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A calf-dominated mammoth age profile from the 27 kyBP stadial Krems-Wachtberg site in the middle Danube valley

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A short rescue-excavation in 1930 at a c.15 m^2 encampment area recovered remains from at least eight individual mammoths (*Mammuthus primigenius*), six wolves (*Canis lupus*), four red foxes (*Vulpes vulpes*), one arctic fox (*Alopex lagopus*), three wolverines (*Gulo gulo*), and single remains from reindeer (*Rangifer tarandus*), red deer (*Cervus elaphus*), ibex (*Capra ibex*), and musk ox (*Ovibos moschatus*). The body part representation and the bone modification patterns of the species are studied, and the death age profile of the mammoth bone sample is figured. The archeological documentation of the site, the preservation state of the bones, and the evidence of delicate bone fragments support a geologically short-time generated origin of the sample with only light disturbance by carnivores. The remains of at least four calves of suckling age, as well as two subadults, and two adults, at least one bull, may be caused by the exploitation of a mammoth family group. Within the body parts of the juveniles, heads including isolated milk teeth are overrepresented. The osteological patterns of the proboscidean finds indicate the utilization of head, back, and foot parts, as well as long bone and rib internals. Cortical bone fragments were used for works and tools. By ethological analogy the death age profile pleads for a proliferating mammoth population. The second main property of the sample is the extraordinary high carnivore representation, which is over 50 % of the minimal number of individuals, and the evidence of their butchering. Under three models about the procurement strategy, the task independent model, the natural co-occurrence model, and the co-occurrence exploiting model, this last one is favoured: The Pavlovian people confronted family herd-units, using any ambush place within the multiformity of the regional landscape, and selectively brought carcass parts back to the residential camp. The prey spectrum and the multiform landscape reflect a variety of potential forage grounds. This and the postulated healthy mammoth herd structure, suggest high yield environmental conditions, and a stable supply position of the Pavlovian people. Site occupation, interpreted from the mammoth calf ages, and from the osteological patterning of the medium-sized herbivore and carnivore carcasses, was probably during the winter months. The contextual occurrence of the zoomorphous burnt clay figurines and the animal parts may reflect a non-subsistential set of human behavior.

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INTRODUCTION

Mammoth research in Austria

Discoveries of mammoth bones in Austria date back at least to the year 1443, when a thigh-bone had been unearthed in the excavation pit of the later 'giant's door' of St. Stephan's cathedral in Vienna's city center (Abel 1939). In 1645 Swedish soldiers found several 'giant's bodies' in humose loess sediments within Krems in the course of military entrenchment (M. Merian jun.1647 as cited in Strobl & Obermaier 1909). The geographer added two precise figures in natural size of an upper molar from both the buccal and the lingual side to this early report of European mammoth discoveries. It is supposed that these finds were under the numerous dumped or re-used mammoth remains within the multi-layered Upper Paleolithic complex site Krems-Hundssteig. This is situated immediately adjacent to the Wachtberg site. First scientific excavations at a mammoth site were carried out in the 1870ies (Wurmbrand 1879). Concerning the regional Paleolithic faunal remains, Karel J. Maska, who practiced keen archeological excavations at the Moravian sites of Sipka cave and Predmostí, is acknowledged as the first careful conservator of Paleolithic animal remains as important data sources and as an accurate determination of the individual mammoth molars as well as of fragments from the postcranial bones of all occurring species. Unfortunately only a portion of his work about Austrian finds has been published (for example, K. Maska in Felgenhauer 1951, K. Maska in Absolon & Klíma 1977). Besides K. J. Maska, the paleontologist Karel Woldrich (1893) published early analyses of Paleolithic faunal remains.

Around 50 cultural mammoth sites are already known in Austria. Nearly all of them are open-air campsites close to the Danube in the NW part of the country, where the loess sedimentation provided a preservative coverage (Fig. 1). Besides these, an uncounted number of single finds in the loess area, from river terraces along the Danube, the Traisen and the Morava in the N, the Mur and the Drava in the S of Austria, and the Rhine in the W,

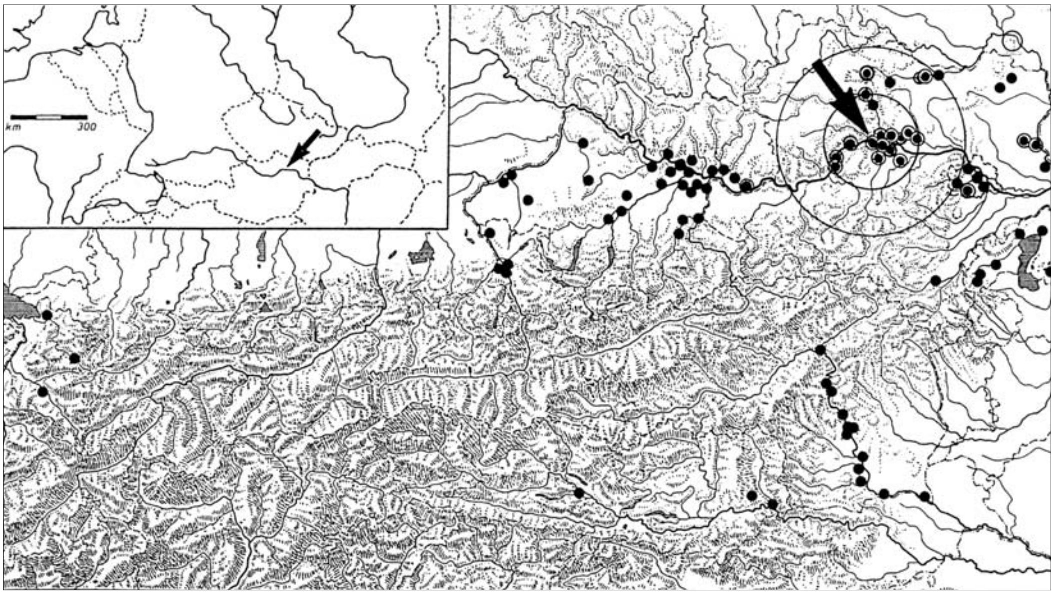

Figure 1 Geographical position of the 27 kyBP Upper Paleolithic Krems-Wachtberg site, and further Paleolithic and non-cultural mammoth sites in Austria (not complete). Small dots: single and mostly unstratified remains (stored in public collections), encircled dots: cultural sites within loess deposits, large open circle: site cluster in Moravia including Dolní Vestonice, Pavlov, Milovice sites. Arrow: Krems-Wachtberg site. Small circle has a diameter of 50 km, the large is 100 km. [from Fladerer 2001]

and from their affluents, sketch the Late Pleistocene asynchronous distribution of *Mammuthus primigenius* within the country (Fig. 1). A few cave sites in Lower Austria, Styria, and Carinthia yielded mammoth remains with unclear taphonomic provenience (compare Döppes & Rabeder 1997). Up till now, thorough studies of faunal remains from Upper Paleolithic mammoth sites in Austria are very rare. The papers on Willendorf II (Thenius 1959), Ruppersthal (Kubiak 1990), and Großweikersdorf C (Rabeder 1996) are taxonomically oriented. Emphasis has further been paid to the different taphonomical agents, and to the cultural patterning of the bones (Logan 1990, West 1997: Grubgraben; Fladerer 1996: Alberndorf 1). The Fuchslucken cave site, which is mainly generated by Late Pleistocene hyenas, is the only site in Austria with a published age profile of represented mammoths (Adam 1966).

Site location and sample bias

The Krems-Wachtberg site is situated within the city of Krems, on a SE exposed slope, at a height of 260 m a.s.l. at least 80 m above the middle Würmian Danube valley floor, close to the confluence of the small Krems river into the Danube (Fig. 1). In the summer of 1930 a short rescue excavation followed the fortuitous finding of fossil animal bones in the loess sediments during a road construction. Subsequently, an area of less than 15 square meters of the site was investigated. The campaign was led by of the prehistorian Josef Bayer, Natural History Museum at Vienna, who, in earlier years, excavated at other Paleolithic sites in Lower Austria. The short documentation is archived at the Prehistorical Department of the Natural History Museum at Vienna, and it includes one sketched plan, two further drawings and 22 photographs (Fig. 2). The most striking

Figure 2 The Krems-Wachtberg site during the excavation in 1930, with the jaw of a mammoth yearling (1.5-2 AEY) with removed premolars (MK 1017) to the left, in front of it a fragment of a left fibula from a sub/adult mammoth with spiral fractures and transverse stepped breaks. To the left and to the right of the tusk (MK 1029) two longitudinal trenches filled with ashy sediments were observed (not seen on the photograph). The rounded larger objects besides the tusk are stones. [photo (by permission of the) Natural History Museum of Vienna, Prehistoric Department]

feature within the small excavation field are two trenches dug c. 30 cm into the then ground surface, which were found filled with ashy sediments (Einwögerer 2000). Thus the main cultural layer had a height of 0.2 to 0.5 m. An upper, as well as a lower cultural horizon, c. 0.5 m under the main archeological layer could be observed, but only a few lithic artifacts and some charcoal, but no faunal remains were found within them. The inventory comprises the oldest, and up until now the only one-two zoomorphous burnt clay figurines from Austria (Einwögerer 2000, Neugebauer-Maresch 1999: fig. 42). The high-density stone artifact sample comprises c. 2,300 objects, containing over 500 bladelets and 70 tools. Under these, Gravette micro points and backend blades are dominant, followed by burins, end scrapers, and edge retouched blades. Two micro saws with backed retouch show strong affinities to those from the Moravian sites of Dolní Vestonice and Pavlov, which are c. 100 km apart (Einwögerer 2000). The artifacts indicate a variety of subsistence and handcraft behaviours. 17 serpulid tubes from regional Neogene sediments represent ornamenting garments or jewelry. Charcoal was kept, which could be determined as *Pinus* sp. with stunted growth and as *Abies alba* (Cichocki in Einwögerer 2000). Radiocarbon dates from charcoal are 27.4 +/- 0.3 kyBP (GrN-3011), 27.7 +/- 0.2 kyBP (VERA 669), and 27.1 +/- 0.17 kyBP (VERA 671). The dating result, the presence of clay figurines, and the stone tool analysis show strongest resemblance to Southern Moravian sites, and the affiliation to the 'Pavlovian' cultural entity (for example Klíma 1963, Svoboda 1996; see large circle in Fig. 1).

The actual bone sample comprises c. 350 elements and fragments. Due to the available archeological documentation a complete sampling of all recoverable bones within the small excavation field is not assumed. Furthermore, a few bones that are figured on the photographs from the excavation in 1930 could not be found within the actual inventory, and modern breaks of the bones with missing parts are observed. This loss of primary data has to be taken into account for the interpretation of the bone counts and the observed patterns (Payne 1975). Regarding the preservation state of the bones, the compact surfaces in general are moderately corroded and have been partly destroyed by root etching. The spongy portion of some mammoth bones is decomposed to a powdery matter during the storage.

THE FAUNAL REMAINS

The represented species spectrum at Krems-Wachtberg, excavation 1930, from an area of c.15 square meters, contains wolf (*Canis lupus*; minimum 6 individuals), red fox (*Vulpes vulpes*; 4), arctic fox (*Alopex lagopus*; 1), wolverine (*Gulo gulo*; 3), woolly mammoth (*Mammuthus primigenius*; 8), reindeer (*Rangifer tarandus*; 2), red deer (*Cervus elaphus*; 1), ibex (*Capra ibex*; 2), and musk ox (*Ovibos moschatus*; 1) (Figs. 3-4). At least 14 individuals of carnivores face a number of five represented medium-sized herbivores (Fig. 4), and at least eight mammoth individuals.

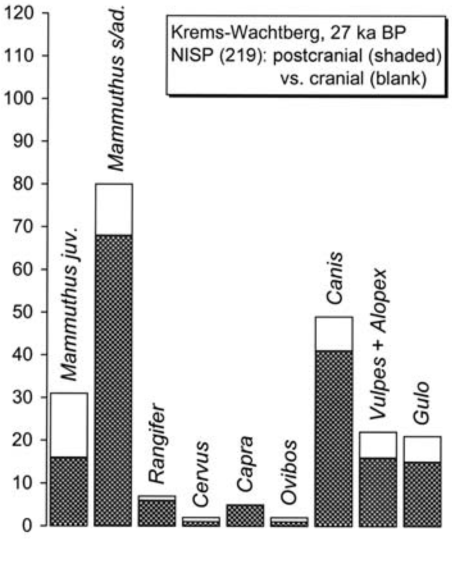

Figure 3 Krems-Wachtberg. Excavation 1930. Number of identified cranial and postcranial specimens, biased towards minimal number of elements.

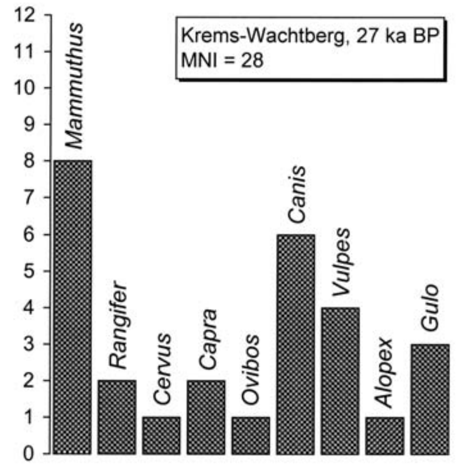

Figure 4 Krems-Wachtberg. Minimal number of individuals.

The carnivores

14 individuals (MNI) of carnivores within the sample, which is over 50 % of the MNI, are recognised as a very high presentation (compare Klein & Cruz-Uribe 1984). Abundance distributions of the carnivore body parts show a high ratio of cranial parts versus postcranial parts (Fig. 3). The percentage of head elements in *Canis* is 16%. It results from seven mandibles plus one maxillary fragment and a total of 41 postcranial specimens (Fig. 5). The percentage is 31 % in the foxes, resulting from five jaws, and 25 % in *Gulo*, resulting from three right mandibles, and one maxillary fragment. Anatomical associations, at least of vertebras and autopodial units, such as one nearly complete paw skeleton, give evidence of (1) the burial of soft tissue bond carcass parts, and (2) a rapid preserving embedding. This could be due to either human behaviour, or to natural causes such as, for example, loess storms. Because of the poor documentation, this question cannot be answered (Fladerer 2001). Both taphonomic processes and a conservative selective recovery method for attractive finds may produce an overproportion of jaws. In the case of Krems-Wachtberg this is not assumed because of the presence of small autopodial parts. Summarising the mere body part representation, postcranial parts are distinctly underrepresented in the primary animal carcasses (Fig. 3).

The bone surfaces are corroded and destroyed by root etching and unidentified agents, and only the deeper man-made cut marks are preserved. In some cases a paleocultural provenance cannot unequivocally be identified. Cut marks could be observed on the cervical column of the wolf, on the distal limbs of both species, and on the ventral side of one wolf rib, and on the ventral side of a mandible and the occipital condyle of a wolverine skull (Fladerer 2001). Furthermore, long bone fragments show impact marks and hinged breaks (transverse stepped breaks *sensu* Gifford-Gonzales 1989: 196). Whereas the ventral cut on the jaw and the cuts close to the autopodium or immediately on the paws concur with the most frequent pattern in the course of fur acquisition, the cuts on the wolverine skull and on the second cervical vertebra of a wolf indicate removal of the heads from the bodies (Fig. 5). This butchering pattern document further steps of carcass processing. The cutting along the inner side of the rib cage, and the breaking of marrow-bearing bones indicate an additional utilization of the corpses, probably for food supply.

Osteometrical and morphological analyses of the wolf remains from the Krems-Wachtberg site, show phenotypic characters similar to the wolves from the Gravettian/Pavlovian Predmostí and Dolní Vestonice sites in Moravia (Fladerer 2001). The wolf sample exhibits peculiarities of the odontological structure that are noticed as anomalies (Benecke 1994). At two jaws the p1 and p2 alveoli join occlusally, thus no bony bridge between the teeth is built. One jaw has a lower p2 with the mesio-distal axis oblique to the jaw body. In two cases, the p3 and the p4 show initial 'Kulissenstellung' (crowding), which is produced by bending of the single mesio-distal tooth axes and a slight shortening of the muzzle. The anomalies and their frequencies between 10-20 % within the sample show affinities to data like those Benecke (1994, 1995) obtained at Predmostí

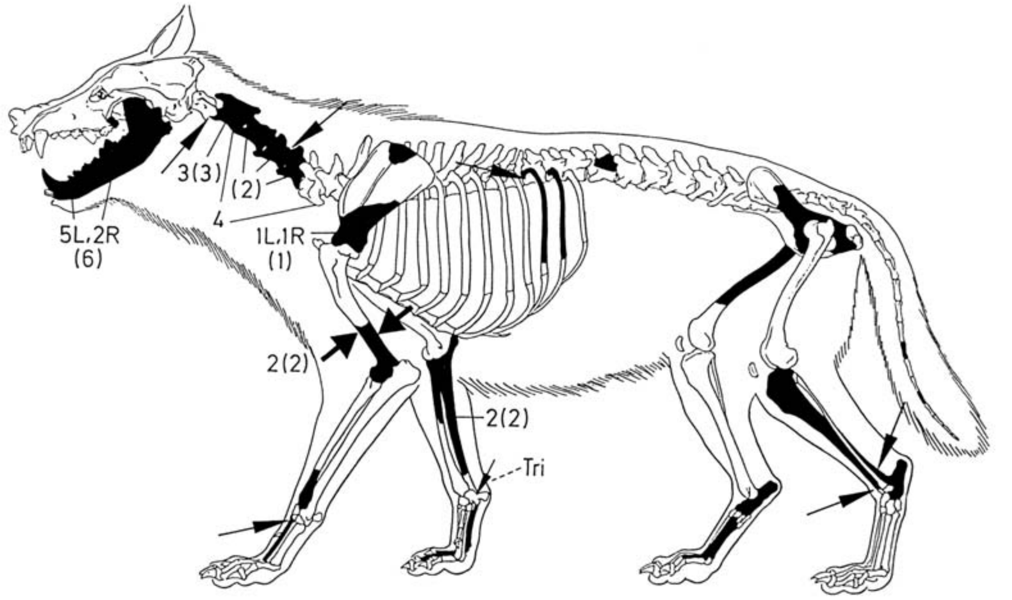

Figure 5 Body part representation of wolves (*Canis lupus*) and modifications on the skeletal parts within the inventory of Krems-Wachtberg. Shaded elements are present. Numbers indicate observed elements. Abbreviations: **L** - left side, **R** - right side, **Tri** - Triquetrum. Minimal number of individuals per skeletal elements in parenthesis. Short, thick arrows indicate impact marks, and long, slender arrows indicate cut marks. Sketch of wolf body and skeleton from Pales & Garcia (1981).

and Dolní Vestonice, but they are less expressed. The author argues about the intermediary setting of the Upper Paleolithic Moravian wolves in this respect between extant wild and zoo populations, and suggests an early phase of wolf domestication. At these sites, in general, a high proportion of carnivore individuals could be observed. Both fox species *Alopex* and *Vulpes* together represent up to 25%, wolves up to 11% (Musil 1959a, 1959b; Klíma 1963). The present analysis suggests that the wolf cranio-skeletal features are a phenotypical pecularity of the synecological relationship between a productive landscape, human-hunted mammoths, and predators of a subdominant trophic rank: wolves adapted to co-utilize the remains of human-made proboscidean carcass remnants. As a result of these unique dietary adaptations, a greater range of variability existed in the osteological features of wolves towards furtherance of 'dog-like' variants than would be expected without the human influence (Fladerer 2001).

The medium-sized herbivores

Rangifer tarandus and *Capra ibex*, which are under the most important prey species for the regional middle Upper Paleolithic groups (for example Woldrich 1893; Thenius 1959; Logan 1990; Fladerer 1996; West 1997), are represented by only a few limb fragments and a piece of antler (Fig. 3). Of the reindeer, two radius fragments with impact notches that document the opening of the medullar cavity, fragments from both the tibia and the metatarsal shafts, and a piece of the pelvis could be determined. From the ibex, with its slightly stronger bones, the distal humerus and the distal tibia with the talus are preserved. Both long bones bear impact marks. Cut-marks can be observed on the hind-limb junction. *Cervus elephus* is represented by only one worked terminal antler fragment and a tibia fragment (Fladerer 2001). The Krems-Wachtberg site is one of the few places in the middle Danube region with finds of musk ox. The proximal fragment of a first phalanx exhibits an impact on one side, which indicates marrow exploitation (compare Münzel 1987). The presence of *Ovibos* clarifies the stadial dry-cold climatic conditions at the time of the local encampment, at c. 27,000 yBP. The species is also present at Predmostí (Kriz 1901).

Mammoth: cranial elements

Proboscideans dominate the animal spectrum (Fig. 3) at Krems-Wachtberg. 53 percent of the number of identified specimen could be attributed to *Mammuthus primigenius*. Cranial elements including isolated teeth are preserved to an amount of 25 percent of the bodies (Fig. 3). The 187 cm long right tusk MK 1024, lying on the lateral side, is nearly complete (Fig. 2). Its diameter at the alveolar insertion is 16 cm, the circumference measures c. 53 cm. 100 cm before the tip the diameter is 12 cm, and the circumference is c. 36 cm. The bone sample contains over 40 further fragments from one or more tusks. The proximal fragment MK 1106/7 allows estimating a diameter of the broken tusk, which had at least a 15 cm diameter and a 42 cm circumference. It is possible, that it is the left tusk to the complete right one. Both tusks are within the male range of a sample of 187 teeth from Siberia (Vereshchagin & Tichonov 1986). Haynes (1991: 43) lists sexed and AEY-aged tusks with a proximal circumference of 41-48 cm, observed in a c. 38 year old individual and two in the late 40s, whereas the tusk from a c. 47 year old female from Berelyokh measures only 33 cm (AEY = African Elephant equivalent Years, see Haynes 1991). For the Krems-Wachtberg tusk an age of c. 35-40 years or more seems very likely.

MK 1018 is the buccal fragment of a right mandibular corpus from a suckling calf with the root cavities of the first two milk molars (Fig. 6). The dp2 has been in full action, whereas the dp3 was in the initial state of eruption. This individual (individual no. 1) can be attributed (after Laws 1966) to age class (I)-II, which is c. 0.4-0.75 AEY. After G. Craig (unpublished, in Haynes 1991) an age of 0.3-0.7 AEY or 4 to 8 months is more accurate (Table 1). Four further fragments may belong to this individual or to another of a similar age (MK 1024).

Two specimens of second milk molars (dp3) are from the right side and the other from the left side (MK 1022, 1027, Fig. 7). Their lamella formula is very similar (Table 1). Because of the great difference of crown height and wear, the two teeth represent different animals, here assigned as individuals nos. 2 and 3. The metrical conformity of the two teeth and the morphological similarity referring to the lamella formula may indicate a close genealogical affinity.

A calf mandible without teeth (MK 1017) is one of the few objects, which are figured on photographs from the excavation (Figs. 2, 8). The minimal distance between the two mandibular bodies is 47.7 mm. Both left and right posterior cavities of the second premolar are visible. The dp4 have been in full function. The first molar was very probably in the state of eruption. The mandible corresponds to Laws' age class IV (Table 1; see also Haynes 1991: table A8). An age between 1.5 AEY after Laws (1966) and 1.8-2.0 after G. Craig (in Haynes 1991) is very likely.

Both third milk molars and skull fragments represent a fifth calf (dP4; MK1021-22; Fig. 9). The teeth are worn over the full length (Table 1). Above the anterior root the dentin is already worn. In this calf the first molar


Figure 6 Krems-Wachtberg, right mammoth calf mandible fragment, lingual view (individual no. 1).

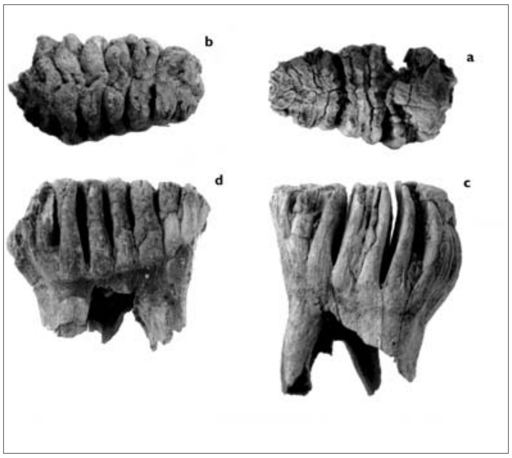

Figure 7 Krems-Wachtberg, mammoth calf second milk molars (dp3). **a** and **c**: individual no. 2 (MK 1027). **b** and **d**: individual no. 3 (MK 1022). Buccal and occlusal views.

has very probably erupted, and was very slightly worn. Laws' age class X-XI is suggested, which corresponds to an estimated age between 11-13 AEY after G. Craig (in Haynes 1991) and 13-15 +/-1 AEY after Laws (1966). Isolated lamellae from at least two early milk molars and from larger teeth with unworn digitellae cannot be identified. They probably belong to recognised individuals.

Mammoth: postcranial elements

From the represented mammoth individuals only a very small portion of postcranial bones is in the sample (Fig. 3). A few fragments of the axial skeleton, vertebras and ribs, a few longbone fragments, and parts of the feet.

Figure 8 Krems-Wachtberg, mammoth lower jaw MK 1017 (individual no. 4), occlusal view.

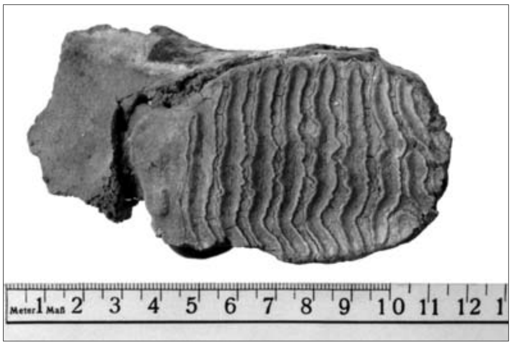

Figure 9 Krems-Wachtberg, mammoth calf maxillary tooth (individual no. 6) dP4 (MK 1020), occlusal view.

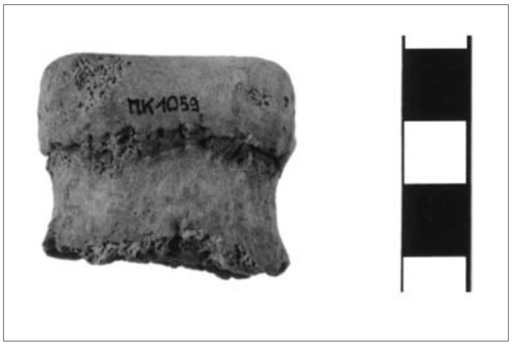

Figure 10 Krems-Wachtberg, mammoth calf phalanx (MK 1059), dorsal view.

Single bones and the bone structure allow the recognition of different ages. The preserved length of a juvenile femur diaphysis (MK1033) is 43 cm long, but c. 2 cm has to be added for their reconstruction. The mean circumference of the shaft is 18 cm. Haynes (1991) listed African elephant femur diaphysis lengths, where a c. 2.3 years old calf has reached a length of 42.5 cm. Taking into account that *Loxodonta* produces distinct greater limb bone lengths (for example Haynes 1991) the juvenile femur may be contributed by analogy to an age of c. 3-5 years. A femur with this length cannot belong to the individual no. 4 (Table 1). It represents an individual no. 5, which is not identifiable by any tooth. An isolated distal phalangeal epiphysis measures 44 mm in medio-lateral width. This, and a proximal phalanx (Fig. 10) are from an individual younger than 5 years. Five fragments of larger vertebrae, a few longbone fragments, the anatomical unit of an anterior left foot, ulnare and lunatum (MK 1036-37) with loose outer bone structure, which indicate their subadult age, and two metapodials without distal epiphysis (MK 1057, 1103) represent at least one animal older than the teenage individual no. 6, and younger than the adult bull. This early adult individual no. 7 may be referred to an age of c. 16-26 years. By means of a low-profile osteometric comparison with sexed mammoths the carpals are from a smaller to medium-sized individual (Fig. 11, Table 2).

Adult individuals could be identified in: the ventral portion of the first rib, and several further thick rib fragments, a 43 cm long fragment of a left femur (MK 1034), a 17 cm long fragment of a right femur (MK 1104), and a 21 cm long fragment of a left fibula diaphysis (MK 1035), with a circumference of 120 mm and a minimum diameter of 34.2 mm.

BONE MODIFICATIONS AND USE

The most evident features are impact marks on several long bones and ribs. Multiple notching is observed on the 43-cm long proximolateral femur fragment (MK 1034, Fig. 12). At least eight aligned impacts on the caudal side face a longitudinal break on the cranial side. A 17 cm long fragment from the

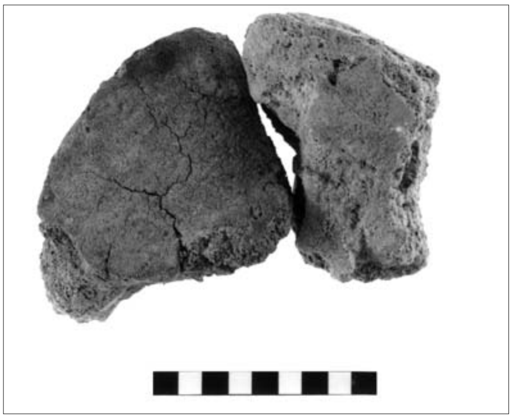

Figure 11 Krems-Wachtberg, Triquetrum (Os ulnare, MK 1036) and Lunatum (Os carpi intermedium, Mk 1037). Proximal view.

Table 1 Tooth measurements and morphology, and age structure of the mammoths at Krems-Wachtberg, Lower Austria. Measurements in mm: **Lmax** - greatest length (molars: vertical to the roots; tusks: outer length), **Lint** - internal length in tusks, **Locc** - greatest length of the mastication surface incl. cementum, **Wmx** - greatest width, **Wocc** - greatest occlusal width, **H** - greatest height of the crown, **CF** - circumference in tusks, **DM** - diameter in tusks, **ET** - enamel thickness. Further abbreviations: **AEY** - African elephant equivalent years after Laws (1966) and modified after Haynes (1991, using unpublished data of G. Craig), **alv** - alveolus, **frg** - fragment, **INC** - tusk, **ind** - individual number, **lam** - lamella, **ACl** - Laws' (1966) age class, **LF** - lamellar formula (x - talon/-id, - missing lamellae), **l** - left side, **mo** - months, ***pos*** - position, **r** - right side, **s** -side, **wear** - worn lamellae.
* = estimated values.

Nr.	pos	s	Lmax	Locc	Wmx	Wocc	H	ET	LF	wear	ACl	AEY	Ind
1018	dp/2 alv	r								all*	(I)-II	0.3 - 0.7 (4-8 mo)	1
1024/1-2	dp3/? frgs	?			≥21		≥38		-2-	0	I-II		
1024/3-4	dp/3? frgs	?			≥29		≥30		-2-	0	I-II		
1025/1-2	dp3 frgs	?							-2-	0	I-II		
1027	dp/3	l	57.5	50.2	32.8	18.6	c.40	0.4-0.6	x7x!	1.-4.	II - III	0.5 - 1 (6-12 mo)	2
1022	dp/3	r	62	c.47	35.5	21.0	c.33	0.7-1.0	x7xx!	1.-4.	II - III	0.5 - 1 (6-12 mo)	3
1017	dp/4 alv	l+r				c.35*				all*	IV	c.1.5 - 2 (18-24 mo)	4
	m1 alv	l+r				c.43*							
1020	dP4/	l	84.9	84.9	55.6	52.0	-	0.8-1.0	-12x	all	X-XI	11-13 +/- 1	6
1021	dP4/	r	88.7	88.7	56.0	54.2	-	0.8-1.0	-9 1/2 2x	all			
1023/1	lam	?	≥49				≥64	1.3-1.7	-1-	0	VIII- XXV	8-50	
1023/2	lam	?	≥57				≥71	0.8-1.2	-1-	0			
1023/3	lam	?	≥50				≥56		-1-	0			
1023/4	lam	?	≥51				≥65		-2x	0			
1029	INC	r	1870 Lint: 1670		DM c.160	CF c.530					≥XXII*	≥35	8
1106/7	INC	?			DM ≥150	CF ≥420					≥XXII*	≥35	

lateral mid-diaphysis portion of a femur (MK 1104) exhibits an impact mark on the cranial side. Spiral fractures produce a four-edged outline of the bone splinter. A 21-cm long mid-shaft fragment of a fibula (MK 1035) is terminated on both ends by spiral fractures. One cut mark is situated parallel to one of the transversal proximal fractures. The distal end is modified by an impact mark on the cranial side, a spiral fracture on the caudal side, and transverse stepped break surfaces on both the lateral and the medial side. These 'hinged' breaks are the result of bending back longitudinal portions of a splintered long bone until it breaks. The described pattern of reducing medullary long bones and ribs is strengthened by four more long bone fragments, which could not be attributed exactly to any element. Comparing elephant limb bone use in different Pleistocene and Holocene cultures, in general two behavioural complexes can be found: either leaving them entirely at the death-site (for example Crader 1983) and smashing them at or close to the death-site, or first bringing them back to the residential area. Here, boiling marrow fat out of the spongy inside and from the epiphyses may be carried out as exploiting procedures. In calf limb bones the cortical bone are thinner, the medullar trabeculae are more delicate, and

Table 2 *Mammuthus primigenius*. Individual no.7 from Krems-Wachtberg. Measurements of the Ulnare (Triquetrum) and the Intermedium (Lunatum) in mm. Abbreviations: **DV** - dorso-ventral depth, **H** - maximum height between proximal and distal articulation facet, **W** - maximum medio-lateral width, **rec** - reconstructed. Borna after Felix (1912), Pfännerhall after Toepfer (1975), Niedzica, Rzeczyca, and Starunia after Kulczycki (1955).

	sex	W	DV	H
Ulnare:				
Krems MK 1036	?	c.155 (rec)	c.100	c.65
Borna	bull	172	129	66
Pfännerhall	bull	183	138	81
Niedzica	?	c.120	111	60
Rzeczyca	?	180	133	65
Starunia	?	130	100	
Intermedium:				
Krems MK 1037	?		c.110 (rec)	c.75
Borna	bull	137	130	78
Pfännerhall	bull	133-135	147	81
Niedzica	?	130	113	68
Rzeczyca	?	130	109	73
Starunia	?	120	100	72

the marrow is more nutritious and tastier.

Special attention has to be paid to the juvenile jaw (MK 1017, Fig. 8). In 1993, the mandible was met in a desolate condition. In order not to mask any Paleolithic modification, only preservatives and no secondary-filling compound were used in the actual restoration phase. Both the mandibular arches with the crown processes are missing. The dark-grey filling of the left alveolus of the third milk molar and the first molar is remarkable. The bottom of the hardened ashy filling of the cavity has been exposed during the excavation or in the course of the following 60 years by breakage of mandibular bone. It has not the irregular appearance as a negative of the reliefed bottom of the cavity, but a regular cup-like one. A Paleolithic manipulation of the jaw is strongly suggested by the lingual edges of the great alveoli. The edges are symmetrically broken, and their fractures are corroded. Both the lingual walls of the alveoli were obviously destroyed (Fig. 13), and the molars were probably intentionally removed. Two lamellae (MK 1024/1 and /2) of milk teeth are terminated at their neck by a corroded cut-like modification. It forms an angle of c. 35° to the sagittal axis (Fig. 14). The orientation is oblique against the breaking pattern, which can be observed more frequently. A very recent find of a 11 mm long pendant-like artifact made from a mammoth tooth lamella from the c. 25 kyBP Gravettian Stillfried-Grub site (90 km to the East) seems to support a human origin of the modification

Figure 12 Krems-Wachtberg, reduced and multiple notched mammoth femur fragment (MK 1034), posterior view.

Figure 13 Krems-Wachtberg, mammoth calf mandible MK 1017, right side. Close-up view of the modified lingual wall.

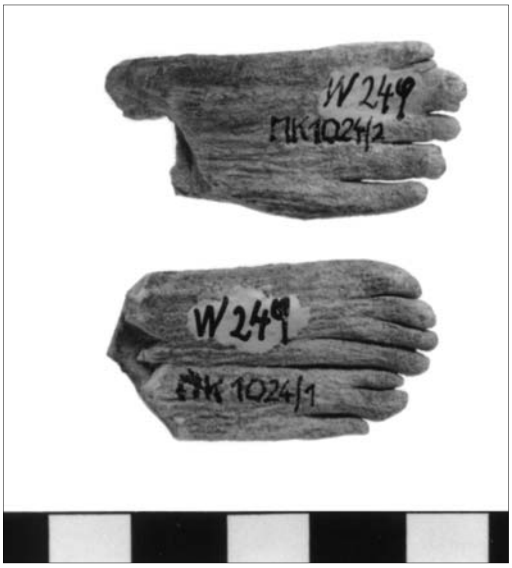

Figure 14 Krems-Wachtberg, mammoth calf tooth lamellae.

Figure 15 Krems-Wachtberg, modified tusk fragment.

Figure 16 Krems-Wachtberg, bone artifact from mammoth bone (MK 1053), from the medullar side. Platform?

of the lamellae from Krems-Wachtberg. A further microscopical proof of the two lamellae does not necessarily corroborate with this hypothesis. Some tusk fragments show modifications, which also are interpreted as produced by man (Fig. 15).

The presence of cranial parts in general, such as skull and jaw fragments, indicates the dismemberment of the head in the advanced butchering phase. One may expect that in very large carcasses this procedure were carried out at or near the death-site (for example Crader 1985). In the case of at least two suckling calves and the late-juvenile individual no. 6 from Krems-Wachtberg, the heads have been transported to the camp. This is evident also through a fragment of a very small atlas besides the preservation of the maxillary and skull fragments. No osteological information is available, if the braincases were opened in the field, for transport economical reasons. The connection of the tusk to the skull is very tight, thus the exploitation may be done only after damaging the maxillary bone by strong force. Feet bones of calves and adults within the living-floor assemblage give evidence of the removal of the feet at the death site. Bringing them back to the camp is common in modern elephant butchering practices (Crader 1983; Haynes 1991). Oil is boiled out here from long bones and from the feet, which provide a very high yield of fat. Osteological evidence of carpals, tarsals and phalanges seems rather common in Paleolithic residential sites, as in Krems-Hundssteig (Fladerer, unpublished).

Mammoth bones were used for works and manufactured for tools: (**1**) A 134 mm fragment of a 12.7 mm thick compact bone is destroyed at the medullar side by scrape- or scar-like modifications (MK 1053, Fig. 16). Its use as a working surface or platform (*sensu* Shipman 1989) is supposed. (**2**) The ventral fragment of an anterior rib with its inner spongy side exposed (MK 1046) has a maximum width of 57 mm. It is nearly identical to the spoon-like tools at Dolní Vestonice II, settlement unit B (Klíma 1995: fig. 121/1; see also Klíma 1963: 391). All three cranial, lateral, and terminal-ventral edge are rounded by use-wear. (**3**) A 165 mm long fragment from a more caudal rib shows reduced cranial and caudal edges along the more dorsal half of the preserved length, and a distinct terminal-ventral rounding (MK 1030, Fig. 17). It shows strong resemblance to the flesher-like or polisher-like implements from near Upper Paleolithic sites (for example Hahn 1991: 284, Klíma 1963: 391 and Klíma 1995: 159). (**4**) A broken juvenile thick rib with 65 mm preserved length (MK 1090) is terminally rounded like the former bone-artifact. (**5**) MK 1047 is a multiple retouched blade-like tool made from cortical long bone. It measures 176 x 51 x 16 mm. On its proximal and distal ends it is terminated by regular transverse fractures. One side is dominated by a broad longitudinal spiral fracture leading to a blade-like appearance. Three small retouch marks, directed from the inner side, are partly masked by the further use-wear of the blade-like edge. The other long side is primarily modified by three impacts, with two directed from the outer side. At least three further smaller notchings with slight inner polish produce a scalloped edge (Fig. 18). The suggestion of the use of the artifact as a spindle or bobbin has to be proved (Fladerer 2001). (**6**) A further few fragments mainly of ribs and of thick cortical long bones with flake scars enlarge the evidence of the importance of mammoth bone as a main raw material resource of the Pavlovian people.

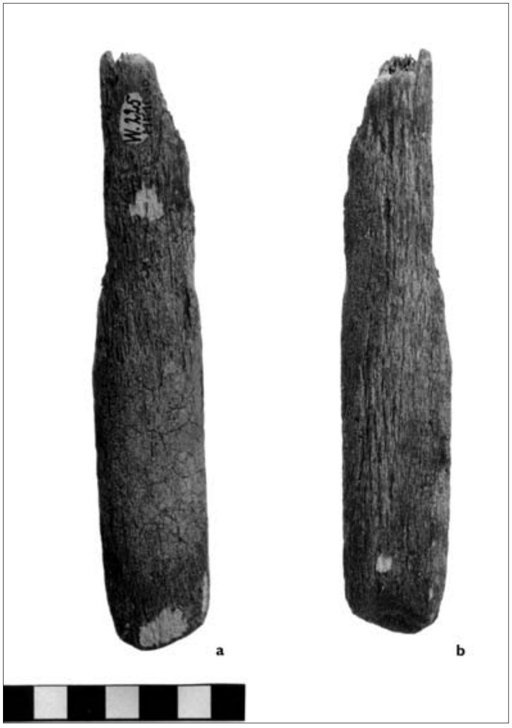

Figure 17 Krems-Wachtberg, bone artifact from mammoth posterior rib (MK 1030), from the anatomical lateral side. Flesher-like tool.

Figure 18 Krems-Wachtberg, bone artifact from mammoth cortical limbbone (MK 1047), from the cortical side (**a**), from the medullar side (**b**), and detail (**c**).

POSSIBLE CLUES TO THE ENCAMPMENT SEASON

The Krems-Wachtberg mammoth sample contains at least six calves and subadults and at least one subadult and one adult animal (Fig. 19). Six of them can be identified by means of tooth ages. Two further individuals can be recognized under the postcranial material. Three nursing calves are less than one year old, and by analogy of African elephant equivalent measure a death age between four and twelve months is very likely. The individuals nos. 1-3 were possibly born in the same spring. The teeth show a variability of age within two months. The calf no. 4 died in its second year of life. Individual no. 5 is older than these calves. It is aged to c. 5 years by its larger femur. The next individual no. 6 is a teenage subadult of around 12 years. At this age extant elephants become sexually mature (e.g., Moss 1988). Further postcranial bones represent a second subadult or a smaller adult animal no. 7. Due to its smaller size it is probably a cow (see postcranial representation chapter). One tusk and tusk fragments represented an adult male individual.

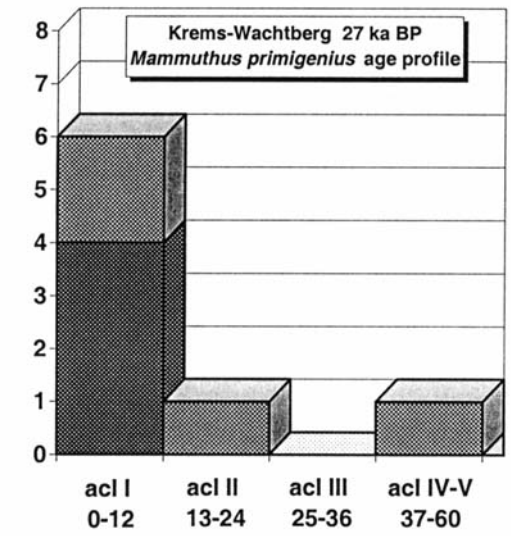

Figure 19 Death age profile of eight mammoths from Krems-Wachtberg, excavation 1930. Dark shaded area in the age class I indicates proportion of suckling calves, younger than two years. Individual count vertically, age classes and year intervals (after Haynes 1987) horizontally.

The assemblage from Krems-Wachtberg represents a living-floor residue rather than a dumped secondary refuse (see site location chapter). The remains are embedded close to, or at the locus of the debris producing activities (compare Gifford 1980). Disturbance of the assemblage by carnivores has only been light. A rather quick embedding may have preserved the faunal remains (for example Binford 1981, Gifford-Gonzales 1989). They probably result from one occupation episode and represent the leftovers of one season, at least averaged through this single season. If the calves died or were killed commonly in the same event, a death season of October till December is indicated (Fig.20) In the next chapter the hypothesis of single-event event exploitation of a mammoth family group, and of subsequent selective transport decisions is proved.

REGIONAL MAMMOTH HERDS AND HUMAN PREDATORS

Four major lines of evidence can trace site formation in a broader sense: locality and geographical context, properties of the objects, assemblage and association, and comparison with a model (Schiffer 1987, see also Carlson & Steele 1992). In the discussion part of this study I do follow principally the proposed strategy, but in a varied procedure. Since the documentation of the fieldwork in 1930 is very poor, and the faunal material is not complete (see introduction chapter) emphasize is given here to reconstruct aspects of the regional mammoth-man interrelationship, and its impact on the formation of the site.

PALEOENVIRONMENTAL IMPLICATIONS

Within a radius of 25 km around Krems there are three different major landscape types with altitudinal differences of c. 800 m (Fig. 1): (1) The Wachtberg site is situated on the Southeastern slope of a highland, which raises to the North and to the West, with a base altitude of c. 500 m a.s.l., and peaks at c.

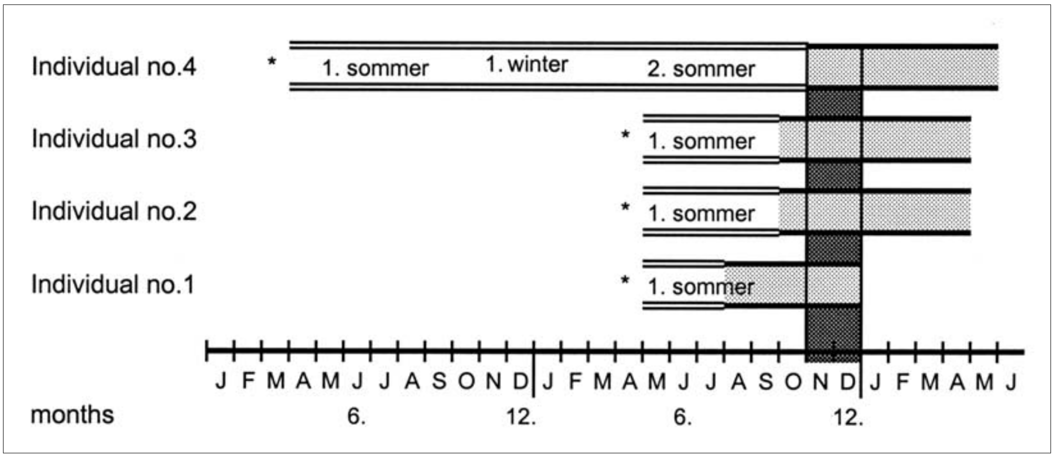

Figure 20 Krems-Wachtberg. Individual age-at-death of four mammoth calves in AEY (African Elephant equivalent years) and possible common death season (dark shaded).

1000 m. It consists of metamorphic Variscean rocks with dominating gneiss and schists. (2) A hilly country spreads to the East and to the South, between c. 250-400 m a.s.l. It consists mainly of marine and lacustrine Tertiary sediments, and is partly covered by Pleistocene Danube terraces. (3) Lowland valley floors at c. 200-190 m a.s.l.

The Danube drains the Würmian Alpine ice-sheet with its tributaries from the fore-Alps to the South. Tributaries to the North link the Danube with the highland. Within a radius of 50 km round the Krems-Wachtberg site (Fig. 1), the Danube flows through two very different landscapes. To the West it passes through a 30 km long river gorge cut into the highland, and to the East it discharges into a flood plain, which is over 10 km wide. The distinct extant climatic differences within this part of the Middle Danube region are expressed by precipitation measures from c. 500 mm/yr to >1000 mm/yr, annual temperature course, winter length and beginning of spring, and wind activities. The multiformity of the landscape, as it is used today with an agricultural and forestral patchiness, may provide some idea of a model of a Pleistocene broader variety mosaic of habitats. At least two Middle Paleolithic sites within this region (see, for example Neugebauer-Maresch 1999) give evidence of its earlier use as human forage-grounds. Non-cultural paleontological sites, as well as faunal spectra from Aurignacian to Magdalénian sites (see, for example, Döppes & Rabeder 1997: different articles) indicate diversified biota, which reflect a variety of plant communities that provide a diversity of potential prey species throughout the monitored time-interval. The multiform landscape morphology, and the subsequent variety of bioresources, attracted the peopling by Paleolithic groups. This holds plausible for the whole Würmian glacial cycle, and much longer before, but up until now, with only poor evidence.

Within the Krems-Wachtberg faunal spectrum, *Cervus elaphus*, *Canis lupus*, and *Vulpes vulpes* are considered as the most euryecic species during the Late Pleistocene. *Rangifer tarandus* may situate in this respect close to the other. New AMS-radicarbon data from Middle Würmian cave finds in Southern Austria suggest continuing reindeer populations in the periphery of the Eastern Alps even during the interstadials (Fladerer 1998). *Capra ibex* and *Gulo gulo* refer to mountinous regions and cliffy valleys, probably, during all phases of Middle and Late Würmian fluctuations (compare Döppes & Rabeder 1997, different articles). Due to the absence of high-resolution fossil lowland sites, one can only argue for a wider distribution of wolverines in forested habitats. A distinct stadial character of the Krems-Wachtberg campsite is expressed by the evidence of *Alopex lagopus* and *Ovibos moschatus*, which are subarctic to arctic species. During interstadial (and less stadial) phases, only *Vulpes vulpes* could be observed in the lowlands in Central Europe. The musk ox is up till now only represented in Austria in the mixed inventory from the adjacent Krems-Hundssteig site (K. Maska in Strobl & Obermeier 1909). The finds derive very probably from a similar chronological position as in Krems-Wachtberg. *Ovibos* is a ruminant, well adapted to a boggy substrate (e.g., Guthrie 1990). The species was very probably not hunted on a short-grass steppe, but more likely within a tundra-like habitat. This could develop to a greater extension on wetter and lesser permeable substrates on the near highland. The reconstruction is supported by the preference of windy upland pastures by extant musk ox populations on one hand, and the actual distinct rougher climate and marshy districts within this part of Northern Austria on the other hand.

Apart from bones, the Krems-Wachtberg site comprises a few charcoal pieces of *Pinus* sp. in a stunt growth form, and of *Abies alba* in a normal growth form (O. Cichocki in Einwögerer 2000). Remains of both species were recently dated to c. 27,200 yBP, thus suggesting contemporaneity and sympatry of the two species. This may be a further argument in favour of a highly diverse paleoenvironment around the encampment of the Pavlovians. It is hypothetically composed of a tundra-like vegetation on the highland, at least in depression settings, of steppe-like vegetation in the hilly upland, and of riparian woodland next to the perennial Danube bed, and along its tributaries. The intermingling of these biota produced a diversified landscape as a part of the western Mammoth steppe (compare, for example, Guthrie 1990).

A HEALTHY MAMMOTH HERD'S OFFSPRING?

Following the next lines of evidence for the site formation which are the properties of the objects and the assemblage characters (see Schiffer 1987), I deal here (1) with the faunal remains of the Krems-Wachtberg site as it concerns the age-structure and the body-part representation, and, (2) with the inferred behaviour of the regional mammoth population, based on the particular osteological observations.

The age structure of the Krems-Wachtberg camp-site mammoth sample exhibits predominant juvenile animals and subordinate adults - at least one bull (Fig. 17). The body parts, which represent the sample, were evidently selected from, at least, one death-site, and transported back to the camp. Further cultural and natural selective process(es), and some unfortunate 20th century influences, led to the actual bone inventory. Taken isolated, without the archeological background and the body part abundance, the death profile from Krems-Wachtberg is basically attritional (*sensu* Klein 1982). In its strictest meaning, it does only say that a larger unknown part of the living herd unit is missing. The age profile at Krems has to be quoted as a type B profile (see Haynes 1987), with predominant juveniles and subadults greatly outnumbering the mature individuals. The profiles published by Klein (1982) and Haynes (1987) display a rougher division into 4-5 age-classes than the profiles figured by Saunders (1980) and Haynes (1985). To deal exactly with the portion of the nursed age group, I set off this portion within figure 17. It is evident, that through the absence of parental individuals, the profiles of type B are created by a selective process. In general, type B profiles could be produced either (1) by an attritional untransported natural assemblage - as it is contemporaneously reported from time-averaged elephant-die-offs in South Africa (Haynes 1991: fig. 4.42f, Haynes 1999: fig. 2), or (2) by age-selective hunting on juvenile animals (for reasons of a higher vulnerability, and their tastier tissue, see Haury *et al.* 1959), or (3) by selective transport of parts from the juvenile carcasses off from an all-age mass death-site (a theoretical behaviour of the first scavengers at the death-site with preference for the youngest individuals). It is a common strategy of scavenging carnivores to select the parts of juvenile carcasses for transport. In cultural attritional age profiles, especially in large herbivores, very young and old animals are best represented, because of their higher vulnerability (Klein 1982). Referring to the Krems-Wachtberg mammoth sample no remarkable intra-site difference of the weathering stage could be observed, so that an attritional age-profile from a time-averaged death-site is unlikely. Possibility (2) and (3) are congruent with the first line of interpretation of the small Krems-Wachtberg excavation field: the sample contains strictly selected parts of a local mammoth herd, which is biased towards juvenile individuals. A similar, but distinctly less pronounced ratio of juveniles to adults could be observed in Pavlov I and Dolní Vestonice (Musil 1959a, 1959b; Klíma 1963).

There is great empirical and theoretical agreement about analogies between woolly mammoth social behavior and that of modern elephants (see, for example, Haynes 1991; Saunders 1992; Lister & Bahn 1994). These and others references also ask for caution because of distinct differences in body characters, environment, and forage. A few presumed generalisations are repeated for the modeling of the Krems-Wachtberg case: the elephant's basic herd unit is the female with its sexually immature offspring. This cow-calf unit is closely linked to other such units within a bond matriarchal cow-with-juvenile kinship group (Douglas-Hamilton 1975, Moss 1988). Sexual maturity is reached at about 12-15 years. Gestation period is around 2 years. Births are spaced at least three years apart. Lactation period is up to c. 2 years (see, for citations, Haynes 1992). Each of the calves that are younger than 2.5 years represents one cow-calf unit. We hardly stress ethological analogy, when we conclude that at least four mother-calf-units, plus two subadults are represented at the Krems-Wachtberg site. If the greater portion of the mammoth remains (MNI 7, without the male) from the excavated living floor at the site are related to one single foraging event, which is strengthened by the identical state of weathering, then at least a matriarchal family unit of ten animals are represented. Haynes (1992) considers an elephant group of 9-29 animals to the scale of a medium sized group. In elephant female groups the youngest are highly protected by the adults, who defend them vigorously against any predator (Saunders 1992). Therefore the interpretation of the assemblage as a time-averaged profile, produced by subsequently and selectively killed young and highly protected individuals, seems rather improbable.

The count of juveniles and their portion within a population is the recruitment rate, which ranges between zero in overstressed and diminishing populations and 10-13% in growing populations. Suckling juveniles argue against long-term stress, either environmental or internal. Stress and repeated catastrophic events in the first line would reduce the births and the nursing calf proportion, thus the recruitment rate goes towards zero (Haynes 1985, 1992). Healthy modern elephant populations contain at least c. 30 % juvenile and subadult animals (see, for citations, Haynes 1992). In a more generalised analogy, the Krems-Wachtberg sample represents a productive kinship group of four nursing females and their calves, which may indicate a herd of up to 20-40 mammoths.

Body parts from at least one male were also left at the site. It may have been part of a targeted mixed herd, or it may derive from another foraging event. In modern elephants a relatively low percentage of adult males, of up to c. 18%, is found mixing with matriarched herds (Laws *et al.* 1975 as cited by Haynes 1992). Adult male elephants usually move in loose temporary groupings, called 'bands', or they live independently, but commonly in the vicinity of adult females. During the mating season both sexes seek more contact. Aggressivity is greatest in that season, when competition takes place, and any natural predator would avoid such encounters, for risk and cost efficiency reasons. But these combats with other males produce often one weakened bull, which might be under or beyond the prime age (compare Douglas-Hamilton 1975, Moss 1988). Preying on a single adult male, or on a teenage male, when leaving his kin-ship group, are the most common hunting strategies of hunter-gatherers who are depending on Proboscideans for subsistence (e.g., Crader 1983, Haynes 1991, Saunders 1992). Elephant hunting people that forage for their subsistence select mostly subadult or senescent adult individuals, since these would be the easiest classes to hunt. From their bodies an economically high yield of fat, blood, meat, sinew etc. would return hunting risk and expense.

COULD A 160 KM² AREA FEED A MAMMOTH HERD OVER THE YEAR?

The question is raised whether the mammoths from Krems-Wachtberg were exploited within their Lower Austrian ´home-range´ or during any migration from one suitable pasture to a distant other one. The grazing succession may either be in a lateral sense, from W to E, or N to S, or in different altitudinal zones between the valley floor and the sub-mountainous altitudes. Modern elephants are described as not being territorial, and the same is supposed for the proboscideans of the Mammoth steppe (Haynes 1992). Movement radii are described as rather large, in which certain pastures may be favoured at certain saisons. Herds in habitats with an optimal water supply and good feeding grounds move or migrate far less. Up to hundreds of kilometers are quoted as the maximal migration radius, the last of them relating to a very high population level within a low-relief landscape (Sikes 1971 in Fox *et al*. 1992; Haynes 1991, using different authors). Haynes (1991) does not argue for mammoth herd migrations between winter and summer ranges, basing his conclusion on wild life observations, and on the theoretical results on a ´common foraging radius´ of c. 48 km for an animal weighing 2,600 kg, and c. 60 km for a 5,000 kg bull (in seasonal tropical regions) and the actualistic improbability of a long-distance migration pattern by a very large mammal with a gestation period of almost two years. Other prehistorians argument for seasonal migrations (for example, Churcher 1980, Soffer 1993). Enough forage for herd groupings and nearly daily water supply is accepted as the most important limiting factors. The preferred diet of woolly mammoths consisted of grasses and herbs, with a prominent part of woody plants and mosses. The water supply, and a higher amount of additive minerals in spring and during the gestation and the lactation periods, are considered necessary in a stable population (Haynes 1991, citing different authors). There is a strong argument in ethological literature for either a sexually different activity radius, and a different behaviour of male elephants being capable of generally travelling farther and faster than females to seek food, or water, or a fitting pasture (Haynes 1990, 1992).

The Krems-Wachtberg mammoth sample and the tens of further sites within the region (Fig. 1), give evidence of all age classes. The density of individual sites within the 25-km radius strengthens that the people camped at the same locales that were used over many generations to observe and exploit mammoth herds, possibly during aggregation phases. Newborn animals are known from the Teufelslucken hyena den site (Adam 1966, who favoured a cultural provenance of the mammoth remains), where 77 % juveniles and subadults dominate the attritional age profile. The site is at c. 35 km NE of Krems, and is situated in a distinct drier upland basin, c.150 m higher than the Danube valley paleofloor. Also from the Willendorf site, c. 25 km up the Danube, Thenius (1959) observed the predominance of younger animals. Newborn mammoth calves are also reported from the

100 km distant Dolní Vestonice region (for example, Musil 1959a, Klíma 1963). There is no osteological proof against a several hundred kilometers walk of the calf no. 4 (1.5 - 2.0 AEY) in the Krems-Wachtberg sample, from its place of birth to the summer grounds, then to any winter grounds, further in spring to the place of birth of its three cousins, and to the place of death near the Danube gorge. It seems plausible, that in stable climatic phases all needs of the mammoths are met within the 50 km radius around the Krems-Wachtberg site by a great variety of feeding areas with seasonal differences to be reconstructed, perennial water supply, as well as open calving grounds. Migrations far beyond the 100 km circle have surely been necessary in cases of resource stress during climatic shifts. Area fluctuations of the species itself on the large scale, on the base scale need movements of individuals, even very young, as members of herds and regional populations. Natural mass-deaths, as well as possible successful herd confronting by human bands, would have surely produced a smaller or greater vacuum to be filled by other herd-units from neighboring areas. It has to be noticed here, that, up till now, the latest archeological evidence of multi-individual proboscidean dumps in Lower Austria date around 20,590 ± 110 (GrA-16.567, Langmannersdorf).

MODELS AND CONCLUSIONS

The calf-dominated mammoth death age profile and the extraordinary high carnivore representation of over 50% of the minimal number of individuals are the two major properties of the Krems-Wachtberg site. The high portion of cranial parts of carnivores, and the burnt clay figurines in the non-osteological inventory, as well as the two ash-filled ditches, are important second-range properties in this view.

The described osteological patterns reflect the following human behaviours: parts of at least six juvenile and two adult mammoths were brought into the Krems-Wachtberg encampment, which is represented by a small living floor area. At least tusks, heads from the juveniles, parts of the vertebral columns, chest parts, long bones, and whole feet were brought to the residential camp. Tissue of the heads, the back, the breast, and the legs, and the feet were used. Long bones were broken, and the spongy bone was taken out. Teeth were extracted from juvenile jaws. Teeth and bones were modified for garment, works, and tools. The people exploited ibex, reindeer, and musk ox. At least parts of the medium-sized herbivore legs were brought back to the camp. Marrow bearing bones were crushed. Whole bodies from wolves, foxes, and wolverines, were brought into the camp, at least from adult individuals. The corpses were skinned here, and their meat and their marrow, and probably other parts were exploited, at least partly. After this in the course of accumulating or collecting behaviors, the bones were left on the camp floor. From the osteological point of view, of course, it is not possible to verify whether the mammoths at the Krems-Wachtberg site were killed by Paleolithic hunters, either in the a single-event encounter with a mixed herd, or with a female kinship group, which has been preceded or followed by killing the bull, and or if the body parts were taken from at least one natural death site. To model the foraging strategy I suggest three sets of hypotheses, which take into account the results of the preceding chapters. One of them postulates complete independent foraging events on carnivores and on mammoths. The second and third hypotheses base on the prey-predator relationship between the animal species, which was used by the regional Gravettian band.

Hypothesis 1

The mammoths were hunted at their trail. It seems rather improbable that they were scavenged from a natural mass death, because of the presence of the high portion of juveniles including their tender distal leg parts, and the quasi-absence of tooth marks. In a natural death assemblage, discovered by people, the tender parts would have been highly destroyed by the represented carnivore species, as well as by lions and hyenas (compare, for example, Binford 1981). Wolves, foxes, and wolverines, in this 'task independent model', were shot or trapped within their territory by use of unknown methods. Some explanation models may be found by ethnographical analogy.

Hypothesis 2

Soergel (1922) supposed a natural cause of the mammoth-carcass accumulation at the c. 27 kyBP Predmostí site in Moravia. He based his conclusion on the catastrophic age-profile, on the dense bone cluster, and observations on the body part representation, and on the destruction by carnivore scavenging. The carcasses decayed only slowly in the stadial climate, thus the people could continue to exploit them (see also Soffer 1993:39). A transported selective age profile with dominant juvenile animals, as in the Krems-Wachtberg case, away from a catastrophic mass-death of a stable herd, may only be produced, when humans are under the first predators who scavenge at the site. In this 'natural co-occurrence model' the scavenging carnivores provided to the people a simple-to-kill fresh resource. Haynes (1985, 1988) reports from African drought sites, were dozens of adult females and young animals die, but less adult males. In the case of the Krems-Wachtberg site, an epidemic or environmental stress caused mass death seems rather improbable, because the youngest bodies would be the first to suffer from decay, and hardly are then attractive to hunter-gatherers. The Krems-Wachtberg site is part of a multi-layered, re-used site cluster under over 30 sites in the region (see introduction). It is hard to imagine that the Paleolithic bands of different cultures, between c. 32 ky and 25 ky, were dependent on opportunistic scavenging, or on local mass-deaths to create their multiple proboscidean skeleton dumps. But a climatically induced single-event catastrophe, as for example early winter freeze or a heavy loess storm, can not be excluded as the kill agent of the Krems-Wachtberg mammoths, as this may affect even a healthy population. These events happened in the Pleistocene (for example Guthrie 1990), and were evidently used by Paleolithic and extant people (for example Soergel 1922; Haynes 1991).

Hypothesis 3

The high portion of juvenile mammoths within the Krems-Wachtberg sample seems consistent with wildlife observations and demography about the reproductive health of a stable elephant population. Perennial environmental stress, or heavy predation, or inaccessibility of fertile bulls would be indicated by the absence, or, at least, by a very low portion of juveniles (Haynes 1985, 1992). By ethnographical analogy the strong social affinity within extant elephant kinship groups would have rendered the whole group with their calves particularly vulnerable to a communal hunting strategy, much more than a band of males (Saunders 1980, 1992). In the contrary, social carnivores usually attack only single young or weakened elephants, and very rarely a complete unit (Douglas-Hamilton 1975, Haynes 1991). Fossil carnivore den sites seem to corroborate principally with this observed behaviour (see, for example, R. Graham, as cited by Haynes 1991: Friesenhahn Cave, Texas). The repeated selection of young animals would be an example of opportunistic hunting by competent hunters, who could (or eventually sometimes could not) successfully face the defense attack by the calves' mothers (compare Saunders 1992). But by the strong arguments for the kinship character of the Krems-Wachtberg sample, communal targeting of the whole family group seems more plausible. The landscape around Krems provided a variety of ambush settings. Several animals may be confronted during passages, or at the highland edge, or at its slopes, or in the shallow waters of the rivers. Proven mammoth kill sites are often located in riversides or at bogs (Fox *et al.* 1992; Haynes 1991). By means of skeletal part representation and age profiles, and site setting, driving a mammoth kinship group off the edge from a headland is a strongly supposed hunting strategy since the Middle Paleolithic (compare Scott 1980). Communal confronting of a medium-sized mammoth herd should be hold for possible within an ambush-rich environment. The same is very probably true for the encampments at Pavlov and Dolní Vestonice near the Thaya, Svratka and Morava rivers, which were at least partly used in the summer. This is indicated by finds of newborn mammoth calves. The taking of the juvenile carcasses may have been for their better taste or their nutritional value (compare Haynes 1991: 230). In this 'co-occurrence exploiting model' the wolves, foxes, and the wolverines, were attracted by the remains of the herd, and shot or trapped during their scavenging activities.

Site occupation, interpreted from the mammoth calf demography, was very probably during the first winter months. This is in accordance with the great volume of ashy deposits within the excavation field. Furthermore, the exploitation of fur-bearing animals, and the bone-breaking procedures for retreiving marrow are of greatest importance during their physiological prime state between autumns and mid-winter.

The accumulation of carnivore parts at the site, especially head parts, and the overrepresentation of juvenile mammoth head parts do not seem to be a product of mere subsistence, or of formal behaviour of the local band. The quantities of meat and other organic matter from the mammoths and the smaller herbivores are not congruent with the explanation of the use of carnivores as emergency food. By ethnographical analogy, adult carnivores are usually not used for food during good times (for example Eidlitz 1969). Soffer (1993) traces some ritual meaning in the abundance of carnivores in Central European Late Paleolithic sites, thus the documentation of the excavated living floor at the Krems-Wachtberg site is very poor, the primary locations and individual orientation of the bones cannot be reconstructed, which would have eventually favoured or disfavoured such a hypothesis. A rapid natural embedding, or a burial by the hand of the people, is indicated for the majority of the bones by their state of preservation and by complex body parts in anatomical position. In the common belief complex of Holocene northern hunter-gatherers, the bones of the exploited animal species, or at least of isolated ones, as a symbol, have a very strong ritual meaning in their foraging economy (Paulson 1959a, 1959b, 1964, Friedrich 1943). The behaviour of preserving, collecting, and sometimes sorting of bones of the same anatomical position, and the burial of carnivore carcass parts, is known from other Pavlovian residential sites with zoomorphous figurines (as in Dolní Vestonice, see Absolon 1938). These facts have to be taken into account for the final reconstruction of the Krems-Wachtberg sample's taphonomic history.

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