on strategic locations, and related to side gorges of the valley slopes, which may have served as ‘‘natural traps’’.
2. The faunal composition inside the settlements, dominated by smaller animals and carnivores, would not have supplied the complex hunter’s community with sufficient food resources (Musil, 1994, 1997). Therefore, the meat and fat content of the mammoth bone deposits should be calculated in the food consumption.
3. The development and complexity of the Gravettian technology suggests that, if ever any Palaeolithic society would be hunting large proboscideans, the Gravettians would represent one well equipped for such a task.

New zooarchaeological analyses which take into account the archaeological features provide new insight upon these issues.

4. Evidence and analysis

4.1. Dolní Věstonice I

Starting with evidence from Dolní Věstonice I, a large and complex site with rich evidence of technological development and symbolic activities, we have to combine earlier field observations by Absolon (1938) with modern evidence by Klíma (1963, 1981, 1983) and with still later control trenching. The site is separated in the lower, middle, upper and uppermost parts. Concerning spatial patterning, the upper and uppermost parts appear to be more clearly structured and readable compared to the middle part with extended but irregular bone and charcoal deposits (Klíma, 1981). Absolon discovered several mammoth bone deposits (named ‘‘kjökkenmöddings’’), especially in the upper part of this large and complex settlement. One of them, because of its circular shape, was later interpreted by Klíma (1983) as the basement of a dwelling structure. However, the largest mammoth bone deposit was excavated by Klíma next to the upper part of the settlement in a shallow, partly watered depression, located longitudinally along the slope, about 45 m long and 12 m wide. Besides mammoths, this bone deposit also contained limited remains of horse, wolf, reindeer, and hare.

Following Klíma (1969, p. 32), the bones deposited in the excavated area belong to 30–40 individuals, whereas the number of molars points to 60–85 individuals. Trying to reconstruct the complete area, the individual count would be 80–100 mammoths, most of which were young individuals. Only a part of the bones were found in anatomic associations such as groups of ribs, vertebrae and groups of carpal/tarsal bones.

4.2. Dolní Věstonice II

Dolní Věstonice II is a well-structured site, both spatially and chronologically (Klíma, 1995; Svoboda, 1991, 2001a), following longitudinally the eastern margin of a side valley, about 500 m long. It is considered as a result of short-term but repeated occupations, expanding over a considerably larger area (almost 500 m) and longer time-span (29–24 ky), with a lower artefact density, rarely of decorative objects, absence of representative art, but, instead, evidence of certain specialised activities. An important series of ^{14}C dates, all from clearly visible settlement units, are concentrated around 27 ky, at the end of the Early Pavlovian, and interrelations between two activity areas related to this horizon are also attested to by refittings (Škrdla, 2001). A later series of dates are within a time-span of 27–25 ky, within the later Pavlovian. Spatial and temporal association to mammoth bone deposits in the adjacent gully is evident. In addition, smaller carnivores represent an important part of the faunal material. Systematic fur and hide working was suggested (West, 2001), and the use–wear analysis seems to confirm this hypothesis (Šajnerová, 2001). Last but not least, this site is renowned for both ritual human burials and scattered fragmented human remains in the cultural layer (Trinkaus et al., 2000).

Svoboda excavated part of a mammoth bone deposit, measuring $10 \times 10\,m^2$ and located in fluviatile sands (with aquatic snails), in the upper part of the gorge (Fig. 1). Additional mammoth bones were scattered in lower parts of the gorge as well. It is not excluded that large portions of the valley floor, together with bones (?), were eroded.

A total of 202 mammoth bones (Table 1) representing at least 3 individuals were analysed (West, 2001) (Fig. 2). Bone specimens most frequently come from thorax (ribs and vertebrae) and the feet/ankles, i.e. bones associated with good meat quality. Portions of rib cages were found in anatomic association. Skulls were mostly disintegrated (a complete skull is still in its gypsum bed), with the exception of molars. Cut marks, indicative of butchery and dismemberment are absent, as well as green bone breaks. Paucity of root etching, together with the lacustrine sedimentary conditions and presence of aquatic molluscs, indicate deposition in water. Carnivore gnawing was recorded on five of the mammoth epiphyses.

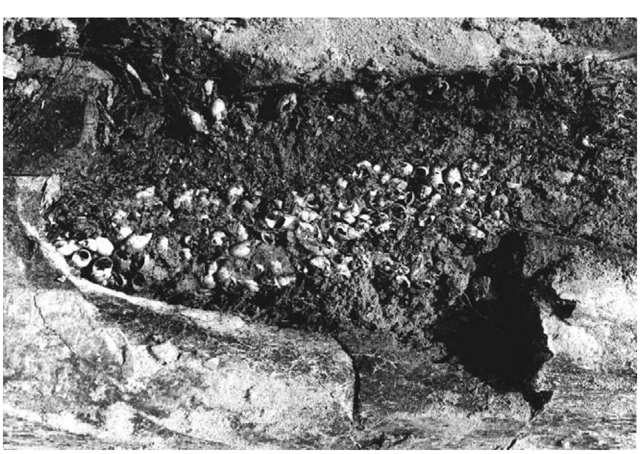

Fig. 1. Dolní V ě stonice II, excavations 1986. The photo demonstrates filling of a mammoth bone by aquatic snails, *Lymnaea palustris* (Müll.).

Table 1
Skeletal distribution of the mammoth bone heaps from Dolní Věstonice I and II

Bone element	DV I-large deposit	DV I Kjök.5–8	DV II
Cranium	7	15	4
Maxilla	4	—	—
Mandibula	48	10	2
Molare	142	35	12
Incisivus	69	14	2
Atlas	39	2	—
Vertebrae	153	7	45
Costae	1235	67	70
Scapula	75	27	4
Humerus	69	28	3
Ulna	76	11	—
Radius	39	5	1
Pelvis	75	58	10
Femur	63	22	6
Patella	22	3	—
Tibia	64	12	6
Fibula	33	7	—
Carpals, tarsals	256	15	16
Phalanges	105	4	7
Metacarpals, metatarsals	—	—	12
Epiphysis	228	5	
Reference	Klíma (1969)	Klíma (2001)	West (2001)

Fig. 2. Dolní V ě stonice II, excavations 1986. Part of the mammoth bone deposit.

4.3. Milovice

This site is located in the terminal part of a large side valley, about 2000 m long. A thick Gravettian layer was found in this site (Oliva, 1988). Two mammoth bone deposits (larger than the adjacent settled areas above them) were located on a slope, about 1500 m from the valley mouth. The main settled area, sector G, yielded most of the archaeological finds: lithic tools, one hearth, and one circular structure made of mammoth bones, interpreted as a dwelling (Oliva, 1988). The lithic implements are mostly small debitage, among which retouched tools are dominated by projectile-shaped elements (microgravettes, *fléchettes* and shouldered points). A large amount of flakes was found but almost no core. The site was interpreted as a place where lithic tools were produced and resharpened. As for worked faunal hard material, only a few unidentified hollows and incisions on reindeer antlers and perforation on fossil molluscs were described. There is no worked ivory or bone.

Within the faunal remains of at least 40 large mammal individuals, 21 mammoth individuals (cMNI) were identified in the Milovice G assemblage, including the ''hut'' bones (Péan, 2001a, b). Beside the predominating mammoth bones, there are also reindeer, horse, large bovid, wolf, cave lion, wolverine, fox and hare remains (Table 2).

From the age profile, based on dental criteria, the mammoth population is dominated by young individuals, mainly juveniles (including at least one fœtus/new-born) and subadults (Fig. 3). Mature adults and old individuals are completely missing. This age profile, without old adults, is interpreted to be generated by a predator agent which selected age classes rather than a natural environmental factor.

Almost all the mammoth remains show a high stage of weathering. Root etching has fairly modified the bone surfaces. Large carnivores gnawing activities are evident only on eight mammoth humerus distal parts (0.7% of mammoth remains). Trampling breakage pattern is also noticed. Observed scratches on cranial, axial and limb bones, are probably due to skinning, dismembering, disarticulation and defleshing activities, which were done in the site. The mammoth bones do not show any anatomical connection. Almost every type of anatomical element was identified among them (except caudal vertebras). We interpret the total skeletal mammoth preservation as in situ deaths of the animals.

In terms of element preservation, there is a low proportion of distal limb bones (especially hand and foot bones), vertebras, and tusks (Fig. 4, Table 3). Axial bones could have been widely destructed by taphonomical processes: notably the differential preservation due to the mechanical fragility of the vertebra bone structure, and/or carnivore action, although this latter taphonomical factor must have been very limited if considered the low proportion of gnawing marks on the total faunal material, and/or human selection, which appears as a serious taphonomical agent. The low head preservation hides a difference between cranium and mandible, with the latter very well preserved by

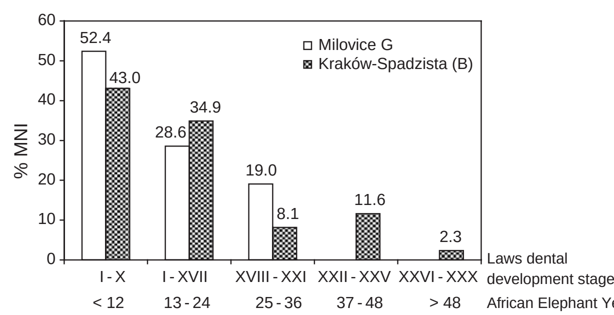

Fig. 3. Comparison of the mammoth age profiles from Milovice G (after Péan 2001a, b) and Kraków Spadzista Street (B) (after Wojtal, unpublished data).

Table 2
Large mammals from Milovice G (after Péan, 2001a: Table B23)

Taxon	NISP	NISP (%)	MNE	MNE (%)	cMNI	cMNI (%)
Mammuthus primigenius	1068	80.5	566	70.8	21	52.5
Equus sp.	70	5.3	64	8.0	3	7.5
Bos/Bison	4	0.3	4	0.5	3	7.5
Megaloceros/Alces	3	0.2	2	0.3	1	2.5
Rangifer tarandus	122	9.2	105	13.1	4	10
Canis lupus	17	1.3	18	2.3	3	7.5
Alopex/Vulpes	1	0.1	2	0.3	1	2.5
Panthera spelaea	9	0.7	9	1.1	2	5
Gulo gulo	4	0.3	4	0.5	1	2.5
Lepus sp.	28	2.1	25	3.1	1	2.5
Total	1326		799		40	

NISP = number of identified specimens; MNE = minimum number of elements; cMNI = combined minimum number of individuals (defined by Poplin, 1983).

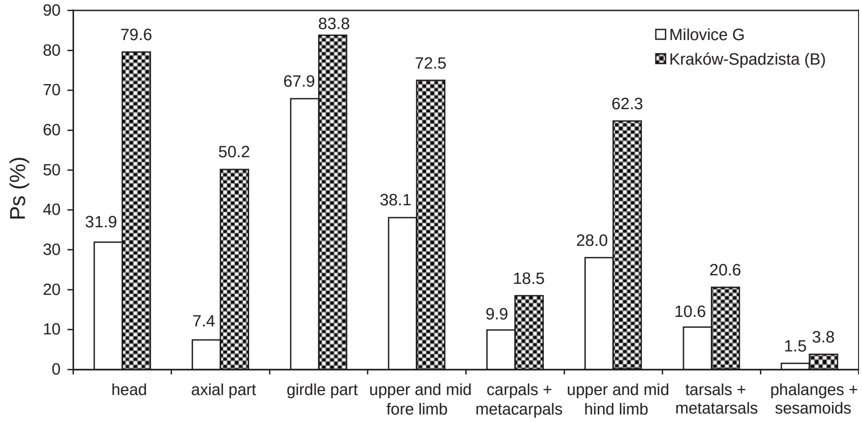

Fig. 4. Comparison of the mammoth skeletal distributions from Milovice G and Kraków Spadzista Street (B).

Ps = 66.7% (Table 3). Crania were too fragile to be well preserved during the rescue excavations (M. Oliva, personal communication). As many expected hard cranial parts, such as occipital condules, are missing, this very low presence of cranium can hardly be caused by recent fieldwork processes. The absence of long limb bones suggests that people probably took them away. The same seems true for autopodials and tusks: as shown in modern African elephant butchery sites (Crader, 1983; Fisher, 1992), these anatomical parts also were probably transported out of the site by people. Tusk ivory was probably worked into tools or art support in other Gravettian sites, such as those located in the vicinity of Milovice (Pavlov and Dolní Věstonice).

The bone accumulating process of the 21 mammoth individuals has probably occurred during repeated events, as pointed out by the differential collagen preservation status, probably in a seasonnal way (Péan, 2001a, b). Reindeer antler remains and teeth, and a milk tooth of horse refer to a corroborating late spring/early summer season of settlement. At that season, in a periglacial environment, yearly mollisol thawing may have created potholes in the clay–loessic sediments of the valley slope within the Milovice range.

Even if it is difficult to make a difference between a hunting strategy or a fast access scavenging one, in both cases, it seems that natural traps must have been used in peculiar palaeoenvironmental conditions. These indirect observations about seasonality and geomorphological background support the possible role of natural traps in mammoth death.

The interpretation of the Milovice G assemblage as a site where mammoths were killed and butchered is consistent with the archaeological material and features, which are restricted to lithic items, mainly composed of locally produced projectile-points and numerous flakes.

Further analyses should take into account the processes of other ungulates at the site, the hypothesis of a mammoth dwelling, which has not been clearly solved yet, and the relation to two mammoth bone deposits in the other close sectors of Milovice.

Kraków Spadzista Street (B)

The best-known sites located on the Saint Bronisława hill are those that make up the Kraków Spadzista Street complex. In a small area encompassing ca. 100 m, several Upper Palaeolithic sites were found: Kraków Spadzista Street (B) and (B)—flint workshop, C and C2, D, E and F. These Aurignacian and Gravettian sites are located on a rocky prominence, which is isolated from the main part of Saint Bronisława hill by a rocky cliff from the north and by a large Pleistocene depression from the east and west. The area of the sites is connected with the main height of Saint Bronisława hill only by the hummock from the south. The promontory dominates the flood plain of the river Rudawa above approximately 50 m. The Kraków Spadzista (B) site was accidentally discovered in 1967. Regular excavations started the following year and have continued almost without pause until today (Figs. 5–7). Among seven radiocarbon dates for the Kraków Spadzista (B) bone accumulation, almost all of them cluster together around 23–24 ky BP, which may suggest a prolonged period of mammoth bone accumulation. The very high density of mammoth bones per m^2 implies that the period of accumulation could have been years or even decades. At the Kraków Spadzista (B) site, one mammoth individual per approximately 2 m^2 was found.

Woolly mammoth remains dominate the bone material found at the Kraków Spadzista (B) site. About 99% of all identifiable remains belong to this species. In addition to mammoth there were recorded isolated bones and teeth of polar fox (NISP = 3; MNI = 2), wolf (NISP = 4; MNI = 1), bear (NISP = 2; MNI = 1), horse (NISP = 1; MNI = 1), woolly rhinoceros (NISP = 1; MNI = 1) and reindeer (NISP = 4; MNI = 1). At Kraków Spadzista (B) all elements of mammoth are

Table 3
Skeletal distribution of the mammoth bones from Milovice G (after Péan, 2001a: Table B25)

Bone element	NISP	MNE	cMNI	Ps (%)
Cranium	61	5	5	23.8
Tusk	14	3	2	7.1
Half-maxilla	11	14	9	33.3
Mandible (pair)	23	14	14	66.7
Single cheek teeth	70	—	—	—
Total cheek teeth (single or not)	—	95	21	37.7
Stylohyoideum	3	3	2	7.1
Cranial part	182	134	21	31.9
Atlas	9	6	6	28.6
Epistropheus	1	1	1	4.8
Cervical vertebrae (3rd–7th)	2	1	1	1.0
Thoracic vertebrae	23	21	2	5.3
Lumbar vertebrae	15	10	3	11.9
Sacrum	0	—	—	—
Coccygial vertebrae	0	—	—	—
Unid. vertebrae	62	18	—	—
Sternum	1	1	1	4.8
Ribs (MNE under-estimated)	385	84	3	10.5
Sub-total axial parts	498	142	6	7.4
Scapula	43	29	15	69.0
Innominate	51	28	16	66.7
Sub-total girdle parts	94	57	16	67.9
Humerus	30	23	12	54.8
Radius	16	13	8	31.0
Ulna	14	12	7	28.6
Sub-total upper and mid fore limb	60	48	12	38.1
Carpals	40	36	4	10.7
Metacarpals	18	18	4	8.6
Sub-total carpals + metacarpals	58	54	4	9.9
Femur	24	14	10	33.3
Patella	3	3	2	7.1
Tibia	28	18	9	42.9
Fibula	20	12	6	28.6
Sub-total upper and mid hind limb	75	47	10	28.0
Tarsals	33	31	6	12.3
Metatarsals	18	18	4	8.6
Sub-total tarsals + metatarsals	51	49	6	10.6
Unidentified metapodials	12	5	—	—
Phalanges	32	25	1	2.1
Sesamoids	6	5	1	0.6
Sub-total acropodial	38	30	1	1.5
Total	1068	566	21	9.9

NISP = number of identified specimens; MNE = minimum number of elements; cMNI = combined minimum number of individuals; Ps = percentage of survival = (MNE × 100)/(Qsp × cMNImax) with Qsp = specific ratio (cf. Péan and Patou-Mathis, 2003).

Fig. 5. Kraków Spadzista Street (B), excavations 1970s. Concentration of mammoth bones.

Fig. 6. Kraków Spadzista Street (B), excavations 1970s. Profile of the excavations.

Fig. 7. Kraków Spadzista Street (B), excavations 2002. A detail from part of mammoth bone accumulation.

represented (Table 4). The presence of a high number of small and rare elements such as hyoid bones (NISP = 41, MNE = 36), caudal vertebrae (NISP = 109 and MNE = 106), sesamoids (NISP = 85) or phalanges (NISP = 172) is a significant feature of the assemblage (Lipecki and Wojtal, 1996; Wojtal, 1996, 2001).

Table 4
Skeletal distribution of the mammoth bone deposit from Kraków Spadzista Street (B), in minimum number of elements (MNE) (after Lipecki and Wojtal, 1996; Wojtal, 2001).

Bone element	MNE
Cranium	397[a]
Maxilla	—[b]
Mandibula	55
Molare	338
Incisivus	—[b]
Atlas	62
Vertebrae	889
Costae	715
Scapula	45
Humerus	50
Ulna	70
Radius	85
Pelvis	42
Femur	58
Patella	48
Tibia	49
Fibula	55
Carpals, tarsals	471
Phalanges	172
Metacarpals, metatarsals	199

[a] Number of identified specimens (NISP).
[b] Not counted.

Fig. 8. Kraków Spadzista Street (B). Mammoth femur distal epiphysis with carnivore gnawing marks.

Table 5
The MNI of mammoths in age groups at Kraków Spadzista Street (B)

Age	MNI	MNI (%)
<12 AEY[1]	37	43
13–24 AEY	30	34.9
25–36 AEY	7	8.1
37–48 AEY	10	11.7
>48 AEY	2	2.3

AEY[1]—African elephant year.

The minimum number of individuals (MNI) for mammoth, based on mandibles and lower teeth, was estimated at 86. The age at death profile of the Kraków Spadzista Street (B) mammoth population is similar to the type A described by Haynes (1991), where subadults predominate and other ages are represented in decreasing proportions (Table 5, Fig. 3).

Haynes (1991) suggests that nonselective death of single animals or abrupt nonselective kills of complete herds could create such a profile. However, it is more likely that at Kraków Spadzista Street (B) single animals perished as opposed to large herds.

This huge mammoth bone accumulation was visited by people as well as by animals before its final conservation. Large carnivores such as wolf or cave hyena gnawed the mammoth bones and left gnawing marks on approximately 6% of identifiable remains. The carnivore gnawing marks are mostly located on the epiphysis and shafts of the long bones (Figs. 8–10).

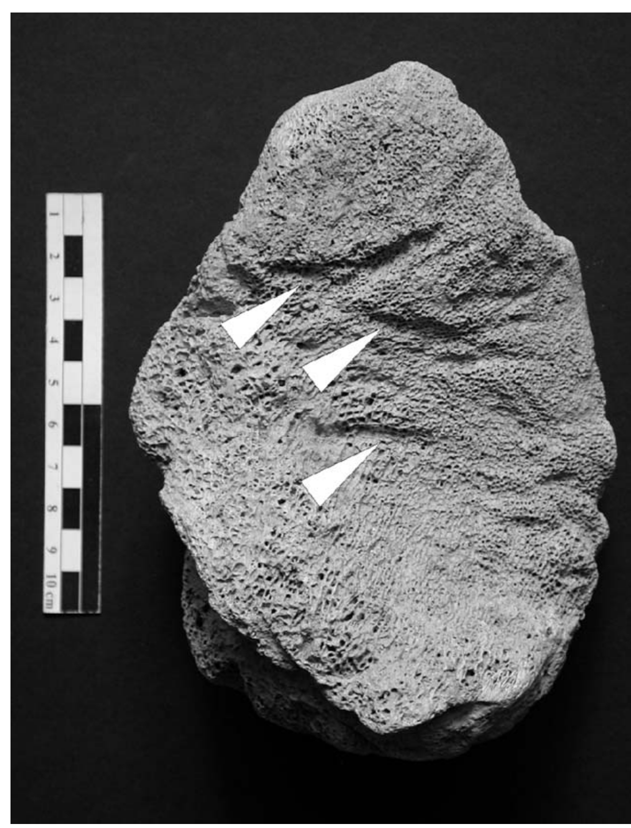

Fig. 9. Kraków Spadzista Street (B). The same bone as in Fig. 6 showing carnivore gnawing marks on internal part of bone.

Fig. 10. Kraków Spadzista Street (B). Head of mammoth femur showing gnawing marks by carnivores.

Fig. 11. Kraków Spadzista Street (B). Mammoth mm3 and M1 in alveolar bone with well-developed cement furrows.

On about 1% of identifiable bones trampling marks were found. It appears that mammoths broke some of the bones through trampling, which could indicate that mammoths reached the Kraków Spadzista (B) site at some time during the accumulation of bone.

Only few pathological bones and teeth (NISP = 18) were found at Kraków Spadzista Street (B). However, about 50% of all mammoth teeth shows furrows in the crown cementum, which could be the result of bacterial activity or influence of environmental stress during development of the molars (Niven and Wojtal, 2002) (Fig. 11). The morphology of the cement furrows reflects regular rhythms of seasonal or annual formation, which might suggest that mammoths were periodically weakened. Although the overall number of pathologies is not large, it looks as if some of the mammoths suffered occasional physiological stress. It is possible that Palaeolithic hunters occasionally focused on mammoths as their prey because the animals were weak due to environmental stress. Haynes (1989) suggests that focus on the mammoths as human prey was connected with heightened vulnerability of mammoth populations due to environmental stress, which could influence the physical condition of these animals.

In the 1970s, the bone accumulation at Kraków Spadzista (B) site had been interpreted as the remains of two or three possible dwellings, heavily disturbed by solifluction (Kozłowski et al., 1974; Kubiak, 1980). The "dwellings" were located in the east and central parts of the site and were thought to be constructed from bones of mammoths killed in the nearby Rudawa valley. The new excavations and the actual archaeological, taphonomical and zooarchaeological studies propose a new interpretation of this bone accumulation (Sobczyk, 1995; Wojtal and Sobczyk, 2003; Wojtal, unpublished data). Kraków Spadzista (B) site appears to be a place where mammoths died or a place very close to where they died. Unfortunately, it is difficult to distinguish between animals that died at the site naturally from those that were hunted by humans, how frequently the area was inhabited, and to what extent scavenging was practised. These difficulties have arisen, among others, from the fact that the concentration of bones at the locus of Kraków Spadzista (B) takes up a larger area than initially estimated. Therefore, our interpretation to this point in time is that Kraków Spadzista Street (B) represents a mammoth butchering site, probably a mammoth hunting site. The presence of the huge number of flint artefacts useable as knives supports the proposition that dismembering and filleting of mammoth carcasses took place at the site. It must be mentioned that some shouldered points have broken tips, which may reflect their use as spear points.

At the other Gravettian sites a large amount of bone tools and art objects were found. At the Kraków Spadzista (B) only two bone fragments that could be described as art objects were found. The first example is a mammoth rib fragment with series of intentional notches on both edges. The second specimen is a mammoth rib fragment with many cut marks. During excavations in 1996 a fragment of reindeer femur was recovered that exhibits very deep cut marks located in the middle of the shaft, suggesting that they were created during tool or art object production as opposed to dismemberment or filleting. However the piece was not finished perhaps due to damage and subsequently thrown away (Fig. 12).

Fig. 12. Kraków Spadzista Street (B). Fragment of reindeer femur with very deep cut marks located in the middle of the shaft.

5. Discussion and conclusion

All three mammoth bone deposits from Dolní Věstonice II (downslope mammoth accumulation), Milovice G and Kraków Spadzista Street (B) have not been intensively influenced by carnivores, as shown by the low rate of gnawing marks. The mammoth bone deposit which lies down slope from the Dolní Věstonice II campsite yielded the remains of at least 3 mammoth individuals. According to the NISP quantitative data (Table 1), interpreted in relation to the specific ratios of skeletal elements, long limb bones seem to be better preserved than foot and axial parts.

Milovice G and Kraków Spadzista Street (B) show similar patterns of large mammoth bone deposit (respectively at least 21 and 86 individuals). Both are associated to archaeological settlements but do not contain bone/ivory modified by humans.

In both sites, mammoth age profiles show decreasing proportions along age classes from younger to older individuals with a higher proportion of juveniles (Fig. 3). This may reflect selective predation on juveniles and subadults.

The difference is the presence, even low, of mature adults and old individuals at Kraków Spadzista Street (B), which are completely missing at Milovice G. The presence of old individuals at Kraków Spadzista Street (B) could also mean that the mammoth assemblage partially results from nonselective catastrophic mortality (in a stable population), which could be caused by another event than human predation.

Skeletal part preservation (Fig. 4) is evidently less at Milovice G in comparison to Kraków Spadzista Street (B). The taphonomical context must have been more favorable in the latter site, where the weathering stage is quite low, and fragile bones, such as those from a foetus or hyoid bones, have been uncovered. Conversely, more activities from large carnivores are recorded on mammoth bones in Kraków Spadzista Street (B) than in Milovice G. These different taphonomic patterns can be due to more rapid arrival of large carnivores on freshly dead mammoths, quicker burial of the mammoth bones, and less acidic geochemical features of the enclosing sediment in Kraków Spadzista Street (B) than in Milovice G.

As for the detailed element survival, skulls/mandibles, axial and long limb bones show larger differences of preservation between the two sites. Their percentage of survival is particularly low at Milovice G. It has been shown above that human activities appear as probably the most influential factor in the setting of the Milovice G mammoth bone deposit.

The low proportion of distal limb bones is the clearest common feature of the two sites. Beyond the influence of mechanical differential preservation, a major role could have been played by humans, who would have taken away these autopodial parts. In Milovice G, the peculiar low proportion of limb long bones, axial parts, crania and tusks have been mainly explained by human carriage as well.

It must be emphasized that palaeoecological and archaeological context must be methodologically taken into account, in order to palethnographically interpret zooarchaeological analyses, notably of mammoth bone deposits (Péan and Patou-Mathis, 2003). Thus, Milovice G can be considered as a location where mammoths were repeatedly killed and butchered.

Kraków Spadzista Street (B) represents a mammoth butchering site and probably, partly, a mammoth hunting site. Some flint blades have broken tips suggesting that they were damaged from impact with bone.

Among the Gravettian settlements which lie on the Pavlov hills, Dolní Věstonice I and II (campsite) and Pavlov I have yielded rich and exceptional archaeological items: bone and ivory tools, multiple graves, fingerprints and textile impressions on clay pieces, mammal and female representations made of engraved and carved bones/ivory and, more astonishing, shaped and fired clay.

Inside the upper station of Dolní Věstonice I, which apparently yielded 150 mammoth individuals (Musil, 1959), the identified specimens of the mammoth bone heap No. III are quite well described (Absolon, 1938), so that bone survival could be quantified (Péan, 2001a, b). In this mammoth heap, girdle (scapula, pelvis) and limb long bone elements are predominant, and fewer autopodials and axial elements are preserved. There is no information about rib preservation. This preservation scheme is close to the mammoth skeletal distribution in Milovice G. It can be also interpreted as a butchery site, perhaps set on the location where the animals died.

The Předmostí site is located about 100 km north-eastwards, in Central Moravia. The scarce published data about mammoth remains in Předmostí (Kříž, 1896) show a better preservation of cranial and limb bones, and also girdle elements. The low proportion of autopodial parts, and an apparent lack of axial parts, could be due to an anthropic activity of butchery. Actually, the situation at Předmostí can only be verified on basis of less representative samples from the preserved parts of the site (Nývltová-Fišáková, 2001).

The mammoth bone deposits from Moravia and Southern Poland namely seem to be human-influenced accumulations of mammoth carcasses. The danger of infections, insects and carnivores would have probably prevented people from settling in the nearest vicinity of such deposits. However we can not exclude occurrences of human scavenging events, with fast access to mammoth carcasses. The Kraków Spadzista (B) site indicates that both people and large carnivores could utilize the mammoth carcasses/skeletons nearly at the same time.

Among the whole Gravettian cultural complex in Central Europe, mammoth bone heaps only appear in the Moravian large open air settlements, and in southern Poland (Kraków Spadzista (B)). In other Gravettian sites of Eastern Central Europe, subsistence seems mainly based on reindeer, several other ungulates (notably horse), and hares (Péan, 2001a). Mammoth is there an exceptional food procurement, mainly brought to the camp as parts of carcasses, possibly scavenged. For example at Moravany-Lopata II (Slovakia) mammoth bones were found in a storage pit (Lipecki and Wojtal, 1998). It appears that archaeological sites with large accumulation of mammoth bones are rare, regionally and temporally restricted.

Mammoth accumulations from Moravia and South Poland can be interpreted as butchery places at the death location, as in Milovice G (Péan, 2001a, b) and as butchery places at the death or killing site, as in Kraków Spadzista Street (B) (Lipecki and Wojtal, 1996; Wojtal, 2001). In these sites, Gravettian people may have seasonnally gathered, taking advantage of peculiar environmental conditions, notably marshes formed at the end of spring, to organize collective mammoth hunting (Péan, 2001a, b). At Dolní Věstonice, similar activities are related to long-termed occupation with a variety of other activities.

Further zooarchaeological analyses are needed to validate this attempted interpretation of the mammoth bone deposit settings from Moravian and Southern Poland Gravettian sites.

If we expand the argument to the archaeological context, it appears however that the exploitation of the mammoth carcasses was only one portion, even if an important one, of a wider range of activities responsible for the site formation. So, the archaeological evidence recorded at Dolní Věstonice I or Předmosti I results from complex resource exploitation, formation of habitation structures, burial and other ritual and symbolic activities. At Dolní Věstonice II, the range of the other activities seems to be reduced, with emphasis on fur working and burial activities. Also, the evidence from Kraków-Spadzista (B) and Milovice G suggests more specialized occupations, where the importance of mammoth exploitation increases.

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