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BIG QUESTIONS FOR BIG BONES – EVALUATING THE EXTENT OF HUMAN INFLUENCE AT THE LOWER PALAEOLITHIC SITE OF BILZINGSLEBEN

Abstract

Over 30 years of excavation work at the Lower Palaeolithic site of Bilzingsleben (Thuringia / Germany) yielded several tons of find material. Human remains and engraved animal bones, interpreted as early artwork, made the site world famous. Site formation is an important issue at Bilzingsleben, the key question being the degree of human influence, which is estimated quite dissimilar by different researchers. The debate has to date mainly been based on the geology and lithic material. Therefore a new approach was adopted with the analysis of the megafaunal remains. They make up about 40 % of the total fauna of the site. *Elephas antiquus, Stephanorhinus kirchbergensis / hemitoechus, Bos primigenius / Bison priscus* and as a control group *Ursus* sp. were studied using zooarchaeological, taphonomic and archaeological methods. The human influence that can be seen in the faunal record was addressed and its extent evaluated.

Keywords

Bilzingsleben, megafauna, Lower Palaeolithic, human impact, bone modification

Introduction

The scarcity of well-preserved sites from the Lower and Middle Palaeolithic in Europe poses a great challenge for scientists studying this period of the human past. While analytical methods have developed since the discovery of the site Bilzingsleben more than 45 years ago, using more and more approaches adapted from the natural sciences, the low quantity of existing sites still poses a limiting factor. Therefore comprehensive analyses of the existing sites are crucial. The few sites known (e. g. Boxgrove, Swanscombe, Hoxne) are exclusively from interglacial contexts, frequently displaying a palimpsest of different overlying signals and events often in connection with poor preservation or excavation techniques. Only very few sites yielded large inventories and were excavated using modern methods (Conard et al. 2003; Gramsch 2010). Among these Bilzingsleben is unique in terms of the sheer quantity of well-preserved and documented find material. Because of this a comprehensive analysis and continuing discussion of the site is essential.

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Bilzingsleben

The Lower Palaeolithic site of Bilzingsleben (Thuringia/Germany) was discovered in 1969 and became world famous soon after with the publication of engraved bones, interpreted as early artwork, settlement structures including huts, hearths, bone and stone tools and an artificial pavement (e.g. D. Mania/U. Mania 2005). Those interpretations have recently been challenged by various scientists, who suggest the site was formed mainly by natural processes (Beck et al. 2007).

Dating most likely to OIS 11, Bilzingsleben is one of only a handful of Middle European sites of that period (Steguweit 2003, 28-36; Jöris/Baales 2003; Müller/Pasda 2011, 27).

Excavations were conducted for more than 30 years, covering an area of about 1770 m² (**fig. 1**, numbered squares). Several tons of lithic and faunal materials were unearthed until 2003 (e.g. Gramsch 2003, 13; D. Mania/U. Mania 2001, 10; Müller/Pasda 2011, 25). Later excavations by a different team examined adjacent areas that were not part of this study (Beck et al. 2007, fig. 1 squares A, B, C).

The site is reconstructed as a lake shore environment close to a calcareous spring with a large alluvial fan leading up to a higher, dry area. The actual find layer was buried under 4-6 m of travertine and is extremely well preserved (D. Mania 1997, 43).

One of the key questions at Bilzingsleben has always been the extent of human influence on the site formation processes. Many studies yielded different and often conflicting results, which were controversially discussed by the scientific community (e.g. D. Mania 2003a; 2003b; 2004a; 2004b; 2005; Pasda 2005). Recently an increasing number

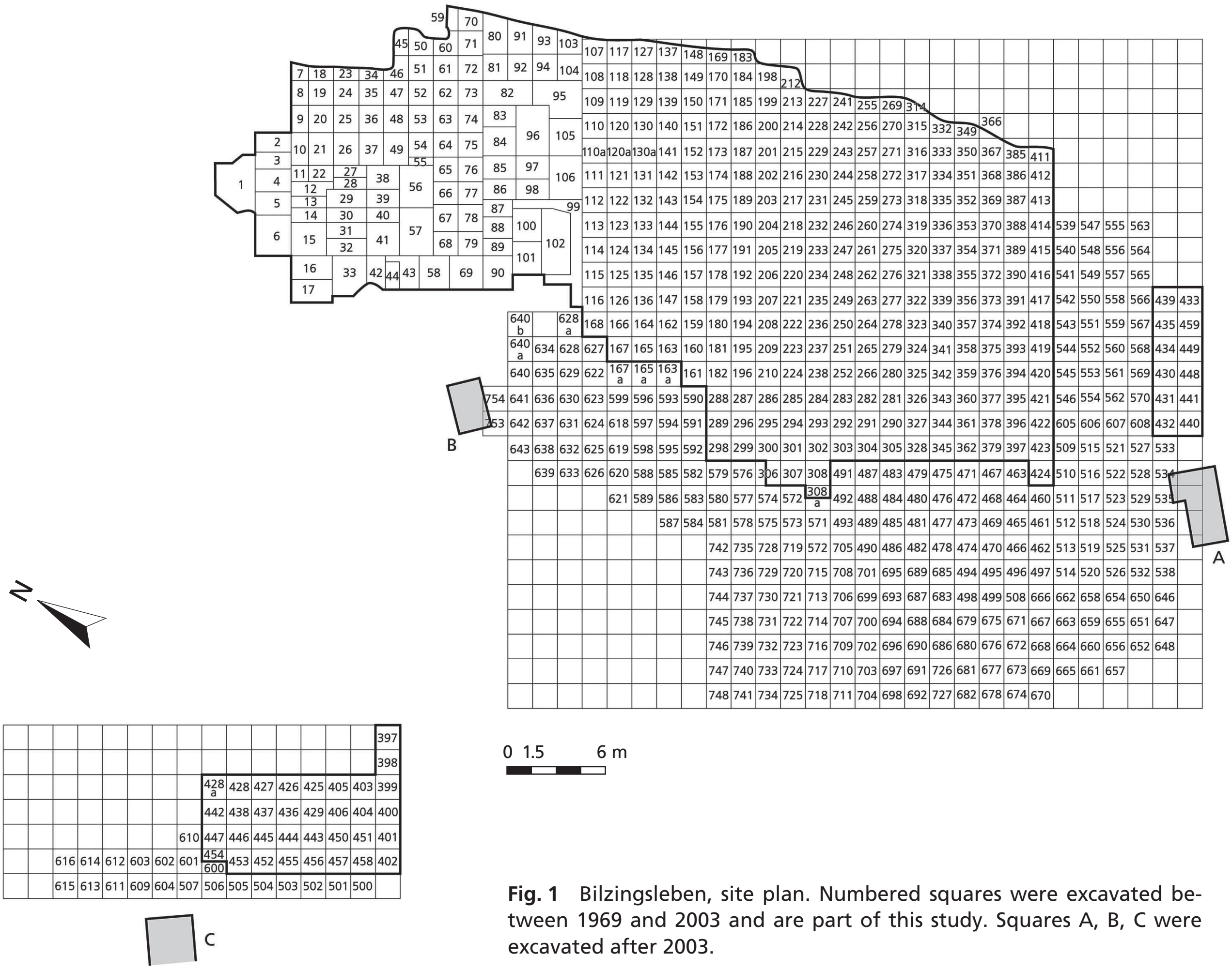

Fig. 1 Bilzingsleben, site plan. Numbered squares were excavated between 1969 and 2003 and are part of this study. Squares A, B, C were excavated after 2003.

of researchers published evidence that biotic and abiotic factors such as fluviatile displacement and carnivores played a more prominent role in site formation than assumed earlier (Beck et al. 2007; Müller/Pasda 2011; Pasda 2012; Vollbrecht 2000).

The debate has so far been based mainly on the geology and lithic material of the site and only to a lesser degree on the animal remains. While single aspects of the fauna have been studied before (most recently the antler remains [Vollbrecht 2000]), they mainly focused on palaeontological questions or limited aspects of taphonomy (see summary in Brasser 2013, 14-22). Therefore a new approach was adopted with the comprehensive analysis of all megafaunal remains.

Material and Methods

Several tons of faunal material were unearthed during the excavations conducted between 1969-2003. Large mammals dominate. However, smaller mammals, reptiles, fish and amphibians were also found (see summary in Brasser 2013, 17-22).

For the current study, all determinable fragments of the megafauna were analyzed and compared. Mammals with a life weight of more than 1000 kg were included here. At Bilzingsleben these are straight tusked elephant (*Elephas antiquus* FALCONER & CAUTLEY, 1847), two species of rhinoceros (*Stephanorhinus kirchbergensis* JAEGER, 1839 and *Stephanorhinus hemitoechus* FALCONER, 1868) and the bovids (*Bison priscus* BOJANUS, 1827 and *Bos primigenius* BOJANUS, 1827). They are best suited to answer the central questions about human influence at Bilzingsleben for two reasons: first of all they are quite abundant, accounting for about 40 % of the total faunal remains (Brasser 2013, 80 f.). This is especially interesting for the rhinoceroses, which are normally considered solitary animals (Laurie 1982, 316). The question here would be whether anthropogenic factors are responsible for their presence. The second important reason for choosing the megafauna was the fact that most of the pieces interpreted and published as bone tools in the past were bones either from elephants or rhinoceroses (U. Mania 1995; D. Mania/U. Mania 1997). In order to ensure that factors which might only influence smaller bones were also considered in the analysis, a smaller species of mammal (*Ursus hercynicus* MUSIL, 2006 and possibly another, smaller bear), was also included. Bears are one of the few smaller species whose bones are abundant at the site.

At present most of the faunal material is kept at a storage facility in Jena (Germany) belonging to the Institut für Ur- und Frühgeschichte of the Friedrich-Schiller-University. About one third of the material is in the depot of the Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt in Halle (Germany). Some pieces are also kept in the permanent exhibitions of the Landesmuseum Sachsen-Anhalt in Halle and the Museum für Ur- und Frühgeschichte Thüringens in Weimar (Germany). All specimens were studied at their present locations by the author. All of the faunal remains were examined but only finds that could be determined to species level were selected for further analysis. The reference collections of the Phyletisches Museum Jena (Germany) and the MONREPOS Archaeological Research Centre and Museum for Human Behavioral Evolution, RGZM in Neuwied (Germany) were consulted where necessary.

The number of allocable fragments for each species is given as NISP (number of identified specimens, Grayson 1984; Lyman 1994b). Each fragment is counted separately as a NISP unless it was a restored (with glue or plaster cast) specimen consisting of several, recently broken fragments. These finds were quite abundant and counted as one specimen. The same applies to other refitting fragments with obvious recent breaks.

Additionally, MNI was tabulated for each bone or tooth (White 1953, 397) taking into consideration age and size ("matching" of possible right and left counterparts, or eliminating matches due to size or state of epiphyseal fusion respectively; Klein and Cruz-Uribe 1984, 26). MNE (minimum number of elements, Binford 1978) and %MAU (minimum animal units necessary to account for the specimens in a collection, Binford 1978, 64-72; Lyman 1994a, 104-

110) were determined in order to characterize skeletal element representation. Fragments of elements were also included in these calculations by observing distinct landmarks on the bones, thus avoiding biasing due to an overlapping of bone parts.

Teeth were used for age determination because there is no reliable data for epiphyseal fusion of most non-domestic animals. In addition the results of dental age analyses cover a greater portion of the overall lifespan (Klein / Cruz-Uribe 1984, 44-62; Steele 2006, 119). For the bovids the method described by Klein and Cruz-Uribe (1984, 44-62) was used. Rhinoceroses were analyzed according to Louguet (2005), elephants according to Haynes (1991) and Roth and Shoshani (1988). Age determination in bears was undertaken following the method of Stiner (1998).

In cases where elephant molars could not be securely determined because of their poor state of preservation, they were allocated provisionally to a particular tooth and distributed equally. This occurred mostly when M V and M VI could not be differentiated due to fragmentation. In these cases, 0.5 was added to the tooth count of M V and M VI respectively. By applying this method, fragmented molars could also be included in the analysis.

For the dental age analysis of the rhinoceroses (Louguet 2005), complete jaw fragments were used rather than single teeth. This method has been shown to produce more reliable results in other species (Turner 2003, 55-58). At Bilzingsleben the large number of such fragments permitted this approach. To avoid duplicate counts of individuals, only the most common jaw element, the left mandibula, was used for the calculation. In cases where tooth abrasion ranged between two stages, both stages were allocated an equal percentage.

Age determination of bovids was conducted using the mandibular M_3 for reasons of preservation. This tooth develops late, only appearing at an age of 24-30 months (Habermehl 1961). Despite this, the M_3 was chosen for this analysis since the only specimen in the collection displaying hardly any abrasion is an M_3. This particular tooth was necessary for the interpretation of different wear stages (Klein / Cruz-Uribe 1984, 46-51). The maximum length (63.34 mm) was measured and used to calculate different wear stages that account for 10 % of the maximum crown height respectively (Klein / Cruz-Uribe 1984, 46). It is not feasible to translate these stages into calendar years, since diverse factors influence the dental wear in bovids (Jones / Sadler 2012, 7). This method is sufficient to enable a comparison of age cohorts between the different species.

In order to compare the age structures of the different animals a ternary plot was constructed (Stiner 1990, 317-321). The spreadsheet TRI-PLOT (Graham / Midgley 2000) was used for this. The position in the diagram is based on the amount of juvenile, adult and senile animals and depicts the variations in age distribution between the different animals for comparative purposes. The classification into three

Tab. 1 Skeletal element representation of *Elephas antiquus, Stephanorhinus kirchbergensis / hemitoechus, Bison priscus / Bos primigenius* and *Ursus* sp.

	NISP	NISP (%)	MNI	MNI (%)
Elephas antiquus	754	9.11	23	9.39
Stephanorhinus kirchbergensis / hemitoechus	4006	48.38	112	45.71
Bison priscus / Bos primigenius	1024	12.37	22	8.98
Ursus sp.	2496	30.14	88	35.92
total	8280	100	245	100

NISP: Number of identified specimens, MNI: Minimum number of individuals

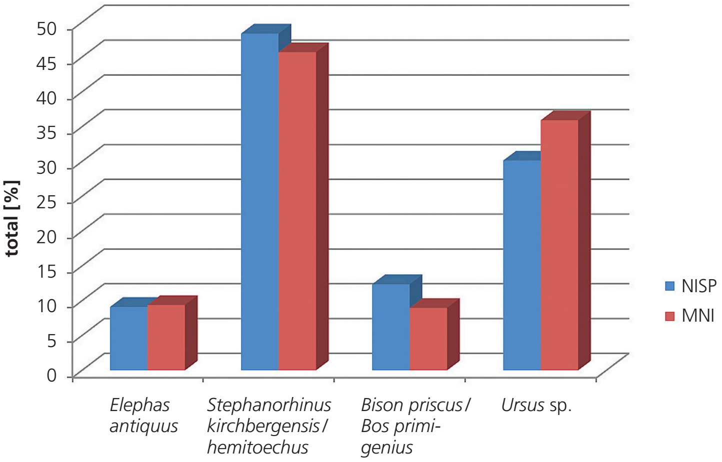

Fig. 2 Abundance of different megafaunal species in the collection (NISP: Number of identified specimens, MNI: Minimum number of individuals).

age stages was undertaken according to Stiner (1998, 312-315) for the bears and analogous for the other animals.

Analyses of bone density were conducted for all species. Lam/Chen/Pearson (1999) showed that there is no significant difference between the density rankings for skeletal elements in different animal species. This principle was applied since there is no data on bone densities of rhinoceroses or elephants. Here the ranking for bovids according to Lam/Chen/Pearson (1999) was applied. The analysis of the ursid bones was undertaken according to Novecosky and Popkin (2005). As suggested by Lam/Chen/Pearson (1998) logarithmized values were used.

A food utility analysis was only possible for the bovids because there are no publications on these analyses for the other species.

In order to determine whether fluviatile processes had an influence on the faunal material, preservation was studied with regard to the Voorhies groups (Voorhies 1969; Behrensmeyer 1975). This method is based on the understanding that certain body parts are transported later than others by streams. For this analysis the MAU of all relevant skeletal parts was used, while single teeth were excluded in order to avoid biasing.

One focus of the analysis was the distinction between natural factors and human influence on the fauna. Carnivores can create marks and patterns on bones that are very similar to human modifications (e.g. Haynes 1991; Johnson 1985; Villa/Bartram 1996, Villa et al. 2004). Therefore these traces have to be distinguished from cut marks and other human modifications. Several authors describe tooth marks from hyenas and other large carnivores in detail (e.g. Haynes 1980; Binford 1981; Lyman 1994a; Suttcliffe 1970; Hill 1989; Villa/Bartram 1996; Villa et al. 2004 and most recently Diedrich 2005a; 2005b; 2005c; 2005d; 2009; 2010a; 2010b; 2010c).

The aim of the archaeological analysis of the find material from Bilzingsleben was to find direct evidence of human modifications and proof of human interaction with the material.

All analyzed bones were searched for cut marks, other butchery marks and traces of the production of organic artefacts. The identification of cut marks was complicated by the vast amount of surface scratches which, due to the embedding matrix, strongly resemble flint induced cut marks. Morphological criteria alone were not sufficient to determine the origin of the cuts. In addition to the general morphology, the anatomical position of the cuts, the number and the overall appearance of the bones were also taken into consideration (Binford 1981, 87-161; Domínguez-Rodrigo et al. 2009; Münzel 1987, 83-101; Olsen/Shipman 1988, 549).

Modifications were only accepted as man-made when other influences could be securely eliminated. This is the case when modifications are neither random nor located next to modification by carnivores.

Tab. 2 Percentages of teeth and bones for all species analyzed. *Elephas* teeth include tusks.

	Elephas antiquus	*Stephanorhinus kirchbergensis/hemitoechus*	*Bison priscus/ Bos primigenius*	*Ursus* sp.
bones (NISP, %)	50.67	40.79	58.11	30.53
teeth (NISP, %)	49.34	59.21	41.89	69.47

NISP: Number of identified specimens

Results

8280 specimens of *Elephas, Stephanorhinus, Bison/ Bos* and *Ursus* could be determined (**tab. 1, fig. 2**). The largest proportion is provided by the remains of rhinoceros, which accounts for almost 50 % of the NISP. Bears make up about 30 % of the sample, while elephants and bovids account for about 9 % and 12 % respectively. The overall MNI of 245 is rather high. The distribution is similar to that observed for the NISP, with rhinoceroses accounting for about 45 %, bears for 35 %, and elephants and bovids for about 9 % of the MNI respectively.

Skeletal element representation

Dental elements are the most common finds for all analyzed species (**tab. 2**). While teeth prevail, maxillar and mandibular bones are also quite abundant. Teeth make up for more than two thirds of all *Ursus* remains and thus dominate the bear inventory. The same applies to a somewhat smaller degree to the megafauna, where teeth make up 45 % (bovids), 50 % (*Stephanorhinus kirchbergensis/hemitoechus*) or even 60 % (*Elephas antiquus*) of the total material. For the elephants this number includes tusk fragments, which alone account for 15 % of the total number of teeth. Overall teeth are quite abundant for all species, even though the actual amounts vary. In contrast, the representation of the skeletal elements shows striking differences between the species. For better comparability **figures 3-6** depict the %MAUs of all skeletal elements excluding isolated teeth (see **tab. 3**).

Cranial bones are not very common for any of the species except the bears where they reach 50 %MAU. The same applies to maxillar bones, that have a %MAU of 98.22 in bears, while none are preserved from the bovids. Vertebrae are most common in elephants. Scapulae are hardly preserved in bears but reach a %MAU of almost 50 in elephants. The other species rank in between these counts. Only elephants show higher numbers of pelvic bones (65.22 %MAU), while they are much rarer in the other species.

Differences can also be seen in long bones. While for *Elephas* proximal humeri are more frequent than distal, it is the other way round for the other species, where distal ends prevail markedly. Elephants and bears show even proportions of proximal and distal radii, but the overall numbers are higher for the elephants. Rhinoceroses and bovids yield markedly more proximal than distal ends. Ulnae obtain a %MAU between 22 and 30 in all species.

Proximal femora are more common than distal femora for all analyzed species. However, there are differences in the overall share of this element varying between 5.56 %MAU (*Ursus*) and 43.9 %MAU (*Bison priscus/Bos primigenius*). Patellae are predominantly preserved from bears (25 %MAU) and elephants (17.39 %MAU). There are more proximal elephant tibiae (43.48 %MAU) than distal (21.75 %MAU), while they are generally rare in the rhinoceroses. For the bovids a few medial and a larger amount of distal tibiae could be determined (53.67 %MAU). Bears show a similar pattern with more distal than proximal tibia fragments. However, the overall numbers are lower for these animals. Carpals and tarsals are quite common for the bovids where they account for a %MAU of almost 55, while the number is much lower for all other animals. The same results could be found for the

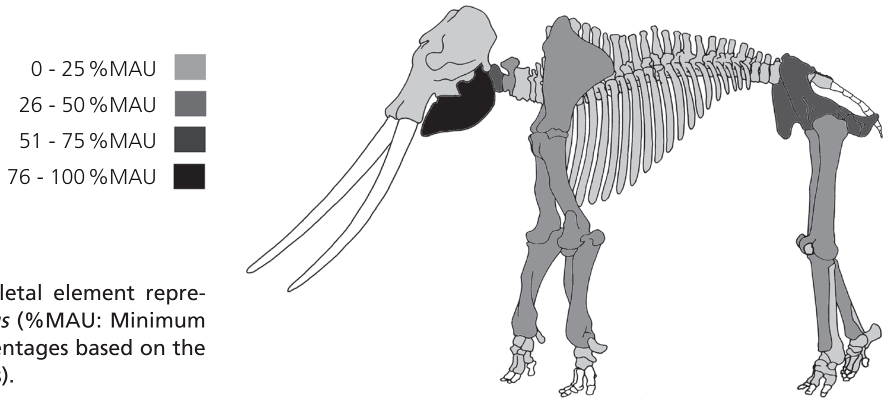

Fig. 3 Illustration of the skeletal element representation for *Elephas antiquus* (%MAU: Minimum number of animal units, percentages based on the total inventory of each species).

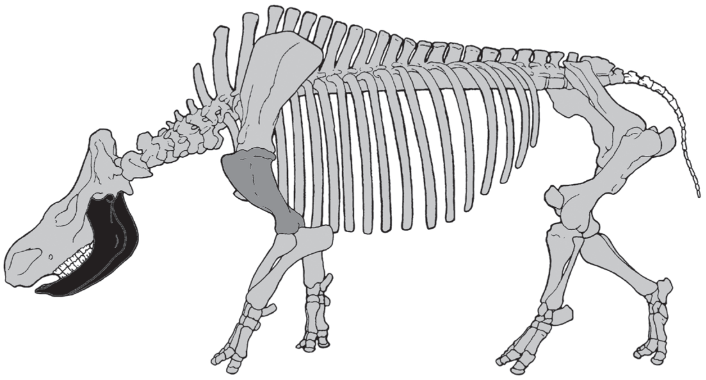

Fig. 4 Illustration of the skeletal element representation for *Stephanorhinus kirchbergensis/hemitoechus* (%MAU: Minimum number of animal units, percentages based on the total inventory for each species).

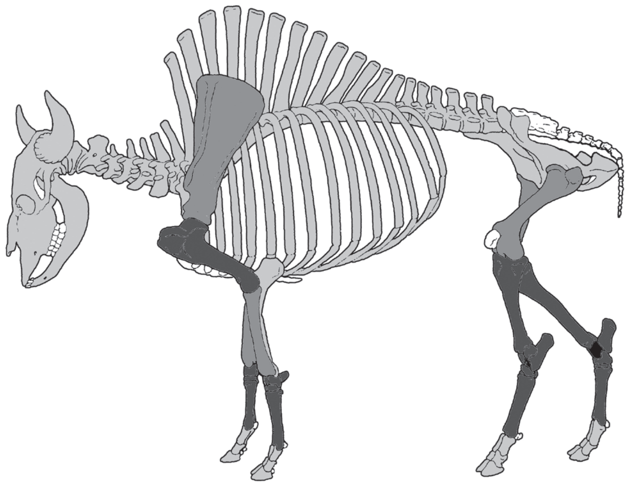

Fig. 5 Illustration of the skeletal element representation for *Bison priscus/Bos primigenius* (%MAU: Minimum number of animal units, percentages based on the total inventory for each species).

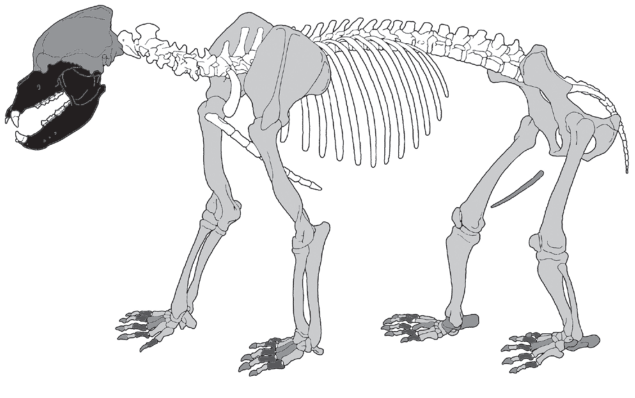

Fig. 6 Illustration of the skeletal element representation for *Ursus* sp. (%MAU: Minimum number of animal units, percentages based on the total inventory for each species).

Tab. 3 Skeletal element representation (without isolated teeth) for all species analyzed.

	Elephas antiquus (%MAU)	*Stephanorhinus kirchbergensis/hemitoechus* (%MAU)	*Bison priscus/ Bos primigenius* (%MAU)	*Ursus* sp. (%MAU)
Cranium	8.7	3.6	4.88	50
Mandibula	100	100	19.51	97.22
Maxilla	13.04	5.86	0	100
Atlas	52.17	3.6	9.76	0
Epistropheus	43.49	4.5	4.88	0
Vertebrae (without atlas and epistropheus)	17.65	3.78	0.39	0
Scapula	47.83	13.96	29.27	2.78
Sternum	17.39	2.7	0	0
Costae	1.3	0.13	0.73	0
Humerus prox.	26.09	9	0	0
Humerus med.	13.04	3.15	2.44	0
Humerus dist.	17.39	33.78	70.73	2.78
Ulna	30.43	23.42	21.95	25
Radius prox.	26.09	19.82	43.9	11.11
Radius med.	0	1.8	0	2.78
Radius dist.	30.43	4.95	21.95	8.33
Carpalia/Tarsalia (without Astragalus and Calcaeneus)	17.39	5.03	54.39	3.89
Sacrum	8.7	0.9	0	0
Pelvis	65.22	23.42	12.2	2.78
Femur prox.	26.09	16.67	43.9	5.56
Femur med.	8.7	10.81	0	0
Femur dist.	34.78	5.86	7.32	16.67
Patella	17.39	0.45	0	25
Tibia prox.	43.48	6.31	0	2.78
Tibia med.	8.7	4.05	2.44	0
Tibia dist.	21.75	9.91	53.67	19.44
Metapodium	5.22	8.11	50.31	35
Astragalus	8.7	14.41	100	30.56
Calcaneus	8.7	9	56.34	36.11
Phalanges	0.43	8.33	20.15	35

%MAU: Minimum number of animal units, percentages based on the total inventory for each species

other autopodials and metapodials. They are rare in elephants and rhinoceroses, while layer quantities of these bones from bovids and bears were preserved.

The patterns of preservation are thus different for each of the analyzed species. Rhinoceros, elephant and bear remains are dominated by mandibular bones. This is particulary true for the assemblage of rhinoceros bones, which has the highest representation of mandibles. Apart from the humerus, all other skeletal elements are represented by less than 25 %MAU. Skeletal representation in the other species is more equal. For *Elephas*, mandibula, pelvis and atlas amount to a %MAU of more than 50. Autopodials, ribs and vertebrae are less common. All long bones (except the fibula) show similar frequencies with %MAUs between 26 and 50. Cranial material, except the mandibula, is rare, a pattern which can also be seen in the other megafaunal species.

Bovids are the only animals analyzed where cranial material does not dominate. Here long bones, and especially metapodials and carpals/tarsals are most common.

Bears show a completely different pattern. Here jaw bones and autopodials clearly dominate. Long bones are present in the sample, but are strongly underrepresented. Ribs and vertebrae are completely absent. In contrast to the other species, maxillar bones are very frequent as well as mandibular bones.

Age

To gain a better impression of age structures at the site, dental age was determined for all species and then compared. The age distribution of the elephant molars shows that most are from young individuals (**tab. 4**). The most common tooth is the M II indicating an age at death between 0.3 and 4.1 years. 14 % of all molars are M I, which are shed between 0.1 and 2.0 years. M III and M IV account for about 20 % of the sample respectively. The results show that elephants over the age of 20 are represented by only about 18 % of all the molars in the sample.

37 left mandibulae containing teeth could be included in the age analysis of *Stephanorhinus* (**tab. 5**). The distribution indicates a "prime dominated" sample. Only a few animals are younger than one year (< 1.5 %). Juvenile animals up to five years of age account for about 11 % of the total. A rise in numbers can be seen for rhinoceroses between 6 and 13 years, which make up for about 75 % of all the determinable specimens. Mature and senile animals are less common. Numbers decrease especially for animals over the age of 22 (2.24 %). Prime age *Stephanorhinus* are thus obviously dominant in the sample.

A total of 27 bovid teeth could be included in the age assessment of *Bison priscus/Bos primigenius* (**tab. 6**). The results show that the greatest number of teeth can be placed in the first half of the maximal tooth lifespan. This indicates that most of the analyzed molars are from adult animals, and that senile bovids are underrepresented. Almost all teeth

Tab. 4 Age distribution of elephants molars including age in years at shedding (according to Haynes 1991).

Molar	NISP	NISP (%)	age in years
M I	21	13.64	0.1-02
M II	41.17	26.73	0.3-04.1
M III	31.42	20.4	2.3-13
M IV	32.25	20.94	5.5-21
M V	17.08	11.09	14.5-40
M VI	11.08	7.19	27.0-61
total	154	100	

NISP: Number of identified specimens

Tab. 5 Age distribution of left rhinoceros mandibulae including age indication (Louguet 2005).

NISP	NISP (%)	age in years
0.5	1.35	<1
2	5.41	1-3
1.5	4.1	4-5
9.66	26.11	6-7
8.66	23.41	8-9
9.5	25.68	10-13
4.33	11.7	14-21
0.83	2.24	>22
37	100	total

NISP: Number of identified specimens

Tab. 6 Age distribution of the M_3 of *Bison priscus/Bos primigenius* including crown height for the different age stages (in mm).

Age stage	crown height (mm)	NISP
Stage 1	63.34-57.01	5
Stage 2	57.00-50.68	2
Stage 3	50.67-44.35	4
Stage 4	44.34-38.02	8
Stage 5	38.01-31.69	4
Stage 6	31.68-25.36	1
Stage 7	25.35-19.03	3
Stage 8	19.02-12.7	0
Stage 9	12.6-6.37	0
Stage 10	< 6.370	0

NISP: Number of identified specimens

Tab. 7 Age distribution of the ursid teeth. Wear stages are according to Stiner (1998).

Stage	NISP	NISP %
II	22	3.17
III	92	13.24
IV	187	26.91
V	143	20.58
VI	128	18.42
VII	64	9.21
VIII	42	6.04
IX	17	2.45
total	695	100

NISP: Number of identified specimens

Tab. 8 Age distribution of the species analyzed based on dental age.

	juvenile (%)	prime (%)	old (%)
Elephas antiquus	60.77	32.03	7.19
Stephanorhinus kirchbergensis / hemitoechus	6.76	79.3	13.94
Bison priscus / Bos primigenius	3.7	85.18	11.11
Ursus sp.	16.41	75.12	8.49

are in the first two thirds of their maximum lifespan. Stage 4 dominates. None of the molars have less than 30 % of the maximum crown height. It can therefore be concluded that adult bovids dominate the sample.

The age distribution of bear teeth shows that most of the bears present died in their prime (**tab. 7**). Juvenile, mature and senile individuals are much less common. Most teeth can be identified in stage IV. The domination of young adult and adult animals is obvious.

The ternary plot, which was used to compare age structures of the species analyzed, shows a distinct difference between *Elephas antiquus* and the other species (**fig. 7, tab. 8**). While *Ursus* sp., *Stephanorhinus kirchbergensis / hemitoechus* and *Bison priscus / Bos primigenius* show a prime dominated distribution, *Elephas* has a U-shaped or attritional distribution (Stiner 1990, 318). This means that very young and older individuals dominate, a pattern that is often linked to natural causes of death where the weakest individuals of a group perish first (Klein / Cruz-Uribe 1984, 56; Stiner 1990, 309). All the other analyzed animals contain less young and very old animals, which can be seen as a sign of non-natural selection (Stiner 1990, 309).

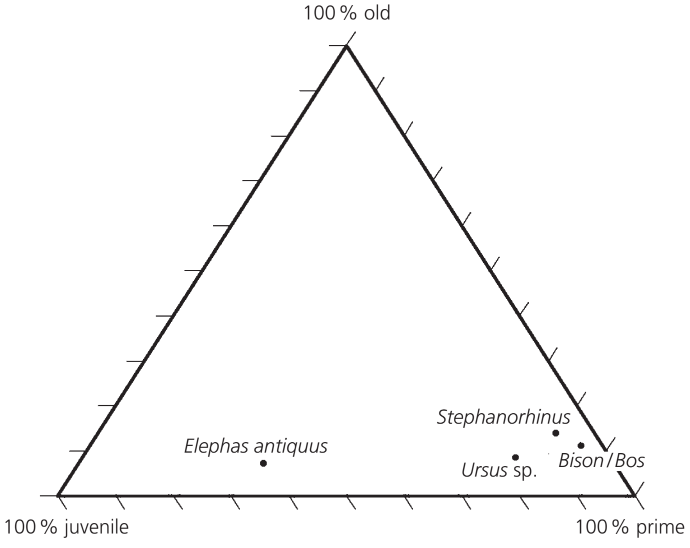

Fig. 7 Age distribution of the species analyzed.

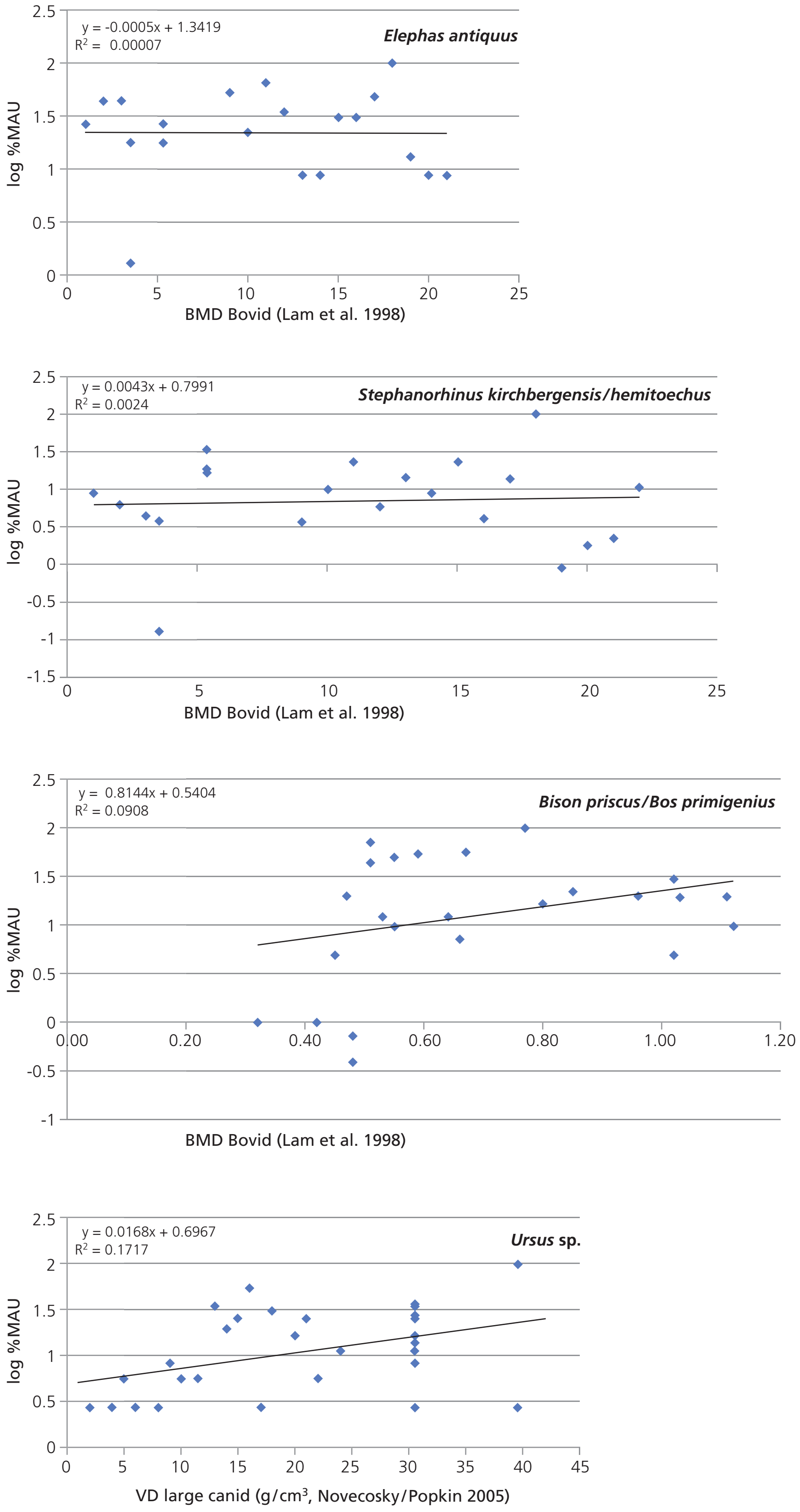

Fig. 8 Assessment of density mediated preservation for all analyzed species. (%MAU: Minimum number of animals units, percentages based on the total inventory of *Elephas antiquus*, BMD: Bone mineral density).

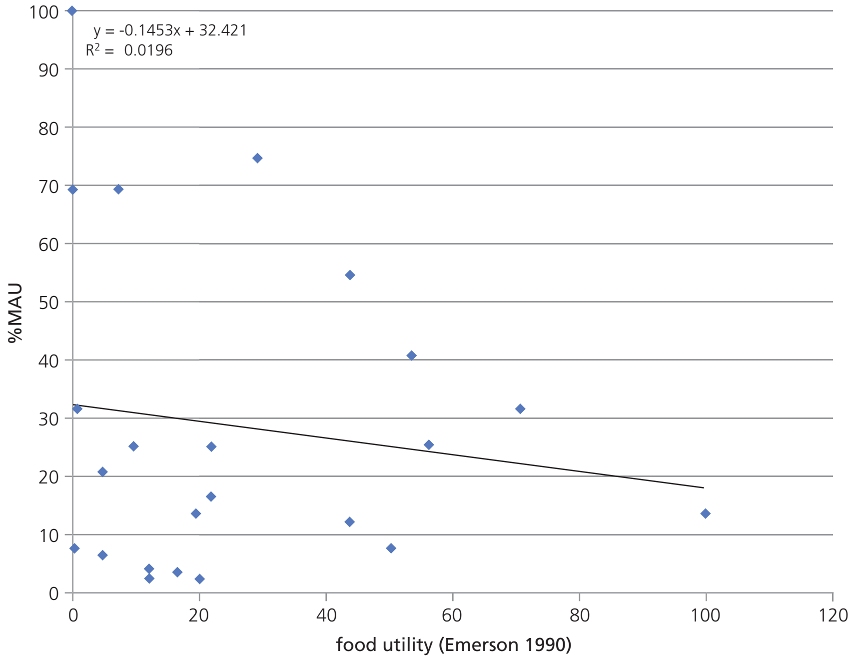

Fig. 9 Food utility, bovids (%MAU: Minimum number of animal units, percentages based on the total inventory of *Bison priscus/Bos primigenius*).

Selection

None of the analyzed species show any connection between bone density and bone frequency (**fig. 8**) and neither positive nor negative correlations were observed. A food utility analysis was only possible for the bovids because there is no data available for the other species. There is no statistically significant correlation between the preservation of the bovids and their food utility (**fig. 9**).

In a further step, it was tested whether fluviatile transport could be responsible for the composition of the Bilzingsleben faunal inventory. The analysis of the Voorhies groups (Voorhies 1969; Behrensmeyer 1975) showed that there are marked differences between the species (**tab. 9, fig. 10**).

Elements from group II, which indicate a winnowed inventory dominate for bovids and elephants, while the distribution is rather equal between groups II and III (lag deposit) for rhinoceroses and bears. However, if skeletal elements in group I/II, which are intermediary between the two groups, are included, it becomes clear that these groups dominate. It can therefore be concluded from the analysis of the Voorhies groups that the inventory has been affected by some fluviatile movement, but is not completely displaced. The ensemble can be considered as winnowed (Voorhies 1969; Behrensmeyer 1975).

Carnivore damage

5.59 % of all analyzed bones from the site show carnivore damage (**tab. 10**). However, there are considerable differences between the species. While more than 7 % of *Elephas* and *Stephanorhinus* remains show gnawing marks, only 4.71 % of *Bison/Bos* are affected. The lowest percentage can be found on the bear bones, where only 1.05 % show traces of carnivore damage. Besides the overall differences between the species, there are also variations in those parts of the skeleton showing the highest traces of gnawing (**tab. 11**). *Elephas* bones yielded the highest number of gnaw marks on the femur (NISP 6) and the pelvis (NISP 8). The other species show less gnaw marks in these areas, which are also less commonly preserved. The same

Tab. 9 MAU representation in the different Voorhies groups (excluding isolated teeth).

Voorhies group	I	I/II	II	II/III	III
Elephas antiquus	9.98	17.44	45.59	0	26.98
Stephanorhinus kirchbergensis/ hemitoechus	4.08	23.28	34.61	1.37	36.53
Bison priscus/ Bos primigenius	2.26	23.11	64.98	0	9.65
Ursus sp.	0	28.82	29.2	7.63	34.35

MAU: Minimum number of animal units

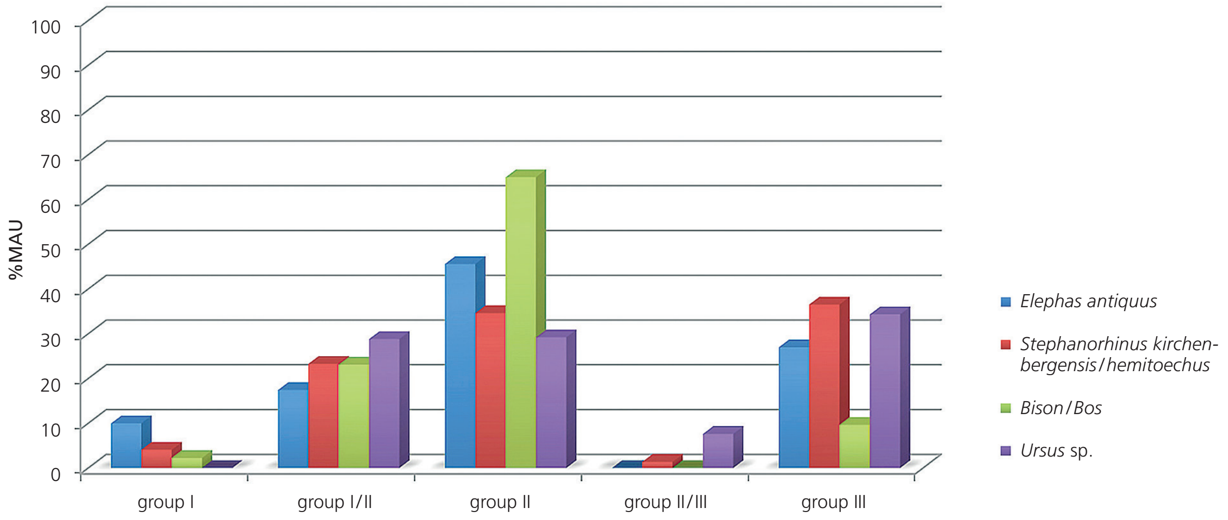

Fig. 10 Distribution of Bilzingsleben animal remains (MAU) in the different Voorhies groups. Isolated teeth are not included (MAU: Minimum number of animal units).

Tab. 10 Counts of bones showing carnivore damage. Total numbers and percentage of the inventory are given for the individual species (left column) and comprehensively for all of the analyzed inventory (right column).

	bones with gnawing marks (NISP)	bones with gnawing marks (NISP %)
Elephas antiquus	35	7.83
Stephanorhinus kirchbergensis/hemitoechus	135	7.18
Bison priscus/ Bos primigenius	28	4.71
Ursus sp.	8	1.05
total	206	5.59

NISP: Number of identified specimens

Tab. 11 Distribution of traces of carnivore damage on skeletal elements (NISP) in comparison to their proportion within the sample (%MAU), including correlation coefficient (R^2).

	Elephas (NISP)	*Elephas* (%MAU)	*Stephanorhinus* (NISP)	*Stephanorhinus* (%MAU)	*Bison/Bos* (NISP)	*Bison/Bos* (%MAU)	*Ursus* (NISP)	*Ursus* (%MAU)
Cranium	0	8.7	3	3.6	0	4.88	1	50
Mandibula	0	100	13	100	0	19.51	2	97.22
Scapula	5	47.83	5	13.96	1	29.27	0	2.78
Vertebrae	3	17.65	2	3.78	0	0.39	0	0
Costae	4	1.3	6	0.13	0	0.73	0	0
Humerus	2	26.09	40	33.78	9	70.73	1	2.78
Radius	1	30.43	4	19.82	0	43.9	0	11.11
Ulna	1	30.43	12	23.42	2	21.95	1	25
Pelvis	8	65.22	12	23.42	1	12.2	0	2.78
Femur	6	34.78	23	16.67	5	43.9	2	16.67
Patella	1	17.39	1	0.45	0	0	0	25
Tibia	0	43.48	3	9.91	1	53.67	0	19.44
Carpalia/Tarsalia	2	17.39	0	5.03	3	54.39	0	3.89
Metapodium	2	5.22	7	8.11	3	50.31	1	35
Astragalus	0	0	2	14.41	1	100	0	30.56
Calcaneus	0	8.7	1	9	2	56.34	0	36.11
Phalanx I	0	8.7	1	8.33	0	16.49	0	26.39
total	35		135		28		8	
Correlation (R^2)		0.0625		0.1706		0.2797		0.3262

NISP: Number of identified specimens, %MAU: Minimum number of animal units, percentages based on the total inventory for each species

Tab. 12 Specimens displaying cut marks.

	Elephas antiquus	*Stephanorhinus kirchbergensis/hemitoechus*	*Bison priscus/Bos primigenius*	*Ursus* sp.	total
cut marks (NISP)	1	12	0	6	19
cut marks (NISP, % of total inventory per species)	0.12	0.3	0	0.24	0.22

NISP: Number of identified specimens

applies to the ribs, where some gnawing traces were observed on the ribs of both elephants (NISP 4) and rhinoceroses (NISP 6) but are not preserved on bones of bovids and bears. *Stephanorhinus* (NISP 40) and *Bison/Bos* (NISP 9) display a larger number of traces of gnawing on the humerus, a bone which is hardly affected in *Elephas* (NISP 2) and *Ursus* (NISP 1). Only the bovids yielded a larger number of gnawing marks on autopodials. *Stephanorhinus* and *Ursus* are the only species that display gnawing damage in the cranial area.

Some details of the gnawed areas show obvious similarities when compared between the species, however clear patterns of carnivore modification were not observed. Since there is no statistically significant correlation between the most commonly preserved bones and those showing most carnivore damage (see **tab. 11**), it can be concluded that a different selection mechanism must be responsible for the pattern. Correlations with the utilization sequence of large carnivores (Blumenschine 1986) could also not be found.

Human modifications

A total of 19 elements show cut marks (**tab. 12**). One was located on a tusk fragment of *Elephas*, 12 on bones of *Stephanorhinus* and 6 on bones of *Ursus*. These are the only cut marks in the inventory which could be securely identified. Due to a large number of sediment scratches, it is possible that some unambiguous cut marks are no longer identifiable. However, a conservative approach was chosen in the identification in order to avoid biasing.

The marks on rhinoceros bones are concentrated on the front legs (distal scapula, proximal and distal humerus and proximal ulna, see **fig. 11**). A few cut marks were also found on the mandibula and autopodials.

Bear bones are less commonly affected by sediment scratches or abrasion and therefore identification of cut marks was easier. Here a distinct pattern could be seen (**fig. 12**). Three of the specimens showed cut marks located on the buccal side of the maxilla, next to the processus zygomaticus (**fig. 13**). The other three are located on the palmar/plantar side of the metapodials.

Cut marks are regularly found in connection with the butchering of animals. This could be shown for

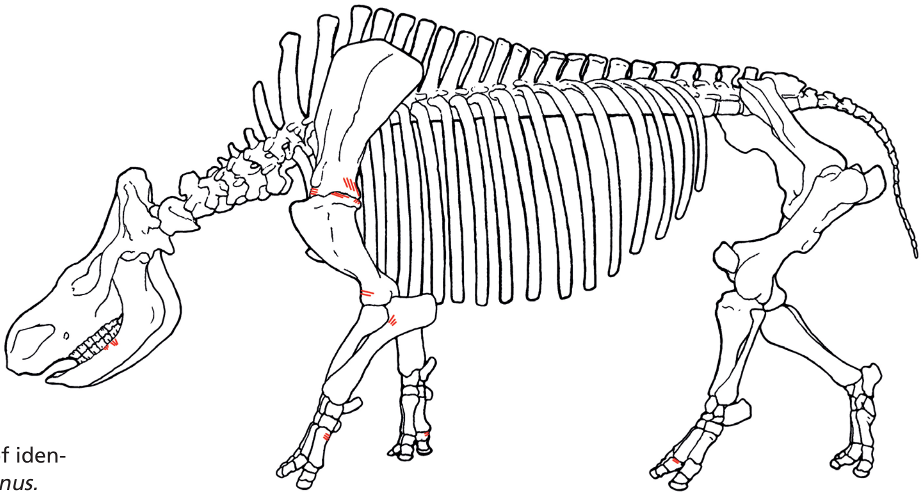

Fig. 11 Schematic illustration of identified cut marks on *Stephanorhinus.*

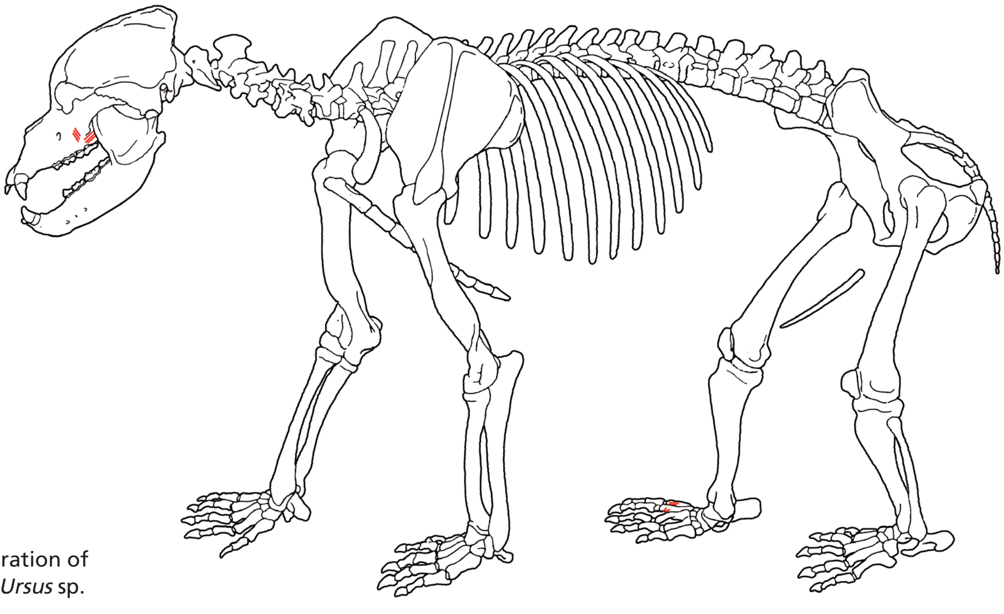

Fig. 12 Schematic illustration of identified cut marks on *Ursus* sp.

Fig. 13 Ursid maxilla with cut marks (indicated by the arrow).

the rhinoceros where the cut marks indicate the dismemberment of the animals. The marks found on the bear bones could also be traces of skinning.

Besides the cut marks there are also other bones that display human modifications. It was assessed whether there are signs of organic artefact production. For this aspect, all bones showing impact marks or any other trace of artificial modification were analyzed individually. These bones are mainly from elephants. Rhinoceros and bovid bones are much less frequent and bear bones show no such traces at all.

In total 364 bones (and some teeth) yield at least one conchoidal flake scar. The agent responsible for these traces could not be identified on most of the specimens, since the pieces only showed single non-diagnostic negatives. Other negatives could be securely attributed to natural processes, mainly because they were found in direct connection with gnawing marks.

Another portion of the bones show impact notches that derived from the deliberate opening of the bone (mainly long bone shafts). A total of 50 bones show interior and/or exterior flakes that were caused by pressure when the bone was opened. Some of these bones contain impact marks that were also caused when the shaft was opened. The question whether humans or animals are responsible for opening these bones can only be answered through analysis of the individual pieces in particular the morphology of the individual negatives. While none of the finds had been retouched, which would have been a clear indicator of human modification, some showed gnawing marks and were therefore considered modified by animals. The diameter of the impact notch could not be taken into consideration for this analysis, because none of them showed any distinct sizing. Therefore, the analysis focussed on the orientation, number and alignment of impacts. A larger number of impact marks with identical orientation in regular intervals should be a strong indicator of human modification. However, the presence of only a single impact does not exclude human handling. Impact marks, induced through dynamic loading, are seen in general as a sign for human interaction with a bone fragment. However, carnivore damage can produce similar patterns (Johnson 1985, 194; Lyman 1994a, 326 f.).

For most of the bones it was not possible to determine whether they had been opened deliberately by humans or animals. However, a total of 9 pieces were quite certainly opened by humans. Here the impact marks are aligned in a way which rules out other possible agents, as can be seen in the example of fragment Bilzingsleben Inv.-Nr. 337,164 (**fig. 14**). All of these pieces show patterns indicating dynamic loading, such as fissures and hackle marks and interior or exterior pressure flakes which developed in connection with the impact when the bone shaft was opened.

Besides these bones there are a number of other specimens that display negatives. For some of them human modifications can be postulated. They contain negatives in one or several rows producing changes of the form of the edge (e.g. **fig. 15, 16**). Natural agents can be ruled out here. There is a total of 6 bones showing these sorts of modifications. They are either from *Elephas antiquus* or could not be securely determined, but are likely to be from elephant because of their size. All of them are large, medial longbone fragments. All but one of the pieces are a slightly less than half as broad as they are long (between 1.77:1 and 1.89:1). While the overall form varies, the proportions remain similar.

Overall the butchering of animals as well as the systematic production of bone artefacts could be verified in Bilzingsleben. When compared to the total count of finds in the assemblage, the number of securely modified pieces is, however, very low.

Discussion

There is conclusive evidence that humans have had the ability to hunt large game as early as the Lower Paleolithic (see summary in Kindler 2012, 3-29). The main question in Bilzingsleben is not whether the humans at this site were able to hunt the megafauna and make use of the carcasses, but rather whether humans actually did hunt at Bilzingsleben and if so to which extent they played a role in the accumulation of faunal material.

The analysis of the bones and teeth of *Elephas antiquus, Stephanorhinus kirchbergensis/hemitoechus, Bison priscus/Bos primigenius* and *Ursus* sp. provided a number of different signals. Some of them supplement, others contradict each other. Since the main goal of this study was to identify human influence at the site, the results presented above will be discussed under this aspect.

A MNI of 245 could be reconstructed from 8280 identifiable specimens. Elephants account for at least 23 individuals, rhinoceroses for 112, bovids 22 and bears for a minimum of 88 individuals. These numbers are large compared to counts from other, even younger, sites. Considering that only a proportion of all species present at the site was studied, the overall number of animals in Bilzingsleben was most likely considerably higher.

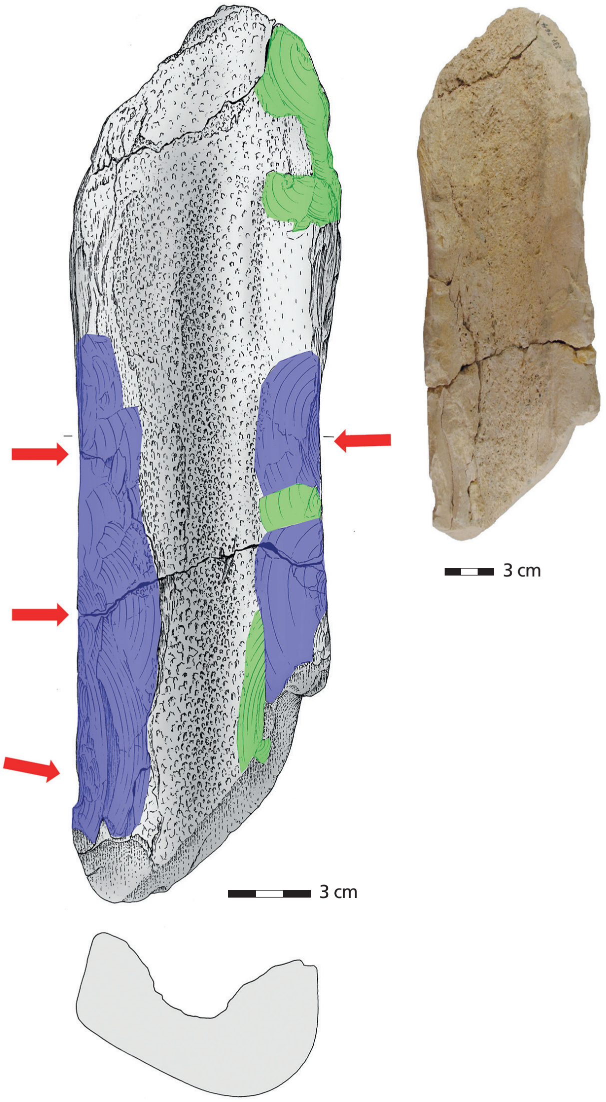

Fig. 14 Bone fragment Bilzingsleben Inv.-Nr. 337, 164 with traces of human modification. Red arrows indicate impact marks, blue areas interior pressure flakes, green areas other negatives. Left: drawing, right: photo.

Especially striking is the large amount of rhinoceroses, as these are mostly solitary animals, that tend to claim large territories (Hutchins/Kreger 2006, 152f.; Laurie 1982, 316f.). There is no indication in the preservation of the fauna that the material was accumulated over a long period of time, ruling out this possibility. The same applies to the

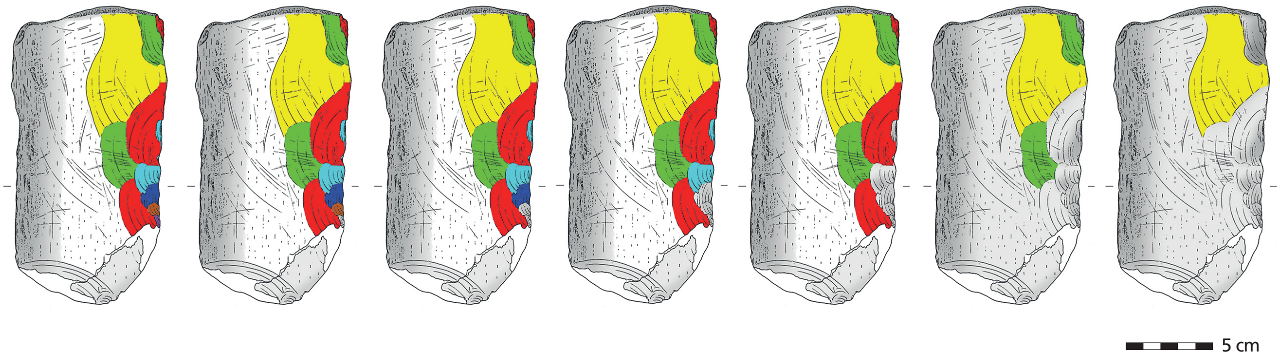

Fig. 15 Colored illustration of the order in which the negatives were created on fragment Bilzingsleben Inv.-Nr. 87, B1 (24.9.70).

bears, who normally also prefer a solitary lifestyle (Hellgren/Vaughan 1989; Dahle/Swenson 2003).

Large mammals often perish close to water sources during droughts (Haynes 1991). Weak bears, however, normally die during hibernation, so that large collections of bones can often be found in winter dens (Stiner 1998, 308f.; Kindler 2012). Large accumulations of dead bears do not naturally occur in the open landscape. Pleistocene open air sites with large amounts of ursid bones are normally interpreted as caused by human hunting activities (e.g. Taubach, see Bratlund 1999 and Biache Saint-Vaast, see Auguste 1995).

The different species all displayed different patterns of skeletal element representation. While the representation of teeth is rather uniform throughout, the largest differences can be found in the bones. The relatively larger overall amount of teeth can be explained with their different mineral structure (Lyman 1994a, 72-80). Another factor is that teeth can often be determined, even when they are strongly fragmented. Thus, at Bilzingsleben, while there were very few teeth that could not be identified, the identification of strongly fragmented long bone shafts of the megafauna was extremely difficult.

The skeletal element representation varies from species to species. A connection with the size of the elements, i.e. larger elements were potentially better preserved, cannot be seen in the material. Smaller pieces are quite common, also for species that were not analyzed here, and it does not seem as if there was a selection towards larger finds. The different patterns of representation for the different species can also not be explained with the overall size of the animals, considering that bovids and rhinoceroses in Bilzingsleben are very similar in size, yet show completely different skeletal representations.

Stephanorhinus kirchbergensis/hemitoechus, Bison priscus/Bos primigenius und *Ursus* sp. show prime dominated age structures, while for *Elephas* young and older animals dominate. The latter pattern is considered a natural death structure since very young and older animals are more vulnerable to natural selection (Lyman 1994a, 118). In the past an active hunting of elephants was postulated at Bilzingsleben (Guenther 1983, 143; D. Mania/U. Mania 1997, 67). The derived age structure indicates otherwise, but must be viewed in connection with the other signals. Haynes (1988, 137f.) writes that subadult elephants often die in larger numbers close to water sources due to droughts, a scenario that should be discussed for the elephants of Bilzingsleben. This would of course not rule out that the carcasses were used by humans.

Natural causes of death most often result in U-shaped death profiles (Stiner 1990, 315), while human hunting practices target mainly prime-age animals and therefore yield prime-dominated age profiles (Stiner 1990, 316f.; 2004, 774). Prime dominated inventories are commonly interpreted in this way (Stiner 1990, 316f.), even though it has been pointed out that the individual behavior of the species of animal has also to be taken into consideration (Lyman 1994a, 128). Wolverton (2006; 2008) describes several sites where prime age bears dominate because they became caught in natural traps. Young, inexperienced bears on the search for new territories are prone to accidents and are therefore dominant at some sites (Wolverton 2006, 541 f.).

While juvenile bears often dominate in caves, open air sites more often show prime dominated age structures, which are interpreted as the results of human hunting (Kindler 2012, 122; Bratlund 1999, 91; Auguste 1995). A natural accumulation of the large amounts of prime age bears in Bilzingsleben is unlikely because of their solitary lifestyle. In addition to this, some of the bones show clear signs of butchering.

The rhinoceros age structure is very similar to that of the bears. The large amount of adult individuals is of key interest here. While there are some very young and older individuals present, the majority died at prime age. However rhinoceroses are more prone to deadly intraspecific conflicts than other herbivores (Mihlbachler 2003, 413 f.). In this context large accumulations of young adult and adult rhinoceros bulls are known from the North American Miocene sites Love Bone Bed and Mixson's Bone Bed (both Florida, Mihlbachler 2003). While there are examples of natural assemblages similar to the Bilzingsleben inventory, these are not very frequent.

On the other hand, the planned exploitation of large amounts of rhinoceroses is only rarely described in Pleistocene contexts. Single rhinoceros bones are regularly found at Pleistocene sites but larger amounts are only known from two other localities in the European Lower and Middle Pleistocene – the sites of Taubach (Germany) and Biache Saint-Vaast (France). This implies that there might be a connection which warrants further research.

The clearest dominance of adult individuals can be seen in the bovids of Bilzingsleben. Here, younger animals are virtually non-existent (only one milk molar was found) while some senile ones are present. The enormous size of the bones, reaching the same dimensions as the rhinoceros specimens, indicates that adult bulls dominate here. The age-structure

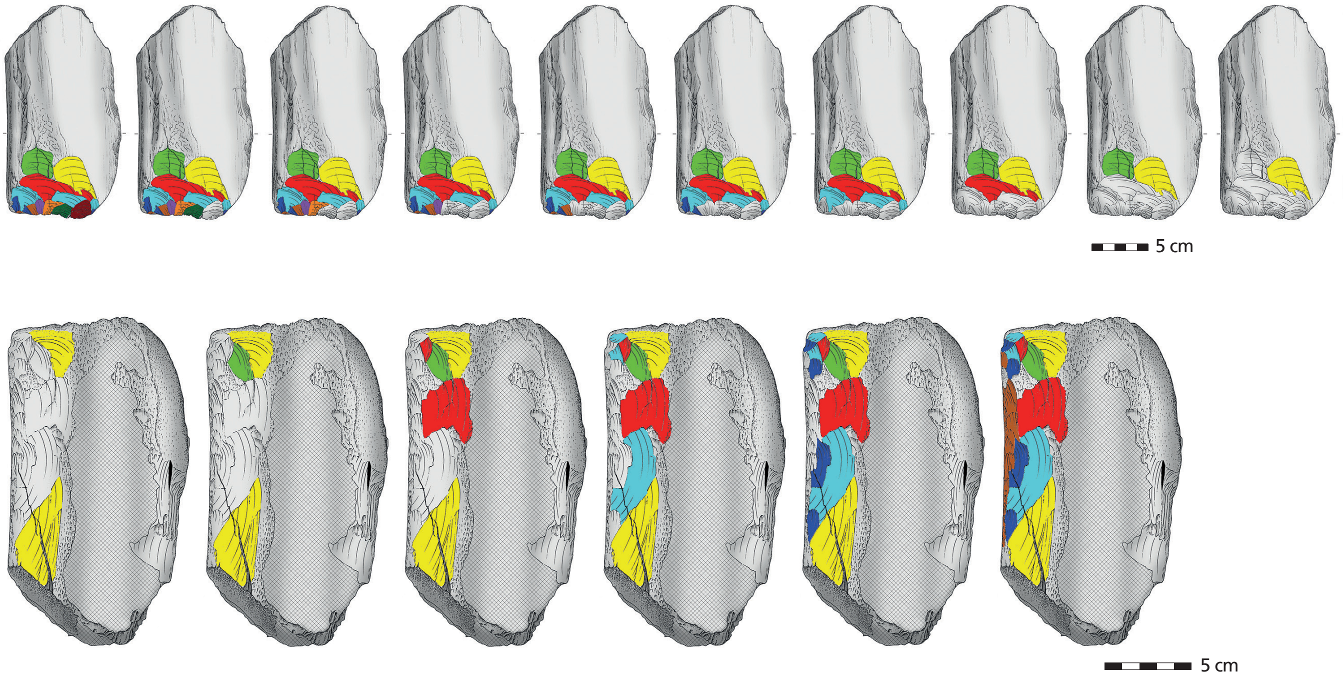

Fig. 16 Colored illustration of the order in which the negatives were created on fragment Bilzingsleben Inv.-Nr. 588, 48. A and B display different sides of the same piece.

also points to a non-natural selection. The overall number of animals is not indicative of a specific selection since bovids are highly sociable and normally live in groups. There are no direct indications for human manipulation on the bones themselves.

Bone density was analyzed for all species using the values published by Lam / Chen / Pearson (1998) and (Novecosky / Popkin 2005). If shaft fragments are not included in bone density analyses, inventories tend to incorrectly display reverse utility caused by the selective analysis (Marean / Assefa 1998, 30 f.). Since many of the megafaunal long bones were highly fragmented, a large portion of them could not be identified. However, the representation of the epiphyses does not seem to be connected to bone density for any of the animals studied at Bilzingsleben. Obviously other factors dominate here. The same applies to the meat utility of the bovids, where no connection could be found to the preservation of the bones. Since studies about meat utility do not exist for the other animals, they could not be considered here. The size of elephant and rhinoceros carcasses suggests that butchering and exploitation of these animals would have required different logistical considerations than the butchering of smaller mammals. Therefore it was decided in this analysis to refrain from the application of data derived through studies of smaller species.

Fluviatile sorting was observed in the material by analysis of the Voorhies groups (Voorhies 1969; Behrensmeyer 1975). The large amount of jaw fragments is especially interesting in this regard. The relatively low number of fragments in Voorhies group I is another indicator that there was some shifting of remains. All species show the same patterns of winnowing. This is in so far problematic as it is obvious that more force is necessary to move an elephant than a bear. While the mechanisms of sorting are identical for all animals, a higher current velocity is necessary for larger animals (Behrensmeyer 1975, 500). In Bilzingsleben however, elephants, rhinoceroses and bears show an identical pattern while the bovid inventory is less thinned out. Those differences are mainly caused by the lower number of jaw fragments for the bovids.

The studies of fluviatile mechanisms were conducted on smaller to medium sized carnivores and ungulates (Behrensmeyer 1975; Voorhies 1969) so it is not clear how the properties change if very large mammals are involved. None the less, if flooding played a major role in Bilzingsleben one would expect the smaller animals to be absent, which is obviously not the case. Therefore it can be postulated that there was some minor fluviatile sorting (possibly also shifting within the site) but that the inventory was not transported in its entirely to the site nor removed from it to a great extent. Fluviatile shifting was certainly not the only selective mechanism.

The amount of gnawed bones varies strongly between the different species. Elephants (7.83 % and rhinoceroses (7.18 %) show the highest proportion, bovids (5.59 %) and bears (1.05 %) yield considerably lower numbers of gnawed bones. Hyenas tend to eat smaller mammals whole, so that in hyena dens those bones are less frequently found than fragments of larger animals (see Dusseldorp 2009, 132). It is therefore possible that the low number of gnawed bear bones does not indicate that they were less frequently eaten, but rather that they were more completely consumed. The skeletal element representation of *Ursus* however does not indicate this. There is no direct connection between the skeletal elements present and the consumption sequence of carnivores (Blumenschine 1986). Therefore it is not likely that large portions of the bears were eaten by hyenas. Moreover carnivores generally avoid eating other carnivores if possible (Kruuk 1972). Megafaunal elements genuinely seem to be more often gnawed by carnivores at Bilzingsleben than elements of other animals. The overall amount of gnawed material is quite considerable and it is obvious that carnivores were important agents at the site. In comparison to bones displaying direct anthropogenic modifications, numbers of carnivore-gnawed bones are a lot higher. Less than 0.5 % of all bones show unambiguous traces of direct human influence. Comparable sites where humans are considered the main agent of site formation tend to yield much higher percentages (e. g. Taubach about 25 %, Bratlund 1999; Biache-Saint-Vaast about 30 % "butchering marks", summary Dusseldorp 2009). However the preservation of such marks depends on the overall preservation of the surfaces of the bones, so that differences do not necessarily illustrate the actual intensity of modifications at different sites.

The direct traces on the bones can be considered secure proof of human interaction with bones at Bilzingsleben. They also show that the animals were butchered and used as a source of raw material for the production of bone artefacts.

Conclusion

The analyzed animal species show different patterns of conservation. Some of these are similar, others not. It is obvious that there is not one single factor responsible for the site formation in Bilzingsleben, but a conglomerate of agents.

The skeletal element representation of *Elephas* gives no clear indication of human influence. MNI and age structure are compliant with inventories caused by natural factors. The same applies to the other analyzed factors of selection. The bones show no evidence of butchery marks. However, they display the largest number of unambiguous secondary modifications. Elephant bones, primarily long bone shafts, were used as a raw material for bone artefact production. There is no indication that elephants were actively hunted. At the same time, elephant bones displayed a large amount of carnivore damage. This percentage is much higher than the counts of bones modified by humans, and could be an indication of primary access by carnivores. Humans likely used the remains of elephants not as food, but as sources of raw material.

The signals derived from the analysis of the *Stephanorhinus kirchbergensis/hemitoechus* material paints a slightly different picture. The large amount of individuals of a solitary living species indicates a non-natural cause of accumulation. However, it could be shown for different sites that there are natural processes that can produce patterns in age and numbers of rhinoceros individuals similar to the one recorded at Bilzingsleben (Mihlbachler 2003). Therefore neither the age distribution nor the large numbers of animals pose sufficient evidence of a non-natural accumulation. *Stephanorhinus* is the species that displays the largest proportion of cut marks in the inventory. Even here the total numbers are low, when compared to the total counts in the Bilzingsleben assemblage. They do, however, evidence the butchering of at least three different individuals of rhinoceros. Only a few bones displayed unambiguous evidence of human modification, in contrast to higher counts of carnivore damage. Whether animals had primary access to the carcasses cannot be ascertained. The skeletal representation shows some signs of fluviatile disturbance but cannot be explained by this alone. It is likely that several mechanisms played a role here. Overall, subsistence activities could be shown for the rhinoceroses from Bilzingsleben. A secure verification of the hunting of those animals was not possible.

None of the bovid bones show direct evidence of human modification. Müller and Pasda (2011, 37 f.) describe a bovid specimen with cut marks from a different area of Bilzingsleben, therefore verifying the existence of such modifications at the site. Even so, the overall amount of butchery marks on the bovid bones is still virtually non-existent. The amount of gnawing marks is also lower than in the other megafaunal species. Other differences are apparent in the skeletal part representation. Here mainly the lower number of mandibula fragments and a domination of autopodials can be noted. The age structure indicates that mainly adult animals died at the site, while the overall numbers of individuals are low compared to the other species in this study. The age structure can be seen as an indicator for hunting but other evidence pointing in this direction is lacking. An unambiguous utilisation of bovids by humans in the assemblage analysed in this study could therefore not be shown.

The skeletal part preservation for *Ursus* differs considerably from that of the megafauna species. The pattern of large amounts of head and foot bones is typically found in caves, where it is attributed to animals dying during hibernation over the course of many years (Fosse/Morel/Brugal 2002).

Since Bilzingsleben is an open air site, different taphonomic agents have to be considered. The cut marks found on identical spots on several specimen could be an indication of the skinning of those animals and possible production of furs. It is also possible that the skins were brought to the site from elsewhere. Signs of meat removal could not be found and, considering the good overall preservation of the bone surfaces, such traces are not likely to have been missed. While some accounts of natural accumulations of large amounts of bear bones in open air sites do exist (Wolverton 2006; 2008), they are always connected with a natural trap situation, something that can be ruled out for Bilzingsleben. Overall, there is strong evidence for human influence on at least part of the inventory of bear bones.

Different scenarios can be discussed for the signals derived from the study of the megafauna and bears in Bilzingsleben. In favor of active hunting, by humans as the main agents of site formation, are the large overall amount of (mainly normally solitary living) animals as well as the age structure for all species except *Elephas.* However, the few butchery marks on the bones contradicts this. While it is possible that some marks were abraded by trampling and there is a large amount of sedimentary abrasion scratches on the megafaunal material, this cannot be concluded for the bears. The surfaces of the bones show very few sediment scratches and the overall preservation is good enough to expect butchery marks to survive.

An accumulation over a long period of time in the vicinity of a water source could explain how the large amount of faunal material assembled. However, the preservation of the bones does not indicate that they were exposed on the surface for a considerable period of time, or for different periods of exposure. The age distribution also indicates a non-natural cause of death. A fluviatile influence on the bones is quite likely but it was probably not a major factor and shifting of bones took place within the site or only over short distances.

The butchering of bears and rhinoceroses could be shown to a small extent. A considerably larger amount of bones show traces of carnivore gnawing. This might indicate that humans only had secondary access to the carcasses, a situation especially likely for the elephants. Bears and rhinoceroses could also have been hunted by humans. While there are sites where large amounts of bones from solitary living animals are preserved under natural circumstances, these are almost always under exceptional conditions. While it seems likely, direct proof of a systematic hunting of the animals by humans could not be deduced. Systematic hunting on a larger scale can be ruled out for *Elephas antiquus* and *Bison priscus / Bos primigenius* where no evidence hints at this. It is quite possible that the utilisation of *Elephas* was more passive and / or secondary, e. g. carcasses of already deceased animals were exploited.

Considering that different animal species were affected by different processes at the site, the remaining faunal material and especially the smaller species should be studied in order to gain a deeper understanding of the complete thanatocoenosis.

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