Antler Headdresses. Implications from a many-faceted study of an earliest Mesolithic phenomenon

Hirschgeweihkappen. Eine vielschichtige Studie eines Phänomens des ältesten Mesolithikums und ihre Auswirkungen

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Abstract - So-called 'antler headdresses' - red deer (*Cervus elaphus*) skulls with antlers specifically modified by humans - were identified early as a typical phenomenon of Early Mesolithic sites in the North European Lowlands. In addition to clearly processed pieces with artificial perforations, longitudinally split antlers and heavy processing of their surfaces, there are also pieces that have only one type of these modifications and others in which human processing is hardly demonstrable. Although comprehensive studies of these 'headdresses' have not until now been carried out, the various artefacts are often discussed functionally and interpreted prematurely. In recent years, the discovery of new finds at several sites has again intensified discussion of the typology, function and meaning of these artefacts. To provide a solid base for future discourses, we here present a synthetic study of the available material.

A comparative analysis of the morphometric, zooarchaeological and technological features of individual specimens shows that certain characteristics often appear in combination. We propose to reserve the term deer antler 'headdress' to a subcategory of specimens which we suggest might indeed have best functioned as headgear. Since several of the deer skull artefacts do not show all the human modifications included in our definition, we adopt a polythetic classification of the term 'headdress'. Under this definition we identify a total of seven 'headdresses' among those frontlets which could be examined, and note further probable specimens among published material unseen by us.

In contrast to the conclusions of some other studies, new direct radiometric dates for the antler headdresses from Berlin-Biesdorf and Hohen Viecheln, together with recent chronological data for Star Carr and Bedburg-Königshoven suggest to us that 'antler headdresses' represent a phenomenon specific for the earliest Mesolithic of the North European Lowlands. Moreover, the presence of at least two or more of these artefacts at the better investigated sites suggests an important role for them in the rarely discernible social rituals of earliest Mesolithic hunter-gatherers, potentially as an aid to consolidating group/territorial identity.

Zusammenfassung - *Sogenannte Hirschgeweihkappen, durch den Menschen spezifisch modifizierte Rothirschschädel (Cervus elaphus) mit Geweih, wurden früh als ein typisches Phänomen frühmesolithischer Fundplätze in der nordeuropäischen Tiefebene erkannt. Neben eindeutig bearbeiteten Stücken mit artifiziellen Perforationen, längs gespalteten Geweihen und starker Bearbeitung der Oberfläche, gibt es auch Stücke, die nur eine Art dieser Modifikationen aufweisen und andere, bei denen menschliche Bearbeitungen kaum belegbar sind. Obwohl umfassende Studien zu dieser Artefaktgruppe weitestgehend fehlen, wurden die verschiedenen Artefakte häufig funktionell diskutiert und teilweise vorschnell interpretiert. In den letzten Jahren kam es zudem durch Neufunde an verschiedenen Fundplätzen zu einer erneuten intensiven Diskussion zu Typologie, Funktion und Bedeutung dieser Artefakte. Um eine solide Basis für den zukünftigen Diskurs zu schaffen präsentieren wir hier den Versuch einer synthetischen Studie des vorhandenen Materials.*

Die vergleichende Beschreibung der morphometrischen, zooarchäologischen und technologischen Merkmale der einzelnen Artefakte zeigt, dass gewisse Charakteristika häufig zusammen auftreten. Wir schlagen vor eine Subkategorie ‚Hirschgeweihkappen' zu definieren, die unserer Meinung nach am ehesten als Kopfbedeckung genutzt worden sein kann. Da nicht alle Artefakte alle hirschgeweihkappentypischen Merkmale aufweisen wird eine polythetische Definition vorgeschlagen, unter die insgesamt sieben aufgenommene sowie weitere nicht aufgenommene Artefakte fallen.

Entgegen den Ergebnissen bisheriger Studien, weisen die neuen absoluten Datierungen der Hirschgeweihkappen von Berlin-Biesdorf und Hohen Viecheln in Verbindung mit Datierungen der Fundplätze Star Carr und Bedburg-Königshoven darüber

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hinausgehend auf ein Phänomen des allerfrühesten Mesolithikums der Tiefebene hin. Der Präsenz von mindestens zwei oder mehr Hirschgeweihkappen auf den einzelnen Fundplätzen deutet dabei auf ein selten erforschbares, soziales Ritual der frühen Mesolithiker hin in das diese Artefakte eingebunden waren und das dem Erhalt der territorialen oder sozialen Identität diente.

Keywords - Osseous technology, Radiocarbon dating, Preboreal, Lowlands, Recolonization, Experimentation
Knochentechnologie, Radiokarbondatierung, Präboreal, Tiefebene, Rekolonisierung, Experiment

Introduction

Ever since Grahame Clark first described artificially modified red deer (*Cervus elaphus*) crania from his seminal excavations at the Mesolithic site of Star Carr (Scarborough, Great Britain) (Clark 1950, 1954), these finds have been generally acknowledged as the type specimens of what are referred to as (more neutrally, reflecting their anatomic position) 'antler frontlets' or (with functional and interpretative implications) as 'headdresses'.

In this paper, the different terms are used as follows:

- (antler) frontlet: broad category of modified crania with the *os frontale* still preserved and mentioned in context with antler headdresses (see below). Frontlets are often modified and found in context of human settlements or burials. Formerly often used synonymous with (antler) headdress.
- (antler) headdress: red deer frontlets with specific anthropogenic modifications (split antler; cleaned neurocranium; perforations (see this paper)) that might have best functioned as headgear.
- (antler) headdress sensu lato: headdresses for which one or two criteria (split antler; smoothed neurocranium; perforations) hold true.
- (antler) headdress sensu stricto: headdress for which all three criteria (split antler; smoothed neurocranium; perforations) hold true.

Since their first publication (Clark 1950, 1954), modified cervid skulls with antlers from a number of geographically and chronologically relevant sites have repeatedly been described as potential 'antler headdresses' (Figs. 1 & 2). We have found reference in the literature to a total of 52 finds (Tab. 1) from 10 sites representing 12 different occupation episodes (e.g., Reinbacher 1956; Rust 1958; Schuldt 1961; Schoknecht 1961; Street 1989a; Pratsch 1994; Grünberg 2000;

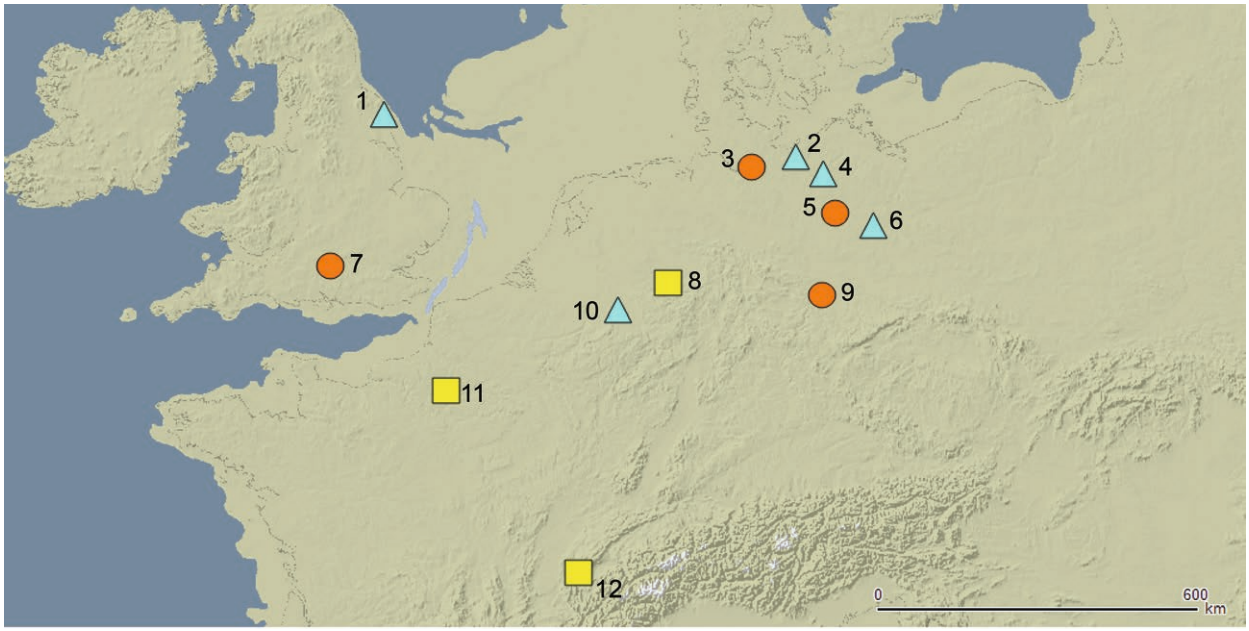

Fig. 1. Sites and find spots mentioned in text. Cyan (blue) triangle: site with antler headdress; red circle: sites with antler frontlets; yellow square: context. Star Carr (1), Hohen Viecheln (2), Poggenwisch (3), Plau (4), Friesack 4 (5), Berlin Biesdorf (6), Thatcham II/V (7), Werl-Büderich (8), Bad Dürrenberg (9), Bedburg-Königshoven (10), Warluis IIIb (11) and Abri de la Croze (12). Late Preboreal EPHA map (www.epha.zbsa.eu; CC BY 4.0; version 1.1.1; compiled by ZBSA after Björck 1995; Brooks et al. 2011; Cohen et al. 2017; Edwards & Brooks 2008; Harff et al. 2017; Moscon et al. 2015; Påsse & Andersson 2005; Seguinot et al. 2018; Weaver et al. 2003).

Abb. 1. *Fundstellen und Funde, die im Text Erwähnung finden. Cyan-(blau)farbenes Dreieck: Fundstelle mit Hirschgeweihkappe; roter Kreis: Fundstellen mit Hirschschädeln, die vermeintlich als Hirschgeweihkappen veröffentlich wurden; gelbes Quadrat: Kontext. Star Carr (1), Hohen Viecheln (2), Poggenwisch (3), Plau (4), Friesack 4 (5), Berlin Biesdorf (6), Thatcham II/V (7), Werl-Büderich (8), Bad Dürrenberg (9), Bedburg-Königshoven (10), Warluis IIIb (11) und Abri de la Croze (12). EPHA Karte des späten Präboreals (www.epha.zbsa.eu; CC BY 4.0; Version 1.1.1; zusammengestellt durch das ZBSA nach Björck 1995; Brooks et al. 2011; Cohen et al. 2017; Edwards & Brooks 2008; Harff et al. 2017; Moscon et al. 2015; Påsse & Andersson 2005; Seguinot et al. 2018; Weaver et al. 2003).*

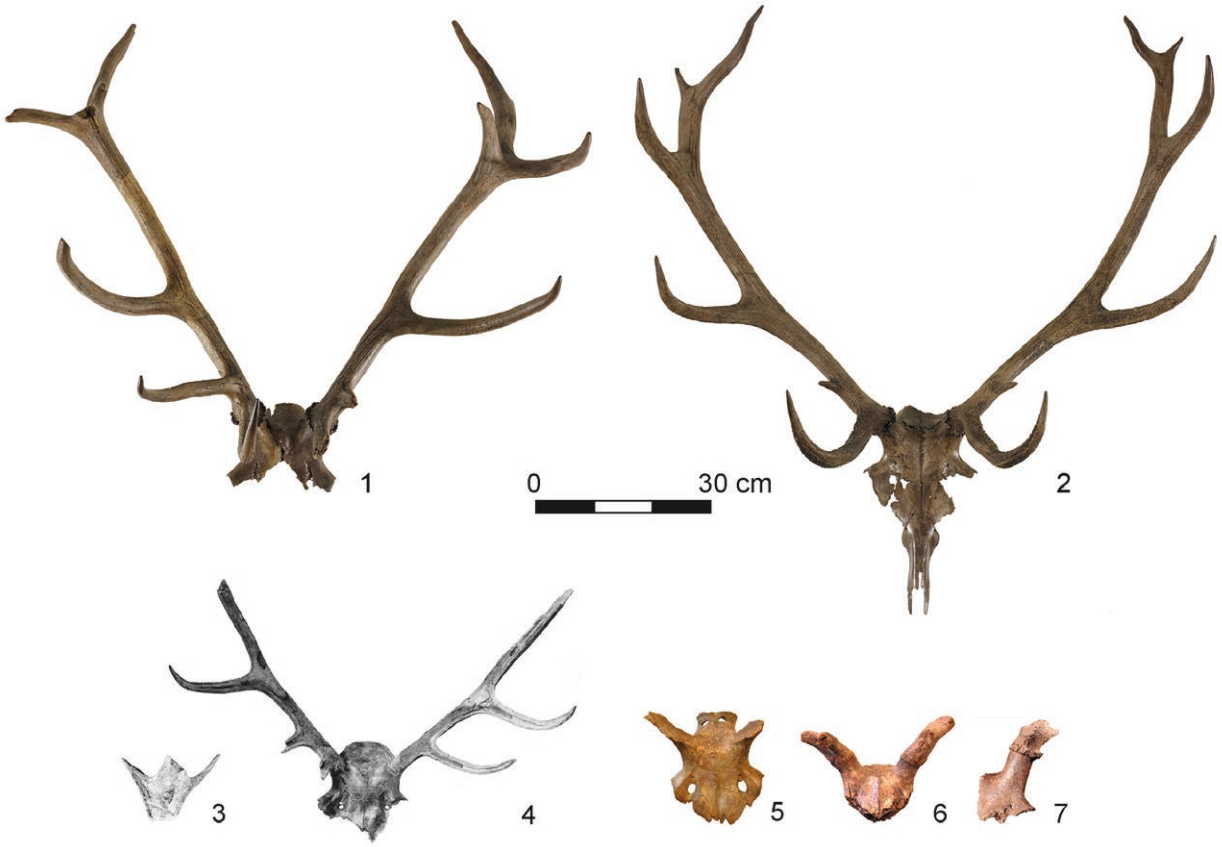

Fig. 2. Various antler frontlets. Bedburg-Königshoven: BK1 (1), BK2 (2); Berlin-Biesdorf: BB1 (3–4); Hohen Viecheln: HV1 (5), HV2 (6), HV5 (7).
Abb. 2. *Verschiedene Hirschschädel, die in Zusammenhang mit Hirschgeweihkappen erwähnt wurden. Bedburg-Königshoven: BK1 (1), BK2 (2); Berlin-Biesdorf: BB1 (3–4); Hohen Viecheln: HV1 (5), HV2 (6), HV5 (7).*

Pratsch 2006; Overton 2014; Little et al. 2016; Elliott et al. 2018; Wild 2019: Fig. 1).

Most of the finds were described in detail but in a non-standardized way and, while 'antler headdresses' are indeed now regarded as a type fossil for the Mesolithic of the North European Plain there has never, to our knowledge, been a synthetic review of them in their entirety. Furthermore, ever since the recognition of this class of finds their interpretation has been dominated by a dichotomy focusing on analogies of shamanism and hunting disguises already established by Grahame Clark (1954), which has to some extent impeded impartial scientific engagement with the finds. Thus, despite a long history of enquiry into this group of artefacts, we still lack satisfactory answers to such simple questions as: How do we define 'antler headdresses'? Why do we see differences in their morphology? Why are they found on just a handful of northern European lowland sites? How can we deal with antler headdresses as a research object?

This analysis combines multi-faceted data from morphometry, zooarchaeology, osseous technology, experimentation and ^{14}C dating to address some of these questions regarding the 'antler headdress' phenomenon. We characterize these artefacts in a manner designed to distinguish a broader class of anthropogenically modified cervid crania 'antler frontlets', which might incorporate deer crania worked for a variety of reasons (e.g., butchery) or waste from antler tool manufacture, from a narrower category of finds for which we reserve the definition 'antler headdresses'. We still intend the latter term only as a formal / technical definition, independent of their ultimate interpretation, although this smaller group might indeed have been most plausibly worn as a headdress.

Material

Antler Frontlets

Star Carr is a multilayer Early Mesolithic site discovered in 1947 and since then methodically but intermittently excavated. Remains of a hunter-gatherer residential camp at the edge of the Lake Flixton palaeolake included both a refuse zone, located in formerly shallow water with consequent good preservation of organic finds, as well as the actual living area on adjacent dry land which was artificially extended out into the lake by different platform constructions (Conneller et al. 2012; Bamforth et al. 2018). Twenty-one modified male red deer frontlets or fragments of such (SC1–21) were discovered during the initial field seasons by Grahame Clark (1954), while recent excavations brought to light 12 further frontlets (SC22–33)

Site	In-text ID	Official ID	Reference	N	Artefact	Cast	Literature	Museum	Detail drawings
Star Carr	SC2	AF2	Clark 1954	1	-	✓	✓	-	-
	SC8	AF8	Clark 1954; Street & Wild 2015	1	-	-	✓	-	✓
	SC1–SC21	AF1 - AF21 (excl. AF2; AF8)	Clark 1954	19	-	-	(✓)	(✓)	-
	SC22	103625	Little et al. 2016	1	-	-	✓	-	-
	SC23–SC33	…	Elliott et al. 2018	11	-	-	✓	-	-
Hohen Viecheln	HV1	HV 5863	Schuldt 1956	1	✓	✓	✓	-	✓
	HV2	HV 3412	Schuldt 1956	1	✓	✓	✓	-	-
	HV3; HV4	HV 5774; 6162	Pratsch 2006	2	✓	-	✓	-	-
	HV5	HoVi 387	Wild 2019	1	✓	-	-	-	-
Berlin-Biesdorf	BB1	I/82/26	Reinbacher 1956	1	✓	✓	✓	✓	-
Poggenwisch	PW1***	Tanzmaske	Rust 1958	1	✓	-	✓	-	-
Plau	PL1	2178g	Schoknecht 1961	1	✓	-	✓	-	-
Bedburg-Königshoven	BK1; BK2	105/104-1; 92/108-4	Street 1989a	2	✓	✓	✓	✓	✓
Friesack 4/II	FS1	K711	B. Gramsch, pers. comm.	1	✓	-	-	-	-
Friesack 4/III	FS2**	K705	B. Gramsch, pers. comm.	1	✓	-	-	-	-
Friesack 4/IV	FS3	K356	B. Gramsch, pers. comm.	1	✓	-	-	-	-
	FS4–FS6	K127; K245; K280	Pratsch 1994	3	✓	-	-	-	-
Bad Dürrenberg	BD1*	HK34:823f	Bicker 1936; Grünberg 2000	1	✓	-	✓	✓	-
Thatcham II	TH1	"upturned red deer antler"	Overton 2014	1	-	-	✓	-	-
Thatcham V	TH2	"right roe deer frontlet"	Overton 2014	1	-	-	✓	-	-
			Total	52	17	6	45	6	4

Tab. 1. Itemization of discussed artefacts and overview over available information of deer crania that have been mentioned in context of Grahame Clark's Star Carr antler frontlets. Grey background: not included in the original combined study (Tab. 2). In parentheses: Information available for some of the artefacts; *roe deer; **elk; ***reindeer.

Tab. 1. *Aufschlüsselung der Artefakte und Übersicht über verfügbare Informationen zu den Hirschschädeln, die im Kontext von Grahame Clarks Hirschgeweihmasken aus Star Carr besprochen wurden. Grauer Hintergrund: Nicht Teil der ursprünglichen Aufnahme (Tab. 2) gewesen. In Klammern: Information für einen Teil der Artefakte verfügbar; *Reh, **Elch, ***Rentier.*

(Little et al. 2016; Elliott et al. 2018), which comprise the frontal and parietal bones of male and female red and roe deer (*Capreolus capreolus*) with antlers often still attached, and that partly reveal perforations through the parietal bones. Furthermore, some of the antlers and burrs are hollowed out.

Hohen Viecheln (Lkr. Nordwestmecklenburg, Germany) is another multilayer Early Mesolithic site at the former northern shoreline of Lake Schwerin. Discovered in 1953, most parts of the site were excavated methodically by 1956. A refuse zone of a residential site investigated in the shallow water of the lake yielded preserved organic finds. During excavation, two red deer crania were described as an antler frontlet (HV1) and as a possible rough out for such an artefact (HV2) respectively (Schuldt 1961: 131). Subsequent re-analysis of the modified antler described two further red deer crania (HV3–4) as frontlet-like artefacts (Pratsch 2006: 71), while a 2015 examination by MW of the supposedly unworked fauna from Hohen Viecheln identified another potential 'headdress' fragment (HV5) (Wild 2019). All these specimens are red deer crania with fragmentary preservation of the antler among which only HV1 shows perforations through the parietal bone.

In 1953, trench-cutting at the Heesestraße in Berlin-Biesdorf (City of Berlin, Germany) encountered early Holocene fluvial sediments of the river Wuhle and brought to light a single red deer cranium (BB1). The frontlet consists of most of the neurocranium of a red deer carrying both antlers. The latter are split artificially so that only their caudal aspect remains (Reinbacher 1956).

The Late Upper Palaeolithic (Hamburgian) site of Poggenwisch (Kr. Stormarn, Germany) was discovered in 1951 at the edge of a kettle hole on the western flank of the Ahrensburg tunnel valley. Here, part of a refuse zone of a small habitation site, which was probably visited over just one autumn (Bratlund 1994), was excavated methodically in lacustrine sediments with excellent organic preservation. One of the finds, half of the *os frontale* of a reindeer (*Rangifer tarandus*) with attached antler worked by the 'groove and splinter' procedure (Clark 1953; Wild 2020a) was mentioned by the excavator Alfred Rust (1958: 107) as a possible antler frontlet (PW1).

In 1933, dredging during the straightening of a section of the river Elde close to Plau (Lkr. Ludwigslust-Parchim, Germany) recovered a complex of bone tools typologically attributed to the Mesolithic. Almost 30 years later and following publication of other sites first describing possible 'antler headdresses', one of the Plau objects (PL1) was also interpreted as such (Schoknecht 1961). At the time of this description, the object had already been damaged during the Second World War by burning of the building where it was stored. PL1 comprises a fragment of red deer frontal bone around the pedicles with a tiny remnant of the antler.

Bedburg-Königshoven (Lkr. Rhein-Erft-Kreis, Germany) is an Early Mesolithic site discovered in 1987 at the centre of an opencast lignite mine and investigated by careful salvage excavation. Originally located on the bank of a palaeochannel of the river Erft, surviving Preboreal limnic sediments preserved the off-bank refuse zone of a hunter-gatherer camp of broadly residential character. Here, two red deer crania with artificially perforated parietal bones but unworked antlers were discovered among other faunal and lithic remains. Recognition of the first frontlet (BK1) uncovered by quarrying indeed first led to the investigation of the site, while the second specimen (BK2) was recovered during systematic excavation (Street 1989a).

Discovered at the beginning of the 20th century (Schneider 1932), Friesack 4 (Lkr. Havelland, Germany) is a multi-occupation Mesolithic site located at the shoreline of a small Early Holocene (palaeo-)island in the Rhinluch (Groß 2020). A number of meticulous excavation campaigns identified several camps with different functions and investigated both refuse zones originally located in shallow water, with perfect preservation of organic objects, as well as parts of the occupied dry land areas (Gramsch 2000). Six recovered artefacts have been compared to the antler frontlets from Star Carr (Bernhard Gramsch, pers. comm.): a fragmented red deer cranium with no preserved antler (FS1) from Friesack 4/II – a complex of layers accumulated in the Late Preboreal (Gramsch 2000); the central part of an elk (*Alces alces*) cranium with parts of both antlers (FS2) from the succeeding complex (Friesack 4/III), which accumulated in the early Boreal (Gramsch 2000); four fragmented red deer crania (FS3–FS6), some with partial antlers (Pratsch 1994), from the youngest complex (Friesack 4/IV) which accumulated from the late Boreal to the early Atlantic period (Gramsch 2000). Some of these artefacts have recently been grouped together with other Mesolithic red deer crania from Poland and Belgium within a group classed as 'ring-frontlets' (David et al. 2016).

In 1934, canalization work in Bad Dürrenberg (Lkr. Saalekreis, Germany) revealed the rich Late Mesolithic burial of a woman and a small child (Bicker 1936). Among diverse faunal remains found in the grave was one partial roe deer cranium with attached antler interpreted as an antler headdress (BD1) (Grünberg 2000: 204).

Thatcham II (District of West Berkshire, Great Britain) is a multi-occupation Early Mesolithic site discovered in 1958 on the bank of a former watercourse and subsequently excavated (Wymer 1959). A recent re-analysis of the faunal remains describes a red deer *os frontale* with attached and shortened antlers (TH1) that is compared with the Star Carr frontlets (Overton 2014: 290–291).

Thatcham V, a site at the same shoreline as Thatcham II, was excavated in 1961 and also produced multiple Early Mesolithic occupations (Wymer & King 1962). A roe deer *os frontale* with attached antler and a possible perforation (TH2) from this site was recently interpreted as headdress-like in character (Overton 2014: 291).

To sum up, a great variety of humanly modified deer skull/antler frontlets has been recovered from North European Lowland sites, almost without exception dating from the Early Holocene. While some of them were described as 'headdress-like' simply because of their suggestive appearance, others indeed appear to be intentionally produced artefacts, showing a range of anthropogenic modifications such as detaching the skull cap, perforation(s) of the cranial bones or reduction of the antlers.

Methods

Morphometric, zooarchaeological and technological analysis

Of the 52 claimed frontlets summarized above, 16 specimens (from 10 occupation episodes at 8 sites) were selected for systematic review in an approach combining analyses of their morphometric, zooarchaeological and technological data (Tab. 2).

Morphometric parameters recorded included the dimensions of the specimens expressed as total length, breadth, height and weight, the lengths of the antler beams and tines, and the length and breadth of any anthropogenic perforations. This data set was supplemented by zooarchaeological information for the species, minimum age of the individual estimated by the development of antler (Wagenknecht 1988:

Parameter	'Antler headdresses'	Rest	SC2	SC8	HV1	HV2	BB1	PW1	PL1	BK1**	BK2**	FS1	FS2	FS3	FS4	FS5	FS6	BD1
Age determination																		
Level of antler growth	4.7	2.3	3	5	2	3	5	4	3	7	6	-	2	-	1	2	5	3
Minimum age in years	3	2.4	3	3	3	3	3	3	3	3	3	1	3	1	2	3	3	2
Weight																		
in g	1,865	280	-	-	425	326	1,850	139	147	2,800	2,384	94	921	159	339	241	340	92
Preservation																		
Antler	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Os nasale	33.3 %	0.0 %	-	-	-	-	(✓)	-	-	-	(✓)	-	-	-	-	-	-	-
Os frontale	100.0 %	100.0 %	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)
Os parietale (sin.+dex.)	100.0 %	50.0 %	(✓)	(✓)	(✓)	(✓)	(✓)	-	-	(✓)	(✓)	-	-	(✓)	(✓)	(✓)	(✓)	-
Os temporale (sin.+dex.)	83.3 %	10.0 %	(✓)	(✓)	-	-	(✓)	-	-	(✓)	(✓)	-	-	-	(✓)	-	-	-
Os interparietale	100.0 %	60.0 %	✓	✓	✓	(✓)	✓	-	-	✓	(✓)	-	(✓)	(✓)	✓	(✓)	(✓)	-
Os sphenoidale	0.0 %	60.0 %	-	-	-	(✓)	-	-	-	-	-	-	(✓)	(✓)	(✓)	(✓)	(✓)	-
Antler working																		
Grooving	66.7 %	22.2 %	✓	✓	✓	✓	✓	x	✓	x	x	-	x	x	x	x	x	x
Cutting	66.7 %	55.6 %	✓	✓	✓	✓	✓	✓	x	x	x	-	✓	x	x	x	✓	✓
Cranial perforation																		
Os temporale (sin.+dex.)	40.0 %	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-
Os interparietale	60.0 %	-	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Cutmarks on cranial bone																		
Os nasale	0.0 %*	-	-	-	-	-	x	-	-	-	x	-	-	-	-	-	-	-
Os frontale	100.0 %	80.0 %	✓	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
Os parietale (sin.+dex.)	100.0 %	0.0 %	✓	✓	✓	x	✓	-	-	✓	✓	-	-	x	x	x	x	-
Os temporale (sin.+dex.)	80.0 %	100.0 %*	(✓)	✓	-	-	x	-	-	✓	✓	-	-	-	✓	-	-	-
Os interparietale	66.7 %	33.3 %	✓	✓	✓	✓	x	-	-	x	✓	-	x	✓	x	x	x	-
Os sphenoidale	-	0.0 %	-	-	-	-	-	-	-	-	-	-	x	x	x	x	x	-
Tabula interna	100.0 %	20.0 %	✓	✓	✓	x	✓	x	x	✓	✓	x	✓	✓	x	x	x	x
Other modifications to cranial bone (pecking. grooving. scraping…)																		
Os nasale	0.0 %*	-	-	-	-	-	x	-	-	-	x	-	-	-	-	-	-	-
Os frontale	50.0 %	30.0 %	✓	x	✓	✓	✓	x	✓	x	x	x	x	x	✓	x	x	x
Os parietale (sin.+dex.)	66.7 %	0.0 %	✓	x	✓	x	x	-	-	✓	✓	-	-	x	x	x	x	-
Os temporale (sin.+dex.)	40.0 %	0.0 %*	x	x	-	-	x	-	-	✓	✓	-	-	-	x	-	-	-
Os interparietale	50.0 %	0.0 %	✓	x	✓	x	x	-	-	x	x	-	x	x	x	x	x	-
Os sphenoidale	-	0.0 %	-	-	-	-	x	-	-	-	-	-	x	x	x	x	x	-
Tabula interna	66.7 %	11.1 %	✓	x	✓	-	✓	x	✓	x	✓	x	x	x	x	x	x	x

Tab. 2. Revision of possible antler headdresses resulted in the segregation of antler headdresses from the rest of examined objects. The presented data manifests this division; abbreviations after table 1. In %: how often these criteria apply to the specific group. Check mark: present; check mark in parentheses: present in fragmentation; x: not present; *: ≤2 specimens; **as the frontlets from Bedburg-Königshoven could be half finished products (cf. Wild 2020b) their antlers had not been considered.

Tab. 2. *Die Neuaufnahme der angesprochenen Hirschgeweihmasken resultierte in der Unterscheidung von Hirschgeweihkappen zu den anderen aufgenommenen Artefakten. Die vorgelegten Daten untermauern diese Unterteilung; Abkürzungen nach Tabelle 1. In %: wie häufig trifft das Kriterium für die entsprechende Gruppe zu. Häkchen: erhalten; Häkchen in Klammern: fragmentiert erhalten; x: nicht vorhanden; *: ≤2 Spezimen; **weil es sich bei den Hirschgeweihkappen von Bedburg-Königshoven um Halbprodukte handeln könnte (cf. Wild 2020b) wurden deren Geweihe nicht mitgezählt.*

141–145), and the representation of antler and cranial bone elements. The technological study recorded the presence of anthropogenic surface modifications to the cranial bones and antlers (artificial depressions, furrows, cutting planes, etc.) and details of specific surface modifications (intentional fractures, incisions), the presence and locations of anthropogenic bone perforations, and the evidence for different perforation techniques. Terminology used in this study follows Wild (2020a).

Radiocarbon dating

The lack of a reliable stratigraphic attribution for the HV1 'headdress' within the probable occupational palimpsest at Hohen Viecheln has so far not allowed a more precise dating of this specimen, which the excavator assigned to the oldest (Early Boreal) occupation (Schuldt 1961: 131). A similar chronological position was proposed for BB1, found at a depth of 5.5 meters below the modern surface in a calcareous gyttja, which was itself overlain by carr peat (Reinbacher 1956). In order to obtain a more precise date for these two contexts the two 'antler headdresses' HV1 and BB1 were directly dated during the course of these studies. It is not possible to date directly the 'headdress' from the third eastern German site, Plau, since fire damage to the artefact during the Second World War has resulted in a replacement of ancient by recent carbon (Zazzo et al. 2012).

Because of the exceptional status of the Hohen Viecheln and Berlin-Biesdorf 'antler headdresses' and since the two artefacts appear to have been treated with consolidants and other materials during conservation and restoration, a specific strategy of sampling, pretreatment and dating was chosen. For HV1 a sample was drilled through the *tabula interna* extending into the pedicle, leaving a hole of a few mm in diameter. A refitted old fracture of the beam of BB1 was dissolved, a sample removed from the fracture surface and the fracture subsequently repaired. The direct date obtained for HV1 was complemented by results for other faunal specimens from the site sampled at the same time (Meadows et al. 2019). In the case of BB1, which was recovered without accompanying archaeological material, the small sample (500 mg) of antler powder was divided and analysed independently by two radiocarbon laboratories following appropriate pretreatment for removal of any consolidants (protocols in Meadows et al. 2019).

Results

Morphometric, zooarchaeological and technological analysis

We identify several of the features observed on the 16 studied artefacts as significant for a classification as 'antler headdress' (cf. Wild 2014, 2019, 2020b):

(1) By definition there is at least partial preservation of the antlers (and frontal bones). This also identifies the sex of the specimen and may contribute information on the season of death. Antler beams and tines which are present are worked down longitudinally (hollowed out, grooved, split?).
(2) The frontal, parietal and interparietal bones are always, the temporal bones sometimes present. The parietal/interparietal (SC2; SC8; HV1) or parietal/temporal bones (BK1; BK2) show at least two artificial perforations. Should one of these be damaged, another asymmetrically located perforation was typically hacked, pecked, or incised into the bone (cf. SC1, Clark 1954: Plate XXII).
(3) The represented cranial bones show anthropogenic modifications. When the state of preservation allows, they can be seen to be deliberately removed from the rest of the skull by incising and pecking. The inner wall of the brain case (*tabula interna*, neurocranium) is partially smoothed down by intensive scraping.

These features are quite specific, with no exact equivalents in Palaeolithic or Mesolithic osseous industries. The identification of one or more of these particular characteristics should therefore be sufficient to identify an antler frontlet more closely as an 'antler headdress' (potentially even when discarded because broken, or an unfinished product or rough out) distinct from grave goods (BD1) or potential trophy objects (HV2–4, FS1–6; cf. Pratsch 2006; David et al. 2016) and from simple butchering and manufacturing waste (HV2–4(?), FS1–6(?), PW1, TH1–2).

Only rarely do all the described features occur on a single specimen (Tab. 2). In fact, they were observed together on only three studied artefacts, SC2, SC8 and HV1. Restricting the definition of an 'antler headdress' to these three specimens would exclude the majority of obviously related finds from consideration in the discussion of this important phenomenon. On the other hand, the sharing of only some of a larger number of potential features is very much the norm in the characterization of polythetic, archaeologically derived assemblages or entities (cf. Clarke 1968: Fig. 3) and we choose to define a larger group by evaluating the identified significant features in this way. Perhaps these could be understood as 'antler headdresses' sensu lato, contrasted with the 'Holy Grail' of 'antler headdresses' sensu stricto represented by only the three specimens which meet all criteria.

Applying the selected criteria as described above we assign 7 of the 16 antler frontlets examined by this study to our polythetic group of 'antler headdresses' sensu lato (Tab. 3): SC2, SC8, HV1, BB1, BK1, BK2, PL1, while, for example, the Poggenwisch antler can be described as simple waste (see also Wild 2020a: 152) or the Dürrenberg antler as a simple grave good.

A more exhaustive description of the 'antler headdresses' defined by our study now follows. We will also refer to red deer crania that were not part of the original study. Direct and indirect access to these specimens was only possible after the first stages of

Feature/find	BD1	BK1	BK2	BB1	FS1	FS2	FS3	FS4	FS5	FS6	HV1	HV2	HV3	HV4	HV5	PL1	PW1	SC2	SC8	SC22	TH1	TH2
1	☐	☒	☒	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☒	☒	☐	☐
2	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☒	☒	☐	☒	☒	☒	☐	☐
3	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐

Tab. 3. Overview of the examined 'antler headdresses' using the three headdress-making characteristics. (1) Perforations on the caudal part (Os temporale, Os parietale, Os interparietale); (2) Antler and pedicle longitudinally split; (3) Inner neurocranium smoothed; abbreviations after table 1. Grey background: not part of the original study; characteristics taken from publications.

***Tab. 3.** Übersicht über aufgenommene ‚Hirschgeweihkappen' nach den drei Merkmalen, die eine Hirschgeweihkappe ausmachen können. (1) Auf der kaudalen Schädelpartie (Os temporale, Os parietale, Os interparietale) befinden sich Perforationen; (2) Das Geweih samt Rosenstock ist längs gespalten; (3) Die Innenseite des Neurokraniums ist stark überarbeitet und sämtliche Kanten sind entfernt worden; Abkürzungen nach Tabelle 1. Grau hinterlegt: nicht Teil der originalen Studie; Merkmale anhand von Publikationen überprüft.*

the analysis but they have since been tested against the suggested definition (Tab. 3).

Both Star Carr frontlets (SC2, SC8) considered by this study combine all three attributes of our definition. The faunal material from the site includes a further 31 deer frontlets, only some specimens of which have so far been adequately published (Elliott et al. 2018). However, it becomes clear that at least some artefacts fulfil the requirements of at least a 'headdress' sensu lato (e.g., artefacts SC22, 99528 & 115876, Elliott et al. 2018: Figs. 26.6, 26.4, 26.12), while others do not (e.g., artefacts 116020, 116601 & 117803, Elliott et al. 2018: Figs. 26.16, 26.17, 26.24).

Of the frontlets at Hohen Viecheln (Schuldt 1956; Pratsch 2006; Wild 2019), only HV1 can be confirmed as a 'headdress' sensu stricto on the definition presented here. Examination of red deer crania from Hohen Viecheln by MW brought a further 'headdress' sensu lato (HV5) to light (Wild 2019). Only the left part of the frontal bone is present; sutures are unfused, and this might be responsible for the absence of other bones, as observed on other 'headdresses' (Tab. 2). Only a few centimetres of the antler beam are left but show working by groove and splinter procedure, as seen on many of the Star Carr specimens (Clark & Thompson 1954), as well as detachment of the medio-anterior part of the basal beam which continues through the burr onto the pedicle. In this, it resembles not only SC2 and SC8 but also HV1 and BB1.

Another 'headdress' to deserve closer discussion is BB1. The inner surface (tabula interna) of this red deer cranium, comprising frontal, parietal and interparietal bones, has been worked down and smoothed by scraping; however, the specimen is not perforated in any way. The antlers and pedicles have been reduced by removing the anterior face of the beams and tines. In this feature it resembles HV1 and some material from Star Carr (e.g., SC9, Clark 1954; artefact 115876, Elliott et al. 2018: Fig. 26.12) and BB1 could therefore perhaps be interpreted as having had a different attachment system (not by means of perforations; cf. Elliott et al. 2018) or as representing a specimen still to be perforated. Regardless of whether it was a finished product, it does not fit the given sensu stricto definition and should be termed a 'headdress' sensu lato.

BK1 and BK2 meet our proposed criteria for a 'headdress' that the cranial bone shows two perforations. The antlers are neither worked down by the groove and splinter nor otherwise longitudinally split. Their location on discovery in the middle of an underwater discard zone in a former lake has recently been considered to possibly indicate unfinished 'antler headdresses' intentionally submerged for soaking (Wild 2020b). That the modifications to the two red deer crania conform to those involved in producing a 'headdress' finds support in the similarity between BK1 and one of the most recent finds from Star Carr (SC22). The similarities cover not only the modified shape of the cranium and the position of the

perforations on the temporal and parietal bones, but also the morphology of the perforations with regard to both size (~1 cm in diameter), their funnel-like appearance and the linear incisions radiating out from both sides of the perforations (Little et al. 2016).

PL1 is the last discussed 'headdress' sensu lato. It lacks the caudal and lateral parts of the cranium. Whether this is due to taphonomy or anthropogenic action can no longer be determined: furthermore, it could also be that some bone parts were broken off while rescuing the artefact when its storage place burned down. This episode of burning changed the colour of the artefact to a light grey and the edges now seem to be smoothed so that slight modifications are no longer determinable. Despite this, the intensive smoothing of neurocranial irregularities and longitudinal dividing of the shortened antler beams and pedicles, show remarkable similarities to HV1.

The amount of discussion needed to integrate all objects into a single definition makes clear that the definition might only work perfectly for one type of specific and highly comparable 'headdress' (the sensu stricto-type). On the other hand, the presence of other finds that seem to lie in the broader variety of this group of artefacts, for whom the strict definition is too narrow, underlines the need for the broader application of the characteristics in the polythetic way as presented in this study. This is supported by the fact that the overall shape and particular characteristics of the discussed artefacts (HV5, BB1, BK1 & BK2, PL1) do not find equivalents in any other close region or contemporary archaeological culture nor they can be explained by means of function.

Radiocarbon dating

Direct radiocarbon dating assigns HV1 to the Late Preboreal and BB1 to the Late Preboreal or the beginning of the Boreal. The collagen content of all samples was judged sufficient and carbon isotope analysis unproblematic. Other samples from Hohen Viecheln dated in the same series produced results consistent with this age, while the result for BB1 is duplicated by the two dating laboratories. There are therefore no indications for doubting the accuracy of the radiocarbon dating results (Tab. 4).

Discussion

Producing an 'antler headdress'

Having defined the features we regard as specific for the identification of an 'antler headdress' we can examine in more detail the morphology of these traces and thus interpolate the methods used to produce these artefacts.

The situation is in some cases complicated by the prior exploitation of some red deer crania for their antler by groove and splinter procedure before their subsequent modification as a 'headdress', for example SC8 (Street 1993: 262; Street & Wild 2014: 281) or HV5 (Wild 2019). This leads to a complicated palimpsest of human modifications; however, the different activities and the traces they left can usually be distinguished. When Grahame Clark originally described the Star Carr frontlet specimens, he noted the regular hollowing out (sensu dividing) of the antlers (Clark 1954). Furthermore, in many cases not only the antlers are divided but the pedicle also shows this kind of modification. Cervid antler usually does not break through the pedicle naturally (Olsen 1989; Pfeifer 2014), and while such fractures might occur during burial process, this has not been observed in any of the studied assemblages nor on any of more than 1,200, sometimes highly weathered reindeer antlers with pedicles at the Ahrensburgian

Sample	Lab code	Extract dated	^{13}C (‰)*	Corrected pMC**	^{14}C BP	calBC
BB1	KIA-51073	8.7 % collagen, 42 % C, 2.6 mg C	-21.71 ± 0.15	31.18 ± 0.19	9,361 ± 50	8,767-8,572
	RICH-22179†				9,425 ± 45	
	weighted mean (T=0.9,T'(5 %)= 3.8, ν=1)‡				9,397 ± 34	
HV1	KIA-51074	15.1 % collagen, 46 % C, 3.8 mg C	-22.00 ± 0.16	30.58 ± 0.18	9,518 ± 46	9,136-8,711

Tab. 4. Results from ^{14}C dating of two 'headdresses', calibrated with OxCal v4.3 (Bronk Ramsey 2017) and the calibration curve IntCal13 (Reimer et al. 2013). CalBC given in 95.4 % propability. *Please note that the δ^{13}C includes the fractionation occurring in the sample preparation as well as in the AMS measurement and therefore cannot be compared to a mass-spectrometer measurement; **Corrected pMC (percent Modern Carbon) indicates the percent of modern (1950) carbon corrected for fractionation using the ^{13}C measurement; †RICH-22179 is an independent date for the same sample by the KIK-IRPA laboratory, Brussels, whose extraction also yielded 8.7 % collagen. FTIR of collagen again showed no evidence of consolidants. EA-IRMS results from this extract, measured in Brussels: 37.8 %C, 13.1 %N, atomic C: N 3.4, δ^{13}C -22.0 ‰, δ^{15}N 3.3 ‰; ‡weighted mean calculated using OxCal's R_Combine function (Bronk Ramsey 1995 after Ward & Wilson 1978).

Tab. 4. *Resultate der ^{14}C-Datierung der zwei ‚Hirschgeweihkappen'. Die Rohdaten wurden mit OxCal v4.3 (Bronk Ramsey 2017) und der Kalibrationskurve IntCal 13 (Reimer et al. 2013) kalibriert. CalBC mit 95.4 % Wahrscheinlichkeit angegeben. *Die Messung des Wertes δ^{13}C erfolgte nach Fraktionierung während der Probenaufbereitung und des AMS-Messvorgangs. Der Wert kann daher nicht mit dem eines Massenspektrometers verglichen werden; **Korrigiertes pMC (percent Modern Carbon) ist ein Indikator für den Anteil von modernem (1950) Kohlenstoff, der für die Fraktionierung korrigiert wurde und mit ^{13}C gemessen wird; †RICH-22179 ist ein eigenständiges Ergebnis des KIK-IRPA Labors, Brüssel für dieselbe Probe. Sie enthielt ebenfalls 8.7 % Kollagen. Die FTIR-Analyse des Kollagens enthielt ebenfalls keine Anzeiger von Konservierungsmitteln. EA-IRMS Resultate dieser Probe wurden ebenfalls in Brüssel gemessen: 37.8 %C, 13.1 %N, atomic C:N 3.4, δ^{13}C -22.0 ‰, δ^{15}N 3.3 ‰; ‡gemittelter Wert, kalkuliert mit OxCals R_Combine Funktion (Bronk Ramsey 1995 after Ward & Wilson 1978).*

site of Stellmoor (MW, pers. obs.). The longitudinal dividing of the antlers extending onto the pedicles seems therefore to be specific to the frontlets defined as 'antler headdresses'.

Incisions on the preserved bones of the 'antler headdresses' which probably derive from the skinning process are usually observed only on the pedicles and around the edge of the skull cap. The only tools necessary to create these marks are the sharp lateral edges of simple flint blades used to cut through the fasciae (cf. Trolle-Lassen 1990; Schmölcke 2016: Fig. 14). This was confirmed by a series of experiments conducted in 2013 by MW und MS on a fresh red deer carcass. The skin was easily pulled away from the nasal and frontal bones without cutting, which was only needed just below the antler burr (Wild 2014: 91, Fig 4.8). Such traces can also be observed on several 'headdresses' (e.g., BK1, BK2, SC8, Street & Wild 2015: Figs. 4b, 6b, 8c). The cut marks around the edges are interpreted as due to cleaning the bone of tissue before removal of the skull cap from the rest of the cranium by percussion.

This operation is shown by the presence of flake-like negatives along the rim of the cranial bone of some 'headdresses' (e.g., BK1, BK2, SC22, Street 1989a; Little et al. 2016). The 2013 experiments showed that simple pecking with the blunt working end of a heavy stone tool can produce these specific breakage patterns, very probably due to the particular structure of the cranial bones, which are composed of two layers of thin compact bone (*tabula interna/externa*) enclosing a layer of cancellous bone (*diploë*). The two compact layers seem to regularly break off as flakes when pecked or hacked from one side or the other and thus behave differently than purely compact bone or antler.

A more complicated method to replicate the traces observed on SC22 has however also been described (Little et al. 2016): Experimentally, a cervid cranium was covered in clay and then baked in an open fire, resulting in the destruction of the contained collagen. This scleroprotein is the most abundant one in bones, providing stability to the micro- and macrostructure by forming long protein chains that act as a framework for poorly crystallized inorganic particles (Nimni & Harkness 1988). The destruction of collagen during heating is used in the case of the Little et al. experiments to shape the brittle bone of the cranium.

Bone collagen is also the component used for dating bone and its destruction due to ancient heating creates problems for ^{14}C dating (Lanting & Brindley 1998; Lanting et al. 2001; Hüls et al. 2010). Following the conclusions regarding manufacture of SC22 (Little et al. 2016) this therefore needed to be considered as a potential factor when obtaining a new direct date for the 'antler headdress' HV1. In order to date this specimen a sample was taken by drilling a thin hole through the tabula interna into the pedicle. In fact, the collagen content measured for this sample was the highest (15.1 %; Tab. 4) for the total of over 30 sampled bone and antler artefacts from the same context and environment at Hohen Viecheln (Meadows et al. 2019), none of which show any macroscopically detectable signs of heat treatment.

The high collagen content of HV1 therefore provides strong arguments against the heat treatment of at least this specimen of an 'antler headdress' during its manufacture (cf. Hüls et al. 2010: Fig. 3). A possible methodological approach to testing the 'heating hypothesis' would be to analyse and compare small samples of potentially heated cranial bone and less-heated antler (further away from the centre of the fire) from the Star Carr frontlets SC22–SC33 (still unaffected by conservation consolidants) and replicated experimental material, using FTIR spectroscopy to compare their respective collagen peaks (cf. FTIR protocol in Hüls et al. 2010; Wild 2020a). Consistent differences between the peaks for organic substances of the cranial bone and antler samples would be predicted by the heating hypothesis.

While some questions still remain about the exact methods used for isolating and shaping the cranial part of an 'antler headdress' there is less ambiguity regarding the origin of incisions on the interior surface. They derive from contact with the bone by a simple flint blade during removal of the soft tissues, whether these are the cooked brain (Little et al. 2016) or the periosteum (Wild 2014).

In combination with the removal of the lateral and caudal extremities of the neurocranium (cf. Fig. 3) and the presence of the perforations, the smoothing of the relief of the neurocranial *tabula interna* can be interpreted as evidence of intent to carry these objects on the head. Although only slight modification of this type was observed on SC2 and SC8 and some other Star Carr specimens, it is present on HV1 as well as on PL1 and BB1. We are aware of no analogous modification to equivalent crania from other Palaeolithic or Mesolithic contexts and the regulation of the *tabula interna* therefore also seems to be a specific characteristic of the skull caps of 'antler headdresses'.

The most evident features of several 'antler headdresses' are their perforations, which indeed first led to the interpretation that they were worn as headdresses fixed by a cord. Such ethnographically documented headdresses have been reported at length (e.g., Clark 1954; Street 1989a). While perforations of osseous materials are not uncommon in Palaeolithic and Mesolithic archaeology (e.g., bâtons percés, beads, barbed points), perforation of the cranial bones is a very rare phenomenon and we could find only one comparable object from a very different context: a cranial bone from Magdalenian (or possibly Neolithic?) levels at Abri de la Croze (Dép. Ain, France) shows a perforation of comparable size to those of the Mesolithic 'antler headdresses' (Malgarini 2014: 331, 332, Fig. 178).

Fig. 3. Hohen Viecheln (HV1) – ventral view. The brain case was laterally reduced, and the remaining surface was regulated and smoothed down.

Abb. 3. *Hohen Viecheln (HV1) – ventrale Ansicht. Die Kalotte wurde seitlich abgebaut und die verbleibende Oberfläche reguliert und geglättet.*

The funnel-shaped appearance of the perforations of Mesolithic 'antler headdress' skull cap is caused by small depressions observed around the holes. These occur on the dorsal aspect (BK1, BK2, SC2 and SC8) and are sometimes also observed on the ventral aspect (SC22; Little et al. 2016: 4, Fig. 3c). Such small depressions can be created by hacking into the perforation with the sharp working end of a heavy stone tool (cf. David 2005: 329–330, Fig. 197, Pl. 371, Pl. 382; Street & Wild 2014: 278; Little et al. 2016: Fig. 8) (cf. Fig. 4). Also associated with these perforations are scars of small flakes removed from the compact bone of the cranium (*tabula*).

Whether it is possible to go beyond a characterisation of the chaîne opératoire for manufacturing an 'antler headdress' and determine e.g., the nature and even intensity of their use, depends upon the ability to distinguish the traces left by manufacturing as defined above from others, potentially produced during the period of their functioning.

It is remarkable that, although numerous traces can be related to activities in the manufacturing process, many other (cutting planes and depressions on the *tabula externa* and especially around the perforations) cannot be explained by this (cf. Fig. 5). These latter modifications may derive from the final intensive use of the 'antler headdresses'. Further typical use-wear as polish on specific worn parts of the 'headdresses' have not been identified yet.

Functional considerations

As has been stated above, there exists a wide range of different 'headdress' types (e.g., those with perforations, without perforations, with replacement perforations, with full antlers, shortened antlers, divided antlers, and with or without smoothing of the neurocranium), which logically hinders attempts to agree upon an interpretation of their function. Ethnological analogies may suggest their interpretation as hunting aids, whether worn actively as a disguise (Clark 1954) or set up as static elements during drives (Street & Wild 2015). These are perhaps not entirely convincing in the given context (Halls 1984; Elliott et al. 2018), certainly some sites were occupied at a season when genuine red deer do not carry full antlers (Gehl 1961; Legge & Rowley-Conwy 1988). Another possible function for the antlers could be as a 'stalking horse' hide, used to move closer to waterfowl easily scared by the silhouette of humans (e.g., Robertson 1875: 194–201). While water birds were found at Star Carr (Fraser & King 1954), Hohen Viecheln (Gehl 1961) and Bedburg-Königshoven (Street 1989a), albeit perhaps due to natural agency, other potentially easier and more efficient methods (e.g., traps, snares) were probably available for taking this kind of prey.

The use of 'antler headdresses' as purely secular objects therefore does not appear entirely convincing and it might be useful to consider more closely an interpretation of this find category as the physical manifestation of a vanished abstract tradition or ritual. The possible use of the 'antler headdresses' in undefined rites or ceremonies has, of course, been suggested by numerous authors since their discovery. The most prominent idea is probably their attribution to (usually poorly defined) shamanistic activities. However, Andy Reymann (2013, 2015) reviews the problems inherent in the use of 'shamanism' as one of the 'most dangerous of these vague words' in archaeology ("Parmi ces mots vagues, l'un des plus dangereux est celui de Chamanisme", Gennep 1903) and other postulated interpretations are considered more plausible.

Furthermore, the evidence of historic and recent hunter-gatherer societies shows a lack of clear differentiation between the different spheres of ritual and secular specialists. For instance, Hill describes that in both southwest Amerindian and Arctic Inuit societies not only the religious specialist but every adult of the group was allowed to perform rites involving the remains of dead animals (Hill 2000, 2011, 2013). Analysis of recent reindeer hunters in Siberia (Grøn 2010) led to similar conclusions.

Chantal Conneller has interpreted the Star Carr 'antler headdresses' as reflecting the numinous status of an exceptional site and envisions a much more complex Mesolithic hunter-gatherer world view than is possible by making a clear distinction between separate secular and ritual spheres (Conneller 2004). This analysis has been critically reviewed by Paul Mellars, who retains a more traditional approach to

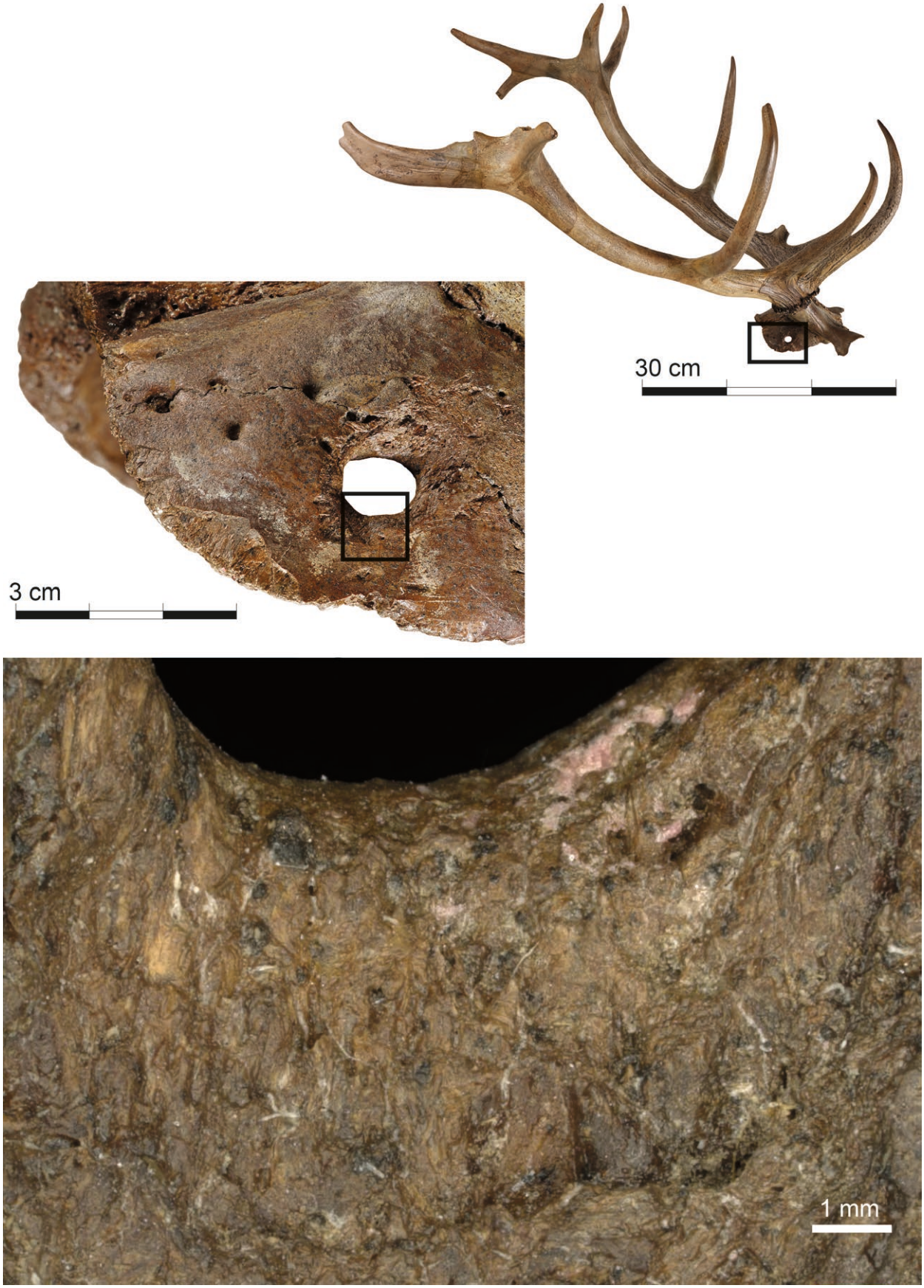

Fig. 4. Bedburg-Königshoven (BK1). Right perforation, dorsal view. One can observe the small, longitudinal removal scars produced during hacking with a heavy stone tool.

Abb. 4. *Bedburg-Königshoven (BK1). Rechte Perforation, dorsale Ansicht. Auffallend sind die langschmalen Negative, die vom Hacken mit einem schweren steinernen Werkzeug stammen dürften.*

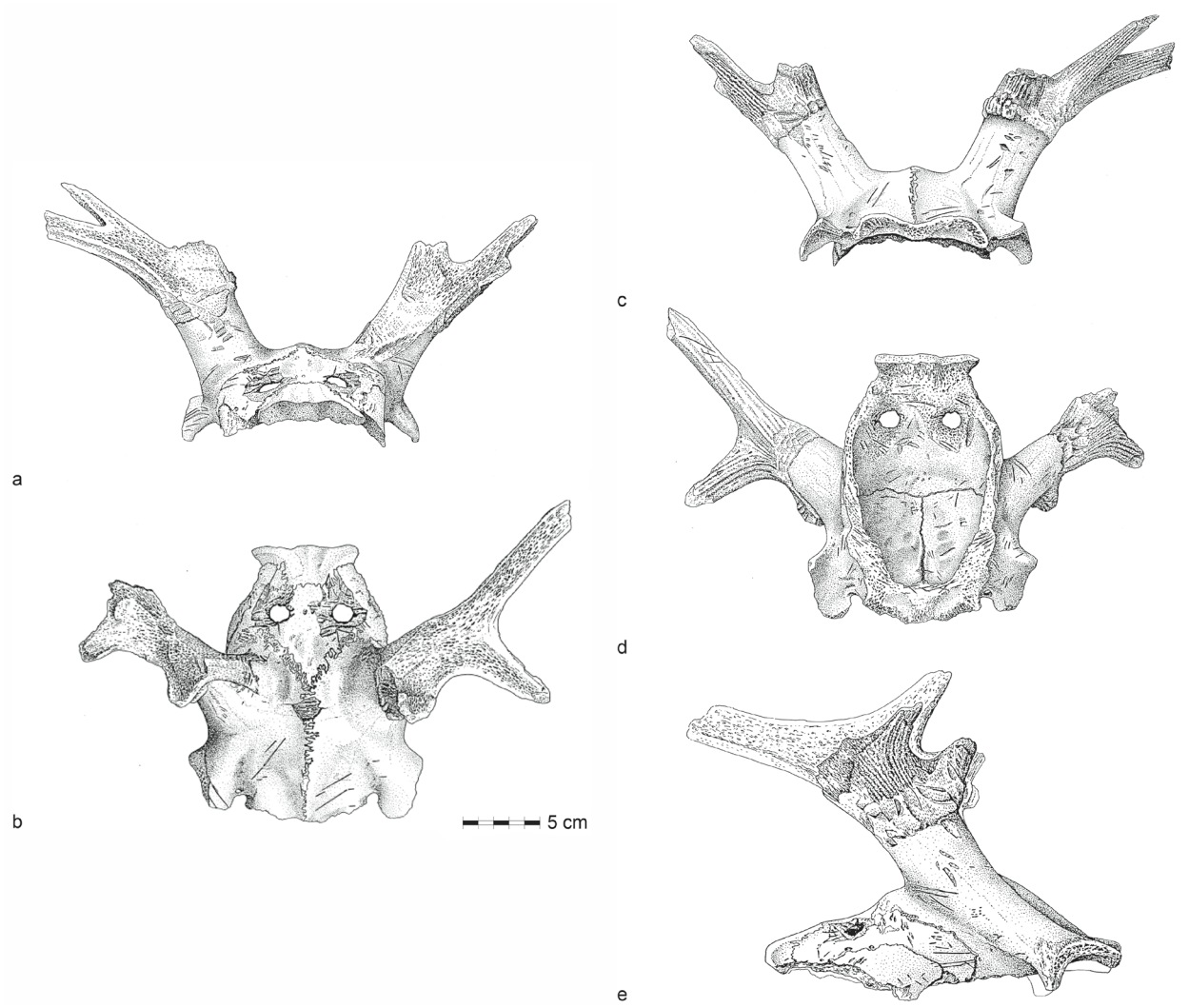

Fig. 5. Starr Carr (SC8) - caudal view (a), dorsal view (b), frontal view (c), ventral view (d) and right view (e) (after Street & Wild 2015: 216–217, Fig. 8).

Abb. 5. *Starr Carr (SC8) - kaudale Ansicht (a), dorsale Ansicht (b), frontale Ansicht (c), ventrale Ansicht (d) und rechte Ansicht (e) (nach Street & Wild 2015: 216–217, Fig. 8).*

the distribution patterns of organic artefacts for his interpretation of the function of the Star Carr site (Mellars 2009).

Nevertheless, in view of the intensified discussion of Mesolithic rituals (e.g., Mikhailova 2006; Galiński 2014; Little et al. 2016) it must be conceded that to date, despite a discussion extending over the past 70 years, there is still no unambiguous evidence or consensus for the attribution of 'antler headdresses' to a ritual or religious context and other interpretations continue to be propagated.

Recently, Grahame Clark's suggestion (1954: 170) that 'antler headdresses' represent trophies of successful hunts (which they by definition always do) was revived by Stefan Pratsch (2006) who interpreted deer frontlets from Friesack 4 (see above) in this way. However, the intensive working of the antler, *tabula interna* and other bones may exceed what would be necessary simply to fix a skull as a trophy. Proven trophies from Mesolithic Kanaljorden (Motala, Östergötlands län) are human crania (described as 'skulls on stakes', Hallgren 2011) that were fixed by wooden stakes through the foramen magnum but without further modifications.

Chronological and cultural context

On our definition, 'antler headdresses' are confirmed from five Early Mesolithic sites (Star Carr, Hohen Viecheln, Bedburg-Königshoven, Berlin-Biesdorf and Plau) and are restricted on contextual, typological or environmental evidence to the Preboreal and Boreal periods. The specimens from only two sites have so far been dated more precisely to the Late Preboreal and Boreal (Star Carr) and the supposed Middle Preboreal (Bedburg-Königshoven) by radiocarbon dates obtained on associated faunal and/or botanical remains, some of them in stratigraphic sequence.

It is instructive to examine more closely the evidence for the age of the other 'antler headdresses' in the light of these most recent direct dates for this class of artefacts from Hohen Viecheln and Berlin-Biesdorf (see above).

At Star Carr, all osseous artefacts derived from the early excavations were treated on site with a chemical consolidant (Clark 1954: Pl. IIIA). Due to this, most radiocarbon dates were obtained on contextual environmental samples (e.g., Arnold & Libby 1951; Dark 1998) or the age of the site extrapolated from finds of other excavations close to the location of the 'headdresses' (e.g., Cloutman & Smith 1988; Conneller et al. 2009; Bayliss et al. 2018).

More recently, a series of direct dates was published on artefacts in private hands (Tot Lord Collection). These artefacts had been taken by Tot Lord from Clark's trenches in 1950 prior to backfilling and thus escaped the regular conservation procedure. One of these objects (T.C. Lord Collection no. 465) is described as a "fragment of tine of red deer antler, from which splinters have been removed" (Dark et al. 2006: 195), although the grooved character of the piece was subsequently rejected (Elliott & Milner 2010: 83). However, while the groove and splinter procedure as defined at Star Carr does not include the splitting of tines (Clark & Thompson 1954), the preparation of 'antler headdresses' can involve this action (see above; cf. Fig. 2: 3–4; and SC9, SC22, BB1…), and the piece might still represent potential manufacturing waste from the production of such an artefact. The date of this specimen is similar to that obtained for HV1 (Tab. 4 & 5).

The context of the majority of the Star Carr artefacts was given by Grahame Clark as within the basal part of the archaeological sequence immediately overlying late glacial gravel (e.g., 'antler headdress' SC9, Clark 1954: Pl. IIIB, Pl. XXIII). However, the oldest dated Star Carr artefact (Dark et al. 2006: 193) is a worked antler crown (T.C. Lord Collection no. 461), which only provides a terminus post quem for the presence of humans (and possibly of 'antler headdresses') immediately after the Middle Preboreal (Tab. 5). Bayesian modelling of new radiocarbon data from Star Carr as well as re-dating of this artefact confirms a Late Preboreal age for the first occupation of the site, and would suggest an early use of the 'antler headdresses' at the site, as supported by three recent direct dates on these artefacts (Tab. 5).

Nevertheless, it has recently been suggested (Elliott et al. 2018) that most of the newly discovered proposed 'antler headdresses' from Star Carr belong to the slightly younger main phases of occupation. Using our criteria, the published photos, illustrations and descriptions only allow four of the newly discovered red deer crania from Star Carr to be assigned to our group of 'antler headdresses'. While one of these, artefact 116862 (Elliott et al. 2018: Fig. 26.19), is not yet dated, the other three specimens cluster tightly at the Late Preboreal. Two of them derive from the detrital wood scatter that produced further contemporary dates. This contradicts an interpretation that the main

Lab-code	Site	Find	Material/Species	^{14}C BP	calBC	Literature
OxA-4577	Star Carr (Clark's excavation)	worked antler crown	*C. elaphus*	9,670 ± 100	9,292-8,782	Dark et al. 2006
OxA-4578	Star Carr (Clark's excavation)	worked antler tine	*C. elaphus*	9,590 ± 90	9,248-8,739	Dark et al. 2006
OxA-33673	Star Carr (2000s excavation)	SC22	*C. elaphus*	9,585 ± 45	9,181-8,795	Bayliss et al. 2018
OxA-33672	Star Carr (2000s excavation)	antler headdress 99528	*C. elaphus*	9,545 ± 45	9,141-8,758	Bayliss et al. 2018
SUERC-66178	Star Carr (2000s excavation)	antler headdress 115876	*C. elaphus*	9,529 ± 35	9,130-8,749	Bayliss et al. 2018
OxA-21238	Star Carr (Clark's excavation)	same as OxA-5477	*C. elaphus*	9,485 ± 38	9,119-8,640	Bayliss et al. 2018
OxA-21239	Star Carr (Clark's excavation)	same as OxA-5478	*C. elaphus*	9,468 ± 38	9,115-8,632	Bayliss et al. 2018
KN-4138	Bedburg-Königshoven	butchered fauna	*B. primigenius*	10,670 ± 100	10,797-10,454	Street et al. 1994
KN-4136	Bedburg-Königshoven	butchered fauna	*B. primigenius*	10,020 ± 100	10,011-9,292	Street et al. 1994
KN-3999	Bedburg-Königshoven	stratigraphy	plant remains	9,780 ± 100	9,650-8,823	Street 1991
KN-4135	Bedburg-Königshoven	butchered fauna	*B. primigenius*	9,740 ± 100	9,402-8,800	Street et al. 1994
KN-3998	Bedburg-Königshoven	stratigraphy	plant remains	9,600 ± 100	9,260-8,722	Street 1991
MAMS-15941	Werl-Büderich	burnt wood	charcoal	9,923 ± 33	9,641-9,287	Heinen 2013
Erl-9383	Warluis IIIb	butchered fauna	*B. primigenius*	10,008 ± 70	9,848-9,300	Coutard et al. 2010

Tab. 5. Relevant ^{14}C dates mentioned in the text. Calibrated with OxCal v4.3 (Bronk Ramsey 2017) and the calibration curve IntCal13 (Reimer et al. 2013). CalBC given in 95.4 % probability.

Tab. 5. *Im Text erwähnte relevante ^{14}C-Daten. Diese wurden mit OxCal v4.3 (Bronk Ramsey 2017) und der Kalibrationskurve IntCal 13 (Reimer et al. 2013) kalibriert. CalBC mit 95.4 % Wahrscheinlichkeit angegeben.*

occurrence of the 'headdress' phenomenon at Star Carr dates to younger phases. We suggest it is more likely that all 'headdresses' sensu stricto/lato at the site are contemporary with the Preboreal occupation.

During the excavation at Bedburg-Königshoven, plant remains were sampled for conventional radiocarbon dating both from the archaeological find horizon and from the stratigraphic sequence which bracketed this. Two dates assigned the layer containing BK1 and BK2 to the Preboreal (Tab. 5), however samples of butchered aurochs bone dated at the same time (also by conventional radiocarbon) produced inconsistent ages ranging from the middle Younger Dryas into the Preboreal and still younger. Since refitting of bone strongly suggests a single or very short-term site occupation (Street 1993), the dates were rejected as clearly methodologically unreliable (Tab. 5; Street et al. 1994). More recently, the butchered aurochs remains from Bedburg-Königshoven were again targeted for (direct AMS) dating in the framework of a comprehensive research study of Early Holocene *Bos primigenius* (DFG-CRC 806, project D4). Following rigorous pretreatment protocols the new results cluster tightly at the very beginning of the Preboreal (Street et al. 2019: 494–495, Table 1). Dating currently in progress on humanly modified material of other species at the site has replicated these results and the true age of site occupation is now the initial Preboreal, making BK1 and BK2 the oldest 'antler headdresses' known so far.

Overall, the available chronological information for 'antler headdresses' (Tab. 4 & 5, Fig. 6) suggests that they are a specifically early Mesolithic phenomenon. Their geographical distribution appears to generally coincide with large parts of the region occupied by an osseous industry designated *technocomplexe septentrional autour de la mer du Nord* by Éva David (2005: Fig. 235).

Origin and context

On present evidence, the first appearance of 'antler headdresses' is at the very beginning of the Holocene on the south-western margins of the North European Plain (e.g., Bedburg-Königshoven). Following the Preboreal Oscillation (PBO 1) it appears to spread to the North and Northeast (Star Carr, Hohen Viecheln, Berlin-Biesdorf, Plau: cf. Conneller & Higham 2015; Groß 2017) in association with all the features of lithic technology and faunal subsistence defining a 'classic' Mesolithic. In order to identify more precisely the ultimate origin of the 'antler headdress' phenomenon in particular, and probably of the Northern European Mesolithic overall, we suggest the need for more and suitable sites dated to the terminal Pleistocene and initial Holocene, which will probably be located at the north-western edge of the Central European Uplands.

Such a site with organic preservation was excavated at Werl-Büderich (Kr. Soest, Westphalia/Germany) (Heinen 2013), while over the past several years promising sites of a Mésolithique initial (Ducrocq 2009; 2014) have been excavated further to the West and Southwest (e.g., Warluis IIIb (Dép. de l'Oise, France), Coutard et al. 2010). The recovered faunal remains are unfortunately mainly of small size and badly preserved, while important parts of the sites have often not been preserved or salvaged. Nevertheless, the presence of these very early Holocene sites in the region between northern France and North

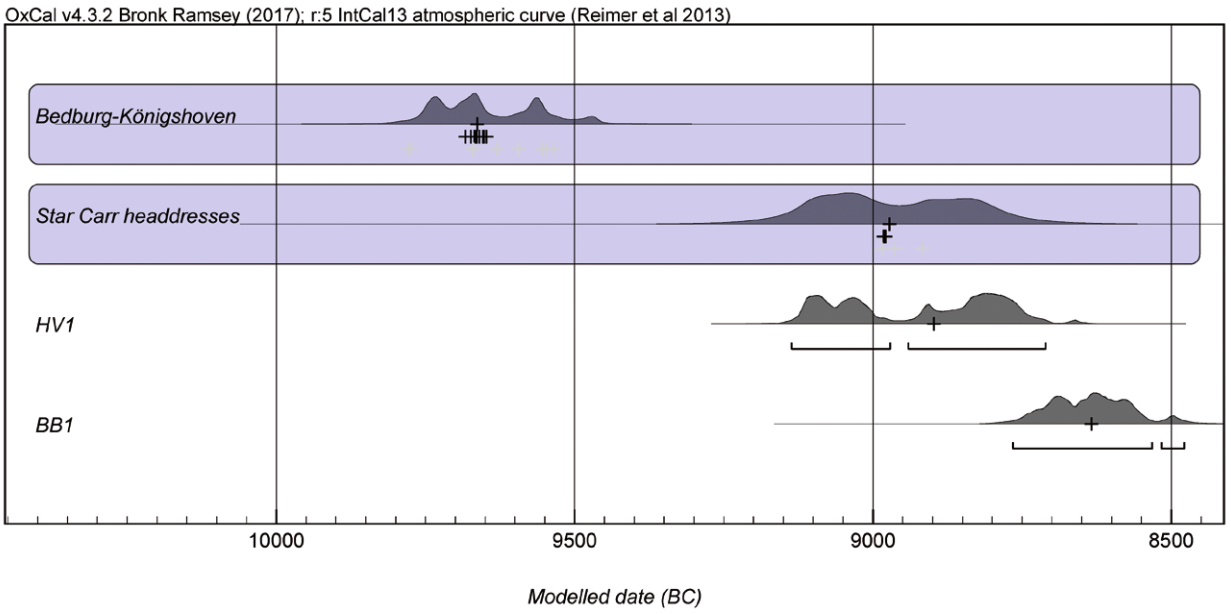

Fig. 6. Bayesian chronology model of the headdresses using data from figures 4 and 5 as well as Street et al. 2019, 494–495, table 1. Calibrated with OxCal v4.3 (Bronk Ramsey 2017) and the calibration curve IntCal13 (Reimer et al. 2013).

Abb. 6. *Bayessches Chronologiemodell der Hirschgeweihkappen. Daten stammen aus den Abbildungen 4 und 5 sowie aus Street et al. 2019, 494–495, table 1. Kalibiriert mit OxCal v4.3 (Bronk Ramsey 2017) und der Kalibrationskurve IntCal 13 (Reimer et al. 2013).*

Rhine-Westphalia offers potential for addressing questions regarding the origin and expansion of the Mesolithic (and implicitly of 'antler headdresses') onto the Northwest European Lowland.

Strikingly, at each of the methodically excavated sites (Star Carr, Hohen Viecheln and Bedburg-Königshoven) we encounter at least two 'antler headdresses', which while underlining the importance of these objects perhaps suggests that their significance was not singular nor their use restricted to a single individual at the site.

All 'antler headdresses' were recovered from a zone of waterlogged sediments with organic preservation adjacent to the terrestrial parts of Mesolithic sites located along the shallow margins of bodies of water which silted up following deposition. BK2 was found in situ surrounded by discarded butchering waste, approximately five meters away from the former shoreline, and the original location of BK1 is reconstructed to be in an equivalent context. Whether BK1 and BK2 were discarded into deeper water as waste or alternatively submerged to prevent destruction by dogs (Street 1989b) or for soaking prior to further preparation (see Wild 2020b for further discussion) cannot ultimately be answered. By contrast, HV1 was found closer to what was then the shoreline and perhaps formerly lay within the actual living area before subsequent transport into the lake by water or sediment movement. Alternatively, it may have been deliberately placed in the lake to preserve it from destruction by prowling dogs or other agents. In both cases, it seems to be only by chance that we have found these artefacts, since the excavated off-bank discard zones at both sites will not mirror exactly what happened in the dry land-living area.

At early Star Carr, it is suggested that a wood scatter located at the ancient shoreline extended the living area beyond the dry land into the lake, within a zone subsequently overgrown by the peat, which preserved organic materials (Bamforth et al. 2018: 70). This might suggest that the exceptionally large number of 'headdresses' found at Star Carr remained in an area of activity (and perhaps of their use) and were not intentionally discarded. It might even imply that many more of these objects could also have originally been present at the other sites, where no or only few osseous remains are recorded within the living areas. This is probably due to taphonomic factors, although excavation methods or site preservation are only in part comparable to those at Star Carr (Elliott & Milner 2010: 83).

Conclusion and Outlook

Drawing together the aforementioned definitions and arguments we can summarise what we know about 'antler headdresses' and attempt some guesses about their possible function and significance.

Despite a common, almost clichéd interpretation of 'antler headdresses' as items of dress indicative of a shaman or some such Mesolithic equivalent, the high number of these objects recovered at Star Carr speaks against their role as the attire of an individual specialist and more in favour of artefacts used by several people for a socially common purpose or activity. The fact that the 'antler headdress' phenomenon seems only to have existed during the earliest Holocene and thus during the initial phase of the Mesolithic within a geographically restricted and newly occupied region (see above) represents another factor for consideration in finding alternative explanations.

In the specific context of an initial occupation of a region at the beginning of the Holocene, the 'antler headdresses' may have served in some way to establish the group identity of Mesolithic pioneers. These extraordinary accessories could have been used as symbols to represent convictions or uniqueness, either prominently displayed, perhaps at the top of dwellings or elsewhere within the camp or, as we have argued in view of the sometimes elaborate processes necessary for their manufacture, perhaps worn indeed as a headdress. These might have been worn in the context of dances or an equivalent ritual ceremony. Performed by the whole or part of the group, these would embody the traditional and formal conventions specific to the group in the person of the individual actors, defining and delimiting the identity of the group by contrast with 'outsiders' (e.g., Vormann 1911; cf. with the small note in Clark 1951: 117).

A combination of further use-wear examination of original finds and experimentally created modification in a functional analysis (Peltier & Plisson 1986; Maigrot 1997; Legrand 2007) might be able to produce evidence in support of this argument.

Besides a thorough functional analysis of headdresses, we suggest further points for a future research agenda: Star Carr is the site with the highest number of 'antler headdresses' and frontlets. We therefore recommend to test these specimens on the definition presented in this paper. Furthermore, the function and interpretation of the perforated cranium from Abri de la Croze is unclear and the perforations of the frontal(?) part of this smaller animal's cranium remains unique for the context. Detailed analysis of this piece should be on any future agenda.

Finally, and in order to move beyond the potential of empirical and material-based studies, such as technology, use-wear analysis and experimentation, future interpretative models should also envisage a greater role for an interdisciplinary, dialectic discourse with ethno-archaeological researchers (cf. Porr 1998).

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and BB1. A process accompanied by Dr. J. Meadows (Leibniz Laboratory for Radiometric Dating and Stable Isotope Research, Kiel/ZBSA). MONREPOS Research Centre and Museum for Human Behavioural Evolution, RGZM and ZBSA Centre for Baltic and Scandinavian Archaeology, SSHLM funded travel costs to examine the possible antler headdresses, while the latter and DFG-CRC 806 project D4 located at the University of Cologne financed the dating of antler headdresses. Dr. B. Gramsch (Potsdam) & Dr. J. Grünberg, (Landesamt für Denkmalpflege und Archäologie Sachsen Anhalt – Landesmuseum für Vorgeschichte Halle, Saale) were always keen to discuss the topic and helped with comments and contacts. Finally, we would like to thank the two anonymous reviewers for their most valuable comments.

Literature cited

Arnold, J. R. & Libby, W. F. (1951). Radiocarbon Dates. *Science* 113: 111–120.

Bamforth, M., Taylor, M., Taylor B., Robson H. K., Radini, A. & Milner, N. (2018). Wooden Structures. *In*: N. Milner, C. Conneller & B. Taylor (Eds.), *Star Carr Volume 1. A Persistent Place in a Changing World*. White Rose University Press, Heslington, 69–121.

Bayliss, A., Taylor, B., Bronk Ramsey, C., Dunbar, E., Kromer, B., Bamforth, M., Conneller, C., Elliott, B., Knight, B. & Milner, N. (2018). Dating the Archaeology and Environment of the Star Carr Embayment. *In*: N. Milner, C. Conneller & B. Taylor (Eds.), *Star Carr Volume 2. Studies in Technology, Subsistence and Environment*. White Rose University Press, Heslington, 33–112.

Bicker, F.-K. (1936). Ein schnurkeramisches Rötelgrab mit Mikrolithen und Schildkröte in Dürrenberg, Kr. Merseburg. *Jahresschrift für die Vorgeschichte der sächsisch-thüringischen Länder* 24: 59–81.

Björck, S. (1995). A review of the history of the Baltic Sea, 13.0–8.0 ka BP. *Quaternary International* 27: 19-40.

Bratlund, B. (1994). A survey of the subsistence and settlement pattern of the Hamburgian Culture in Schleswig-Holstein. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 41: 59–93.

Bronk Ramsey, C. (1995). Radiocarbon calibration and analysis of stratigraphy; the OxCal program. *Radiocarbon* 37: 425–430.

Bronk Ramsey, C. (2017). Methods for summarizing radiocarbon datasets. *Radiocarbon* 590: 1809–1833.

Brooks, A. J., Bradley, S. L., Edwards, R. J. & Goodwyn, N. (2011). The palaeogeography of Northwest Europe during the last 20,000 years. *Journal of Maps* 7: 573-587.

Clark, J. G. D. (1950). A Preliminary Report on Excavations at Star Carr, Seamer, Scarborough, Yorkshire, 1949. *Proceedings of the Prehistoric Society* 15: 52–65.

Clark, J. G. D. (1951). Preliminary Report on Excavations at Star Carr, Seamer, Scarborough, Yorkshire (Second Season, 1950). *Proceedings of the Prehistoric Society* 16: 109–119.

Clark, J. G. D. (1953). The groove and splinter technique of working reindeer and red deer antler in Upper Palaeolithic and Early Mesolithic Europe. *Archivo de Prehistoria Levantina* 4: 57–65.

Clark, J. G. D. (1954). *Excavations at Star Carr. An Early Mesolithic site at Seamer near Scarborough, Yorkshire*. Cambridge University Press, Cambridge.

Clark, J. G. D. & Thompson, M. W. (1954). The Groove and Splinter Technique of working antler in Upper Palaeolithic and Mesolithic Europe. *Proceedings of the Prehistoric Society* 19: 148–160.

Clarke, D. L. (1968). *Analytical Archaeology*. Methuen, London.

Cloutman, E. & Smith, A. G. (1988). Palaeoenvironments in the Vale of Pickering. Part 3: Environmental History at Star Carr. *Proceedings of the Prehistoric Society* 54: 37–58.

Cohen, K. M., Westley, K., Erkens, G., Hijma, M. P. & Weerts, H. J. T. (2017). The North Sea. *In*: N. C. Flemming, J. Harff, D. Moura, A. Burgess & G. N. Bailey (Eds.), *Submerged Landscapes of the European Continental Shelf. Quarternary Paleoenvironments*. John Wiley & Sons Ltd., Oxford, 147–186.

Conneller, C. (2004). Becoming Deer. Corporeal Transformations at Star Carr. *Archaeological Dialogues* 11: 37–56.

Conneller, C. & Higham, T. F. G. (2015). The early Mesolitic colonisation of Britain: preliminary results. *In*: N. Ashton & C. Harris (Eds.), *No Stone Unturned. Papers in Honour of Roger Jacobi*. Lithic Studies Society Occasional Paper 9. Lithic Studies Society, London, 157–166.

Conneller, C., Milner, N., Schadla-Hall, T. & Taylor, B. (2009). The temporality of the Mesolithic landscape: new work at Star Carr. In: P. Crombé, M. Van Strydonck, J. J. Sergant, M. Boudin & M. Bats (Eds.), *Chronology and evolution within the Mesolithic of north-west Europe. Proceedings of an International Meeting, Brussels, May 30th-June 1st 2007*. Cambridge Scholars, Newcastle, 77–94.

Conneller, C., Milner, N., Taylor, B. & Taylor, M. (2012). Substantial settlement in the European Early Mesolithic: new research at Star Carr. *Antiquity* 86: 1004–1020.

Coutard, S., Ducrocq, T., Limondin-Lozouet, N., Bridault, A., Leroyer, C., Allenet, G. & Pastre, J.-F. (2010). Contexte géomorphologique, chronostratigraphique et paléoenvironnemental des sites mésolithiques et paléolithiques de Warluis dans la vallée du Thérain (Oise, France). *Quaternaire. Revue de l'Association française pour l'étude du Quaternaire* 21: 357–384.

Dark, P. (1998). Radiocarbon dating of the lake-edge deposits. *In*: P. Mellars & P. Dark (Eds.), *Star Carr in context: new archaeological and palaeoecological investiagations at the Early Mesolithic site of Star Carr, North Yorkshire*. McDonald Institute Monographs, Oxbow books, Oxford, 119–124.

Dark, P., Higham, T. F. G., Jacobi, R. & Lord, T. C. (2006). New Radiocarbon Accelerator Dates on Artefacts from the Early Mesolithic Site of Star Carr, North Yorkshire. *Archaeometry* 48: 185–200.

David, É. (2005). *Technologie osseuse des derniers chasseurs préhistoriques en Europe du Nord (Xe-VIIIe millénaires avant J.-C.* Ph.D., dissertation, University Paris 10. url: https://halshs.archives-ouvertes.fr/halshs-00120258, 17th January 2013.

David, É., Casseyas, C., van der Sloot, P. & Léotard, J.-M. (2016). A symbolic use of antler in-growth, to face neolithization. *In*: S. Vitezović (Ed.), *Close to the bone: current studies in bone technologies*. Institute of Archaeology, Belgrade, Belgrade, 112–120.

Ducrocq, T. (2009). Eléments de chronologie absolue du Mésolithique dans le Nord de la France. *In*: P. Crombé, M. Van Strydonck, J. J. Sergant, M. Boudin & M. Bats (Eds.), *Chronology and evolution within the Mesolithic of north-west Europe. Proceedings of an International Meeting, Brussels, May 30th-June 1st 2007*. Cambridge Scholars, Newcastle, 345–362.

Ducrocq, T. (2014). The complex evolution of the Mesolithic in Picardie. *In*: A. Henry, B. Marquebielle, L. Chesnaux & S. Michel, (Eds.), *Techniques and Territories: New Insights into Mesolithic Cultures, Proceedings of the Round table, November 22–23 2012, Toulouse (France). P@lethnology* 6, 89–95.

Edwards, R. & Brooks, A. (2008). The island of Ireland: drowning the myth of an Irish land-bridge? *The Irish Naturalists' Journal* 2008: 19–34.

Elliott, B. & Milner, N. (2010). Making a Point: a Critical Review of the Barbed Point Manufacturing Process Practised at Star Carr. *Proceedings of the Prehistoric Society* 76: 76–94.

Elliott, B.,Knight, B. & Little, A. (2018). Antler Frontlets. *In*: N. Milner, C. Conneller & B. Taylor (Eds.), *Star Carr Volume 2. Studies in Technology, Subsistence and Environment*. White Rose University Press, Heslington, 297–333.

Fraser, F. C. & King, J. E. (1954). Faunal remains. *In*: J.G.D. Clark (Ed.), *Excavations at Star Carr. An Early Mesolithic site at Seamer near Scarborough, Yorkshire*. Cambridge University Press, Cambridge, 70–95.

Galiński, T. (2014). Obozowiska łowieckie ze schyłku preborealu w Bolkowie na Pomorzu Zachodnim. *Archeologia Polski* 59: 79–120.

Gehl, O. (1961). Die Säugetiere. *In*: E. Schuldt (Ed.), *Hohen Viecheln: ein mittelsteinzeitlicher Wohnplatz in Mecklenburg*. Akademie-Verlag, Berlin, 40–63.

Gennep, A. V. (1903). De l'emploi du mot chamanisme. *Revue de l'histoire des religions* 47: 50–57.

Gramsch, B. (2000). Friesack: Letzte Jäger und Sammler in Brandenburg. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 47: 51–-96.

Grøn, O. (2010). Evenk Shamans – a non-exotic Approach. Ethnoarchaeological Observations. *In*: K. Hardy (Ed.), *Archaeological Invisibility and Forgotton Knowledge. Conference Proceedings, Lodz, Poland, 5th-7th September 2007*. BAR International Series 2183, Archaeopress, Oxford, 108–113.

Groß, D. (2017). *Welt und Umwelt frühmesolithischer Jäger und Sammler. Mensch-Umwelt-Interaktion im Frühholozän in der nordmitteleuropäischen Tiefebene*. Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Ostseeraum 8, Ludwig, Kiel.

Groß, D. (2020). Islands in the swamp. Lakescape reconstructions of Mesoithic sites in the Rhinluch area (Germany). *In*: A. Garcia-Moreno, J. M. Hutson, G. M. Smith, L. Kindler, E. Turner, A. Villaluenga & S. Gaudzinski-Windheuser (Eds.), *Human Behavioural Adaptations to Interglacial Lakeshore Environments*. RGZM-Tagungen 37, Propylaeum-eBooks/Verlag des Römisch-Germanischen Zentralmuseums, Heidelberg/Mainz, 31–42.

Grünberg J. M. (2000). *Mesolithische Bestattungen in Europa: Ein Beitrag zur vergleichenden Gräberkunde*. Internationale Archäologie 40, Verlag Marie Leidorf GmbH, Rahden/ Westfalen.

Hallgren, F. (2011). Mesolithic skull depositions at Kanaljorden, Motala, Sweden. *Current Swedish Archaeology* 19: 244–246.

Halls, L. K. (1984). *White-tailed deer: ecology and management*. Stackpole Books, Harrisburg.

Harff, J., Flemming, N. C., Groh, A., Hünicke, B., Lericolais, G., Meschede, M., Rosentau, A., Sakellariou, D., Uscinowicz, S., Zhang, W. & Zorita, E. (2017). Sea level and climate. In: N. C. Flemming, J. Harff, D. Moura, A. Burgess & G. N. Bailey (Eds.), *Submerged landscapes of the European continental shelf*. John Wiley & Sons Ltd, Oxford, 11–50.

Heinen, M. (2013). *Auf der K18n in die Steinzeit...Die archäologischen Ergebnisse des Kreisstraßenneubaus der K18 bei Werl-Büderich im Kreis Soest*. Verlag Philipp von Zabern, Darmstadt.

Hill, E. (2000). The Contextual Analysis of Animal Interments and Ritual Practice in Southwestern North America. *KIVA* 65: 361–398.

Hill, E. (2011). Animals as Agents: Hunting Ritual and Relational Ontologies in Prehistoric Alaska and Chukotka. *Cambridge Archaeological Journal* 21: 407–426.

Hill, E. (2013). Archaeology and animal persons: toward a prehistory of human-animal relations. *Environment and Society: Advances in Research* 4: 117–136.

Hüls, C. M., Erlenkreuser, H., Nadeau, M.-J., Grootes, P. M. & Andersen, N. (2010). Experimental Study on the Origin of Cremated Bone Apatite. *Radiocarbon* 52 587–599.

Lanting, J. N. & Brindley, A. L. (1998). Dating Cremated Bone: The Dawn of a New Era. *The Journal of Irish Archaeology* 9: 1–7.

Lanting, J. N., Aerts-Bijma, A. T. & van der Plicht, J. (2001). Dating of cremated bones. *Radiocarbon* 43: 249–254.

Legge, A. J. & Rowley-Conwy, P. (1988). *Star Carr Revisited - A Re-Analysis of the Large Mammals*. Birkbeck College, Oxford.

Legrand, A. (2007). *Fabrication et utilization de l'outillage en matières osseuses du Néolithique de Chypre*. British Archaeological Report 1678, Archaeopress, Oxford.

Little, A., Elliott, B., Conneller, C., Pomstra, D., Evans, A. A., Fitton, L. C., Holland, A., Davis, R., Kershaw, R., O'Connor, S., O'Connor, T., Sparrow, T., Wilson, A. S., Jordan, P., Collins, M. J., Colonese, A. C., Craig, O. E., Knight, B., Lucquin, A. J., Taylor, B. & Milner, N. (2016). Technological Analysis of the World's Earliest Shamanic Costume: A Multi-Scalar, Experimental Study of a Red Deer Headdress from the Early Holocene Site of Star Carr, North Yorkshire, UK. *PLoS One* 11: 1–10.

Maigrot, Y. (1997). Tracéologie des outils tranchants en os des V^{e} et IV^{e} millénaires av. J.-C. en Bassin parisien (Essai méthodologique et application). *Bulletin de la Société Préhistorique Française* 94: 198–216.

Malgarini, R. (2014). *Les Gisements Magdaléniens dans le Jura et les Alpes du Nord et leurs Industries Osseuses*. Ph.D., unpubl. dissertation, University of Franche-Comté.

Meadows, J., Boudin, M., Groß, D., Jantzen, D., Lübke, H. & Wild, M. (2019). Radiocarbon dating consolidated bone and antler artefacts from Mesolithic Hohen Viecheln (Mecklenburg-Vorpommern, Germany). *In*: D. Groß, H. Lübke, J. Meadows & D. Jantzen (Eds.), *Working at the sharp end: from bone and antler to Early Mesolithic life in Northern Europe*. Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Ostseeraum 10, Wachholtz Verlag, Kiel/Hamburg, 113–126.

Mellars, P. (2009). Moonshine over Star Carr: post-processualism, Mesolithic myths and archaeological realities. *Antiquity* 83: 502–517.

Moscon, G., Correggiari, A., Stefani, C., Fontana, A. & Remia, A. (2015). Very-high resolution analysis of a transgressive deposit in the Northern Adriatic Sea (Italy). Alpine and Mediterranean. *Quaternary* 28: 121–129.

Mikhailova, N. (2006). The cult of the deer and "shamans" in deer hunting society. *Archaeologia Baltica* 7: 187–198.

Nimni, M. E. & Harkness, R. D. (1988). Molecular structures and functions of collagen. *Collagen* 1: 1–77.

Olsen, S. L. (1989). On Distinguishing Natural from Cultural Damage on Archaeological Antler. *Journal of Archaeological Science* 16: 125–135.

Overton, N. J. (2014). *Memorable Meetings in the Mesolithic: Tracing the Biography of Human-Nonhuman Relationships in the Kennet and Colne Valleys with Social Zooarchaeology.* Ph.D., dissertation, University of Manchester. url: https://www.research.manchester.ac.uk/portal/files/54553728/FULL_TEXT.PDF, 17th January 2015.

Påsse, T. & Andersson, L. (2005). Shore-level displacement in Fennoscandia calculated from empirical data. *GFF* 127 : 253-268.

Peltier, A. & Plisson, H. (1986). Micro-tracéologie fonctionnelle sur l'os, quelques résultats expérimentaux. *In*: E. Aguirre & M. Patou-Mathis (Eds.), Outillage peu élaboré en os et en bois de cervidés II. *Artefact* 3, 69–80.

Pfeifer, S. (2014). Von Grönland zum Petersfels - Taphonomische Untersuchungen an rezenten Rentiergeweihen und ihre Relevanz für die Archäologie. *Archäologisches Korrespondenzblatt* 44: 11–28.

Porr, M. (1998). Ethnoarchäologie: Ein Plädoyer für Interdisziplinarität und Disziplinlosigkeit in der Archäologie. *Archäologische Informationen* 21: 41–49.

Pratsch, S. (1994). Die Geweihartefakte des mesolithisch-neolithischen Fundplatzes von Friesack 4, Kr. Havelland - Formenkundlich-chronologische und technologische Untersuchungen. *Veröffentlichungen des Brandenburgischen Landesmuseums für Ur- und Frühgeschichte* 28: 7–98.

Pratsch, S (2006). *Mesolithische Geweihgeräte im Jungmoränengebiet zwischen Elbe und Neman. Ein Beitrag zur Ökologie und Ökonomie mesolithischer Wildbeuter.* Studien zur Archäologie Europas 2, Verlag Dr. Rudolf Habelt GmbH, Bonn.

Reimer, P. J.,Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Cheng, H., Edwards, R. L. & Friedrich, M. (2013). IntCal13 and Marine13 radiocarbon age calibration curves 0-50,000 years cal BP. *Radiocarbon* 55: 1869–1887.

Reinbacher, E. (1956). Eine vorgeschichtliche Hirschmaske aus Berlin-Biesdorf. *Ausgrabungen und Funde* 1: 147–151.

Reymann, A. (2013). ‚Schamane' oder nicht ‚Schamane'? Zur Problematik der Nutzung eines ethnologischen Terminus bei der Analyse vorgeschichtlicher Bestattungen. In: N. Müller-Scheeßel (Ed.), *Irreguläre' Bestattungen in der Urgeschcihte: Norm, Ritual, Strafe ...? Akten der Internationalen Tagung in Frankfurt a. M. vom 3. bis 5. Februar 2012*. Kolloquien zur Vor- und Frühgeschichte 19. Verlag Dr. Rudolf Habelt GmbH, Bonn, 65–74.

Reymann, A. (2015). *Das religions-ethnologische Konzept des Schamanen in der prähistorischen Archäologie*. Frankfurter Archäologische Schriften 28, Verlag Dr. Rudolf Habelt, Bonn.

Robertson, H. R. (1875). *Life on the upper Thames*. Virtue, Spalding, and Co., London.

Rust, A. (1958). *Die jungpaläolithischen Zeltanlagen von Ahrensburg*. Karl Wachholtz Verlag, Neumünster.

Schmölcke, U. (2016). Die Säugetierfunde vom präboreal- und borealzeitlichen Fundplatz Friesack 4 in Brandenburg - gewidmet dem Andenken an Lothar Teichert. *In*: N. Benecke, B. Gramsch & S. Jahns (Eds.), *Subsistenz und Umwelt der Feuchtbodenstation Friesack 4 im Havelland. Ergebnisse der naturwissenschaftlichen Untersuchungen*. Brandeburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum, Wünsdorf, 45–116.

Schneider, M. (1932). *Die Urkeramiker: Entstehung eines mesolithischen Volkes und seiner Kultur*. Verlag Kabitzsch, Leipzig.

Schoknecht, U. (1961). Eine Hirschmaske aus Plau, Kr. Lübz. *Ausgrabungen und Funde* 6: 169–173.

Schuldt, E. (1961). *Hohen Viecheln: ein mittelsteinzeitlicher Wohnplatz in Mecklenburg*. Akademie-Verlag, Berlin.

Seguinot, J., Ivy-Ochs, S., Jouvet, G., Huss, M., Funk, M. & Preusser, F. (2018). Modelling last glacial cycle ice dynamics in the Alps. *The Cryosphere* 12: 3265-3285.

Street, M. (1989a). *Jäger und Schamanen: Bedburg-Königshoven, ein Wohnplatz am Niederrhein vor 10000 Jahren*. Verlag des RGZM, Mainz.

Street, M. (1989b). Ein frühmesolithischer Hund und Hundeverbiss an Knochen vom Fundplatz Bedburg-Konigshoven, Niederrhein. *In*: Das Aktuelle Thema: Archäozoologie. *Archäologische Informationen* 12: 203-215.

Street, M. (1993). *Analysis of Late Palaeolithic and Mesolithic Faunal Assemblages in the Northern Rhineland, Germany*. Ph.D., dissertation, University of Birmingham. https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.544001, 17th January 2015.

Street, M. & Wild, M (2014). Schamanen vor 11000 Jahren? Die "Geweihmasken" von Bedburg-Königshoven. *In*: L. Bonn (Ed.), *Eiszeitjäger. Leben im Paradies - Europa vor 15.000 Jahren*. Nünnerich-Asmus Verlag, Mainz, 274–287.

Street, M. & Wild, M (2015). Technological aspects of two Mesolithic red deer ‚antler frontlets' from the German Rhineland. *In*: N. Ashton & C. Harris (Eds.), *No Stone Unturned. Papers in Honour of Roger Jacobi*. Lithic Studies Society Occasional Paper 9. Lithic Studies Society, London 2015, 209–219.

Street, M., Baales, M., Gehlen, B., Heinen, M., Heuschen, W., Orschiedt, J., Schneid N., Zander, A. (2019). Archaeology across the Pleistocene-Holocene boundary in western Germany: Human responses to rapid environmental change. *In*: C. Montoya, J.-P. Fagnart & J.-L. Locht (Eds.), *Préhistoire de l'Europe du Nord-Ouest: mobilité, climats et entités culturelles. Actes du 28e congrès préhistorique de France (Amiens, 30 mai-4 juin 2016),* Vol. 2. Société préhistorique française, Paris, 491-510.

Street, M., Baales, M. & Weninger, B. (1994). Absolute Chronologie des Späten Paläolithikums und des Frühmesolithikums im nördlichen Rheinland. *Archäologisches Korrespondenzblatt* 24: 1–28.

Trolle-Lassen, T. (1990). Butchering of Red Deer (*Cervus elaphus* L.). *Journal of Danish Archaeology* 9: 7–37.

Vormann, P. F. (1911). Tänze und Tanzfestlichkeiten der Monumbo-Papua (Deutsch-Neuguinea). *Anthropos* 6: 411–427.

Wagenknecht, E. (1988). *Rotwild*. Deutscher Landwirtschaftsverlag, Berlin.

Ward, G. K. & Wilson, S. R. (1978). Procedures for comparing and combining radiocarbon age determinations: a critique. *Archaeometry* 20: 19–31.

Weaver, A. J., Saenko, O. A., Clark, P. U. & Mitrovica, J. X. (2003). Meltwater pulse 1A from Antarctica as a trigger of the Bølling-Allerød warm interval. *Science* 299: 1709-1713.

Wild, M. (2014). *Funktionelle Analyse an zwei perforierten Hirschschädeln vom frühmesolithischen Fundplatz Bedburg-Königshoven*. Master of Arts, unpubl. thesis, University of Mainz.

Wild, M. (2019). Evaluation of the Antler Headdress Evidence from Hohen Viecheln. In: D. Groß, H. Lübke, J. Meadows & D. Jantzen (Eds.), *Working at the sharp end: from bone and antler to Early Mesolithic life in Northern Europe*. Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Ostseeraum 10, Wachholtz Verlag, Kiel/Hamburg, 163–177.

Wild, M. (2020a). *Coping with risk through seasonal behavioural strategies - Technological analysis of selected Late Upper Palaeolithic antler assemblages from northern Germany, southern Scandinavia and the Paris Basin*. Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Ostseeraum 12, Wachholtz Verlag, Kiel/Hamburg.

Wild, M. (2020b). Antler Headdresses and the Preboreal site of Bedburg-Königshoven: The emergence of Mesolithic behaviour in the Northern European Lowlands. *In*: A. Garcia-Moreno, J. M. Hutson, G. M. Smith, L. Kindler, E. Turner, A. Villaluenga & S. Gaudzinski-Windheuser (Eds.), *Human Behavioural Adaptations to Interglacial Lakeshore Environments*. RGZM-Tagungen 37, Propylaeum-eBooks/Verlag des Römisch-Germanischen Zentralmuseums, Heidelberg/Mainz, 173–189.

Wymer, J. (1959). Excavations on the Mesolithic site at Thatcham, Berks - 1958. *Berkshire Archaeological Journal* 57: 1–24.

Wymer, J. & King, J. E. (1962). Excavations at the Maglemosian Sites at Thatcham, Berkshire, England. *Proceedings of the Prehistoric Society* 28: 329–361.

Zazzo, A., Saliège, J.-F., Lebon, M. Lepetz, S. & Moreau, C. (2012). Radiocarbon dating of calcined bones: insights from combustion experiments under natural conditions. *In*: E. Boaretton & N. R. Rebollo Franco (Eds.), Proceedings of the 6th International Radiocarbon and Archaeology Symposium. *Radiocarbon* 54: 855–866.