Late Pleistocene Environments and Hominin Ecology at Schafstall Rock Shelter in Southwestern Germany

An Archaeological Study based on E. Peters' Excavations (1934-1948) and New Fieldwork

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A question we asked ourselves during the excavation regarding the existence or not of the geological horizon 2b. A question which ultimately accompanies the making of every large work before it comes into being. Drawing by Giulia Toniato 2017.

ACKNOWLEDGEMENTS

The following work would not have been possible without the contribution of many people which I here want to thank.

I am very grateful to Professor Nicholas Conard for giving me the possibility of working on this research project and for having entrusted me with the lead of the excavation. I will treasure this as one of the highest moments of my Ph.D. journey. Thanks for the guidance and support given to me throughout these years and for having instilled in me the importance of staying positive.

I would also like to thank Dr. Britt Starkovich for her advice and for having encouraged me to believe in myself and to think and work independently.

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My research on the historical background of the excavations and on the work of Eduard Peters was greatly facilitated by the mass of data collected by Jürgen Scheff, whom I want to thank profoundly. A special thanks also goes to Thomas Fink, son of Stefan Fink, former mayor of Veringenstadt and an intimate friend of Peters, who kindly passed on to me biographical information about Peters from his father’s archive.

The materials presented in this study derive from multiple collections and could not have been analysed without the agreement and support of David Hendel of the Hohenzollerisches Museum of Hechingen, Dr. Fabian Haack of the Landesmuseum of Stuttgart and Dr. Dieta Ambros of the University of Erlangen, to whom I am extremely thankful.

I would also like to thank Professor Michael Bolus and Dr. Berrin Çep for having classified some of the lithic artefacts and for their help in retrieving useful historiographic sources employed in this study.

In these years as a Ph.D. student, I also had the valuable opportunity to deepen my knowledge in isotopes by working as a Hiwi in the laboratory of Professor Hervé Bocherens and Dr. Dorothée Drucker. To both I am very grateful and here want to thank for letting me join their highly competent and friendly working group.

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A large thanks goes to Dr. Susanne Münzel for sharing with me her great knowledge on the archaeology of the Swabian Jura accumulated over years of experience and zooarchaeological studies in this region. I will always treasure those delightful moments engaging in science and non-science discussions over a nice cup of tea and a tasty slice of Kuchen or an ice-cream during the hot summer days at the INA. And I will also cherish the warmth and support given to me by the best colleagues one could possibly have, Chris Baumann, Gillian Wong, Shyama Vermeersch, Julia Zastrow, Anika Heck, Keiko Kitagawa, Abay Namen and Patrick Cuthbertson.

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Most of all I would like to thank my parents, Carmen and Antonio, and my brother Davide for having always encouraged me to follow my dreams and to work hard for achieving them. This work is dedicated to them.

SUMMARY

The University of Tübingen has a century old tradition of archaeological research on the Middle and Upper Palaeolithic sites of the Swabian Jura in Southwestern Germany. Over the past decades extensive research has revolved around the rich archaeological record of the Ach and Lone valleys which includes the earliest examples of figurative art and musical instruments attributed to anatomically modern humans. These findings represent a hallmark in the origins of modern human behaviour and have led researchers to consider the Swabian Jura as a central area in the debate on the causes of the expansion of modern humans in Europe and the disappearance of Neanderthals at the beginning of the Upper Palaeolithic. However, the role played by other sites located along the river valleys that crossed the Danube, especially those in the southwestern part of the Swabian Jura, remains poorly understood and much of the archaeological work relative to this area is limited to pioneeristic excavations that were carried out during the first half of the 20th century.

In this framework, we decided to resume research at the rock shelter site of Schafstall in the Lauchert Valley along the Upper Danube. The site consists of two contiguous areas, named Schafstall I and Schafstall II, which were excavated in the 1940s by Eduard Peters yielding Middle Palaeolithic and Aurignacian artefacts. Unfortunately, all the excavation documentation as well as part of the finds excavated by Peters went missing in the general turmoil of the Second World War. However, a recent study on the surviving lithic remains from Schafstall II highlighted the presence of Aurignacian tools possibly associated with human remains. To contextualize these findings, new investigations were carried out in the area of the old excavations and a new test pit was opened at Schafstall II.

The results of the zooarchaeological study on the large faunal remains from the old excavations reveal clear differences in faunal composition and in bone damage patterns between Schafstall I and II that reflect distinct activities in the two areas of the site. At Schafstall I evidence for anthropogenic activities is greater compared to Schafstall II where cave bears that died from natural causes during hibernation account for the majority of bone remains. Stone tool technology and radiocarbon determinations indicate a strong Middle Palaeolithic signature for the archaeological assemblage of Schafstall I which contrasts with the dominant Aurignacian component of the assemblage from Schafstall II.

This study also highlights apparent inconsistencies in the archaeological data between the old and new excavations of Schafstall II that may be explained by the site’s particular physical configuration and by the varying level of exposure of the different site areas to the action of geological and post-depositional processes. Even though this work focuses primarily on the idiosyncrasies of Schafstall, on a wider scale it sets the framework for further investigations in the western part of the Swabian Jura and provides new and significant data on regional patterns and variations in human occupation and subsistence strategies during the Middle and Upper Palaeolithic.

ZUSAMMENFASSUNG

Die Universität Tübingen hat eine Jahrhunderte alte Tradition archäologischer Forschung Mittel- und Jungpaläolithischer Fundstellen der Schwäbischen Alb in Südwest-Deutschland. In den des modernen in Europa Jahrzehnten hat sich extensive Forschung gedreht um den reichen archäologischen Ertrag des Ach- und Lonetals, der die frühesten Beispiele figurativer Kunst und Musikinstrumenten erbracht, die dem anatomisch modernen Menschen zugeschrieben werden. Diese Funde stellen ein Kennzeichen für den Ursprung modernen menschlichen Verhaltens dar und haben Forscher dazu geführt, die Schwäbische Alb als ein Kerngebiet für die Debatte der Gründe zur Ausbreitung des modernen Menschen in Europa in Erwägung zu ziehen und das Verschwinden des Neanderthalers am Beginn des Jungpaläolithikums.

Jedoch, bleibt die Rolle, die andere Fundplätze entlang anderer Flusstäler, die die Donau kreuzen, insbesondere diejenigen, die im südwestlichen Teil der Schwäbischen Alb liegen, bleiben schlecht verstanden und ein Großteil der archäologischen Arbeit in diesem Gebiet ist beschränkt auf Pionier-Ausgrabungen, die während der 1. Hälfte des 20. Jahrhunderts durchgeführt wurden.

Unter diesen Rahmenbedingungen haben wir entschieden, die Forschung wieder aufzunehmen an der Abri Fundstelle Schafstall im Lauchert Tal entlang der Oberen Donau. Die Fundstelle besteht aus zwei zusammenhängenden Bereichen, nämlich Schafstall I und Schafstall II, die in den 40iger Jahren von Eduard Peters ausgegraben wurden und mittelpaläolithische sowie aurignacienzeitliche Artefakte erbracht haben. Unglücklicherweise ist die Ausgrabungsdokumentation, ebenso wie Teile der Funde nach dem 2. Weltkriegs verloren gegangen. Aber eine neuere Untersuchung an den verbliebenen lithischen Funden aus Schafstall II hat die Bedeutung der Aurignacien Werkzeuge herausgestellt, die wahrscheinlich mit menschlichen Resten assoziiert sind. Um diese Funde in den Kontext zu setzen, entschieden wir, die alten Ausgrabungen wieder zu öffnen und legten einen Testschnitt in dem nicht ausgegrabenen Bereich von Schafstall II an.

Die Ergebnisse der archäozoologischen Untersuchung an der Großsäugerfauna der alten Grabungen ergaben klare Unterschiede in der Faunenzusammensetzung und der Knochenerhaltung zwischen Schafstall I und II, die auf unterschiedliche Aktivitäten in den beiden Bereichen der Fundstelle hinweisen. Im Schafstall I sind die Anzeichen für anthropogene Aktivitäten größer im Vergleich zu Schafstall II, wo Höhlenbären, die eines natürlichen Todes während der Winterruhe gestorben sind, den Hauptanteil der Fauna bilden.

Die Steintechnologie und die Radiocarbondatierungen sprechen für eine starke Mittelpaläolithische Signatur im archäologischen Inventar von Schafstall I, das im Kontrast steht mit der dominanten Komponente des Aurignacien des Inventars von Schafstall II.

Die Untersuchung zeigt auch die offensichtlichen Inkonsistenzen der archäologischen Daten zwischen der alten und den neuen Grabungen in Schafstall II. Die sich eventuell durch die speziellen physikalischen Gegebenheiten des Fundplatzes und durch variierenden Niveaus der Exposition der verschiedenen Fundstellenbereiche auf die Wirkung geologischer und post-sedimentärer Prozesse. Auch wenn sich diese Arbeit hauptsächlich auf die Eigenheiten des Schafstall konzentriert, so setzt sie doch in einem größeren Maßstab den Rahmen für weitere Forschungen im westlichen Teil der Schwäbischen Alb und bietet neue und signifikante Daten für regionale Muster und Varianten der menschlichen Besiedlung und Subsistenz-Strategien während des Mittel- und Jungpaläolithikums.

CONTRIBUTION

The excavation project was coordinated by Professor Nicholas Conard and me. Sarah Rudolf was responsible of the technical management for the excavation campaign of 2016, while the technical work for the campaign of 2017 was carried out by me with the help of Azubis Lennard Schnoor and Luka Witzig.

The field notes were written by me and Professor Nicholas Conard. The profile drawing of Schafstall I is from Sarah Rudolf, while the profile drawings and descriptions of Schafstall II were made by me with the help of Lennard Schnoor and Professor Nicholas Conard.

The classification of the lithic artefacts was made by Professor Michael Bolus and the artefact drawings are from Mojdeh Lajmiri.

Unpublished documentation and photos of Peters' excavations were borrowed from Herr Jürgen Scheff of Albstadt.

Christian Sommer made the map in the first chapter showing the location of the sites in the Swabian Jura.

The photos of the artefacts were made and elaborated partly by me and partly by Angel Blanco Lapaz and Maria Malina of the University of Tübingen.

Radiocarbon dating was performed at the ETH (Eidgenössische Technische Hochschule) in Zürich, Switzerland.

Angel Blanco identified the fish remains. The rest of the faunal identification and analysis and all other parts of this manuscript are the product of my work.

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1 INTRODUCTION

Over the past century, a growing body of archaeological research on the Palaeolithic sites of the Swabian Jura has highlighted the importance of this geographic area in the ongoing debate on the causes of Neanderthal extinction and their replacement by anatomically modern humans during the Late Pleistocene. One of the reasons why the Swabian Jura plays a key role in addressing such questions has to do with the discovery of the earliest examples of portable art and musical instruments attributed to our species (Conard, 2009; Conard et al., 2009; Hahn & Münzel, 1995; H. Müller-Beck & Albrecht, 1987; Riek, 1932; Wagner, 1981). At sites like Geißenklösterle and Hohle Fels, such finds are documented in the lower layers of the Aurignacian (Conard, 2003; Teyssandier, 2002). Radiocarbon dates from these levels fall in the range of 43 cal ka BP and indicate a very early origin of the Swabian Aurignacian (Bataille & Conard, 2018; Conard & Bolus, 2008; Higham et al., 2012). With the *Kulturpumpe* model, Conard and Bolus (2003, 2006) attempt to provide an interpretive framework for such data. On one hand, they postulate that anatomically modern humans arrived into Europe following the Danube corridor. On the other hand, they justify the unprecedented cultural and technical innovations of the Swabian Aurignacian as the effect of multiple variables such as climatic stress, interspecific competition with Neanderthals and social-cultural and demographic factors. In this sense, the Aurignacian record of the Swabian Jura represents a hallmark in the development of modern behaviour and marks a turning point in the evolution of cultural modernity. However, not all researchers agree with their interpretation. Zilhão and d'Errico (2003) have challenged the model by attributing the early age of the Swabian Aurignacian to post-depositional processes and the palimpsest nature of the archaeological deposits. In other words, the earliest dated finds from the Aurignacian layers of Geißenklösterle should be regarded as outliers which were deposited independently of hominid activities albeit their stratigraphic proximity to Aurignacian cultural remains. Disregarding the few samples of Geißenklösterle that yielded early radiocarbon dates, Conard and Bolus (2003, 2006) conclude that the true timing of the occupational events that produced the bulk of the Swabian Aurignacian artefacts is consistent with the younger Aurignacian chronology of the rest of Central and Southern Europe. They also suggest that cognitive abilities equivalent to those expressed by the Aurignacian people of the Swabian Jura are recognizable in much earlier technocomplexes, like the Châtelperronian, traditionally ascribed to Neanderthals.

Without entering into the debate on the origins of the Aurignacian, it should be noted that multiple lines of evidence, in particular the absence of stratigraphic evidence for cultural continuity between the Middle and Upper Palaeolithic, support the hypothesis that Neanderthals and modern humans did not come into contact in the Swabian Jura, ruling out the possibility that the cultural innovation embodied by the Swabian Aurignacian was triggered by competition with Neanderthals as suggested by the *Kulturpumpe* model. The existence of a clear chronostratigraphic break between the Middle and Upper Palaeolithic is well documented at Geißenklösterle and Hohle Fels which have been excavated in the past decades to a very high standard (Conard, Langguth, & Uerpmann, 2003; Conard & Malina, 2002). Unlike Geißenklösterle and Hohle Fels, most other sites in Swabia were excavated in the first half of the twentieth century and lack of systematic and well controlled data. According to Çep (2013), the absence of adequate comparative data could perhaps be partially obscuring the real nature of Middle Palaeolithic settlement patterns in Swabia, which have generally been characterized as low intensity occupations reflecting lower population densities compared to the Upper Palaeolithic (Conard, Bolus, & Münzel, 2012; Münzel & Conard, 2004a). This brings up an important point concerning our approach to investigating the Middle Palaeolithic, which often deduces patterns of extinction and replacement based on the unequal comparison between Middle and Upper Palaeolithic cave assemblages, the latter being generally much richer in materials than the former. New excavations of Middle Palaeolithic contexts with the aid of high-quality recovery techniques hold therefore great potential for increasing the archaeological evidence available and improving our understanding of the driving forces that led to the local disappearance of Neanderthals and the expansion of modern humans. In response to this need, we set out to investigate the site of Schafstall in the town of Veringenstadt along the Lauchert Valley. Here, previous unfinished research carried out by Eduard Peters (Peters, 1936a, 1946; Peters & Rieth, 1936) during the first half of the 20th century highlighted the presence of deposits containing Middle and Upper Palaeolithic artefacts.

Our interest in the Lauchert Valley and in Schafstall was not only motivated by the wealth of unpublished data from the old excavations but also by the promising results of a recent study on the lithic assemblage of Schafstall II (Schumacher, 2014). Moreover, what makes this area interesting is its geographic position in the western part of the Swabian Jura, close to the edge of the Black Forest, which connects the Swabian Alb to the Rhineland, another region rich in Palaeolithic sites. As opposed to the sites of the Ach and Lone valleys in the eastern Swabian

Jura, most of the archaeological work conducted in the West is limited to early pioneering excavations, carried out at the beginning of the last century, that lack of modern revisions and of integrative studies (Albrecht & Engen, 1991; Peters, 1946; Peters & Toepfer, 1932). If we are to make an assessment of Middle and Upper Palaeolithic social patterns at a regional scale, it is of fundamental importance to intensify the study of sites to the east and west of the Ach and Lone Valleys and that old excavated assemblages be reconsidered with the aid of modern methodologies. In this work I address this issue and present the results of our recent archaeological investigations of Schafstall and the complete study of the large fauna from the old and new excavations accompanied by an overview of Peters' work on other nearby sites in Veringenstadt.

Though this study in itself does not suffice to adequately illustrate the role occupied by the sites in the Lauchert Valley in relation to Middle and Upper Palaeolithic networks, migration routes and settlement dynamics, it offers a valid starting point for further research.

Ultimately, this work represents a continuation of Eduard Peters' research on the Veringenstadt cave sites. Due to the disruptions caused by the World War II and the death of Peters in 1948, the results of his research have remained unpublished and largely inaccessible to the scientific community.

Picking up the threads of Peters' work has been a twofold challenge, not only because of the usual difficulties every archaeologist encounters in trying to bridge the gap between the present archaeological evidence and the past we want to learn about, but also because of the problems posed by the interpretation of Peters' work which was riddled with missing data and incomplete documentation. I hope the outcome of this study represents a satisfactory attempt at addressing some of the questions left unanswered by Peters and at finding new ones.

2 CONTEXTUALIZATION OF THE ARCHAEOLOGICAL SITES IN THE LAUCHERT VALLEY

2.1 Geographical and geological setting

The Swabian Jura, also known as Swabian Alb, is a mountain range of Jurassic origin located in southwestern Germany, stretching about 200 km from southwest to northeast across the region of Baden-Württemberg, from Lake Constance to the Nördlinger Ries, a meteorite impact crater between the Swabian and Franconian Alb. It is part of a limestone belt which also encompasses the French and Swiss Jura to the west and the Franconian Jura to the east. The topography is characterised by a tilted plateau with rounded hills degrading gently towards the Danube to the south and a steep escarpment delimiting the northern flank. These reliefs are made up of well-bedded successions of limestones and marls which deposited on the seabed of the Tethys Ocean during the Jurassic period (Kaufmann & Romanov, 2008).

The karstified landscape hosts numerous caves and overhangs exploited by hominids throughout the Middle and Upper Palaeolithic. The most well-known and investigated are the sites of the Ach and Lone valleys, where research has been carried out extensively since the end of the nineteenth century (Fraas, 1886). Sites such as Hohle Fels, Geißenklösterle, Große Grotte, Sirgenstein and Brillenhöhle in the Ach Valley and Vogelherd, Hohlenstein-Stadel, and Bockstein in the Lone Valley are worth mentioning.

The Lauchert Valley lies about 130km and 50km south-west of the Lone and Ach river valleys, respectively (Fig. 2.1). It takes its name from the tributary river that traverses it for about 60km before flowing into the Danube at the height of Sigmaringendorf. The sites considered in this study are located in the town of Veringenstadt, which lies within a tectonic graben, the so called “Lauchertgraben". In this area, caves and rock shelters occur abundantly in the white Jura limestone outcrops overlooking the Lauchert river. Four sites are of interest for the present research, namely Schafstall, Nikolaushöhle, Göpfelsteinhöhle and Annakapellenhöhle. All were excavated and partially studied by Eduard Peters (Peters, 1936a, 1946; Peters & Paret, 1949; Peters & Rieth, 1936) during the first half of the twentieth century.

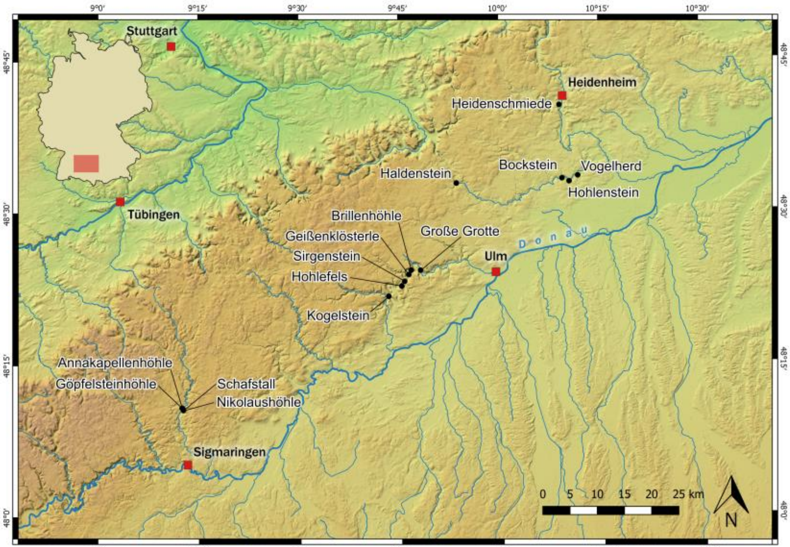


Figure 2.1 Map of the Swabian Jura showing the geographic location of the Palaeolithic sites of the Lauchert Valley in relation to those of the Ach and Lone valleys.
https://doi.org/10.5281/zenodo.3460301

2.2 Local and regional climate and environment during the late Middle and Upper Palaeolithic

Hominid lifeways and subsistence strategies are intrinsically tied to the natural environment in which they play out. In this respect, our understanding of human behaviour and settlement dynamics during the Middle and Upper Palaeolithic of the Lauchert Valley necessitates consideration of past climatic and environmental variability. Regional and local proxy sources provide us with such key information. The archaeological sequences from cave and open-air sites in southwestern Germany are distinguished by an almost complete absence of deposits older than MIS3. At present, reconstruction of climate and environmental changes in the Swabian Jura during MIS3 and 2 draws mostly upon the natural records of the Ach and Lone valleys, which have been more intensively investigated compared to sites in the neighbouring valleys. Micromorphological studies (Barbieri et al., 2018; Miller, 2015) based on cave and open-air sediments in the Ach and Lone valleys have proven useful in explaining depositional processes related to site formation and in tracking local environmental changes throughout the Middle and Upper Palaeolithic. According to Miller (2015), the presence of bedded karstic clays coupled with the evidence of increased phospatization in the late Middle Palaeolithic horizons at Geißenklösterle and Hohle Fels points to relatively warm and wet conditions. At both sites, the Middle Palaeolithic and Aurignacian layers are separated by a stratigraphic hiatus containing evidence for frost-related processes linked to increasingly drier and colder climatic conditions, a progressive trend that continued until the LGM. This non-linear trend was characterized by an alternation of warm and cold phases that correspond to different Dansgaard-Oeschger oscillations. Indeed, the earliest appearance of the Aurignacian in the Ach Valley would have coincided with a relatively warm and moist period (Miller, 2015). By contrast, the younger aged Gravettian deposits underwent extensive erosion and were affected by higher loess sedimentation rates associated with lower temperatures and increased aridity compared to the Aurignacian (Barbieri et al., 2018). The progressive climatic deterioration during the LGM would have led humans to abandon the region, which was recolonized at the beginning of the Late Glacial by Magdalenian people (Barbieri et al., 2018).

The results of the micromorphological analysis are broadly in line with the signal provided by the faunal record represented by the avian and small and large mammal remains (Krönneck, 2012, 2019; Starkovich et al., in press). In particular, recent studies of the small mammal assemblages of Hohle Fels and Geißenklösterle (Rhodes et al., 2019; Rhodes et al., 2018; Ziegler, 2019) contribute a more nuanced picture on the environmental changes that operated in the background of hominid occupation of the Ach Valley and that, to a larger extent, played a role in regional settlement dynamics. The taxonomic composition of the microfaunal assemblages from the late Middle Palaeolithic and Aurignacian deposits is generally distinguished by the dominance of cold tundra adapted species and by lower proportions of wooded steppe species. During the final phase of the Middle Palaeolithic, the landscape would have been relatively stable with a fluctuating tendency towards colder conditions and the expansion of cold tundra environments. This pattern continued into the Aurignacian and was disrupted by a markedly cold event, probably corresponding to Heinrich 4, which modern humans would have experienced some time after their arrival in the Ach Valley. The cold peak was successively followed by a warmer phase and an abrupt return to more temperate and wooded environments.

Another natural record reflecting the environment around the cave sites of the Ach Valley is provided by palaeobotanical remains. Despite the generally poor preservation of botanical remains in Central European cave contexts, the study of plant micro- and macrofossils at Hohle Fels (Riehl, Marinova, Deckers, Malina, & Conard, 2015) reinforces evidence gleaned by the other palaeoenvironmental proxies pointing to the continuative presence of a cold tundra vegetation with shifting proportions of steppe elements and of sparse wooded species throughout the Upper Palaeolithic.

While some of the cave sites in the Ach and Lone valley have been the object of several palaeoenvironemental studies, the numerous sites located in other river valleys across the Swabian Jura have not been much researched. The few palaeoenvironmental data available for the Lauchert Valley comes from old studies on the microfauna and bird remains (Götz, 1949; Heller, 1937) from the cave sites of Veringenstadt. The signal they provide is constrained by the low resolution of such natural records, by their innate limitations related to the nature of their accumulation and by the post-depositional processes affecting the record. The work of Götz (1949) on the Middle Palaeolithic avian fauna of Schafstall I provides some insight into the environmental diversity of the Lauchert Valley at the time of Neanderthal occupation. The occurrence of cold adapted species associated with rocky mountainous environments suggests a cool and arid climate. These species would have likely dwelt on the Jurassic limestone outcrops overlooking the Lauchert river. The high proportion of ptarmigan is indicative of open landscapes which allowed for the presence of patches of woodland and wet areas, as testified by the lower numbers of boreal and temperate species and of waders. Overall, according to Götz (1949), the taxonomic composition is suggestive of a preglacial phase characterized by a cool-dry climate possibly tending towards colder conditions. Unfortunately, the results of the microfaunal analysis conducted by Florian Heller are no longer available for comparison.

In another study, Heller (1937) considers the environmental and ecological variables that led to the formation of the Magdalenian deposits of Nikolaushöhle. Though the microfauna occupies the foreground of his work, his conclusions are rather speculative and vaguely informative. Based on similarities in the faunal composition between Nikolaushöhle and Sirgenstein, he confirms Peters' attribution of the assemblage to the Late Glacial. However, he does not provide sufficient contextual information and quantitative data to support his interpretations, so that his arguments sound very subjective. The lack of more detailed environmental analyses for the Lauchert Valley and the total absence of studies covering the period corresponding to the Aurignacian, which is also represented archaeologically in the Veringenstadt sites, calls for an integrated multi-disciplinary approach that considers the data available from other sites of the Swabian Jura to reconstruct the local palaeoenvironment and climate variability during the Last Glacial Period. Such an approach has its limitations in that it does not account for localized environmental variation, but provides, nonetheless, some useful insights on the environmental and climatic conditions that influenced those hominid groups that settled in the Lauchert Valley throughout the course of the Middle and Upper Palaeolithic.

2.3 The sites

In this section a concise presentation of the sites and the history of their research is given. The topography of each site is first described, followed by a summarized history of the excavations. The old research results are then presented with a description of the finds and a short review of the published literature. As the focus of this study is the reconstruction of site use and occupation during the Palaeolithic, more recent (i.e. Holocene) archaeological finds won’t be discussed. For more details on these and on Eduard Peters’ life and deeds in Veringenstadt, the reader is referred to the biographical article written by Jürgen Scheff (2004), who painstakingly documented and collected most of the historical information on which this chapter is based on.

2.3.1 Annakapellenhöhle

Annakapellenhöhle is a small cave that lies at 680 m a.s.l., approximately 250 m to the west of Göpfelsteinhöhle, which is situated on the opposite side of the hill (Fig. 2.2). The 2,5 m high and 7 m wide entrance faces the north and opens directly onto a 10m long chamber with outwardly sloping sediments (Luz, 2004). Nowadays the site shows evidence of use as a denning place by badgers.

Figure 2.2 Annakapellenhöhle, picture taken during the archaeological survey of 2016

Excavations

Annakapellenhöhle was first investigated in 1910 by Robert Rudolf Schmidt of the University of Tübingen, who left no record whatsoever of his excavation (Scheff, 2004). Between July and August 1934, Peters undertook a new test excavation at the site obtaining positive results even though the integrity of the deposit had been partially compromised by the previous excavations (Peters and Rieth, 1936). In 1935, between July 25 and October 20, excavations at Annakapellenhöhle were resumed systematically. All of the remaining sediment was removed, yielding sparse evidence of Magdalenian occupation, as well as sporadic remains of younger periods, such as the Neolithic, Urnfield culture, Late Latène and the Roman period. Most of these finds went missing during the French occupation of southwestern Germany in 1945. Peters was then forced to move from Sigmaringen to Veringenstadt and in doing so left his finds and documentation in the Landeshaus of Sigmaringen, which became a French military headquarter. Under these circumstances the materials which Peters thought to be safely stored were inexplicably lost and never found again.

Artefacts

Peters reports a total of 77 lithic artefacts, including 18 tools or tool fragments, generally described as blades, scrapers, burins and backed bladelets, and also a worked jet fragment.

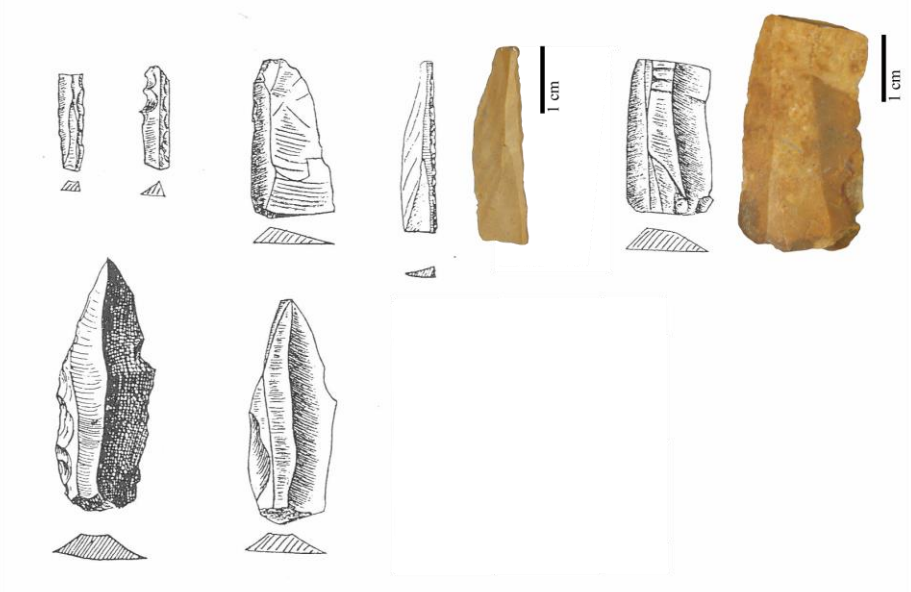


Figure 2.3 Annakapellenhöhle, drawings of Magdalenian artefacts from Peters' excavation (1935) and pictures of two lithic artefacts from the Hohenzollerisches Landesmuseum of Hechingen. Modified from an original drawing preserved in the Archiv Landesdenkmalamt of Baden-Württemberg

According to Peters (1936a), the assemblage shows close affinities with the late Magdalenian industries of Petersfels near Engen. As mentioned above, all the artefacts are missing, except for two pieces housed at the Hohenzollerisches Landesmuseum of Hechingen. These consist of a blade fragment and a bladelet of the same raw material, which also appear in old find drawings alongside other Magdalenian artefacts from Annakapellenhöhle (Fig. 2.3).

Fauna

The only information handed down to us over the fauna from the Magdalenian layers is that it is very scanty and consists mostly of horse and reindeer remains (Peters, 1936a). Unlike the faunal materials from the other sites of Veringenstadt, which were assigned for study to different researchers and therefore spared from war loss, the bone assemblage of Annakapellenhöhle went missing completely in 1945.

2.3.2 Göpfelsteinhöhle

Figure 2.4 View of Göpfelstein from the Lauchert river. Courtesy of Jürgen Scheff

Walking across the main bridge over the Lauchert river in Veringenstadt towards the townhall, the forthcomer’s attention is immediately drawn by the imposing appearance of Göpfelsteinhöhle, located on the top of the hill overlooking the old town. The picturesque view is further enhanced by the stone statue of a crouching Neanderthal man at the side of the bridge, which neatly falls in the same perspective plane of the cave. In 1964 the mayor of Veringenstadt made the prehistorian Gustav Adolf Rieth in charge of developing a conceptual idea for a statue, which would have been placed in the historic centre as a tribute to the role played by this specific geographical area in the prehistory of Southwestern Germany (Rieth, 1966).

Göpfelsteinhöhle is one of the most famous cave sites of Veringenstadt (Fig. 2.4). The entrance is preceded by a large open space measuring about 50 sqm (Fig. 2.5). The cave mouth opens to the south and leads to a single chamber. The limestone wall at the back of the cave forms a ledge that divides the chamber into two levels and was once part of a roof which later collapsed. The lower level is about 3,5 m wide and 1,2 m high and terminates in a blocked passage. The upper one takes up the rest of the chamber and is 7 m wide and 5m high (Luz, 2004).

Figure 2.5 Entrance of Göpfelsteinhöhle photographed during the archaeological survey of 2016

Excavations

Preliminary unrecorded excavations were carried out by Robert Rudolf Schmidt in 1910. In 1934 and 1935 Göpfelsteinhöhle was re-investigated thoroughly by Peters (Fig. 2.6), who had all sediments waterscreened by his team of excavators. The level of the original surface before Peters' excavation can still be seen today as indicated by a blue line drawn on the cave walls. Peters also adopted this practice at the other sites he excavated in Veringenstadt. In fact, his blue lines are more or less visible today at Nikolaushöhle and Schafstall.

The repeated use of the Veringenstadt caves in modern times as sheep corrals and dung sources by local farmers severely compromised the archaeological stratigraphy of the sites. This is especially true for Göpfelstein. Peters (1936a) reports the presence of numerous stray finds in the upper layers and the difficulty of recognizing distinct archaeological layers. Based on the artefact distribution, he postulates two distinct occupation phases. One, ascribed to the Middle Palaeolithic, when hominids occupied the lower level at the back of the cave. In this area there was also compelling evidence of a hyena den assemblage. The other, corresponding to the Aurignacian, developed principally in the front area after the limestone roof had collapsed making the inner part largely inaccessible.

Due to the cave’s opening being directly exposed to the sun, the sediments in the back area proved to be too hard to dig, bringing the excavations to a halt. An attempt to remove the consolidated sediments was made again in September and October of 1947, without much success (Scheff, 2004).

More recently, upon re-inspection by two local amateurs, Ulrich Binder in 1950 and Franz Werz in 1955, a small collection of finds was recovered and stored in the Rathaus Museum of Veringenstadt (Scheff, 2004).

Figure 2.6 Eduard Peters (centre) at the entrance of Göpfelsteinhöhle. Picture from Nachlass Fink

Artefacts

The lithic assemblage excavated from Göpfelstein before 1945 is entirely missing. The only information available is a short published description of the artefacts which had been excavated until 1936 (Peters, 1936a). The Middle Palaeolithic assemblage consisted of 800 artefacts including various tools. According to Peters (1936a), these were typologically comparable to those of Heidenschmiede, though notably smaller in their dimensions. The lithic industry was characterized by a large variety of raw materials. Local Jurassic chert was predominant, but also radiolarite, quartzite and alpine chert, probably originating from the Riß moraine around Sigmaringen, were present.

The Aurignacian artefacts were considerably less numerous, amounting to 200 pieces. Among these, Peters identified 79 tools or tool fragments comprising 41 scrapers, 35 blades and blade fragments and 3 burins. Due to the unclear stratigraphy and the partial disturbance of the layers in the front area of the cave, some undiagnostic artefacts were tentatively assigned to the Aurignacian, meaning that the actual size of the assemblage was likely smaller.

The Middle and Upper Palaeolithic artefacts were later reviewed in the works of Bosinski (1967) and Hahn (1977). The former provides a short list, accompanied by drawings, of the Mousterian artefacts excavated in 1947. The illustrations also include two pieces that had previously appeared in a publication of Peters and Paret (1949). The work of Hahn (1977) focuses instead on the Aurignacian and re-lists most of the artefacts already published by Peters (1936a), with the addition of few others from the post-war excavation stored at the Rathaus Museum of Veringenstadt. Most of these have also disappeared from the collection. Their absence was noticed by Markus Schumacher (2014), an archaeology student of the University of Tübingen, who wrote his Master thesis on the Upper Palaeolithic lithic industries of Schafstall II. In his work he also considered the lithic assemblage of Göpfelstein, which includes the artefacts recovered by Peters in 1947 and the surface finds collected in the fifties by Franz Werz. In total he counted about 1100 artefacts and observed that those assigned by Peters to the Aurignacian were easily distinguishable from the others because they had been marked in black ink with the letter A.

Few unpublished lithics were documented by the author in the Hohenzollerisches Landesmuseum of Hechingen. These were donated in the fifties to the museum by the regional conservator Adolf Rieth (Scheff, 2004) and consist of four artefacts that are described in the museum inventory as two blades, a scraper and a core (Fig. 2.7). The artefact classified as a scraper is missing the typical retouched edges and appears to be a preparation flake. Additionally, another artefact attributed to Schafstall II, probably belongs to the Göpfelstein assemblage, as suggested by the handwritten A in black ink on its ventral surface (Fig. 2.7,3).

Aside from the lithics, Peters (1936a) documented several Aurignacian bone tools and worked bone fragments that were later drawn and re-published by Hahn (1977). These include an antler point, two bone awls and a notched and engraved fragment with parallel lines and crosses. Additionally, Peters reports the presence of four bone retouchers used for shaping stone tools.

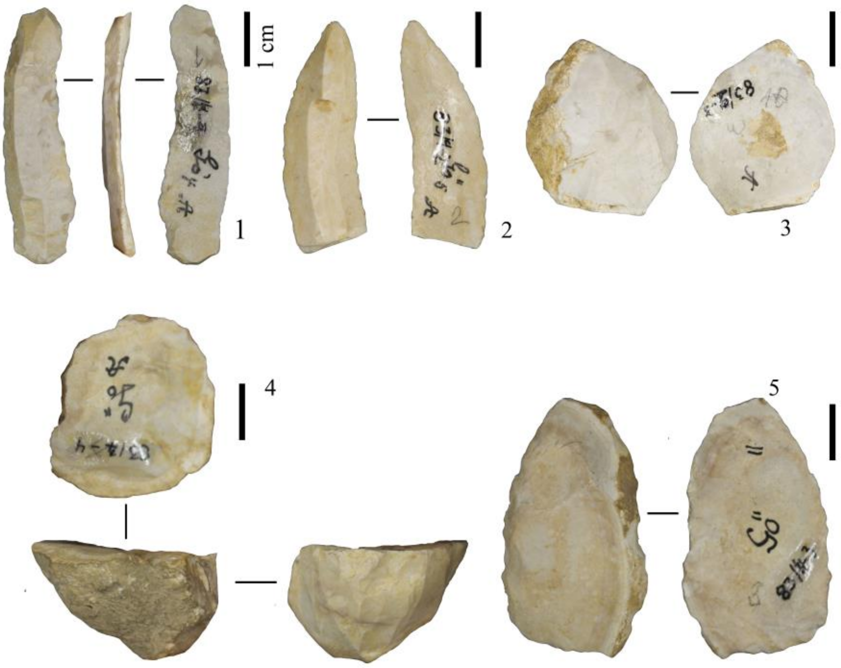


Figure 2.7 Göpfelstein, artefacts. Hohenzollerisches Landesmusem Hechingen

Fauna

The large mammal remains from the 1934 and 1935 excavation campaigns were assigned to palaeontologist Fritz Berckhemer and stored at the Staatliche Museum für Naturkunde in Stuttgart, where they are still kept today together with the few recent finds collected by Ulrich Binder in 1950. Around that time, Werz also investigated the Göpfelsteinhöhle and gathered a small collection of finds, which are housed at the Rathaus Museum of Veringenstadt. The University of Erlangen also hosts some of the large mammal bone finds from Göpfelstein as well as small vertebrate and gastropod remains,which were studied by palaeontologist Florian

Heller. In 1948 Heller sent Peters his finished manuscript on the microfauna analysis of Göpfelstein and Schafstall, however it was inexplicably lost and the results were never published (Scheff, 2004).

The faunal assemblage of Göpfelsteinhöhle was partially analysed by Fritz Berckhemer, who lists, in a brief report presented by Peters (1936a), the following taxa: spotted hyena (*Hyaena spelaea*), cave bear (*Ursus spelaeus*), wolf (*Canis lupus speleaus*), wolverine (*Gulo borealis*), steppe polecat (*Foetorius eversamnii*), lion (*Felis spelaea*), horse (*Equus germanicus*), woolly rhinoceros (*Rhinoceros antiquitatis*), reindeer (*Rangifer tarandus*), mammoth (*Elephas primigenius*), bison (Bison priscus), giant deer (*Megaceros*), red deer (*Cervus elaphus*) and ibex (*Capra ibex*).

Berckhemer notes that the impact of hyenas on the bone assemblage is considerable, making the distinction between different bone accumulators a challenging task. Moreover, the prevalence of gnawing coupled with the high number of hyena skeletal remains, including those of several juvenile individuals, point to the use of the site as a hyena den. However, the occurrence of split bone remains and shed antler beams with gnawing marks indicates, in his opinion, that in some instances hyenas had secondary access to the bones, after discard by humans. Overall, little information is to be gained from Berckhemer’s study with regards to the mode and type of human occupation at the site.

In a recent review of the faunal assemblages of Veringenstadt, palaeontologist Thomas Rathgeber (2004) argues that the minimum number of individuals for hyena and cave bear at Göpfelstein are very similar, meaning that Peter’s classification of the site as a den used exclusively by hyenas is not entirely accurate.

Rathgeber mentions also the association of few relatively well-preserved belemnites in the assemblage. These are typical of the Black Jura, many kilometres away from Veringenstadt and their occurrence in the archaeological record of this geographic area has not yet been explained, though Rathgeber posits that they could have been brought by humans.

2.3.3 Nikolaushöhle

Nikolaushöhle is the largest cave site in Veringenstadt and overlooks the Lauchert river from the south, in the opposite direction of Göpfelsteinhöhle (Fig. 2.8). It lies at 670 m a.s.l. on top of a forested hill slope, about 20m above the site of Schafstall. Its massive entrance is about 12 m wide and 6 m high and leads to a large chamber that extends 30m into the hill (Luz,

2004) (Fig. 2.9). In the front area of the cave there is a small opening in the ceiling and further towards the interior the walls are intersected by two chimneys. The cave terminates in three clastic filled conduits. Overall, the site preserves a thick sedimentary deposit, sloping markedly from the back of the cave towards its entrance.

Figure 2.8 Entrance of Nikolaushöhle as it appears today. Picture taken during the archaeological survey of 2016

Figure 2.9 View of Nikolaushöhle from Göpfelsteinhöhle

Excavations

Early mentions of the rich surface finds from Nikolaushöhle, later ascribed to the Urnfield culture, the Late Latène and the Roman periods, appear in a short text written by Von Hofkavalier Carl Freiherr von Mayenfisch in 1869 (Scheff, 2004). It was at this time that a new interest in collecting antiquities and prehistoric objects prompted a spontaneous wave of cave exploration and excavations. In this framework, at the end of the 19th century Karl Theodor Zingeler (1894) attempted to excavate Nikolaushöhle without any success.

Research oriented investigations began only later in 1910 with Schmidt's undocumented excavation and in 1934 with Peters´ test excavations in Veringenstadt (Peters and Rieth, 1936). Proper excavations were carried out for three years consecutively between 1935 and 1937, yielding multiple archaeological assemblages spanning different time periods e.g. the Middle Ages, Bronze Age, Neolithic, Magdalenian and Aurignacian. The protohistoric and historic remains were analysed by Adolf Rieth, while Peters himself studied the Palaeolithic artefacts. Despite there being no final comprehensive overview of the site and excavation, some information on the stratigraphy is available to us thanks to a published study on the microfauna conducted by Florian Heller (1937). The top layer is defined as a Neolithic horizon and is delimited in its lower part by a burnt feature. As in Göpfelstein and Schafstall, the upper layers showed significant damage from dung removal related to modern farming activities. The following layer is dominated by microfauna, which according to Peters was largely disturbed, and separates the Neolithic horizon from a thin black cultural layer about 25cm thick. Here, Peters found evidence for Early Magdalenian and late Aurignacian occupations. The black cultural layer overlies a dark brown horizon that was questionably attributed to the Aurignacian. At the bottom of this layer there was a thick cluster of bear bones, which Peters decided not to remove, ultimately halting the excavation. The presence of several chimneys and openings in the ceiling must have played an important role in the reworking of the cave sediments, so that different occupation phases could not be solidly identified in the stratigraphic sequence.

Recent surveying of the site suggests that Peters' excavation must have focused primarily on the front area of the cave. This seems to be suggested by a small square-like depression in the ground filled with rocks and debris. The blue line drawn by Peters on the cave wall is still visible in this area and abruptly disappears just a few metres into the cave. Furthermore, in his account on the Neolithic finds of Nikolaushöhle, Rieth (Peters & Rieth, 1936) states that these were principally found in the anterior part of the cave, where evidence of a fireplace was also discovered.

After the conclusion of Peters' campaigns in the 1940s, no other research excavations were conducted, though the site continued to attract the interest of both locals and scientists. In 1950 Ulrich Binder surveyed the cave gathering several pottery fragments from the Urnfield and late Latène periods. Five years later, Franz Werz from Veringenstadt carried out a small investigation that yielded also older finds pertaining to the Neolithic and Palaeolithic. Further investigations, which resulted in the collection of few pottery sherds, were later conducted by Werner Simon in 2002 and 2003 (Scheff, 2004).

Artefacts

According to Peters (1936a), the site was primarily used as a bear den and intermittently occupied by humans. The Aurignacian is signalled by very few diagnostic stone tools. Peters also mentions the presence of an antler point that probably corresponds to a worked red deer or roe deer antler tine with a stepped end, housed at the Rathaus Museum of Veringenstadt (Fig. 2.10). The attribution to red deer or roe deer is motivated by the longitudinal ridges and furrows visible below the tip, a feature that is absent in reindeer, whose antlers are characterized by a plain and smooth surface. The modified end displays a sharp transversal break and two transverse incisions run through the spongy tissue of the interior surface. The fracture margins present negative scars, which were probably produced during the separation of the tine from the beam. All in all, the piece seems to be a by-product of antler working.

By contrast, the Magdalenian assemblage, though small, is better represented and comprises 114 artefacts, such as blades, scrapers, borers and burins. Peters also mentions the presence of

Figure 2.10 Nikolaushöhle, modified antler from Peters' excavations (1935-37)

what he defines a “Gravettespitze”, most likely ascribable to the Gravettian, a cultural category that was brought into use in southwestern Germany only much later by archaeologist Joachim Hahn (1976, 1988). Among the organic artefacts there are small pierced ammonites purportedly used as pendants, a jet bead and a baton fragment. All of these went missing in 1945 and are only known to us through few publications released prior to that date (Peters, 1936a, 1936b, 1937; Peters & Rieth, 1936). The missing finds also included those artefacts recovered during the campaigns of 1936 and 1937 that never made it to publication. The Rathaus Museum of Veringenstadt holds today only the finds from Werz´s supplementary investigation in the ´50s. These were recently analysed by Schumacher (2014) and consist of 6 artefacts: 3 made of matt grey Jurassic chert, which is also found at Schafstall, and 2 in brown yellow chert. Among these, Schumacher discovered an artefact that refitted with an angular debris from Schafstall II.

Fauna

Peters’ approach to archaeological fieldwork was very innovative, in that he was one of the first archaeologists in southern Germany to use water-screening for the recovery of small remains (Fig. 2.11). In Veringenstadt he set up a waterscreening station on the Lauchert river in proximity of the investigated sites. In this way, it was possible to retrieve even the small and copious microfaunal remains of Nikolaushöhle which were studied by palaeontologist Florian Heller (1937) and are today preserved in the University of Erlangen. His publication is one among the very few completed studies on the sites of Veringenstadt. Heller’s analysis focuses mainly on the microfauna from the black cultural layer, directly below the so called “rodent layer”. The latter, according to Peters, had a volume of about 2 m^3 and contained thousands of rodent skeletal remains, which were only marginally considered by Heller because of their uncertain stratigraphic context. Heller’s study also takes into account the microfauna from some of the pockets close to the cave walls, which he assumes to be more or less contemporaneous with the rodent layer despite their higher position in the stratigraphic sequence. This assumption rests on his belief that karst activity would have caused the progressive sinking of the more exposed areas farther away from the cave walls.

The results of the microfaunal analysis are broadly consistent with Peters’ interpretation of the lithic industries as pertaining to two distinct time periods, the late Aurignacian and the Early Magdalenian, though it is not clear, based on the microfauna, which criterion Heller used to separate the two cultural periods. The taxonomic list includes the ground squirrel

(*Spermophilus rufescens*), the European hamster (*Cricetus cricetus*), the steppe pika *(Ochotona pusilla*) and the collared lemming (*Dicrostonyx* sp.), which dominates the black cultural layer. By contrast, the rodent layer, which Heller attributed to an indefinite period postdating the late Magdalenian, shows clear signs of disturbance with the mixing of species which became locally extinct during the Pleistocene, such as the European snow vole (*Microtus nivalis* aka *Chionomys nivalis*), the tundra vole (*Microtus ratticeps* aka *Microtus oeconomus*) and the narrow-headed vole (*Microtus anglicus* aka *Microtus gregalis*) and Holocene species, like the edible dormouse (*Glis glis*), the common dormouse (*Muscardinus avellanarius*) and the rat (*Epymis rattus* aka *Rattus* sp.).

Heller also mentions the presence of fish, reptile, amphibian and bird remains, though he does not go into detail concerning the represented species. Regarding the contribution of birds to the assemblage, he posits that the birds roosting in the cave were likely preying on phasianids, hence the presence of numerous gastroliths comprising different types of materials, such as bean ores, limestone, belemnites, crinoids and other Jurassic fossil fragments. The accuracy of such interpretation is questionable, seeing that bean ores are relatively frequent in the Pleistocene sediments of the Swabian Jura and some of the purported gastroliths could have also been the product of geological rounding.

Little information is available on the large mammal remains. A limited sample of finds recovered by Werz in the ´50s and housed today at the Rathaus Museum of Veringenstadt remains unstudied. The carnivore remains are stored at the University of Erlangen and were studied by Heller (1937). The taxon list comprises cave bear (*Ursus speleaus*), red fox (*Vulpes vulpes*), stoat (*Mustela erminea*) and least weasel (*Mustela nivalis*). Heller reports the

Figure 2.11 Eduard Peters and his excavators going through the waterscreened materials from the Kohltalhöhle next to the Lauchert River. Landesdenkmalamt Tübingen

presence of cave bear in the Magdalenian horizon, an additional aspect that hints to stratigraphic disturbance and bioturbation, underpinning the problematic nature of the assemblage.

2.3.4 Schafstall

The site of Schafstall lies just a few hundred metres to the west of Nikolaushöhle and is barely visible from the valley floor, being partially hidden by the thick canopy. As seen today, it is a rockshelter with two contiguous sites, named by Peters “Schafstall I” and “Schafstall II”. The limestone overhang extends for about 36m, curving inwards to form an elongated niche corresponding to the area of Schafstall I. The eastern part of the site is occupied by a 20 m^3 stone wall made by Peters with the boulders that were removed from the excavation area. Moving towards the western part of the rockshelter, the ground slopes gradually upwards as the rock wall turns abruptly outwards and makes an almost right-angled turn to the west, delimiting the smaller sheltered area of Schafstall II. In this second area, the signs of Peters’ excavation are still clearly visible in the form of a 12 m long ditch running beside the wall. The area in front of the rockshelter is very narrow and constricted by the sloping hillside (Fig. 2.12)

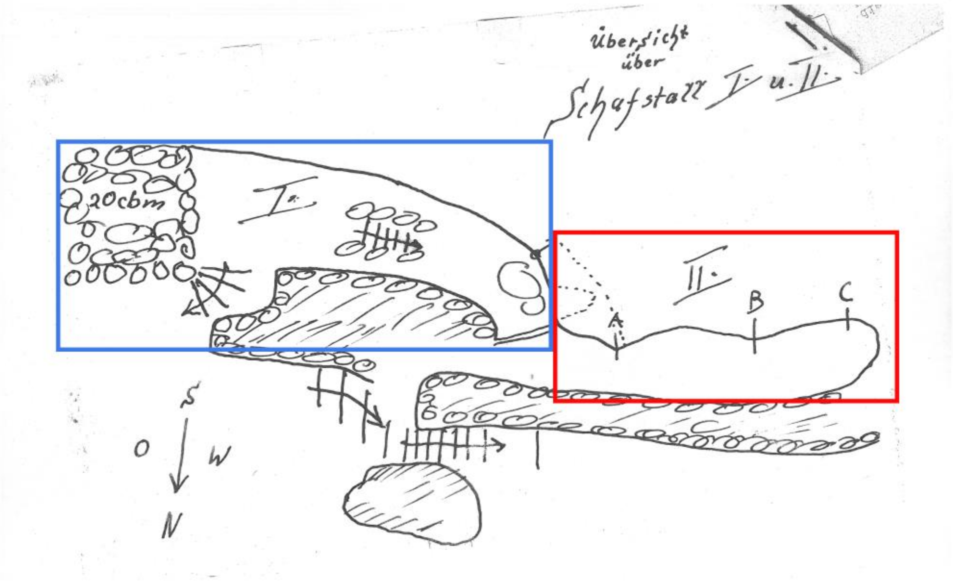


Figure 2.12 Sketch of the site plan of Schafstall. Drawing by Johann Riedinger, 1948. Highlighted in blue the area of Schafstall I, in red the area of Schafstall II

Schafstall I

Peters' excavations

Peters was informed about the existence of the site in the autumn of 1934 at the end of his first excavation campaign in Veringesntadt. At that time the rockshelter was still being used as a sheep corral, hence the choice of the name "Schafstall".

Three initial campaigns funded by the province of Hohenzollern were carried out in the late summer and early autumn seasons between 1935 and 1937 (Fig. 2.13). In his usual fashion, Peters drew a blue line, still partly visible, on the rock wall to mark the ground level at the beginning of the excavation and waterscreened all the sediment in the Lauchert river.

Figure 2.13 Eduard Peters with his excavation crew at the beginning of the excavation at Schafstall 1935. Archiv Heimatmuseum Veringenstadt

The stratigraphic sequence can be reconstructed as follows:

-a top layer considerably damaged by farming activities ascribable to the Holocene

-a thick layer of Late Pleistocene age filled with large rocks and debris originating from the cave roof collapse

-a cultural layer with Mousterian artefacts and burnt bones.

One of the major obstacles encountered during excavation of the southeastern area of the site was the presence of large boulders, which could only be removed by blasting. This operation was carried out during the winter season between 1936 and 1937 with the aid of the well-known and established archaeologist, Hugo Obermaier (Peters, 1939). The presence of massive blocks and boulders, indicative of a rockfall, suggested that the site had once been a cave, which Peters (1936a) believed to have been linked to the Nikolaushöhle.

The outbreak of war caused the halt of the excavations, but Peters could not be refrained from conducting two further campaigns at Schafstall I, in 1943 and 1944, with a reduced team of workers. After the tragic loss of all the documentation and archaeological finds in 1945, he resumed the excavation of Schafstall I on his own at the beginning of 1946. In 1947 he cleared out the eastern part of the excavation next to the dry-stone wall and moved on to the western area. The following year, work was continued in this area reaching the westernmost corner where the rock face turned sharply forming another smaller overhang. A few heavy blocks were removed and beneath them several lithic artefacts, bone and teeth remains were uncovered. This unexpected discovery prompted Peters to continue the excavation to the west, in the area of Schafstall II, where he worked incessantly until his death on May 22nd, 1948.

After this date, no further investigations were carried out at Schafstall until 2016, when together with Professor Nicholas Conard and excavation technician Alexander Janas of the University of Tübingen, we conducted a survey of the archaeological sites of Veringenstadt. The objective was to open a new test excavation in the Lauchert Valley picking up the threads of Peters unfinished work.

New excavation - 2016

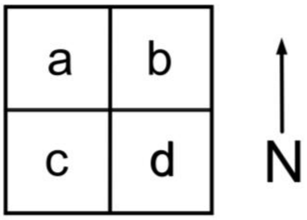
In April 2016, at the beginning of spring, we set out on our survey. Jürgen Scheff, a former history teacher and honorary inspector of the heritage department, guided us to the sites providing useful information on their excavation history. We surveyed a total of 6 sites. These included the four that had been excavated by Peters and two additional ones, the Mühlberghöhle and the Hagentorhöhle. The former did not seem appropriate for a potential excavation because of its proximity to the riverbank and the high risk of finding strongly rewashed and redeposited sediments, while the latter had long been used by the village people as a storage place and most of its sediments had been damaged or removed. After having ascertained the absence of sediments also at Göpfelsteinhöhle and Annakapellenhöhle, our attention turned to the sites of Nikolaushöhle and Schafstall. Several factors dissuaded us from conducting a test excavation at Nikolaushöhle. The large size of the cave and the presence of numerous openings and chimneys coupled with the effects of karst activity made it difficult to delimit a potential excavation area with reduced soil disturbance. Such issues

Figure 2.14 Schafstall I, view of the excavation of 2016

had evidently also been encountered by Peters (1936a), who reports the presence of large quantities of intrusive materials together with the Magdalenian finds.

By contrast, the site of Schafstall seemed more promising. For one thing, this was the last site that had been excavated by Peters, who died before completing the work, and for which we had the largest amount of primary information in terms of archaeological finds and field notes. A test excavation here would have had the advantage of enabling us to place the old finds into context and to correlate our work with that of Peters. Moreover, because of the relatively small size of the site, the location choice for our excavation trench would have been quite straightforward and it would have been possible to gain a fairly good picture of the stratigraphy by making few test pits. We decided to start our investigation in the area of Schafstall I (Fig.2.14). In this way we could reconnect to Peters' excavation trench and verify the presence of unexcavated archaeological layers.

First, we set up an excavation grid with the aid of a total station and established eleven points on the rock face for horizontal and vertical reference. The point of origin was in the westernmost corner of Schafstall I, where the dry rock wall lies. Despite the slight northeast orientation of the site, for sake of simplicity we chose to align the grid north. The first field campaign was carried out between September 19th and October 10th of 2016 (Conard et al., 2017). Excavation technician, Sarah Rudolf and I oversaw the excavation under the supervision of Professor Nicholas Conard. We opened a 4x5 m^2 excavation trench close to the dry-stone wall. Each square metre unit was divided into four subsquares designated by a low case alphabet letter between a and d starting from the top left corner of each north-south orientated square. A schematic picture is provided below:



Using a total station and computer we measured the position of layers and rocks and piece-plotted single finds larger than 3cm. All data was recorded using a modified version of Dibble and McPherron's (1996) excavation software.

The first half of the campaign was spent removing the backdirt from Peters´ old excavation trench. Beneath the trench bottom we uncovered a sterile layer overlying bedrock that caused us to halt the excavation.

Stratigraphy

The stratigraphic sequence consists of only two geological horizons (Fig. 2.15). GH 1 corresponds to the backfill of Peters' excavation, a non-homogeneous layer characterized by different types of sediment and clasts, containing sporadic lithic artefacts and faunal remains mixed with glass sherds and other modern intrusive material.

Below it, there is GH 2, a pedogenic sterile layer overlying the bedrock. It is a brownish yellow, very clayey and compact horizon with few subangular limestone clasts up to 15 cm long. Very few bone fragments were recovered from this layer, some of which came from the interface with GH1, to which they could possibly belong.

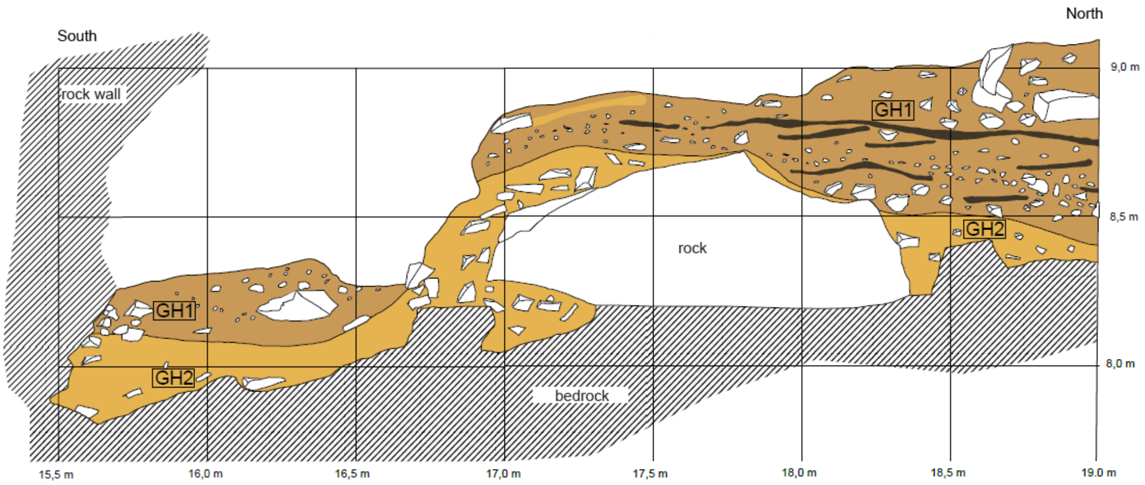


Figure 2.15 Schafstall I, western stratigraphic profile from the excavation of 2016. Drawing by Sarah Rudolf

Artefacts

Peters (1936a) managed to publish only the material excavated in 1935. The assemblage comprised 967 lithic artefacts. These included 65 tools or tool fragments and 8 chores. The most common raw material was Jurassic chert, followed by red and green radiolarite and quartzite. Peters classified the artefacts typologically attributing them to the Mousterian. In comparison with Göpfelsteinhöhle, the tool forms and the flaking techniques seemed more refined, bringing him to the conclusion that the Mousterian of Schafstall was probably younger. This idea was reinforced by the presence of “Upper Palaeolithic-like” forms, which he tentatively ascribed to a “transitional culture”. Bosinski (1967), who later published the Mousterian artefacts from the post-war excavations (Plate I), agreed with Peters’ interpretation of the assemblage as pertaining exclusively to the Middle Palaeolithic. On the contrary, Hahn (1977) argued for a mixed stratigraphy to account for the presence of both Middle and Upper Palaeolithic artefacts. His argument was based on the typological classification of the artefacts that had been excavated in 1947. Though he remained cautious in attributing them to the Aurignacian, he clearly thought that the “transitional culture” identified by Peters was more likely the product of mixing between layers. The presence of an Aurignacian technocomplex at Schafstall I was later confirmed by Schumacher (2014), who had also access to the artefacts stored at the Rathaus Museum of Veringenstadt, which holds around 1600 pieces. In his master thesis he highlighted the close affinity of the lithics with the assemblage of Göpfelsteinhöhle. In particular, he interpreted the occurrence of bladelet reduction sequences and of carinated pieces at both sites as a clear indicator of the Aurignacian. Furthermore, he claimed that the two assemblages were more or less contemporaneous based on technological and typological similarities and the use of the same raw materials. However, there were also slight differences, in that Göpfelstein displayed a larger variety of raw materials and the grey chert used was of better quality than that of Schafstall I.

All of the Mousterian artefacts recovered before 1945 (Peters, 1936a) are now missing with the exception of a single piece preserved at the Württembergisches Landesmuseum of Stuttgart which was classified by Bosinski (1967) as an atypical convergent scraper (Plate I, Fig. 19). Three additional finds from Peters’ later excavations are displayed at the Hohenzollerisches Landesmusem of Hechingen. These consist of a lithic artefact from the post-war excavation, drawn by Oscar Heck (Plate II, Fig. 7), and of two putative limestone handaxes, which, upon recent re-inspection, have been classified as geofacts (Çep, personal comment). One of these appears in Peters' (1936a) publication of 1936, where it is referred to as a "*Faustkeil*" and can therefore be associated with the find assemblage excavated in 1935. The Mousterian finds from the post-war excavation are housed at the Rathaus Museum of Veringenstadt. Some of them were drawn by Oscar Heck, a friend of Peters and leading exponent of the cultural and heritage management of the Hohenzollern province in southwestern Germany, during the 1946 excavation campaign.

The archaeological assemblage of Schafstall I also comprises a collection of bone retouchers that are discussed in detail in chapter 4. These were classified by Peters as "auxiliary bone tools" employed in stone tool production.

Few additional artefacts were recovered during the new campaign of 2016 (Table 1). These were mainly found in GH 1, the backfill of Peters' excavation. We did not record any diagnostic artefacts with the exception of a putative Upper Palaeolithic blade (Conard et al., 2017) with a seemingly retouched end from GH 2 (Plate II, Fig. 2).

GH	Tools	Cores	Blanks	Small debitage	Micro debitage	Total
1	3	2	21	22	2	50
2	1		1			2

Table 2.1 Schafstall I, total number of artefacts divided by geological horizon (GH). The artefact count considers both single finds and finds recovered during waterscreening.

Fauna

Of the faunal material excavated during the first three campaigns, carried out between 1935 and 1937, we presently hold only a few finds housed at the Staatliche Museum für Naturkunde in Stuttgart. These probably belong to the find lot of the 1935 archaeological campaign and were published in a preliminary report by Fritz Berckhemer (Peters, 1936a), who worked as a palaeontologist in Stuttgart and collaborated with Peters in the study of the faunal remains from Göpfelstein and Schafstall. His results are reported in the table below (Table 2.2) and were included in our study, which also concerned the bulk of unstudied material excavated between 1944 and 1948 and housed at the Rathaus Museum of Veringenstadt. Interestingly, some of the bone fragments analysed in this study were drawn by Oscar Heck in 1946. It was possible to recognize these from their ink signatures in Roman numerals followed at times by the letters “a” and “b”, which refer respectively to the number of the drawing and perhaps to the orientation of the piece.

The small mammal remains were analysed by Florian Heller, who summarized his results in a manuscript that was never found. His conclusions are partly known to us through the work of Wilhelm Heinrich Jakob Götz (1949), who worked at the Staatliche Museum für Naturkunde in Stuttgart and studied the bird remains recovered in 1935. While the location of the bird remains analysed by Götz remains unknown to us, it is highly probable that the large number of small mammal remains in the palaeontological collection of the University of Erlangen corresponds to the unpublished material studied by Heller.

Taxa	**Common Name**	**MNI**				**Total NISP**
		Total count	N juveniles	N adults	N senile	
Carnivores						
Ursus speleaus	cave bear	9	6	2	1	23
Canis lupus	wolf	1		1		7
Herbivores						
Equus germanicus	horse	6-7	3	3-4		4 (5)
Rhinoceros antiquitatis	woolly rhinoceros	3		2	1	9
Rangifer tarandus	reindeer	4-5	1-2	3		8
Elephas primigenius	mammoth	2		2		
Capra ibex	ibex	1				horn core

Table 2.2 Preliminary results of the faunal analysis of Schafstall I as reported by Fritz Berckhemer (in Peters 1936).

Schafstall II

Peters’ excavations

Excavations at Schafstall II (Fig. 2.16) began in March of 1948 and were carried out as a continuation of those initiated in the area of Schafstall I. Peters worked mostly on his own, assisted only occasionally by a couple of volunteers. One of these was Johann Riedinger, who compiled the excavation documentation following the sudden death of Peters in May of 1948. The short report of Riedinger summarizes the last two years of archaeological activity at Schafstall I and II. Concerning the excavation at Schafstall II, Riedinger reports that three test pits were opened near the rock wall, namely A, B and C. These were placed at less than half a dozen metres apart from each other following the east-west orientation of the rock face. Each pit was about 1 to 1.20 m wide and 5 m long. As the excavations proceeded from the first to the second and then to the third pit, the limits between them were demolished resulting in an overall 1.20 to 1.40 m wide and 12 m long trench. A rudimentary sketch of the site plan drawn by Riedinger (Fig. 2.12), illustrates the location of the excavation trenches. The drawing also shows how the area around the site was organized, with neatly piled rocks delimiting the two excavation areas and a narrow trail, that still exists today, climbing up the top of the embankment flanking the rockshelter. A small arrow pointing inwards to the rock face of Schafstall I indicates the place where Peters carried out a smoke test to verify the existence of an internal passage connecting the two sites.

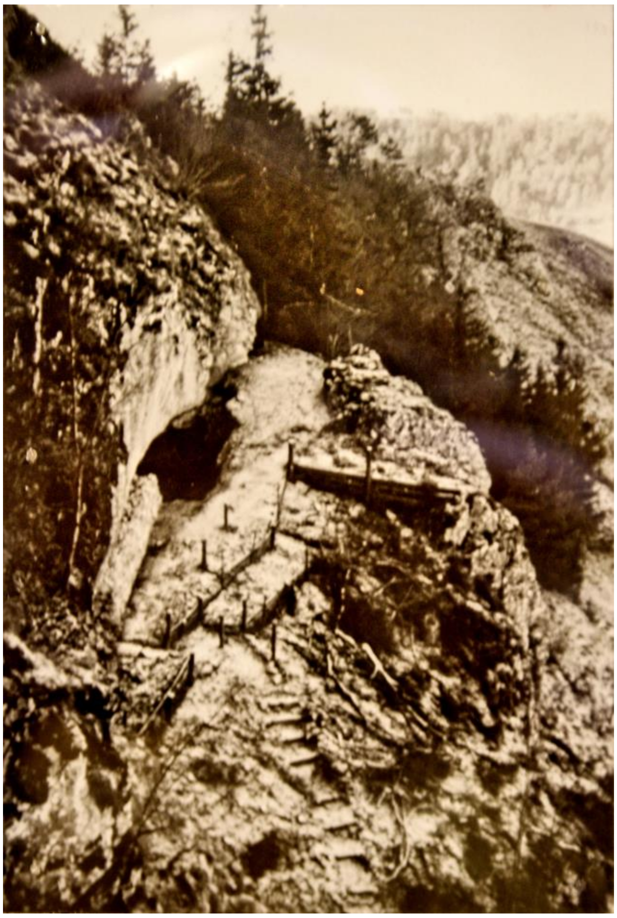


Figure 2.16 View of Schafstall II at the time of Peters' excavation. Rathaus Museum Veringenstadt

Riedinger provides a detailed description of the stratigraphy, which is characterized as follows:

-a black top layer, about 30 cm below the surface, containing Neolithic artefacts and pottery fragments

-a second horizon, beginning at about 1.10 m below the surface, marked by a glacial deposit containing bone fragments of Pleistocene species, such as mammoth and bison

-a yellow brown cultural layer about 80 cm thick, yellow in the upper part and dark brown in the lower part. The layer is described as containing mostly cave bear remains and a high concentration of lithic artefacts, burnt bones and hematite coming in its lower part. Riedinger mentions also the finding of a human tooth in the dark brown layer.

-a 5cm thick black cultural layer

The stratigraphic description reveals some discrepancies with regard to Riedinger's profile drawing of test pit C (Fig. 2.17). In the profile drawing the lithic artefacts, burnt bones, hematite and human tooth are associated with the black cultural layer and not with the dark brown layer. Furthermore, the thickness of the black cultural layer is of 30 cm and is inconsistent with the measurement reported in the stratigraphic description. A reason for this could perhaps be that the written account refers to the stratigraphy of test pit A or B, though the mention of the human tooth, associated in the drawing with test pit C, then seems contradictory. Another explanation could be that the thickness of the black cultural layer was very irregular and perhaps, rather than it being a true layer, it constituted a feature. In any case, the profile drawing is oddly rendered, in that instead of representing the stratigraphic section, Riedinger outlined the shape of the partly emptied trench, creating a negative image of the excavation, to which he added in the form of side notes the depth and description of the various layers. From the drawing it appears that the layers were excavated horizontally and defined arbitrarily without any consideration of the vertical transition between them.

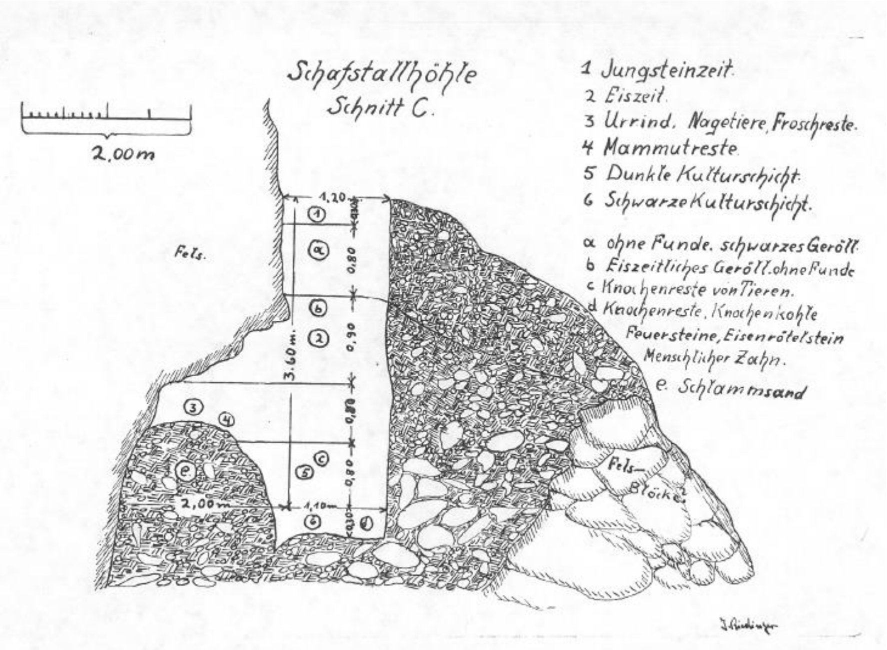


Figure 2.17 Schafstall II, profile section of test pit C. Drawing by Johann Riedinger, 1948

Müller-Beck (1956) later proposed a geological interpretation of Riedinger´s stratigraphy, though it is not quite clear from which sources he drew his data from. In fact, his reconstruction of the geological events involved in the formation of the stratigraphic sequence seems to be too detailed to be based exclusively on Riedinger’s simplistic account. Müller-Beck recognized different depositional phases represented in the stratrigraphy:

-a bottom most reddish layer that deposited during a relatively warm period. This probably corresponds to the red-brown rocky layer that, according to Riedinger, was reached by the middle of May 1948 facilitating the excavation of the cultural layer. Such layer does not appear in the profile drawing of Riedinger but could have been intermixed with the black cultural layer.

-a second depositional event, possibly separated from the lower one by a gap in the stratigraphy, comprising two layers and ascribed to the early preglacial period

- a third depositional event coinciding with the onset of the Last Glacial Maximum

The Upper Palaeolithic occupation is related to the end of the second and the beginning of the third depositional event. Müller-Beck also observes that the latter is not fully represented in the stratigraphy and posits that the upper part of the deposit was subject to erosion.

A comparison with the stratigraphic description and profile drawings from the new excavations of 2016 and 2017 hardly throws light on the issues so far presented due to substantial inconsistencies with Riedinger´s data, most notably the absence of any kind of cultural layer.

New excavations -2016-2017

Following the death of Peters, the excavation was interrupted, and the site went unresearched until the new campaign of 2016 led by Professor Nicholas Conard of the University of Tübingen and the present author (Conard et al., 2017). After the closure of our initial test pit at Schafstall I, we decided to move our attention to Schafstall II and extended our excavation grid from Schafstall I by adding 9 station points to the rock wall of Schafstall II.

Since Peters´ had investigated the area close to the wall, thus creating a long ditch apparently devoid of sediment, we decided to position our test pit along the narrow embankment flanking the old excavation trench (Fig. 2.18). We delimited a 2x3 m excavation area and proceeded with the removal of the topsoil layer containing loose sediment with mixed modern and early Holocene finds. Beneath a pile of loose angular rocks, we uncovered an intact stratigraphic sequence that prompted us to continue our investigations in the following year. Before the end

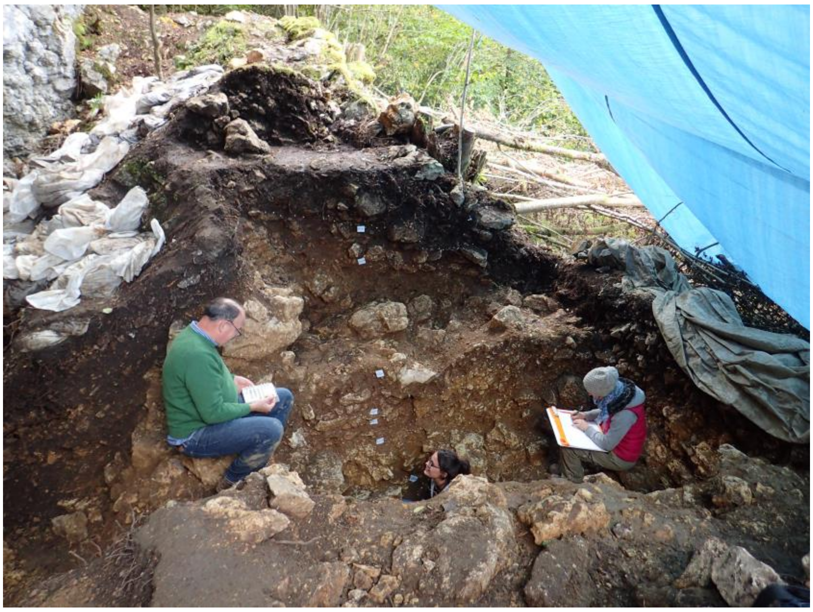


Figure 2.18 Schafstall II, view of the excavation of 2017

of the field season we established a new excavation grid, that was in axis with the wall of the shelter, and subsequently redefined and renamed our excavation units. The second campaign took place between August 21st and October 5th of 2017 (Conard & Toniato, 2018). The excavation area was extended to the east so that its size was brought to 3x3 m. Each metre square was subdivided into four subunits following the same procedure used for Schafstall I (see above). We decided to waterscreen subunit C of each unit in order to better control the recovery of small archaeological finds and collect a microfaunal sample suitable for study. The excavations revealed a ca. 4 m thick stratigraphic sequence with no secure archaeological horizons and very sparse lithic scatters. At the bottom of the sequence we uncovered a compact clayey layer superposed over weathered limestone residuum that rested on bedrock. The excavation could not be continued. We therefore began to investigate the area of the old trench in the attempt to link the two excavations and gain a general picture of the stratigraphic sequence. This step enabled us to ascertain the depth of the lower limit of Peters´ excavation and to verify the absence of archaeological layers below it.

Stratigraphy

The stratigraphic sequence of our excavation comprises six main geological horizons (GH 1-GH 6). An attempt was made to reconnect the geological horizons of our test pit to those underlying the bottom of Peters´ trench. These were designated with the number of the hypothetically corresponding GH followed by the letter “P”, that stands for “Peters” (Fig. 2.19, 2.20). GH 1 is the top layer and is characterized by dark brown loose silt with many roots and humic material as well as randomly oriented subangular clasts up to 20-30cm in diameter. It contains mixed modern and archaeological materials, such as pottery sherds and faunal remains of Holocene species, namely wild boar, roe deer and red deer. GH 1 pronouncedly slopes down to the north following the inclination of the hillslope and lies directly on top of GH 2, a yellowish-brown clayey silt layer containing Pleistocene faunal remains, mainly of cave bear. Like GH 1, GH 2 thins to the north running over the edge of the hill. The transition to the next horizon, GH 2a, is gradual. GH 2a is the thickest horizon of the stratigraphic sequence and the richest in terms of finds. These consist mostly of cave bear remains and few sporadic lithic artefacts. The matrix is very similar in colour and texture to that of GH 2 and it includes large sub-angular and sub-rounded rocks up to 50 cm in diameter that likely derive from a cave wall collapse. To the north GH 2a is flanked by an unsorted deposit with variable amounts of limestone rubble spanning almost the entire sequence.

Figure 2.19 Schafstall II, eastern stratigraphic profile of the new excavation of 2016-17

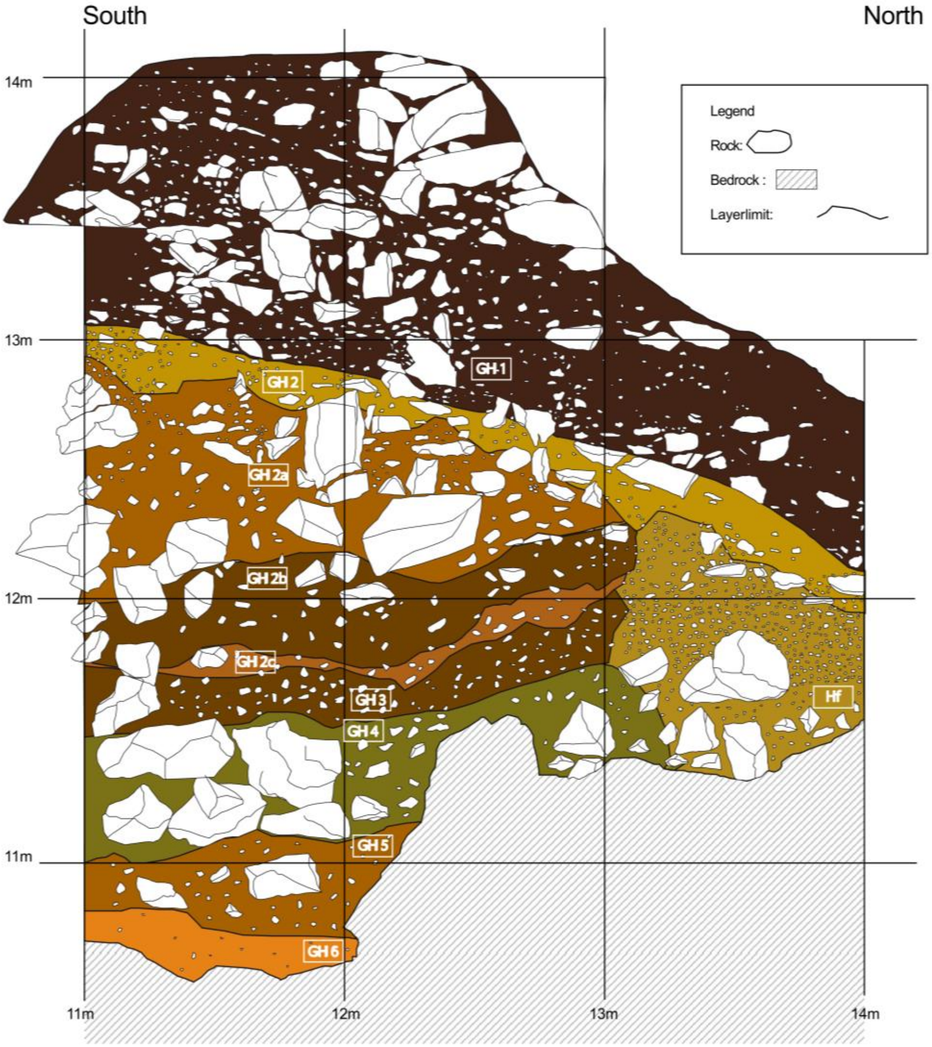


Figure 2.20 Schafstall II, western stratigraphic profile of the new excavation of 2016-17

This unstratified deposit was named the “Hangfazies”, abbreviated to “Hf”.

Its southern limit coincides with the drip line of the cave roof that once covered the site. In the western area of the excavation GH 2a is followed by two thin localized features that were named GH 2b and GH 2c. Both are only visible in the western profile (Fig. 2.19). GH 2b has a variable thickness, between 15 and 40 cm. It is dark brown in colour and consists of silt with fine-grained limestone and has a high density of bone finds. GH 2c is a very thin horizon, its thickness is generally uniform measuring about 10 cm. It is followed by GH 3, a reddish-brown silty layer with fine limestone inclusions, similar in texture to GH 2c. To the south of the excavation area GH 3 includes massive limestone blocks that are part of a rockfall deposit which extends to GH 4, a clayey silt greenish-brown clast supported layer. GH 4 wedges out to the north against a seemingly massive rockfall that continues down into the lower layers sloping downwards to the south towards the rock wall. GH 4 transitions sharply to GH 5, a light yellowish-brown clayey silt layer. Directly below GH 5 lies GH 6, a yellow clay compact layer found in irregular pockets with a very low concentration of bone finds. GH 6 is interspersed with weathered limestone residuum superposed on bedrock.

Micromorphology samples were taken from the western profile, from GH 2a, GH 4 and GH Hf, and from the interfaces between GH 2b-2c, GH 2b-3, GH 3-4 and GH 5-6. Sediment was also sampled from GH 2a, GH 2b, GH 2c and GH Hf.

Hominin remains

Riedinger reports the finding of a hominin tooth in the black cultural layer, specifically a permanent lower right incisor (Plate III, Fig. 3). Two additional skeletal remains were discovered by Markus Schumacher (Conard, et al., 2016; Schumacher, 2014) and morphologically identified by Bernd Trautmann and Hannes Napierala of the Institute of Archaeological Sciences in Tübingen. One is a right clavicle of a class 2 infant according to Martin’s (1928) ageing scheme which corresponds to an individual aged between 7 and 13 years (Plate III, Fig. 1). The bone bears a series of deep parallel cutmarks on antero-inferior that could be related to mortuary practices, similar to those documented at other sites of the Swabian Jura (Gieseler & Czarnetzki, 1973; Orschiedt, 1997; Sala & Conard, 2016). The other find consists of a middle phalange of a juvenile with an unfused proximal end which makes the identification not entirely certain (Plate III, Fig. 2). The age of the remains and the species determination remain uncertain and await future analyses.

Artefacts

As of today, the lithic assemblage of Schafstall II, housed at the Rathaus Museum of Veringenstadt, hosts 320 artefacts which were analysed by Schumacher (2014) and constitute the focal point of his Master thesis. The lithic materials come from the excavation of 1948, which we know little about from the unpublished account and drawings of Riedinger. Schumacher noticed that the artefacts drawn by Riedinger are missing from the archaeological collection of the Rathaus Museum. The author found three of these in the collection of the Hohenzollerisches Landesmuseum of Hechingen (Plate IV, Figg. 7, 9, 10). Though the museum inventory lists five lithic artefacts from Schafstall II, four of these bear the typical red-ink signature "Sch II" visible also on many of the bone finds from Schafstall II, while one of the other two is labelled in black ink with the letter "A" and likely belongs to the Aurignacian assemblage of Göpfelstein.

The Schafstall II lithic assemblage consists primarily of stone chips and small debitage, which make up two-thirds of the total material. The larger artefacts include 3 cores, 7 pieces of angular debris, 60 flakes and 12 blades including 14 retouched tools (Conard et al., 2016). Though the sample size is quite small and lacks clear diagnostic pieces, the technological features of the lithic industry are typically Upper Palaeolithic and ascribable to the Aurignacian. Schumacher observed that the cores were specifically prepared by unidirectional reduction in order to obtain regular blades and blanks for artefact production and drew parallels with the Aurignacian technocomplex of Geißenklösterle (Hahn, 1988). The attribution to this chrono-cultural period is further supported by the presence of a fragmented split-based antler point, an index fossil of the early Aurignacian. Compared to the other sites, the raw material variety is more limited and dominated by high quality Jurassic chert. The use of this material type is also documented at the neighbouring cave site of Nikolaushöhle. Schumacher was able to refit a surface find from Nikolaushöhle, collected by Werz in the fifties, with one of the artefacts from Peters' excavation campaign of 1948 (Plate IV, Fig. 6), thus demonstrating the contemporaneity of occupation of the two sites.

During our re-investigation of the site in 2016 and 2017, we collected a total of 110 artefacts comprising micro- and small debitage debris, blanks, tools and an angular debris (Table 2.3). These were found mostly isolated or scattered in low concentrations throughout the stratigraphic sequence. The majority of the assemblage is made up of small debitage debris, between 5 and 10 mm in size, and of microdebitage, below 5 mm, recovered mostly by waterscreening. A similar pattern was also observed by Schumacher among the old finds from

Peters' excavation; in comparison with Göpfelsteinhöhle, he claimed that the lithic assemblages of Schafstall I and II are more fragmented and include a higher number of small flaking debris. GH 2a has the largest concentration of lithic finds but also corresponds to the thickest layer of the sequence. The only working tools were discovered in this layer and consist of a blade with a retouched end (Plate IV, Fig. 1), a probable nosed endscraper (Plate IV, Fig. 4) and a pointed scraper (Plate IV, Fig. 5). Again, the only raw material represented in our assemblage is Jurassic chert. Its colour is light grey and most of the larger pieces have a whitish patina like those analysed by Schumacher. The organic artefacts all derive from the old excavations and consist of a split-based antler point (Plate V, Fig. 1), 13 retouchers and an elongated pointed tool reminiscent of a bone awl (Plate V, Fig 2). All the finds are housed at the Rathaus Museum of Veringenstadt except for one retoucher on a bear canine belonging to the historical collection of the Hohenzollerisches Landesmuseum of Hechingen.

GH	Blanks	Tools	Angular debris	Small debitage	Micro-debitage	**Total**
1						
2	2		1	3	12	**18**
2a	6	3		19	24	**52**
2b					1	**1**
2c				7		**7**
3				2	1	**3**
4				1		**1**
5				1	1	**2**
6						**0**
Hf				1	11	**12**
2ap						**0**
3p	1				1	**2**
4p	1			1	9	**11**
5p						**0**
6p	1					**1**
Total	**11**	**3**	**1**	**35**	**60**	**110**

Table 2.3 Schafstall II, total number of artefacts divided by geological horizon (GH). The artefact count considers both single finds and finds recovered during waterscreening

The split-based point is made on reindeer antler, it has an elongated and tapering form and a suboval cross section. The tip is broken off and the base is considerably damaged, one of the wings being almost.completely destroyed. Split-based antler points also appear at other sites of the Swabian Jura, such as Vogelherd, Geißenklöstlerle, Hohle Fels, Brillenhöhle and Bockstein (Dotzel, 2011; Hahn, 1988; Liolios & Teyssandier, 2003; Wolf, Münzel, Dotzel, Barth, & Conard, 2016). The largest numbers have been registered at Vogelherd and Geißenklösterle.

The other bone artefact, similar to an awl, presents a marked curvature linked to the natural shape of the anatomical element on which it is made, which could have been a reindeer ulna. It has an elongated form with a flat cross section and the sides converge to form a rounded point. The tip is slightly damaged and bears small rounded pits attributable to carnivore gnawing. The opposite end is broken and presents a series of small notches along the fracture edge and an isolated pit that might also be associated with carnivore activity.

Fauna

Most of the large mammal remains are housed at the Rathaus Museum of Veringenstadt. The museum collection includes the finds that were recovered by Peters in 1948 as well as five surface finds gathered by Werz in the ´50's. Additionally, few cave bear specimens, consisting of two mandible fragments and several teeth, were found at the Hohenzollerisches Landesmuseum of Hechingen and probably form part of the small collection donated by Adolf Rieth in the `50's. Another part of the faunal assemblage was sent for analysis by Dr. Helmut Müller to palaeontologist Florian Heller shortly after Peters' death in 1948 (Scheff 2004) and is now preserved at the University of Erlangen. Here, the author found a considerable amount of large faunal remains as well as bird, small mammal and herpetological remains. The large faunal mammal and bird remains are the focus of the present study.

Radiocarbon dating of Schafstall I and Schafstall II

A single radiocarbon date for Schafstall II was obtained by Dr. Wilfried Rosendahl of the University of Mannheim on a charred bone fragment found in association with the human tooth discovered by Peters (Götze, 2010). Notice of this is contained in a letter exchange dated 5th April 2007 between Jürgen Scheff and Dr. Rosendahl. The latter reports an age of 23,870 ± 310 BP, that seems aberrant and falls outside the expected time range for the Gravettian, between 27 and 30ka BP, documented at other sites in the Ach and Lone valleys (Conard & Bolus, 2008; Higham et al., 2012).

Following our recent investigation of the site and the faunal analysis of the old assemblages, we selected a set of bone samples from Schafstall I and Schafstall II for AMS ^{14}C dating. We took samples from both the old and the newly excavated bone assemblages, being careful to cover as far as possible the vertical extent of the main stratigraphic sequence. Priority was given to anthropogenically modified and identifiable bone fragments, and secondly, to herbivore remains, which can often be assumed to have been brought to Palaeolithic cave sites by humans.

AMS ^{14}C analysis was performed on a total of fourteen samples (Table 2.4) at the ETH (Eidgenössische Technische Hochschule) in Zürich, Switzerland. The samples were treated by ultrafiltration following the procedure reported by Hajdas (Hajdas, 2008; Hajdas et al., 2007). The dates are reported according to Stuiver and Polach (1977) and the ages are calibrated with IntCal 13 (Reimer et al., 2013) using the programme OxCal 4.3 (Ramsey, 2009, 2017). The age ranges are listed at 2σ and represent the highest probability distribution at 95.4%. The dates obtained on samples ETH-95105 and ETH-95113, respectively a small ungulate metatarsus from GH 2 of Schafstall I and a retoucher on a bear femur from the old excavation of Schafstall II, are not considered here because, in the first case, the date result fell outside the range of radiocarbon dating, and in the second, the collagen yield was too low to produce a reliable age value. Of the five dated bone samples from Schafstall I, four belong to the faunal material excavated by Peters and one pertains to the new excavation of 2016. The bone samples from the old excavations are all anthropogenically modified and include two retouchers and two bones with cut- or impact marks. The absence of a secure stratigraphic context for the finds from Peters´ excavations entails that the chronological interpretation based on the techno-typological classification of the artefacts and on the radiocarbon determinations must be regarded with caution and gleans only a minimal approximation of the different cultural groups represented at the site. ETH-95103, a large ungulate bone fragment with cutmarks, and ETH-95104, a horse metapodial with impact marks, fall within the same time range of the Late Middle Palaeolithic of Hohle Fels and Geißenklösterle, which ends at ~44ka cal BP (Bataille & Conard, 2018; Higham et al., 2012; Richter et al., 2000) (Fig 2.21). The earliest Aurignacian in the Swabian Jura is dated at Geißenklösterle to around 42.5ka cal BP (Higham et al., 2012). ETH 95102, a retoucher on a large ungulate bone shaft, yielded a result that falls between this date and the upper boundary of the Middle Palaeolithic. The calibrated age ranges between 43,556 and 42,430 cal BP making its cultural attribution unsure. Conversely, the other retoucher from Peters’ assemblage, ETH 95106, falls fully in the range of the Swabian Aurignacian. Another sample, ETH 95101, a bone fragment from GH 1, the backfill of Peters’ excavation, produced a radiocarbon age between 42,813 and 41,919 cal BP corresponding to the early Aurignacian of Hohle Fels and Geißenklösterle.

Sample-Nr.	Sample Code	GH	Description	Anthropogenic modification	C14 age BP	±1σ	2σ range cal BP	
							Lower	Upper
Schafstall I								
ETH-95106	SS I, 256	Old excavation	large ruminant bone	retoucher	34908	217	39993	38859
ETH-95101	SS I, 45/18_58	1	horse/bear size long bone		38196	318	42813	41919
ETH-95102	SS I, 217	Old excavation	large ungulate bone	retoucher	39138	355	43556	42430
ETH-95103	SS I, 366	Old excavation	large ungulate bone	cutmarks	42355	521	46713	44743
ETH-95105	SS I, 47/16_13	2	roe deer (?) metatarsal		>42558			
ETH-95104	SS I, 398	Old excavation	horse metapodial	impact marks	44911	710	49878	46833
Schafstall II								
ETH-95111	SS II, 17/12_37	2a	woolly rhino metapodial		27780	132	31828	31219
ETH-95107	SS II, 17/11_164	2a	large mammal bone	cutmarks	31417	147	35684	34898
ETH-95108	SS II, 17/13_196	Hf	cave bear mandible	cutmarks	30188	129	34535	33921
ETH-95110	SS II, 16/9_17.16	3p	indet bone	cutmarks	32666	170	37224	36139
ETH-95109	SS II, 16/12_365	4	Cervid metatarsal		40447	414	44830	43241
ETH-95114	SS II, 17/7_7.1	4p	medium size ungulate, possible juvenile bear		41452	637	48255	44985
ETH-95112	SS II, 358	Old excavation	large ungulate bone	scraping marks	43067	777	46099	43748

Table 2.4 Schafstall I and Schafstall II radiocarbon determinations

Overall, the radiocarbon determinations indicate a clear Middle Palaeolithic and Aurignacian signature at Schafstall I. The results of radiometric dating confirm the presence of a late Middle Palaeolithic occupation at the site in agreement with Peters' typological attribution of the lithic assemblage to the late Mousterian. The radiocarbon dates attest a second occupation phase during the Aurignacian, which is consistent with Hahn´s (1977) hypothesis of a mixed stratigraphy and with the results of Schumacher's (2014) analysis of the lithic assemblage.

The radiocarbon determinations for Schafstall II can be broadly divided into two groups. The first set of dates includes two unmodified bones from GH 4 and GH 4p and a scraped bone fragment from Peters' excavations. These interestingly yielded an older date than the other two samples, which are supposed to come from the layers underlying the bottom of the old excavation trench. The time range covered by these samples corresponds to the Late Middle Palaeolithic and overlaps considerably with the date results of Schafstall I. The inconsistency between the radiocarbon age of the bone fragment from Peters' excavation and the dates obtained on the newly excavated materials may be explained by post-depositional mixing and taphonomic processes or by stratigraphic differences between the area excavated in the 1940s and our test trench.

The second group of radiocarbon results spans the period between the Upper Aurignacian and the end of the Gravettian, from ~37,000 cal BP to ~30,000 cal BP. The timing of the transition between the Aurignacian and Gravettian is placed between ~36,000 cal BP and ~34,000 cal BP at both Hohle Fels (Bataille & Conard, 2018) and Geißenkösterle (Higham et al., 2012). At both sites there is no stratigraphic break between the two cultural layers (Conard & Moreau, 2004). Interestingly, the only three specimens with cutmarks from the 2016-2017 excavation campaigns plot in this time frame. ETH-95108, a cave bear mandible base with cutmarks found in GH Hf, can be firmly attributed to the Gravettian and adds up to the body of evidence for cave bear exploitation by humans during the Upper Palaeolithic known from other sites in the Swabian Jura (Münzel and Conard; Riek, 1973; Münzel et al., 2011, 2014; Kitagawa, 2014; Bertacchi, 2017).

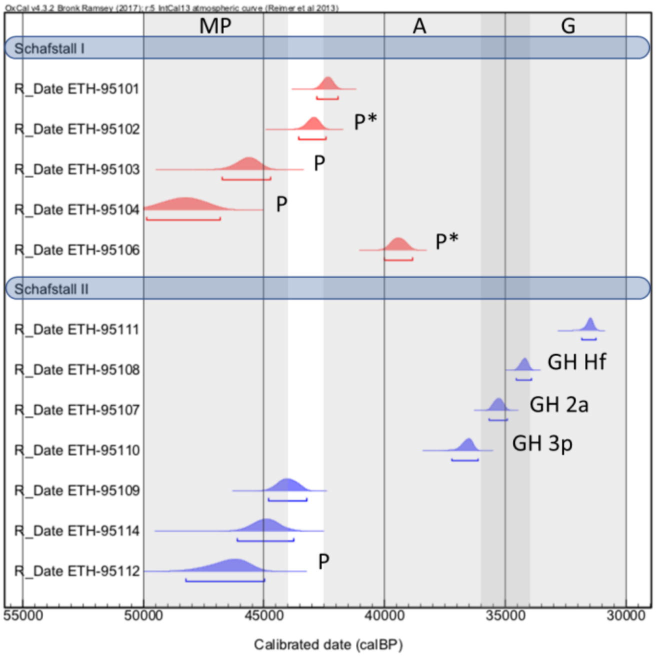


Figure 2.21 Calibrated AMS 14C determinations from Schafstall I and Schafstall II. Calibrated results are divided by cultural association: MP=Middle Palaeolithic, A=Aurignacian, G=Gravettian. Anthropogenically modified bones are labelled according to their provenience as follows: P=Peters excavations, P*=retouchers from Peters' excavations, GH Hf=geological horizon Hf of the 2016-2017 excavations, GH 2a=geological horizon 2a of the 2016-2017 excavations, GH 3p= geological horizon 3p of the 2016-2017 excavations.

2.4 Significance of the historical background for this study

In this chapter, I have presented the geological, environmental and historical information that provide a background for the faunal study illustrated in the following chapters. To conclude this first part of the thesis, the data hitherto presented on the sites of Veringenstadt is summarized in three tables (Tables 2.5, 2.6 and 2.7).

As a large part of my research is based on the material excavated by Peters' in the 1940s, it was essential for me to assess the integrity of the archaeological assemblages he recovered, by locating all the finds that had survived the loss of 1945. This task was made possible by the large amount of data collected by Jürgen Scheff, who had ample access to a diverse array of written primary sources. I began my research by going through the faunal remains housed at the Rathaus Museum of Veringenstadt. It was immediately clear that the site of Schafstall had the most complete archaeological record. Following the decision to resume excavation of the site in 2016, my attention became primarily focused on documenting the faunal material related to Schafstall I and II. Additional material from this site was found in the collections of several other institutions, namely the Hohenzollerisches Landesmuseum of Hechingen, the Staatliche Museum für Naturkunde in Stuttgart and the University of Erlangen. More finds hosted at other institutions are accounted for in Scheff's (2004) biographical article on Peters, but these were of much younger age than the Palaeolithic and were therefore not considered for the purposes of this study. In the following chapters I present the results of our study, which draws upon the materials from the old and new excavations.

	Lithic artefacts	
Site	Location	Year of excavation
Annakappellenhöhle	Hohenzollerisches Landesmuseum Hechingen (2)	1935
Göpfelstein	Rathaus Museum Veringenstadt (~1100)	1947 + 1955 (Sammlung Werz)
	Hohenzollerisches Landesmuseum Hechingen (5)	?
Nikolaushöhle	Rathaus Museum Veringenstadt (6)	1955 (Sammlung Werz)
Schafstall I	Rathaus Museum Veringenstadt (~1600)	1944(?)-47
	Hohenzollerisches Landesmuseum Hechingen (1)	1944-46?
	Landesmuseum Württemberg Stuttgart (1)	1934-37
Schafstall II	Rathaus Museum Veringenstadt (320)	1948
	Hohenzollerisches Landesmuseum Hechingen (4)	1948

Table 2.5 List of lithic artefacts from all sites with indication of their current location and the year of excavation. The numbers in parentheses indicate the number of artefacts counted at each location.

	Organic artefacts		
Site	Location	Tool type	Year of excavation
Nikolaushöhle	Rathaus Museum Veringenstadt (1)	modified antler	1935-37
Schafstall I	Rathaus Museum Veringenstadt (15)	retouchers	1944(?)-47
Schafstall II	Rathaus Museum Veringenstadt (12)	retouchers	1948
	Hohenzollerisches Landesmuseum Hechingen (1)	retoucher	1948
	Rathaus Museum Veringenstadt (1)	split based antler point	1948
	Rathaus Museum Veringenstadt (1)	bone awl(?)	1948

Table 2.6 List of organic artefacts from all sites with the description of each tool type and indication of their current location and year of excavation. The numbers in parentheses indicate the number of artefacts counted at each location**.**

		Fauna		
Site	Location	Year of excavation	microfauna	large mammals
Göpfelstein	Rathaus Museum Veringenstadt	1955 (Sammlung Werz)		x
	Staatliches Museum für Naturkunde Stuttgart	1935 + 1950 (Sammlung Binder)		x
	Universität Erlangen	1935 (?)	x	x
Nikolaushöhle	Rathaus Museum Veringenstadt	1935-37		x
	Universität Erlangen	1935-37	x	x
Schafstall I	Rathaus Museum Veringenstadt	1944-47		x
	Universität Erlangen	?	x	
	Staatliches Museum für Naturkunde Stuttgart	1935		x
Schafstall II	Rathaus Museum Veringenstadt	1948		x
	Hohenzollerisches Landesmuseum Hechingen	1948		x
	Universität Erlangen	1948		x

Table 2.7 List of faunal collections from all sites with indication of their location and year of excavation and general classification of the remains. The microfauna includes small mammals, fish, reptile and amphibian remains.

3 MATERIALS AND METHODS

3.1 Materials studied

The present study considers the faunal assemblages from the two excavation areas of Schafstall. For both sites, the materials from the old and new excavation campaigns were considered. Since the finds recovered during the recent excavation of Schafstall I were very few and derived from the backfill sediments (GH 1) of the old excavations, I decided to exclude them from the faunal analysis. The newly excavated material from Schafstall II comprises the single (*Einzelfunde*) and collection finds (*Sammelfunde*) recovered during excavation in 2016 and 2017, as well as the small remains recovered by water screening. The study sample from the old excavations conducted by Peters includes materials that were drawn from the collections of the Rathaus Museum of Veringenstadt, the Hohenzollerisches Landesmusem of Hechingen and the Friederich-Alexander University of Erlangen.

3.2 Analytical methods

Most of the analytical methods presented in this section are those used in traditional zooarchaeological studies that face the challenge of untangling taphonomic histories from those traces left behind by hominid activities. I here provide an overview of the methods and criteria adopted in the faunal analysis as a key to deciphering site history and landscape use by the Palaeolithic occupants of the Lauchert Valley.

3.2.1 Identification of the remains

Though the faunal assemblage of Schafstall includes the remains of various classes of living organisms, the large mammal finds constitute the primary focus of this study. I define as large mammals all those taxa with a body size larger or equal to a hare (*Lepus* sp.). Only the largest of the small mammals were identified for this study, namely marmot and hare. The few bird remains were also identified and considered in the analysis, while reptile, amphibian and small mammal remains were recorded when present and quantified but not taxonomically identified. A small sample of the fish remains from the new excavation of Schafstall II was also identified but only for taxonomic reference.

Identification of the remains was carried out using the modern and archaeological reference collections housed at the University of Tübingen. The use of several identification keys contained in osteological atlases (Pales & Lambert, 1971; Schmid, 1972) and zoological reference studies (Niethammer & Krapp, 1986, 1993, 2003) aided in this process. For the avian remains identification to species level within different families followed the identification keys provided by various studies. In specific, Ebersdobler (1968) and Kraft (1972) for the Phasianids, Langer (1980) for the Strigiforms and Woelfle (1967) for the Anatids.

Bone remains were identified when possible to species level or otherwise assigned to body size classes using the code system adopted by Münzel for the study of Geißenklösterle (see Appendix) (Münzel, 2019; Münzel, Morel, & Hahn, 1994). The recording of skeletal elements and anatomical landmarks followed the code system used by Stiner (see Appendix) (Stiner, 1994; Stiner, Bar-Yosef, & Belfer-Cohen, 2005) which was implemented and adapted to the idiosyncrasies of the studied assemblages.

3.2.2 Quantification

The Number of Identified Specimens (NISP) is the basic unit of quantification used in this study and refers to the number of specimens identified at species or genus level.

For sake of comparison with older studies and in agreement with the long tradition of zooarchaeological methods employed by researchers at the University of Tübingen (Münzel, 2009; Ürpmann, 1973), I decided to present also the weight of identified specimens (WISP) even though I did not take it into account in the analysis, preferring the use of other quantitative units, such as the minimum number of elements (MNE) and minimum animal unit (MAU), to WISP.

The bone weight method compares the skeletal weight of each taxon in an archaeological assemblage with the average bone weight of a complete reference specimen. The underlying assumption of this method is that bone weight is proportional to biomass and therefore the relative weight proportion of each skeletal element within a specific taxon reflects the dietary contribution of that body portion. Similarly, this method measures taxonomic abundance through diachronic changes in the relative weight proportion of the taxa that compose the archaeological assemblage. However, we don´t see any advantages that justify the use of bone weight instead of NISP and MNE, which are the most common quantification units used in zooarchaeological studies and thus make our data more comparable to that of other studies. Furthermore, the bone weight method tends to exaggerate the importance of head elements because teeth are not considered separately from the rest of the cranium. In fact, since teeth have a great mineral component, they are generally heavier and more resistant than the bony parts of the skull and their better preservation in archaeological assemblages will likely produce higher weight ratios for head parts compared to other skeletal elements that are more susceptible to degradation. This analytical bias is best avoided by using MNE and determining its value for cranial bones and teeth separately.

MNE or the Minimum Number of Elements is derived from NISP and corresponds in each taxon to the most common anatomical portion of each skeletal element. It is determined by summing the highest values obtained for the left and right sides (Lyman, 1994; Stiner, 1994). MNE is the basic unit for deriving Minimum Animal Unit or MAU. This analytical unit was introduced by Binford (1981) in order to estimate the food utility represented by the bones found in archaeological sites. MAU is calculated by dividing MNE counts by the number of their respective expected elements in a complete anatomical model. In this study, I employed Stiner's (Stiner, 1994; Stiner et al., 2005) method of determination of MAU which lumps raw MNE counts into nine distinct anatomical regions that comprise one or more skeletal elements. MNE values are then standardized against the total MNE value of their respective anatomical region (Table 3.1). In this work, I used this method to compare cave bear body profiles across different sites and so assess the degree of skeletal completeness (see Chapter 4.4).

In the following chapters, I occasionally refer to MNI or the Minimum Number of Individuals of each species represented in the archaeological assemblage. This is another derived measure and is determined by taking the highest MNE count of a species after having tallied left and right MNE values separately. Specifically, I used this quantitative unit to compare the number of individuals of different age classes within a specific taxon.

In the first part of the analysis, I reconstruct the faunal composition of the different assemblages under study and make cross comparisons using evenness. The concept of evenness is drawn from ecological studies (Magurran, 1988) and refers to the distribution of specimens in a biological community across different taxonomic categories. Evenness can be measured by different diversity indexes that encompass three different variables: evenness, taxonomic richness and taxonomic hetereogeneity. In this study, I use the Reciprocal of Simpson's index (1/D) (Simpson, 1949). When considering an infinitely large population the equation for deriving the index is expressed as follows

$$1/D=1/\Sigma\rho_i^2$$

	Expected MNE						*Total MNE by anatomical region*				
	Bear	**Other Carn**	**Rhino**	**Horse**	**Artio**		**Bear**	**Other carnivores**	**Rhino**	**Horse**	**Artio**
horn/antler					2						
1/2 cranium	2	2	2	2	2						
1/2 mandible	2	2	2	2	2	HEAD	4	4	4	4	6
atlas	1	1	1	1	1						
Axis	1	1	1	1	1						
cervical vertebra	5	5	5	5	5	NECK	7	7	7	7	7
thoracic vertebra	13	13	13	13	13						
lumbar vertebra	7	7	7	7	7						
Sacrum	1	1	1	1	1						
Rib	26	26	26	26	26						
Innominate	2	2	2	2	2	AXIAL	49	49	49	49	49
Scapula	2	2	2	2	2						
Humerus	2	2	2	2	2	UPPER FRONT	4	4	4	4	4
Radius	2	2	2	2	2						
Ulna	2	2	2	2	2						
Mc	10	10	6	2	2	LOWER FRONT	14	14	10	6	6
Femur	2	2	2	2	2	UPPER HIND	2	2	2	2	2
Tibia	2	2	2	2	2						
Fibula	2	2									
Calcaneum	2	2	2	2	2						
Astragalus	2	2	2	2	2						
Mt	10	10	6	2	2	LOWER HIND	18	18	12	8	8
ph1	20	20	12	4	8						
ph2	16	20	12	4	8						
ph3	20	20	12	4	8	FEET	56	60	36	12	24
Total	**154**	**158**	**124**	**92**	**106**		**154**	**158**	**124**	**92**	**106**

Table 3.1 Expected MNE values by skeletal element and anatomical region for bear, other carnivores, rhinoceros, horse and artiodactyls. Modified from Stiner (1994) so as to include the different taxa represented at Schafstall

where ρ_i stands for the proportional abundance of taxon *i* in the total collection

Because zooarchaeological assemblages comprise a finite number of specimens, I calculated Simpson's index by using the following formula,

$$D = \Sigma n_i(n_i-1)/N(N-1)$$

and then derived the reciprocal (1/D). n_i stands for the total number of specimens identified to a specific taxon, while N corresponds to the sum of all identified specimens in the assemblage. As expressed by Simpson's reciprocal, evenness values will range from a minimum of 1 to a maximum value close to the total number of species present in the assemblage. Lower values correspond to lower evenness and indicate the dominance of a particular taxon, while greater values signify that the assemblage is evenly distributed. In a recent study comparing various evenness indexes, Faith and Du (2018) demonstrate that Simpson's index is relatively insensitive to changes in taxonomic richness which can bias the measurement of evenness and that this index works well on small sample sizes and is more likely to detect minor changes in evenness. For these reasons, as well as comparability with other regional faunal studies (Kitagawa, 2014; Rhodes et al., 2019, 2018; Wong et al., 2020), I decided to include Simpson's evenness in my analysis.

3.2.3 Taphonomy

Taphonomic modifications were observed with the aid of a 12x hand lens and of a 200x stereomicroscope. Each specimen underwent careful observation in order to identify anthropogenic marks, gnawing damage by carnivores or rodents, burning traces, weathering degree, abrasion and types of fracture patterns. Categories such as abrasion, weathering, burning and fracture patterns were measured on an ordinal scale, while anthropogenic and animal modifications were treated as a dichotomous variable by recording their presence or absence.

A detailed description of each taphonomic modification is provided here below, starting from those produced by biological agents, like abrasion, weathering and burning, and moving then on to fracture patterns and animal and human modifications.

Abrasion refers to the rounding and polishing effect produced on bones by movement in the sediment due to natural processes such as water or wind transport and to animal and human trampling (Fernandez-Jalvo & Andrews, 2016). In this study, abrasion was assessed by assigning a score from 0 to 3 based on the degree of roundedness of bone surfaces. A score of 0 was given when bones presented sharp unrounded edges, 1 when they showed mild signs of abrasion, 2 when about 50% of the edges were rounded and 3 when all the edges were rounded.

Along with abrasion, weathering linked to exposure of bones on the sedimentary surface prior to burial was recorded following the criteria listed by Behrensmeyer (1978). In particular, I measured the effects of weathering processes by assigning each bone a score from 0 to 5 according to the degree of exfoliation and cracking of bone surfaces (see Appendix, Coding form).

Other diagenetic modifications, observed in lower rates, such as chemical weathering, oxide and mineral staining, trampling and microbial damage were also recorded.

Burnt bones were identified macroscopically based on their brittleness and colour and were grouped in categories using the method proposed by Stiner (Stiner et al. Kuhn, 1995). I distinguished six categories: unburnt, less than 50% carbonized or blackened, over 50% carbonized, fully carbonized, less than 50% calcined or whitened, over 50% calcined and fully calcined.

Because most of the burnt bone consisted of small fragments (1cm max. length), the extent of burning was assessed based on bone weight and not specimen counts.

Bone fracture patterns constitute another important feature in the present taphonomic analysis, as their appearance can provide information on the timing of bone breakage, e.g. peri-depositional or post-depositional, and occasionally, when found in association with other types of modification, on the responsible agent. Fracture typologies have been documented in several ways by different authors (Marshall, 1989; Outram, 2001; Shipman et al., 1981; Stiner et al., 1995; Villa & Mahieu, 1991), and there seems to be some ambiguity in the terminology used to describe the different patterns. Stiner (Stiner, 1994; Stiner et al., 2005), for example, focuses exclusively on green fractures and uses the terms “split”, “transverse” and “spiral” to characterize different fracture types assumedly produced by humans. Shipman (Shipman et al., 1981) designates transverse and split fractures respectively as “perpendicular” and “longitudinal” and distinguishes four subtypes: “smooth perpendicular” versus “irregular perpendicular”, and “longitudinal” versus “stepped or columnar”. More specifically Shipman (Shipman, 1981), discerns between Type I fracture types, that have a smooth appearance and result from the breakage of fresh bone, and Type II fractures, that present smooth and roughened surfaces and derive from the breakage of dry bone. Along with other parameters, several authors (Davis, 1985; Outram, 2001; Villa & Mahieu, 1991) have incorporated some of these observations on fracture types in fracture classification systems designed to discern fresh from dry broken bones. Though fracture patterns on single bones are in most cases uninformative about the agents that produced them, the abundance of specific fracture types may be linked to specific animal or human activities.

In this study, I document breakage patterns in the same manner as Niven (2006) in the faunal study of Vogelherd by assigning a score from 0 to 5 based on bone freshness at the time of breakage (see Appendix). This feature was evaluated by considering the criteria proposed by Shipman et al., (1981) on fracture smoothness and roughness. Additionally, I also used fracture colour and angle to separate green from dry breaks and curation damage (Johnson, 1985; Villa & Mahieu, 1991). The latter is easily recognizable because recent breaks generated during or after excavation present a different colour from the rest of the bone surface. Fracture angle refers to the angle made by the cortical and fracture surfaces, which tends to be around 90° in dry bones and obtuse or acute in bones that are broken while fresh.

Most importantly, the taphonomic analysis sought to quantify the abundance of animal and anthropogenic activities. Gnawing damage in the form of pits, drag marks, punctures and notches was tallied for each specimen following the guidelines for identification provided by numerous authors (Binford, 1981; Brain, 1983; Haynes, 1980, 1983; Sala et al., 2014). Pits are round or subround depressions left on the bone surface by teeth cusps and are frequently associated with drag marks that appear like shallow linear marks found perpendicular to the bone axis. Punctures constitute another taphonomic signature of carnivores and consist in perforations of the bone surface generally produced by the action of canine teeth. Attention was also given to notches which were determined according to the criteria proposed by Capaldo (Capaldo & Blumenschine, 1994) for distinguishing notches produced by carnivore teeth on fracture edges from those created by humans through hammerstone percussion. Digestion was recorded when present and was recognizable from a combination of features such as polishing of the bone surface, thinning and rounding of the edges and a general gooey appearance.

Anthropogenic marks comprise an array of modifications such as cutmarks, percussion, scraping and retouch marks. Cutmarks are generally linear with a V-shaped profile and may at times be confused with trampling marks (Domínguez-Rodrigo et al., 2009). When cutmarks were present on bones, I documented their number and position and measured their length. Percussion marks were recognized by the presence of shallow irregular depressions associated with striations and crushing (Blumenschine et al., 1996; Fisher, 1995). Finally, I classified as scraping any parallel and superposed bundles of linear marks similar to cutmarks with the same orientation and which were usually parallel to the bone axis (see Fernandez-Jalvo & Andrews, 2016; Fisher, 1995). Retouch marks were also recognized on several specimens and were identified based on comparisons with similar published archaeological materials (Mallye et al., 2012; Mozota Holgueras, 2013; Münzel & Conard, 2004b; Patou-Mathis, 2002; Taute, 1965). A detailed description on the morphology of retouch marks, their identification and interpretation are provided in Chapter 4.

4 RESULTS

4.1 Recovery methods and sample size

Though Peters reportedly water screened all sediments, differences in bone size class representation between the old and newly excavated materials could be macroscopically observed during the analysis. Notably, small unidentifiable bone fragments under 3 cm in size were rare compared to the amounts collected during the new excavation. It is very likely that Peters' excavators did not pull smaller unidentified specimens when sorting. To quantify the extent of sampling bias associated with different recovery methods, I tried comparing the degree of bone fragmentation across assemblages. Because bone fragments below 3 cm of length were very numerous among the water screened material from the recent campaigns, I quantified them by weight instead of by frequency counts (Table 4.1).

The majority of bones recovered during the old excavations of Schafstall I are between 3 and 6 cm in size (Fig. 4.1), suggesting that the assemblage is heavily fragmented. The weight percentage of this bone size class is greater than that of the larger size categories, the proportions of bone fragments over 12 cm being the smallest. In comparison, most of the bone fragments recovered during the recent excavations fall within the 0 to 3 cm size category. This is because even the smallest fragments were retained during excavation. However, despite the apparent difference in bone size selection between the old and new excavations of Schafstall I, one must not overlook the fact that the total number of bone remains from the new excavation is very low and compares poorly against the larger but scanty assemblage from Peters' excavation.

Conversely, the new excavations at Schafstall II yielded a conspicuous amount of bone fragments, most of which are below 3 cm in size. The weight of the bone fragments in this size class exceeds by large that of the other size classes recovered, and the proportion of bone fragments larger than 12 cm is very low. By contrast, bones between 3 and 6cm of length make up the largest weight category among the bones collected by Peters, followed by those between 6 and 9 cm, while the proportion of bone fragments under 3 cm is comparatively low. Overall, it seems that the old excavators recovered mostly bone fragments larger than 3 cm, while smaller unidentifiable remains were either overlooked or discarded. Apart from these differences, the general distribution of bone weight for each size class is similar between the old and newly excavated assemblages of Schafstall II, with larger size classes over 9 cm in length being underrepresented. On the whole, the bone assemblage of Schafstall II is therefore largely fragmented.

	Weight (g)			
Bone size	**SSII new**	**SSII old**	**SSI old**	**SSI new**
0-3cm	6812,1	1646,65	184,6	158,9
3-6cm	3472,66	5710,87	2719,6	53,8
6-9cm	1855,6	4207,78	1521,1	8,2
9-12cm	483,8	1907,3	615,2	25,8
12-15cm	664,1	945,6	148,9	0
15-18cm	426,9	1204,5	139,5	0
18-21cm	0	127	0	0

Table 4.1 Weight of bone fragments divided by size class for both the assemblages of Schafstall I and II, old and new excavations are compared.

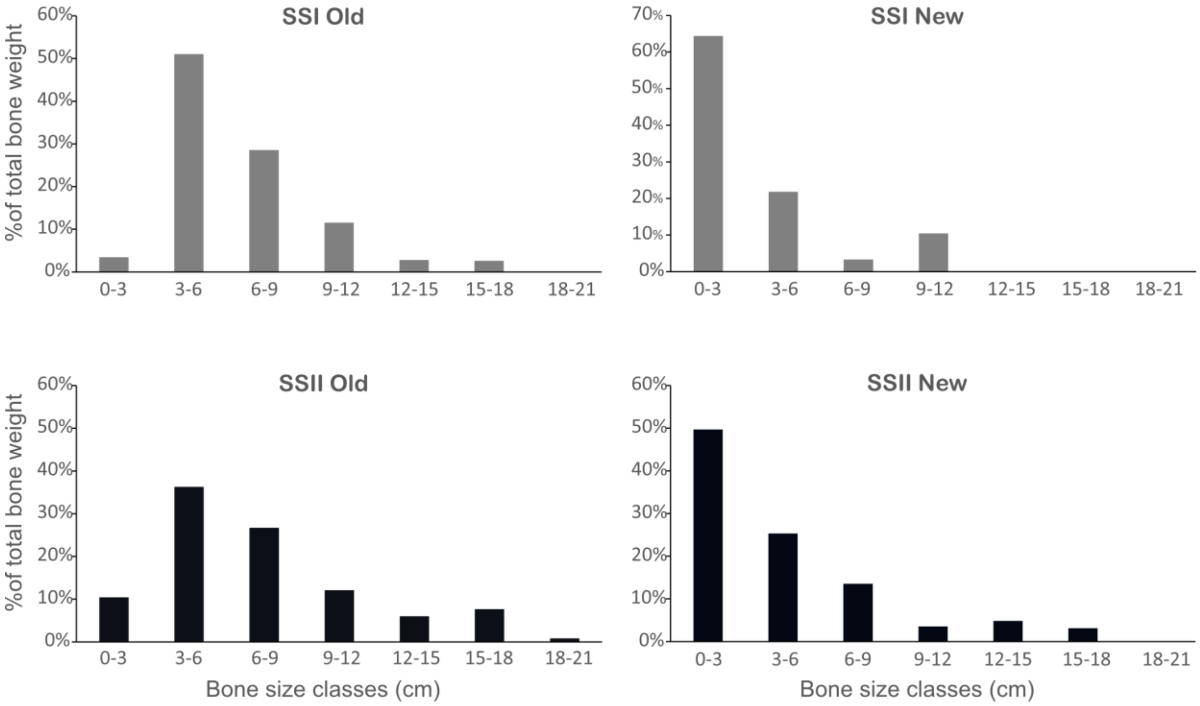


Figure 4.1 Distribution of total bone weight percentages for different bone size classes of Schafstall I and II. Faunal assemblages from both the old and the new excavations are considered

4.2 Late Pleistocene mammalian and avian taxa of the Lauchert Valley

4.2.1 Carnivores

The fossil record may be regarded as a pale reflection of ancient animal communities, but it still remains the only direct source of information on past life. One of the challenges faced by zooarchaeologists analysing faunal assemblages from cave sites is discerning faunal accumulations produced by humans from those generated by animals that inhabited or visited caves when humans were not around. Cave bear, scientifically known as *Ursus speleaus* (Rosenmüller, 1794), is one of the most common species composing the so called natural *background fauna* found in numerous cave contexts. In most cases, bears died there due to natural causes during hibernation and are not related to human activities. Typical bear death assemblages tend to include primarily the remains of senile or very young individuals, which represent the most vulnerable age categories. Additionally, deciduous teeth shed by lactating cubs often contribute to the abundance of cave bear remains found in many palaeontological assemblages. It is therefore not surprising to find large amounts of cave bear remains within cave contexts.

At Schafstall I and II bear is among the most abundant taxa recorded. Though it is reasonable to assume that most of the identified remains belong to cave bear, in the absence of clear diagnostic features, it is not possible to rule out the occurrence of brown bear in the Schafstall assemblages. For this reason, the nomenclature *Ursus* cf. *speleaus* was preferred for the taxonomic classification and only diagnostic elements such as complete skeletal elements and teeth were securely attributed to *Ursus* ex gr. *speleaus*. Such designation does not distinguish between the various species and subspecies of cave bear that inhabited Europe during the Late Pleistocene, which are mainly distinguishable by genetic analyses (Baryshnikov, 1998; Rabeder et al., 2004). In fact, recent developments in ancient DNA studies have detected and characterized the relationships between different regional haplogroups, taxonomically designated as *Ursus spelaeus spelaeus, Ursus spelaeus eremus, Ursus speleaus ladinicu*s and *Ursus ingressus,* that roamed across Europe during the Late Pleistocene (Gretzinger et al., 2019). The resulting picture provides meaningful insight into the complex population dynamics and migration flows of the different cave bear groups that populated a wide geographic area ranging from Northwestern Spain (Grandal-d’Anglade, 1993) to the Urals (Kosintsev, 2007) and from Belgium (Ehrenberg, 1935) and Northern Germany (Athen, 2007) to Greece (Kostopoulos & Vasileiadou, 2006) and Northern Italy (Romandini et al., 2013).

According to radiometric (Münzel et al., 2011; Pacher & Stuart, 2009) and population genetic studies (Gretzinger et al., 2019; M. Stiller et al., 2010; Mathias Stiller et al., 2014), cave bears became extinct before the Last Glacial Maximum (LGM). As a matter of fact, recent genomic research on modern brown bears has demonstrated admixture between cave bears and brown bears revealing a much more complex picture than previously suggested and proving the concept of species to be very fluid (Barlow et al., 2018).

Many factors may have contributed to the disappearance of cave bears and cooling temperatures and environmental changes triggered by the onset of the LGM may not have been the only decisive agents. Over the past years, scientists have documented loss of genetic diversity coupled with an abrupt decline in cave bear population sizes which is not evidenced in contemporary brown bear populations (Stiller et al., 2010; Stiller et al., 2014). Other ecological factors such as the maintenance of a highly specialized herbivorous diet (Bocherens et al. 1994; Kurtén, 1976; Münzel et al., 2014; Rabeder et al., 2000) and their homing behaviour, manifested in the repetitive use, spread over generations, of the same birth cave (Fortes et al., 2016), may have had in the long term a disadvantageous effect on the survival of the species.

Humans also seem to have played a major role in the demise of cave bears (Münzel & Conard, 2004a; Romandini et al., 2018; Wojtal et al., 2015). In the Swabian Jura, several lines of evidence suggest bear hunting and exploitation occurred during the Upper Palaeolithic (Münzel & Conard, 2004a). Researchers have surmised that there is a correlation between the numerous cave bear bones with anthropogenic modifications and the intensification of site occupation by the Aurignacian and Gravettian human groups that settled in the Ach and Lone Valleys (Münzel et al., 2011). In a study on the cave bears of the Swabian Jura, Münzel et al. (2011) identified two cave bear species that cohabited cave sites in the Ach Valley, *Ursus speleaus* and *Ursus ingressus*. According to these researchers, around 28,000 BP, *Ursus ingressus* replaced *Ursus speleaus* (Münzel et al., 2011) and continued inhabiting the region up until around 25,000 BP. The timing of this local extinction event provides a *terminus ante quem* for the relative dating of the Swabian sites.

During the recent excavation of Schafstall II, cave bear remains were recovered throughout the entire sequence, from GH 2 to GH 6. Given the integrity of the stratigraphic sequence, which is consistent with radiocarbon dating results and the absence of mixed materials of younger age, there is no reason to assume that the top layers were disturbed. Therefore, the bear remains can be regarded as a fossil indicator validating the Pleistocene age of the deposit.

Besides cave bears, several carnivore species found cave sites attractive. Much like their modern counterparts in Africa, spotted hyena (*Crocuta crocuta spelaea*) are also known to have used caves as shelters or denning places for raising their offspring (Klein et al., 1999; Pokines & Peterhans, 2007; Stiner, 1994, 2004; Villa et al., 2010). Very few remains of spotted hyena were recovered from Schafstall, namely a carpal bone from Schafstall I, a third phalanx from the old excavation of Schafstall II, and a third upper incisor from the new excavation of Schafstall II (GH 5). The scantiness of the remains suggests that these carnivores were probably short-stay visitors at the site, but consistent evidence of hyena denning has been documented at the neighbouring site of Göpfelsteinhöhle. Here, Berckhemer (Peters, 1936a) and Rathgeber (2004) recorded several hyena remains, including deciduous teeth of juveniles, and bone damage patterns typical of hyena. Like cave bears, spotted hyenas did not survive into the Late Glacial in Northern Eurasia and became extinct in Central Europe and Russia around 40,000 BP (Stuart & Lister, 2014).

Among the other large carnivores recorded at Schafstall there is also cave lion (*Panthera spelaea*), represented by few remains, specifically, a second phalanx from the old excavation of Schafstall I, a fifth metatarsal from the old excavation of Schafstall II, two second phalanges and a second lower incisor from the new excavation of Schafstall II. This large predator did not typically inhabit caves but could have used caves occasionally as a resting place and for hunting cave bears during their hibernation. Lion remains are also known to have entered the archaeological record through human activities, for example, as pelts (Cueto et al., 2016) or even tools for retouching (C. Leroy-Prost, 2002; Riek, 1973; Taute, 1965). In contrast to hyenas, isotopic studies indicate that cave lions in Central Europe had an opportunistic predatory behaviour and that their dietary niche was more varied compared to that of spotted hyenas (Bocherens et al., 2011). This characteristic combined with the fact that they were likely better adapted to living in cold environments might have led to the survival of cave lions into the Late Glacial (Stuart & Lister, 2014). The youngest known lion remains from Germany and Eurasia are from Zigeunerfels, close to Veringenstadt, in the Schmeien Valley, and have been dated to 14,378 cal BP (Stuart & Lister, 2011). Late Glacial lion remains were recently found at Langmahdhalde in the Lone Valley, another site in the Swabian Jura (Wong et al., 2017). The bones were recovered from Magdalenian layers AH IV and V, which have yielded radiometric dates between 15,381 and 15,084 cal BP (Wong et al., 2020), further validating the significance of the Swabian Jura as one of the last geographic areas in Eurasia where cave lion is documented.

As opposed to cave bears, spotted hyenas and lions, wolves (*Canis lupus*) survived the waves of megafaunal extinctions at the end of the Last Glacial. A new genetic study has shown that modern wolves are descended from a Beringian population that survived through the LGM and subsequently expanded across Eurasia and North America (Loog et al., 2020). Though the authors claim that long-range migrations might have played a major role in the survival of wolf populations, another reason could be their greater ability at adjusting their ecological niche to incorporate commensal-like behaviours with human groups compared to other carnivore species. Multidisciplinary studies involving genetics, stable isotope analyses and skeletal morphology have provided evidence for wolf domestication in Eurasia during the Late Upper Palaeolithic (Boudadi-Maligne et al., 2012; Napierala & Uerpmann, 2012; Pionnier-Capitan et al., 2011; Thalmann et al., 2013) and perhaps even as early as the Gravettian (Germonpré et al., 2012, 2014; Bocherens et al., 2015), hence before the genetic divergence between wolf and dog that is estimated to have occurred between 14,000 and 6400 years ago (Frantz et al., 2016).

Wolves at Schafstall are among the most abundant carnivores together with two other canid species, the arctic (*Vulpes lagopus*) and the red fox (*Vulpes vulpes*). The latter two are morphologically very similar. For this reason a great number of bone fragments were only identified to the genus level, as *Vulpes* sp.. The distinction between the two species could be made only for complete or partially complete post-cranial elements and tooth elements by comparison with metric data provided by Baumann (2016), Niethammer and Krapp (1993) and Monchot and Gedron (2010).

Four fox remains from Schafstall I, namely one left mandible, a humerus and a scapula of a red fox and a mandible fragment of an arctic fox were selected for mitochondrial DNA analysis conducted by Yumeko Tarusawa as part of her Master’s thesis (2019). The arctic fox mandible did not contain enough genomic material, but the other three specimens of red fox were analysed successfully. The phylogenetic analysis revealed that two of the red foxes from Schafstall I belonged to a basal clade, which was separate from the other two in which all other pre-LGM fox specimens from the Swabian Jura clustered. Conversely, the third specimen from Schafstall I fell in the second clade together with specimens from Sirgenstein, Hohle Fels, Geißenklösterle, Vogelherd and Hohlenstein-Stadel. According to Tarusawa (2019), the clustering also of modern red foxes from Israel in this clade suggests that the

Swabian red foxes, which disappeared after the LGM, had a Middle Eastern ancestry. Most of the Swabian foxes that grouped in the second clade derive from Upper Palaeolithic deposits, except for two individuals from Hohlenstein-Stadel and one from Schafstall I. It must be noted that none of the remains were directly dated and that the fox specimens from these sites were attributed to the Middle Palaeolithic based on previous stratigraphic interpretations (Beck, 1999; Peters, 1936b; Wetzel, 1961). Taken at face value, the results of the genetic analysis seem to suggest the co-existence of two distinct red fox populations during the Middle Palaeolithic of the Swabian Jura. Both appear to have been present at Schafstall, while only those from clade 2 were documented at Hohlentstein-Stadel in the Eastern Swabian Jura, where foxes from the same clade continued living during the Aurignacian and perhaps also during the Gravettian. Alternatively, another possible interpretation is that the fox individual from Schafstall I that clustered in the second clade belongs to the Upper Palaeolithic. This would explain its separation from the first clade, which includes all the other Schafstall specimens, and could suggest a replacement of the red fox population of Schafstall by a different population between the Middle Palaeolithic and Aurignacian. However, these hypotheses remain to be tested with radiometric dating and further genetic data.

Other carnivore species found at Schafstall include several mustelids, such as stoat (*Mustela erminea*), least weasel (*Mustela nivalis*) and otter (*Lutra* sp.). The latter is represented by a tibia which has been analysed isotopically as part of a study still in progress conducted by Chris Baumann of the University of Tübingen. Otters rarely appear in the European archaeological record of the Last Glacial and are more commonly found in Holocene deposits (Sommer & Benecke, 2004; Willemsen, 1992). In southern Germany some of the oldest known remains were found at Ofnet and Probstfelsenhöhle near Beuron and were generically assigned by Koken to the Late Plaeistocene (Koken, 1912). Otter remains of Pleistocene age were also discovered in association with Magdalenian deposits at Geißenkösterle (Münzel, 2019; Münzel & Conard, 2004b) and at Petersfels (Peters & Toepfer, 1932). The specimen from Schafstall could also be of Late Glacial age, a period in which increased precipitation and warmer winter temperatures, as documented by palaeoenvironmental studies (Wong et al., 2020), would have favoured the increase of water bodies available to this species.

4.2.2 Herbivores

Herbivore remains found in caves and rock shelter sites often represent the food waste of carnivores or humans. The ungulate fauna contained in the Late Pleistocene deposits of

Schafstall is dominated by typical glacial species of the so called “mammoth steppe” (Guthrie, 1982), which includes mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), reindeer (*Rangifer tarandus*), bison (*Bison priscus*), ibex (*Capra ibex*) and chamois (*Rupicapra rupicapra*) as well as more ubiquitous species like horse (*Equus ferus*) and red deer (*Cervus elaphus*).

Mammoth is present only at Schafstall II and is represented by few tooth remains and one small ivory fragment. The paucity of remains contrasts with the higher abundance of the species reported by Berckhemer (Peters, 1936a) at the nearby site of Göpfelsteinhöhle.

The ecology of mammoths and their exploitation by humans during the Upper Palaeolithic of the Swabian Jura have been approached using different lines of research, all of which have led to similar conclusions. The study of organic tools coupled with the results of faunal analyses revealed a shift in raw material choices between the Aurignacian and Gravettian (Münzel et al., 2017), most markedly evidenced by a decline in ivory exploitation in favour of other animal parts and organic materials in the production of ornaments and points. Such a break in the material record has been interpreted as the reflection of technological and structural changes that might have led to increasing hunting pressure on mammoths.

The exclusion of environmental changes as a primary agent of this technological development is corroborated by the results of stable isotopic analysis on mammoth and horse remains from the Ach Valley (Drucker et al., 2015; Münzel et al., 2017). Overall, the isotopic signatures for the two species remains unchanged throughout the Aurignacian and Gravettian. However, the foraging niche of horses was observed to be broader compared to that recorded at contemporaneous sites in the Dordogne region, in southwestern France, which has a similar faunal spectrum and community structure. The fact that the foraging niches of mammoth and horses are partially overlapping is indicative, according to Drucker et al. (2015), of intra-specific competition among horses which probably led to the expansion of some individuals into the partly vacant niche of mammoths characterized by elevated $\delta^{15}N$ values. This would be consistent with the hypothesis of a reduction in mammoth population size during the Upper Palaeolithic that could be tentatively associated with human hunting. However, partial overlap between horse and mammoth $\delta^{15}N$ values based on amino acids from collagen have been observed also among the Pleistocene Arctic fauna of the Old Crow Basin in Yukon, Canada (Schwartz-Narbonne et al., 2015), where evidence for human activities is scarce (Harington, 2011) suggesting that resource partitioning could have been influenced by other factors unrelated to humans. Interestingly, Schwartz-Narbonne et al. (2015) suggest that mammoths occupied a highly specialized dietary or habitat niche characterized by specific forage comprising arid vegetation and coarse grasses with high nitrogen contents arising partly from dung fertilization produced by the mammoths themselves. Horses, which occupied a wider array of habitats and presented a broader dietary range, would have therefore occasionally shared the same foraging niche as mammoths.

Except for one ivory fragment with cutmarks (Plate VIII, Fig. f), at Schafstall there is no other evidence of mammoth exploitation by humans and the total number of remains is very low. Furthermore, ivory objects or modified mammoth bones such as those found in the Ach and Lone valleys were never published by Peters and seem to be completely missing from the archaeological record of the Lauchert Valley.

Along with mammoth, megafaunal remains of woolly rhinoceros were also recovered at Schafstall I and II. This large megaherbivore was present in Central and Western Europe until the Late Glacial. Its foraging niche was very similar to that of horse including mostly forbs and occasionally shrubs and woody plants (Bocherens, 2003; Boeskorov, 2012). Though the youngest dated remains in Central Europe come from the Magdalenian settlement of Gönnersdorf in the Middle Rhine region (Stuart and Lister, 2012), in the Swabian Jura woolly rhinoceros is recorded only in deposits predating the LGM and is generally more abundant in Middle Palaeolithic assemblages (Conard et al., 2013).

Both large and small bovids are represented at Schafstall, albeit in low numbers. Because of the close resemblance between bison and aurochs bones, most remains were classified as large bovid, *Bos* vel *Bison*, and only few elements could be attributed morphologically to bison (*Bison* sp.). The identification to genus level instead of species was preferred due to the impossibility of distinguishing between the steppe bison, *Bison priscus*, and the wisent, *Bison bonasus*. The two species are difficult to differentiate morphologically, and their evolutionary history and geographical distribution are a matter of strong debate (Markova et al., 2015; Massilani et al., 2016; Wang et al., 2018). Though large bovids were part of the mammoth steppe fauna that ranged through Europe during the Last Glacial, their remains are poorly represented in the Palaeolithic sites of the Swabian Jura (Berckhemer & Peters, 1935; Bertacchi, 2017; Gamble, 1999; Kitagawa, 2014; Krönneck, 2012; Lykoudi, 2017).

Much like large bovids, small bovids, namely ibex, *Capra ibex,* and chamois, *Rupicapra rupicapra* are also rare at Schafstall. Both species are adapted to living in mountainous environments where they feed mostly on graminoids, and though nowadays their habitat is mostly restricted to alpine mountaintops, during the Last Glacial they had a broader geographic range. In the Swabian Jura, they are both found in archaeological contexts from the Middle Palaeolithic up until the Magdalenian. Chamois is present at Heidenschmiede (Münzel & Çep, in press) in the Brenz Valley, at Bocksteinschmiede/-loch (BS III) (Krönneck, 2012) and Vogelherd (Niven, 2006) in the Lone Valley, and Sirgenstein (Bertacchi, 2017), Brillenhöhle (Boessneck et al., 1973), Geißenklösterle (Münzel, 2019), and Kogelstein (Böttcher et al., 2000) in the Ach Valley. Ibex occurs in the Lone Valley at Bocksteinloch/-schmiede and in the Ach Valley at Hohle Fels (Kitagawa, 2014), Geißenklösterle, Große Grotte (Weinstock, 1999) and Kogelstein.

Red deer (*Cervus elaphus*) is also poorly represented at Schafstall. This is not surprising, given that red deer prefer mesic habitats where they feed on grasses, forbs, sedges and woody plants. Their occurrence is sparsely documented at several Palaeolithic sites in the Swabian Jura from the Middle Palaeolithic to the Magdalenian (Böttcher et al., 2000; Kitagawa, 2014; Krönneck, 2012; Lykoudi, 2017; Münzel, 2019; Niven, 2006; Wong et al., 2017). Subsequent post-glacial environmental and climatic changes favoured the expansion of their range, making them one of the predominant herbivore species encountered in the Mesolithic assemblages of southwestern Germany (Rathgeber & Ziegler, 2003).

In contrast, horse (*Equus ferus*) and reindeer (*Rangifer tarandus)* are the most abundant ungulate species found in the Palaeolithic record of the Swabian Jura. Both animals were widespread across the Holarctic during the Last Glacial Period and were important prey species for humans. Their great ecological flexibility may have perhaps contributed significantly to their wide scale distribution. Horses in fact, are mainly grazers and feed mostly on herbaceous low protein plants, but as evidenced by isotopic studies, they can diversify their diet by including the forage of other herbivorous species (Drucker et al., 2015; Schwartz-Narbonne et al., 2015). Reindeer also feed on a variety of shrubs and grasses, and additionally rely on the consumption of lichens, which are indigestible for most other animals. The absence or low competition with other species coupled with their resilience to environmental changes could have been important factors in their survival into the Holocene.

4.2.3 Small game

With the term “small game”, I here refer to the largest of the lagomorphs and rodents that could be identified macroscopically without the aid of a stereo microscope, namely hare and marmot.

Two hare species occur at Schafstall, the European hare (*Lepus europaeus*) and the mountain hare (*Lepus timidus*). The two species are distinguishable by the morphology of their third lower premolar and upper second premolar (Pelletier et al., 2016; Vismara, 2013). All other remains were identified to the genus level. During the last glaciation, in southwestern Germany the mountain hare was more common than the European hare (Rathgeber & Ziegler, 2003), which became more widespread towards the end of the Last Glacial.

Alongside hare, marmot (*Marmota* sp.) is also represented at Schafstall. A mandible and incisor were recovered by Peters at Schafstall I, and two incisors, two lower cheek teeth, a second metacarpal and a first phalanx were found during the old excavations of Schafstall II.

The identification to genus level is motivated by the impossibility of discerning between the the alpine marmot (*Marmota marmota*) and the bobak marmot (*Marmota bobak*). Both appear in several Late Pleistocene deposits of the Middle Rhein (Kalthoff, 1999b). In the Swabian Jura, Ziegler (Böttcher et al., 2000) recorded the occurrence of *Marmota primigenia* at Kogelstein. It appears that Ziegler agrees with Kalthoff (1999b) in classifying *Marmota primigenia* as a separate species from the alpine marmot on the basis of skeletal morphology. Yet, there are no genetic studies that support the separation of the two species. Marmot remains have also been recovered at other sites in the Swabian Jura, such as Geißenklösterle (Münzel, 2019), Bockstein (Krönneck, 2012) Irpfelhöhle (Berckhemer & Peters, 1935), Heidenschmiede (Münzel & Çep, in press), always in Middle Palaeolithic contexts. At Kogelstein, Ziegler (Böttcher et al., 2000) identified a femur with cutmarks. The importance of marmots in human subsistence has been recognized at several Palaeolithic sites across Europe where the exploitation of this animal has been associated with food consumption and pelt use (Patou, 1987; Romandini et al., 2012; Tomé & Chaix, 2003).

4.2.4 Birds

The bird remains from Schafstall I, which were excavated by Peters in 1935, were analysed by Wilhelm Götz (1949), who based his identifications on the comparative material from the Württembergische Naturalien-Sammlung in Stuttgart. Because of the impossibility of locating the bird remains analysed by Götz, the data here presented are exclusively based on his publication (1949).

Conversely, the analysis of the bird assemblages from both Peters' and the new excavation of Schafstall II are presented in this study for the first time. Overall, Schafstall II presents a lower number of bird remains (78 specimens) compared to Schafstall I (111 specimens) (Table 4.2).

Following the method used by Krönneck (2019) in the study of the avian fauna from Geißenklösterle, the species were sorted according to habitat type (Table 4.3) and comparative data derived from modern species was used to estimate the time of year in which they were likely present in the Lauchert Valley. Ecological data was retrieved from the IUCN Red List of Threatened Species (https://www.iucnredlist.org/) and from Beaman and Madge (1998).

Both assemblages are dominated by bird species associated with open landscapes, in particular by ptarmigan, which represents the most abundant taxon and is closely related to tundra environments (Fig. 4.2). The second most common species is the white-throated dipper, which inhabits areas with fast flowing rivers and streams and breeds on cliffs and rock crevices. Waders, characteristic of wetland environments, like the common snipe, the common redshank and the Eurasian goldenplover, are proportionally greater at Schafstall I in comparison to Schafstall II and indicate the presence of mudflats and stagnant water pools along the Lauchert river. At the same time, the existence of large river expanses with shallow waters is indicated by the presence of a variety of water birds, like the common teal, the common goldeneye, the goosander, the common shelduck and the coot, which are again more abundant in the assemblage of Schafstall I. Though the environmental signal is driven by open habitat species like the ptarmigan, the presence of forested patches is signalled by several other species, which include the capercaillie, the black grouse, the great spotted woodpecker, the Eurasian woodcock and the tawny owl. Compared to Schafstall I, the assemblage of Schafstall II is characterized by a larger proportion of mixed forest species.

By contrast, indicator species of coniferous and broadleaved forests, such as the nutcracker and the song thrush, occur within the assemblage of Schafstall I. The existence of a mosaic environment characterized by the presence of grasslands and shrublands with patches of woodland is further supported by the occurrence of birds like the little owl, the mistle thrushand the ring ouzel, which live in partially forested and semi-open landscapes. Additionally, the occurrence of the yellow-billed chough, the crag martin and the white-winged snowfinch indicate higher levels of exposure of the rock surface and increased aridity compared to the present, as these species necessitate rocky areas and crags for breeding.

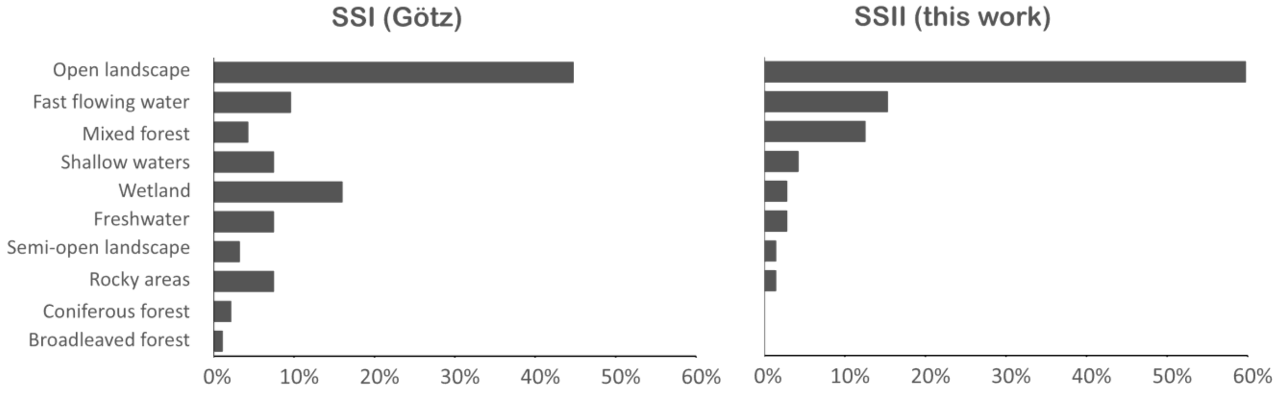
Table 4.2 Bird species of Schafstall sorted by habitat type with indication of their estimated seasonal occurrence. For Schafstall I, specimens from the old and new excavations are combined

Bird species of Schafstall		**NISP**	
		SSI	**SSII**
Species	**Common name**	**Götz (1949)**	**This work**
Anas crecca	common teal	4	1
Anas platyrhyncos	mallard	6	1
Bucephala clangula	common goldeneye	2	0
Mergus merganser	goosander	1	0
Aythya sp.	diving duck	0	1
Tadorna tadorna	common shelduck	0	1
Haliaeetus albicilla	white-tailed sea eagle	1	0
Falco tinnunculus	common kestrel	6	11
Perdix perdix	grey partridge	1	0
Lagopus sp.	ptarmigan	34	32
Lyrurus tetrix	black grouse	1	5
Tetrao urogallus	capercaillie	1	0
Fulica atra	common coot	0	1
(*Capella* sp.) *Gallinago* sp.	snipe	14	0
G.gallinago	common snipe	0	1
Tringa totanus	common redshank	1	0
Pluvialis apricaria	Eurasian goldenplover	0	1
Scolopax rusticola	Eurasian woodcock	1	0
Numenius sp.	curlew	1	0
(*Micropus apus*) *Apus apus*	common swift	1	0
(*Dryobates major*) *Dendrocopos major*	great spotted woodpecker	1	0
(Riparia rupestris) Ptyonoprogne rupestris	crag martin	1	0
Asio sp.	eared owl	3	0
Asio otus	long-eared owl	0	2
Athene noctua	little owl	0	1
Strix aluco	tawny owl	0	4
Bubo bubo	Eurasian eagle-owl	2	0
Pyrrhocorax sp.	chough	0	1
Pyrrhocorax graculus	yellow-billed chough	7	0
Corvus corax	common raven	0	3
Pica pica	common magpie	2	0
Nucifraga caryocatactes	nutcracker	2	0
Montifringilla nivalis	white-winged snowfinch	3	0
Melanocorypha sp.	lark	1	0
(Parus caerulus) *Cyanistes caerulus*	Eurasian blue tit	1	0
Turdus sp.	thrush	0	1
Turdus viscivorus	mistle thrush	2	0
(*Turdus ericetorum*) *Turdus philomelos*	song thrush	1	0
Turdus torquatus	ring ouzel	1	0
C.cinclus	white-throated dipper	9	11
Total		**111**	**78**

Table 4.3 Avian taxa from Schafstall I and II expressed as number of identified specimens (NISP). NISP values for Schafstall I are taken from Götz's study (1949). NISP values for Schafstall II are first presented in this work. Species in parentheses correspond to the old taxonomic classification assigned by Götz

Species	Common name	Habitat type	Season
Water			
Anas platyrhyncos	mallard		
Anas crecca	common teal	slow running rivers with shallow waters, marshes	summer
Bucephala clangula	common goldeneye	lakes with shallow waters surrounded by coniferous forests	summer
Mergus merganser	goosander	lakes with shallow waters	summer
Tadorna tadorna	common shelduck	lakes with shallow waters	summer
Aythya sp.	diving ducks		
Fulica atra	common coot	still or slow flowing shallow waters	all year round
Gallinago sp.	snipe		
G.gallinago	common snipe	wetlands	summer
Tringa totanus	common redshank	wetlands	summer
Pluvialis apricaria	Eurasian goldenplover	tundra, marshlands, shrublands	summer
Numenius sp.	curlew		
C.cinclus	white-throated dipper	fast-flowing rocky streams	all year round
Haliaeetus albicilla	white-tailed sea eagle	large lakes, coast or river valley	
Open landscape			
Falco tinnunculus	common kestrel	open and partially forested habitats	(summer)
Perdix perdix	grey partridge	grassland, shrubland	all year round
Lagopus sp.	ptarmigan	tundra, heathlands, meadows	all year round
Melanocorypha sp.	lark	open habitats, grasslands, steppe, semi-deserts	
Semi-open landscape			
Athene noctua	little owl	semi-open habitats, shrublands, grasslands	all year round
Turdus viscivorus	mistle thrush	mosaic of wooded and open country	summer, winter, migration
Turdus torquatus	ring ouzel	mountain steppe with conifers, grasslands, shrublands	summer
Forest			
Nucifraga caryocatactes	nutcracker	coniferous forest	all year round
Tetrao urogallus	capercaillie	mainly coniferous or mixed coniferous deciduous	all year round
Lyrurus tetrix	black grouse	coniferous or mixed forest clearings, heathlands, meadows	all year round
Dendrocopos major	great spotted woodpecker	broadleaved and coniferous forest	all year round
Scolopax rusticola	Eurasian woodcock	broadleaved or mixed broadleaved and coniferous forest	summer
Strix aluco	tawny owl	broadleaved, mixed and coniferous forests	all year round
Turdus philomelos	song thrush	all types of temperate forest and woodland	summer
Rocky areas			
Pyrrhocorax sp.	chough	cliffs, crags, mountains, rocky areas	all year round
Pyrrhocorax graculus	Yellow-billed chough	high altitude, rocky areas	all year round
Ptyonoprogne rupestris	crag martin	mountains, crags, coastal cliffs	summer
Montifringilla nivalis	white-winged snowfinch	rocky areas, inland cliffs, mountain peaks	all year round
Unspecific habitat type			
Apus apus	common swift		
Bubo bubo	Eurasian eagle-owl		
Asio sp.	eared owl		
Asio otus	long-eared owl		
Pica pica	common magpie		
Corvus corax	common raven		
Cyanistes caerulus	Eurasian blue tit		
Turdus sp.	thrush		

Figure 4.2 %NISP of birds from Schafstall I and II grouped according to habitat type



4.2.5 Microfauna

The microfauna of Schafstall is not included in the faunal analysis, which only dealt with the remains of large mammals and birds. As with the bird remains analysed by Götz, there is no record of the location of the microfaunal assemblage from Schafstall I studied by Florian Heller. In his publication of 1949, Götz cites Heller's manuscript on the small mammals of Göpfelsteinhöhle and Schafstall as being in press. Unfortunately, as far as we know, it was never published, and the results of Heller's work remain unknown to us. However, among the faunal material housed at the University of Erlangen, there was microfauna that could correspond to the assemblage studied by Heller. The remains were sorted according to species with handwritten labels made presumably by Heller. Neither the year of excavation nor the area of the site from which they came from are indicated on the labels, and the provenance of the remains is generically indicated as "Schafstall". In some cases, the word "Block" abbreviated as "Bl" follows the name of the site and likely refers to the geological unit from which the material was excavated. There was probably a total of five different units and each one was designated with a Roman number. From the identifications recorded on the tags, I was able to reconstruct part of Heller`s species list (Table 4.4) which included cold adapted tundra species like the Norway lemming and the collared lemming, as well as stepped grassland mammals like the ground squirrel and inhabitants of open forests with cool and moist environments like the common shrew.

Fish, amphibian and reptile remains also make up the microfaunal assemblage of Schafstall. Reptile and amphibian remains are very few and are more common among the material collected during Peters' excavation.

Fish are also rare and comprise freshwater species, such as the European bullhead (*Cotus gobio*) and the burbot (*Lota lota*). The fish remains from the new excavation were analysed by Angel Blanco Lapaz of the University of Tübingen and probably originate from a non-anthropogenic accumulation given the absence of modifications and the presence of light digestion attributable to avian predators (Russ & Jones, 2011).

Small mammals (Heller, unpublished)

Species	Common name
Insectivora	
Soricidae	
Sorex araneus	common shrew
Crocidura sp.	
Talpidae	
Talpa europea	European mole
Chiroptera	
Myotis sp.	mouse-eared bat
Rodentia	
Sciuridae	
(Spermophilus rufescens) Spermophilus major	russet ground squirrel
*Sciurus vulgaris**	red squirrel
Cricetidae	
Cricetus cricetus	Eurasian hamster
Arvicolidae	
Dicrostonyx gulielmi	
Dicrostonyx henseli	
Dicrostonyx sp.	collared lemming
Lemmus lemmus	Norway lemming
Gliridae	
Glis glis	edible dormouse
Ochotonidae	
Ochotona pusilla	steppe pika

**probably from the Holocene*

Table 4.4 Small mammal species identified by Florian Heller. Species in parentheses correspond to the outdated taxonomy assigned by Heller

Fish species of Schafstall II - new excavations 2016-17

Species	**Common name**	**GH**									
		2	**2a**	**2b**	**4**	**5**	**6**	**Hf**	**4p**	**5p**	**Total**
Cottus gobio	European bullhead	2	7	2	7	15		3		3	39
Lota lota	burbot	1	1			1					3
Cyprinidae	cyprinids		11			5	2	1		1	20
Pisces indet	unidentified	3	3		3	7	1	2	8	1	28
Total		6	22	2	10	28	3	6	8	5	90

Table 4.5 Number of fish specimens from the new excavation of Schafstall II

4.3 Taxonomic abundance and faunal composition

The material from the old excavations available for study is only a subsample of the original assemblage recovered by Peters at Schafstall I and comprises a total of 864 specimens, of which 237 (27%) were identified to species or genus level. The largest taxonomic group is represented by the herbivores, which account for 16% (N=138) of the total number of specimens (NSP) (Appendix, Table 6.1). Among these, horse is the most common taxon (N=63) and constitutes 7% of the total assemblage and 46% of the identified herbivores. Woolly rhinoceros is overrepresented because of the high number of tooth fragments. The second largest taxonomic group comprises the carnivore species, which make up 11% (N=92) of the total bone assemblage. The proportion of carnivores is inflated by the large number of cave bear remains, which account for about 84% of the total number of carnivores. The weight proportion of cave bear is equivalent to that of all herbivores grouped together (%WSP=28,9). The dominance of cave bear and horse is reflected by the great proportion of unidentified bones that fall into the horse/bear size category and constitute about 25% of the whole assemblage. In fact, because the medullary cavities of cave bear and horse long bones are generally filled with higher amounts of cancellous bone tissue compared to ruminants, it was possible in most cases to separate them from the other unidentified bone fragments. Bird and small mammal remains are very few in comparison to Schafstall II. The reason for this probably lies in the fact that the small sized taxa, that were pulled out for study by Götz (1949) and Heller, were never returned to the original collection.

From the recent excavation of Schafstall I, 695 remains were analysed, the majority of which, about 98% of the total bone count, derived from the backdirt of Peters' excavation and consisted of small unidentifiable remains recovered through water screening. The proportion of identifiable remains was very small and equivalent to only 3% of the total bone assemblage (Appendix, Table 6.2). The remaining 2% of the total number of remains was recovered from GH2, a geogenic and archaeologically sterile layer overlying bedrock. Given the small sample size of the identified specimens, these were not considered in this study.

Out of the four sites excavated by Peters in Veringenstadt, Schafstall II presents the most complete bone assemblage comprising all or almost all the material collected during the old excavations. The analysed remains amount to 4846 specimens, of which only 34% were identified (Appendix, Table 6.3). The sample is dominated by mammalian taxa but includes also bird remains which make up about 3% of the total bone assemblage. Cave bear is the predominant species and accounts for 17% (N=840) of the whole assemblage and for 57% of the total number of identified mammalian specimens. In terms of weight, cave bear contributes to 60% of the total bone weight. Other large carnivore taxa are barely represented, while among the small carnivores, foxes are relatively frequent, making up 5% (N=76) of the identified mammal bones. The second most abundant taxon is hare (N=357). When all the hare remains identified to species and genus level are considered, they represent 7% of the total number of bones and 24% of the identified mammals. As opposed to Schafstall I, herbivore remains are very few and account for only 3% of the total bone assemblage and 10% of the mammalian taxa. The proportion of bird remains is almost equal to that of the herbivores with ptarmigans (*Lagopus* sp) being the most common bird taxon (N= 26).

In comparison to the old excavations, the new campaigns of 2016 and 2017 at Schafstall II yielded a slightly larger study sample of 6985 specimens. The proportion of identified bird and mammal remains makes up 31% of the entire assemblage. Except for GH 1, the topmost layer containing Holocene deposits and small amounts of reworked material from the underlying Pleistocene sediments, all other geological horizons are dominated by cave bear. Compared to the old assemblage, the overall relative frequency of cave bear bones is higher, equalling 87% of the identified specimens and 27% of the analysed remains (Appendix, Table 6.3, Fig. 4.3). All other species are scarcely represented. When comparing the proportions of cave bear and all other taxonomic groups with those of the old assemblage, the χ^2 value indicates that there is a significant difference between the two (Table 4.6). Not only is the proportion of cave bear higher in the new assemblage compared to the old one, but all other taxonomic groups are comparatively smaller, especially the small mammals, i.e. hare and marmot, and birds (Table 4.6), which amount to 3% and less than 1% respectively of the total NISP.

The distribution of ungulates and carnivores across the various geological horizons is uneven and does not increase or decrease linearly through time (Table 4.7). The only exception is represented by the ungulates that were recovered from the layers underlying Peters' excavation trench (GH 2 ap to GH 5p), in that their frequencies increase proportionally in the lower layers displaying a strong correlation with time. The opposite is true for cave bear, which decreases significantly in the lower horizons (Table 4.7). Compared to the geological horizons of the newly excavated trench (GH 2 to GH 6), layers GH 2ap to GH 5p display a higher percentage of ungulates, though, it should be noted that their sample size is considerably smaller.

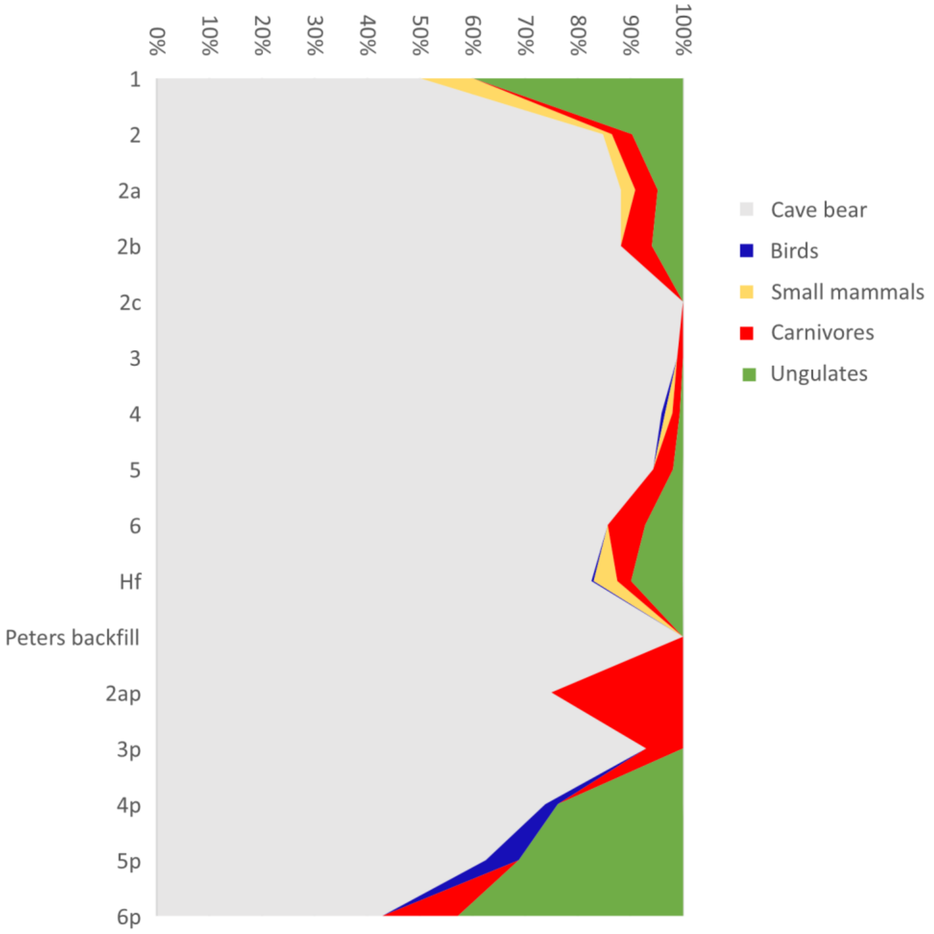


Figure 4.3 %NISP of each taxonomic group across geological horozons (GH) in the new excavation of Schafstall II

Schafstall II				
Taxon	SSII Old	AR	SSII New	Total
Cave bear	840	**-24,4**	1905	2745
Small mammals (hare and marmot)	364	**19,3**	55	419
Carnivores	116	**5,6**	69	185
Ungulates	153	**3**	147	300
Birds	158	**14,2**	6	164
Total	1631		2182	3813
χ^2		729,627		

Table 4.6 Number of specimens for each taxonomic group from the old and new excavations of Schafstall II and adjusted residuals. Underscored and bold values indicate that the correlation is very significant, with significant values at p<0,001.

Overall, when all assemblages from the old and new excavations of Schafstall I and II are considered, the number of mammalian taxa identified to species or genus level (NTaxa) is comparatively similar and there is a weak positive correlation with the degree of identifiability (total NISP) (N=4, $\tau_{b}=$ 0,333, p=0,497), meaning that sample size does not significantly affect the range of taxa represented (Table 4.8). The low taxonomic richness of the new assemblage from Schafstall I is a consequence of the large number of small unidentifiable fragments retrieved from the backdirt during the recent excavations.

	%NISP		
	Herbivores	Carnivores	Cave bear
GH2-6	-0,067	0,2	0,067
GH2ap-6p	**0,949**	-0,316	**-0,8**

Table 4.7 Kendall`s tau correlation statistics for herbivore, carnivore and cave bear abundance across the geological horizons of the new excavation trench (GH2-6) and the horizons underlying the old excavation trench of Peters (Gh2ap-6p). Significant values at $p<0,05$. Values in bold indicate that the correlation is significant.

Assemblage	**Total NISP**	**NTaxa M+B**	**Total NISP M**	**NTaxa M**	**1/D M**	**NTaxa U**	**1/D U**	**Ntaxa C**	**1/D C**
SSI Old	222	17	220	15	4,58	7	3,19	6	1,42
SSI New	21	7	18	5	.	.	.	.	.
SSII Old	1543	33	1452	17	2,52	8	4,38	7	1,28
SSII New	2160	17	2157	14	1,28	6	2,94	7	1,07

Table 4.8 Comparison of taxonomic richness (NTaxa) and of Simpson's Reciprocal Index of diversity (1/D) across all excavation assemblages. M=mammalian taxa, B=bird taxa; U=ungulates; C=carnivores. Simpson's reciprocal could not be calculated for the new excavation assemblage of Schafstall I due to the very small sample size.

When bird taxa are included in the count, the taxonomic richness of the old assemblage of Schafstall II surpasses considerably that of all other assemblages. As noted previously, differences in bird bone representation across the assemblages are to be ascribed to the removal of the bird remains from the old assemblage of Schafstall I by Götz and to discrepancies in the relative abundance of different taxonomic groups between the old and new assemblages of Schafstall II. Because of these inconsistencies, I decided to exclude the bird remains in the calculation of the evenness index.

The assemblage from the old excavation of Schafstall I shows greater taxonomic evenness compared to Schafstall II, which is primarily dominated by cave bear. Even so, the old and new assemblages of Schafstall II present some differences and the mammalian taxa are more evenly distributed in the old assemblage than in the new one (Table 4.8). The low evenness values for carnivores are easily explained by the dominance of cave bear across all assemblages. Interestingly, the assemblage from the new excavation of Schafstall II displays the lowest value, which reflects the higher proportion of cave bear among the carnivore taxa. Likewise, ungulate evenness shows the lowest value for the new assemblage of Schafstall II, further validating strong differences in faunal composition and structure between the old and new assemblages originating from this area.

4.4 Bone survivorship and modification

Patterns of skeletal element representation mirror differentials in accumulation and can be influenced by predation and transportation choices made by humans or other predators that contribute to the formation of the assemblage. However, the interpretation of such patterns is intrinsically problematic due to the complexity of archaeological palimpsests and the superposition of diverse taphonomic and environmental factors obscuring the original record. Consequently, a critical assessment of all those processes affecting bone survivorship, such as attrition and peri- and post-depositional alterations, is crucial for our understanding of the time and modes of assemblage formation and ultimately of the agents responsible of bone accumulation. In this section, I discuss in detail these issues and illustrate their effect on the bone assemblages of Schafstall providing new insights into the interpretation of site use in the Lauchert Valley during the late Middle to Upper Palaeolithic.

4.4.1 Attrition

Due to the highly mineralized and low-porosity structure of enamel, teeth are particularly hard and resistant to mechanical stresses, and therefore, tend to preserve remarkably well in archaeological assemblages. Contrastingly, bone tissue has a lower content of inorganic material and is more prone to the mechanical alterations imparted by diagenesis. Therefore, we would expect an assemblage with high levels of attrition to present large numbers of isolated teeth and of small unidentifiable bone fragments. When plotting bone NISP against isolated tooth NISP, this trend would be ideally represented by a concave downward curve, where the first half of the curve sloping upwards indicates a positive correlation between the number of tooth finds and bone identifiability, while the second half of the curve sloping downwards represents the reduced identifiability of very fragmented bones in relation to teeth, which remain substantially unaffected by diagenesis (see also Stiner, 1994).

Comparison of bone and isolated tooth NISP for Schafstall I and Schafstall II reveals a strong linear relationship ($N=51$, $r=0{,}815$; $r^2=0{,}920$; $p<0{,}01$) between the two variables (Fig. 4.4). To check for disparities in attrition rates across taxonomic groups, I decided to single out the different large mammal categories. Likewise, for the new assemblage of Schafstall II, all geological horizons were considered separately. The deciduous teeth of cave bear were excluded from the comparison because traces of root resorption combined with occlusal wear indicate that most of these were naturally shed by young bears inhabiting the site during

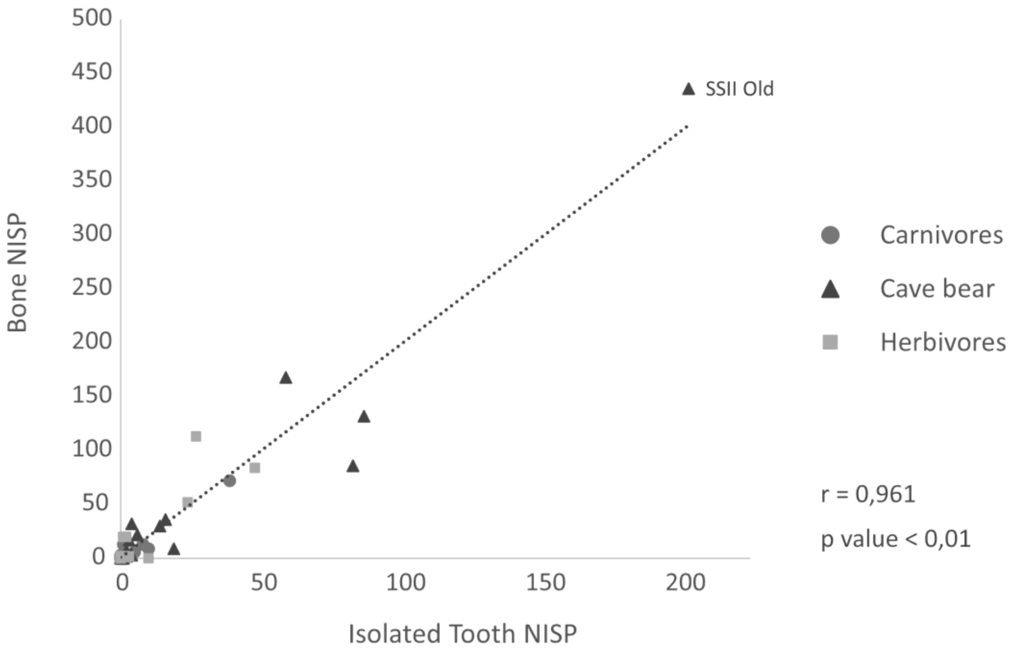


Figure 4.4 Plot of bone NISP to isolated tooth NISP for carnivore, cave bear and ungulate remains in all excavation assemblages. For the new excavation of Schafstall II values are plotted separately for each geological horizon. Cave bear deciduous teeth are not considered.

winter periods. Most of these teeth have therefore no relation with the death assemblage and are found isolated for reasons which have nothing to do with attrition.

The exceedingly large NISP values for cave bear bone and isolated teeth in the old assemblage of Schafstall II are a result of all remains being lumped together because of their unknown stratigraphic position. The linear trend represented for all assemblages (Fig. 4.4) indicates that overall, the level of preservation is relatively good and does not go beyond the critical value for which the majority of bones is too fragmented to be identified.

The extent to which attrition impacted skeletal element representation of single ungulate and carnivore taxa, excluding cave bear, could not be tested by using bone mineral density values of analogous modern species because of the very small sizes of the samples under study. However, relative attrition could be assessed on the numerous remains of cave bear. This species presents an additional advantage compared to ungulate taxa because its occurrence in cave contexts is in most cases a result of natural death, therefore its skeletal completeness serves as a good indicator of post-depositional damage. While a number of studies provides bone mineral density values for ungulates and small mammals (Kreutzer, 1992; Lam et al., 1999; Lyman, 1984), no data is yet available for ursids. Despite this knowledge gap, during data collection, scan sites for cave bear bones were recorded by referring to the anatomical locations taken on canid bones by Novecosky and Popkin (Novecosky & Popkin, 2005). Since the anatomical location of scan sites does not vary much across the different species for which bone density values are known, the recording of scan sites for cave bear might prove useful in the future when new studies on bear bone density become available. Though bone mineral density values derived for canids can be assumed to have a similar rank order as the density of bear bones, previous studies have suggested that caution must be taken when applying species specific structural density values to other species, as this method can generate considerable variation in the interpretation of density mediated attrition (Lyman et al., 1992). Furthermore, there are major differences in skeletal structure between canids and ursids. The former have an appendicular skeleton that is highly adapted for running, whereas the latter are noncursors and have developed distinct structural and functional adaptations in the forelimbs which allow them to manipulate items. As an effect of such functional specialization, the long bones of cursorial predators are more slender and less robust than those of noncursorial taxa (Martín-Serra et al., 2015) and their density values likely present a differing rank order. We therefore did not deem appropriate to use the density values of canid bones for reconstructing the effect of density mediated attrition on cave bear. Instead, the highest cranial and mandible bone-based MNE were plotted against the highest tooth-based MNE values (Fig. 4.5.). By doing so it was possible to broadly assess the rate of attrition because teeth articulate with cranial and mandible bones, therefore, under optimal preservation conditions, we would expect an equal representation of both classes of skeletal materials. Graphically, this is ideally represented by a line with an intercept of 0 and a positive slope of 1.0. Lower levels of preservation lead to a decline in bone identifiability, which only minorly affects teeth. Consequently, the slope acquires increasingly smaller values closer to 0 as bone loss from fragmentation or decomposition rises (see Stiner, 1994; Stiner et al., 2005). The slope values for cranial and mandible bone-based and tooth-based MNEs for Schafstall I and II are both in the range of 0,4 and 0,5, hence the level of preservation is intermediate (Fig. 4.5). Between 28% and 17% of all variation in bone based and tooth based values of cave bear cranial (r^2=0,721) and mandibular (r^2=0,826) MNE could be attributed to density mediated attrition, meaning that overall the cave bear remains from Schafstall I and II were moderately affected by attrition. Moreover, there seems to be very little difference in preservation between the bear bone assemblages from the old and new excavations (Fig. 4.5).

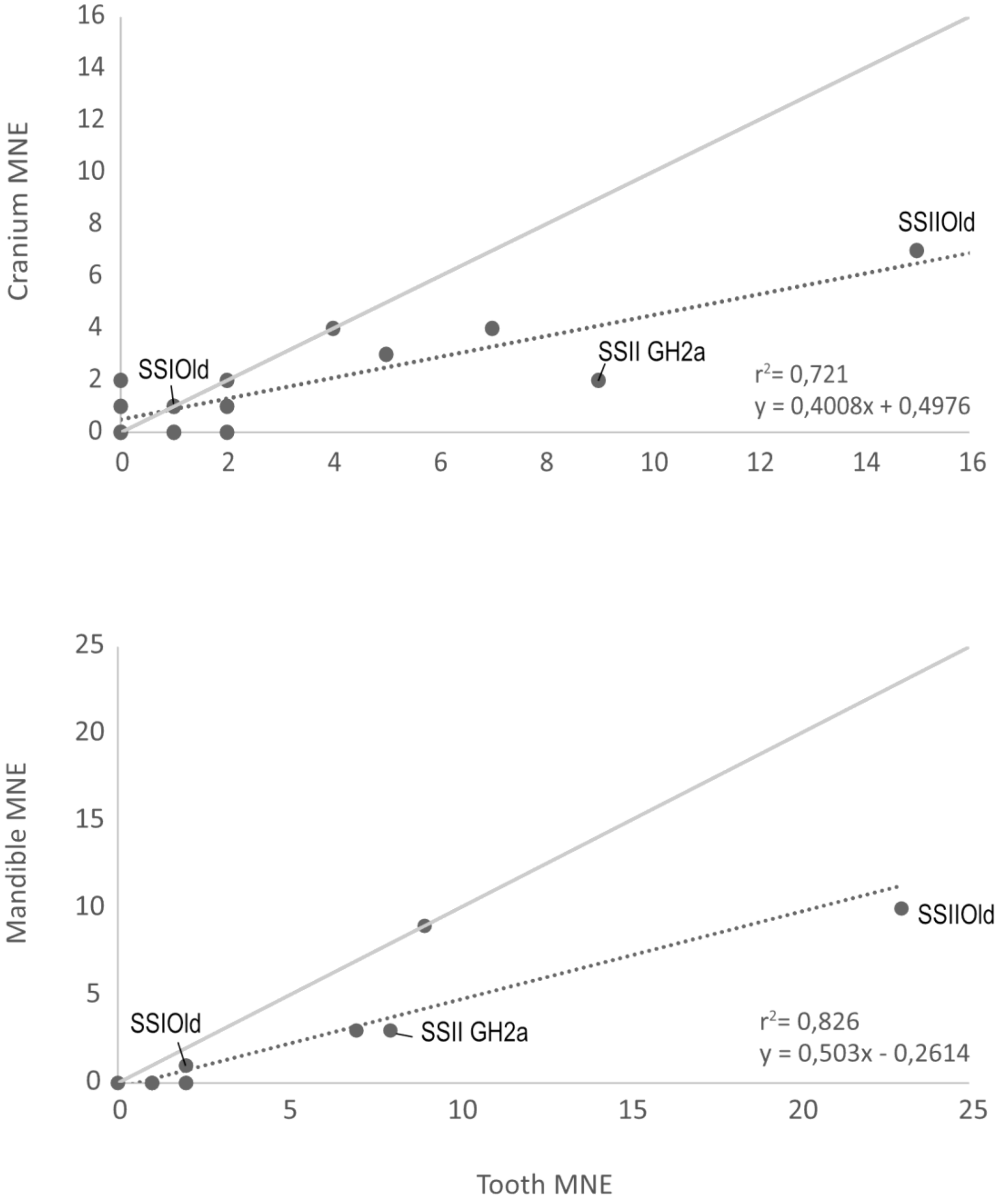


Figure 4.5 Relative attrition measured through tooth based MNE to bone-based cranial and mandibular MNE of cave bear. For the new excavation of Schafstall II values are plotted separately for each geological horizon.

4.4.2 Taphonomic processes and agents of bone accumulation

Weathering, root etching, abrasion and other minor taphonomic modifications

Weathering damage in the form of cracks and exfoliation of bone surface is visible on a small percentage of bone remains and is mostly mild across all assemblages (Table 4.9). Similarly, root etching caused by the mechanical and chemical action of plants is overall relatively infrequent (Table 4.10). Interestingly, the bone assemblage from the old excavation of Schafstall I displays higher frequencies of weathering and root etching compared to that from Schafstall II. This might be explained by the site's peculiar configuration in that the area of Schafstall I is larger and more sheltered than that of Schafstall II, and has thus been used more

		Weathering stages											
		0		**1**		**2**		**3**		**4**		**5**	
	Total bone NSP	N	%	N	%	N	%	N	%	N	%	N	%
SSI Old													
	765	507	66%	86	11%	24	3%	3	< 1%	139	18%	33	4%
SSII Old													
	4092	3703	90%	123	3%	64	2%	4	< 1%	190	5%	27	1%
SSII New													
GH													
2	1038	898	87%	89	9%	5	0%	2	< 1%	69	7%	1	< 1%
2a	1209	1064	88%	28	2%	5	0%	0	0%	72	6%	1	< 1%
2b	87	73	84%	1	1%	0	0%	0	0%	8	9%	1	1%
2c	30	27	90%	2	7%	0	0%	0	0%	2	7%	0	0
3	106	97	92%	2	2%	0	0%	0	0%	7	7%	0	0
4	99	91	92%	1	1%	0	0%	0	0%	5	5%	0	0
5	189	181	96%	0	0%	1	1%	0	0%	6	3%	0	0
6	6	4	67%	0	0%	0	0%	0	0%	2	33%	0	0
Hf	963	902	94%	13	1%	3	0%	1	0%	39	4%	0	0
P. backfill	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0
2ap	9	7	78%	2	22%	0	0%	0	0%	1	11%	0	0
3p	25	23	92%	1	4%	0	0%	0	0%	2	8%	0	0
4p	31	28	90%	0	0%	0	0%	0	0%	2	6%	0	0
5p	24	24	100%	0	0%	0	0%	0	0%	0	0%	0	0
6p	3	2	67%	0	0%	1	33%	0	0%	1	33%	0	0
Total SSII New	3819	3421	90%	139	4%	15	< 1%	3	< 1%	216	6%	3	< 1%

Table 4.9 Incidence of weathering damage by stage on bone remains from Schafstall I and II. Antler and ivory are included in bone NSP count. Weathering stages are taken from Behrensmeyer (1978) and Stiner (Stiner et al., 2005) and defined as follows: 0=none, 1=fine linear cracks, most open, 2=fine cracks, some open, 3=many cracks, most open, 4=some exfoliation, 5=advanced exfoliation

	Root damage		**Staining**		**Trampling**		**Chemical weathering**	
	N	%	N	%	N	%	N	%
SSI Old								
	47	6%	4	1%	53	7%	23	3%
SSII Old								
	126	3%	8	< 1%	39	1%	41	1%
SSII New								
GH								
2	94	9%	0	0%	1	< 1%	0	0%
2a	43	4%	6	< 1%	4	< 1%	0	0%
2b	4	5%	0	0%	0	0%	0	0%
2c	0	0%	0	0%	0	0%	0	0%
3	1	1%	0	0%	0	0%	0	0%
4	4	4%	0	0%	1	1%	1	1%
5	1	1%	0	0%	1	1%	0	0%
6	0	0%	0	0%	0	0%	0	0%
Hf	8	1%	7	1%	2	< 1%	0	0%
P. backfill	0	0%	0	0%	0	0%	0	0%
2ap	1	11%	0	0%	0	0%	0	0%
3p	0	0%	0	0%	0	0%	0	0%
4p	0	0%	0	0%	0	0%	0	0%
5p	0	0%	0	0%	0	0%	0	0%
6p	0	0%	0	0%	0	0%	0	0%
Total SSII New	156	4%	13	< 1%	9	< 1%	1	< 1%

Table 4.10 Frequencies of root etching, staining, trampling and chemical weathering on bone remains from Schafstall I and II

intensively until recent times by humans and animals which have undoubtedly contributed to the partial exposure of the underlying deposits and perhaps to an increase in biotic activity.

At Schafstall II the specimens from the upper layers (GH 2 and GH 2ap) of the new excavation exhibit heavier weathering and root etching damage compared to those from the lower horizons, probably due to their proximity to the ground surface.

Chemical weathering and staining were very rarely observed, and scratches produced by trampling and movement of sediment particles were also seldomly recorded. The only exception is represented by Schafstall I, where trampling marks were documented on about 7% of the total number of bone remains (Table 4.10).

The degree of sedimentary abrasion based on bone roundedness is generally quite limited, though specimens from the old excavation of Schafstall I and from the lower layers of the new excavation of Schafstall II exhibit higher percentages of rounding compared to the other bone remains of Schafstall II (Table 4.11). This might be due to the fact that the assemblages from the lower layers of Schafstall II and from Schafstall I are more or less coeval and might have been affected by the same geological and depositional processes.

Rodent marks were observed only on very few specimens from the old assemblage of Schafstall II and interested mostly bird remains.

	Abrasion					
	none 0		**rounded 1**		**very rounded 2**	
	N	%	N	%	N	%
SSI Old						
	626	82%	119	16%	21	3%
SSII Old						
	3931	96%	115	3%	46	1%
SSII New						
GH						
2	1011	97%	27	3%	0	0%
2a	1154	95%	44	4%	11	1%
2b	85	98%	2	2%	0	0%
2c	29	97%	0	0%	1	3%
3	104	98%	1	1%	1	1%
4	88	89%	10	10%	1	1%
5	180	95%	7	4%	2	1%
6	5	83%	1	17%	0	0%
Hf	934	97%	28	3%	1	< 1%
P. backfill	0	0%	0	0%	0	0%
2ap	6	67%	2	22%	1	11%
3p	24	96%	1	4%	0	0%
4p	25	81%	5	16%	1	3%
5p	21	88%	2	10%	1	5%
6p	3	100%	0	0%	0	0%
Total SSII New	3669	96%	130	3%	20	1%

Table 4.11 Abrasion damage by stage on bone remains from Schafstall I and II

Burning

Burnt bones associated with human activities may provide an important source of information on site use and maintenance, cooking practices and food processing, as well as use of bone as fuel. However, their presence in an archaeological context must be critically evaluated because burnt bones can also be the product of indirect burning when they are unintentionally burnt after burial and can result from natural fires. Evidence for burning from the old excavations of Schafstall I and II must therefore be treated cautiously. All the more so because during Peters' excavations apparently only the larger bones, comprising mostly charred fragments, were recovered. The finer bone fraction less than 1 cm in size, which is very well represented among the waterscreened materials of the new excavation of Schafstall II, is almost completely absent. Since the rate of bone fragmentation increases with burning intensity, the incomplete recovery of burnt bones strongly impairs their interpretative value and may generate a biased representation of different burning classes. Furthermore, the number of burnt bones in Peters´ assemblages is very low and no indication is given concerning their archaeological context.

Of particular interest are the taxa affected by burning at Schafstall II. These include three cave bear elements, a femoral proximal epiphysis of a medium ungulate and five proximal and four distal phalanges of 4.7. All identifiable burnt remains derive from the old excavations because burnt bone was very infrequent in the new excavation. Most fragments collected during the recent re-excavation were millimetric in size and fully carbonized (burning class 3). The highest percentages of burnt bone were recovered from the bottom of Peters´ excavation

	% weight per burning category							bone weight (g)	burnt bone weight(g)	%burnt bone
	0	1	2	3	4	5	6			
SSI Old										
	99%	<1%	1%	<1%	<1%	<1%	<1%	8691,4	116	1%
SSII Old										
	98%	<1%	<1%	1%	<1%	<1%	<1%	27508,04	603,8	2%
SSII New										
GH										
2	>99%			<1%				4387,04	0,16	<1%
2a	99%	<1%	<1%	1%	<1%	<1%	<1%	6721,65	79,6	1%
2b	>99%	<1%	<1%	<1%	<1%			992,36	1,56	<1%
2c	>99%			<1%	<1%			301	0,02	<1%
3	99%		1%	1%	<1%			664,78	8,75	1%
4	>99%		<1%	<1%	<1%			592,49	2,93	<1%
5	99%		<1%	1%	<1%	<1%		412,02	4,97	1%
6	99%		<1%	1%				40,58	0,48	1%
Hf	>99%		<1%	<1%	<1%			5553,76	5,9	<1%
3p	85%	<1%	6%	7%	<1%		<1%	152,09	23,09	15%
4p	86%	1%	4%	6%	<1%	1%	<1%	133,14	18,8	14%
5p	98%	<1%	<1%	1%	<1%		<1%	159,9	2,6	2%
6p	>99%		<1%	<1%	<1%			219,56	0,56	<1%
Total SSII New	99%	<1%	<1%	<1%	<1%	<1%		20330,37	149,42	1%

Table 4.12 Burning damage frequency by stage. 0=unburned; 1=<1/2 carbonized; 2=>1/2 carbonized; 3=fully carbonized; 4=<1/2 calcined; 5=>1/2 calcined; 6=fully calcined

trench (GH 3p and 4p), whereas the new test trench yielded very small concentrations of burnt remains with slightly higher estimates in GH 2a and 3 (Table 4.12). Excluding the layers underlying Peters´ trench, percentages of burnt remains never exceed 1% of total bone weight in the new excavation. This may be taken as yet another indicator of substantial differences in bone accumulation at Schafstall II between the back of the cave next to the rock wall and the recently investigated outer area.

Disentangling carnivore and hominin activities

Because cave sites and rock shelters were largely exploited by carnivores as well as humans, gnawing damage is a crucial component in evaluating the impact of carnivore activities on bone accumulation. Carnivore damage was assessed by tallying separately the frequencies of gnawing marks, carnivore tooth notches and digestion marks. The latter two types of marks were very rarely recorded, and their relative frequency never exceeded 1% of total bone NSP across all assemblages (Table 4.13). Gnawing damage, which includes tooth pits, furrowing and drag marks produced on the cortical surface of bones by carnivore teeth, is generally relatively low both at Schafstall I and Schafstall II. Albeit the low percentages of gnawed bones, carnivore activity was recorded in almost every level of the new excavation at Schafstall II (Table 4.14). Although pits and tooth scores were not measured, most of the damage observed was ascribable to medium or large sized carnivores. When comparing the extent of gnawing damage for each taxonomic group, we realize that in both areas of Schafstall ungulate bones display the heaviest damage from carnivores (Table 4.15), while most of the damage inflicted on non-ungulate taxa is observable on cave bear remains. At Schafstall I, cave bear represents the only non-ungulate taxon with carnivore marks. Interestingly, at Schafstall II gnawing damage is considerably higher on cave bear specimens from the old excavation compared to the new one. By contrast, carnivore bones from the old assemblage of Schafstall II are less affected by gnawing than those from the recent excavation. Hare and bird bones from the old excavation of Schafstall II are also moderately damaged, with gnawing marks recorded on 14 % and 11% respectively of the total number of bone specimens.

The proportions of carnivore, cave bear and ungulate bones with gnawing marks in Schafstall I and II differ significantly (χ^2=20,396, N=222, df=4, p<0,0001). Cave bear and ungulate remains of Schafstall I present the highest significant adjusted residual values and proportionally display the largest variation in gnawing damage across the three taxonomic

	Animal modifications							
	rodent marks		carnivore gnawing		carnivore notches		digestion	
	N	%	N	%	N	%	N	%
	SSI Old							
	0	0%	51	7%	5	1%	1	<1%
	SSII Old							
	11	<1%	391	10%	7	<1%	1	<1%
	SSII New							
GH								
2	0	0%	25	2%	3	<1%	0	0%
2a	0	0%	65	5%	3	<1%	0	0%
2b	0	0%	5	6%	0	0%	0	0%
2c	0	0%	1	3%	0	0%	0	0%
3	0	0%	4	4%	0	0%	1	1%
4	0	0%	1	1%	0	0%	0	0%
5	0	0%	1	1%	0	0%	2	1%
6	0	0%	0	0%	0	0%	0	0%
Hf	0	0%	32	3%	1	<1%	3	<1%
P. backfill	0	0%	0	0%	0	0%	0	0%
2ap	0	0%	0	0%	0	0%	0	0%
3p	0	0%	1	4%	0	0%	0	0%
4p	0	0%	1	3%	0	0%	0	0%
5p	0	0%	1	5%	0	0%	0	0%
6p	0	0%	2	67%	0	0%	0	0%
Total SSII New	0	0%	139	4%	7	<1%	6	<1%

Table 4.13 Incidence of animal modifications on bone remains from Schafstall I and II

SSII New	**1**	**2**	**2a**	**2b**	**2c**	**3**	**4**	**5**	**Hf**	**5p**	**6p**	
V. vulpes									11%			
C. lupus			40%	50%		100%						
Carnivores Mean												**13%**
U. speleaus	20%	6%	10%	5%	6%	6%	3%		11%	33%		
Cave bear Mean												**8%**
Equus sp.		25%										
C. antiquitatis		100%		100%					4%			
R. tarandus			20%									
Bos vel Bison											100%	
Caprinae									100%			
C. ibex	100%											
medium ungulate		100%										
large ungulate (ruminant)											100%	
Ungulates Mean												**18%**
medium bird								50%				
Birds Mean												**4%**

Table 4.14 Percentages of bone NISP with gnawing damage in the geological horizons of the new excavation of Schafstall II. Specimens identified to the large carnivore size classe were excluded from the count so as not to further inflate this category, but ungulate size classes were considered

	SSI Old		SSII Old	
Taxa	**N gnawing marks**	**% Bone NISP**	**N gnawing marks**	**% Bone NISP**
Vulpes sp			2	4%
C.lupus			1	9%
Carnivores Mean				**4%**
Ursus speleaus	4	**13%**	93	**21%**
Equus sp.	2	4%	13	34%
C. antiquitatis			7	47%
Cervidae	2	18%	1	14%
Cervus elaphus	1	50%		
R. tarandus	2	20%	8	23%
Caprinae			1	50%
C. ibex	1	33%	4	40%
R. rupicapra	2	22%	2	67%
medium ungulate	3	21%	2	17%
large ungulate	2	3%	4	15%
Ungulates Mean		**9%**		**27%**
Lepus sp.			38	14%
Hare Mean				**14%**
A. crecca			1	100%
Anas cf. *platyrhyncos*			1	100%
Anatidae			1	13%
Asio otus			1	50%
Charadriiformes			1	14%
Corvidae			2	13%
Falco tinnunculus			1	9%
Laridae			1	100%
Lagopus sp			6	23%
Lyurus tetrix			1	20%
Tetraoninae			1	8%
Phasianidae			1	10%
Turdidae			1	100%
small to medium bird			5	13%
medium bird			6	9%
large bird			1	17%
Birds Mean				**11%**

Table 4.15 Number of specimens and percentages of bone NISP with gnawing marks from the old excavations of Schafstall I and II. Specimens identified to the large carnivore size class were excluded from the count so as not to further inflate this category, but ungulate size classes were considered

groups considered. This is explained by the large proportion of gnawed ungulate bones and the very low amount of ravaged cave bear bones compared to Schafstall II.

When gnawing damage frequencies on ungulate and cave bear bones relative to total bone NSP are plotted against each other (Fig. 4.6). the relative proportion of gnawing marks on cave bear remains at Schafstall II is always greater than on ungulate bones, while the opposite holds true for the bone assemblage of Schafstall I, suggesting differences in the way bones were accumulated at the two sites.

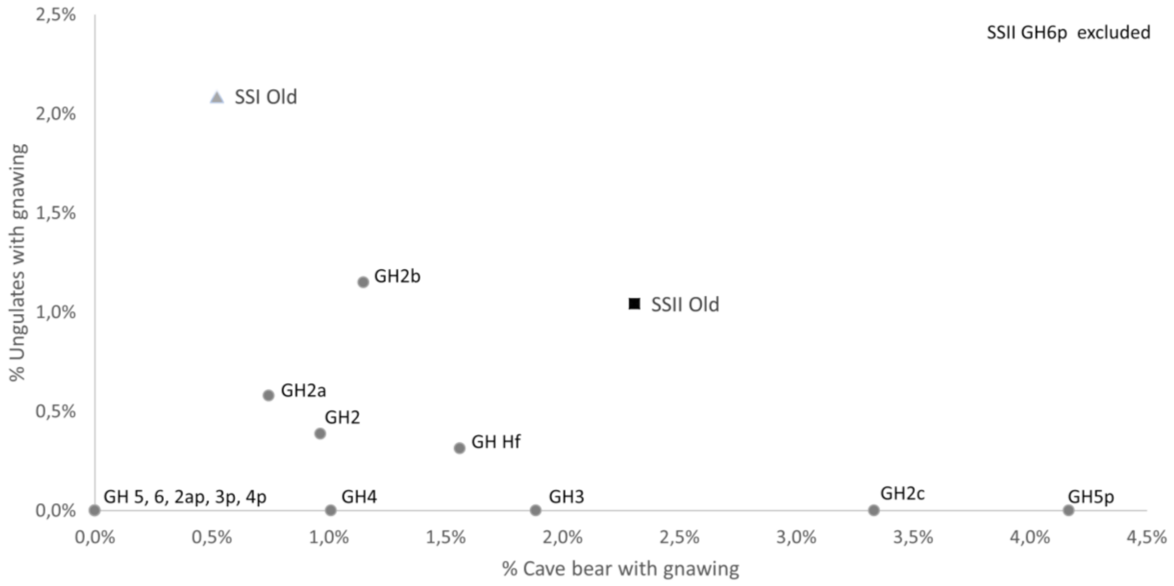


Figure 4.6 Comparison between percentages of gnawing damage on cave bears and ungulates from the old excavations of Schafstall I and II and the new excavation of Schafstall II. Percentages are calculated out of total bone NSP. For the new excavation of Schafstall II, percentage values are plotted separately for each geological horizon. GH 6p was excluded because percentage values are inflated due to the very small sample size

To assess the degree of peri-depositional damage produced by humans and carnivores, which would have disposed of carcasses when still fresh, bone fracture patterns were recorded (Table 4.16). For most of the bone specimens it was not possible to distinguish between green and dry break fractures, but when the distinction could be made, dry fractures were predominant. At Schafstall II, the relative frequency of fragments with green breakage patterns is very low and in stark contrast with that of Schafstall I, where about 20% of the bone remains display smooth and regular fracture surfaces.

If carnivores were mainly responsible of green break fractures, we would expect their relative frequencies to be similar at both sites since the proportion of gnawing damage is roughly equivalent, but fresh fractures are very rare at Schafstall II. This seems to suggest that the

	Breakage patterns											
	none		**dry**		**curation**		**curation/dry**		**green fracture**		**unknown**	
	0		**1**		**2**		**3**		**4**		**5**	
	N	%	N	%	N	%	N	%	N	%	N	%
SSI Old												
	22	3%	119	16%	26	3%	35	5%	145	19%	460	60%
SSII Old												
	250	6%	256	6%	136	3%	128	3%	179	4%	3203	78%
SSII New												
GH												
2	20	2%	83	8%	41	4%	132	13%	60	6%	727	70%
2a	30	2%	111	9%	82	7%	89	7%	55	5%	874	72%
2b	4	5%	11	13%	9	10%	10	11%	3	3%	50	57%
2c	2	7%	2	7%	14	47%	1	3%	1	3%	11	37%
3	11	10%	13	12%	8	8%	2	2%	2	2%	71	67%
4	7	7%	7	7%	2	2%	3	3%	3	3%	79	80%
5	7	4%	3	2%	1	1%	1	1%	0	0%	177	94%
6	2	33%	1	17%	0	0%	1	17%	0	0%	2	33%
Hf	58	6%	82	9%	44	5%	59	6%	54	6%	671	70%
P. backfill	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
2ap	1	11%	0	0%	0	0%	2	22%	0	0%	6	67%
3p	4	16%	4	16%	4	16%	0	0%	0	0%	14	56%
4p	1	3%	2	6%	1	3%	1	3%	1	3%	25	81%
5p	0	0%	1	5%	0	0%	0	0%	0	0%	19	95%
6p	1	33%	1	33%	0	0%	0	0%	1	33%	0	0%
Total SSII New	148	4%	321	7%	206	5%	301	8%	180	5%	2726	71%

Table 4.16 Frequencies of different bone breakage patterns in the fauna of Schafstall I and II

higher proportion of green fracture patterns at Schafstall I is not so much linked with carnivore ravaging but rather with other taphonomic agents like human activities.

Furthermore, when comparing frequencies of split, transverse and spiral fracture forms to anthropogenic modifications, we can observe a clear difference between the two sites. At Schafstall I green fracture forms occur often in association with anthropogenic marks and their frequency distribution for the ungulate taxa roughly follows a similar trend to that of the bones with cut-, scraping and percussion marks, while gnawing damage is comparatively low (Fig 4.7). Rather than representing an exception, the high proportion of gnawing on ibex bones is inflated by the small number of remains attributable to this species. By contrast, gnawing and green fracture frequencies follow broadly similar trends in the newly excavated assemblage of Schafstall II, suggesting that green fractures; albeit few in number, might be associated with carnivore activity (Fig 4.7).

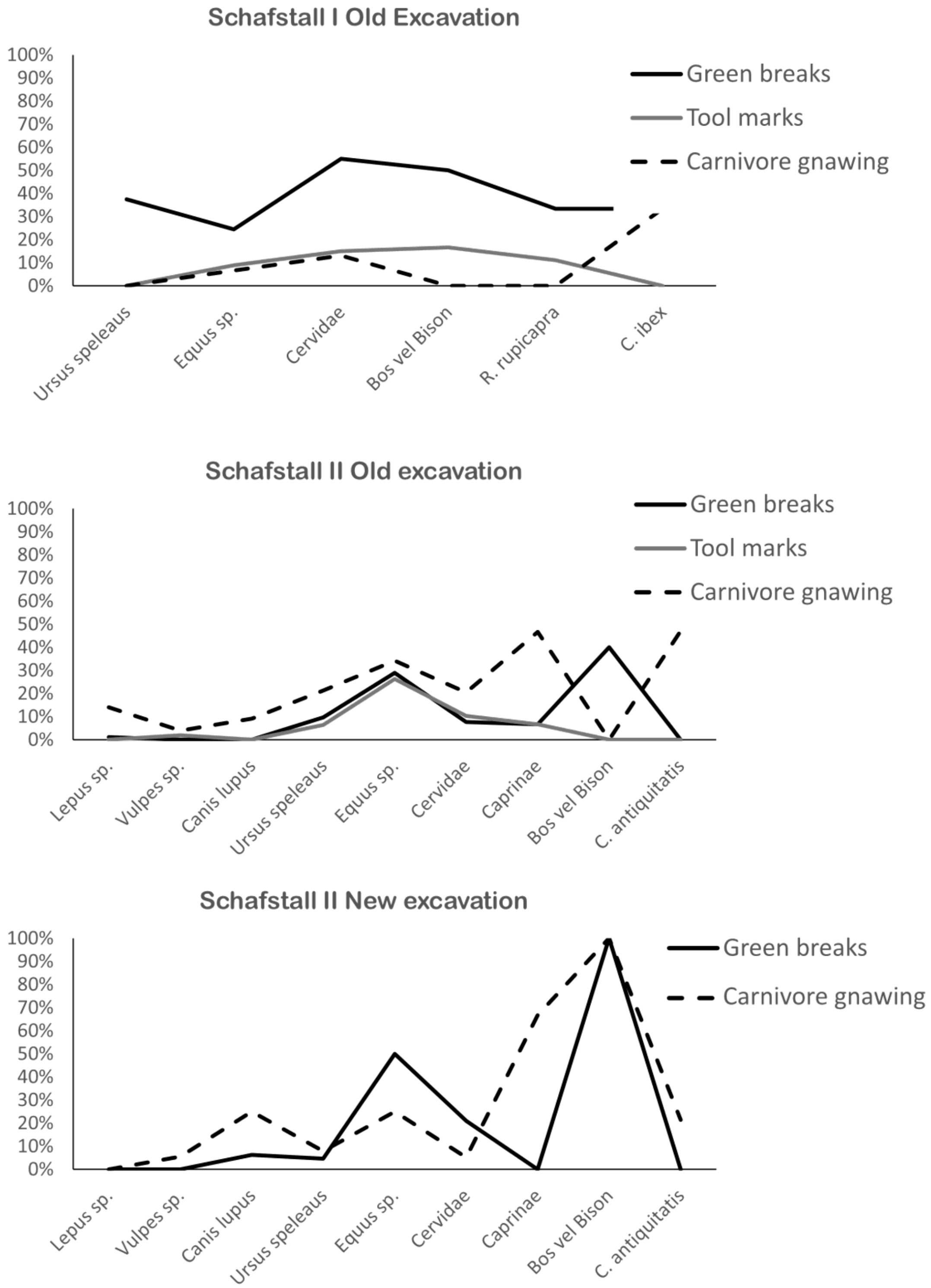


Figure 4.7 Relative frequency distribution of carnivore damage, tool marks and green breaks on mammal species of Schafstall I and II

This pattern is also reflected in the old assemblage of Schafstall II, which presents a high incidence of carnivore damage, but green fracture breaks on cave bear, horse and cervid bones could also be connected to human activities given the higher proportions of anthropogenic marks observed on these taxa. Humans may have therefore had initial access to these resources prior to ravaging by carnivores or we may be looking at a palimpsest in which various agents contributed independently to the assemblage formation. Notably, the small number of bison and woolly rhino remains, consisting mostly of foot and head bone fragments, exhibit extensive gnawing damage which suggest that carnivores were responsible for their accumulation.

The influence of human activities on bone accumulation can be gauged by the frequency of anthropogenic modifications, such as cut-, percussion and scraping marks related to carcass-processing or bone tool manufacturing. Even though human activities not always leave marks on bones, it is assumable that as their intensity increases their effects in terms of bone alteration become more visible within an assemblage.

Proportionally, anthropogenic modifications are more frequent at Schafstall I than at Schafstall II, and there is a significant difference in the frequency distribution of anthropogenic and carnivore marks across the different assemblages (Fig. 4.8, Table 4.17). On one hand Schafstall I shows the highest adjusted residuals because of the larger proportion of anthropogenic modifications compared to gnawing marks. On the other hand, the new assemblage of Schafstall II displays a significant adjusted residual value ($p<0.0001$) which reflects the very low abundance of anthropogenically modified bones in the assemblage.

Gnawing vs Anthropogenic marks				
Site	Gnawing	AR	Anthropogenic marks	Total
SSI Old	51	**-8,3**	60	111
SSII Old	391	1	112	503
SSII New	139	**6,3**	5	144
Total	581			758
χ^2			90,586	

Table 4.17 Number of specimens with gnawing and anthropogenic damage from the old and new excavations of Schafstall II and adjusted residuals. Bold values indicate that the correlation is significant, with significant values at $p<0,001$.

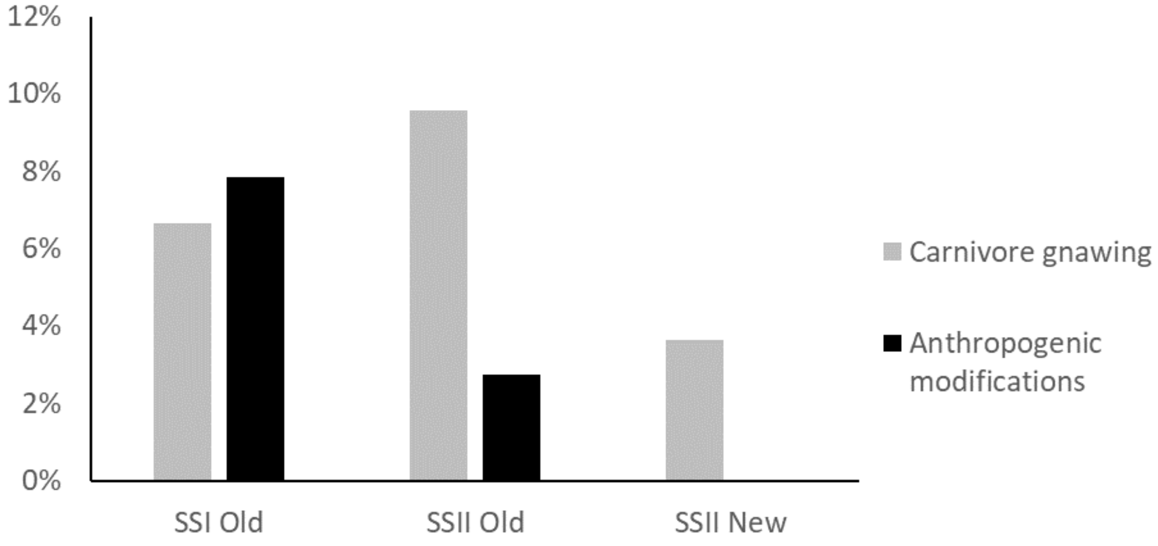


Figure 4.8 Relative frequency of carnivore gnawing and anthropogenic modifications based on bone NSP in the faunal assemblages of Schafstall I and II

Cutmarks represent the most common anthropogenic mark identified on bone specimens and may be linked to butchering or skinning of animal carcasses. These two types of activities may be differentiated based on the anatomical position of the marks when recurring patterns of bone modification are accounted for within an assemblage (Binford, 1981). However, at Schafstall I the small size of the assemblage and the high fragmentation of the remains did not allow us to recognize clear patterns related to butchering or dismembering. The only identifiable fragments bearing cutmarks are a horse scapula and a red deer tibia (see Appendix, Tables 6.5, 6.6 and 6.7). Impact marks in the form of crushed bone surfaces were recorded on few horse limb bones and on a bison or aurochs scapula fragment, while cone fractures possibly related to bone breakage for marrow extraction were assessed on a horse long bone element, two cervid metapodials and on a chamois tibia that was split open longitudinally to its axis (Plate VI, Fig. d).

Despite the small absolute number of modified remains, it was possible to identify a collection of fifteen bone retouchers predominately on large ruminant size long bone fragments. These will be treated separately in more detail in the following section, but in relation to the present discussion on the different types and significance of anthropogenic marks, it is interesting to note that at Schafstall I most scraping marks occur in association with retouch marks. Experimental work on bone tools has shown that such practice most likely has the aim of removing the slippery periosteal sheath from the bone surface in order to prepare the working area of the retoucher (Vincent, 1993).

	SSI Old		SSII Old		SSII New	
	N AM	% BoneNISP	N AM	%BoneNISP	N AM	%BoneNISP
Taxon						
Vulpes sp.			1	2%		
Ursus speleaus			28	6%	1	<1%
M. primigenius			1*	100%		
Equus sp.	4	9%	10	26%		
R. tarandus			3	9%		
Cervidae	3	27%	1	25%		
Bos vel *Bison*	1	17%				
R. rupicapra	1	11%				
Caprinae			1	50%		
Size class						
medium carnivore/small ungulate size	3	9%				
large carnivore			1	2%		
small ungulate			1	20%		
medium ungulate size	14	16%				
large ungulate	2	22%	2	11%		
large ruminant	20	40%	2	25%		
fox/hare size			2	2%	1	<1%
horse/bear size	9	4%	36	5%	2	<1%
unidentifiable	3	2%	23	1%	1	<1%

*mammoth specimen with modification corresponds to an ivory fragment and was included in the count

Table 4.18 Number of specimens and percentages of bone NISP with Anthropogenic Modifications (AM) in the faunal assemblages of Schafstall I and II. N indicates the number of modified specimens, not the absolute number of modifications

Given the high frequency of retouchers on large ruminant size remains, this category is the most affected by anthropogenic modifications. At a more specific level, cervids and large bovids exhibit the highest proportions of anthropogenic modifications (Fig. 4.9). I here refer to taxonomic family instead of species, because the small average size of the bone fragments did not allow us in most cases to identify the cervid and large bovid remains to species level.

While human activities at Schafstall I seem to be mostly connected with ungulate consumption and exploitation, the area of Schafstall II also contains evidence for interaction with carnivores and cave bears. One fox mandible and several cave bear mandibular fragments display cutmarks on the lingual side that were presumably produced during tongue removal. Of all identified species bearing anthropogenic modifications, cave bear presents the highest number of cutmarks (Table 4.18) on the widest array of elements. Cutmarks were recorded on ribs as well as on the appendicular skeleton, in particular on hind limbs and on feet elements (Fig. 4.9). The latter include metapodials and phalanges that were probably cut

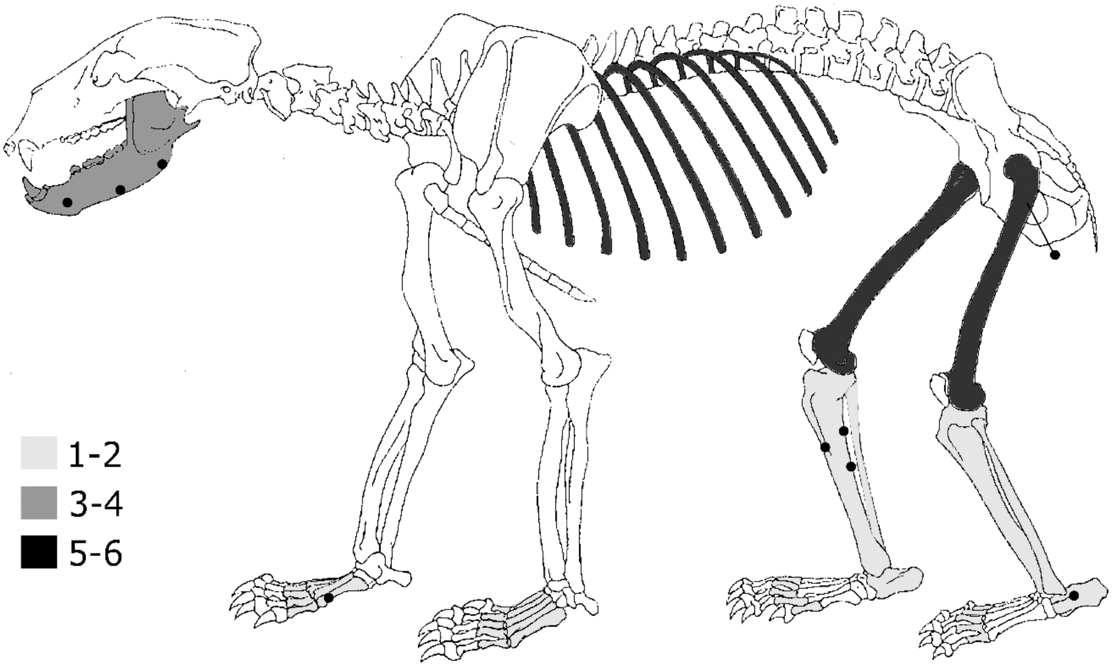


Figure 4.9 Location and number of anthropogenic modifications on cave bear remains from Schafstall II, old and new excavation combined.

while skinning. Ribs and femoral shafts display the highest cutmark frequencies likely associated with butchering and removal of meaty parts. Aside from cutmarks, impact marks and cone fractures were also observed on several femur and tibia fragments. Perhaps some of the percussion marks recorded on these elements derive from the production of bone blanks for retouchers as suggested by the finding of two retouchers on femur fragments and one on a tibia shaft. A rather singular piece is a cave bear canine bearing retouch marks on the root portion. Like for Schafstall I, retouchers are quite common, but hominids exploited different taxa for the preparation of bone blank, using horse remains in addition to cave bear. These two taxa show the highest degree of damage inflicted by hominid activities as anthropogenic modifications on other species, such as reindeer and caprines, are very infrequent due to the paucity of their remains (Fig. 4.10). In particular. caprines are very rare and out of two identified specimens, one carried cutmarks**.**

Despite the very low proportion of anthropogenically modified remains, the old assemblage of Schafstall II barely compares with that of the new excavation which is almost completely devoid of human-modified bones. Cutmarks were observed on only five bone fragments, two of which were recovered from the underlying layers of Peters´ excavation trench. The only identifiable specimen consists of a cave bear mandible from the so called "Hangfazies", an unstratified horizon containing mixed deposits probably of colluvial origin. The large variation in anthropogenic mark frequency between the old and new excavation is striking and seems to corroborate evidence for differences in the spatial distribution of remains at Schafstall II. As noted previously, the faunal composition of the old and newly excavated assemblages is markedly different, with birds, hares and ungulates being considerably underrepresented in the new excavation. The difference in taxonomic structure is further evidenced by the lack of mammoth remains from the layers of the new test trench compared to the area of the old excavation. Besides an ivory fragment with cutmarks (Plate VIII, Fig. f) from the old assemblage excavated by Peters, several mammoth teeth fragments were recovered during the recent re-excavation of the old excavation trench from GH 4p and GH 5p.

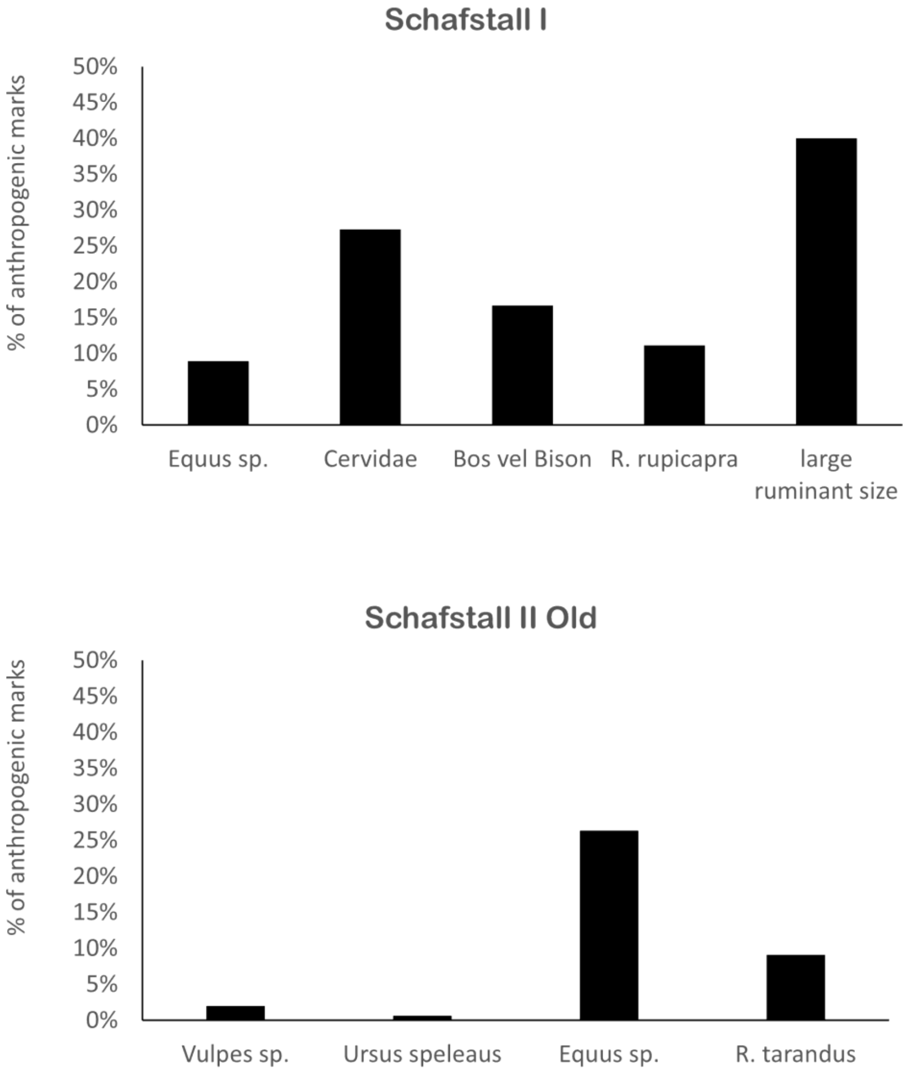


Figure 4.10 Relative frequency distribution of anthropogenic marks on the mammalian taxa of Schafstall I and II

All in all, the taxonomic and taphonomic signatures of Schafstall I and II suggest that hominids carried out different types of activities in the two areas. On one hand, the abundance of ungulate taxa with cutmarks at Schafstall I is indicative of butchering and processing of hunted game (Fig. 4.11) On the other hand, the old assemblage of Schafstall II contains mostly evidence for cave bear exploitation and the proportion of cave bear bones with cutmarks is remarkably greater than that of ungulates (Fig. 4.11).

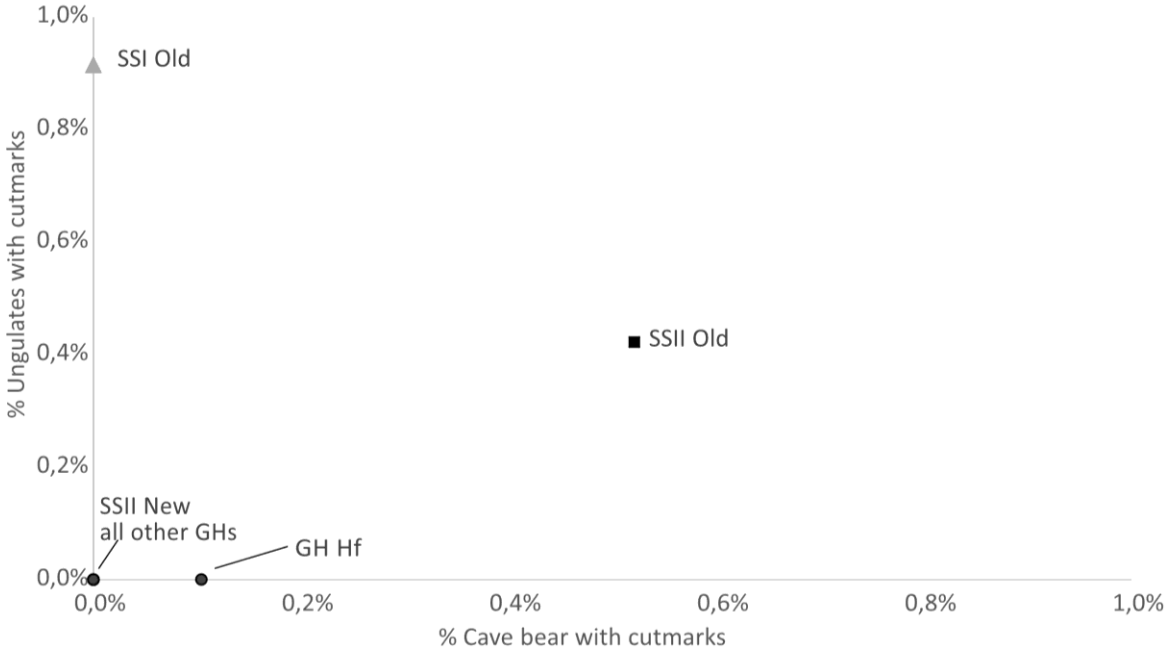


Figure 4.11 Comparison between percentages of cutmarks on cave bears and ungulates from the old excavations of Schafstall I and II and the new excavation of Schafstall II. Percentages are calculated out of total bone NSP.

By contrast, the faunal record of the new excavation holds hardly any evidence of human occupation. Besides the considerably low cutmark frequency, lithic artefacts are also distinctly less numerous compared to the old excavation. Reasons for this spatial differentiation may be sought in the topography of the site. In fact, the new test trench is located close to the edge of the escarpment and the northernmost quadrants of the excavation are exposed to rain wash and soil erosion. That these quadrants were majorly affected by the input of unconsolidated colluvial sediments is supported by the unstratified and poorly sorted deposits of GH Hf, a localized geological horizon, restricted to the northernmost area of the excavation, with a considerable vertical extension spanning a large part of the stratigraphic sequence. The vertical interface between GH Hf and GH 2a to GH 3 probably marked the drip line of the cave before its roof collapsed leaving the interior rock wall exposed. The bone assemblage from the recent excavations derives either from the outer area of the cave (GH Hf) or from the stratified interior area at its threshold (GH 2a to GH 6), which was probably less intensely occupied by hominids compared to the inner area next to the rock wall excavated by Peters. Hence, intra-site differences in bone assemblage formation may relate to hominid behaviour as well as erosional and depositional processes obliterating the record. The study of geomorphological processes active in the Lauchert Valley during the Middle and Upper Palaeolithic would be beneficial in integrating the picture provided by the archaeological record.

4.4.3 Bone retouchers

As scanty as the archaeological evidence may be at Schafstall, both areas of the site yielded a number of bone tools that were identified among the bone materials collected during the old excavations. Retouchers are the most common artefact type found at both Schafstall I and II and are generally interpreted by researchers as tools used for flintknapping. Their identification as such became widespread at the beginning of the 20th century following the work of French archaeologist Henri Martin (1906, 1907), who first postulated their use in stone tool production as hammers, “maillet”, or anvils, “enclume”. As more of these finds came to surface, research around them intensified and scholars began to debate around the ways these tools were used and adopted the term “retouchoir” (Capitan and Peyrony, 1912, 1928; Cotte, 1917) to designate them. The use of osseous tools for shaping stone artefacts was also known to Peters (1936b), who identified four retouchers at Göpfelstein and nineteen at Schafstall I, which he ascribed to the Mousterian.

Despite their classification as tools, I prefer to make a further distinction by defining them as “expedient tools” or “informal tools” *sensu* Andrefsky (1994) in that they require minimal investment of time and effort in production, they have an unstandardized shape, are made on abundant and easily accessible material and are generally discarded after use.

Retouch marks are very distinctive and often appear in high concentrations on small localized areas of bone fragments corresponding to the work surface or use area of the tool (see Mallye et al., 2012). They are quite variable and may take the form of short clear-cut linear marks, trihedral impressions or pits, and widespread chipping or scales, when negative impressions are left by the detachment of small plaques of bone from the cortical surface (*sensu* Mozota Holgueras, 2013).

Several retouchers have been found in the Middle and Upper Palaeolithic cave deposits of the Swabian Jura. Unsurprisingly, most of them pertain to the Upper Palaeolithic, which, as the archaeological evidence suggests (Conard et al., 2006), was characterized by higher population densities reflected by increased intensity of occupation of cave sites compared to the Middle Palaeolithic. In a recently published article (Toniato et al, 2018), we attempted to compare the evidence for retouchers from different sites of the Swabian Jura in order to check for diachronic changes in their production and utilization. Our study takes into account most of the bone retouchers from Schafstall I (Plate VII), attributed by Peters to the Middle Palaeolithic. The retouchers from Schafstall II are not included because, at the time of our study, the bone assemblage had not yet been analysed. In the meantime, two of the studied retouchers from Schafstall I have been dated. One of them (ETH 95106) yielded a younger date than expected, between 39,993 and 38,859 calBP (95% peak), which falls in the chronological range of the Aurignacian. Thus, not all retouchers from Schafstall I originate from Middle Palaeolithic layers and, rather than there being evidence for a transitional industry, as put forward by Peters, it seems that the Upper Palaeolithic horizons were not clearly recognized at the time of his excavation.

The retouchers of Schafstall I (Plates X, XI) are on bone shaft fragments that are too small to be clearly identified. At a macroscopic level they seem to pertain to a large sized ruminant given the absence of cancellous bone and the smoothness of the medullary cavity. However, the possibility that the smoothness was conferred by post-depositional processes and that the bones belonged to horse or bear, which usually have a lot of spongy tissue in their medullary cavities, should not be ruled out. Considering that all other remains identified to species level bearing cutmarks and other anthropogenic modifications belong to ungulates and not to cave bear, it is highly likely that the retouchers were made on large ungulate bones.

By contrast, most of the retouchers of Schafstall II (Plates X, XI) were identifiable to species level and show similarities in taxa selection with the Aurignacian retouchers of Hohle Fels and Vogelherd (Taute, 1965; Toniato et al., 2018), as there are several retouchers on horse and bear elements, including a retoucher on a cave bear canine (Plate XI).

Another interesting observation is related to the orientation of retouch marks, which differs between Schafstall I and the other sites of the Swabian Jura. In general, marks are predominately transverse and oblique to the main axis of the retoucher, but at Schafstall I oblique marks, when present, are all inclined upwards to the right (Plate VII, Fig. c), while at all other sites, including Schafstall II, oblique marks are primarily oriented in the opposite direction. While some authors associate variation in mark orientation is with handedness (Semenov, 1964; Uomini, 2011), we also took into account the ways of using retouchers proposed by Taute (1965) and posit that these traces may also result from the application of different techniques and the active or passive use of retouchers in lithic tool manufacture (see Toniato et al., 2018).

4.4.4 Skeletal completeness and body part representation

The taphonomic histories of the assemblages discussed so far provide an interpretive framework for the analysis of skeletal completeness and body part representation, which was carried out by comparing the minimum number of elements (MNE) for each anatomical region of a specific taxon. With "anatomical region" I intend a specific set of skeletal elements that may be looked upon by human and non-human predators as distinct structural and nutrient packages. MNE counts were collapsed in nine anatomical regions, following an approach proposed by Stiner (1994; Stiner et al., 2005), which distinguishes between horn/antler, head, neck, axial column, upper front limbs, lower front limbs, upper hind limbs, lower hind limbs and feet. This method has the advantage of circumventing potential analytical problems deriving from the loss of low density bone elements or from differential identifiability of single bone elements because each anatomical region comprises several skeletal elements with different bone density values. Raw MNE values were estimated for each skeletal element, then all MNE values accounting for one anatomical region were summed together and finally standardized against the expected number of elements given for that region in a complete skeleton of the taxon under study. The use of standardized MNE values allowed to make comparisons between different taxa and taxonomic groups. Carpal and tarsal bones with the exception of the calcaneum and astragalus were excluded from the MNE calculation of anatomical regions because, due to their high bone mineral density, they tend to be overrepresented in archaeological assemblages.

The strong dominance of cave bear coupled with the little evidence for human activity at Schafstall II suggest that most of the bear remains derive from individuals that perished during hibernation at the site. This is partially substantiated by the good representation of all anatomical regions, even ones which are more susceptible to attrition and tend to be preferentially targeted by carnivores, e.g. the axial and neck parts (Blumenschine, 1986; Marean et al., 1992). Even though teeth were excluded from MNE calculations, the head is the best represented anatomical region (Fig. 4.13). In the newly excavated assemblage, head elements are also markedly predominant.

Head dominated patterns have been documented at other cave bear hibernation sites, such as Yarimburgaz Cave in Turkey (Stiner et al., 1996) and Goyet Cave in Belgium (Germonpré & Sablin, 2001) (Fig. 4.12). The site of Yarimburgaz was occupied ephemerally by hominids during the Lower Palaeolithic and contains abundant evidence for its repeated use as a bear den. Despite the high degree of gnawing damage, the general preservation of bear remains is good and enabled the development of an age-scoring technique (Stiner, 1998). Similarly, the Late Pleistocene bone horizon 4 in Chamber B of Goyet Cave yielded a very large number of excellently preserved bear remains that have been interpreted as part of a bear death assemblage (Germonpré and Sablin, 2001; Germonpré, 2004) comprising mostly female individuals and their cubs. At both sites head elements are strongly represented. Values for all other anatomical regions compare poorly, with limb elements at Goyet accounting for a considerably lower number of body portions compared to Yarimburgaz and neck, axial and feet elements being strongly underrepresented. Surprisingly, at Yarimburgaz feet elements are much more numerous than at Goyet and axial and neck elements are proportionally greater despite the high impact of carnivore damage, suggesting that other taphonomic agents may have played a role in the removal of elements from the assemblage. When summed up, these differences in anatomical representation weigh on the strength of association between the profiles of the two assemblages, which show a weak correlation to one another (N=8, τ_b =0,357, p=0,216). Bear body part representations for Schafstall II, where carnivore damage is rare, compare best with those of Goyet (N=8, τ_b =0,786, p=0,006), though similarities in body part representation also exist between the bears from the new excavation of Schafstall II and those from Yarimburgaz (N=8, τ_b =0,571, p=0,048). Both the old and newly excavated bear remains present a strong positive correlation with the anatomical profile of Goyet (N=8, τ_b =0,786, p=0,006). Naturally, intra-site comparisons of anatomical profiles are always risky and must take into account site-specific taphonomic biases. Furthermore, data on skeletal element representation of cave bears at hibernation sites is often difficult to retrieve due to the broad range of analytical methods employed by zooarchaeologists in quantifying abundances of mammalian taxa (e.g. MNE, bone weight, MNI) as well as differences in the way analytical indexes are determined by individual researchers. Despite these issues, the general

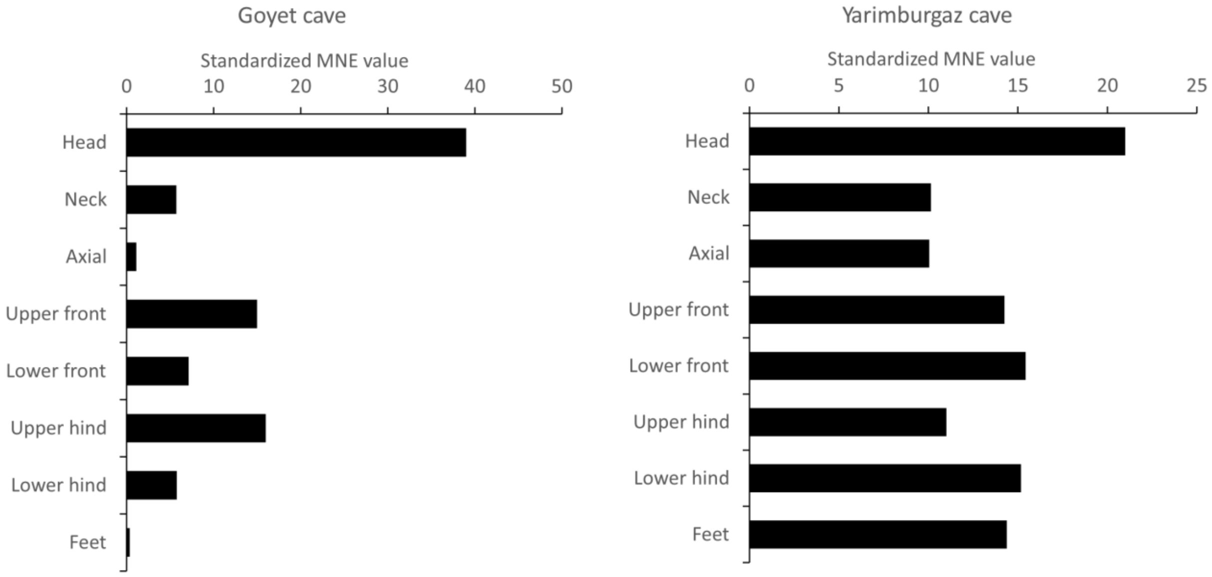


Figure 4.12 Comparison between anatomical representations of cave bear based on standardized MNE values from the den assemblages of Goyet Cave in Belgium and Yarimburgaz Cave in Turkey. Data taken respectively from Germonpré & Sablin, 2001 and Stiner et al., 1996

overrepresentation of head bone elements at different sites seems worthy of consideration. Though bone density values for ursids are so far unavailable, mandible density values for other taxa, including ungulates and canids, are generally medium to high, meaning that mediated attrition might play a major role in the differential preservation of body parts and especially of head elements. Another factor to be considered is the inter-taxonomic identifiability of different skeletal elements as cranial elements of bear have numerous diagnostic traits that make them more easily identifiable than, for example, femur shaft fragments, though this problem should be partially compensated by grouping skeletal elements in anatomical regions.

At Schafstall I, head parts are not so frequent and upper front and hind limb elements are more common, whilst axial and feet remains are very few. The low abundance of vertebral and rib elements is most likely explainable by their low bone mineral densities, which make them more prone to the effects of attrition. Given the similarities in the anatomical representations of cave bear at Schafstall II and Goyet and the low degree of taphonomic alteration in both assemblages, I attempted to compare these two assemblages to that of Schafstall I, where the incompleteness of the assemblage and the small size of the study sample might have majorly affected body part representation. Whilst considering the effects of taphonomy and density mediated attrition mentioned earlier on and the fact that repeated use of cave sites by bears is known to cause significant spatial damage and dispersal of skeletal elements (Camarós et al., 2013, 2017), we would expect cave bears to have a similar body part representation also at Schafstall I if their deaths occurred naturally and hominid activities or other factors, such as selective recovery or incompleteness of the assemblage, did not considerably alter the record (Fig. 4.13). Kendall´s tau correlation coefficient evidences a strong relationship between bear skeletal part representations at Schafstall I and II for both the old (N=8, τ_b =0,618, p=0,034) and the new assemblage of Schafstall II (N=8, τ_b =0,764, p=0,009). Likewise, the bear skeletal parts of Schafstall I reveal a significant association with those of Goyet (N=8, τ_b =0,618 p=0,034), meaning that overall the bear bone assemblage of Schafstall I is similar to what we would expect to find at a site where bears died during their winter rest and that the original signature of the assemblage was not drastically altered by taphonomic agencies, such as hominid or animal activities, or by the partial loss of the excavated finds. Similarly, we can also expect the herbivore assemblage to give us a roughly representative picture of the original depositional patterns at the site. Herbivore remains at Schafstall I are not very numerous but are the only taxonomic category bearing traces of human activities. The anatomical profiles of horse and cervids are the most uniform and complete (Fig. 4.14), with spongy low-density axial and neck elements being either underrepresented or completely missing. Among cervids, the proportions of limb bones are evenly distributed, and antler parts are most frequent despite the total absence of head elements (Fig. 4.14). Given the very small sample size and the fragmentary condition of the

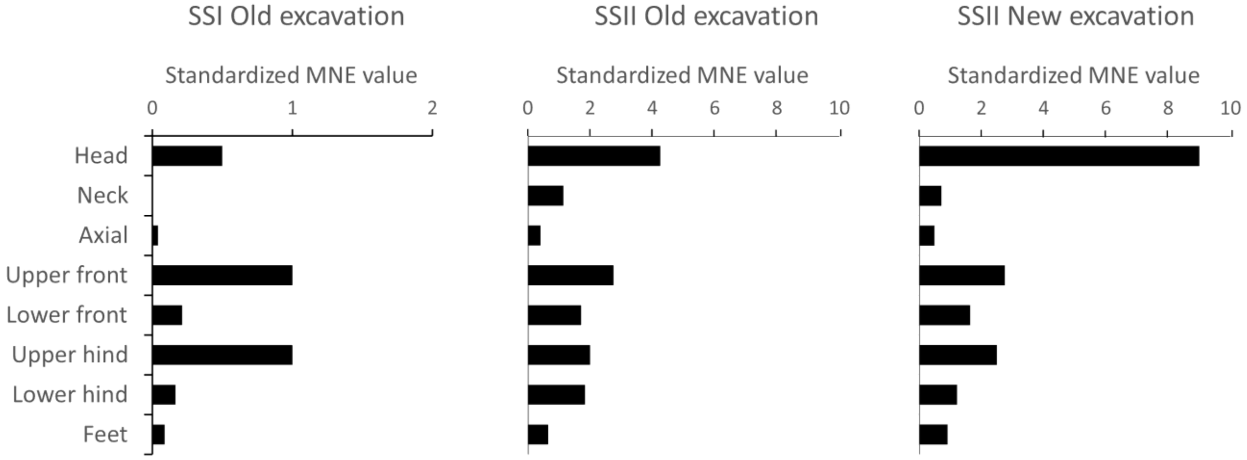


Figure 4.13 Anatomical representation for cave bear from the old and newly excavated assemblages of Schafstall I and II. Note that the fibula is included in the Lower hind element count and that caudal vertebrae are not considered. The expected number of second phalanges is equivalent to 16 and differs from the model proposed by Stiner (1994).

assemblage, we cannot assume that this relates to specific behavioural choices adopted by hominins and is not an artefact of taphonomic or post-excavation bias. By contrast, horse skull parts are present but do not outnumber limb bones, which are again among the best represented anatomical regions, in particular the hind limbs, which have high structural density values.

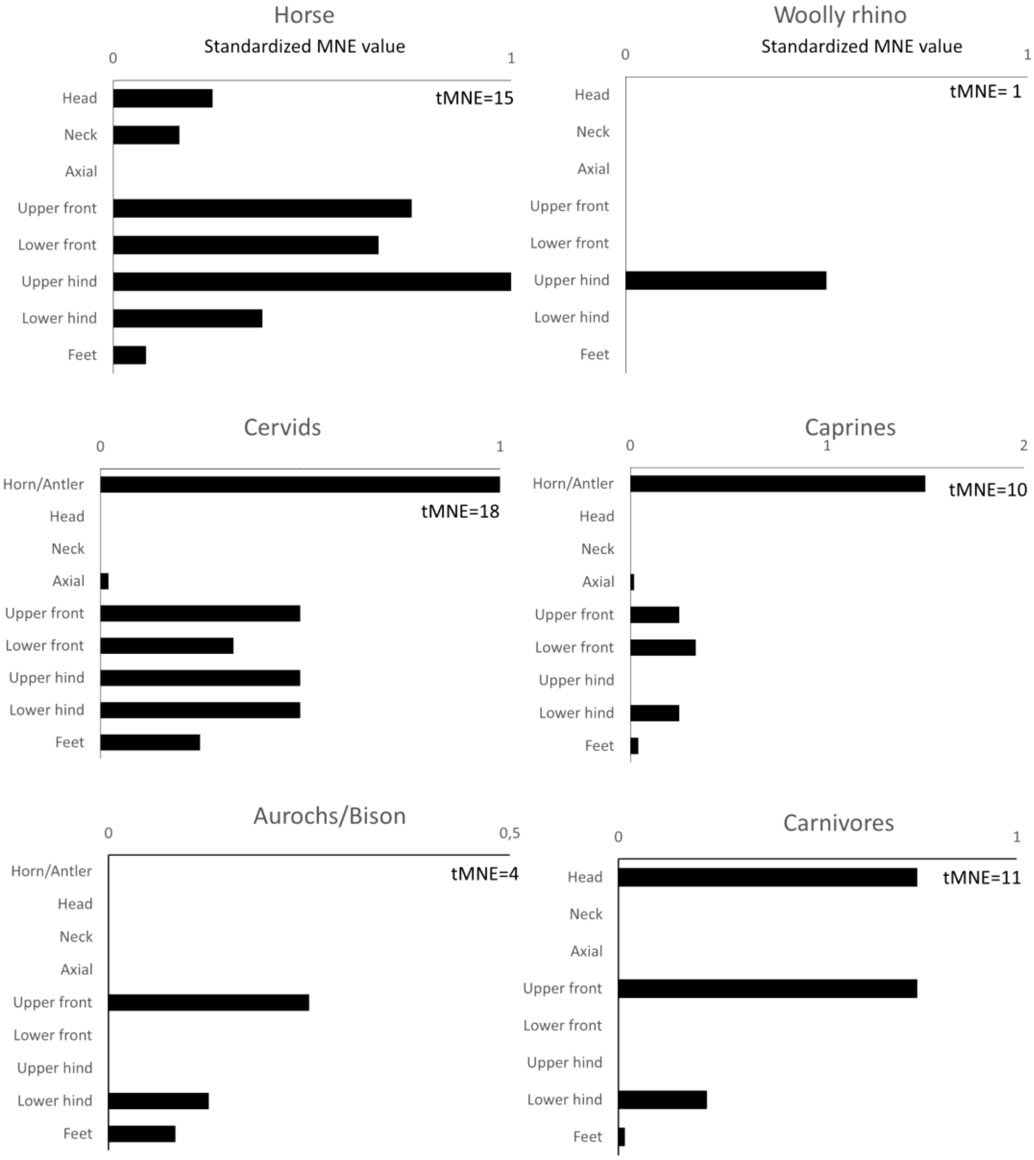


Figure 4.14 Anatomical representations for ungulate species from the old excavation of Schafstall I

Woolly rhino and bovid remains are generally very scarce. Apart from several tooth fragments, the woolly rhino is represented by only one femur fragment of a possible juvenile. The occurrence of juvenile remains at Schafstall I is also testified by a lower deciduous fourth premolar (D_4). The bovids comprise caprine and aurochs/bison bone remains. Horns constitute the most common element among the caprines, while all other body regions appear to be underrepresented (Fig. 4.14). The evidence for aurochs/bison is limited to few bone elements pertaining to the foot and upper front and lower hind regions. Interestingly, the body part representation of carnivores shows a very similar pattern, with the only difference that head elements are also present (Fig. 4.14). However, the scarcity of remains does not permit a reliable interpretation of the etiology of these patterns. In general, the low incidence of carnivore remains probably reflects the periodical presence of predators at the site and might be associated with episodes of scavenging or inter- and intra-specific aggression triggered by food and/or sexual competition.

Moving on to Schafstall II, ungulate body-part representations for the old and new assemblages are strikingly different to one another and overall, the ungulate profiles of the old assemblage of Schafstall II compare better against those of Schafstall I. The reason for this is that in the new assemblage, herbivores, except for reindeer, are almost completely absent. At Schafstall II, cervids, which include primarily reindeer, are the dominant ungulate taxon and their remains account for most body parts (Fig. 4.15). As with Schafstall I, cranial and mandible elements are missing, while antler remains are only observed in the newly excavated fauna (Fig. 4.15). Considering that in both the old and the new assemblages, cervid teeth are very few, we can surmise that head parts were either usually not transported to the site or they were secondarily removed. While horse is fairly well represented in the old assemblage (Fig. 4.15), hardly any bone elements were found during the new excavation (Fig. 4.16). The same pattern is also evidenced for other ungulate taxonomic categories, such as caprines and aurochs/bison. A possible explanation for this, as discussed previously, can be sought in the different horizontal distribution of the bone finds possibly associated with the prevalent use by hominids and carnivores of the area of the site closer to the rock face as well as the action of colluvial processes on the outer and more exposed area corresponding to the new excavation.

Among the ungulates, several remains of woolly rhino consisting mostly of head and foot elements were also identified. Worthy of mention is the finding of an almost complete right hemimandible of a juvenile. Most of these bone remains display heavy gnawing damage from carnivores. Additionally, since scavenging by carnivores is often associated with a bimodal distribution of anatomical regions skewed towards head parts and foot elements (Stiner, 1994, 2004), much like that recorded for woolly rhino, it is reasonable to assume that predators also had a role in the accumulation of some of the herbivore remains at Schafstall II. Furthermore,

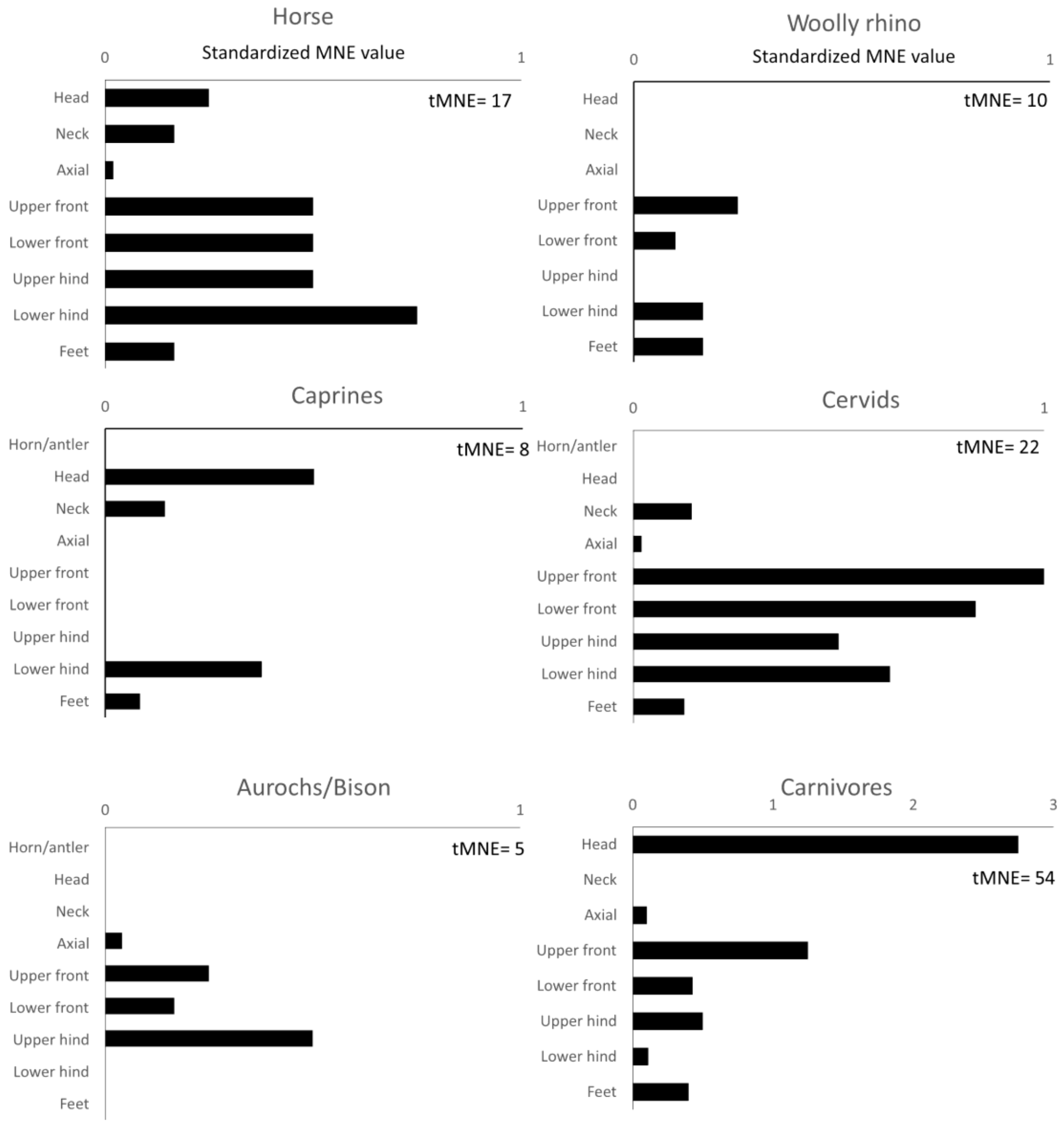


Figure 4.15 Anatomical representations for ungulate species from the old excavation of Schafstall II

age determination based on the epiphyseal fusion of long bone elements (Shpansky, 2014) and on the eruption and wear stages of teeth (Louguet, 2015) indicate that most of the identifiable remains from the new excavation pertain to a juvenile aged between 1.5 and 3 years. Given that all the woolly rhino remains, except for one tooth recovered from GH 6p, were found in the upper horizons of the excavation (GH 2, 2a and Hf) and at a similar elevation, it is highly likely that they belonged to the same individual and were brought on site by carnivores. Radiocarbon dating results on one of the metapodials provide information on the timing of their deposition, which occurred between 31,828 and 31,219cal BP.

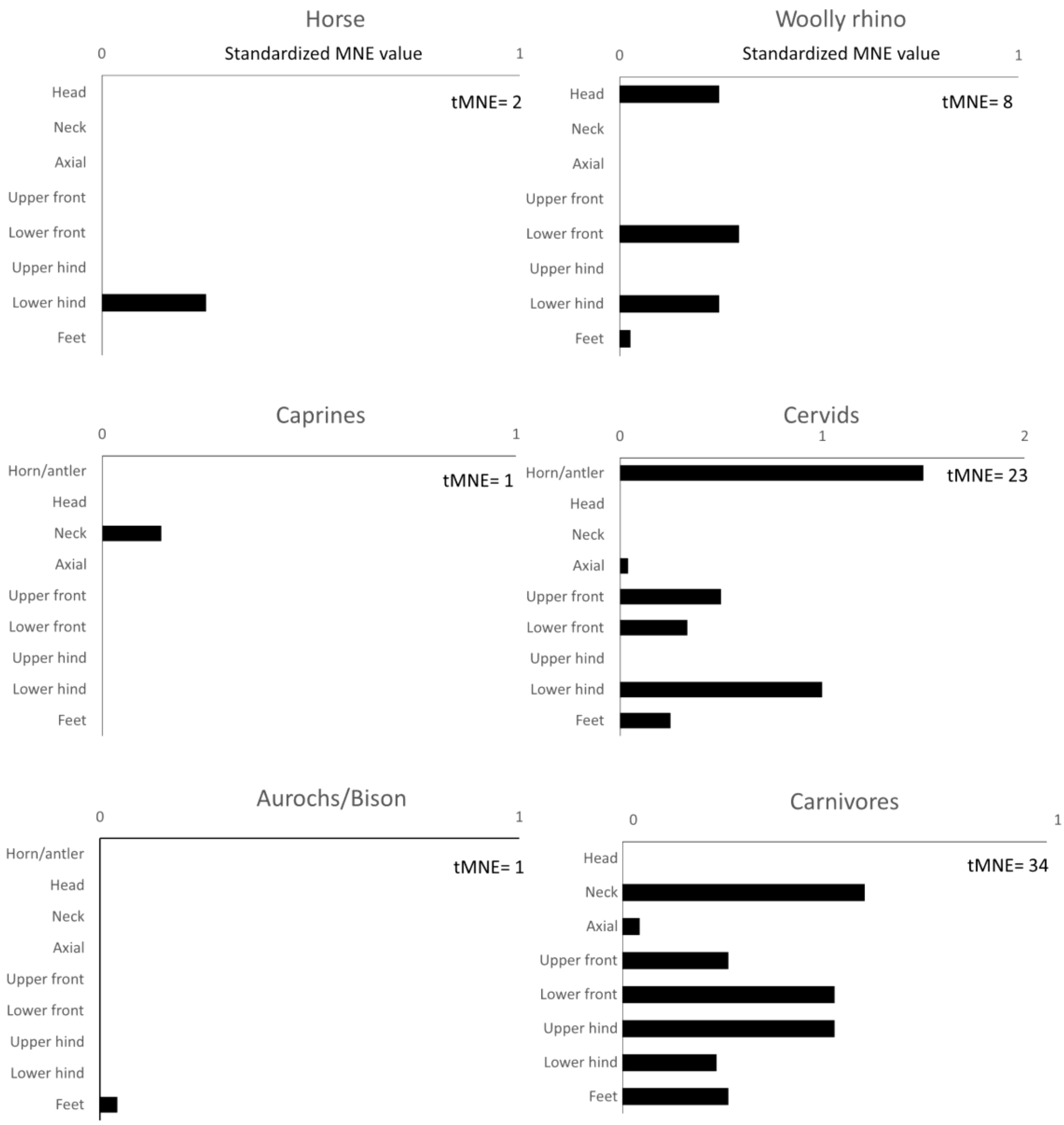


Figure 4.16 Anatomical representation for ungulate species from the new excavation of Schafstall II

4.5 Piecing together the archaeological evidence of Schafstall II

So far, I have analysed and considered the faunal evidence of Schafstall in its entirety in order to outline the processes of assemblage formation and the agents therein involved. The comparison between the different bone assemblages recovered during the old and new excavations ultimately allowed to highlight differences in site use between the two areas of Schafstall. However, while the meagre and unprovenanced archaeological evidence from Schafstall I offers a faded and patchy picture of the site's history, which the results of the new investigations could not integrate, the availability of adequate stratigraphic data from the recent re-excavation of Schafstall II made it possible to glean more insight in the ways hominids occupied this part of the site. Though appreciable differences in the spatial distribution of the finds between the two excavated areas of Schafstall II prevented the complete reconstruction of the stratigraphic sequence and hence, of the spatiotemporal position of the remains recovered by Peters, the large body of information available enabled to assess more accurately the nature and intensity of hominid activities illustrated in more detail in the following sections.

4.5.1. Intensity of hominin activities

One way of assessing variation in the intensity of site occupation is by measuring and comparing lithic artefact densities throughout the stratigraphic sequence. This procedure however, is not alone sufficient and needs to be integrated and contextualised against all other types of archaeological information available in order to accurately interpret occupational patterns. So far, I have only marginally considered the lithic assemblage of Schafstall II. In contrast to all other sites of Veringenstadt, for which an unquantifiable number of archaeological finds has gone missing, Schafstall II holds the most complete archaeological record. Schumacher (2014), who analysed the lithics from the old excavation, reported a total of 320 artefacts, of which about two thirds consist of small debitage debris. The size and composition of the assemblage are consistent with those of the finds recovered during the recent excavation comprising mostly small flakes and microflakes and very few diagnostic artefacts. Considering that no documentation of the excavation methods exists from the time of Peters, lithic find densities were calculated only for the new excavation and may be regarded as an indirect indicator of occupation, proven that post-depositional mixing and taphonomy have not moved them from their original context. No such evidence was documented during the recent re-excavation and though it cannot entirely be excluded that the deposits were partially reworked, this should not have greatly affected the assemblage judging from the progressive increase of age with depth of the radiocarbon dated bone samples.

The highest lithic density values were observed in GH 2a (Table 4.19), which represents the thickest horizon in the new excavation trench. In specific, the largest concentration of artefacts relative to sediment volume was recorded in GH 2c, a very thin horizon localized in the western perimeter of the excavation and interpretable as a subunit of GH 2a. Values decrease gradually from the upper to the lower layers, in particular from GH 3 through to GH 6. In the area of the old excavation, the density of lithics recorded in GH 2ap to GH 5p is also appreciably high (Table 4.19), especially considering that much less sediment was removed. Once again, this increases the evidence for the differential horizontal distribution of archaeological finds between the inner and outer areas of the site.

GH	Sediment volume (l)	N of lithics	Lithic find density (n/m^3)
1	524	0	0
2	2923	18	6
2a	4171	52	12
2b	956	1	1
2c	19	7	368
3	466	3	6
4	1256	1	1
5	297	2	7
6	279	0	0
Hf	1321	12	9
2ap	51	0	0
3p	261	2	8
4p	223	11	49
5p	36	0	0
6p	12	1	83

Table 4.19 Lithic find density (n/m3) by geological horizon in the new excavation of Schafstall II

The vertical distribution of the finds also provides valuable insight to potential patterns of association between stone artefacts and different mammalian taxonomic categories. To this end, I compared lithic artefacts and faunal abundances expressed as NISP across the stratigraphic units of the new excavation by using Pearson's correlation coefficient (Table 4.20). All mammalian groups display strong positive correlations to one another. Notably, carnivores show the strongest correlations with cave bear and herbivore remains, and the latter two are also strongly correlated with one another. A strong association is also observed between stone artefacts and cave bear and non-ursid carnivores albeit at a lower level of significance. Such patterns contrast sharply with the very weak correlation existing between lithic tools and herbivore remains and suggest that hominids might have contributed in small measure to the accumulation of ungulate remains at the site. Rather, it is highly probable that carnivores were the main collectors of ungulate body parts. The strong correlation with cave bear remains also suggests that carnivores regularly visited the site in winter periods and may have actively predated on dormant bears or scavenged the remains of those which did not survive the cold season. Bear carcasses may have attracted opportunistic predators to the site

	Lithic artefacts	Ungulates	Cave bear	Carnivores
Lithic artefacts	–			
Ungulates	0,352[a]	–		
	0,318[b]			
Cave bear	**,643***	**,842****	–	
	0,045	0,002		
Carnivores	**,745***	**,862****	**,908****	–
	0,013	0,001	0	

Number of geological horizons = 10 (GH1-Hf: new test trench)

	Lithic artefacts	Ungulates	Cave bear	Carnivores
Lithic artefacts	–			
Ungulates	0,808[a]			
	0,098[b]			
Cave bear	0,264	0,063		
	0,668	0,92		
Carnivores	-0,307	-0,736	0,358	
	0,616	0,156	0,554	

Number of geological horizons= 5 (Gh2ap-6p: layers below Peters' trench)

Table 4.20 Pearson correlation matrix of the abundance of lithic artefacts, ungulates, cave bear and other carnivores (NISP) across geological horizons in the new excavation of Schafstall II. [a] Correlation coefficient [b] p value *Correlation is significant at the 0,05 level (2-tailed) **Correlation is significant at the 0,01 level (2-tailed)

fuelling episodes of violence and intra-specific aggression that could have led to the death and deposition of carnivore remains. At the same time, hominid activities appear to be sporadic and are poorly associated with ungulate processing but are perhaps more oriented to the exploitation of cave bear as supported also by the range of anthropogenic modifications documented on bear bones. Specific information on the different types of modifications and on hominin interactions with cave bears are presented later in this chapter.

Marked differences were once more observable between the new test trench and the small portion of the old excavation located next to the rock wall. There were no significant correlations between stone tools and any of the mammalian categories. The largest discrepancy was evidenced by the negative association between carnivores and ungulates in the area of Peters' excavation (Table 4.20), although the number of remains is too small to consider the statistical data as truly representative of occupational patterns.

When the results of Schumacher’s study are also taken into account, the overall picture that emerges is that the lithic assemblage of Schafstall II reflects a different archaeological signal compared to Schafstall I. In fact, Schumacher (2014) found that there were more similarities between the lithic assemblages of Schafstall I and Nikolaushöhle than between those of Schafstall I and II. The most notable differences concern the raw material choice and the methods employed in tool production. While at Schafstall I and Göpfelstein a wide variety of raw materials are represented, the lithic assemblage of Schafstall II is dominated primarily by high-quality grey Jurassic chert, which is otherwise only found at Nikolaushöhle.

Even though the assemblage from the old excavation of Nikolaushöhle was entirely missing, Schumacher was able to draw parallels with Schafstall II on the basis of a very small collection of finds gathered in the ´50’s by a local amateur. Among these finds, he also discovered the presence of an artefact that refitted with one of the lithics of Schafstall II and so demonstrated the close temporal association between the two lithic assemblages. Schumacher also observed that the lithic assemblage of Schafstall II completely lacked the carinated forms and bladelet cores found at Schafstall I and Göpfelstein, and believed that this trait combined with the presence of endscraper blades and splintered pieces suggests a close resemblance to the Upper Palaeolithic technology represented in AH II of Geißenklösterle described by Hahn (1988). Conversely, the lithic assemblages of Schafstall I and Göpfelsten were, in his view, comparable with those from the older layer of AH III of Geißenklösterle.

The results from the recent re-excavation offer a more nuanced picture and show that the chronostratigraphic sequence of Schafstall II spans a broad time range, which encompasses multiple occupational events that assumedly took place in the Middle and Upper Palaeolithic. This is testified by the different age results obtained by radiocarbon dating of anthropogenically modified bone remains and by the nearly ubiquitous, albeit scanty, presence of lithics across the entire sequence. In the absence of any type of contextual information from the old excavations, one can easily, and perhaps inevitably, begin to look at the old assemblages as a single archaeological unit. However, the faunal data so far presented indicates that hominids carried out different types of activities at Schafstall, that were mainly directed towards the modification of ungulate remains at Schafstall I, and the procurement of cave bears at Schafstall II. The small size of the lithic assemblage of Schafstall II could therefore not only reflect short-term occupation episodes which produced few tools and common types of debris, but also partially reflect the variability of subsistence activities in the different areas of Schafstall.

4.5.2. Cave bear ecology and interactions with Pleistocene humans

Because of their habit of using caves as hibernation dens, cave bears are the most frequently found species in the pre-LGM Swabian cave deposits. Most of the skeletal remains encountered in this type of context result from the natural death of bears due to starvation, old age, disease or inter- and intra-specific violence and competition during the time of winter hibernation. The reconstruction of bear denning habits from palaeontological assemblages is made possible by the combination of multiple ageing and sexing methods. In this regard, mortality profiles based on tooth eruption sequences and wear stages are a reliable indicator of age structure within a bear death assemblage. In fact, bone accumulations from cave bear dens are typically characterized by attritional or U-shaped mortality patterns distinguished by the abundance of juvenile and/or old adult remains, the most vulnerable age groups. given Mortality data is often combined with sex ratio patterns, usually obtained from morphometric analyses of specific skeletal elements, in order to reconstruct the population structure of the bears that lived and died at a certain site. However, when using this aging and sexing data one must remember that the signal provided is a reflection of the death assemblage rather than the living population at any given time. So, to deduce offhandedly age and sex composition of a biological population of ancient bears which lived at a site from their bone remains would be inaccurate and misleading. Rather, the body of information immortalized in the fossil record offers us only a glimpse over past community structure and ecology.

In the following sections, we present sex and age data for the bears of Schafstall II and attempt to reconstruct the characteristics of their habitat use and population structure. Without such a framework, it would be difficult to fully comprehend space use and interactions between the hominids and cave bears that occupied Schafstall.

At Schafstall II, cave bear is not only predominant, but is also the taxon with the highest absolute number of anthropogenically modified skeletal elements. Evidence for cave bear exploitation is however not unique to this site and has ample parallels in the Upper Palaeolithic record of other sites in the Swabian Jura. While most of the evidence comes in the form of cutmarks related to skinning or butchering, as seen for example at Hohle Fels, Geißenklösterle, Fetzershaldenhöhle, Bocksteinschmiede/loch, Vogelherd and Hohlenstein-Stadel (Kitagawa, 2014; Kitagawa, Krönneck, Conard, & Münzel, 2012; Krönneck, 2012; Lykoudi, 2017; Münzel, 2019; Münzel & Conard, 2004a; Niven, 2006), bone tools like retouchers on bear skeletal elements, especially canines, are not uncommon and have been documented at sites such as Vogelherd and Hohle Fels (Taute, 1965; Toniato et al., 2018). A cave bear vertebra with an embedded flint projectile from the Early Gravettian layers of Hohle Fels testifies to the active hunting of bears by humans (Münzel & Conard, 2004a). Indeed, based on the available archaeological data, evidence for cave bear hunting and exploitation in this geographic region increases considerably throughout the Upper Palaeolithic reaching its peak during the Gravettian (Wojtal et al., 2015). Radiocarbon results place the local extinction of cave bears around 25,000 ^{14}C BP at the beginning of the Last Glacial Maximum (Münzel et al., 2011). Although genetic studies have provided evidence that the decline of European cave bears started about 25,000 years before their extinction (Stiller et al., 2010), recent advances in analytical techniques have allowed researchers to gain more fine-grained information on cave bear population dynamics around the time of their disappearance (Gretzinger et al., 2019). Such studies have in fact highlighted a drastic decline in European cave bear populations corresponding with the arrival in Central Europe of modern humans, around 40 ka BP, thus suggesting that humans ultimately played a major role in the extinction of cave bears. The bear remains from Schafstall II provide further evidence for this regional trend and present a number of modification types. In the following sections, these are described in detail in the attempt of reconstructing the range of human activities associated with bear consumption at Schafstall II.

Age structure and sex ratio of cave bears

In both the old and new excavation cave bear is largely represented by tooth remains (Table 4.21). Isolated deciduous teeth are particularly abundant and make up over 50% of the bear remains in most horizons of the new excavation. The high number of milk teeth is very typical of hibernation sites that were occupied by females and their offspring. Though some of the deciduous teeth belonged to newborns or yearlings that died during the winter, most were naturally shed by growing cubs. Therefore, as opposed to bone and permanent tooth remains left behind by bears that died in the cave, the multitude of deciduous teeth also accounts for those young individuals that were part of the living population.

As Kurtén (1976) and Pappa (2014) clearly illustrate, shed teeth are usually easily recognizable by their worn crowns and root resorption marks. Based on the degree of wear and resorption, the two authors attempted to reconstruct mortality rates of young bears and seasonality. While such features were also observed and recorded on the bear milk teeth of Schafstall II, secure attribution to a specific development stage was often hindered by natural

GH	Site	Bone	Cave bear Permanent teeth	Deciduous teeth	Total NSP
	SSII Old	52%	25%	23%	840
2	SSII New	69%	29%	3%	245
2a	SSII New	22%	23%	55%	388
2b	SSII New	37%	10%	53%	60
2c	SSII New	49%	9%	43%	35
3	SSII New	20%	9%	71%	178
4	SSII New	21%	10%	69%	142
5	SSII New	9%	19%	72%	100
6	SSII New	17%	17%	67%	12
Hf	SSII New	20%	13%	67%	657
Peters backfill	SSII New	0%	100%	0%	1
2ap	SSII New	33%	0%	67%	3
3p	SSII New	18%	5%	78%	40
4p	SSII New	13%	6%	81%	31
5p	SSII New	30%	40%	30%	10
6p	SSII New	0%	0%	100%	3

Table 4.21 Relative frequencies of cave bear bone and teeth remains at Schafstall II

and post-depositional fragmentation of tooth roots which in some cases made it impossible to macroscopically distinguish worn and broken unshed teeth from shed teeth. By contrast, isolated teeth with complete roots and unworn or lightly worn crowns were attributed to deceased cubs. Even when considering possible taphonomic bias, the number of complete deciduous teeth with fully grown roots was very low and the majority of remains could be safely assigned to young individuals that lost their teeth during growth.

The mortality rate of young bears was additionally measured by recording the degree of epiphyseal fusion on cave bear long bones. Recent ontogenetic studies (Fosse & Cregut-Bonnoure, 2014) on postcranial skeletal development of young modern brown bears have attempted to provide an ageing scheme for the classification of juvenile appendicular elements of cave bear, however due to the poorness of well-preserved intact skeletal elements, it was not feasible to order the long bones in age-specific groups. The classification used in this study more generically distinguished between neonate, juvenile and subadult bone remains and took into account both long bones and cranial parts. Foetal or neonate bones were mostly found among the water-sieved sediments of the new excavation and are similar in size to fox or hare bones. They have a woven bone texture and their morphology mimics that of the adult bone, thus making them at times quite difficult to identify. The juvenile class is characterised by larger sized bones, comparable to those of a medium to large sized carnivore and comprises skeletal elements that are still unfused and not fully formed. Instead, subadults are here defined as those individuals which have reached the final stages of bone development and whose bones are fully formed but are still unfused or partially fused. Even though this method does not provide any information on seasonality or age of death, as it combines several age groups, it serves the scope of quantifiying the abundance of young individuals.

In both the assemblages from the old and new excavation, the MNI values for young bears are tendentially lower compared to those of adults (Fig. 4.17). The high number of newborn remains from the new test trench is likely due to the accurate and undifferentiated retrieval of small bone remains which were overlooked during the past excavations leading to an underrepresentation of this age group.

Mortality and seasonality patterns are better understood by looking at eruption and wear stages on permanent teeth. The present analysis benefitted from the use of two age-scoring techniques drawn from Münzel (2019) and Stiner (1998).

The ageing scheme developed by Münzel seeks to reconstruct the denning behaviour of cave bears by correlating the timing of dental development with seasonal use or abandonment of cave sites by bears. While Münzel considers tooth development sequences observed in modern brown bears (Dittrich, 1961), she calls into question the assumption that the timing of dental development in brown bears and cave bears are identical to each other. In fact, the faunal assemblages of Geissenklösterle (Münzel, 2019) and Hohle Fels (Münzel, pers. comm.) show a bimodal distribution with peaks representing the 3-4 and the 7-10-month-old bears. While the 3-4 month age group fits well with the time of den emergence, Münzel observes that the second age-group falls in the autumn period, a time when bears are expected to forage intensively in order to build up fat resources before hibernation. This leads her to argue that dental development in cave bears was slower compared to brown bears and that the second age group represented at Geissenkösterle and Hohle Fels probably corresponds to cubs that died during their second winter rather than in autumn.

At Schafstall II Münzel’s age system suggests that both assemblages are made up mostly of teeth which belong to adult individuals older than two years (Fig. 4.18). The second largest group is represented by young bears in their second winter which were probably still being cared for by their mothers. The number of tooth remains of cubs in their first winter is considerably smaller and seems to indicate lower mortality rates for this age category but could also be the result of taphonomic bias. In fact, all the remains that fall into this age group

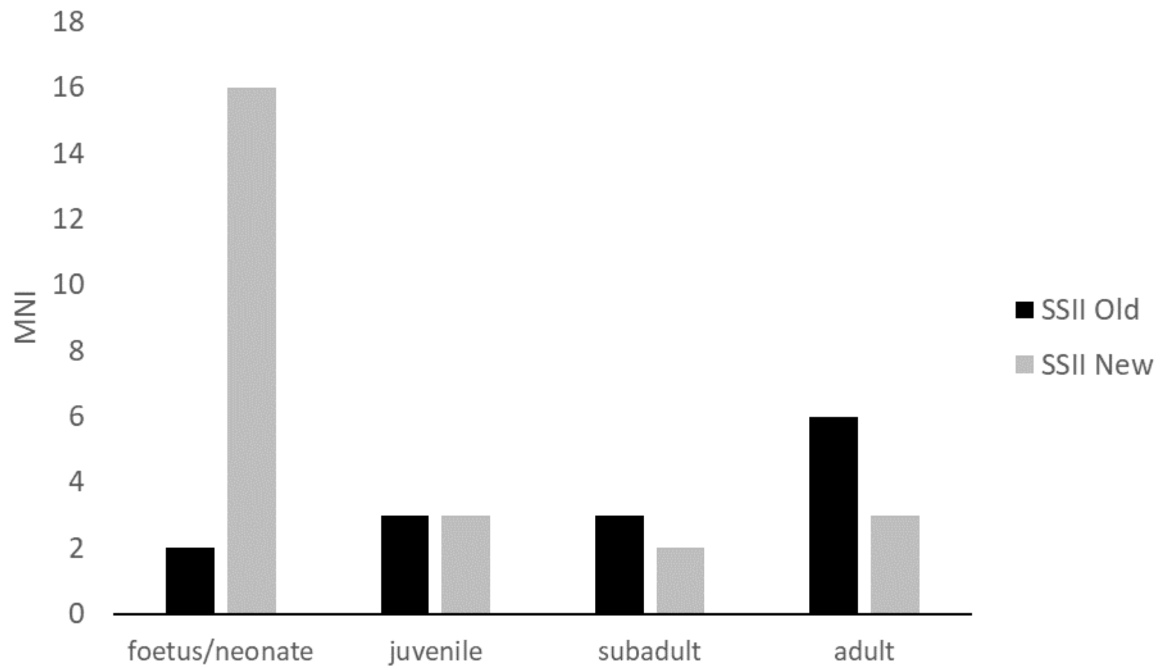


Figure 4.17 Cave bear MNI by age class. MNI values refer to true MNI and not standardized MNI

consist of partially formed tooth crowns showing incomplete mineralization and a fragile structure prone to disintegration. Very few remains corresponded with bears in their first spring or summer that either died at the end of the winter season or during episodic summer visits to the site.

By contrast, the age system devised by Stiner builds up on the use of mortality patterns derived from modern ungulate populations and subsequently infers from these causes of death. In specific, Stiner (1990) identifies three mortality age structures. The living structure mortality pattern takes the form of a half pyramid shaped bar graph and is distinguished by the progressive increase in frequency counts with age. The attritional or U-shaped mortality patterns is characterized by the overrepresentation of juveniles and to a lesser extent of old animals, while the prime-dominated mortality patterns is marked by the predominance of prime adults. In ungulate populations, the first two cases usually coincide with mortality patterns created by carnivorous predators. While the living structure pattern is primarily associated with non-selective ambush predators, such as felids, the U-shaped pattern finds correspondences with the mortality profiles generated by cursorial predators, like wolf and hyena. Stiner observes that prime dominated age structures are instead common in ethnoarchaeological and ethnohistorical assemblages created by humans.

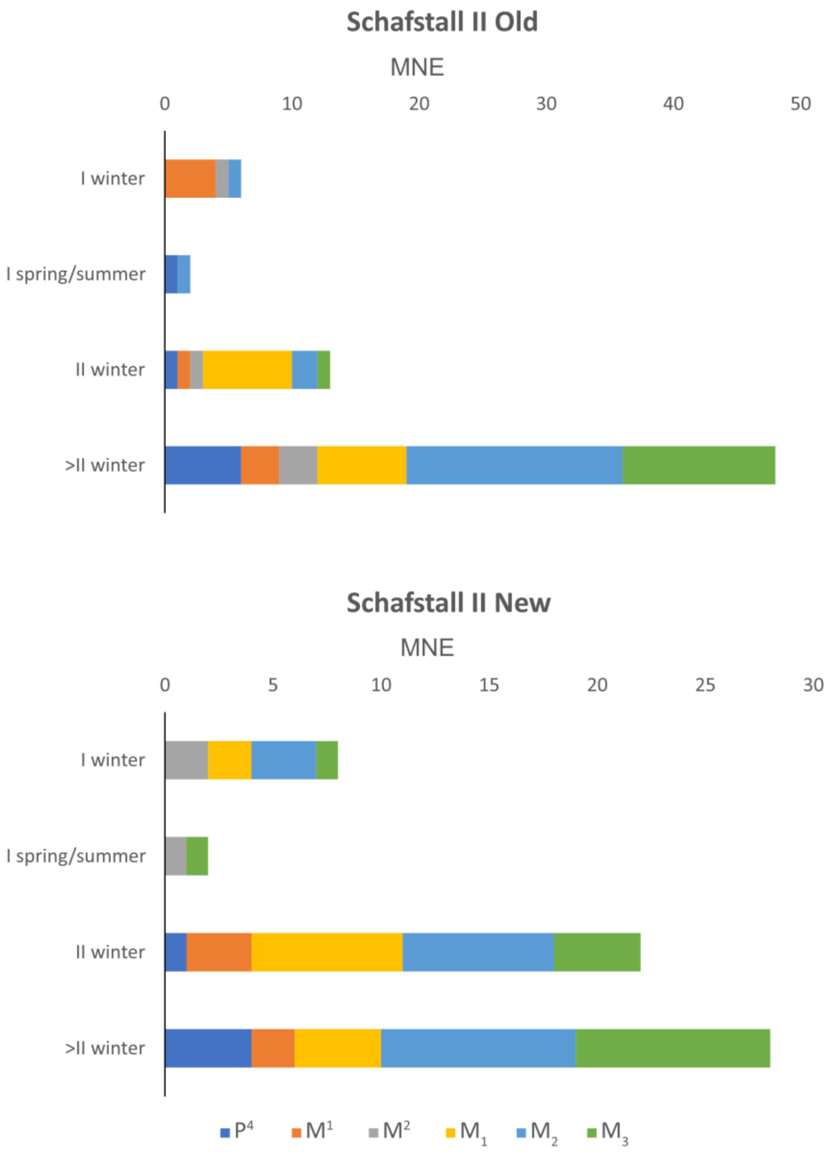


Figure 4.18 Cave bear permanent teeth (MNE) ordered by wear and eruption stages into seasonal groups following Münzel's (2019) age system

In the case of cave bear death assemblages, the U-shaped pattern corresponds to the normal non-violent attrition pattern characterized by the overrepresentation of the most vulnerable age classes which were more likely to succumb to the rigours of winter. Conversely, according to Stiner (1998), the living structure mortality pattern within a bear bone accumulation is more likely to result from random prey selection by carnivores or humans, as opposed to the prime-dominated mortality pattern, which is associated with intentional targeting of a specific age class. These patterns are best conveyed graphically in a tripolar graph, which emphasizes the greater abundance of an age group relative to the other two groups.

Mortality profiles are obtained by applying classical age-scoring techniques, such as those based on tooth eruption and wear developed for ungulates by Grant (1982) and Lowe (1967). Stiner proposes a similar age scoring technique for bears (Stiner, 1998), which was also adopted in this study. Age frequency counts for each cohort are then lumped together into three age groups, juvenile, prime adult and old adult. The boundary between each age group is established by Stiner according to specific landmarks of the animal's life cycle e.g. age of reproduction.

In applying Stiner's ageing system to the bear assemblage of Schafstall II, the tooth finds from the geological horizons of the new excavation were combined with those from Peters' excavation. The strict observation of stratigraphic boundaries was considered to be negligible as bears can alter the deposits of cave sites considerably by digging and clawing and the ultimate aim of the analysis was to assess the general effects of repeated site use by bears.

While M_1 and M_3 fall within the non-violent attrition family (Fig. 4.19, Table 4.22), the distribution of M_2, which is the most common tooth type, reflects the living structure. This pattern may be explained by the occasional death by starvation especially of prime aged female individuals that suffered higher energetic costs compared to males due to lactation and gestation during the winter period.

		SSII Old									
Tooth element	Number of age-scored teeth	MNI	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
P^4	8	5	1	1	2		1			2	1
M^1	8	4	4	1							3
M^2	5	5		1	1						3
M_1	17	11		3	6	2	3				3
M_2	21	14	1	2	4	2	3	2	3	3	1
M_3	13	9	1	2	3				2	3	2
		SSII New									
P^4	7	5	1	1	1	1				1	2
M^1	5	3		1	1	1					2
M^2	3	2	1	2							
M_1	15	10	2	3	3	4	1			1	1
M_2	20	12	2	3	3	5		1	2	1	3
M_3	15	8	2	2	3	2		2	1	2	1

Table 4.22 Cave bear age-scored teeth from Schafstall II sorted into nine age cohorts

Another possible scenario, which does not exclude the preceding one, is the predation of bears by either carnivores or humans who took advantage of their vulnerability during the winter sleep. The upper cheek teeth are comparatively less abundant, perhaps due to their lower preservation, and fall within the old dominated area of the graph reinforcing the interpretation of the assemblage as a natural death sample.

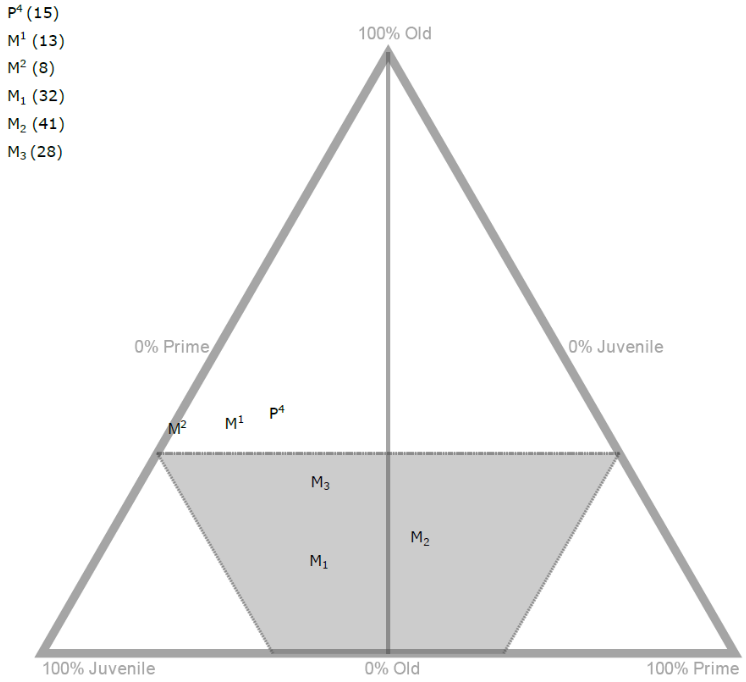


Figure 4.19 Tripolar graph of cave bear mortality in Schafstall. Tooth finds from the old and new excavations are combined

The sex composition of the bears that died at the site was determined using the crown measurements of the lower canines, which were more numerous and better preserved than the upper ones. Measurements of crown length or buccal-lingual length (L) and breadth or mesio-distal length (B) were taken at the crown basis and were compared to those recorded at other sites in the Swabian Jura, namely Hohle Fels (Münzel, unpublished data), Geißenklösterle (Münzel, 2019) and Hohlenstein-Stadel (Kitagawa, 2014) (Fig. 4.20) (see Appendix, Table 6.8 for measurements). To reconstruct the sex ratio, a multivariate cluster analysis was applied to crown length and breadth measurements obtaining two distinct clusters which are graphically represented by a dashed line. Subsequently, based on a most likelihood Bayesian estimation, a best-fit ellipse comprising 40% of all specimens assigned to a specific cluster, was defined for both clusters. The resulting graph indicates that, except for Hohlenstein-Stadel, where bear individuals are predominately male, the sites of the Swabian Jura, including Schafstall II, are dominated by females. Furthermore, both the male and female specimens of Hohlenstein-Stadel display the largest canine size variation falling mostly outside the most likelihood ellipse. While researchers correlated sex ratio with altitude at alpine sites to suggest preferential use of high altitude cave sites by females in order to hide and protect their offspring from male aggression (Reisinger & Hohenegger, 1998), this interpretation is not applicable to the Swabian sites, which are all located at similar elevations. A more probable explanation for the predominance of female individuals is that given by Kurtén (1976), who posits that cub bearing females would most likely choose small and easily defendable sites as denning places. Although Kurtén´s hypothesis provides a plausible explanation to our female dominated assemblage, additional data on sexual dimorphism, for example long bone measurements, would be required in order to provide more solid evidence. The lack of well-preserved postcranial elements and the small sample size of measurable inferior canines cautions us against advancing hypotheses based on sex ratio variation. Furthermore, we must also consider that sex ratio is exclusively representative of the dead

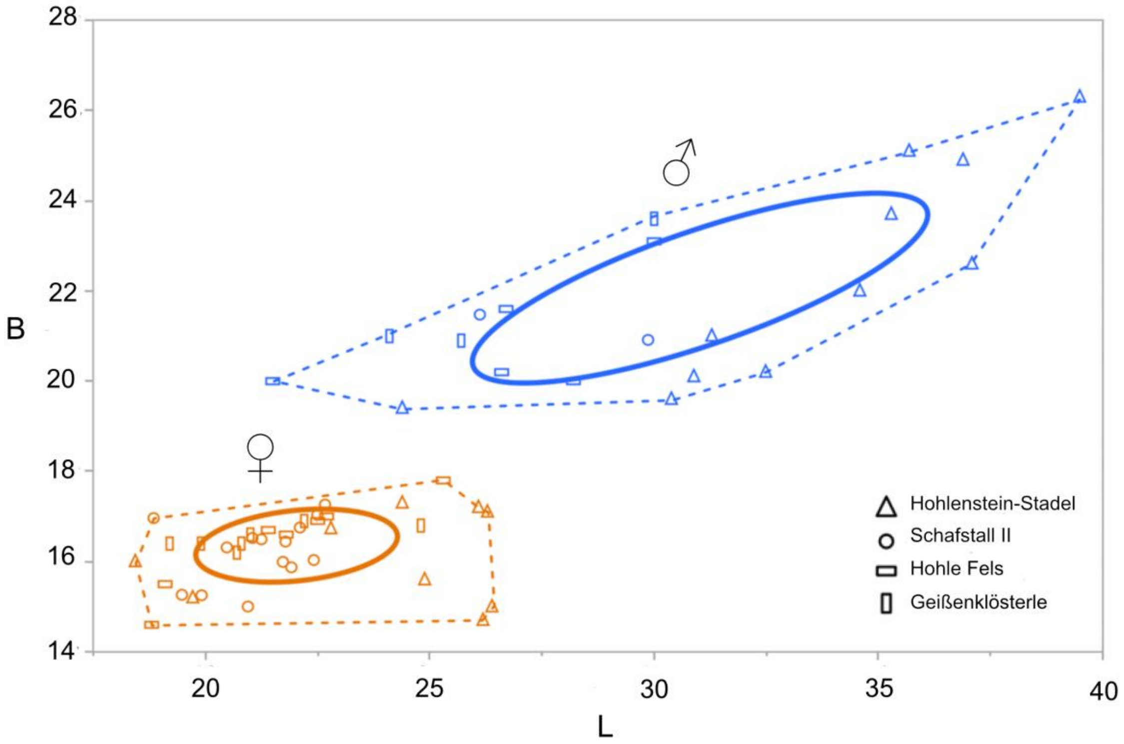


Figure 4.20 Comparison of cave bear sex ratio across different sites in the Swabian Jura based on canine crown length and breadth measurements. Best fit ellipse comprises 40% of all specimens in that cluster

population and does not account for those individuals that seasonally occupied cave sites and survived the harshness of winter without leaving visible traces in the archaeological record. Finally, taphonomic bias and bone destruction are also factors that must be taken into account and may cause stochastic variation in the archaeological record leading to misrepresentation of sex ratio.

Hominin and cave bear interactions

In the area of Schafstall II, cave bear is the taxon with the highest absolute frequency of anthropogenic modifications. The variety of modifications testifies to the multifaceted use of cave bear by hominids. Human interactions with this extinct species are deeply rooted in time and have always attracted the attention of archaeologists and scholars. The appreciable number of cave sites with bear remains paired with stone implements led various researchers in the first half of the 20th century to hypothesize a strong link between bear bone depositions and human activities (see Pacher, 1997 for an exhaustive overview). In some instances, these interpretations went so far as to give rise to bear cult theories which advocated ritual behaviour as an explanation for certain apparently deliberate bone deposits (E. Bächler, 1940; Emil Bächler, 1921; Ehrenberg, 1931; Hörmann, 1930; Zotz et al., 1939),. Successive methodological and analytical developments in archaeological and palaeoecological studies opened up new perspectives on the topic of human and cave bear interactions, enabling researchers to demystify the spiritual nature of many bear bone accumulations found in cave sites by linking their origin to hibernation death (Cramer, 1941; F. Koby, 1951; F.-E. Koby, 1942; Kurtén, 1976). The ever-growing body of archaeological evidence has also helped redefine site use patterns and the nature of the interrelation between the two species providing a path to a hunting and exploitation scenario both spatially and temporally diffused. In this way, the importance of bear as a nutritional and economic resource has been documented at numerous Middle and Upper Palaeolithic sites throughout Europe, including Belgium (Abrams, et al., 2014; M. Germonpré & Hamalainen, 2007; Mietje Germonpré & Sablin, 2001), France (Auguste, 1995; Soulier, 2014; Tartar, 2012) , Germany (Kitagawa, 2014; Kitagawa et al., 2012; Münzel, 2019; Münzel & Conard, 2004b), Italy (Romandini et al., 2013, 2018; Peresani et al., 2014) and Poland (Wojtal et al., 2015).

At Schafstall II, the exploitation of cave bear is evidenced by several bone elements with cutmarks related to butchering activities (Table 4.23).

Cutmarks on mandible remains were produced mainly on the horizontal ramus. Apart from one mandibular base fragment with two oblique and parallel cutmarks, all other fragments were assigned to specific anatomic portions. A right anterior mandible fragment with its canine still in place bears two series of diagonal cutmarks on the lingual side close to the mandibular symphysis. Similarly, two short oblique cutmarks are found on the lingual side of another fragment of a horizontal ramus. This specimen was also damaged by burning, which produced a longitudinal black-brownish streak on the side of the mandible opposite to that with the cutmarks (Plate IX, Fig. i). Only one remain from the new excavation, namely a right posterior mandibular fragment from GH Hf, displayed cutmarks (Plate IX, Fig.a). These are located on the lateral side in proximity of the ventral rim and may be connected with skinning. By contrast, cutmarks on the lingual side found on other specimens likely derive from filleting of the tongue.

On the axial skeleton, cutmarks were documented on five rib fragments. One of these fragments includes a series of marks close to the head of the rib, which appears to have been subsequently chewed off by carnivores (Plate IX, Fig, e). On most rib fragments cutmarks take the form of scattered bundles which are either parallel or oblique to the main axis and were likely produced during dismemberment of the carcass.

Limb and feet bones underwent major modifications. Cut and impact marks are mostly observed on hind limbs (Table 4.23). The most impacted element is the femur. A total of nine shaft fragments with cutmark and/or impact damage were recorded. The combination of these two types of marks is indicative of at least two distinct processing phases that happened on site. The first one, evidenced by the cutmarks, was linked to meat removal and was followed by bone breakage by percussion, perhaps associated with marrow extraction or with the production of blanks for retouching. This supposition is supported by the occurrence among the modified bone material of four retouchers. These consist of two femur shafts, a tibia fragment and a canine (Plate X, XI). The latter displays three distinct use areas, two on either side of the root end and one at the crown basis. Similar finds are also known from the lower Aurignacian layers IV-V of Hohle Fels and layer V of Vogelherd (Riek, 1934; Taute, 1965; Toniato et al., 2018) in the Swabian Jura as well as from other sites in France (Castel & Madelaine, 2003; C. Leroy-Prost, 2002; Soulier, 2014; Tartar, 2012) ascribed to the early Aurignacian. On the contrary, retouchers on bear long bones have also been found in the Middle Palaeolithic layers of sites like Scladina Cave (Abrams et al., 2014) in Belgium and Rio Secco and Fumane cave (Romandini et al., 2018) in Italy.

	Ursus speleaus								
	NISP	**NMR**	cutmarks	impact	scraping	cone fracture	retoucher	ochre stained	burnt
lower canine	**22**	**1**					1		
mandible	**97**	**4**	4						1
rib	**47**	**5**	5						
femur	**18**	**9**	6	1	1	1	2	1	
fibula	**17**	**1**	1						
tibia	**35**	**6**	2	3		1	1		
astragalus	**7**	**1**	1						
I phalanx	**41**	**2**	2					1	
I metacarpal	**6**	**1**	1						
II cuneiform	**5**	**1**							1
III cuneiform	**3**	**1**							1

Table 4.23 Categories of anthropogenic modifications on cave bear skeletal elements from Schafstall II. Old and new assemblages are combined. Each modification type is tallied separately from the others, so that one specimen bearing multiple modification types is counted a number of times equal to the number of modification types recorded on that specimen. NMR= Number of Modified Remains

A few foot remains also contribute to the evidence for cave bear exploitation by humans. A left astragalus fragment shows three transverse cutmarks on the medial articular surface inflicted during disarticulation of the foot. A series of transverse cutmarks on the lateral-plantar surface of a first distal metacarpal (Plate IX, Fig. g). and bundles of cutmarks on two first phalanges (Plate IX, Fig. h) may be possibly related to the filleting of the paws.

One of the first phalanges with cutmarks, corresponding to a distal fragment, presents faint reddish ochre stains on the distal articular surface and on the spongeous bone tissue of the medullary cavity, accompanied by millimetric residues of burnt material. This is not the only ochre-stained specimen in our assemblage. Among the faunal material excavated by Peters and stored at the University of Erlangen, I also found six small unidentifiable bone fragments and a cave bear femur shaft with tenuous traces of ochre. The most striking specimen is the cave bear femur (Plate IX, Fig. f), which presents a bundle of diagonal cutmarks on the medial portion in proximity of the lesser trochanter and on the posterior surface. On this side, the cutmarks are superposed by small oval depressions produced by percussion. The bone was probably broken after meat and tissue removal as evidenced by a set of incomplete cutmarks on the medial side along the edge of a green fracture break, whose production determined the partial loss of the cutmark bearing bone surface. On the medial side, the bone fragment is split longitudinally and shows vivid bright red ochre staining. The pigment is powdery and tiny grains of seemingly burnt material are embedded in it. Small blots of ochre are faintly visible also on the cortical surface of the femur close to the area with cutmarks and residues of burnt material are deeply embedded in the intricate meshwork of the medullary cavity. The excellent preservation of the red ochre and charred residues is possible because bone fragments were not cleaned after the excavation.

Schafstall II is not the only site in Europe to have yielded cave bear bones with ochre traces. Ochre stained remains have also been found at several sites in Belgium reviewed by Germonpré and Hamalainen (2007), who interpreted them as a form of bear ceremonialism based on the distribution of ochre traces on skeletal elements and on close resemblances to ethnographic accounts. Given their small number and fragmentary condition, not much can be surmised around the origin of the two ochre stained bear remains from Schafstall II. However, the ochre does not appear to have been intentionally applied to the bones because the stains extend to the spongeous tissue in the medullary cavity, are randomly shaped and distributed on the bone surface and do not appear to be well-defined as would be expected if the pigment was directly applied with fingers or with the use of a tool. It is therefore more likely that they originated by contact with ochre-containing sediment or by ochre unintentional spilling over the bones. This is also supported by Riedinger´s excavation account of 1948, in which he mentions the presence of a dark brown layer containing miscellaneous finds including stone artefacts, flint debris, bone remains and burnt bones together with ochre.

The association of burning traces with the ochre stains is not readily explainable but could be related to the use of burnt trabecular bone as a binder in the preparation of the ochre compound (Henshilwood et al., 2011) or heat treatment of ochre for altering its colour (Velliky et al., 2018; Wadley, 2013).

In regard to its provenance, recent mapping and characterization of ochre sources in southwestern Germany produced by Velliky et al. (2019) suggest that the closest ochre sources to the Lauchert Valley are located in the Black Forest as opposed to the Ach and Lone valleys in the central-eastern area of the Swabian Jura, which also contain numerous sources. Their survey, however, focused on a ca 20 km radius of Hohle Fels and Geißenklösterle, meaning that other potential ochre sources in the western part of the Swabian Jura could still be unidentified (Velliky et al., 2019).

Finally, two burnt carpal bones of cave bear constitute further evidence of carcass utilization. The two bones consist of a middle and an external cuneiform that are respectively half calcined and fully carbonized, meaning that they were heated at relatively high temperatures in the range of 500 and 900°C (Shipman et al., 1984). Though burning may have been unintentional, it is highly likely that it was deliberate given that the burning colours seem to indicate direct contact with fire and stand in contrast to those observed on experimentally burnt bones replicating the effects of indirect burning (Stiner et al., 1995). Additionally, the high fat content of carpal bones would have made them an optimal fuel source and the close relationship between burning and cave bear processing is also testified by the burnt residues found embedded in the ochre stained bones.

Schafstall II may therefore be added to the growing list of sites with evidence of cave bear exploitation and possibly hunting. The archaeological evidence here presented speaks in favour of intensive manipulation and multi-purpose exploitation of bear remains that must have required significant time investment on the part of human hunter gatherers. The arrangement of cutmarks on high utility meat bearing skeletal elements coupled with the low frequency of gnawing marks suggest that humans had primary access to the bear remains (Blumenschine, 1986; Shipman, 1986). The wide array of modifications observed must have been left by expert hunters that had the technical skills to process carcasses efficiently. Field processing involved a chain of tasks that probably included meat stripping, bone cracking for marrow and/or retoucher manufacture and finally waste discard and burning. Even though it is not possible to determine whether the modified bear bones derive from one or more occupational events, the evidence suggests that hominids visited the site in winter. Regardless if humans hunted or scavenged the bears of Schafstall II, procurement would have been most effective during the winter season, when bears are the most vulnerable to natural deaths and other predators, and their bodies are rich in fat stores to sustain themselves during hibernation. This is consistent with what is known from several ethnographic sources of Northern Eurasia (Bogoras, 1904; Jochelson, 1905; Scheffer, 1675) and North America (Hallowell, 1926), where bears are commonly hunted in their winter lairs.

The ethnographic literature on bear hunting and ceremonialism contains a wealth of information on bear utilization by Arctic peoples. The killing of a bear is often accompanied by a ceremony and specific rites, in the course of which the bear carcass is handled and its meat is distributed for consumption to the community members (Hallowell, 1926; Hogguér, M., 1841; Leem, 1771; Scheffer, 1675). Most body parts are then used for different purposes. The Itelmens in Kamchatka, for example, employ the skin in the production of bedding, garments and harnesses for draft animals (Steller, 1774). Bear fat can also be smeared on leather shoes and clothing implements as well as on weapons (Ditmar, 1900) and has different types of medical uses (Karjalainen, 1921; Leem, 1771). Among several Siberian folks, the gall too is considered to have special healing properties (Karjalainen, 1921) and claws and teeth are treasured as amulets against diseases (Dyrenkova, 1930; Karjalainen, 1921). Bones, however, are often left intact and interred or hung on trees or poles as a sign of deference towards the bear (Hallowell, 1926). Hominids at Schafstall II might have treated certain bear body parts similarly. Though the archaeological evidence does not permit a complete reconstruction, taken altogether, the anthropogenic modifications documented indicate that they processed and disposed of one or more bear carcasses at the site.

4.6 Summary

In this section I summarize all the information so far presented. In comparing the old and newly excavated faunal assemblages of Schafstall, it was essential to check for divergences resulting from different recovery methods and sampling strategies. The rate of bone fragmentation indicates that even though the old excavators did not recover most unidentifiable bone remains below 3 cm, all other size classes are equally represented in both assemblages and the underrepresentation of small bone fragments in Peters' assemblages does not affect comparability with the faunal remains from the new excavation. Overall, bone preservation at Schafstall I and II is relatively good and weathering patterns show that bones did not lie exposed on the surface for long time periods.

Although the interpretation of the assemblage of Schafstall I may be affected by small sample size, the general impression is that bones were accumulated differently in this area compared to Schafstall II. This is supported by substantial differences in faunal structure and composition. Most notably, at Schafstall I ungulates are the predominant taxonomic group and, albeit the similarity of taxa and taxonomic richness, the assemblage presents a higher evenness compared to Schafstall II.

Results of the taphonomic analysis show that anthropogenic marks related to human activities at Schafstall I are more frequent than carnivore damage and that both modification categories affect mostly ungulate remains. Green fractures and anthropogenic activities are proportionally higher than at Schafstall II.

The mortality profile of cave bear in Schafstall I corresponds to a non-violent attrition pattern characteristic of natural death assemblages. Thus, despite the incompleteness of the assemblage, the lack of stratigraphic context for the finds and possible recovery biases, the bone assemblage still offers a coarse signal of the original depositional events that determined its formation. The dominance of ungulates and the presence of anthropogenic modifications on their remains suggest that hominids brought and processed hunted game at the site.

Contrastingly, the bone assemblage of Schafstall II offers a different interpretative scenario. Cave bear is the dominant species making up most of the assemblage. Gnawing damage is comparatively greater than that produced by humans and was recorded primarily on cave bear bones. Anthropogenic marks are proportionally lower than at Schafstall I and are most abundant on cave bear skeletal elements. Exploitation of cave bear is suggested by cut and percussion marks left on several elements, and by the presence of retouchers made on different skeletal parts. Burning of bear remains is also suggestive of on-site carcass processing, perhaps associated with consumption. Regardless if cave bear was hunted or scavenged, hominids most likely encountered these animals at the site during the winter, when their lowered metabolism would have made them easier preys for human and non-human hunters and vulnerable to starvation deaths.

What is striking about Schafstall II are the large discrepancies between the old and new excavations. These differences are particularly strong when comparing the stratigraphic sequences of Peters' excavation and our own. Specifically, the brown and black cultural layers that Riedinger illustrated and described in his excavation report of 1948 were not encountered during the recent excavation. Nor was there evidence of the existence of a *cultural layer* in the sense of archaeological horizons characterized by a large enough collection of artefacts with diagnostic technological and typological traits.

The results of the zooarchaeological analysis speak in favour of objective differences between the accumulation processes that governed the deposition of the faunal assemblages of Schafstall II. Such differences emerge, for example, in the faunal composition. While in the newly excavated assemblage cave bear constitutes the dominant species, in the old assemblage the various taxa are more evenly distributed, and ungulates especially are more abundant. Another interesting aspect is the almost complete lack of bird and hare remains in the new assemblage compared to the old one.

Further differences concern the horizontal distribution of the remains. Despite the unknown stratigraphic position of the remains from Peters' assemblage, the frequency of burnt bones and of carnivore and human modifications is considerably greater compared to the new excavation. This is not surprising, as in the new excavation the scarcity of anthropogenically modified bone remains is closely associated with a very low number of stone artefacts.

The key to understanding inter-site differences at Schafstall II lies perhaps in the heterogeneity of its spatial configuration which could have affected the geological and anthropogenic processes that modelled the formation of the archaeological assemblage. As mentioned in previous sections of this work, the site of Schafstall II was originally protected by a limestone roof which later collapsed producing a large volume of rock debris encountered during the recent excavation. The latter exposed the sediments lying at the entrance and outside of the cave. However, cave bears and humans would have sought shelter inside the cave next to the rock wall, hence the higher density of stone tools and modified bone remains from this area compared to the one uncovered during the new excavations. Additionally, the higher exposure of the deposits near the cave entrance to the action of external agents could have contributed to the partial obliteration of the archaeological record in this area.

5 DISCUSSION

5.1 The site of Schafstall in local and regional perspective

Before proceeding in the contextualization of the results, it is necessary to make a premise on the nature of the archaeological data available for this study. As mentioned above, the lack of stratigraphic information from the old excavations and the large discrepancies in terms of material finds between these and the new ones, which were virtually devoid of archaeological finds, precluded any type of chronostratigraphic analysis at Schafstall. However, what remains of the lithic and organic artefacts from Peters' excavations as well as the limited number of publications available on the topic (Peters, 1936a, 1936b, 1939, 1946; Peters & Paret, 1949; Peters & Rieth, 1936) offer us some insight regarding the cultural attribution of the site. The lithic analysis indicates the presence of Middle Palaeolithic and Aurignacian industries at Schafstall I and technological affinities suggest contemporaneity between the Aurignacian assemblages of Schafstall I and of the nearby Göpfelsteinhöhle (Bosinski, 1967; Conard et al., 2016; Schumacher, 2014). The lithic assemblage of Schafstall II, on the other hand, contains exclusively Aurignacian tool forms and was linked by Schumacher (2014) to the neighbouring site of Nikolaushöhle through the finding of a refit of two artefact fragments. Radiocarbon dates obtained on anthropogenically modified bones support these results. While most of the radiocarbon determinations of Schafstall I fall in the range of the Middle Palaeolithic, those of Schafstall II are more consistent with an Aurignacian and Gravettian occupation.

Techno-typological features of stone artefacts make them good chrono-cultural markers but the same does not hold true for faunal remains. Except for a split-based antler point from Schafstall II, characteristic organic artefacts of the Swabian Upper Palaeolithic, including personal ornaments, figurines and musical instruments are entirely missing from the assemblages of the Veringenstadt cave sites. Furthermore, given that the faunal spectrum of the Swabian Jura remains largely unchanged throughout the Middle and Early Upper Palaeolithic, it is practically impossible to assign a temporal succession to the faunal remains of Schafstall based on the presence of fossil indicators or the biochronological distribution of species. A diachronic approach to the examination of the faunal record from the old excavations is therefore not possible. The faunal assemblages excavated by Peters were considered in this study as single comprehensive units which are assumed to broadly reflect the major processes that produced them. An empirical approach to the material evidence made it possible on one hand to make meaningful intra-site comparisons between Schafstall I and II, and on the other, to record and interpret differences on an inter-site level between the old and new excavations of Schafstall II.

The results of this study indicate substantial differences in the use of the two areas of Schafstall. These differences are reflected mainly in the faunal composition and in the taphonomic histories of the bone assemblages. Despite the small size of the study sample from Schafstall I, the relatively high number of ungulate remains and their association with anthropogenic modifications denote a strong influence of human hunting activities on their accumulation. At the same time, the abundance of cave bear remains suggests these animals used the site as a winter quarter. Evidence for cave bear denning is however most conspicuous in the area of Schafstall II, which displays markedly lower percentages of modified bone remains compared to Schafstall I. In this area of the site, cave bear is the taxon which shows the highest incidence and the broadest variety of anthropogenic marks indicating an intensive exploitation by humans. The relatively low number of artefacts and of modified bone remains suggest that Schafstall II was used by hominids for short stays and may have functioned as a hunting camp and possibly even a cave bear kill site.

The results of the new excavation of Schafstall II are somewhat puzzling and at first sight seem inconsistent with those of Peters' excavation, which yielded a considerably higher number of archaeological finds. The magnitude of the differences is even more surprising given the short distance of only a few metres which separates the area of the old excavation, close to the rock face, from that of the new one, towards the hillside. A close examination of such differences strongly suggests that there is a connection between the site's physical configuration and the differential horizontal distribution of the archaeological remains. This may be explained by a natural preference of hominids and animals for the more sheltered area at the back of the cave compared to the area at the entrance and outside of the cave. Additionally, the higher exposure of the deposits near the cave entrance to reworking and erosional processes could have contributed to the partial obliteration of the archaeological record in this area.

In the absence of detailed chronostratigraphic and faunal data on the other sites of Veringenstadt, it is almost impossible to make a meaningful comparison with Schafstall. However, the little information published by Peters allows us to make some general considerations. Out of the four sites investigated in Veringenstadt, Peters took the most time to excavate Schafstall, first between 1935 and 1937, and later discontinuously, between 1943 and 1948. By contrast, the excavations of Annakapellenhöhle, Göpfelstein and Nikolaushöhle were completed in three years, between 1934 and 1937 (Peters, 1946; Scheff, 2004). Based on the preliminary results published by Peters in 1936 (Peters, 1936b) and on Schumacher's recent revision of the lithic assemblages from Veringenstadt (Schumacher, 2014), Schafstall I appears to be the site which yielded the highest number of artefacts, followed by Göpfelstein (Table 5.1).

N lithics	**Excav. Year**	**Publication**
	Annakapellenhöhle	
95	1934-35	Peters (1936)
	Göpfelstein	
~1000	1934-35	Peters (1936)
~1100	1947+1955	Schumacher (2014)
	Nikolaushöhle	
205	1934-35	Peters (1936)
6	1955	Schumacher (2014)
	Schafstall I	
967	1935	Peters (1936)
~1600	1946-47	Schumacher (2014)
	Schafstall II	
320	1948	Schumacher (2014)
110	2016-17	This work

Table 5.1 Number of lithics described in the literature from each of the Veringenstadt sites with respective excavation year

Despite the missing information on Peters' latest excavations, it is very unlikely that the unpublished data would have altered substantially the cultural patterns which he had already identified. Taken at face value, the lithic evidence suggests that in the Veringenstadt cave sites the Middle Palaeolithic is better represented than the Aurignacian (Table 5.2). Moreover, the Aurignacian assemblages of Schafstall and Göpfelstein are much smaller compared to those from sites like Vogelherd in the Lone Valley and Hohle Fels, Geißenklösterle and Sirgenstein in the Ach Valley (Table 5.2). The different representation of these chrono-cultural assemblages may be related to diachronic differences in site and landscape use associated with resource procurement from the surrounding environment. Alternatively, it could also reflect geological and taphonomic processes overprinting the record. All these factors must be critically evaluated before drawing any conclusions on Palaeolithic settlement dynamics in the Lauchert Valley in relation to the rest of the Swabian Jura. This study alone cannot resolve these problems but provides a foundation on which further research can build on. To this end, in the following section, I propose several lines of future research which may help address some of the issues presented so far.

	Indet	MP	A	G/A	Total
Lauchert Valley					
Göpfelsteinhöhle	~1100	800	200		**~2100**
Schafstall I		~2600[a]			**~2600**
Schafstall II			320	110[b]	**430**
Ach Valley					
Große Grotte		~2000			**~2000**
Geißenklösterle		665[b]	~15800[b]		**~16500**
Hohle Fels		859[b]	31073[b]	3570[b]	**35502**
Sirgenstein		704	1892		**2596**
Kogelstein		449[b]			**449**
Lone Valley					
Vogelherd		121	5520		**5641**
Hohlenstein-Stadel		1358	313		**1671**
Hohlenstein-Bärenhöhle		1464	94		**1558**
Bocksteinschmiede		2791			**2791**

[a] includes a small number of Aurignacian artefacts. Schumacher (2014) mentions 15 carinated forms but it is not known if there are more.

[b] values include complete small debitage

Table 5.2 Comparison between lithic counts from Middle and Upper Palaeolithic deposits in the Swabian Jura. Artefact counts for sites in the Ach and Lone Valleys are taken from Conard et al. 2012.

5.2 Future research directions

Though this study brings together different forms of evidence in analysing the site of Schafstall, further work from other fields is required in order to increase our confidence in the results presented. In particular, the human remains from Schafstall II should be dated and analysed genetically. To date, only a few human remains associated with the Aurignacian are known from the Swabian Jura, namely a premolar from Hohlenstein-Stadel (Kitagawa, 2014) and two upper canines and a molar from Sirgenstein (Schmidt, 1912). The lack of bone remains from Aurignacian contexts has so far hindered the possibility of investigating mortuary practices through taphonomy, as has been profusely done, for example, for the Magdalenian remains of Hohle Fels and Brillenhöhle (Gieseler & Czarnetzki, 1973; Orschiedt, 1997; Sala & Conard, 2016). In this respect, the juvenile clavicle with cutmarks from Schafstall II could represent an important piece of evidence for understanding human ritual activities during the Aurignacian. If Riedinger's excavation report is reliable and the cultural layer in which the human remains were found is of Aurignacian age, as is supported also by the results of the lithic analysis (Conard et al., 2016; Schumacher, 2014), then Schafstall II would be the only known site of the Swabian Jura to contain evidence of funerary practices and/or cannibalism in the Aurignacian. In the opposite scenario, if the remains yielded a younger radiocarbon age, it would be possible to prove the mixing of layers in Peters' excavation. The presence of post-depositional reworking should also be verified through micromorphological studies based on the new excavation. These could help explain the different spatial distribution of the archaeological remains between the old and new excavations and identify the causes for the apparent absence of post-LGM deposits at Schafstall II. Erosional processes or re-working may have in fact played a prominent role in modifying the deposits below GH 1, which accumulated during the Holocene. The occurrence of cave bear, whose extinction is dated to the pre-LGM, in GH 2 may be therefore interpreted in two ways. On one hand, the absence of post-LGM deposits marking the transition from GH 1 to GH 2 could be caused by erosional processes. On the other hand, the cave bear bones found in GH 2 could be the product of re-working. These hypotheses will have to be addressed by future studies.

Another important aspect that could be further explored, concerns the relationship between the different sites of Veringenstadt. So far, lithic refitting and the identification of technological similarities have demonstrated inter-site connections between Schafstall I and Göpfelsteinhöhle and between Schafstall II and Nikolaushöhle. Unfortunately, the faunal analysis did not evidence the presence of bone refits between Schafstall I and II, but this does not exclude a possible relationship between the faunal assemblages of Schafstall and those of the neighbouring cave sites. It is therefore essential that future studies take into account the material evidence from these sites. In particular, the large faunal remains from Göpfelsteinhöhle housed in the Staatliche Museum für Naturkunde in Stuttgart and in the University of Erlangen make up a good study sample that would allow meaningful comparisons with Schafstall. As the site of Göpfelsteinhöhle was used as a den by hyenas (Peters, 1936a; Rathgeber, 2004), we expect there to be marked differences in the taxonomic and taphonomic signatures of the faunal assemblage compared to Schafstall. A comparison of these two assemblages could provide an additional key for reconstructing differences in the use of the Veringenstadt caves by humans and carnivores throughout the Middle and Upper Palaeolithic. As for Nikolaushöhle, although the faunal material from the old excavations is scarce and not very informative, the available literature and find descriptions (Peters, 1936b, 1936a, 1939, 1946; Rieth, 1966) indicate that the excavation was carried out mainly in the entrance area due to difficulties in removing the hard clayey sediments towards the back of the cave. In this area, we recorded the presence of thick sediment deposits during the archaeological survey of 2016. Therefore, the opening of a new test pit at the site might be worthy of consideration in the framework of a more ample research project on the archaeological sites of the Western Swabian Jura.

Additionally, combined with other disciplines, the results of the faunal analysis of Schafstall could add important data for reconstructing past ecological and environmental changes. A good example of this is given by the results of the palaeogenetic study on pre-LGM red fox specimens from the Swabian carried out by Tarusawa (2019). The study reveals the presence of two distinct clades of foxes at Schafstall I, of which one is considered to be ancestral to the other. Out of the three red fox specimens from Schafstall I, two group in the basal clade, while the third one clusters in the second group which comprises all the analysed red fox specimens of the Ach and Lone valleys. Radiocarbon dating is needed to determine whether these two populations were contemporaneous or not and to verify if the Schafstall I individuals are actually older than those from the Ach and Lone valleys. Nevertheless, if this assumption were true, it would imply a turnover in red fox populations between the Middle and Upper Palaeolithic in the Lauchert Valley. Under this scenario, new questions would emerge about the possible causes of such replacement and whether these affected also the local extinction of Neanderthals.

To sum up, although this work covers an important part of the research in the Lauchert Valley, it certainly does not have the pretension of being exhaustive and much more work is required in order to improve our understanding of Schafstall in its regional setting.

6 CONCLUSIONS

A large part of current archaeological research in the Swabian Jura revolves around sites that were discovered and partially or completely investigated during the first half of the last century. Nowadays the discovery of new unexcavated sites has become more the exception than the rule. Therefore, much of our knowledge of the region’s archaeology relies on the important work of our precursors. Using a metaphor taken from the 12th century philosopher Bernard of Chartres, “*nanos gigantum humeris insidentes*”, we are dwarfs standing on the shoulder of giants. However, if on one hand, as researchers we are required to interrogate our sources and be ready to revise and re-interpret past results in light of new questions and problems raised by the continuous advancement of research; on the other, as archaeologists, we have to deal with the inherent constraints of the archaeological materials which we study. In other words, we must work with the evidence we have, however little it may be.

The present work reunites both these strains in reinterpreting the site of Schafstall based on the faunal remains from the old and new excavations.

Despite the missing archaeological materials and the lack of information on the provenance of the surviving remains, the analysis of the old faunal assemblages enabled us to make cross-comparisons between the two areas of Schafstall. Differences in faunal composition and in bone damage patterns distinguish different types of hominid activities in these areas. At Schafstall I the evidence for human activities related to the butchering of ungulates is greater compared to Schafstall II. Cave bear remains, though numerous, are not predominant and do not bear traces of human manipulation. Mortality and seasonal data suggest that most of their remains may be attributed to individuals that died at the site due to natural causes. The same holds true for the cave bear remains of Schafstall II, which account for the largest part of the bone assemblage from the old and new excavations. The archaeological record from this area of the site displays in all respects the structure of a cave bear death assemblage with little evidence for human occupation. Anthropogenic modifications are very rare, and though ungulates are proportionally more affected, cave bear bones display the highest number and variety of modifications, including retouch marks. The location and types of modifications are indicative of carcass processing possibly in connection with bear hunting.

The differences between the faunal assemblages of the two areas do not only reflect a diversified use of the site but also represent temporally distinct occupational events, as suggested by the lithic technology and the radiocarbon ages from the bone remains. While the material evidence and radiocarbon determinations of Schafstall I are mostly attributable to the Middle Palaeolithic, the archaeological assemblage of Schafstall II shows a strong Aurignacian signature, suggesting different choices in space use between Middle Palaeolithic and Aurignacian people. Such choices can be better understood by looking at connections between the cave sites of Veringenstadt, as exemplified by the lithic refit found by Schumacher, which links Schafstall II to Nikolaushöhle and demonstrates the contemporaneous occupation of the two sites. Future work should therefore consider in more detail the unstudied remains from Göpfelstein and Nikolaushöhle as well as the possibility of conducting new test excavations at Nikolaushöhle. This would provide a larger data-set for investigating diachronic variations in settlement choice and landscape use in the Lauchert Valley in relation to other sites in the Swabian Jura. Ultimately, it would enable us to gain a more nuanced picture of the socio-cultural, biological and environmental processes that modelled the Middle and Upper Palaeolithic in southwestern Germany.

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PLATE I

ILLUSTRATION PLATES

Schafstall I, lithic artefacts from the excavation campaign of 1947 and few preserved pieces from the earlier campaigns of 1934-36, after Bosinski 1967

1- Simple scraper, fragment with straight working edge
2- Simple scraper, bladelike flake with lightly retouched edges
3- Simple scraper with slightly convex edge
4- Simple scraper with straight working edge
5- Simple scraper with convex working edge
6- Simple scraper with straight edge
7- Simple scraper with straight edge
8- Simple scraper with straight edge
9- Simple scraper, fragment
10- Scraper?, fragment
11- Flake with shallowly retouched edge
12- Small transverse scraper with slightly convex edge
13- Small transverse scraper with concave edge
14- Flake with retouched edge
14 Blade with trihedral cross section and lateral retouch
15 Convergent scraper
16 Narrow point with straight retouched edge
17 Lost find, re-drawn after Peters (1936a): elongated narrow point broken in two parts, the middle section is missing
18 Atypical convergent scraper, retouched ventrally on the right side
19 Small rectangular scraper, retouched ventrally on the left side
20 Blade with lateral retouch
21 Blade fragment with retouched lateral edges

PLATE I

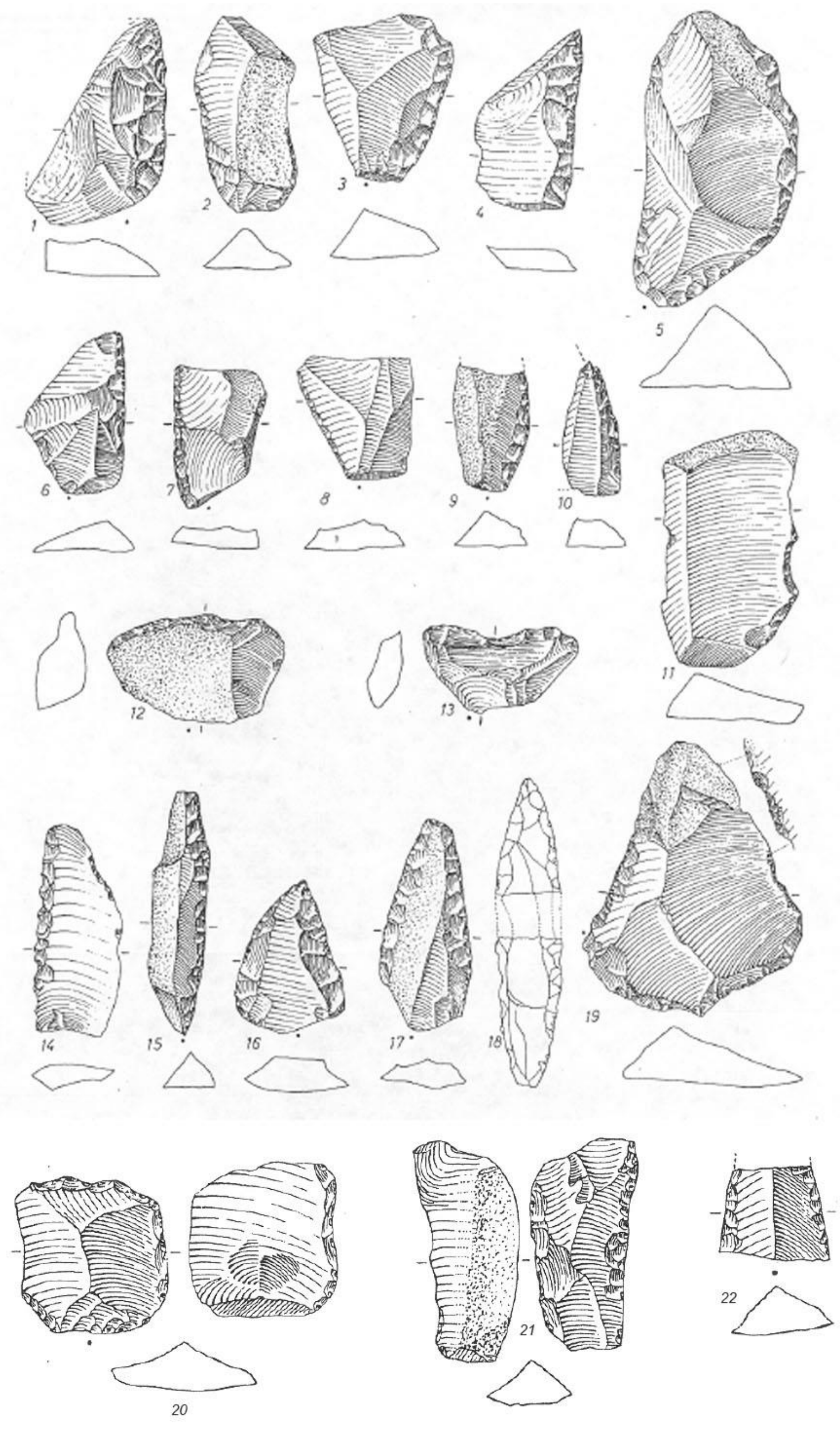


PLATE II

Schafstall I, lithic artefacts from the excavation of 2016., after Conard et al. 2017.

1-3,6: artefacts from GH1

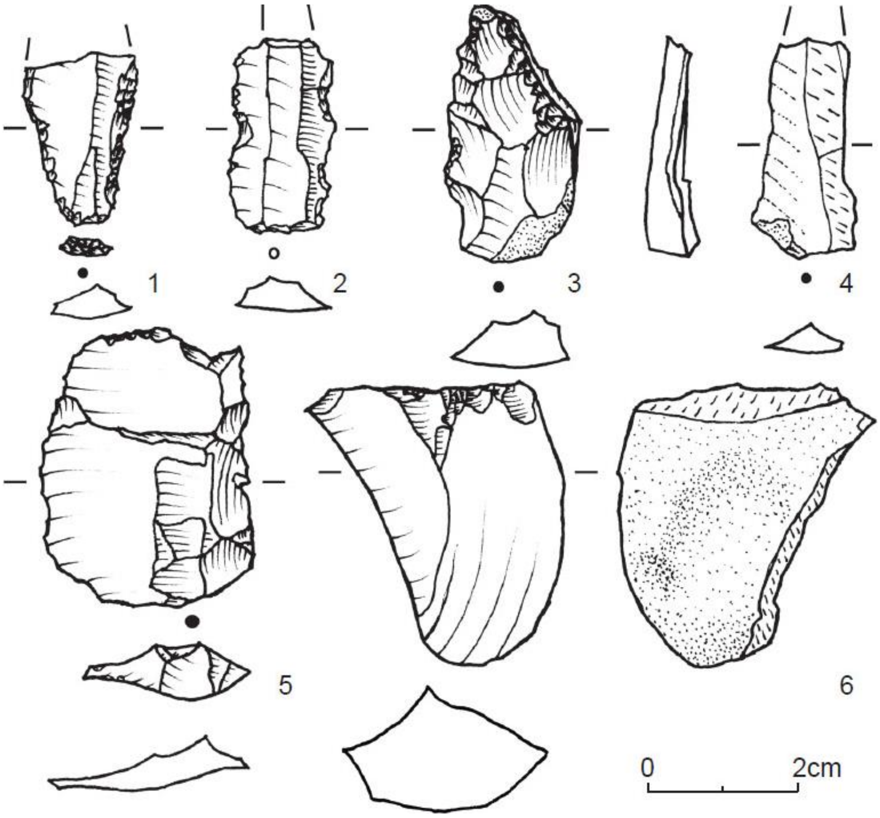
2: artefact from GH2

1- Point fragment
2- Blade fragment with denticulated edges and possible retouched end
3- Denticulated tool
4- Blade fragment
5- Retouched flake
6- Core

Schafstall I, artefact drawings by Oscar Heck, 1946

7- Laterally retouched blade fragment, Hohenzollerisches Landesmuseum Hechingen

PLATE II



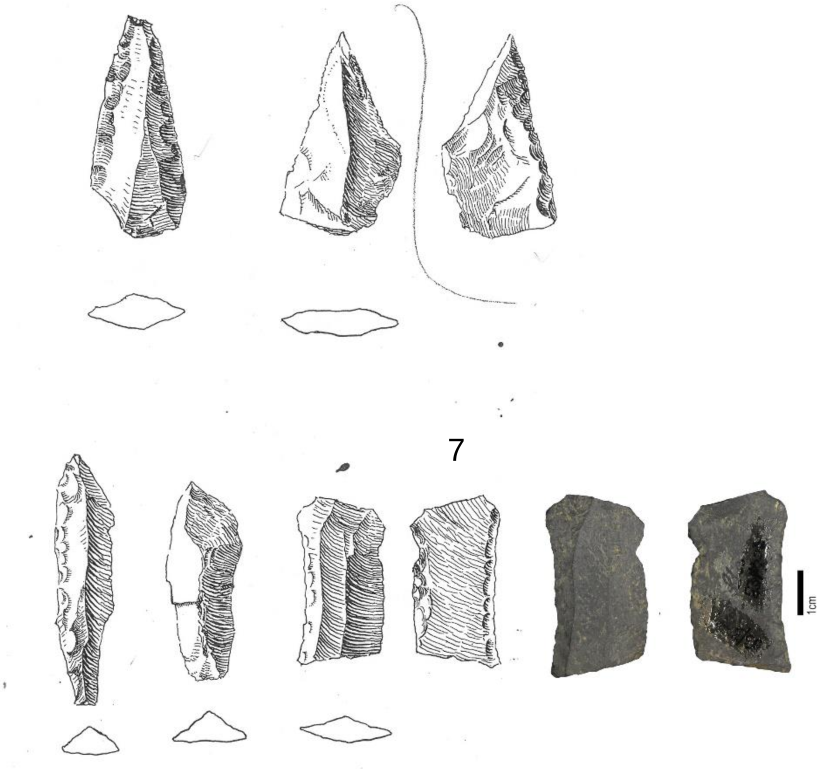


PLATE III

Schafstall II, human remains from the excavation of 1948.

1- Right clavicle of a juvenile with cutmarks on the antero-inferior surface
2- Middle phalanx of a juvenile
3- Lower right second incisor

PLATE III

PLATE IV

Schafstall II, lithic artefacts from the excavation campaign of 2017, after Conard and Toniato 2018.

1- Blade with retouched end
2- Flake
3- Flake
4- Nosed endscraper?
5- Pointed scraper

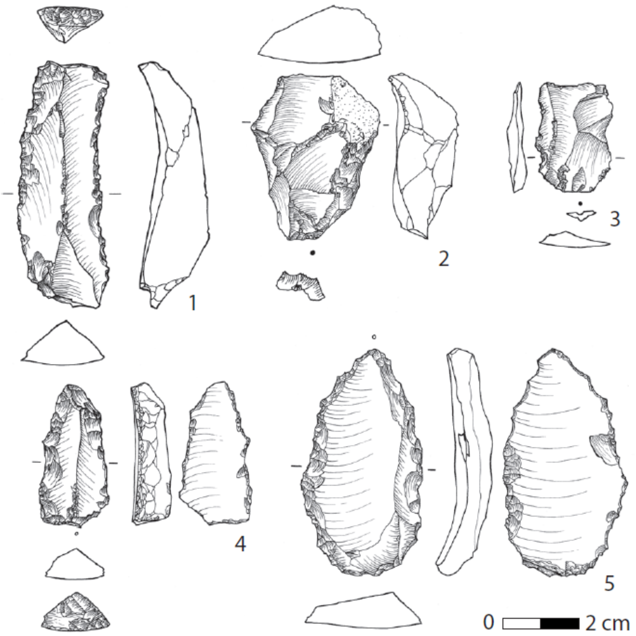
Schafstall II, lithic artefacts from the excavation campaign of 1948.

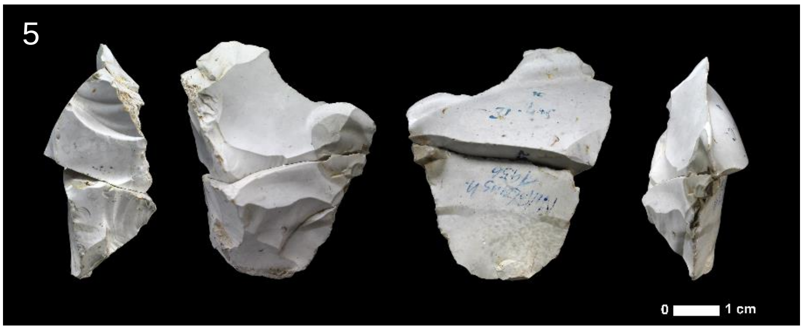
6- Two refitted flakes from Schafstall II and Nikolaushöhle (surface find collected by Franz Werz in the fifties), housed in the Rathaus Museum of Veringenstadt

Schafstall II, lithic artefacts stored in the Hohenzollerisches Landesmuseum Hechingen compared with drawings by Johann Riedinger, 1948.

7- Blade fragment with distal hinge fracture
8- Regular blade fragment
9- Endscraper
10- Fragment with steep lateral retouch

PLATE IV





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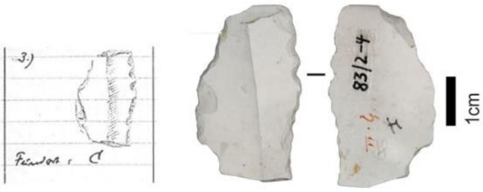

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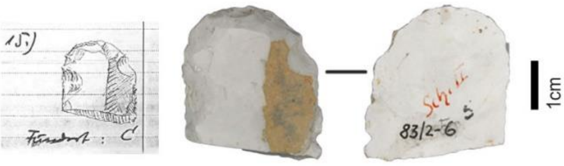


9

PLATE V

Schafstall II, organic artefacts from Peters' excavation (1948). Rathaus Museum Veringenstadt.

1- Split base antler point
2- Bone tool fragment similar to an awl

PLATE V

1

2

PLATE VI

Schafstall I, bones with anthropogenic modifications from Peters' excavations (1944-45)

a) Rib fragment of a large ungulate with scraping marks and cutmarks

b) Horse metapodial with impact marks

c) Aurochs/Bison scapula shaft with impact damage on scapular spine and cranial margin

d) Chamois tibia split longitudinally with double cone fracture

e) Horse scapula with impact and cutmarks

PLATE VI

PLATE VII

Schafstall I, bone retouchers from Peters' excavations (1944-45)

a) Retoucher on a rib fragment of a large ungulate

b) Retoucher on a long bone shaft of a large ungulate sized mammal

c) Retoucher on a long bone shaft of a large ungulate sized mammal

d) Retoucher on a long bone shaft of a large ungulate sized mammal

e) Retoucher on a long bone shaft of a large ungulate sized mammal

PLATE VII

PLATE VIII

Schafstall II, bones with anthropogenic modifications from Peters' excavation (1948). Rathaus Museum Veringenstadt.

a) Medium ungulate metatarsal fragment with cutmarks

b) Reindeer scapula fragment with cutmarks

c) Reindeer metacarpal with cutmarks

d) Long bone fragment of a large sized mammal with impact and cutmarks

e) Horse tibia fragment with cutmarks and gnawing damage in the form of pits

f) Ivory fragment with cutmark

PLATE VIII

PLATE IX

Schafstall II, human modified cave bear bones from Peters' excavation (1948) and from the new excavations of 2016 and 2017.

a) Mandible base with cutmarks

b) Tibia shaft with cone fracture and impact marks

c) Tibia shaft with impact and cutmarks

d) Rib fragment with cutmarks

e) Rib fragment with cutmarks and gnawing damage

f) Femur with cutmarks on the medial and posterior surfaces. Ochre staining is visible on the cortical surface and expands from the fracture edge to the spongy tissue of the medullary cavity, where traces of burning are also present

g) Distal metapodial with cutmarks

h) First phalanx with cutmarks

i) Charred mandible base

j) Tibia fragment with cutmarks

PLATE IX

PLATE X

Schafstall II, bone retouchers from Peters’ excavation (1948)- Rathaus Museum of Veringenstadt.

a) Retoucher on a horse/bear sized mammal long bone fragment

b) Retoucher on a cave bear femur shaft fragment

c) Retoucher on a cave bear femur shaft fragment

PLATE X

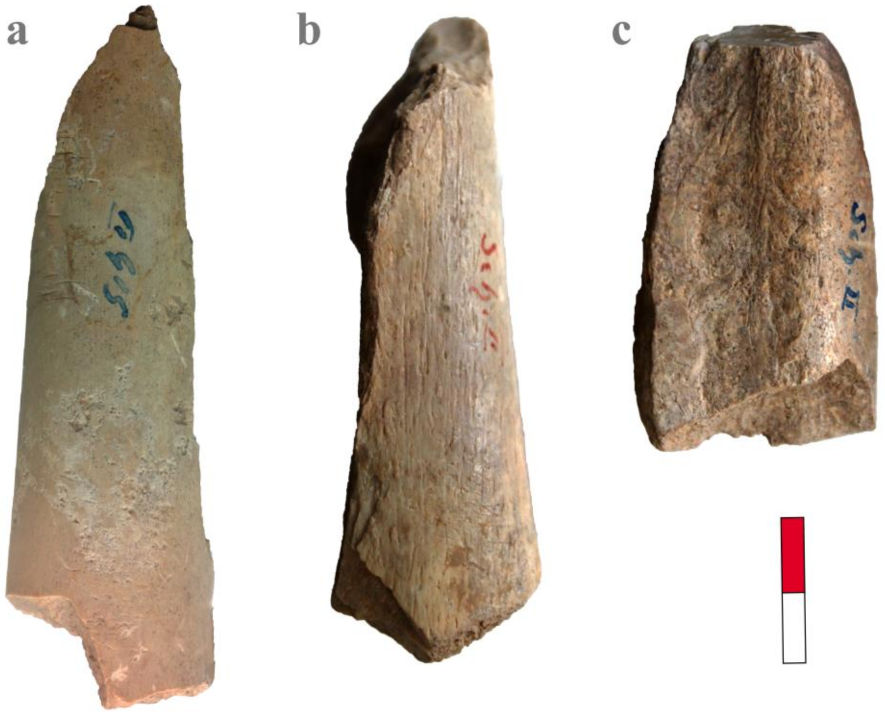
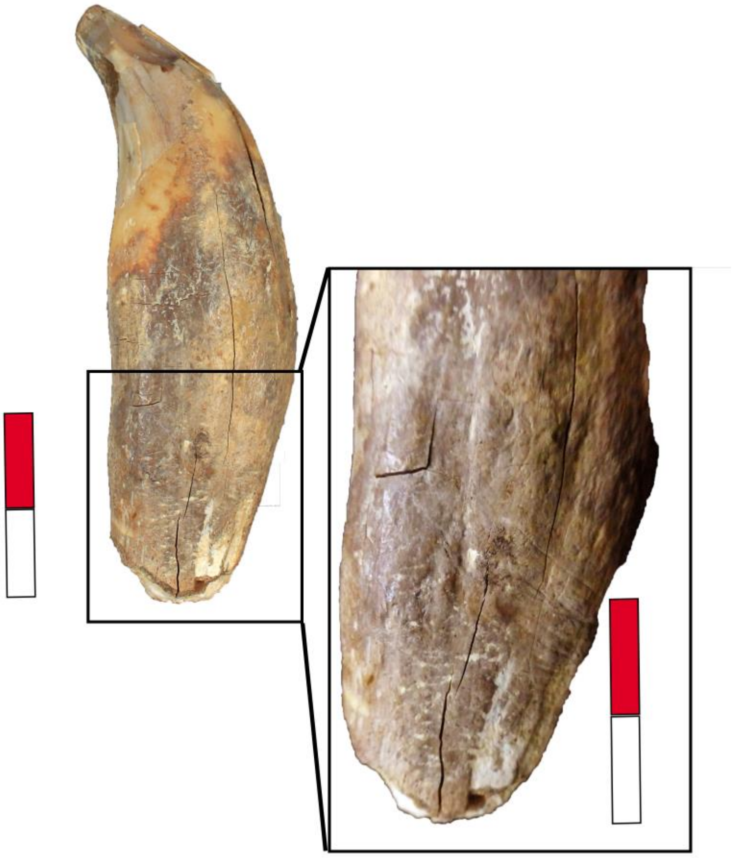


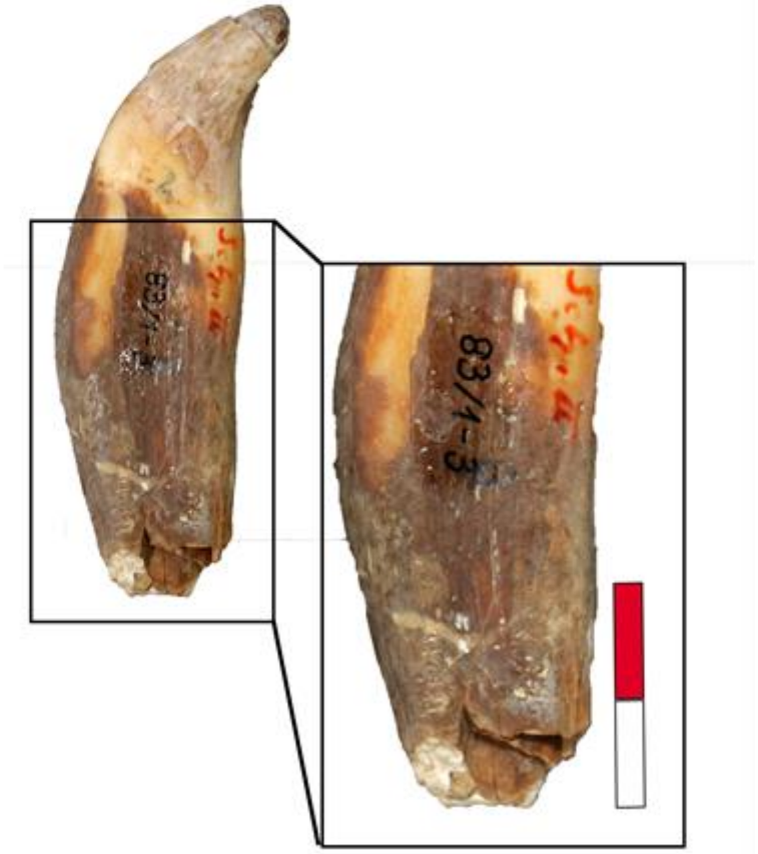
PLATE XI

Schafstall II, retoucher on a cave bear canine from Peters’ excavation (1948).

Hohenzollerisches Landesmuseum Hechingen.

PLATE XI





APPENDIX

Taxonomic coding from adapted from Susanne Münzel`s coding form

Code (new) T2	Code (old) T1	Class	Order	Family	Genus	Species
		MAMMALIA				
01					Homo - **Hominid**	
10			INSEKTIVORA indet. - Insectivores			
11				ERINACEIDAE		
12					Erinaceus	
13	**94**					**E. europaeus – European hedgehog**
14						Erinaceus sp.
15				TALPIDAE		
16					Talpa	
17						**T. europaea** (LINNAEUS 1758) **– European mole**
18						Talpa sp.
19				SORICIDAE		
20					Sorex	
21						**S. araneus** (LINNAEUS 1758) **– Eurasian shrew**
22						**S. minutus** (LINNAUES 1766) **– Pygmy shrew**
23						S. alpinus – Alpine shrew
24						Sorex sp.
25					Neomys	
26						**N. fodiens** (PENNANT 1771) **– Eurasian water shrew**
27						N. anomalus – Mediterranean water shrew
28						Neomys sp.
29					Crocidura	
30						C. leucodon - russula Group
31						Crocidura sp.
32	**95**			**indet. Insectivore**		
33			CHIROPTERA indet			
34				RHINOLOPHIDAE		
35					Rhinolophus	
36				VESPERTILIONIDAE		
37					Vespertilio	
38						V. murinus –Part-coloured bat
39					Myotis	
40						M. myotis – Greater mouse-eared bat
41					Plecotus – Langohrfledermäuse	
42					Miniopterus – Langflügelglattnasen	
43					Eptesicus	
44						E. serotinus – Breitflügelfledermaus
45						E. nilssoni – Nordfledermaus
46					Nyetalus	
47						N. noctula – Abendsegler
48					Pipistrellus	
49						P. pipistrellus – Zwergfledermaus
50					Barbastella – Mopsfledermäuse	
51						**B. barbastellus** (SCHREBER 1774) **–Western barbastrelle**
52			LAGOMORPHA			
53				OCHOTONIDAE		
54					Ochotona	
55	19					O. pusilla – steppe pika

56		LEPORIDAE – Hasen
57	91	L. europaeus – European hare
58	92	L. timidus (LIMNAEUS 1758) – Mountain hare
59	**90**	**Lepus sp. – Hare**
60		Oryctolagus – Rabbit
61		**O. cuniculus – European rabbit**
62		RODENTIA indet. – Indet. rodent
63		CAPROMYIDAE
64		Myocastor coypus (MOLINA) – Coypu
65		CASTORIDAE
66		**Castor fiber (LINNAEUS 1758) – Eurasian beaver**
67		SCIURIDAE
68		Sciurus
69	**11**	**S. vulgaris** (LINNAEUS 1758) **– Red squirrel**
70		Citellus
71		C. citellus – Ground squirrel
72		Marmota
73	**10**	**M. marmota – Alpine marmot**
74		ZAPODIDAE
75		Sicista betulina (PALLAS 1778) –Northern birch mouse
76		**Sicista sp.**
77		GLIRIDAE
78		Glis
79		**G. glis (LINNAEUS 1766) – Edible dormouse**
80		Eliomys
81		E. quercinus (LINNAEUS 1766) – Garden dormouse
82		MURIDAE
83		Apodemus
84		A. sylvaticus (LINNAEUS 1758) – Wood mouse
85		A. flavicollis (Melchior 1834) – Yellow-necked mouse
86		**Apodemus sp.**
87		Rattus
88		CRICETIDAE
89		Cricetus – Hamster
90		**C. cricetus (LINNAEUS 1758) – European hamster**
91		SPALACIDAE
92		ARVICOLIDAE
93		Arvicola
94		**A. terrestris (LINNAEUS 1758) – Water vole**
95		Clethrionomys
96		**C. glareolus – Bank vole**
97		Dicrostonyx
98		D. torquatus – Arctic lemming (Koenigswald
99		grouped D. gulielmi + henseli under torqu.)
100		Lemmus/Dicrostonyx
101		**L. lemmus (LINNAEUS 1758) – Norwegian lemming**
102		Pitymys
103		MICROTIDAE
104		Microtus
105		**M. nivalis (MARTINS 1842) – Snow vole**
106		M. arvalis (PALLAS 1779) – Common vole
107		M. agrestis (LINNAEUS 1761) – Field vole
108		**M. arvalis/agrestis**
109		**M. oeconomus (PALLAS 1776) – Tundra vole**

110					**M.gregalis (PALLAS 1778) – Narrow-headed vole**
111	**93**		**indet. small rodent**		
112			indet. large rodent (beaver, rat, etc.)		
113		CARNIVORA			
114			CANIDAE		
115	**55**				**C. lupus – Wolf**
116					C. farmiliaris - dog
117				Canis sp	
118				Vulpes	
119	**16**				**V. vulpes – Red fox**
120				Alopex	
121	**24**				**A. lagopus – Arctic fox**
122	**82**			**VULPES vel ALOPEX**	
123			URSIDAE		
124	**80**				**U. spelaeus – Cave bear**
125	**59**				**U. arctos – Brown bear**
126					Ursus sp.
127			FELIDA E		
128				Panthera	
129	**84 od. 54**			**P. leo spelaea - Lion**	
130				Lynx	
131	**83**				**L. lynx – Eurasian lynx**
132				Felis	
133					F silvestris – Wild cat
134					F. familiaris – Domestic cat
135	**34**				**Felis sp.**
136			MUSTELIDAE		
137				Mustela	
138	**88**				**M. erminea – Stoat**
139	**86**				**M. putorius – European polecat**
140					**M. nivalis – Least weasel**
141	**13**				**M. erminea/nivalis**
142					Mustela sp.
143				Martes	
144	**71**				**M. foina – Beech marten**
145					M. martes – European pine marten
146	**85**				**Martes sp.**
147				Gulo	
148	**44**				**G. gulo – Wolverine**
149				Meles	
150	**81**				**M. meles – Badger**
151				Lutra	
152	**87**				**L. lutra – Eurasian otter**
153			HYAENIDAE		
154				Hyaena	
155	**89**				**H. (Crocuta) spelaea – Spotted hyena**
156			indet. very small carnivore (stoat/ least weasel)		
157	**30**		**indet. small carnivore (marten, fox)**		
158			indet. medium carnivore (wolverine, lynx)		
159	**04**		**indet large carnivore (wolf, hyena, bear)**		
160		PROBOSCIDEA			
161			MASTODONTIDAE		
162			ELEPHANTIDAE		
163				Archidiskodon	
164				Paleoloxodon	
165				Mammuthus	
166	**69**				**M. primigenius – Mammoth**
167		PERISSODACTYLA			
168			EQUIDAE		

169	**57**				**Equus sp. – Horse**	
170				RHINOCEROTIDAE		
171					Dicerorhinus	
172					Coelodonta	
173	**62**					**C. antiquitatis – Woolly rhino**
174	**60**			**indet. perissodactyl (horse / woolly rhino)**		
175			ARTIODACTYLA			
176				SUIDAE		
177					Sus	
178						S. scrofa – Wild boar
179						S. domesticus – Domestic pig
180	**40**					**Sus sp. – wild boar/ domestic pig**
181			HIPPOPOTAMIDAE			
182			CAMELIDAE			
183			CERVIDAE			
184					Megaloceros	
185	**72**					**M. giganteus – Giant deer**
186					Cervus	
187	**70**					**C. elaphus – Red deer**
188					Dama	
189						D. dama
190					Capreolus	
191	**73**					**C. capreolus – Roe deer**
192					Rangifer	
193	**75**					**R. tarandus.- Reindeer**
194					Alces	
195						A. alces – Elk
196			BOVIDAE			
197					**B. priscus – Steppe bison**	
198					Bos	
199						B. primigenius - Aurochs
200						B. taurus – cattle
201	**46**				**Bos vel Bison**	
202					Buffelus – Buffalo	
203					Ovibos	
204						O. moschatus – Muskox
205					Capra	
206	**64**					**C. ibex – Ibex**
207						C. hircus – Domestic goat
208					Soergelia	
209					Ovis	
210	**41**					**O. aries – Sheep**
211					Hemitragus	
212					Rupicapra	
213	**78**					**R. rupicapra – Chamois**
214					Saiga	
215	**77**					**S. tatarica – Saiga antelope**
216	**49**				**indet small ruminant (ibex/ chamois/ saiga antelope/ roe deer)**	
217	**79**				**indet large ruminant (reindeer/red deer/aurochs/ bison)**	
218					**Ovis aries/Capra hircus (Sheep/goat)**	
220		**large ungulate (horse/aurochs/bison/giant deer)**				
301	**01**	**unidentified**				
302	**02**	**smaller than fox/hare size**				
303	**03**	**fox/hare size**				
305	**05**	**medium carnivore/small ungulate size**				
306	06	small ungulate/medium carnivore size*				
307	**07**	**medium ungulate size**				

308	**08**	**horse/bear size**
309	**09**	**mammoth/woolly rhino size**
310		**large ruminant/aurochs/bison/giant deer**
400	96	AVES - Birds
500		REPTILIA Reptiles
600		AMPHIBIA- Amphibians
700	99	PISCES - Fish

***can be lumped together with 305**

CODING FORM SCHAFSTALL

ELEMENTS

HORN/ANTLER (10s):
11 horn core
12 antler
13 ivory

SKULL (20s):
21 half cranium, L or R
22 half mandible, L or R
23 quadrate
24 hyoid

NECK (30s):
31 atlas
32 axis
33 cervical vertebra

MAIN AXIAL COLUMN (40s):
40 vertebra, type unknown
41 thoracic vertebra
42 rib
43 lumbar vertebra
44 sacral vertebra
45 innominate (1/2 pelvis)
46 caudal vertebra
47 sternal segment
48 costal cartilage
49 furculum

FRONT LIMB (50s & 60s):
51 scapula
52 humerus
53 coracoid (e.g., birds)
54 trapezium
60 pisiform
61 radius
62 ulna
63 carpal (type unknown)
64 metacarpal (bird=carpometacarpus)
641 first metacarpal
642 second metacarpal
643 third metacarpal
644 fourth metacarpal
645 fifth metacarpal
65 cuneiform *(pyramidal)*
66 magnum – *capitatum- grand os*
6670 trapezoid magnum
67 lunate
6768 scapholunate
68 scaphoid
69 unciform – *crociato- hamate*
70 trapezoid

HIND LIMB (70s & 80s):
71 femur
72 navicular - *scaphoid*
73 cuboid
74 external cuneiform – *III cuneiform*
75 middle cuneiform – *great cuneiform (II)*
76 internal cuneiform – *small cuneiform (I)*
80 fibula
81 tibia (bird=tibiotarsus)
82 patella
83 astragalus
84 calcaneus
85 tarsal (type unknown)
86 metatarsal (bird=tarsometatarsus)
861 first metatarsal
862 second metatarsal
863 third metatarsal
864 fourth metatarsal
865 fifth metatarsal
87 naviculo-cuboid
88 external & middle cuneiform
89 lateral malleolus

FEET(90s):
77 1st phalanx of digit 3
90 sesamoid
901 grand sesamoid (horse)
902 petit sesamoid (horse)
91 first phalanx
92 second phalanx
93 third/terminal phalanx
94 unknown hind phalanx *(phalanx type unknown)*
95 1st phalanx of digit 2
96 unknown wing phalanx
97 2nd phalanx of digit 2
98 1st phalanx of digit 1

TEETH (100s, mammals only)

9_ _ _deciduous tooth
100 from upper jaw
200 from lower jaw
300 dental position unknown
_10 incisor (type unknown)
_11 first incisor
_12 second incisor
_13 third incisor
_20 canine
_30 premolar (type unknown)
_31 first premolar
_32 second premolar
_33 third premolar
_34 fourth premolar
_40 molar (type unknown)
_41 first molar
_42 second molar
_43 third molar
_3040 molar/premolar

TORTOISE SHELL:

55 carapace (tortoise only)
56 plastron (tortoise only)
57 indeterminate tortoise shell

GENERAL ELEM. CATEGORIES

1 metapodial (type unknown)
2 long bone shaft (type unknown) – *compact bone* *
3 flat bone (skull or scapula fragment)
4 carpal or tarsal (type unknown)
5 spongy element (axial)
6 auxiliary third phalanx
7 auxiliary second phalanx
8 auxiliary first phalanx
9 auxiliary metapodial
10 eggshell (bird)
13 Ivory
14 Coprolite
15 Osteoderm
99 Indeterminate

*used in this sense with waterscreened fragments

PORTIONS-OF-ELEMENTS

TEETH:
6 root
7 crown

HORN/ANTLER:
8 shaft-rosette-pedicel-braincase
9 tip/tine (5=shaft frag.; 80=diaphysis section)
10 rosette (base)
11 pedicel-braincase

CRANIUM:
12 articulation to hyoid
13 upper orbit
14 palatine
15 parietal
16 posterior margin to mandibular symphysis
17 basicranium/ *basihyoid*
18 temporal
19 alisphenoid
20 premaxilla (or “incisive” of anterior mandible)
21 nasal
22 zygomatic (mastoid-squamous area)
23 maxilla (~complete half)
24 maxilla frag. (241 anterior rim; 242 post. rim)
25 petrous
26 auditory bulla
27 braincase fragment
28 occipital (dorsal rim)
29 occipital condyle (right or left)
32 lacrimal (foramen)
101 frontal foramen
102 orbit (lower rim)
107 frontal bone

MANDIBLE, BASE MISSING:
30 anterior foramen of mandible
31 gonial angle of mandible *(angular process in Ursus sp)*
33 middle horizontal ramus
34 mid-anterior horizontal ramus
35 anterior horizontal ramus (anterior alveolus of LP2)
36 mid-posterior horizontal ramus
37 posterior horizontal ramus (dorsal ridge behind LM3)
38 "dip" between condyle-coronoid
3841 dip and coronoid process
39 base of horizontal ramus
40 condyloid process
41 coronoid process
42 condyle & coronoid
43 ascending ramus (431 lingual foramen)

MANDIBLE, BASE INTACT:
44 horizontal ramus (whole)
45 middle horizontal ramus
46 anterior horizontal ramus
47 posterior horizontal ramus
48 mid-anterior horizontal ramus
49 mid-posterior horizontal ramus

INNOMINATE:
104 groove on ilium
105 pubic section
57 acetabulum fragment
58 acetabulum section—pubic body (581 anterior rim of symphysis; 582 ridge)
59 acetabulum, complete
60 acetabulum & ilium (~complete)
61 acetabulum section—iliac body fragment
62 acetabulum-ischium (~complete)
63 acetabulum section—ischial body fragment
64 iliac body (diaphysis)
65 iliac blade
66 ilium
67 ischial body
68 ischial blade
69 ischium

VERTEBRAE:
50 epiphysis (501 anterior; 502 posterior; 50_5 half of epiphysis)
51 centrum (body)
52 transverse process
53 pre-zygapophyses (5353=intact pair)
54 post-zygapophyses (5454=intact pair)
55 dorsal spine (also proximal heel of ulna olecranon)

56 half
106 zygapophysis (type unknown)

LIMB ("LONG") BONES:
70 proximal (P) epiphysis
75 distal (D) > 1/2
76 D 1/2
77 D < 1/2 (771 countable distal metapodial half)
78 D epiphysis fragment (see also 81-84)
79 D epiphysis
96 unknown epiphysis fragment (e.g., for unfused shafts)

LONG BONE EPIPHYSIS PORTIONS:
81 medial distal (D) epiphysis
82 lateral D epiphysis
83 anterior D epiphysis
84 posterior D epiphysis
91 anterior proximal (P) epiphysis
92 posterior P epiphysis (horse=lesser trochanter)
93 medial P epiphysis
94 lateral P epiphysis (for calcaneus 941 tuberosity; 942 tip)
95 trocanther minor
96 third trochanter
986 posterior distal humerus section (below foramen)
988 distal lateral posterior humerus
989 distal medial posterior humerus

LONG BONE SHAFT FEATURES:
103 base of glenoid process of scapula
990 w/ foramen present*/ prx shaft Ursus ulna with foramen*
991 w/ attachment scar (proximal end of radius feature) *also rugosity on Ursus ulnaprx end*
992 “waist” on scapula
994 anterior "angle" (tibia) *deltoid tuberosity humerus*
995 muscle insertion scar
996 posterior rugosities (tibia); countable “v” on femur (horse=third trochanter)

71 P epiphysis fragment (see also 91-94)
72 P < 1/2
73 P 1/2
74 P > 1/2

9961 groove on bear distal tibia
997 interior diagonal lattice (humerus)
998 anterior groove (metapodials)
999 posterior groove (metapodials)

TORTOISE SHELL FEATURES:
993 tortoise shell bridge (anterior or posterior edge)
952 tortoise shell edge fragment
953 tortoise nuchal carapace plate
954 tortoise anal carapace plate

GENERAL PORTION CODES:
1 complete
2 nearly complete
3 1/3 complete
4 1/4 complete
56 half
561 anterior half tooth
562 posterior half tooth
80 shaft fragment
85 long diaphysis (~~not countable~~) *tube*
86 short proximal diaphysis (tube – countable)
88 short distal diaphysis (tube – countable)
90 long countable shaft
93 epiphysis fragment
95 spongy bone fragment
97 flat bone fragment
99 unknown fragment

FOR SHAFTS (86, 88 +…)

-1 anterior
-2 posterior
-3 medial
-4 lateral

AGEING CRITERIA

BONE FUSION & DEVELOPMENT

0 not applicable or no information
1 unfused
2 partly fused*/ only half bone fused*
3 nearly fused (line visible)
4 fully fused
22 unfused diaphysis
33 unfused epiphysis
50 woven bone tissue (immature)
81 (probably) fetus or neonate
88 (probably) juvenile
90 antler base—shed
99 antler base—unshed

TOOTH ERUPTION & WEAR

0 not applicable or no information
1 alveolus just opening
2 alv. open, tooth crown partly formed
3 tooth crown beginning to erupt
4 tooth crown half erupted
5 tooth crown >1/2 erupted
10 no occlusal wear
11 slight wear
12 light wear
13 light-medium wear
14 medium wear
15 medium-advanced wear
16 advanced wear
17 crown completely destroyed by wear
41 pathology, infection/resorption, age unclear (notes taken)

OTHERS

SIDE:

1 = left
2 = right
0 = not applicable or not known

WEATHERING:

0 none
1 fine linear cracks only
2 fine cracks, some "open"
3 many cracks, most "open"
4 some exfoliation
5 advanced exfoliation
6 chemical weathering (add comments)
7 root damage
8 staining
9 trampling

GENERAL ABRASION DAMAGE:

0 = none
1 = mild
2 = medium
3 = severe

TOOL MARK TYPES

C = cutmark
I = blunt impact w/local crushing
^ = cone fracture
Z = scraping, scratching
A = abrasion by deliberate grinding method

TOOL MARK ORIENTATIONS:

P perpendicular or transverse (to main axis)
A axial (to main axis)
D oblique or diagonal (to main axis)
(also record mark length, number & position)

BURNING (location in comments):

0 unburned
1 <1/2 carbonized (<1/2 blackened)
2 >1/2 carbonized
3 fully carbonized
4 <1/2 calcined (<1/2 whitened)
5 >1/2 calcined
6 = fully calcined
88 darkened not burned

FRACTURE TYPES:

TR transverse to main axis
SR spiral fracture
SL split relative to main axis
CR crushing
RI ripped
RR very ragged
HG hinge fracture
CONE cone fracture (*measure diameter*)
OPP opposing cone fractures
I impact damage (bruise, dent)

BREAKAGE

0 none
1 dry
2 curation/ modern
3 curation/dry
4 green
5 indeterminate

GNAWING TYPES:
CARNIVORE
(record presence & comment on types, abundance, position)
damage types include:
  B = bite marks
  C = crenulation
  D = digested
  P = punctures
R = rodent (record presence & comment on types, abundance, position)

Schafstall I -Old excavation					
Taxa		**NSP**	**%NSP**	**WSP**	**% WSP**
MAMMALIA					
Small mammals					
Rodentia					
Marmota marmota	marmot	2	0,22%	3,1	0,03%
Lagomorpha					
Lepus sp.	hare	5	0,58%	12,7	0,14%
Total Small mammals		**7**	**0,80%**	**15,80**	**0,17%**
Carnivores					
Carnivora					
Lutra sp.	otter	1	0,12%	6,6	0,07%
Vulpes vulpes	red fox	4	0,46%	12,1	0,13%
V. vulpes vel *V. lagopus*	fox	6	0,69%	11,3	0,13%
Canis lupus	wolf	2	0,23%	9,1	0,10%
Crocuta crocuta spelaea	Spotted hyena	1	0,12%	2,4	0,03%
Ursus speleaus/ cf. *speleaus*	cave bear	77	8,91%	2620,3	28,93%
Panthera spelaea	cave lion	1	0,12%	7,2	0,08%
Total Carnivores		**92**	**10,66%**	**2669**	**29,47%**
Herbivores					
Perissodactyla					
Coelodonta antiquitatis	woolly rhinoceros	18	2,08%	388,5	4,29%
Equus sp.	horse	63	7,29%	1438,3	15,88%
Artiodactyla					
Cervidae	cervid	10	1,16%	70,5	0,78%
	(antler)	2	0,23%	2,9	0,03%
Cervus elaphus	red deer	9	1,04%	63,7	0,70%
Rangifer tarandus	reindeer	13	1,50%	84,7	0,94%
Bos vel *Bison*	aurochs/bison	6	0,69%	199,8	2,21%
Caprinae	ibex/chamois	5	0,58%	39,8	0,44%
Capra ibex	ibex	3	0,35%	262,8	2,90%
Rupicapra rupicapra	chamois	9	1,04%	68,8	0,76%
Total Herbivores		**138**	**15,96%**	**2619,8**	**28,93%**
Other					
large carnivore	wolf, hyena, bear, lion	5	0,58%	11,2	0,12%
small ungulate	chamois, roe deer	1	0,12%	10,5	0,12%
medium ungulate	red deer/reindeer/ibex	14	1,62%	98,5	1,09%
large ungulate	aurochs/bison/horse/giant deer	59	6,83%	793,7	8,76%
body size 1	hare/fox size	7	0,81%	9,6	0,11%
body size 2	small ungulate/medium carnivore size	36	4,17%	101,5	1,12%
body size 3	medium ungulate size	85	9,84%	417,9	4,61%
body size 4	horse/bear size	216	25,00%	1657,1	18,30%
unidentified		196	22,68%	643,4	7,10%
Total Other		**619**	**71,64%**	**3743,4**	**41,33%**
AVES					
Anseriformes					
Anatidae		4	0,46%	5,6	0,06%
Galliformes					
Lagopus sp.	ptarmigan	1	0,12%	1,7	0,02%
Strigiformes					
Asio otus	long-eared owl	1	0,12%	0,7	0,01%
Passeriformes					
Corvidae	corvid	1	0,12%	0,4	0,00%
Total Birds		**7**	**0,82%**	**8,4**	**0,09%**
Other					
medium bird		1	0,12%	0,6	0,01%
Total Other		**1**	**0,12%**	**0,6**	**0,01%**
Total		864	100,00%	9057	100,00%

Table 6.1NSP, %NSP, WSP(g) and %WSP of mammalian and avian taxa and body size classes from Schafstall I, old excavations

Schafstall I -Excavation of 2016					
			GH		
Taxa			**1**		
MAMMALIA		**NSP**	**%NSP**	**WSP**	**%WSP**
Small mammals					
Lagomorpha					
Lepus sp.	hare	4	0,59%	0,9	0,33%
Total Small Mammals		**4**	**0,59%**	**0,9**	**0,33%**
Carnivores					
Carnivora					
Ursus speleaus/ cf. *speleaus*	cave bear	11	1,61%	42,4	15,37%
Mustela sp.	stoat/least weasel	1	0,15%	0,1	0,04%
Total Carnivores		**12**	**1,76%**	**42,5**	**15,41%**
Herbivores					
Perissodactyla					
Cervidae	Cervid	1	0,15%	0,7	0,25%
Total Herbivores		**1**	**0,15%**	**0,7**	**0,25%**
Other					
large carnivore	wolf, hyena, bear, lion	2	0,29%	2,2	0,80%
carnivore indet		1	0,15%	0,1	0,04%
small ungulate	chamois, roe deer	1	0,15%	0,1	0,04%
smaller than hare/fox size		1	0,15%	1	0,36%
body size 1	hare/fox size	5	0,73%	2,3	0,83%
body size 2	small ung./medium carniv. size	3	0,44%	3,6	1,30%
body size 3	medium ungulate size	1	0,15%	8,2	2,97%
body size 4	horse/bear size	29	4,25%	57,9	20,99%
unidentified		618	90,61%	155,2	56,24%
Total Other		**661**	**96,91%**	**230,6**	**83,57%**
AVES					
Phasianidae					
Lagopus sp.	ptarmigan	2	0,29%	0,3	0,11%
Lyrurus tetrix	black grouse	1	0,15%	0,8	0,29%
Total Birds		**3**	**0,44%**	**1,1**	**0,40%**
Other					
medium bird		1	0,15%	0,1	0,04%
Total Other		**1**	**0,15%**	**0,1**	**0,04%**
Total		**682**	**100,00%**	**275,9**	**100,00%**

Schafstall I – Excavation of 2016 *(continuation)*				
	GH 2			
Taxa	**NSP**	**%NSP**	**WSP**	**%WSP**
Carnivores				
Carnivora				
V. vulpes vel *V. lagopus*	1	8%	0,1	1,16%
Total Carnivores	**1**	**8%**	**0,1**	**1,16%**
Herbivores				
Perissodactyla				
Equus sp.	1	8%	1,4	16,28%
Cervidae				
Total Herbivores	**1**	**8%**	**1,4**	**16,28%**
Other				
small ungulate	1	8%	2,4	27,91%
unidentified	10	76%	4,7	54,65%
Total Other	**11**	**84%**	**7,1**	**82,56%**
Total	**13**	**100%**	**8,6**	**100,00%**

Table 6.2 NSP, %NSP, WSP(g) and %WSP of mammalian and avian taxa and body size classed from Schafstall I, excavation of 2016

Schafstall II – Old excavation					
		NSP	**% NSP**	**WSP**	**%WSP**
MAMMALIA					
Small mammals					
Rodentia					
Marmota marmota	marmot	7	0,1%	2,8	<0,1%
Lagomorpha					
Lepus europaeus	European hare	2	0,0%	0,2	<0,1%
Lepus timidus	Mountain hare	3	0,1%	0,3	<0,1%
Lepus sp.	hare	352	7,3%	252,6	0,9%
Small mammals total		**364**	**7,5%**	**255,9**	**0,9%**
Carnivores					
Carnivora					
Panthera spelaea	lion	1	0,0%	27,8	0,1%
Crocuta crocuta spelaea	spotted hyena	1	0,0%	0,7	<0,1%
Vulpes vulpes	red fox	3	0,1%	6,1	<0,1%
Vulpes lagopus	arctic fox	1	0,0%	1,7	<0,1%
V. vulpes vel *V. lagopus*	fox	76	1,6%	53,7	0,2%
Canis lupus	wolf	18	0,4%	48,1	0,2%
Ursus speleaus/ cf. *speleaus*	cave bear	840	17,3%	16450,75	55,9%
Mustelidae	mustelid	1	0,0%	0,8	<0,1%
Mustela erminea	stoat	9	0,2%	0,7	<0,1%
Mustela nivalis	least weasel	5	0,1%	0,2	<0,1%
Martes sp.	marten	1	0,0%	0,2	<0,1%
Carnivores total		**956**	**19,7%**	**16590,75**	**56,3%**
Herbivores					
Proboscidea					
Mammuthus primigenius	mammoth				
ivory		1	0,0%	0,4	<0,1%
Perissodactyla			0,0%		<0,1%
Coelodonta antiquitatis	woolly rhinoceros	17	0,4%	1350,3	4,6%
Equus sp.	horse	43	0,9%	1140,4	3,9%
Artiodactyla			0,0%		<0,1%
Cervidae	cervid	6	0,1%	21,4	0%
antler		3	0,1%	16,1	0%
Capreolus capreolus	roe deer		0,0%		
Cervus elaphus	red deer	5	0,1%	53,1	0,2%
Rangifer tarandus	reindeer	38	0,8%	287,2	1,0%
antler		2	0,0%	30,4	0,1%
Bison sp.	bison	1	0,0%	29,2	0,1%
Bos vel *Bison*	aurochs/bison	5	0,1%	365	1,2%
Caprinae	ibex/chamois	11	0,2%	18,7	0,1%
Capra ibex	ibex	18	0,4%	54,7	0,2%
Rupicapra rupicapra	chamois	3	0,1%	9	<0,1%
Total Herbivores		**153**	**3,2%**	**3375,5**	**11,5%**

Schafstall II – Old excavation *(continuation)*

		NSP	%NSP	WSP	%WSP
Other					
small carnivore	marten/fox/wild cat	3	0,1%	0,6	<0,1%
medium carnivore	badger/lynx	1	0,0%	0,7	<0,1%
large carnivore	wolf, hyena, bear, lion	133	2,7%	446	1,5%
small ungulate	chamois, roe deer	5	0,1%	12,3	<0,1%
medium ungulate	red deer/reindeer/ibex	23	0,5%	84,9	0,3%
large ungulate	aurochs/bison/horse/giant deer	32	0,7%	505,2	1,7%
smaller than hare/fox size		3	0,1%	18,5	0,1%
body size 1	hare/fox size	100	2,1%	36,5	0,1%
body size 2	small ungulate/medium carnivore size	19	0,4%	35,9	0,1%
body size 3	medium ungulate size	43	0,9%	184,7	0,6%
body size 4	horse/bear size	734	15,2%	5358,74	18,2%
body size 5	megaherbivore size	3	0,1%	110,6	0,4%
unidentified		1987	41,0%	2312,68	7,9%
Total Other		**3086**	**63,7%**	**9107,32**	**30,9%**
AVES					
Anseriformes					
A. crecca	common teal	1	0,0%	1,3	<0,1%
Anas cf. *crecca*		1	0,0%	0,2	<0,1%
Anas platyrhyncos	mallard	1	0,0%	0,6	<0,1%
Anas cf. *platyrhyncos*		1	0,0%	0,2	<0,1%
Anas sp.		2	0,0%	0,6	<0,1%
Anatidae		8	0,2%	5,8	<0,1%
Aythya sp.		1	0,0%	0,2	<0,1%
Tadorna tadorna	common shelduck	1	0,0%	0,5	<0,1%
Falconiformes					
Falco tinnunculus	common kestrel	11	0,2%	3,9	<0,1%
Falco cf. *tinnunculus*		1	0,0%	0,2	<0,1%
Falco sp.		2	0,0%	0,6	<0,1%
Falconidae		3	0,1%	0,4	<0,1%
Galliformes					
Lagopus cf. *mutus*		5	0,1%	1,9	<0,1%
Lagopus sp.	ptarmigan	26	0,5%	15,7	0,1%
Lyrurus tetrix	black grouse	5	0,1%	5	<0,1%
Tetraoninae		13	0,3%	5,6	<0,1%
Phasianidae		10	0,2%	5,1	<0,1%
Gruiformes					%
Fulica atra	common coot	1	0,0%	0,5	<0,1%
Charadriiformes					
Gallinago gallinago	common snipe	1	0,0%	0,2	<0,1%
Pluvialis apricaria	Eurasian golden plover	1	0,0%	0,5	<0,1%
Charadriidae		1	0,0%	1,1	<0,1%
Scolopacidae		3	0,1%	0,8	<0,1%
Laridae		1	0,0%	1,4	<0,1%
Charadriiformes indet		7	0,1%	4,2	<0,1%

Schafstall II – Old excavation *(continuation)*					
		NSP	**%NSP**	**WSP**	**%WSP**
Strigiformes					%
Asio otus	long-eared owl	2	0,0%	0,4	<0,1%
Athene noctua	little owl	1	0,0%	0,1	<0,1%
Strix aluco	tawny owl	4	0,1%	2,5	<0,1%
Passeriformes					%
Turdidae		1	0,0%	0,3	<0,1%
C.cinclus	white-throated dipper	11	0,2%	1,2	<0,1%
Pyrrhocorax sp.	chough	1	0,0%	0,1	<0,1%
Corvus corax	common raven	3	0,1%	2,6	<0,1%
Corvidae		15	0,3%	4,7	<0,1%
Passeriformes indet		13	0,3%	1,3	<0,1%
Total Birds		**158**	**3,3%**	**69,7**	**0,2%**
Other					
small bird		8	0,2%	0,7	<0,1%
small to medium bird		38	0,8%	5,3	<0,1%
medium bird		64	1,3%	25,3	0,1%
medium to large bird		4	0,1%	3,2	<0,1%
large bird		6	0,1%	12,1	<0,1%
very large bird		1	0,0%	1,8	<0,1%
bird indet		8	0,2%	0,9	<0,1%
Total Other		**129**	**2,7%**	**49,3**	**0,2%**
Total		**4846**	**100,0%**	**29448,47**	**100,0%**

Table 6.3 NSP, %NSP, WSP(g) and %WSP of mammalian and avian taxa and body size classes from Schafstall II, old excavations

Schafstall II - Excavations of 2016-2017

				GH			
MAMMALIA		**Surface**	**1**	**2**	**2a**	**2b**	**2c**
Small mammals							
Lagomorpha							
Lepus sp.	hare		1	5	12		
Small mammals total			**1**	**5**	**12**		
%NISP		**0%**	**7%**	**2%**	**3%**		
Carnivores							
Carnivora							
Ursus speleaus /cf. *speleaus*	cave bear	2	5	245	388	60	35
Panthera spelaea	lion				1		
Crocuta crocuta spelaea	spotted hyena						
Vulpes vulpes	red fox			1			
V.vulpes vel *V. lagopus*	fox			3	11	2	
Canis lupus	wolf			7	7	2	
Mustela sp.	stoat/least weasel						
Martes sp.	marten						
Carnivores total		**2**	**5**	**256**	**407**	**64**	**35**
%NISP cave bear		**17%**	**36%**	**85%**	**88%**	**91%**	**100%**
%NISP other csrnivores		**0%**	**0%**	**4%**	**4%**	**6%**	**0%**
Herbivores							
Proboscidea							
Mammuthus primigenius	mammoth						
Perissodactyla							
Coelodonta antiquitatis	woolly rhino			1	8	1	
Equus sp.	horse			10			
Artiodactyla							
Sus scrofa	wild boar	8*		1*			
Cervidae	cervid			2			
antler		1*		1			
Cervus elaphus	red deer	1*	1*	6*			
Capreolus capreolus	roe deer		4*				
Rangifer tarandus	reindeer			5	11	1	
Bison sp.	bison				1		
Bos vel *Bison*	aurochs/bison						
Caprinae	ibex/chamois			2	1		
Capra ibex	ibex		3				
Herbivores total		**10**	**8**	**28**	**21**	**2**	
%NISP Herbivores			**57%**	**10%**	**5%**	**3%**	
Other							
small carnivore	marten/fox/wild cat			2	2		
medium carnivore	badger/lynx						
large carnivore	wolf, hyena, bear, lion			23	29	2	1

Schafstall II - Excavations of 2016-2017 *(continuation)*

		Surface	1	2	2a	2b	2c
small ungulate	chamois, roe deer						
medium ungulate	red deer/reindeer/ibex			6	3		
large ungulate	aurochs/bison/horse/giant deer						
smaller than hare/fox				1	1		
body size 1	hare/fox size			14	15	1	2
body size 2	small ung. /medium carniv. size	3	1	6	13	3	1
body size 3	medium ungulate size		5	13	17		1
body size 4	horse/bear size		3	163	272	22	
body size 5	megaherbivore size				1		
unidentified		5	26	645	1060	111	63
Other total		**8**	**35**	**873**	**1413**	**139**	**68**
Birds size class							
small bird				1			
medium bird					5		
medium to large bird					1		
large bird				2			
Other total				**3**	**6**		
Total		**20**	**49**	**1165**	**1859**	**205**	**103**

Schafstall II - excavations of 2016-17 *(continuation)*

		GH					
MAMMALIA		**2ap**	**3p**	**4p**	**5p**	**6p**	**Total**
Small mammals							
Lagomorpha							
Lepus sp.	hare						56
Small mammals total							**56**
%NISP							**3%**
Carnivores							
Carnivora							
Ursus speleaus /cf. *speleaus*	cave bear	3	40	31	10	3	1912
Panthera spelaea	lion						3
Crocuta crocuta spelaea	spotted hyena						1
Vulpes vulpes	red fox		2				6
V.vulpes vel *V. lagopus*	fox	1	1				32
Canis lupus	wolf						24
Mustela sp.	stoat/least weasel					1	2
Martes sp.	marten						1
Carnivores total		**4**	**43**	**31**	**10**	**4**	**1981**
%NISP cave bear		**75%**	**93%**	**74%**	**63%**	**43%**	**86%**
%NISP other csrnivores		**25%**	**7%**	**0%**	**0%**	**14%**	**3%**
Herbivores							
Proboscidea							
Mammuthus primigenius	mammoth			10	1		11
Perissodactyla							
Coelodonta antiquitatis	woolly rhino					1	67
Equus sp.	horse				2	1	13
Artiodactyla							
Sus scrofa	wild boar						9
Cervidae	cervid				1		9
antler							5
Cervus elaphus	red deer						8
Capreolus capreolus	roe deer						4
Rangifer tarandus	reindeer						32
Bison sp.	bison						1
Bos vel *Bison*	aurochs/bison					1	1
Caprinae	ibex/chamois						4
Capra ibex	ibex				1		5
Herbivores total				**10**	**5**	**3**	**169**
%NISP Herbivores				**24%**	**31%**	**43%**	**8%**

		2ap	3p	4p	5p	6p	Total
Other							
small carnivore	marten/fox/wild cat	1					11
medium carnivore	badger/lynx						1
large carnivore	wolf, hyena, bear, lion		3		1		142
small ungulate	chamois, roe deer						2
medium ungulate	red deer/reindeer/ibex			1	2		19
large ungulate	aurochs/bison/horse/giant deer					1	1
smaller than hare/fox							2
body size 1	hare/fox size	1	1	2	2		135
body size 2	small ungulate/medium carnivore size		1	3			53
body size 3	medium ungulate size			1	5		67
body size 4	horse/bear size	4	3	6	2		757
body size 5	megaherbivore size						7
unidentified		13	42	46	16		3559
Other total		**19**	**50**	**59**	**28**	**1**	**4756**
AVES							
Anseriformes							
Anatidae				1			1
Galliformes							
Lagopus sp.	ptarmigan						1
Charadriiformes							
G.gallinago	common snipe						1
Charadriidae					1		1
Chardriiformes							1
Passeriformes							
Turdus sp.	thrush						1
Birds total				**1**	**1**		**6**
%NISP Birds		**0%**	**0%**	**2%**	**6%**	**0%**	**<1%**
Other							
small bird				1	1		4
medium bird					1		10
medium to large bird							1
large bird							2
Other total				**1**	**2**		**17**
Total		**23**	**93**	**102**	**46**	**8**	**6985**

Table 6.4 NSP, %NSP, WSP(g) and %WSP of mammalian and avian taxa and body size classes from Schafstall II, new excavation of 2016-2017. Frequency counts marked with an asterisk (*) indicate intrusive specimens from the Holocene

SSI Old - cutmarks

	horse	Red deer	large ungulate	large ruminant	horse/bear size	medium carnivore/small ungulate size	medium ungulate size	indet
rib			1		1			
scapula	1							
tibia		1						
cervical vertebra							1	
long bone			1		6	1	10	
indet				4	1			2

SSI Old – impact marks

	horse	Aurochs/bison	indet	medium ungulate size	large ungulate
scapula	2	1			
tibia	1				
metapodial	1				
long bone				1	
indet			1		5

SSI Old – scraping marks

	Red deer	large ungulate	large ruminant	small ungulate size	medium ungulate size	horse/bear size
rib		1				
tibia	1					
long bone		1	9		1	1
indet				1		

SSI Old – cone fractures

	horse	cervid	chamois	small ungulate size	medium ungulate size	large ruminant
tibia			1			
metacarpal		1				
metapodial		1				
long bone	1			1	3	2
indet						

SSI Old - retouchers			
	large ruminant	horse/bear size	indet
rib		1	
long bone	13		
indet			1

Table 6.5 Number of anthropogenic modifications affecting the different skeletal elements of identified taxa and body size classes in the old assemblage of Schafstall I

SSII Old -cutmarks

	fox	cave bear	large carnivore	mammoth	horse	reindeer	Capra sp.	large ungulate
mandible	1	3						
scapula					1	1		1
radius					3			
rib		5	1		2			
femur		6						
fibula		1						
tibia		2			1			
astragalus		1						
I phalanx		2						
I metacarpal		1			1	1		
metatarsal						1	1	
ivory				1				
long bone					1			

SSII Old - cutmarks

	indet	fox/hare size	horse/bear size	large ruminant
vertebra			1	
rib			5	2
tibia		1		
long bone		1	20	
indet	21		6	

SSII Old - impact marks

	cave bear	horse	indet	horse/bear size
rib				2
femur	1			
tibia	3			
I metacarpal		1		
long bone				2
indet			1	

SSII Old – scraping marks

	cave bear	small ungulate	large ungulate	horse/bear size
mandible		1		
femur	1			
long bone			1	1

SSII Old - cone fractures			
	cave bear	horse	reindeer
scapula			1
femur	1		
tibia	1		
metacarpal		1	

SSII Old - retouchers			
	cave bear	horse	horse/bear size
lower canine	1		
radius		1	
rib			1
femur	2		
fibula			
tibia	1		
metacarpal		1	
long bone		1	2

Table 6.6 Number of anthropogenic modifications affecting the different skeletal elements of identified taxa and body size classes in the old assemblage of Schafstall II

	SSII New - cutmarks			
	2a	Hf		3p
	horse/bear size	fox/hare size	Ursus speleaus	horse/bear size
long bone	1	1		
mandible			1	
scapula				1
indet				1

Table 6.7 Number of anthropogenic modifications affecting the different skeletal elements of identified taxa and body size classes in the new assemblage of Schafstall II

Site	Sex	Cultural layer	L	B
Gk	f	**n.a**	19,2	16,4
Gk	f	**n.a**	22,2	16,9
Gk	f	**n.a**	19,9	16,4
Gk	f	**n.a**	24,8	16,8
Gk	f	**n.a**	21	16,6
Gk	f	**n.a**	20,7	16,2
Gk	f	**n.a**	20,8	16,4
Gk	m	**n.a**	24,1	21
Gk	m	**n.a**	25,7	20,9
Gk	m	**n.a**	30	23,6
Hf	f	**GR**	18,8	14,6
Hf	f	**GR**	26,7	21,6
Hf	f	**GR**	19,1	15,5
Hf	f	**A**	22,7	17,0
Hf	f	**GR**	21,8	16,6
Hf	f	**MP**	21,4	16,7
Hf	f	**GR**	22,5	16,9
Hf	f	**MP**	25,3	17,8
Hf	f	**A**	26,6	20,2
Hf	m	**A**	21,5	20,0
Hf	m	**MP**	30,0	23,1
Hf	m	**GR**	28,2	20,0
HS	m	**A**	26,3	17,1
HS	m	**A**	37,1	22,6
HS	m	**A**	30,9	20,1
HS	f	**A**	22,81	16,73
HS	m	**A/MAG**	34,6	22
HS	f	**MP R**	26,1	17,2
HS	f	**MP R**	26,4	15
HS	f	**MP R**	24,4	17,3
HS	m	**MP U**	32,5	20,2
HS	m	**MP U**	35,3	23,7
HS	m	**MP U**	39,5	26,3
HS	m	**MP U**	36,9	24,9
HS	m	**MP U**	35,7	25,1
HS	f	**MP U**	24,9	15,6
HS	f	**MP U**	26,2	14,7
HS	f	**MP U**	24,4	19,4
HS	f	**MP U**	19,73	15,2
HS	f	**MP U**	18,45	16
HS	m	**MP U**	31,3	21
HS	m	**MP U**	30,4	19,6
HS	m	**MP U**	35,3	23,7
HS	m	**MP U**	39,5	26,3
SSII	f		22,43	16,02
SSII	f		21,26	16,48

(continuation)			
SSII	f	19,49	15,25
SSII	f	21,80	16,43
SSII	f	20,96	14,99
SSII	f	21,74	15,98
SSII	f	21,06	16,51
SSII	f	22,12	16,74
SSII	f	19,93	15,24
SSII	f	18,86	16,95
SSII	f	21,93	15,86
SSII	f	20,49	16,30
SSII	f	22,68	17,25
SSII	f	22,51	17,02
SSII	m	26,13	21,46
SSII	m	29,88	20,90

Table 6.8 Lower canine specimens from Geißenklösterle (Gk), Hohle Fels (Hf), Hohlenstein Stadel (HS) and Schafstall II (SS II) and their respective measurements taken at the crown basis. Measurements for GK were taken from Münzel (2019), while those for HF and HS were borrowed respectively from Münzel (unpublished data) and Kitagawa (unpublished data).