

# New Insights Gained from the Faunal Material Recovered During the Latest Excavations at Vogelherd Cave

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**Abstract:** *Vogelherd Cave, which was discovered and excavated in 1931, is one of the most important Aurignacian sites in Europe. Although the excavator Gustav Riek performed the excavation under high standards for the time, he did not recover all material. They removed all sediments in 1931. This sediment was re-excavated and analyzed by an international team under the lead of Nicholas Conard starting in 2005. These new excavations revealed exceptional artwork in form of flutes, beads, and figurines carved from mammoth ivory, bone and stone tools, and faunal material. Here we present the first analysis of the faunal material. Results are compared to the 1931 material analyzed by Laura Niven in the early 2000s. Due to the higher methodological standard during the recent excavations, the excavators recovered a large number of small game remains. This work shows the importance of re-excavations and detailed recovery methods, and how they can change the picture of a site.*

**Keywords:** *Swabian Jura, Aurignacian, subsistence, fauna, small game*

## Neue Erkenntnisse aus dem Faunenmaterial der jüngsten Ausgrabungen am Vogelherd

**Zusammenfassung:** Die 1931 von dem Tübinger Urgeschichtsforscher Gustav Riek ausgegrabene Vogelherdhöhle ist einer der bedeutendsten aurignacienzeitlichen Fundplätze Europas. Riek definierte neun Kulturschichten, die vom Mittelpaläolithikum bis ins Neolithikum reichen. Die in das Aurignacien datierten Fundschichten AH IV und V lieferten neben Hinweisen auf die Ernährung des nach Europa eingewanderten modernen Menschen außergewöhnliche aus Mammutfelßen geschnitzte Tierfiguren. Trotz der für die Zeit hohen Maßstäbe, blieb Material nach der Ausgrabung zurück. Dieser Abraum, welcher noch vor der Höhle vorlag, wurde von 2005 bis 2012 unter der Leitung von Nicholas Conard neu untersucht.

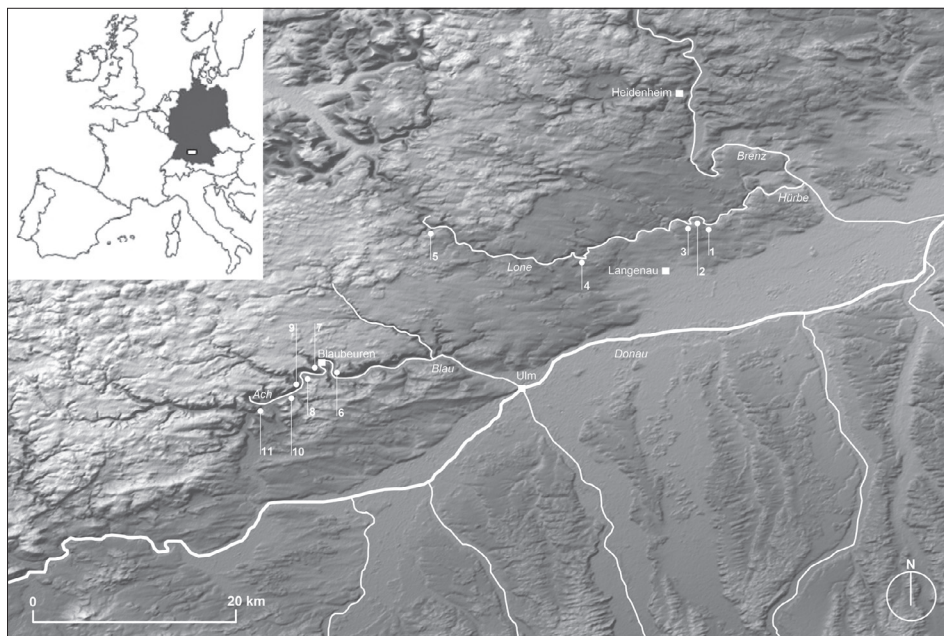
Die Nachgrabungen lieferten zahlreiche Kunstwerke, Steinwerkzeuge, Elfenbeinschmuck und Tierknochen. Zielsetzung dieser Arbeit war es, das Faunenmaterial der Nachgrabungen mit dem 1931 ausgegrabenen zu vergleichen. Zusätzlich zu den Untersuchungen am Material aus dem ehemaligen Höhlensediment wurde auch Material aus stratifizierten Schichten ausgewertet. Die Auswertung der

Großfauna, Pferd, Rentier und Mammut, und der sekundären Jagdtiere, u.a. Auerochse, Rothirsch und Wildschwein, bestätigte das bisherige Bild der Subsistenz auf der Schwäbischen Alb. Ein weiterer bisher am Vogelherd unbekannter Aspekt, der mit dieser Arbeit den vorangehenden Arbeiten von Ulrich Lehmann und Laura Niven hinzugefügt werden konnte, ist die Jagd auf Kleinwild, insbesondere Hasen. Somit fügt sich der Vogelherd in das Bild der Erweiterung des Nahrungsspektrums, welche auch an anderen Fundstätten ab dem Aurignacien beobachtet wird und welche meist im Gravettien ihren Höhepunkt erreicht.

**Schlagwörter:** Schwäbische Alb, Aurignacien, Subsistenz, Fauna, Kleinwild

## Introduction

The caves of the Swabian Jura, located in the Ach and Lone valleys, yielded extraordinary artifacts and help to answer the question of when and how Europe was populated by anatomically modern humans and how they lived. Before modern humans, Neanderthals lived in this area and interestingly, the stratigraphic sequences of several Swabian sites, including Geißenklösterle, Hohle Fels, Sirgenstein and Vogelherd (Fig. 1) show an occupational hiatus at the shift from the Middle to the Upper Paleolithic (Schmidt 1912; Riek 1934; Hahn 1988; Conard and Bolus 2006; Conard et al. 2006, 2012; Bolus 2011; Conard 2011). Many sites contained figurative ivory artwork, depicting animals and anthropomorphic creatures, and the first musical instruments found to date, in the form of flutes carved from mammoth ivory and bird bone (Conard and Malina 2008). Evidence, like the lion-man found at Hohlenstein-Stadel, shows that the occupants of these cave sites were highly sophisticated and shared an advanced cultural belief system (Conard 2009a, 2013).

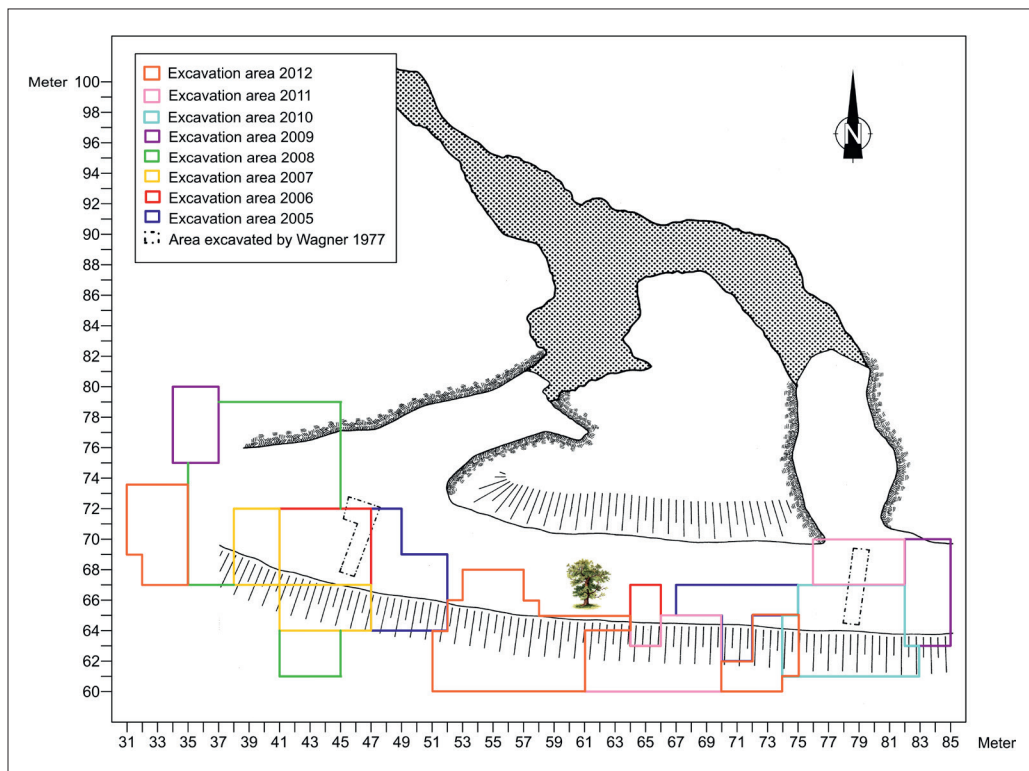


**Fig. 1:** Map of the Swabian Jura showing the location of cave sites. Lone Valley: 1 Vogelherd, 2 Hohlenstein, 3 Bockstein, 4 Fohlenhaus, 5 Haldenstein; Ach Valley: 6 Große Grotte, 7 Brillenhöhle, 8 Geißenklösterle, 9 Sirgenstein, 10 Hohle Fels, 11 Kogelstein.

This study focuses on the faunal remains discovered during the recent excavations at Vogelherd. These materials originate from the backdirt of an excavation conducted in 1931, as well as some previously unknown intact layers. First, faunal remains from the former cave sediment are compared to a previous analysis conducted by Laura Niven, who examined large finds from the earlier investigation (Niven 2001, 2003, 2006, 2007). Second, the fauna recovered from intact layers is examined.

Vogelherd Cave is located in the Lone Valley in southwestern Germany. It consists of two corridors of 15-25 m length and a hall (Fig. 2). The two main entrances lie about 18 m above the valley floor. A third entrance is narrow and was likely not used by the occupants. North of the Lone Valley lies the dry plateau of the Swabian Jura, south of it the flatlands of the *Flächenalb*, which expand to the Danube River. Throughout the Paleolithic, game and lithic raw material sources were abundant in this environment (Hahn et al. 1985; Burkert and Floss 2005).

The cave was discovered in 1931 and excavated the same year in a three month campaign under the lead of Gustav Riek, then assistant at the Department of Prehistory at the University of Tübingen. While the excavation had high standards for its time, Riek's team did not screen the sediments. Nonetheless, they recovered and curated extraordinary artworks made from mammoth ivory and, exceptional for the time, a large number



**Fig. 2:** Vogelherd Cave. Areas of recent excavations in the backdirt of Riek's 1931 fieldwork. Modified after Conard et al. 2013b.

of faunal remains. In the early 1950s, Ulrich Lehmann examined the faunal material, consisting of about 18,800 bones. He focused on easily identifiable specimens and interpreted the assemblage as the remains of human meals (Lehmann 1954). Almost fifty years later, in the 2000s, Laura Niven examined the complete fauna in a number of articles and her 2006 monograph ‘The Palaeolithic Occupation of Vogelherd Cave’.

While Niven analyzed the faunal remains of Riek’s excavation, researchers of the Eberhard Karls University Tübingen lead by Nicholas Conard started to re-excavate the former deposits of Vogelherd Cave, which were still located in front of the cave. Over eight years the team excavated four hundred sixty two square meters, representing about 90% of the former cave sediment. The new excavations changed the picture of the Vogelherd Aurignacian. For example, Riek recovered no ivory beads or ornaments in 1931, while so far 346 have been discovered during the screening of the sediment, making the Vogelherd bead assemblage the richest in the Swabian Jura (Conard et al. 2013b). Since 2005, additional ivory figurines have been found in the Vogelherd backfill and corroborate the role of the cave as one of the most important Aurignacian sites in Central Europe (Conard et al. 2007, 2008, 2009b; Conard and Zeidi 2014).

Riek identified nine cultural horizons (Table 1) at Vogelherd, spanning from the Neolithic to the Middle Paleolithic. Dating of the Swabian cave sites is important for the understanding of the age and the cultural context of the Middle Paleolithic and the early Aurignacian in Europe. There is a good radiocarbon data set for the Aurignacian (Table 2), but unfortunately the Middle Paleolithic lies beyond the limits of this method. The first radiocarbon dates of the Swabian Jura were produced in the mid 1970s, suggesting the Aurignacian in the Lone Valley lasted from 32,000 until 23,000 BP (uncal.) (Hahn 1977). In 2003, new AMS radiocarbon dates for the Aurignacian horizons IV and V of Vogelherd Cave were published confirming its contemporaneity with the Aurignacian of nearby Hohlenstein-Stadel, and Hohle Fels and Geißenklösterle Caves in the Ach Valley (Conard and Bolus 2003; Conard et al. 2003). New dates, published by Higham and colleagues (2012), indicate that the Swabian Aurignacian lasted from 38,000 to 43,000 BP (cal.).

AH	Riek’s designation	revised designation
I	Neolithic ( <i>Neolithikum</i> )	Neolithic
II	Magdalenian ( <i>Magdalénien</i> )	Magdalenian
III	Magdalenian ( <i>Magdalénien</i> )	Magdalenian
IV	Upper Aurignacian ( <i>Oberes Aurignacien</i> )	Aurignacian
V	Middle Aurignacian ( <i>Mittleres Aurignacien</i> )	Aurignacian
VI	Lower Aurignacian ( <i>Unteres Aurignacien</i> )	Middle Paleolithic
VII	Mousterian ( <i>Moustérien</i> )	Middle Paleolithic
VIII	Upper Acheulean ( <i>Jungacheuléen</i> )	Middle Paleolithic
IX	Cave floor ( <i>Höhlensohle</i> )	Middle Paleolithic

**Table 1:** Vogelherd Cave. Cultural stratigraphy. Left: Riek’s (1934) designation; right: revised designation (Müller-Beck 1956). AH = Archaeological Horizon.

Lab.nr.	AH	Material	Date [BP]	Cultural Group	First Publication
KIA 19542	?	brown bear canine	29,620±210	Aurignacian	Conard et al. 2003
OxA-10196	III	mammoth molar	25,780±250	Gravettian?	Conard et al. 2003
OxA-10198	III	giant deer dentin	26,110±310	Gravettian?	Conard et al. 2003
OxA-10195	III	mammoth tooth dentin	31,680±310	Aurignacian	Conard et al. 2003
OxA-10197	III	rhino, tooth dentin	39,700±650	?	Conard et al. 2003
KIA 19537	IV	human cranium (Stetten 2)	3,980±35	Neolithic	Conard et al. 2004
KIA 8966	IV	bovid/horse femur	13,015±55	Magdalenian	Conard et al. 2003
KIA 8957	IV	worked longbone	26,160±150	Gravettian?	Conard and Bolus 2003
PL0001340A	IV/V	reindeer meta-tarsal	13,630±410	Magdalenian	Conard et al. 2003
PL0001339A	IV/V	horse tibia	32,180±960	Aurignacian	Conard and Bolus 2003
PL0001342A	IV/V	bovid/horse rib	34,100±1,100	Aurignacian	Conard and Bolus 2003
KIA 19538	V	human mandible (Stetten 1)	4,715±35	Neolithic	Conard et al. 2004
KIA 19539	V	human vertebra (Stetten 4)	4,735±30	Neolithic	Conard et al. 2004
KIA 20967	V	human cranium (Stetten 1)	4,910±25	Neolithic	Conard et al. 2004
KIA 20969	V	human mandible (Stetten 1)	4,985±30	Neolithic	Conard et al. 2004
KIA 19540	V	human humerus (Stetten 3)	4,995±35	Neolithic	Conard et al. 2004
KIA 8968	V	artiodactyl tibia	31,790±240	Aurignacian	Conard and Bolus 2003
PL0001338A	V	horse tibia	32,400±1700	Aurignacian	Conard and Bolus 2003
KIA 8969	V	reindeer long bone	32,500 +260/-250	Aurignacian	Conard and Bolus 2003
KIA 8970	V	horse longbone	33,080+320/-310	Aurignacian	Conard and Bolus 2003
PL0001337A	V	bovid/horse long-bone	35,180±710	Aurignacian	Conard and Bolus 2003
	HL/KS	human metatarsal	4,895±30	Neolithic	Conard 2009b

**Table 2:** Vogelherd Cave. Radiocarbon dates.



## Human Remains

Riek recovered seven human bones, belonging to at least three individuals, from the Aurignacian deposits (AH IV/V) at the southwestern and southern entrances of Vogelherd Cave (Riek 1934). For about 70 years, they were one of the best pieces of evidence for anatomically modern humans as producers of the Swabian Aurignacian (Churchill and Smith 2000; Conard and Bolus 2006). In 2004, they were dated directly to around 5000 BP (uncal.) (Table 2), making them about 25,000 years younger than animal bones from the same horizon (Conard et al. 2004). Additional human bones, discovered during the new excavations, also are of the same age as the intrusive Neolithic skeletal remains (Conard 2009b).

## Research Background and Previous Faunal Studies

### Middle Paleolithic

There is sparse archaeological material dating to the Middle Paleolithic and none of the Middle Paleolithic horizons spans the entire area of the cave. In the four stratigraphic layers dating to the Middle Paleolithic (AH VI-IX), only 124 lithic artifacts and 677 faunal remains were found. The tool assemblage consists of hand axes, scrapers, possible points, and flake tools produced from local raw material (Riek 1934; Hahn et al. 1985). Nine organic artifacts were recovered from the Middle Palaeolithic horizons, most of them retouchers (Taute 1965). Although Riek described most of the lithic artifacts as Mousterian, he designated AH VI as Lower Aurignacian (*Unteres Aurignacien*). In a revision of the lithic material, AH VI was identified as Mousterian (Müller-Beck 1956).

Niven (2006) examined the AH VII faunal assemblage more closely, and interpreted it as the result of a carnivore and Neanderthal occupation. This refutes Riek's (1934) and Lehmann's (1954) interpretation, who thought the Middle Paleolithic faunal assemblage was produced solely by Neanderthals. Vogelherd Cave was regularly occupied by Neanderthals, but much less intensively than the Aurignacian occupation by anatomically modern humans. Koenigswald and Müller-Beck (1975) proposed a pattern of repeated, short-term visits during the Middle Paleolithic.

### Upper Paleolithic

Swabia is a key area of Aurignacian innovation, with early figurative art and music. New dates on the Early Aurignacian of Geißenklösterle indicate that it precedes the Proto-Aurignacian and Early Aurignacian of Italy and southern France (Higham et al. 2012). This observation is explained by the movement of modern humans into Europe along the Danube River until they reached the depopulated Swabian Jura around 40,000 BP (Conard 2003; Conard and Bolus 2003, 2006; Bolus 2011).

At Vogelherd, Aurignacian finds are distributed over the entire area of the cave and also spread out onto the terraces. The Aurignacian faunal assemblage makes up 94% of the total faunal remains from the site. Both Aurignacian horizons (AH IV and V) are exceptionally rich in cultural material and likely represent multiple occupation events

(Hahn 1977). According to Riek (1934), lithic artifacts were produced at the southwestern entrance, while organic artifacts were produced in the hall. The lithic inventory consists of scrapers, burins, and blades, showing similarities to Hohlenstein-Stadel AH IV (Hahn et al. 1985). An abundance of reworked tools is interpreted as an indicator of raw material scarcity caused by a reduction in mobility during periods of cold weather (Riek 1934). During the excavations from 2005 to 2012 additional Aurignacian lithic artifacts dominated the assemblage of every field season (Conard et al. 2013b). The organic tool assemblage is typical for Aurignacian sites, consisting of split-based points, retouchers, smootheners, awls, and ivory rods. Personal ornaments at Vogelherd include beads and perforated teeth. In addition, some of the artworks are perforated and are therefore believed to have been worn as pendants.

In the faunal analysis, Niven combined AH IV and V for two reasons. First, Riek labelled one third of the specimens AH IV/V, and second, bone (Niven 2006) and lithic refits (Hahn 1977) between the two horizons suggest a mixing of the layers prior to Riek's excavation.

Previous analyses show that the primary prey animals during the Swabian Aurignacian were horse (*Equus ferus*) and reindeer (*Rangifer tarandus*). Preservation is good and the bones have minimal gnawing damage by wolves and foxes, so their role as accumulators seems to be insignificant. Unlike other sites in the Lone Valley, like Hohlenstein-Stadel (Kitagawa 2014), Kogelstein, and Geißenklösterle (Münzel and Conard 2004a), cave hyena are also rare and seem to have played a little or no role. Instead, the bones preserve multiple signs of human exploitation, like cutmarks, chopmarks, and impact marks (Niven 2006). The horse assemblage shows signs of selective transport, with an abundance of cranial and appendicular elements, while axial elements are scarce. Transport decisions were probably not always based on the economic value of body parts, since, with exception of femora, the most nutritionally valuable body parts are under-represented (Niven 2003). Using the standardized Food Utility Index (FUI) developed by Outram and Rowley-Conwy (1998), Niven (2003) investigated the introduction of valuable and non-valuable body parts to the site. Apparently, the occupants transported elements based on within-bone nutrients (Niven 2003, 2007). Age profiles indicate that people hunted horse from summer to early autumn, and reindeer from late summer to autumn during their seasonal migration. Both species were in their best physical condition at the time of the hunt. Hunting of horses during winter is reported for Hohle Fels and Geißenklösterle, based on foetal horse bones found in these caves (Münzel 2001a). Normally, prime-aged adult animals are best represented in Paleolithic horse hunting sites (e.g., Turner 2002). At Vogelherd juveniles and old adults are present in the same proportion as prime adults, a pattern also visible at Wallertheim F (Prindiville 1998) and Grubgraben, Austria (West 1996). Over what was likely thousands of years of occupation, butchery and marrow processing patterns of reindeer and horse are consistent at Vogelherd, which might also indicate seasonal occupation of the site. Year-round occupations tend to result in coarse-grained resolution among faunal remains, leading to less clear behavioral signals due to the palimpsest nature of these types of deposits (Binford 1981).

Remains of at least 28 mammoth individuals make Vogelherd one of the richest mammoth sites in Central Europe (Niven 2001). Mammoth assemblages are typically fragmentary, whereas the Vogelherd assemblage consists partly of complete teeth and bones

(Niven 2003). Remarkably, six deciduous tusks were recovered from the Aurignacian layers in 1931. Although deciduous tusks are rare in most archaeological assemblages, they are known in the Swabian Jura from several caves, including Geißenklösterle, Hohle Fels and Vogelherd. Juveniles make up one third of the Vogelherd mammoth assemblage. The nearest site with a comparable abundance of juveniles is Geißenklösterle Cave in the Ach Valley, where the remains of at least five one-month-old individuals were found (Münzel 2001a).

Since anthropogenic modifications are visible at most sites with a high number of sub-adults, like Geißenklösterle (Münzel 2001a), but are absent at Vogelherd, other explanations are needed. Mammoth was clearly exploited at Vogelherd, however it remains unclear whether they were hunted or whether their bones and tusks were simply collected. Niven (2006) assumes opportunistic hunting of physically disabled mothers and their calves. She interpreted a bone pile located at the southwest entrance, containing scapulae, tusk fragments, molars, a cranium, and unidentified bones as storage for building material, fuel, and raw material for the production of artifacts. It is also possible that the inhabitants of the cave blocked the southern entrance with mammoth raw material as shelter from weather and carnivores (Riek 1934; Niven 2001, 2006).

Less common taxa in the Vogelherd Aurignacian assemblage are woolly rhinoceros (*Coelodonta antiquitatis*), other ungulates, small mammals, birds, and carnivores. The role of woolly rhinoceros is not clear at Vogelherd Cave. Adults slightly outnumber juveniles, which could be evidence for human predation, but since cutmarks are missing there is no definitive proof of this. They could have served the same industrial needs as mammoth (Niven 2006, 2007). During the Upper Paleolithic, hunting of small game, especially hare (*Lepus* sp.), increased, as is apparent from the Aurignacian of Hohlenstein-Stadel, Geißenklösterle, and Hohle Fels. At Geißenklösterle and Hohle Fels small game peaks in the Gravettian, where 40% of the NISP and 3.9-6.4% of bone weight are made up of small game (Conard et al. 2013a).

While the Aurignacian is well represented both in the Ach and Lone Valley, the Gravettian is concentrated in the Ach Valley caves Hohle Fels, Brillenhöhle, and Geißenklösterle. Bockstein-Törle VI is the only Gravettian layer in the Lone Valley (Hahn et al. 1985; Conard and Moreau 2004; Conard and Malina 2009; Moreau 2010). In Swabia the Gravettian spans from 30,000 to 26,000 BP (uncal.) and has a main phase of occupation around 29,000 to 27,000 BP (uncal.). Afterwards, occupation of the region ends and does not start again until 13,000 BP (uncal.) (Waiblinger 2001). Although Riek described no Gravettian layer at Vogelherd, possible Gravettian blades and points, however, were discovered during the 2012 campaign (Conard et al. 2013b) and several dates at Vogelherd fall within the Gravettian. Specifically, a long bone with cutmarks dated 26,160±150 BP (uncal.) and a mammoth molar dated 25,780±250 BP (uncal.) indicate a short Gravettian occupation (Conard et al. 2003).

The Magdalenian in the Swabian Jura starts around 13,000 BP (uncal.) and represents a phase of reoccupation at the end of the Last Glacial Maximum (Jochim 1987; Waiblinger 2001; Taller et al. 2014). AH II and III contained little faunal and lithic material. These layers are thin and discontinuous across the cave. The Magdalenian fauna, represented by 217 specimens, is dominated by cold-adapted species comparable to the Magdalenian horizon III of nearby Hohlenstein-Stadel (Niven 2006).



AH I is designated as Neolithic. Riek (1934) describes a disturbed *Linearbandkeramik* burial of several individuals. Two of them were found in the flexed position, common during this period, while the other ones were disturbed by the digging activities of badgers. During the analysis presented here, additional human bones and several bones of domestic sheep and goat were identified. The human bones date to the Neolithic (Conard 2009b).

## Material and Methods

### Material

The material examined in this work includes the single finds excavated during the years 2007 until 2012 at Vogelherd Cave. Most of the bones derive from unstratified sediments (geological unit HL/KS), which were removed from the cave during the first excavation in 1931. About 12% of the material was excavated from stratified sediments discovered beneath HL/KS. These sediments formed the former area in front of the cave. The intact layers were divided into four different geological units (DKS, GF/KS, DS/MF/K, GL/GKS) based on composition and colour (Conard et al. 2010; Conard and Zeidi 2011). All of the sediment was screened and the material found during the screening is currently being analyzed.

While most of the material does not show signs of post-depositional weathering, some showed root etching and minor signs of weathering. A small percentage of the material is burned. Riek reported several hearths, and more burnt bone was expected. Since there is a correlation between size and burning (Stiner et al. 1995), it is possible that the burnt bones are among the screened material which is still to be analyzed.

### Methods

The first step in faunal analysis is the identification of specimens. If possible, all bones and teeth were identified to the species or genus level. Bones that were in a condition which made identification impossible were sorted into size classes following Brain (1981).

### Quantification

In this study the standard units for quantification in zooarchaeology were used: number of identified specimens (NISP) (Grayson 1984), minimum number of elements (MNE) (Lyman 1994), minimum number of animal units (MAU) and %MAU (Reitz and Wing 2008), and minimum number of individuals (MNI) (Grayson 1984). MAU is calculated by dividing MNE values for certain elements by the number of these elements in a complete skeleton. To calculate %MAU, all MAU values are divided by the largest MAU, which is taken as a standard, and multiplied by 100 (Binford 1984; Reitz and Wing 2008). The MNI estimates the minimum number of individuals represented by the specimens taking into account side, age, size, and sex (White 1953; Bökönyi 1970; Chaplin 1971; Reitz and Wing 2008).

## Ageing

When possible, specimen age was determined based on epiphyseal fusion, tooth eruption and tooth abrasion after data provided by Habermehl (1975, 1985) for domestic and wild animals. Data on the ageing of mammoths is provided by Maschenko (2002).

## Density mediated destruction of bone

The survivorship of bones depends heavily on their density, and structural density varies between bones, and within a single element (Lyman 1994). This means that the degree of post-depositional bone degradation has to be evaluated before predictions on economic choices can be made. This is done by comparing the bone mineral density (BMD) values of skeletal elements with their abundance in the assemblage. These values are produced by measuring the mineral content at a scanned section of a bone via Photon Densitometry (PD) or Computer Tomography (CT). The advantage of the CT method is that it can exclude the medullary cavity (Lam et al. 2003). A positive correlation between BMD and %MAU shows an underrepresentation of elements with low BMD values. This can be caused by the destruction of these elements by agents like carnivores or chemical and mechanical weathering. Pavao and Stahl (1999) examined different leporid species and provided a shape adjusted mean BMD<sub>2</sub> value (mean VD<sub>SA</sub>), which was used in this study.

## Diversity

Diversity indices are used to compare species richness or evenness over time, based on the assumption that higher evenness is an indicator for increasing dietary breadth (e.g., Jones 2004). Evenness in a biological sense means that all species are represented in the same numbers. In this study, the reciprocal of Simpson's index (D) (Simpson 1949) was used to compare geological unit HL/KS to the archaeological layers AH IX–II, to see whether it is possible to determine which horizon HL/KS originally derived from. The Simpson's index (D) calculates the dominance of the most abundant taxon, but because it decreases as evenness increases, its reciprocal (1/D) is more suitable for visualization, since this value increases with ascending evenness. The lowest possible value for 1/D is one, and the highest value depends on the number of species found at a site. A taxonomically even assemblage has a higher 1/D-value, while an uneven (one that is dominated by a single species) assemblage has a lower value.

## Analysis of the Faunal Remains

Most of the faunal material derives from the former cave sediment, which was designated HL/KS (*heller Lehm/Kalkschutt*; light coloured loam/limestone debris). Unfortunately, this geological unit showed no stratigraphy, and identification of the former Archaeological Horizons was not possible. In 2009 and 2010 intact layers, underlying geological unit HL/KS, were discovered west of the southwestern entrance of Vogelherd Cave (Conard et al. 2010; Conard and Zeidi 2011, 2012). Four geological units were distinguished. The uppermost, DKS (*dunkler Lehm/Kalkschutt*; dark coloured loam/limestone debris), is a humus layer that was covered with sediment during Riek's excavation

Taxon	AH II-IX		HL/KS		intact layers	
	NISP	%NISP	NISP	%NISP	NISP	%NISP
<i>Lepus</i> sp. (hare)	30	0.23	106	4.53	14	4.36
<i>Erinaceus europaeus</i> (hedgehog)	-	-	7	0.3	-	-
<i>Canis lupus</i> (wolf)	45	0.34	74	3.16	3	0.94
<i>Vulpes</i> sp. (fox)	20	0.15	102	4.36	7	2.18
<i>Ursus</i> sp. (bear)	152	1.14	129	5.51	18	5.61
<i>Crocuta crocuta spelaea</i> (cave hyena)	27	0.2	27	1.15	7	2.18
<i>Meles meles</i> (badger)	-	-	188	8.03	16	4.98
<i>Gulo gulo</i> (wolverine)	1	0.01	1	0.04	-	-
<i>Martes</i> sp. (marten)	-	-	5	0.21	-	-
<i>Mustela</i> sp. (polecat)	-	-	1	0.04	-	-
<i>Panthera leo spelaea</i> (cave lion)	6	0.05	2	0.08	-	-
<i>Felis silvestris</i> (wild cat)	3	0.02	36	1.54	1	0.31
<i>Elephas antiquus</i> (straight-tusked elephant)	1	0.01	-	-	1	0.31
<i>Mammuthus primigenius</i> (woolly mammoth)	3585	26.85	686	29.29	19	5.92
<i>Equus ferus</i> (wild horse)	1825	13.67	229	9.78	69	21.5
<i>Coelodonta antiquitatis</i> (woolly rhinoceros)	185	1.38	33	1.41	11	3.43
<i>Sus scrofa</i> (wild pig)	8	0.06	35	1.49	2	0.62
<i>Cervus elaphus</i> (red deer)	29	0.22	11	0.47	1	0.31
<i>Megaloceros giganteus</i> (giant deer)	8	0.06	-	-	6	1.87
<i>Rangifer tarandus</i> (reindeer)	1679	12.58	123	5.25	16	4.98
<i>Capreolus capreolus</i> (roe deer)	-	-	80	3.42	5	1.56
<i>Bos/Bison</i> (aurochs/bison)	111	0.83	52	2.22	12	3.74
<i>Rupicapra rupicapra</i> (chamois)	2	0.02	-	-	-	-
<i>Capra hircus/Ovis aries</i> (goat/sheep)	-	-	25	1.07	-	-
Birds	13	0.1	15	0.64	2	0.62
<b>total identified to taxon</b>	<b>7730</b>	<b>57.9</b>	<b>1967</b>	<b>83.99</b>	<b>210</b>	<b>65.42</b>
body size 5 (mammoth/rhinoceros)	1721	12.9	100	4.27	45	14.02
body size 4 (horse/bear/red deer)	2588	19.39	168	7.17	32	9.97
body size 3 (reindeer/roe deer)	1285	9.63	88	3.76	23	7.17
body size 2 (fox/hare)	26	0.2	19	0.81	11	3.43
<b>total identified to size</b>	<b>5620</b>	<b>42.1</b>	<b>375</b>	<b>16.01</b>	<b>111</b>	<b>34.58</b>
<b>comprehensive total</b>	<b>13350</b>	<b>100</b>	<b>2342</b>	<b>100</b>	<b>321</b>	<b>100</b>

**Table 3:** Vogelherd Cave. Species composition of geological unit HL/KS and intact layers expressed as NISP and %NISP in comparison to a previous study by Niven (2006) (AH II-IX). Note that Niven excluded all badger remains in her study.

in 1931. The intact layers contained the same species as the former cave sediment (Table 3), but yielded fewer specimens. Nearly 2400 specimens found in HL/KS and 330 found in the intact layers were analyzed in this study. A separation of HL/KS and the intact layers was not always clear.

Several species were added to the previously known Vogelherd fauna. These are marten (*Martes* sp.), polecat (*Mustela* sp.), European hedgehog (*Erinaceus europaeus*), and roe deer (*Capreolus capreolus*). Since previous studies ignored the Neolithic at Vogelherd, the remains of domestic sheep (*Ovis aries*) and goat (*Capra hircus*) were also added to the range of species

### The Fauna of the Backfill (HL/KS)

One objective of this study was to assign the material to its original Archaeological Horizon. Material from the Middle Paleolithic layers can be differentiated from younger material by its state of preservation. The fauna of AH VII has rounded edges, an overall abrasion of the bone surface, and many specimens show yellow staining, due to moister conditions and a high ochre content in this particular layer (Niven 2006). Preservation in the Aurignacian layers is variable, but we also used exploitation patterns to assign specimens to their former layers. Since horse and reindeer were butchered in standardized ways during the Aurignacian, specimens showing these patterns were assigned to AH IV/V. The other objective was to compare the fauna of the backfill with that of the Archaeological Horizons analyzed by Niven.

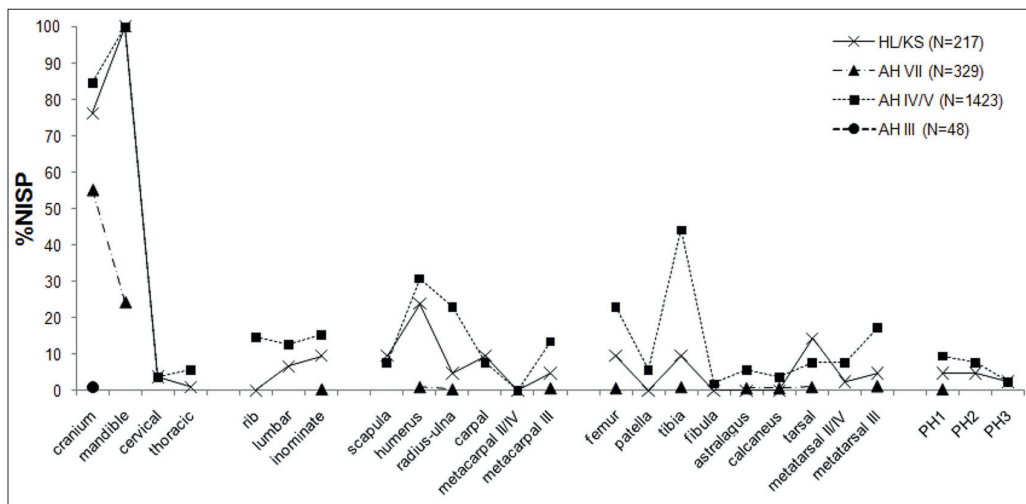
Presumably, the material in this study derives in the same proportions from the Aurignacian layers as the material analyzed by Niven. In her study, 94% of the material is of Aurignacian origin. Some specimens date to the Holocene, such as remains of domestic sheep (*Ovis aries*) and goat (*Capra hircus*), which were probably introduced in the cave together with the Neolithic skeletal remains. Burying animals alongside humans was not uncommon in the Swabian Neolithic, as seen at the *Knochenrümmerstätte* at Hohlenstein-Stadel, which also contained remains of sheep and goat associated with human skeletal remains (Wehrberger 2013). Bones of anatomically modern humans, found during the new excavation, are assumed to belong to the known Neolithic individuals (Conard 2009b). Nevertheless, the question whether they are part of the Stetten fossils or of the *Bandkeramik* burial in the upper levels remains unclear. Three human bones were discovered in the intact layers, and were probably introduced into these layers by trampling during the 1931 excavation.

Along with reindeer, horses are a main prey animal in the Paleolithic of the Swabian Jura (Table 3). There is ample evidence for its exploitation by Paleolithic humans (e.g., Turner 2002; Münzel and Conard 2004a) and there is consistency in horse butchery and marrow extraction patterns over the time the cave was used (Niven 2006). Horse elements in HL/KS represent seven adult and six juveniles younger than two years (after Habermehl 1975) (MNI based on left lower third molar and lower second deciduous premolar). Overall preservation of the bones is good (Table 4), with 50.6% of the bones exhibiting weathering stage 1 (unweathered after Brain 1981). Two hundred and twenty-nine horse specimens were recovered from HL/KS, making it the dominant species in this geological unit.

	weathering stages					root etching	cutmark	green breakage	im-pact	gnaw-ing
	1	2	3	4	5					
horse	50.6	29.9	10.4	10.4	1.3	10.4	20.8	33.8	5.7	34
reindeer	49.5	39.6	6.6	3.3	0	16.5	23	41.5	19.5	23

**Table 4:** Vogelherd Cave. Weathering stages, root etching, presence of gnaw marks, and modifications for HL/KS horse and reindeer bones expressed as %NISP.

Niven (2006) tested the density mediated attrition of the horse and reindeer assemblage in AH IV/V. A scarcity of dense elements, including distal scapulae, innominates and reindeer mandibles, led to the conclusion that other factors may also have influenced the reindeer and horse assemblage. The skeletal element distribution of HL/KS horse remains is strikingly similar to the AH IV/V horse assemblage (Fig. 3). Skeletal element distribution shows that the AH IV/V horse assemblage represents a wider range of elements than the HL/KS assemblage. While all skeletal portions are represented in AH IV/V, smaller parts, like vertebrae, are missing in HL/KS. This discovery is further evidence for the high standards of Riek's excavation, and shows the reliability of Niven's results. Particularly notable is the large number of cranial and mandibular elements in both assemblages, due to the amount of teeth, and their physical properties. Their high mineral content makes teeth highly resistant against weathering effects (Lyman 1994). In addition, horse teeth are diagnostic, allowing the identification of even the smallest fragments. Cranial bone is nearly absent (Table 5).



**Fig. 3:** Vogelherd Cave. Representation of HL/KS horse body parts in comparison to representation of horse body parts in Archaeological Horizons III, IV/V, and VII. Elements are grouped by body segment.

Horse crania have a high nutritional value compared to the crania of other species (Lupo 1998), which could be a reason for their introduction into the cave. Stiner (1994) argues for a stronger focus on crania in times when prey is in poor physical condition, because the fat to protein ratio in cranial and axial elements remains constant, which



could be an indication for cave occupation in winter as proposed by Münzel (1997) for Geißenklösterle Cave. Niven (2006) also emphasizes the accessibility of an element's nutritional value as an important factor in the selective transport of body parts, and Lupo (1998) and O'Connell and colleagues (1988) showed the ease of breaking horse crania. Breakage of horse crania would also explain the low amount of cranial bone in comparison to teeth, since the destruction of the cranium would reduce its resistance against weathering processes, and limit the possibility of identifying cranial elements to species level.

	HL/KS				AH II-IX			
	Horse		Reindeer		Horse		Reindeer	
	NISP	MNE	NISP	MNE	NISP	MNE	NISP	MNE
cranial bone	3	1	1	1	6	1	11	3
cranial teeth	68	28	22	19	335	241	7	6
mandibular bone	3	2	1	1	54	5	23	8
mandibular teeth	57	36	10	8	238	46	20	14

**Table 5:** Vogelherd Cave. Representation of cranial and teeth elements for HL/KS horse in comparison to AH II-IX. AH II-IX data from Niven (2006).

Geological unit HL/KS yielded 123 reindeer remains representing an MNI of six. Preservation is comparable to the AH IV/V reindeer, but some elements, especially phalanges are heavily damaged by root etching. This is also visible in the 1931 material and presumably caused by the position of these deposits in the cave. A comparison of the skeletal element representation of reindeer in HL/KS and AH IV/V shows differences in their distribution. Tibia are dominant in AH IV/V, and Niven (2006) describes an underrepresentation of reindeer crania (MAU of two) as the main difference between the AH IV/V horse and reindeer assemblages. Overlooking reindeer teeth in 1931 could be a cause for this disparity, since reindeer teeth are only about a quarter of the size of a horse tooth. In HL/KS, cranial elements are represented by an MAU of five. Apart from this difference overall distribution in HL/KS resembles distribution in AH IV/V.

The size of the distal tibia was used to compare the reindeer from HL/KS to those from the Aurignacian layers, since reindeer in southern Germany underwent size diminution after the Gravettian (Weinstock 2000). The dimensions of the distal tibia fit in the AH IV/V size class (Fig. 4) and indicate an age not younger than Aurignacian for HL/KS reindeer. A Middle Paleolithic origin of the reindeer specimens is unlikely based on their overall preservation and damage patterns, such as the systematic breakage of long bones for marrow extraction, which is typical for the Vogelherd Aurignacian.

HL/KS horse and reindeer remains also show similar types of butchery (Table 4) as is seen in AH IV/V. Marrow extraction is visible in the breakage of all long bones. Green breaks are the most common, indicating the processing of fresh bones. Cutmarks on the lower elements, like metapodials, are associated with the removal of the periosteum, facilitating their breakage (Binford 1981). Twenty-three percent of reindeer and 20.8% of horse bones show cutmarks. The location of the cutmarks on scapula and long bones indicate meat removal, while cutmarks located on the innominate are associated with disarticulation. Impact scars are present on 19.5% of reindeer and 5.7% of horse remains.

A major difference between the HL/KS and AH IV/V assemblages is the percentage of gnaw marks. While the percentage of gnaw marks in AH IV/V is in single-digit range, in HL/KS 23% of reindeer and 34% of horse bones bear gnaw marks. It is, however, important to mention that modified bones in AH IV/V outnumber those from HL/KS.

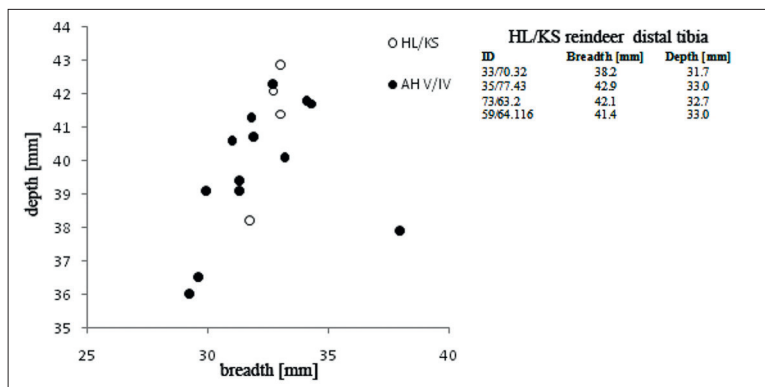


Fig. 4: Vogelherd Cave. Size comparison of HL/KS and AH IV/V reindeer distal tibia.

Vogelherd Cave yielded one of the key mammoth assemblages in Central Europe. Mammoth bones were thoroughly recovered during the first excavation. Ninety four percent of the new mammoth assemblage is ivory fragments, and more will be added once the screened sediments are analyzed. Twenty-eight mammoth individuals, including six juveniles, were identified in previous analyses. During this study an additional right deciduous tusk, from a three to four month old individual, and a lower left first deciduous molar, from a one to two month old animal (age estimation after Maschenko 2002) was identified. If we assume that mammoths gave birth in spring as suggested by Guthrie (1990), then these individuals probably died in summer. This correlates with the season of occupation of the site as determined by Niven. The presence of mammoth calves of different ages is also reported for Hohle Fels Cave in the Ach Valley (Münzel 2001a).

Other ungulates played a minor role next to horse and reindeer in the subsistence of the inhabitants of Vogelherd (Table 3). Human use is indicated by cutmarks on the remains. Niven (2006) suggests hunting on an opportunistic basis for these taxa. Secondary subsistence taxa identified in this study include aurochs or bison (*Bos/Bison*), wild pig (*Sus scrofa*), red deer (*Cervus elaphus*), chamois (*Rupicapra rupicapra*), and roe deer (*Capreolus capreolus*). Aurochs, wild pig and roe deer are more common during interglacials, but according to Koenigswald (2002), they are not restricted to warm phases.

In 1931 no roe deer remains were recovered, probably due to their small size and because the team did not screen the sediments. Cutmarks are visible on three specimens and indicate human exploitation of roe deer at the site. Around one third of the specimens were gnawed by carnivores showing that carnivores had access to the bones, or acted as accumulators of at least part of the assemblage. Roe deer was not continuously present in Central Europe during the Pleistocene. According to Sommer and colleagues (2009), roe deer repeatedly reached Central Europe during the Middle and Late Weichselian Pleniglacial (ca. 60,000–20,000 BP), retracted during the Last Glacial Maximum

(21,000–14,500 BP), returned during Greenland Interstadial 1 (14,500–12,900 BP), retracted again during the Younger Dryas (12,800–11,500 BP), and were reintroduced during the Preboreal (11,600–10,800 BP) contemporary with the disappearance of reindeer in Central Europe. From the Mesolithic onwards, roe deer was one of the main prey animals in southwestern Germany (Jochim 2008; Kind 2009). Roe deer is also known as grave good, for example from the Mesolithic site of Bad Dürrenberg (Porr and Alt 2006).

Large carnivores, including brown or cave bear (*Ursus arctos* or *Ursus spelaeus*), cave lion (*Panthera leo spelaea*), cave hyena (*Crocota crocuta spelaea*), and wolf (*Canis lupus*), played a role as accumulators of bones at Vogelherd, especially during the Middle Paleolithic. Evidence of their exploitation by humans is scarce. Cutmarks on wolf remains were observed in this study, and also reported by Niven, which indicates the skinning of at least two individuals at Vogelherd. Wolves were usually not exploited for meat, but fur, bones, and teeth, which were used as raw material in the production of clothes, tools, and pendants (Soffer 1985; Bosinski 2008). Other carnivores seem to have occupied the cave during the absence of humans. The HL/KS carnivore assemblage is dominated by bear. Seven individuals, three juveniles and four adults, are represented by 129 specimens, 40 of which could be identified as cave bear (*Ursus spelaeus*). Although no specimens of brown bear (*Ursus arctos*) were identified during this analysis, its presence at Vogelherd is indicated by specimens found in 1931, including one incisor used as a pendant (Riek 1934). Intensive occupation of Vogelherd Cave by modern humans probably made the cave unattractive for bears seeking a hibernation shelter, which might explain the low number of bears in comparison to neighboring caves. They make up 78% of the total fauna at Hohlenstein-Stadel and Brillenhöhle, and around 30% at Geißenklösterle Cave in the Ach Valley (Gamble 1979; Münzel 2001b; Kitagawa 2014). A possible scenario is the death of bear cubs together with their mother (Stiner 1998). A canine belonging to a female bear was recovered. AH IV and V contained remains of one neonate cave bear, and during the recent excavations remains of three more juveniles were found. Gnaw marks are present on four specimens, and cutmarks are absent. Overall, evidence for cave bear hunting at the Swabian Jura is rare. An exception is the reported cave bear hunting in the Gravettian at Hohle Fels Cave in the Ach Valley, visible by cutmarks and one lithic point stuck in a lumbar vertebra of *Ursus spelaeus* (Münzel and Conard 2004b).

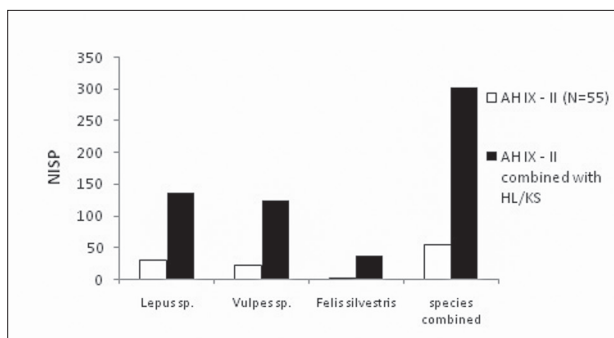
Cave lion, wolverine, and cave hyena were not represented in significant amounts. Similar to the 1931 excavation, a large number of badger remains was recovered during the recent excavations. They were excluded from previous analyses because of their intrusive character, visible from their colour and overall preservation that differs from the archaeological material (Niven 2006). Riek (1934) also described the mixing of layers and the destruction of a burial in the upper layers caused by badgers. Without direct dating of each single bone, it is nearly impossible to decide, whether they are intrusive or not (Kurtén 1968), so badgers are in general excluded from archaeozoological analyses. Skeletal representation of badgers at Vogelherd implies introduction of complete carcasses to the site, resulting from the natural death of animals that burrowed into the site. Badgers are sometimes hunted for their fur (Koenigswald 2002), but since no cutmarks were found on the analyzed elements, this was probably not the case at the site, supporting the hypothesis that the Vogelherd badger remains are intrusive.

The lack of stratigraphy of unit HL/KS made it necessary to test the origin of the material, assuming that it originates from a layer with a species representation most similar to HL/KS. The reciprocal of Simpson's index ( $1/D$ ) was used to make this comparison. Surprisingly, the  $1/D$  value of HL/KS does not resemble any of the archaeological layers (Table 6), although the remains of Neolithic species, such as sheep, goat, badger and modern human, were excluded from the calculation. Roe deer was also excluded, because no remains of this species were recovered in 1931. AH IX was excluded from the comparison because of its small sample size ( $n=1$ ). The  $1/D$  values of other horizons span from 2.33 to 3.57, while the HL/KS  $1/D$  value is 8.4, so it contains a much more diverse faunal assemblage. The main difference in the species composition between HL/KS and AH IX–II is the number of small mammal remains. Large game NISP is higher for all species in AH II–IX, but small game was found in larger numbers during the recent excavations. Species in this category are brown hare (*Lepus europaeus* or *Lepus timidus*), European hedgehog (*Erinaceus europaeus*), fox (*Vulpes vulpes* or *Vulpes alopex*), and wild cat (*Felis silvestris*). Additionally, one left mandible of a marten (*Martes* sp.) and one left femur of a polecat (*Mustela* sp.) was identified to genus level. The small carnivores did not show signs of human exploitation and their origin is unclear. Presumably, they used the cave as a den. A number of bird bones were recovered during the new excavation, of which one radius of a swan-sized bird showed signs of anthropomorphic alteration, similar to those on the Geißenklösterle flutes (Hahn and Münzel 1995; Münzel et al. 2002; Münzel and Conard 2009). This specimen was probably part of a flute.

Horizon	II	III	IV/V	VI	VII	VIII	HL/KS
$1/D$	3.18	2.38	3.57	3.00	2.33	2.66	8.40

**Table 6:** Vogelherd Cave. Reciprocal Simpson's indices ( $1/D$ ) for AH II–VIII and geological unit HL/KS.

To depict the increase in small mammals, the proportion of small mammal species as NISP was compared between the 1931 assemblage and the 1931 assemblage combined with the HL/KS assemblage, respectively (Fig. 5). The comparison shows the amount of small game remains that were not recovered during the first excavation. Small game made up 1.04% of the complete assemblage before the recent excavations, and the current amount is up to almost 5%. This value is expected to rise further after analysis of

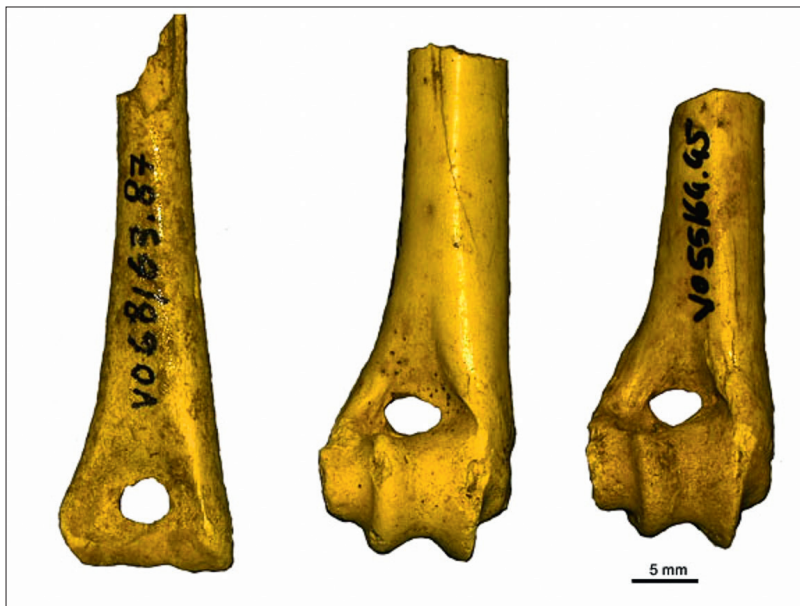


**Fig. 5:** Vogelherd Cave. Abundance of small game remains expressed as NISP in the 1931 assemblage (AH II–VII) and the 1931 assemblage combined with HL/KS.

the screened material, which consists almost solely of small game remains. The lack of stratigraphic context complicates the interpretation of the small mammal assemblage, but the fact that only five small mammal specimens in AH II–IX do not derive from Aurignacian layers, suggests an Aurignacian origin for the HL/KS small mammals.

Though two species of hares could have been present at Vogelherd Cave, in this study they were only identified to the genus level because of a lack in diagnostic elements. While Niven identified 30 hare remains, the new excavation yielded 109 specimens. Since only one specimen showed gnaw marks, Niven interpreted the role of carnivores as accumulators as minimal. Five specimens showed signs of marrow extraction by broken-off articular ends (Niven 2006). The 106 identified hare specimens in HL/KS represent at least 15 individuals (four of which were around 5–6 months old, based on fusion stages presented in Habermehl 1985). Human modification is visible in the form of cutmarks on two tibiae, which are a result of skinning, and systematic breakage of humeri for marrow extraction (Fig. 6). People or carnivores introduced hares into the cave, since it is not their nature to dig burrows like rabbits. They naturally hide and give birth in shallow depressions on the ground (Macdonald and Barrett 2002).

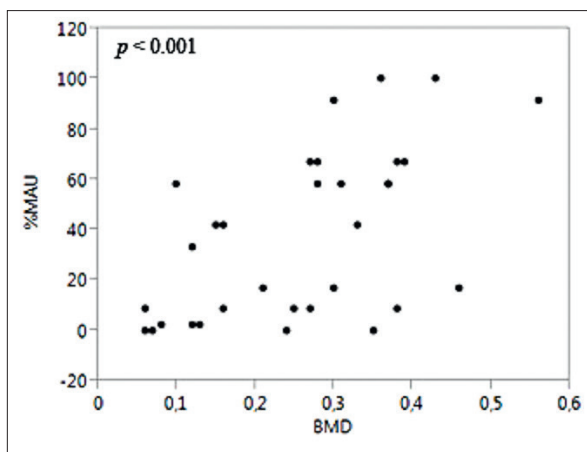
To test how the assemblage was influenced by density mediated attrition, bone density values for leporids were plotted against relative element abundance (Fig. 7). There is a positive correlation between %MAU and BMD (Pearson  $r^2=0.32$ ,  $p\leq 0.001$ ), suggesting density mediated attrition at least in the case of leporids.



**Fig. 6:** Vogelherd Cave. Distal humeri of hare showing breakage for marrow extraction.



Hares are prey of all carnivores present at Vogelherd Cave and of humans (e.g., Andrews 1990; Stiner 1994; Stiner et al. 2000). In HL/KS 41.25% of hare specimens show gnaw marks. It remains open, whether they are human or carnivore gnaw marks, since both tend to gnaw on bones, and there is no convincing way of distinguishing their gnaw marks (but see Blasco 1995). Although some evidence, like bite marks and a high proportion of front limbs, point to carnivores or raptors as accumulators of the hare bones (Hockett and Haws 2002), there are two lines of evidence pointing to humans. First, the presence of cutmarks is a clear sign of human activity. They may be scarce, but this is typical for the butchering of small mammals, because they neither need to be disarticulated for transport nor for procurement (Hockett and Haws 2002). In Niven's (2006) analysis one left tibia found in AH I showed cutmarks. During this analysis two more tibiae bearing cutmarks were identified. Second, the presence of broken-off ends of long bones is typical for modern human exploitation of hares and rabbits (Hockett and Bicho 2000). This type of damage was reported by Niven for five specimens from AH IV/V, and is visible in HL/KS. Articular ends of long bones are broken-off to extract marrow, leading to an extra gain of ca. 7 g fat. Hockett and Bicho (2000) argued that hares provide as many nutritional benefits as large game and even contain more fat than deer. Additionally, they are hunted for their skins.



**Fig. 7:** Vogelherd Cave. Hare %MAU plotted against bone density for geological unit HL/KS.

### The fauna of the intact layers

Compared to HL/KS, the intact layers contained sparse archaeological material and the possibility that materials were introduced from the overlying backfill cannot be excluded. Some of the species, particularly badger and fox, most likely were not introduced to the site, while others were transported by humans as implied by cutmarks and freshly broken bones.

Admixing of layers is indicated by the species composition. This is likely caused by its exposed location outside the cave. Layer GL/KS, for example, contained a tusk fragment of straight-tusked elephant and Middle Paleolithic stone tools, which indicates a date to the Eemian interstadial. However, specimens identified as modern humans presumably

belong to the Neolithic individuals inside the cave. It is unclear whether the mixing occurred during the 1931 excavation, or earlier. The most likely scenario would be a combination of both. Additionally, badgers might have played a role in the disturbance of the layers, and in the transport of archaeological material. Riek reported disturbance of a Neolithic burial in the upper layers by badgers.

The species composition of the intact layers is similar to the composition in AH II–IX (Table 3). Horse and woolly mammoth-sized species dominate the assemblages. The dominance of Aurignacian faunal and lithic remains is also visible in these layers. The abundance of hare in DKS is interesting, however, it is possible that this layer contains intrusive material from 1931.

Overall, the findings indicate a minimal use of the area in front of the cave. Like faunal remains, other types of finds are rare. Conard and colleagues report low numbers of lithic and organic artifacts (Conard et al. 2010; Conard and Zeidi 2011, 2012). Nevertheless, there is also the possibility of erosion of archaeological material caused by the exposure on the outside of the cave and its location on a slope.

## Summary and Conclusion

The new excavations at Vogelherd Cave ended in 2012. They resulted in many significant discoveries, including several new pieces of art, such as the first complete ivory figurine of the Swabian Jura (Conard et al. 2007). Ivory beads, which were not known from the site, were recovered in high numbers and strengthened the role of Vogelherd as one of the most intensively occupied Aurignacian sites in the region (Conard et al. 2013b).

In addition to figurative art, the sites of the Swabian Jura are known for the world's oldest musical instruments in form of Aurignacian-aged flutes. Modern humans perhaps made music before, but if so their instruments have not been found. The good preservation of the wind instruments of the Swabian Jura is caused by the physical properties of their raw materials ivory and bone. Flutes were also found at Hohle Fels and Geißenklösterle (Hahn and Münzel 1995; Conard and Malina 2006; Conard et al. 2009a).

Analysis of horse, reindeer, and secondary prey remains consolidate the picture of Paleolithic subsistence in the Lone Valley proposed by Niven (2001, 2003, 2006, 2007). Systematic exploitation of horse and reindeer in summer and autumn, as well as the occasional hunting of wild pigs, red deer, aurochs, and bison is visible in the material. Though, the recovery of additional deciduous woolly mammoth teeth raises the number of mammoth calves recovered at the site, direct evidence for hunting is still missing.

The material discovered in the recent excavation sheds light on a new aspect of subsistence at Vogelherd. As in many sites not excavated using modern standards (Hockett and Haws 2002), small mammal remains were only recovered sporadically in the 1931 excavation. At other caves in the area (Conard et al. 2013a), small game was an important part of the diet from the Aurignacian onwards. The occupants of Vogelherd exploited hare in similar ways as the occupants of other sites in Central and Western Europe exploited local leporids (Hockett and Bicho 2000; Cochard 2004; Hockett and Haws 2009; Jones 2012; Manne et al. 2012). At Geißenklösterle and Hohle Fels, hare exploitation increases in the Aurignacian and has its peak in the Gravettian, but since a

Gravettian occupation at Vogelherd is minor, an Aurignacian origin of the hare remains is more likely. Direct dating of hare remains could solve this problem. All the excavated sediments were screened and more insights into small game exploitation will be revealed after the analysis of these remains. Additionally to terrestrial small game, fish remains are among the screened material. This is not surprising, since the site is located near a river and fishing is common in this area, as indicated by a harpoon found in the Magdalenian layers, and a fish figurine found during the new excavations (Conard 2009c). Other Swabian sites, excavated with modern techniques, also revealed fish remains (Conard and Malina 2012; Conard et al. 2013a).

Although excavation standards were lower in the past, this can be circumvented to a certain extent by re-analyzing previously excavated sediments, as shown successfully at the Neandertal (Neander Valley), where elements fitting to the first Neanderthal skull were found (Schmitz et al. 2002), and at Vogelherd. Material excavated in the last decade help support hypotheses about the Vogelherd material which could not be tested previously because of a lack of information. This study, along with ongoing excavations in the Swabian Jura, including those at Hohle Fels and two newly discovered caves in the Lone Valley (Glatzle 2012; Conard and Zeidi 2014), will continue to enhance our understanding of Paleolithic lifeways in this key geographic region in Europe.

## Acknowledgements

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