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RECAPITULATING ZOOARCHAEOLOGY AT SALZGITTER-LEBENSTEDT: CURRENT STATE OF RESEARCH AND PERSPECTIVES

Abstract

This review article summarizes the state of research on zooarchaeology at the German Middle Palaeolithic site of Salzgitter-Lebenstedt. The site has become famous as analyses demonstrated mass hunting of reindeer in Middle Palaeolithic contexts and provided an up to now unparalleled assemblage of bone tools manufactured from mammoth bones. Results of studies undertaken with a time-offset of almost 20 years on faunal material unearthed during the 1950s (Lebenstedt I) and the 1970s (Lebenstedt II) are compared, previously unpublished data from Lebenstedt I are additionally included, and the potential of the site for future research is outlined.

Keywords

Neanderthals, mass hunting, bone tools, mammoth, subsistence, reindeer

INTRODUCTION

The last 20 years have witnessed a paradigmatic change in our perception of Neanderthals. Neanderthals made it from our underachieving cousins, to popular mating partners, a perspective that trace back to interpretations of DNA studies of the Neanderthal genome (Prüfer et al., 2014; Vernot and Akey, 2014). Neanderthals, however, are very different from anatomically modern humans, especially in the way they behaved. Therefore, it is not astonishing that today a research focus re-emerges, aiming to more clearly define and understand the differences in behaviour between them and us or to phrase it better, between us then and now. It was in the mid 1990s that the discovery of wooden spears at the late Middle Pleistocene site of Schöningen (Germany) (Thieme, 1997; Schoch et al., 2015) fueled debates on Neanderthals' cognitive abilities, that ranged from scavengers hardly able to survive (Binford, 1985) to efficiently adapted daredevils (Trinkaus, 1995). Among the studies that at that time contributed to the rehabilitation of Neanderthals from a behavioural perspective was the zooarchaeological analysis of bones and bone tools from Salzgitter-Lebenstedt (Gaudzinski, 1998, 1999; Gaudzinski and Roebroeks, 2000). It suggested a specialization in the exploitation of Reindeer that could only be explained by intentional cooperative hunting encounters. Moreover, until today Salzgitter has provided the only large series of Middle Palaeolithic bone tools. The study of the faunal assemblage was a repeated focus of intense discourse (Munson and Marean, 2003; Gaudzinski and Roebroeks, 2003; White et al., 2016) illustrating the interpretative potential that lurks among the bone and bone tools discovered at the site.

Against the background of the paradigmatic shift in the perception of Neanderthals that has taken place since, there is hardly a better time to recapitulate the study and the results on Salzgitter-Lebenstedt, even if the study, though not the results obtained meanwhile, have become of age.

The particular studies reported here focus on material from the original 1952 excavation (Lebenstedt I) and were undertaken during the latter part of the 1990s (Gaudzinski, 1998). By that time, it was not possible

to additionally include material unearthed during a new excavation in 1977 (Lebenstedt II; Grote and Preul, 1978), as the study of the 1977-material was already underway when the analysis of the 1952-material started. The analysis of the 1977-material took some time and was not published until 2017 (Ludowici and Pöppelmann, 2017). By then the 1952-sample had been published for almost 20 years and the authors took the opportunity to draw on these results, considerably increasing the sample size and adding valuable in-depth information on the character of the species represented.

The current review article takes the opportunity to outline the similarities and differences between the different studies, starting from the analysis of the 1952 bone material. In addition, previously unpublished data from Lebenstedt I on the role of humans in the assemblage formation are added.

This compilation and evaluation of study results with its relatively narrow site-focus is far from the current research focus on tracing Neanderthals ecology. Though new research is currently underway at Salzgitter that focuses on traceological studies of the numerous bone-tools from the site, there is hardly a better moment for recapitulation of this particular site that is so very important for the understanding of human lifeways during the Middle Palaeolithic.

Geological and taphonomical parameters

Salzgitter-Lebenstedt looks back on two archaeological excavations – in 1952 (Lebenstedt I) and 1977 (Lebenstedt II). Both excavations unearthed material from fluvial deposits, i. e., fine sands and gravel of a small stream. Based on the two field campaigns, the accumulation of lithics and faunal remains extends over at least 30 m in NS direction and ca. 40 m in WE direction. Topographically, Salzgitter-Lebenstedt is located between the Central European low mountain ranges (*Mittelgebirge*) and the Northern German Plain, on the northern slope of the Krähenriedebach riverlet, where its formerly narrow and steep valley joined the wide, flat glacial valley of the Fuhse river. At the valley bottom ran a small, mostly dried up riverlet with intermittently changing water-level and meandering stream, with two backwater ponds not exceeding 1 m in depth that were occasionally silted up by strong water currents coming from north-eastern slopes (Tode et al., 1953; Kleinschmidt, 1953a). Lebenstedt I preserved especially the faunal material in the two backwater ponds (main find horizon) with concentrations of artefacts around these ponds (Tode, 1953).

To understand the depositional history of Lebenstedt I Kleinschmidt (1965) studied the stratinomy of small fluvial systems. He emphasized that the surfaces of the bones unearthed at Lebenstedt I mirrored their burial milieu. Bones deposited in sand were severely affected, their surface preservation contrasting that of bones deposited in humic environments, from which most of the finds were unearthed. Accordingly, the surface of a bone can display differing preservation according to the varying chemical composition of the burial milieus. The depositional history of the assemblage is complex and a homogeneous spatial pattern for the entire site was not observed. What can be outlined however is a para-autochthonous deposition of the bone assemblage, influenced by changes in the water regime and by cryoturbation, the latter leading to vertical transport of up to 1 meter and to the very local vertical arrangement of bones (Kleinschmidt, 1953a). Excavation plans (Tode, 1982: Taf. 131-136) as well as the photo documentation display animal body parts aligned still in anatomical order, among them complete feet from reindeer and *Bison*, isolated mammoth molars, reindeer antler and bone-fragments from *Esox* (Tode, 1953; Kleinschmidt, 1953a).

In contrast to such findings, the excavation plans also illustrate the presence of poly-specific bone concentrations with faunal remains that had accumulated around large, bulky skeletal elements stopping their leeward spatial scattering. Together with an analysis of the surrounding sediment matrix these bone concentrations allow an estimate on flow direction, velocity and water level (Kleinschmidt, 1965; Tode, 1982:

Taf. 131-136). In parts of the site, the spatial distribution of small bones ran parallel to the direction of the shoreline. Based on the presence of bones belonging to the same individual, Kleinschmidt reconstructs vertical bone transport with a distance of at least 8 m (Kleinschmidt, 1965). Other sections of Lebenstedt I survived completely unaffected by mechanisms which caused the spatial displacement of animal bones and teeth.

The depositional history of Lebenstedt II with the archaeological finds accumulated in a loose scatter, is also of complex nature though different from Lebenstedt I as it is characterized by the presence of three gullies that eroded and cut into the main find horizon (Preul, 1991, 2017: Fig. 10).

MATERIAL AND METHODS

The study of the faunal material from Salzgitter-Lebenstedt comprised a total of n = 3,056 faunal remains (Kleinschmidt, 1953a) unearthed during the excavation of the site in 1952 (Lebenstedt I). This material is stored at the Braunschweigisches Landesmuseum Wolfenbüttel (Germany). Numerous mammoth teeth which had originally been part of the faunal assemblage and published by Guenther in 1991 were not stored together with the rest of the material and could not be studied. Guenther's (1991) results, however, are considered in the present study. The sample unearthed in 1952 also included bone fragments, among them a huge amount of reindeer long-bones. A comparison with the bone sample unearthed during the more recent excavations in Salzgitter in 1977 (Lebenstedt II) illustrates that the 1952 sample suffered from a strong collection bias towards bone fragments. A strong collection bias is equally apparent for the lithic material (Gaudzinski, 1998). It was therefore decided to exclude these fragments altogether from the analysis.

In the following the methods that served the analysis of Lebenstedt I are listed:

Taxonomic determination, age and sex determination, and determination of season of death

Part of the faunal material was taxonomically determined by A. Kleinschmidt, this especially applied to skeletal remains from reindeer. Further in-depth determination for a variety of taxa as to skeletal elements were undertaken by the author.

The mammoth teeth had been studied by Guenther (1991). He provided information on the ages of the individuals represented. The mortality structure for mammoth was calculated based on data provided by Haynes (1993), Laws and Parker (1968) and Laws (1966).

For reindeer, determination of age is based on Habermehl (1985) and a comparative study with reindeer, aged between 2 months and 12.5 years, from West Greenland from the comparative collection of the MONREPOS Archaeological Research Center and Museum for Human Behavioural Evolution. For information on epiphyseal fusion Hufthammer's data (1995) were used. The seasonality of mortality based on reindeer antlers is based on Berke (1989) and Sturdy (1975).

Minimum Number of Individuals (MNI)

MNI calculation followed Binford (1978), but additionally took information on individual age into consideration. For reindeer the %-MNI (Minimum Number of Individuals) were calculated against the most frequent

postcranial element (i. e., the metatarsus) and were obtained by putting the proximal metatarsus at 100 %, calculating the other %-MNIs relative to this.

Weathering

Traces of weathering indicating the relative duration between the death of an individual and its final burial were documented based on information about climatically induced weathering provided by Behrensmeyer (1978).

Abrasion

As with traces of weathering, abrasion is another parameter that indicates the relative time between the death and the burial of an individual. Among other taphonomic variables, fluvial transport can lead to bone abrasion. The study of bone abrasion distinguishes between unrolled, heavily rolled and partially rolled skeletal elements as suggested by Shipman (1981).

Bone mineral density

Selective post-depositional bone destruction can be related to bone mineral density. In order to evaluate if the assemblage was affected by selective processes, skeletal element representations for reindeer, horse and bison were analysed using bone mineral density data (Lyman, 1994; Gaudzinski, 1998: Tab. 14) that were correlated with %-MNI for the individual species.

Bone loss due to fluvial transport

Fluvial dynamics can cause selective transport of bones. Documentation of presence/absence of particular bones of a carcass can help to evaluate if a bone assemblage was affected by these processes, as it leads to a loss of more easily transportable parts (Voorhies, 1969). The transport potential of different bones is known (Voorhies, 1969; Behrensmeyer, 1975). Bones with similar dispersal behaviour are combined into Dispersal-Groups, where bones of Dispersal-Group 1 (various vertebrae, carpals, tarsals) are very susceptible to fluvial transport whereas bones of Dispersal-Group 3 (elements of the skull) characterize lag deposits. Bone loss due to fluvial transport was checked for *Rangifer tarandus*, *Mammuthus primigenius*, *Equus ferus*, *Bison priscus* and *Coelodonta antiquitatis* (for a detailed definition of Dispersal-Groups for the individual species, cf. Gaudzinski, 1998).

Modification by carnivores and deer

For the identification of traces of carnivore modification, the zooarchaeological comparative collection of the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution was used. Identification followed Haynes (1983), Zapfe (1939) and Sutcliffe (1973).

	NISP 1952	MNI 1952	NISP incl. 1977	MNI incl. 1977
Rangifer tarandus	2130	86	4358	not specified
Mammuthus primigenius	410	17	478	not specified
Equus sp.	227	8	515	not specified
Bison priscus	79	3	128	3
Coelodonta antiquitatis	9	1	38	3
Canis lupus	1	1	8	2
Megaloceros giganteus	-	-	8	2
Panthera leo spelaea	-	-	2	2

Tab. 1 Salzgitter-Lebenstedt (Lebenstedt I and II). Qualitative and quantitative composition of the large mammal assemblage according to frequency. NISP includes Lebenstedt II, taken from Ludowici and Pöppelmann (2017). NISP = Number of Identified Specimens per taxon, MNI = Minimum Number of Individuals.

Bone surface modifications and fragmentation by humans

Bone surfaces were studied using a hand lens with a magnification of 32×. All traces were registered per bone and recorded by anatomical position. The taphonomic comparative collection of the MONREPOS Archaeological Research Centre and Museum for Human Behavioral Evolution and diagnostic criteria were used to identify hominin induced cut-marks and anthropogenic fractures (Binford, 1981; Blumenschine and Selvaggio, 1991).

For the visualisation of characteristics on bone retouchers and cut-marked bird-bones a Smartzoom 5 digital microscope was used, featuring a PlanApo D 1.6×/0.1 objective.

RESULTS FROM THE ANALYSIS OF LEBENSTEDT I, CONTEXTUALISED AGAINST LEBENSTEDT II

In the following results of the zooarchaeological analysis of Lebenstedt I are reported and evaluated against the results of new zooarchaeological analysis that also included the material from the 1977 excavation at Lebenstedt II (Ludowici and Pöppelmann, 2017). In parts, these studies followed a different methodological apparatus that cannot be replicated for the entire newly analysed assemblage. It is therefore not always possible to directly compare the results of both studies. The Ludowici and Pöppelmann (2017) study had strong focus on palaeontology, on species determination and demography and considerably enlarged sample size. It becomes apparent that results obtained from the extended sample supports the results obtained from the 1952 assemblage, while adding additional valuable information.

Bone preservation at Salzgitter is generally very good, as is shown for example by the survival of bones from neonate mammoths or the survival of numerous complete reindeer hemi-mandibles. Kleinschmidt's finding that the character of bone surface preservation can vary on a single bone, was repeatedly confirmed (cf. Gaudzinski, 1998: Tab. 9), however and therefore, for this assemblage weathering and abrasion do not serve as suitable indicators for the relative time between the death of an individual and its final burial.

Staesche (2017a) identified more than 30 bone-fragments exposed to fire. Whereas some of these show only slight traces of burning, others are completely calcinated. They were detected among bone-fragments
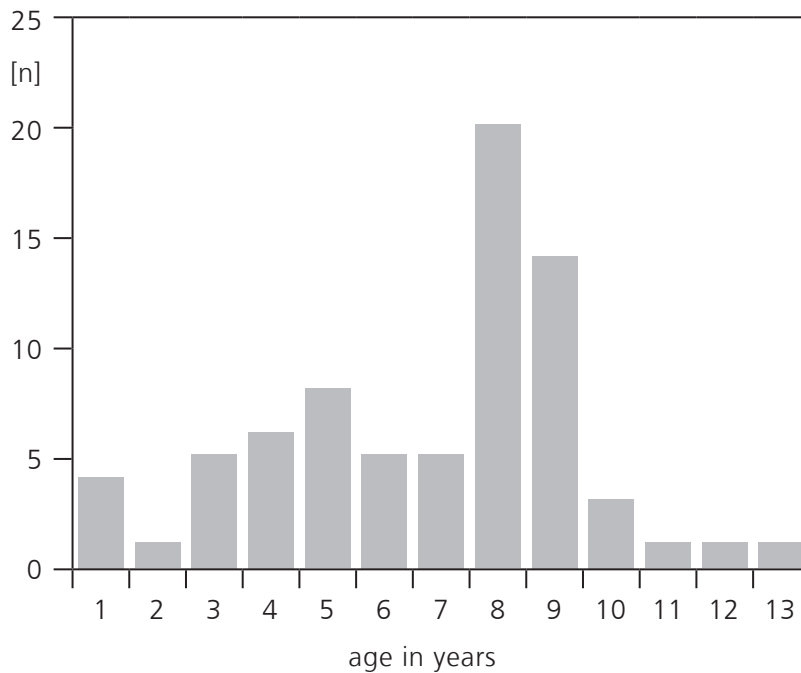
Fig. 1 Lebenstedt I. Age profile for *Rangifer tarandus* based on age estimates for complete hemi-mandibles [n].

from Lebenstedt I and II. Staesche interprets these bones to have been used as fuel. Hearths, however, were neither documented for Lebenstedt I (Tode, 1952) nor for Lebenstedt II.

The assemblage of large mammal species from Lebenstedt I comprised species listed in **Table 1**.

The new round of faunal studies Ludowici and Pöppelmann (2017) that included the Lebenstedt II material presented an enlarged species composition, in which *Megaloceros giganteus* (Staesche, 2017d) and *Panthera leo spelaea* (Staesche, 2017e) were additionally identified.

Rangifer tarandus

In total, 2,130 reindeer bones from Lebenstedt I were analysed, amounting to an MNI of 86. Age composition for Lebenstedt I indicates a stable presence of young individuals with a peak at 8 to 9 years (**Fig. 1**). A number of 74 more or less completely preserved hemi-mandibles were included in the study (Gaudzinski and Roebroeks, 2000).

For an estimate on the sex ratio represented in Lebenstedt I, measurements of antler bases were undertaken (Gaudzinski and Roebroeks, 2000) that reveal a clear bimodal distribution with a large group of adult males and a second group of sub-adult males, females and young individuals (**Fig. 2**). Season of death was stipulated for Lebenstedt I (Gaudzinski and Roebroeks, 2000) based on the dentition of young individuals, stages of epiphyseal fusion in young individuals, and the state of antler as late summer/autumn, leading to the interpretation of autumn-hunting of entire reindeer-herd(s), an interpretation later supported by studies on tooth-microwear analysis (Rivals et al., 2015).

The new zooarchaeological studies (Staesche, 2017b) which included Lebenstedt II, considerably enlarged the reindeer-sample to NISP = 4,358. However, MNIs were not calculated. This study puts particular empha-

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sis on the determination of sex, age and season of death, underlining the relatively high amount of juvenile and subadult individuals and concluded a balanced gender ratio, possibly with a very slight prevalence of females, and resumed that age- and sex composition reflects the structure of a naturally occurring population (Staesche, 2017b). Histological analysis of root cementum annulations of two mandibular first molars stretched the season of death for the reindeer from late fall to winter, as both seasons were evidenced (Kirdorf and Witzel, 2017).

Skeletal element representation for reindeer in Lebenstedt I (**Tab. 2**) showed frequent survival of elements of the skull and distal parts of hind legs, a result consolidated by the new studies (Staesche, 2017b: Tab. 3). At Lebenstedt I the skeletal element representation was evaluated for bone selection by fluvial processes and density mediated attrition. For the latter, the correlation coefficient ($r = 0.63$) and the coefficient of determination (r^2) indicate that less than half of the observed variation can be attributed to the influence of the density-to-%MNI relationship (Gaudzinski and Roebroeks, 2000: 503, Fig. 3). Analysis of fluvial selection with the abundant presence of bones of all Dispersal-Groups indicates a relatively undisturbed faunal assemblage, with only little material loss (Gaudzinski, 1998; Gaudzinski and Roebroeks, 2000).

Equally, carnivores modified the Lebenstedt I bone assemblage to a minor degree, with only 16 bones displaying evidence for carnivore modification (Gaudzinski, 1998; Gaudzinski and Roebroeks, 2002: Tab. 1). The substantial extension of the reindeer sample achieved by including Lebenstedt II, further lowered this
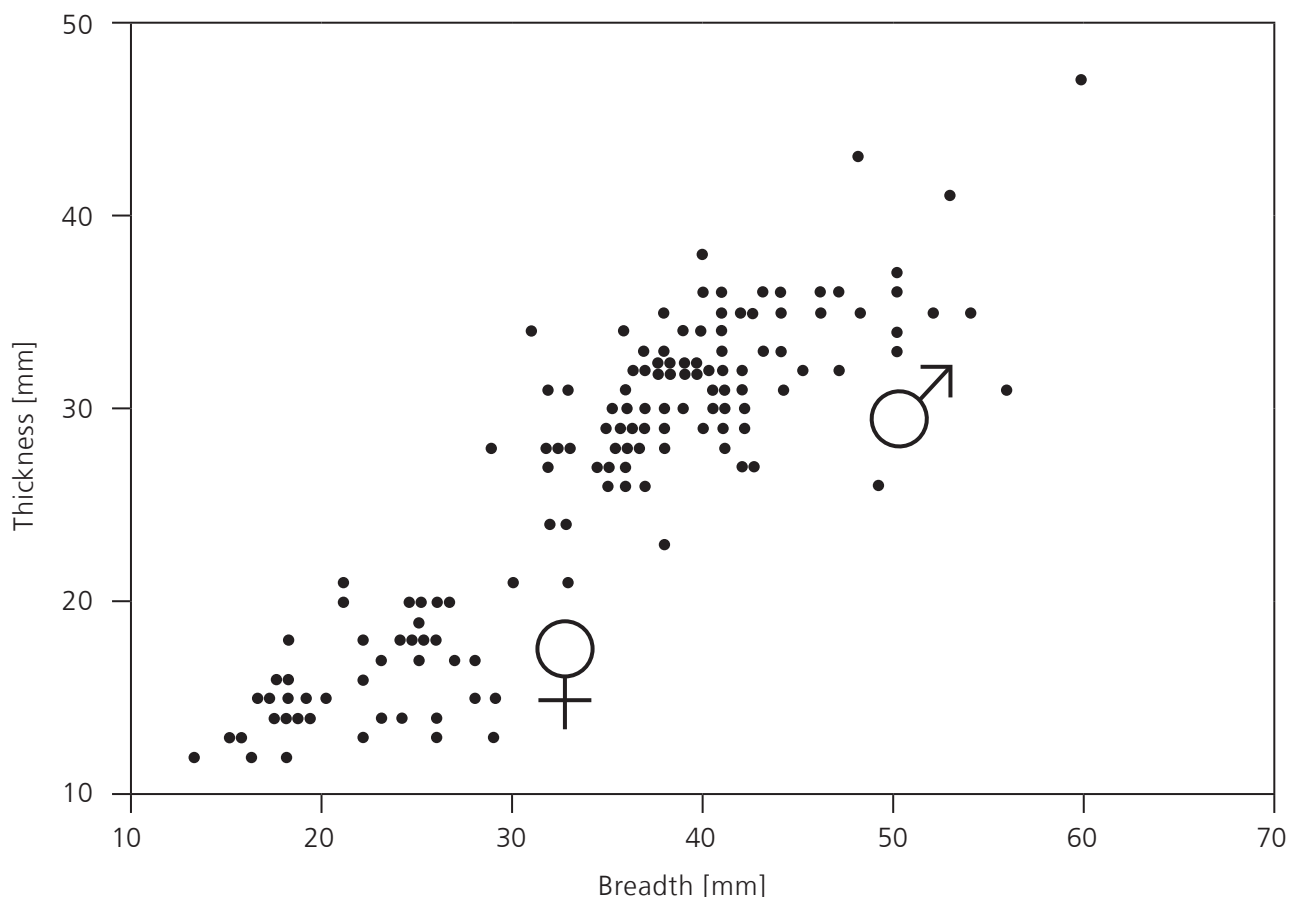

Fig. 2 Lebenstedt I. Thickness *vs*. breadth for antler beams (n = 135). For position of measurements taken see Sturdy (1975: Fig. 1, position 2).

	NISP	MNI sin	MNI sin./dext.	MNI dext.	MNI	MNI [%]
Antler	156	78	-	86	82	186.4
Maxilla	34	17	-	15	16	36.4
Mandible	83	48	-	33	41	93.2
Atlas	18	-	18	-	18	41.0
Epistropheus	15	-	15	-	15	34.1
Cervical	44	-	17	-	10	22.7
Thoracal	92	-	13	-	8	18.2
Lumbar	39	-	11	-	9	20.5
Sacral	8	-	8	-	8	18.2
Pelvis	52	27	-	25	26	59.1
Ribs	275	17	-	19	11	25.0
Scapula	49	28	-	21	25	56.8
Humerus prox.	18	15	-	3	9	20.5
Humerus dist	54	31	-	23	27	61.4
Radius prox.	55	20	-	35	27	61.4
Radius dist.	39	14	-	25	20	45.5
Ulna	36	16	-	20	18	40.9
Metacarpus prox.	38	23	-	15	19	43.2
Metacarpus dist.	41	20	7	14	17	38.6
Femur prox.	27	13	-	14	14	31.8
Femur dist.	50	30	-	20	25	56.8
Tibia prox.	67	31	-	36	34	77.3
Tibia dist.	83	49	-	34	42	95.4
Metatarsus prox.	87	45	-	42	44	100.0
Metatarsus dist.	97	34	-	41	38	86.4
Calcaneus	63	43	-	20	32	72.7
Astragalus	46	23	-	23	23	52.3
Phalange I	95	32	-	29	24	55.0
Phalange II	38	16	-	11	11	25.0
Phalange III	20	5	-	6	5	11.4

Tab. 2   Lebenstedt I, *Rangifer tarandus*. Qualitative and quantitative composition of skeletal elements. NISP = Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half.

already low ratio, as Staesche counts only 27 modified bones for the entire assemblage (Staesche, 2017a: 74, Tab. 1).

Apart from carnivores, herbivores additionally modified the thanatocoenosis and their traces can occasionally be documented on antler fragments in the form of forking of fragments or of flat, blunt, and broad grooves on antler beams (Gaudzinski, 1998: Tab. 7,3). Staesche considers faunal remains with these modifications intentionally modified tools (Staesche, 2017a: 81, Figs. 14-17).

Lebenstedt I gives evidence for numerous traces of hominin meat and marrow processing, in the form of cut-marked bones and bones with conchoidal impact fractures (**Tab. 3**; **Fig. 3**) (Gaudzinski and Roebroeks, 2003). The documented traces must be read as a quantitative minimum estimate, as a thin sedimentary film covered some of the bones and blurred traces. Cut-marks and impact fractures were documented on 512 skeletal elements or fragments thereof, with 222 skeletal elements displaying conically induced impacts. Bone fracture patterns point to a very standardized marrow exploitation (Gaudzinski and Roebroeks, 2000:

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Figs. 11-13). The systematic and standardised way of marrow exploitation is particularly well illustrated by metatarsals. For opening the marrow cavity, the anterior face of the bone was taken off like a lid (Gaudzinski, 1998; Gaudzinski and Roebroeks, 2000: Fig. 13) (**Fig. 3**).

Staesche (2017a) also analysed traces of hominin meat and marrow exploitation but only documented part of these (Staesche, 2017a: 77, Tab. 3). In contrast to the documentation of cut- and fracture marks at Lebenstedt I, he documented the number of cuts, not the number of cut-marked bones, and additionally mentions that the assemblage yielded numerous additional unspecified cut-marked fragments. Though Staesches documentation of traces is knowingly incomplete, his observations on the occurrence of cut-marks adds valuable information. He primarily observed cuts on ribs, tibiae and metatarsi, a result already outlined for Lebenstedt I, consolidating the low abundance of traces on metacarpi and forelegs as well as on the upper part of hindlegs. This is quite remarkable as the inclusion of all shaft-fragments in the analysis did obviously not alter the general pattern observed in the analysis of Lebenstedt I only.

Staesche additionally observes conically induced impacts and, again in contrast to the analysis of Lebenstedt I, documents the number of impacts, not the number of elements on which these traces have been observed. Again, the highest number of impacts is observed on tibiae and metatarsi, as is also documented for Lebenstedt I. These results consolidate observations made for Lebenstedt I, showing that during the process of marrow exploitation a selection against subadult individuals, mandibles, metacarpi and phalanges occurred (Gaudzinski and Roebroeks, 2000: 508-509, Fig. 14).

Several long bone fragments show scars due to the fragments having been used for stone tool production. Some of the bone retouchers preserved tiny flint fragments embedded in their scar-fields (**Fig. 4**). Staesche (2017a) counted 67 scar-fields, most of them on fragments of tibiae (n = 37) and metatarsi (n = 21).

Reindeer-antler was also modified by humans. One of the best examples is an almost complete left antler beam, still attached to the skull, with distinct chopping marks on the brow-tine (Tode et al., 1953; Gaudzinski, 1998).

Mammuthus primigenius

A number of 410 remains from *M. primigenius* have been studied from Lebenstedt I. A MNI of 17 was calculated based on the abrasional pattern of the occlusal face of upper (n = 11) and lower (n = 10) molars (Guenther, 1991). Guenther (1991) additionally provides information on the age of death of these individuals. Even though the sample is small, thought on the mortality structure represented was given (Gaudzinski, 1998).

For the interpretation of mortality structures in elephants, Haynes (1991) suggested a subdivision of ages according to 12 year-intervals. Elephants reach the height of their reproductive career, i. e., their prime, at an age between ca. 37-45 years (Haynes, 1991). For the Salzgitter mammoths a clear dominance of juveniles and subadult individuals and noticeable under-representation of prime adults and old individuals becomes apparent (Gaudzinski, 1999). This result finds support in Krönneck's recent analysis of the mammoth age composition based on the epiphyseal state of the postcranial skeleton that included material from Lebenstedt I and II (Krönneck, 2017b).

The general skeletal element representation for mammoth (**Tab. 4**) from Lebenstedt I is clearly dominated by molars and fibulae. A number of 13 fibulae were recorded that represent a minimum of seven individuals. The abundance of fibulae does not correspond to the rather small number of skeletal elements that articulate with the fibula, i. e., the tibia or tarsal bones.

Moreover, 161 rib fragments of 10 cm to more than 1 m length were documented with the provison that no confusion with *Coelodonta antiquitatis* ribs occurred (especially for the smaller fragments) (cf. Wolsan,

	Impact fractures		Cut-marks		
	sin.	dext.	sin.	dext.	sin./dext.
Mandible					
lateral			16	7	
medial			6	4	
medial and lateral			25	18	
Humerus Shaft					
cranial	0	0	2	1	
caudal	0	1	3	3	
lateral	3	3	1	3	1
medial	4	4	7	7	
lateral and medial			2		
Humerus distal					
caudal	0	0	0	3	
lateral	0	0	2	0	
medial	0	0	4	6	
Radius/Ulna prox.					
cranial	0	1	1	1	1
caudal	0	0	0	0	
lateral	0	1	1	3	1
medial	1	0	1	0	
Radius/Ulna Shaft					
cranial	7	11	10	12	
caudal	1	5	0	1	
lateral	0	0	1	0	
medial	1	0	1	0	
Radius/Ulna dist.					
caudal	0	0	0	1	
Metacarpus Shaft					
cranial	0	1	5	3	1
caudal	0	0	0	0	1
lateral	0	0	1	1	
medial	4	1	5	1	1
Metacarpus dist.					
cranial	0	0	0	1	
Femur prox.					
caudal	0	0	1	0	
lateral	0	0	1	0	
Femur Shaft					
cranial	6	2	7	8	
caudal	2	1	0	2	
lateral	1	1	1	1	2*
medial	7	5	1	2	
Femur dist.					
cranial	0	0	1	0	
lateral	0	0	1	0	
medial	0	0	0	1	

	Impact fractures		Cut-marks		
	sin.	dext.	sin.	dext.	sin./dext.
Tibia Shaft					
cranial	4	1	3	2	
caudal	6	13	12	9	
lateral	0	1	4	2	
medial	19	18	8	9	
lateral and medial	1			2	
Tibia dist.					
cranial	0	0	1	0	
caudal	0	0	0	1	
Astragalus					
lateral			0	2	
medial			1	3	
lateral and medial			1	4	
Calcaneus			16	11	
Os cubo-naviculare			4	1	
Metatarsus prox.					
cranial	0	0	0	0	
caudal	0	0	0	0	
lateral	1	0	0	2	
medial	0	0	1	1	
medial and lateral	0	0	1	0	
Metatarsus Shaft					
cranial	0	0	1	1	
caudal	0	0	0	0	
lateral	25	9	13	14	
medial	10	16	12	10	
medial and lateral	18	6	4	8	8

Tab. 3 Lebenstedt I, *Rangifer tarandus*. Frequency of cut-marks, percussion marks and gnawing marks on skeletal elements.
The table presents the number of skeletal elements (or fragments thereof) on which one or more cut-marks and/or percussion marks have been observed. ant. = anterior; post. = posterior; lat. = lateral; med. = medial; sin. = left; dex. = right; * = lat. or med.

	Cut-marks		
	sin.	sin./dext.	dext.
Skull			
Maxilla	10	2	11
Os Nasale	5	0	4
Os Zygom.	1	0	0
Os Frontale		16	
Os Hyoid.	5	1	3
Skull indet.		6	
Scapula	22	10	18
Vertebrae			
Atlas		15	
Epistropheus		5	
cerv 3		6	
cerC 4		0	
cerv 5		2	
cerv 6		3	
cerv 7		2	
th 1		9	
th 2		12	
th 3		7	
th 4		6	
th 5		5	
th 6		0	
th 7		2	
th 8		4	
th 9		2	
th 10		5	
th 11		4	
th 12		7	
th 13		3	
l 1		7	
l 2		10	
l 3		0	
l 4		5	
l 5		7	
Sacrum		3	
Ribs			
1. Rib	1		1
2. Rib	2		2
3. Rib	2		3
4. Rib	5		11
5. Rib	10		7
6. Rib	8		7
7. Rib	9		11
8. Rib	9		8
9. Rib	10		9
10. Rib	8		9
11. Rib	6		8
12. Rib	3		6

	Cut-marks		
	sin.	sin./dext.	dext.
13. Rib	1		3
14. Rib	1		3
Rib-Fragments		48	
Sternum Segment			
1		3	
2			
3		1	
4			
5			
6		1	
7			
indet		1	
SterCum Segment 1-3		2	
Pelvis	18		7
Phalanx 1			
ant. sin. med		5	
ant. sin. lat.		6	
ant. dex. lat.		7	
post. dex. lat.		2	
post. dex. med.		2	
post. sin. lat.		4	
post. sin. med.		3	
Phalanx 2			
post. sin. lat.		1	
Phalanx 3			
post. sin. lat.		2	
post. sin. med.		2	

	gnawed	tooth marks	possible tooth marks
Mandible	2	2	2
Scapula	1	4	2
Pelvis	4	0	0
Humerus	1	0	1
Radius/Ulna	2	0	1
Femur prox.	2	0	1
Femur dist.	4	4	0
Metatarsus	0	2	2

Fig. 3 Lebenstedt I. Typical fracture patterns for (**a**) metatarsals from *Rangifer tarandus* and (**b**) Radius/Ulna with enlargements of three proximal locations with cut-marks.

1982). Only six of these ribs were complete, a number of 40 proximal ends survived as well as 14 distal ends. The sum of the length of all fragments is 75.55 m, and thus it could be pointed out that ribs represent a further dominant element within the prostcranial element representation for this species. The observed skeletal element representation clearly deviates from patterns generally observed in the archaeological and palaeontological record (cf. Haynes, 1991).

The faunal study from 2017 (Krönneck, 2017b) of Lebenstedt I and II excluded teeth from the analysis, but underlines the results obtained from Lebenstedt I, in that it also observes ribs to be among the most numerous skeletal elements. Due to a higher number of fragments of femora and acetabuli, the 2017 study highlights pelvis and femora as second most frequently represented in the comparative compilation of skeletal elements based on bone weight.

Lebenstedt I also yielded bones from neonate individuals. They are primarily represented by complete mandibles (n = 3) and pelves (n = 2). Additional three fragmented pelvis remains from juvenile individuals complete the assemblage, indicating a clearly biased skeletal element representation for juvenile/subadult mammoths (Gaudzinski, 1998).

The profile of mammoth body parts (**Tab. 4**) is characterized by an anecdotal presence of bones and bone loss by fluvial transport. However, bones of all Dispersal-Groups were present in relatively equal proportions (cf. Gaudzinski, 1998: 194, Fig. 14), with selective fluvial mechanisms seemingly having played no or only a minor role in the survival of skeletal elements of this species (Gaudzinski, 1998).

For Lebenstedt I, carnivore modification affected a high number of these skeletal elements, as 27.7 % show traces of gnawing. The damage pattern indicates hyena damage. A number of 93 small long bone fragments that could not be determined to skeletal element complete the assemblage. Among them are 45 bone fragments, again a very high ratio, with clear hyena modification (Gaudzinski, 1999). In contrast, Staesche (2017a) outlines a number of only 18 bones for Lebenstedt I and II modified by carnivores, mostly hyaenas.

The degree of hominin interaction with the mammoth remains judged from cut-mark frequencies is difficult to assess. Various surface modifications can be observed on ribs due to post-excavational conservatorial measures. Among bones from Lebenstedt I are six rib fragments with unambiguous cut-marks. As other presumable cut-marks have been observed associated with surface modifications that clearly originated from conservatorial measures, quali- and quantification of cut-marks was not undertaken for this assemblage.

Staesche (2017a) was able to increase this sample by including Lebenstedt II, with a further cut-marked rib as well as two fibulae and two pelvis fragments.

Hominin influence on the mammoth assemblage is also clearly indicated by modified ribs and fibulae. Within Lebenstedt I a total of 23 skeletal elements shows modifications made by humans. In addition, Tode mentions a further two ribs (Tode, 1953: Fig. 18 bottom; Tode, 1982: Taf. 124b.2) as well as a modified fibula (Tode, 1982: Taf. 124b.1) with modifications similar to those described below. These bones are not stored in Wolfenbüttel and were therefore not included in the analyses of bone-tools from Lebenstedt I. A comparison of 20 mammoth ribs with unmodified (cf. Gaudzinski, 1999: Fig. 5a), broken off (cf. Gaudzinski, 1999: Fig. 5b), carnivore gnawed (cf. Gaudzinski, 1999: Fig. 5c) or split-by-drying (cf. Gaudzinski, 1999: Fig. 5e) ends from Lebenstedt I clearly illustrates the morphological differences between these ribs and those modified by humans.

It can generally be outlined that the majority of ribs modified by humans are characterized by a spiral fracture resulting from the removal of the head. Due to the high degree of carnivore modification it is unclear whether hyaenas or humans were responsible for these damages. All modified ribs show a convex curvature corresponding to their natural bending.

Three modes of modification on the ribs can be distinguished. One way of modifying the ribs is characterized by the symmetrical or unsymmetrical tapering of the ribs' ends opposite the spiral fractured end from
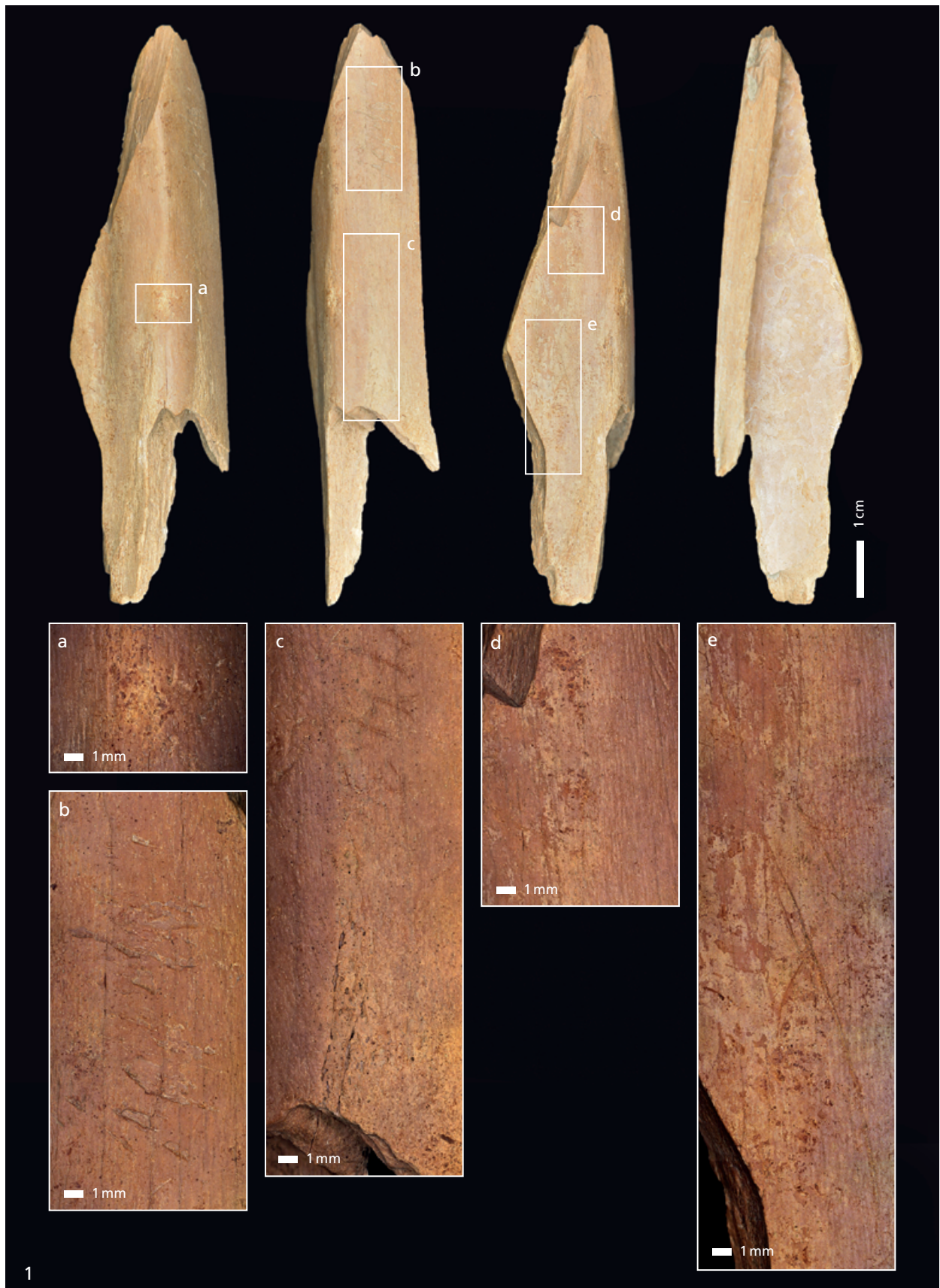
Fig. 4 1 Lebenstedt I. Bone retoucher.

Fig. 4   2 Lebenstedt I. Bone retoucher.

Fig. 4   3 Lebenstedt I. Bone retoucher with flint fragments (indicated with an arrow) still embedded in the scar-fields.

	NISP	MNI sin.	MNI sin./dext.	MNI dext.	MNI [%]
Maxilla	8	5	-	3	57.1
Mandible	14	7	-	7	100.0
Cervical	2	-	1	-	2.3
Thoracal	17	-	3	-	2.5
Lumbar	3	-	1	-	2.0
indet.	25	-	1	-	-
Pelvis	4	-	2	-	14.2
Ribs	(161)				
Scapula	4	2	-	2	28.5
Humerus dist.	1	1	-	-	7.1
Radius prox.	6	3	-	2	35.7
Ulna	6	2	-	3	35.7
Os carpale	1	1	-	-	7.1
Os naviculare	1	1	-	-	7.1
Patella	1	-	-	1	7.1
Tibia prox.	3	1	1	1	21.4
Fibula	13	7	-	6	92.8
Talus	1	-	1	-	7.1
Phalanges	2	1	-	1	14.2

Tab. 4 Lebenstedt I, *Mammuthus primigenius*. Skeletal elements. NISP = Minimum Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half; MNI sin./dext. = body side indeterminate.

cranial and/or caudal direction. These modifications either affect or remove the compacta on the lateral face of the bone and produced short, flat points (compare Rib 1 and Rib 4; **Fig. 5** and **Fig. 8**; Note: modified ribs are addressed below in paragraphs of their own). It is striking that some of the ribs modified this way lack a clearly pointed tip (see Rib 1; **Fig. 5**) and it is unclear if the tip was intentionally broken off or broke off from functional stress.

A further modification of the ribs produced long and compact tips (compare Rib 2 and Rib 3; **Fig. 6** and **Fig. 7**). Tapering and pointing of the tip was either obtained by abrading the bone compacta while the convex curvature of the bone was retained by splitting off one half of the bone to reduce the tips circumference (see Rib 7; **Fig. 9**).

Furthermore, the morphology of ribs was altered by bone splitting (see Rib 1; **Fig. 5**). Numerous conical impacts on the bones' lateral and caudal edges attest to wedges, which were rammed into the caudal and lateral faces of the ribs in order to initiate the process of splitting. These impacts distinguish intentionally modified ribs from bones that disintegrated during storage due to drying. In order to reconstruct the workstages necessary to produce the modifications observed in detail, traceological studies based on controlled experiments are necessary. These analyses are already initiated at the TraCEr Laboratory for Traceology and Controlled Experiments at the MONREPOS Archaeological Research Centre for Human Behavioural Evolution and will provide more insight into the quantification of the degree of functional stress as an additional variable in tool morphology.

All modified pieces have been described in detail in Gaudzinski (1998); therefore only a representative selection will be described below.

Rib 1 (**Fig. 5**)

(fragment, sin.; length: 60.3 cm, max. breadth: 3.7 cm, max. width: 2.5 cm)

The proximal end of the rib shows a spiral fracture 7.9 cm in length, indicating damage when the bone was still green. On its medial face the distal end was tapered by diagonal abrasion of the compacta from cranial, reducing the bone thickness from 1.8 cm (measured at the base of the modification) to 0.8 cm (measured at the tip) exposing the spongiosa. The modification also reduced the breadth of the bone (from 3.0 cm to 1.1 cm). The tip ends in a flat break.

Rib 2 (**Fig. 6**)

(fragment, sin.; length: 78.0 cm, max. breadth: 4.2 cm, max. width: 2.7 cm)

The proximal end of the rib shows a spiral fracture covering 11.4 cm and 3.4 cm of the cranial and caudal edges of the bone. At its distal end, the lateral face is modified by convergent abrasion of the bones' compacta from cranial and caudal resulting in a pointed tip, 10.4 cm in length. The bone was reduced in thickness from 1.6 cm (measured at the base of the modification) to 0.3 cm (measured at the tip) and breadth (from 3.5 cm to 0.9 cm), exposing the spongiosa at the end of the tip.

Rib 3 (**Fig. 7**)

(fragment, indet.; length: 37.6 cm, max. breadth: 3.3 cm, max. width: 2.2 cm)

Rib 3 is a fragment with a plain fracture. At the opposite end, the lateral face shows a tip similar to Rib 2. The unidirectional modification affected the compacta of the bone retaining the convex curvature of the bone surface. The tip measures 8.9 cm in length. At the tip, the bone was reduced in thickness from 1.2 cm (measured at the basis of the modification) to 0.3 cm (measured at the tip).

Rib 4 (**Fig. 8**)

(fragment, sin.; length: 63.3 cm, max. breadth: 3.9 cm, max. width: 2.4 cm)

The head of the rib was removed leaving a spiral fracture. At the distal end the lateral face was tapered from cranial and caudal to form a tip. The modification reduced the breadth of the bone from 1.3 cm (measured at the base of the modification) to 0.4 cm (measured at the tip) and exposed the spongiosa of the bone. In addition, the thickness was reduced from 3.4 cm to 0.6 cm by smoothing/abrading the lateral face.

Rib 7 (**Fig. 9**)

(fragment, indet.; length: 80.5 cm, max. breadth: 4.6 cm, max. width: 3.2 cm)

Rib 7 was equipped with a compact tip, 15.9 cm in length. On the lateral face, the compacta was modified retaining the concave curvature of the rib and probably subsequently additionally smoothed. The width of the tip was reduced by splitting off the medial half of the bone as shown by small conical impact fractures on the cranial and caudal edges of the bone. By producing a tip, the bones' breadth and width were reduced from 4.4 cm to 0.6 cm and from 3.3 to 0.5 cm.

Split rib 1 (**Fig. 10**)

(fragment, indet.; length: 72.5 cm, max. breadth: 5.1 cm, max. width: 2.4 cm)

The most striking feature that characterizes this bone fragment are numerous small conical impacts on the cranial and caudal side of the bone with a total of 18 impacts on one and 9 impacts on the opposite side. These damages result from the splitting of the bone. The proximal articular joint of the rib was broken off when the bone was still fresh, leaving a spiral fracture. The bone was equipped with a tip by tapering from
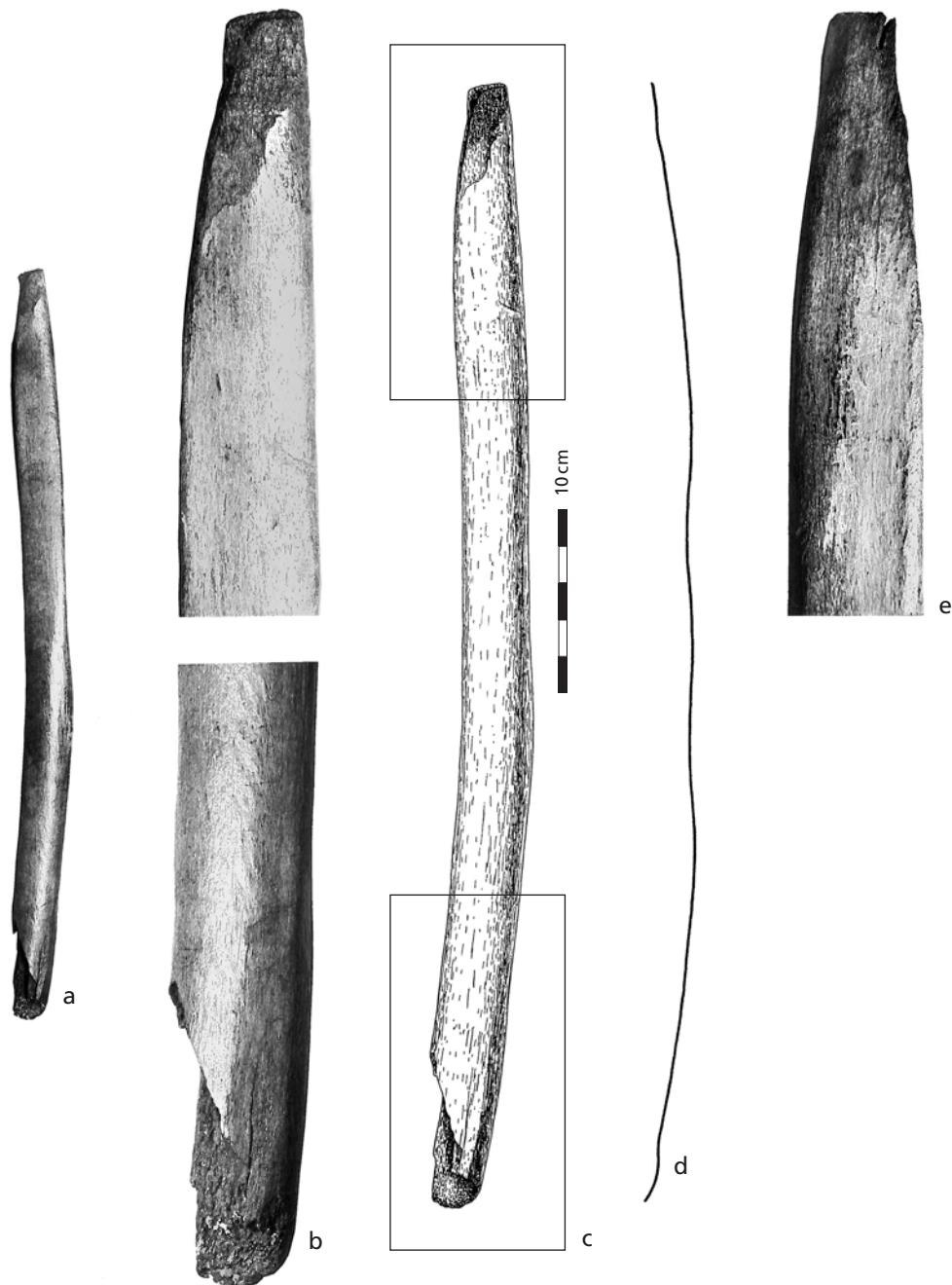
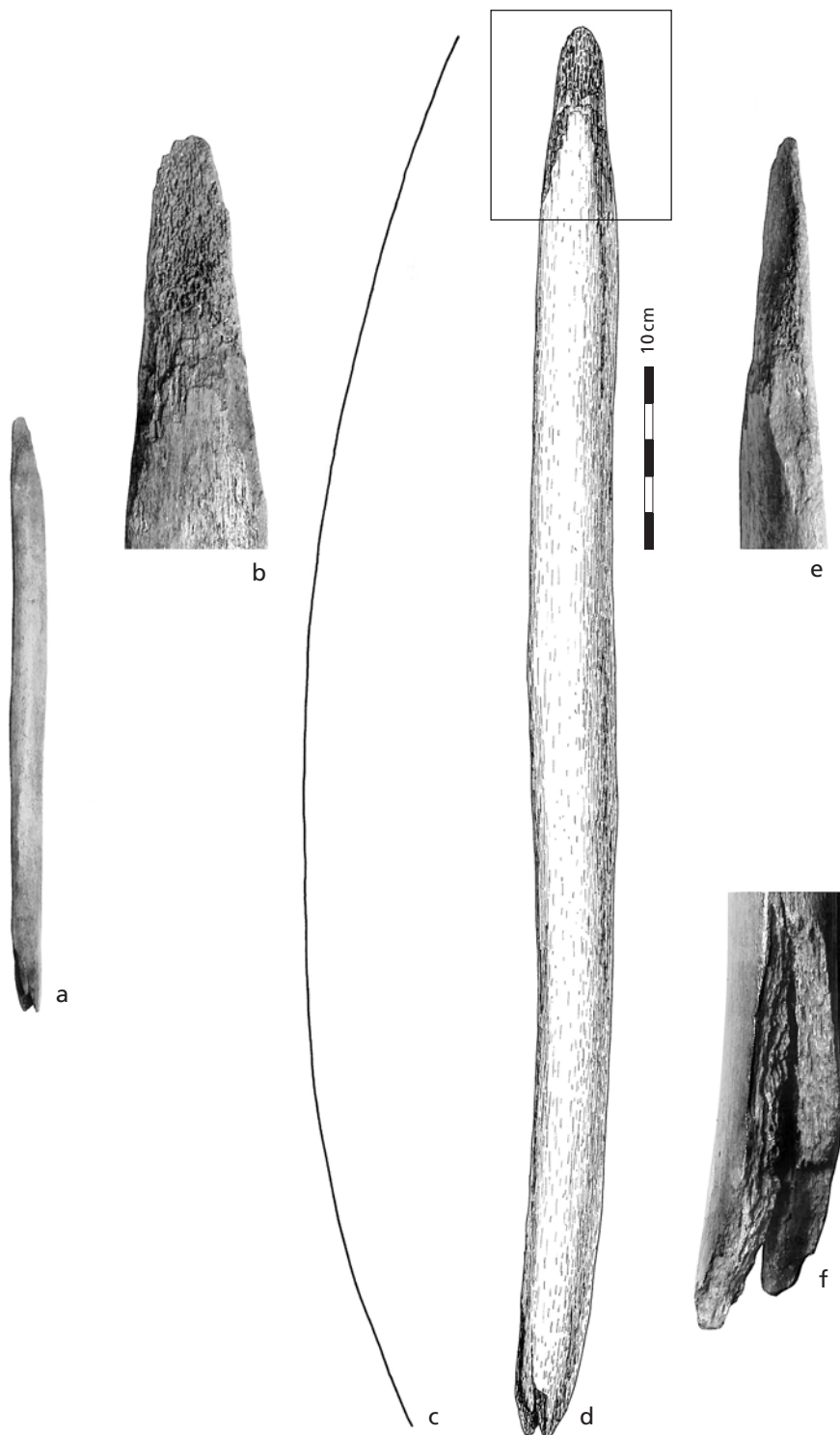**Fig. 5** Lebenstedt I. Modified Rib 1. **a-c** medial view; **d** caudal view; **e** lateral view.

Fig. 6   Lebenstedt I. Modified Rib 2. **a-b, d** lateral view; **c** cranial/caudal view; **e-f** caudal/cranial view.
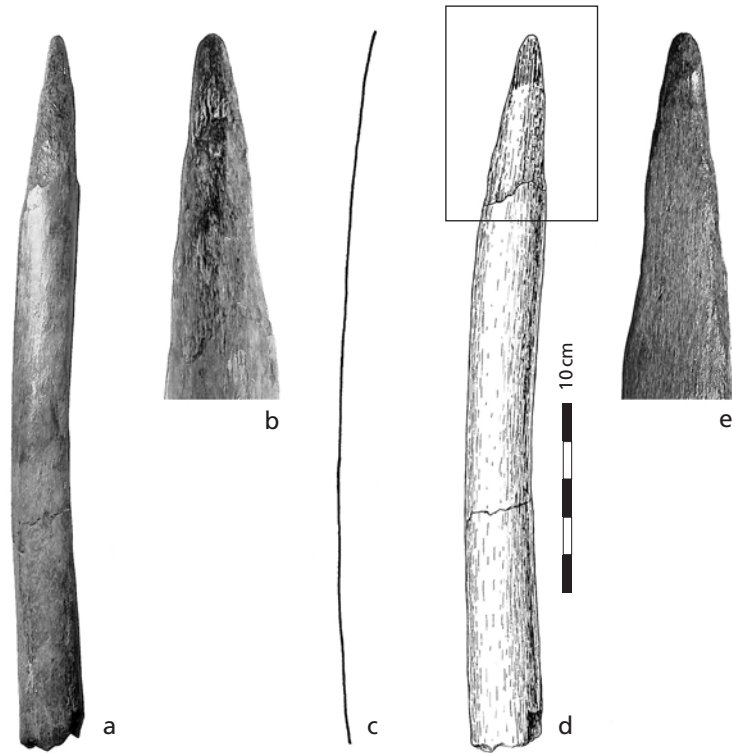
Fig. 7 Lebenstedt I. Modified Rib 3. **a-b, d** lateral view; **c** cranial/caudal view; **e** medial view.

cranial and caudal direction reducing the breadth of the bone from 3.5 cm to 1.4 cm. Both edges of the tip show rounding. The bones' thickness was reduced from 1.0 cm to 0.6 cm.

In addition to ribs, mammoth fibulae served as raw material for tool production. These bones show modifications comparable to the ones observed for the ribs. All modifications occurred proximal. The distal joint can be present (n = 2), absent (n = 1) or carnivore gnawed (n = 2). Fibula 1 (**Fig. 11**) serves as an example to illustrate the modifications observed.

Fibula 1 (**Fig. 11**)

(fibula, dext.; length: 50.2 cm, max. breadth: 5.0 cm, max. width: 4.0 cm)

Proximal, the bone was equipped with a point, 11.0 cm in length, by reducing the bones breadth (from 3.1 to 0.4 cm) and width (from 3.8 to 0.4 cm). The edges of the bone have been abraded and additionally smoothed. Distal, the bone bears traces of carnivore modification.

Bone point (**Fig. 12**)

An unequivocal piece of evidence for the manufacturing of tools is provided by a bone point, 6.3 cm in length. The bone fragment was shaped into a triangular form as shown by its abraded distal edges. Notching of the distal end occurred in order to produce a winged base. Proximally, a conical blunt tip indicates that the point was either used or manufactured to be used for drilling. The point was either produced from mammoth or rhino long-bone, judging from the surface properties of the winged base.

It has repeatedly been outlined that the bone point is probably intrusive to the assemblage, as according to Müller-Beck (1966), it indicates an unexpectedly evolved technique for the Middle Palaeolithic. Judging
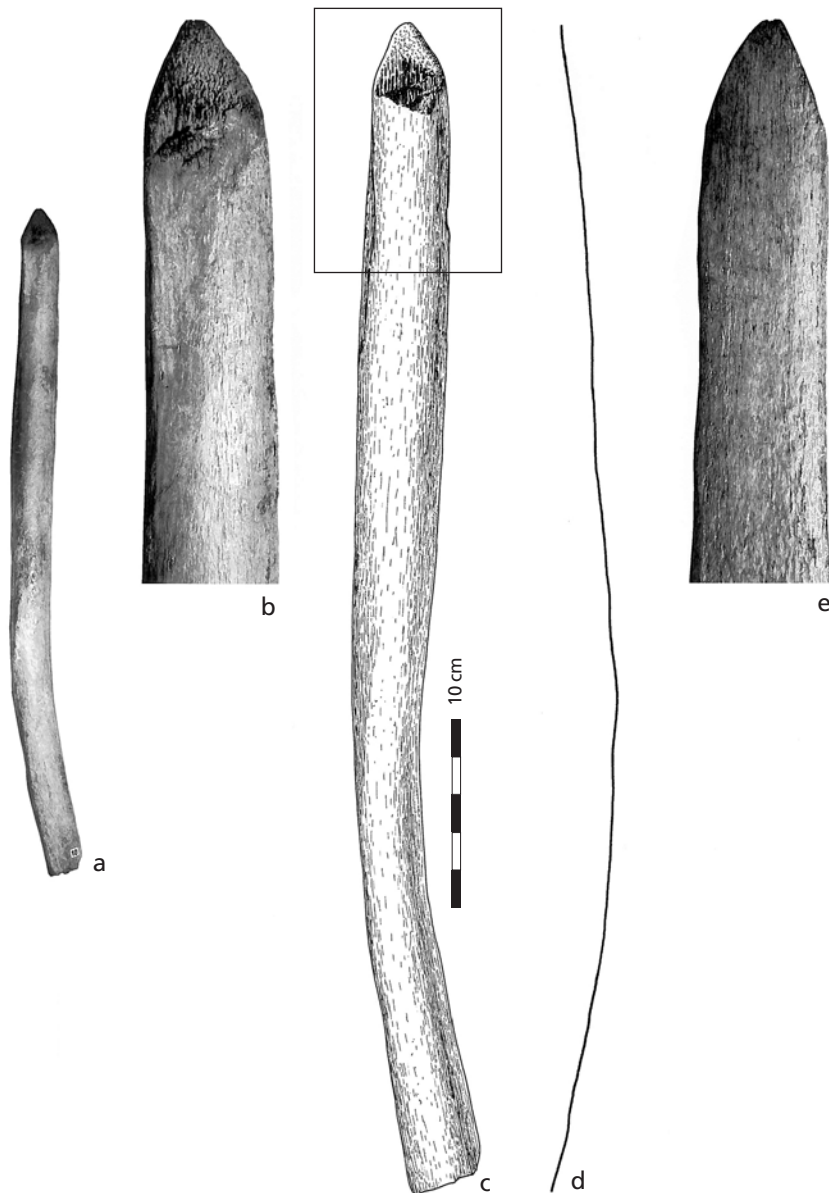
Fig. 8 Lebenstedt I. Modified Rib 4. **a-c** lateral view; **d** caudal view; **e** medial view.

from the depositional setting of the site there are no indications to support this suggestion (Preul, 1991). In his 1952 publication Tode mentions that the point was not found in primary position though definitely originates from Middle Palaeolithic substrate and quotes Kleinschmidt who considered the point to have been produced from a rib, probably of mammoth (Tode, 1953: 214).

According to Staesche (2017d, 2017a) who quotes unpublished documentation by Kleinschmidt, the tool was however found on the excavations soil heap and Staesche (2017a) outlines that Kleinschmidt himself doubted the contemporaneity of this tool with the worked ribs and fibulae. These doubts were based on results of x-ray analyses indicating that the raw-material used for the point was red deer antler, with red deer not being part of the Middle Palaeolithic faunal assemblage. Thus, further studies are currently underway, which will shed light on these differing perspectives.
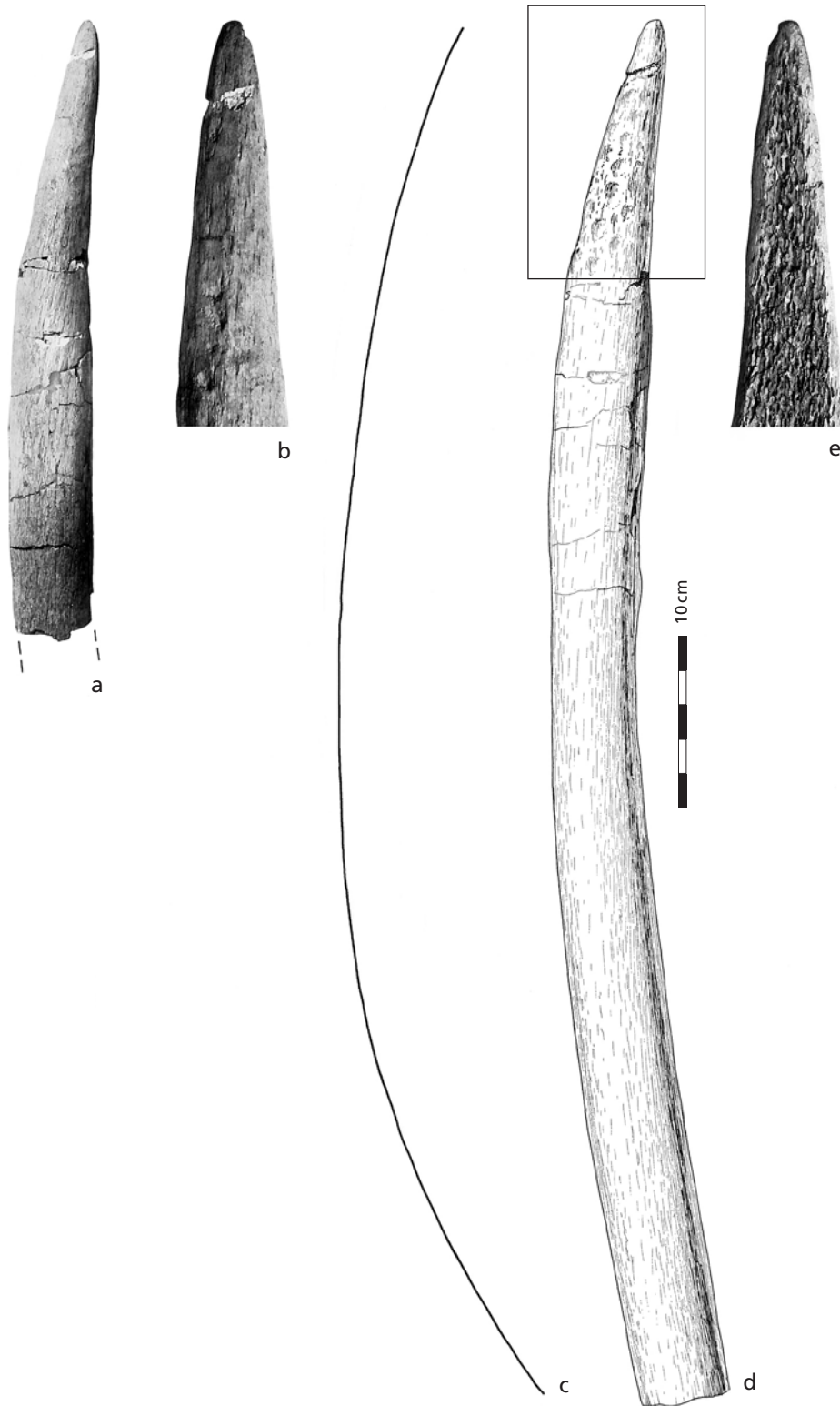
Fig. 9 Lebenstedt I. Modified Rib 7. **a-b, d** lateral view; **c** cranial/caudal view; **e** medial view.
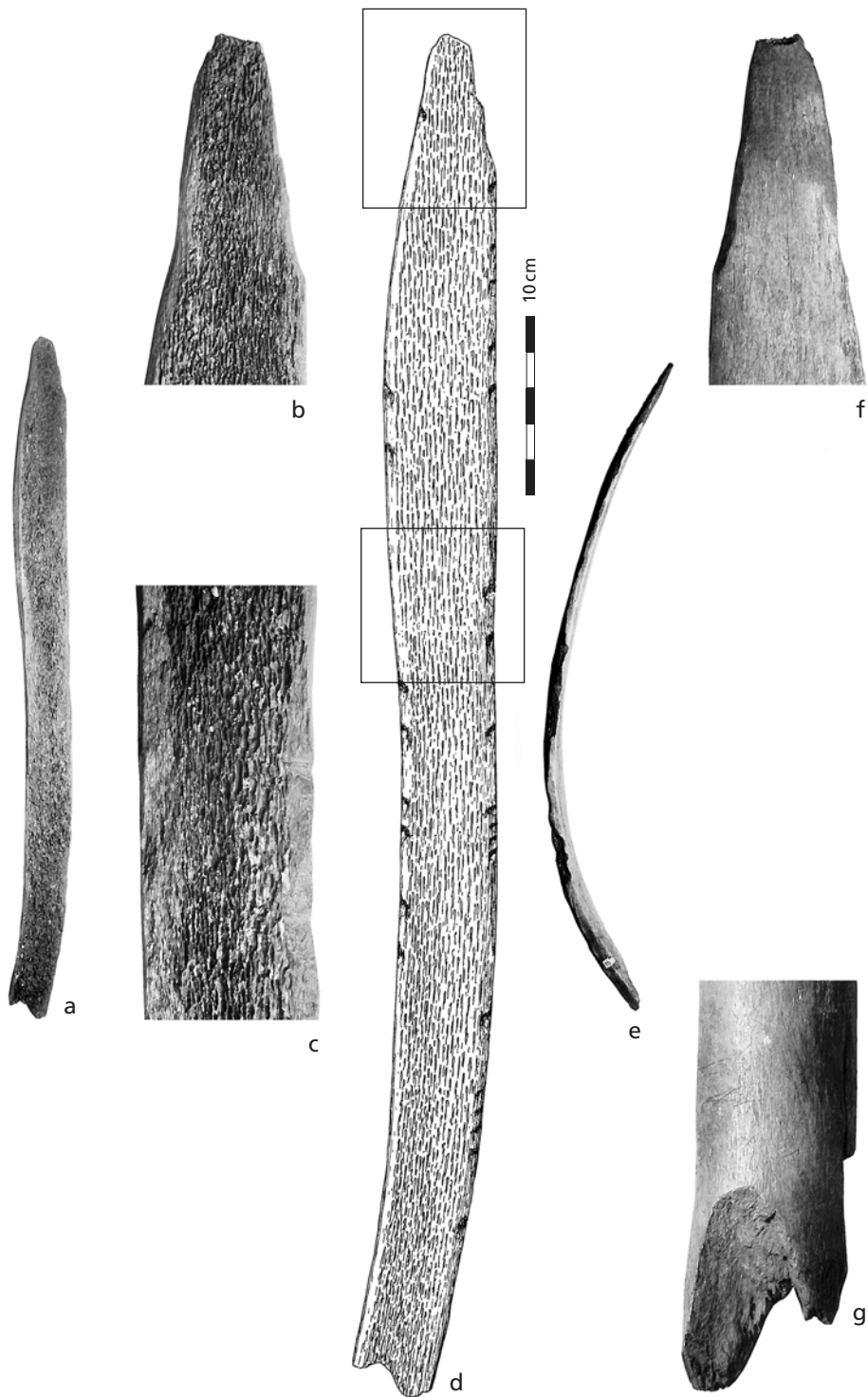
Fig. 10 Lebenstedt I. Split rib 1. **a-d** lateral view; **e** cranial/caudal view; **f-g** medial view.

Fig. 11 Lebenstedt I. Modified fibula 1. **a-b, e-f** lateral view; **c** medial view; **d** cranial view.

Equus sp.

Horse remains were numerously documented at Lebenstedt I. Based on a number of 228 bones and teeth, a MNI of 8 was calculated. During re-analysis of the material including bones from Lebenstedt II Cramer and Staesche (2017) identified 515 bones from this species, which they taxonomically classify as *Equus ferus*. It was outlined that the horses documented in Salzgitter were considerably smaller than the comparative population from Mosbach (Cramer and Staesche, 2017), a Middle Pleistocene context considerably older than Salzgitter.

Concerning age composition of the horse sample, Cramer and Staesche (2017) point out that 41 % of the sample represents bones and teeth from sub-adult to adult individuals, with only 6 % of the horse remains representing juveniles to subadults. The remaining bones and teeth do not allow an age estimate.

Fig. 12   Lebenstedt I. Bone point.

The skeletal element representation for Lebenstedt I horses (**Tab. 5**) is characterized by the presence of almost all body parts. Heads, scapulae and metatarsi dominate, while humeri, femura and phalanges are clearly under-represented, as are vertebrae. The assemblage is completed by rib fragments for which a minimum of at least three individuals could be calculated (Gaudzinski, 1998). The inclusion of Lebenstedt II by Cramer and Staesche (2017) consolidated these results in that it also emphasized the abundant presence of skull-elements, scapulae and metapodials (metacarpi being less well preserved than metatarsi) as well as an under-representation of phalanges and elements of the rump. However, it also modified the results in that the relatively equal survival of radius/ulnae and tibiae obvious for Lebenstedt I is deferred in favor of radius/ulnae. What is striking for Lebenstedt I is the high number of complete bones. For horse, the number of determinable postcranial elements amounts to 72, among which are 33 complete bones (45.8 %).

For an estimate if the differing bone preservation at the site depended on the burial environment impacting on the survival of horse bones, skeletal element representation for Lebenstedt I was matched against bone mineral density (Gaudzinski, 1998: Tab. 14, Fig. 12). A correlation could not be established indicating that the bone survival for horse was not, or only to a minor degree mediated by their density.

The same can be outlined for selective processes due to fluvial mechanisms that might have impacted the skeletal element representation. As for mammoth, again, bones of all Dispersal-Groups were present (cf. Gaudzinski, 1998: 194, Fig. 14).

Carnivore modification was documented for 16 bones, i. e., 22.2 % of the total sample. Fragments of tibiae showed conical impacts though it was not apparent if these traces originated from hominin or carnivore modification. Finally, for Lebenstedt I it could not be argued that humans were responsible for the bone accumulation as direct traces of interaction in the form of cut-marks could not be observed.

For Lebenstedt II, however, Staesche regularly observed cut-marks on a scapula, on ribs (n = 8), a pelvis, a femur, and on tibiae (n = 4) and metatarsi (n = 3) (Staesche, 2017a) and additionally reports conically induced impacts on three bones that he considers to have been induced by humans (Staesche, 2017: Tab. 2). Moreover, he reports three fragments of long-bones that were used as retouchers (Staesche, 2017a).

Bison priscus

The large mammal assemblage from Lebenstedt I yielded 79 skeletal remains identified as *Bison priscus.* A MNI of 3 was calculated based on the presence of three almost complete hemi-mandibles. The general pattern of skeletal element survival is characterized by a corresponding frequency of articulating bones. The axial skeleton in heavily under-represented, in contrast to the distal hind leg and elements of the skull.

To evaluate if the skeletal element representation is density mediated, body profiles were correlated with bone mineral densities, however no correlation was observed (Gaudzinski, 1998), and indications for a selective transport of bones by fluvial mechanisms were not shown as bones of all Dispersal-Groups, are represented despite the highly selective survival of body parts for *Bison* (Gaudzinski, 1998). The bones lacked modifications by carnivores and show indubitable butchering traces by hominins (Gaudzinski, 1998). The inclusion of faunal material from Lebenstedt II raised the NISP to 128 though the extension of the sample did not lead to an increase in MNI. The resulting skeletal-element representation is more or less congruent with Lebenstedt I. Larger differences occurred with the lower values for the survival of Metacarpi and elements of the skull (Krönneck, 2017a: 224, Fig. 1). These data were raised due to weight-proportions (Krönneck, 2017a). Staesche (2017a) observed a carnivore modification on a femur fragment, cut-marks on eight ribs and a humerus as well as retouching scars on a fragment of a radius/ulna.

	NISP	MNI sin.	MNI sin./dext.	MNI dext.	MNI [%]
Max.	18	5	8	5	66.6
Mandible	2	1	-	1	16.6
Thoracal	6	-	6	-	8.3
Lumbar	6	-	6	-	16.6
Sacral	2	-	2	-	8.3
Pelvis	5	4	-	1	41.6
Ribs	122	-	122	-	41.6
Scapula	10	4	-	6	83.3
Humerus prox.	2	1	-	1	16.6
Humerus dist.	3	1	-	2	25.0
Radius prox.	6	5	-	1	50.0
Radius dist.	6	5	-	1	50.0
Ulna	6	5	-	1	50.0
Metacarpus prox.	6	2	-	4	50.0
Metacarpus dist.	6	3	-	3	50.0
Femur prox.	3	2	-	1	25.0
Femur dist.	4	2	-	2	33.3
Tibia prox.	6	1	-	5	50.0
Tibia dist.	6	2	-	4	50.0
Metatarsus prox.	11	5	2	4	75.0
Metatarsus dist.	9	4	2	3	58.3
Calcaneus	4	3	-	1	33.3
Astragalus	1	1	-	-	8.3
Phalange III	3	-	3	-	8.3

Tab. 5 Lebenstedt I, *Equus* sp. Skeletal elements. NISP = Minimum Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half; MNI sin./dext. = body side indeterminate.

	NISP	NISP sin.	NISP sin./dext.	NISP dext.
Mandible	2	-	1	1
Cervical	1	-	1	-
Ribs	1	-	1	-
Scapula	1	-	-	1
Humerus prox.	1	-	1	-
Humerus dist.	1	-	1	-
Radius prox.	1	-	-	1
Radius dist.	1	-	-	1
Femur prox.	2	1	-	1
Femur dist.	2	1	-	1

Tab. 6 Lebenstedt I, *Coelodonta antiquitatis*. Skeletal elements. NISP = Minimum Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half; MNI sin./dext. = body side indeterminate.

Coelodonta antiquitatis

For woolly rhino Lebenstedt I only yielded nine skeletal elements (**Tab. 6**), representing at least one individual. The bones represent the rump and upper extremities. Staesche points out that a femur (Gaudzinski, 1998: Taf. 6.1) included in the recent study (Staesche, 1977), was unearthed from the Salzgitter-lake and not from the excavation itself. By including Lebenstedt II, material stored in the Landesmuseum Hannover and Museum Schloss Salder in Salzgitter, Staesche could considerably enlarge the sample to 39 bones and teeth. These additional bones and bone fragments also represent rump and upper extremities with the exception of one tibia. MNI could be raised to two adult and a neonate individual (Staesche, 2017c).

For Lebenstedt I it was evaluated if fluvial processes might have played a role in the survival of woolly rhino skeletal elements (Gaudzinski, 1998: Fig. 14) and it was outlined that due to the lack of bones belonging to Dispersal-Group I, bones winnowed first by fluvial dynamics, showing that the taphonomic history of *Coelodonta* in the Lebenstedt I assemblage differed from that of other species represented. The inclusion of the material from Lebenstedt II modify these results as the larger sample additionally included four vertebra fragments, i. e., bones belonging to Dispersal-Group I.

Most of the *Coelodonta* remains from Lebenstedt I (70 %) are heavily modified by hyaenas in that the proximal and distal epiphyses have been gnawed off, leaving characteristic funneling. Modifications by humans were not observed.

The compiled sample obviously yielded no additional bones or bone fragments with carnivore modifications (Staesche, 2017c) but did add a cut-marked fragmented scapula to the taphonomic history of the Lebenstedt I assemblage (Staesche, 2017a), originally interpreted as a non-anthropogenic faunal component based on grounds of (1) the relative completeness of the bones, (2) the almost 70 % amount of traces of carnivore-gnawing/funneling and (3) the absence of cut-marked specimens.

Canis lupus

Lebenstedt I yielded a left Metartasus-V from *Canis lupus*. The bone showed neither traces of biotic nor abiotic agents that would enable the reconstruction of its taphonomic history. Staesche additionally reports

seven skeletal elements from *Canis lupus* from Lebenstedt II, among them two tibia fragments which raise the MNI to two (Staesche, 2017f).

Megaloceros giganteus

Among the finds uncovered from Lebenstedt II was a shed antler Staesche (2017d) determined to belong to *Megaloceros giganteus*. It showed that six small bone fragments from Lebenstedt I and II of tibiae, mandible, femur and metatarsus and a further small antler fragment belong to the same species (Staesche, 2017d). Due to thickness of the fragments' bone compacta Staesche calculated an MNI of 2 individuals. According to Staesche (2017a) the femur-fragment showed traces of carnivore modification as well as cut-marks.

Fig. 13 Lebenstedt I. Velvet Scoter (*Melanitta fusca*). Cut-marked humerus.

Panthera leo spelaea

Staesche reports a complete canine and Metacarpus-III of *Panthera leo spealea* from Lebenstedt II. The size of the metacarpus indicates a female individual, whereas the canine belonged to a male, therefore a MNI of 2 was calculated (Staesche, 2017e).

Birds, fishes and small mammals

The faunal assemblage is completed by small mammals, fishes and birds.

Among the small mammals *Desmana moschata* and *Arvicola terrestris* were identified (Kleinschmidt, 1952; van Kolfschoten, 2017) in addition to *Allactaga major* (Staesche, 2017g). Remains taxonomically determined as *Esox lucius* and *Perca fluviatilis* testify the survival of fish-bones (Kleinschmidt, 1953a; Staesche, 2017h). The most striking finding in the faunal assemblages is the occurrence of *Torgos tracheliotus*, the lappet-faced vulture published by Kleinschmidt (1953b) together with an extended discussion on how this species which today typically lives in Africa and on the Arabian Peninsula, can be explained in the context of the species composition documented at Salzgitter. From this huge vulture an almost completely preserved sternum, fragments of a left proximal tibiotarsus and a radius and a right ulna were identified among the Lebenstedt I bones (Kleinschmidt, 1952). *Torgos tracheliotus* is a typical scavenger, although its impact on the taphonomic history of the faunal assemblage at Salzgitter-Lebenstedt has yet to be demonstrated.

For two additional bird-species, handling by humans can be argued. A humerus from Lebenstedt I determined by Kleinschmidt to belong to *Melanitta fusca*, the velvet scoter. This bone survived in pristine condition and shows numerous cut-marks on its medial and distal diaphysis (**Fig. 13**). Wing bones are particularly low in meat, this being one of the reasons why it is assumed that Neanderthals targeted at feathers. The sustained processing of birds, raptors and corvids in particular, for their dark feathers has been shown to be a regular feature at sites across the western-mid latitude belt (Finlayson et al., 2012). Based on an ethnographic survey the authors indicate that use of feathers for adornment represents a human universal behaviour that might root in the Middle Palaeolithic (Finlayson et al., 2012).

It is not clear if the humerus of the velvet scoter from Salzgitter represents a male or a female specimen, but in this context it is quite interesting to note, that in velvet scoters males are all black with white only around their eyes, sporting a white speculum.

A phalanx prox. digit. III. ped. from *Cygnus* sp., the swan (Kleinschmidt, 1953a), provides further insight into the exploitation of birds as the bone also showed a cut-mark on its diaphysis (**Fig. 14**), a trace difficult to explain, though that might have been produced during recovery of the webbing.

DISCUSSION AND PERSPECTIVES

The reindeer sample from Lebenstedt I was the focus of particular interest as zooarchaeological analysis indicated mass death encounters of reindeer by humans with a subsequent bias in exploitation depending on the primeness of resources (Gaudzinski and Roebroeks, 2000). The implicit consequences of the results of this analysis was manyfold with regard to Neanderthals social interaction, as mass death encounters imply coordinated group hunting. Moreover, the cost/benefit-targeted exploitation of reindeer carcasses demonstrated the purposeful handling of resources by Neanderthals, at the same time – with evidence of mass

Fig. 14 Lebenstedt I. Swan (*Cygnus* sp.). Cut-marked phalanx.

death encounters – challenging the "optimum foraging paradigm" that has prevailed in interpretations of zooarchaeological analyses of that time. Finally, the study highlighted the parallels between Middle Palaeolithic and Upper Palaeolithic and especially Late Glacial exploitation of reindeer (Gaudzinski and Roebroeks, 2003).

New zooarchaeological studies at Salzgitter (Ludovici and Pöppelmann, 2017) consolidate the results obtained by earlier analysis that were based on the Lebenstedt I assemblage only. The new study considerably enlarged the sample size by the inclusion of material from Lebenstedt II, unearthed in 1977. Two additional species were identified: *Megaloceros giganteus* (Staesche, 2017d) and *Panthera leo spelaea* (Staesche, 2017e). Apart from these obvious additions, the new study adds more complexity to the taphonomic history of the assemblage, e.g., with the identification of burned and charred bones which had not been observed before (Ludowici and Pöppelmann, 2017). By generally adding more variables to the puzzle, our reading of elements that must be or had been considered as part of the natural background fauna changed as it now appears that species, which based on the study of Lebenstedt I lacked clear evidence for hominin interference, must be added to hominin prey as indicated e.g., for horse.

The equivalents in content observed between Lebenstedt I and II underline observations by geomorphological studies (Preul, 2017) that both samples sprang from the same original source and survived in separate, considerably different geomorphological contexts.

With the new studies, the classical zooarchaeological analysis of the Lebenstedt assemblage is finally completed. Why then is the site still an important research target for our understanding of the past?

The geochronological position of the site during a time period a few millennia before the onset of the Central European Upper Palaeolithic makes Salzgitter-Lebenstedt a valuable research target. This is also true because Salzgitter, with a relatively reasonable temporal resolution compared to contemporaneous cave sites, is surely still among the best-preserved Middle Palaeolithic open-air contexts known to date. The geological setting (Preul, 1991, 2017) suggests a chronological position in an early or mid-Weichselian Interstadial,

probably the Oerel-Interstadial (Behre and Lade, 1986; Behre and van der Plicht, 1992; Litt, 2007) as paly-nological comparison shows.

Analyses of pollen and macro-remains (Pfaffenberg, 1991; Schüttrumpf, 1991; Selle, 1991) draw the picture of a shrub-tundra with cold adapted species such as *Betula nana*, *Salix polaris* and *Salix herbacea*. Composition of micro- and macro-fauna underlines these results as do the habitat requirements of preserved fungi (Johannes and Schuh-Johannes, 1991), and it can be summarized that during the time of occupation, arctic/subarctic conditions with moderate, continental climate prevailed. Attempts to substantiate the chronology by reconstructions of the palaeotemperature by oxygen isotope studies on horse and reindeer bones and teeth, have however, come up with ambiguous results (Stephan, 2017). Attempts to directly date the site (Preul, 2017: Table 1 for a compilation of ^{14}C-ages) indicate an age of at least 55 ka.

Roughly between 110.000 and 50.000 years we witness an increasing complexity of social environments on the individual and group level that led to massive population growth, reflected in a sheer explosion in the number of sites, that turned the custom of neighbouring groups to share traditions into the implementation of sets of rules and regulations of the earliest societies of the Upper Palaeolithic. These processes can only be understood in detail by contextualisation of well-preserved records attributed to this particular time slice.

Moreover, analysis of Lebenstedt I outlined parallels in subsistence tactics to Late Glacial contexts (Gaudzinski and Roebroeks, 2000) at a time when results of many archaeological studies implied that Neanderthals' cognitive capacities were inferior to those of modern humans. Studies at Lebenstedt I concluded that subsistence tactics were either not suited to describe the behavioural differences between Middle and Upper Palaeolithic humans, or the tactics employed did simply not differ, at least when particular game such as reindeer was exploited.

Our perspective on the behavioural differences between Middle and Upper Palaeolithic humans has broadened over the decades and we have become increasingly aware of the social embedding of subsistence behaviour during the Upper Palaeolithic, where we see the effects of social rules and regulations imprinted on human's perceptions of prey species, as evidenced in Upper Palaeolithic depictions, mobile art, and personal ornaments (cf. Street and Turner, 2015).

Social consensus in the form of regional cultural entities has been reported many times for Middle Palaeolithic contexts (e.g., Jöris, 2004) but are difficult to identify when subsistence tactics are at stake. The fact that humans made use of ethological characteristics to target prey, as observed for reindeer in Middle and Upper Palaeolithic contexts, leads to similar patterns in the zooarchaeological record. The observation of these patterns is surely relevant for reconstructions of the hunting methods employed, but are probably rather useless for the reconstruction of the social dynamics behind subsistence practices. Given the complexity in social environments that is visible in the Upper Palaeolithic and are, in comparison, almost invisible in the Middle Palaeolithic, it seems rather unlikely that the social embedding of subsistence followed the same agenda. To disentangle and understand these social frameworks, again, we need to contextualise additional information from contemporaneous archaeological archives.

Over the years, many aspects from Salzgitter-Lebenstedt have been suggested that might provide insight into Neanderthal lifeways, apart from the obvious archaeological evidence revealed by studying lithics and bones. What was by research-standards of the 1990s rather on the speculative side, is still speculative today. Today though, some of these speculations can be contextualised. In recent years studies from other Neanderthal sites demonstrated non-utilitarian exploitation of bird feathers (e.g., Peresani et al., 2011). Although the Salzgitter duck humerus is only a singular find, it could indicate that the exploitation of dark

feathers for personal adornments during the Middle Paleolithic stretches geographically towards northern latitudes.

A further avenue concerns the consumption of medicinal plants by Neanderthals (Hardy et al., 2012). It is interesting to note that fungi were unearthed from altogether 11 find-spots at Lebenstedt I identified as *Bovista plumbea* and *Calvaria uteriformes* (the assemblage being completed by an additional find from Lebenstedt II). Johannes and Schuh-Johannes (1991) point out that only ripe specimens of the latter were represented, their find-spot not being equivalent to their natural local habitat. Due to the antibiotic character of the fungi, they speculate on whether these were particularly collected by humans (Johannes and Schuh-Johannes, 1991, compare Hardy et al., 2012). In a comparable line of argumentation Krönneck and Staesche (2017) highlight the discovery of tree-fungi (n = 15) from Lebenstedt II that might have been used as tinder.

Salzgitter can help us to further evaluate the potential of craftmanship during the Middle Palaeolithic. The use of heat/water/pressure for tool/glue engineering is long since known from Middle Palaeolithic contexts (e.g., Boeda et al., 1996; Grünberg, 2002; Mazza et al., 2006). This evidence is scarce, however, and it is therefore difficult to evaluate these observations, and to assign their consequences for our knowledge of the archaeological record. This is where controlled experiments and traceological studies can help us to understand tool function and the skills needed for manufacturing. Against the scarcity of evidence and the heterogeneity of tool morphology, results of traceological studies and controlled experiments help to define set skills in Middle Palaeolithic organic tool production, and therewith provide a more profound bracket for our understanding of Middle Palaeolithic organic industries.

Current interdisciplinary meta studies on the reconstruction of anthropic impacts on Middle Palaeolithic ecosystems, to evaluate human's ecological footprint, are focussing on the extensive (28 ha) Last Interglacial lake-landscape of Neumark-Nord (Kindler and Gaudzinski-Windheuser, in prep.). The site of Salzgitter-Lebenstedt with its excellent organic preservation is surely a suitable next candidate to finally evaluate to which degree hominin subsistence had emancipated from the 'dictate of nature' shortly before these strategies became embedded and steered by social rules and regulations in Upper Palaeolithic contexts.

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