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SUB-AQUATIC DISPOSAL OF BUTCHERING WASTE AT THE EARLY MESOLITHIC SITE OF BEDBURG-KÖNIGSHOVEN

Abstract

The early Mesolithic site of Bedburg-Königshoven was discovered in the Garzweiler open-cast lignite mine (German Lower Rhineland) at the end of the 1980's. A four month salvage operation recorded the 3D location of all identified finds and wet-sieving ensured the contextually secure recovery of smaller material. Pollen analysis and radiocarbon date Mesolithic activities at the site to the initial Preboreal warming. Among the more remarkable finds are two intentionally modified antler frontlets and the skull of a dog. The find-bearing horizon at Bedburg was formed under sub-aquatic conditions in the still or very slow moving water of a palaeochannel of the River Erft. It was not expected that distribution plots of finds deposited underwater would reveal any spatial patterning meaningful for human activity at the site. In fact it was possible to identify clear spatial sorting of well preserved (mainly large mammal) faunal remains which, in combination with zooarchaeological analysis of cut and impact marks, located sites of repetitive processes of butchery and disposal for specific elements of the carcass. Since faunal material deposited upon terrestrial surfaces will generally be preserved only poorly or perhaps not at all, faunal waste deposited in adjacent bodies of water can provide better insights into the details of how an animal carcass was processed.

Keywords

Early Mesolithic, initial Preboreal, sub-aquatic discard, spatial patterning, butchering processes

Introduction

The following presentation examines the context of early Holocene finds recovered by salvage excavations at Bedburg-Königshoven, an early Mesolithic camp discovered at the end of 1987 during quarrying at the Garzweiler open-cast lignite mine. The site was located west of the lowland Cologne Embayment of the Lower Rhine Valley in the valley of a tributary, the River Erft (Street 1989a; 1991; 1995) (**fig. 1**).

The discovery of an early Holocene archaeological site in stratigraphic context and with well preserved faunal remains, both features until then almost unknown for the period in the region, were reason enough to initiate a campaign of salvage excavation. Recognition of an antler frontlet analogous to those from Star Carr (Clark 1954) provided a further incentive for carrying out exhaustive and intensive investigations of the site over just four months in winter before its final destruction at the beginning of 1988. Much of the original site had in fact already been removed by railway construction in the 19th century, long before lignite quarrying began. Con-

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Fig. 1 Location of the Bedburg-Königshoven initial Mesolithic site on the western edge of the Cologne Embayment and at the boundary between the North European Lowland and the Central European upland zone. – (Map created by S. B. Grimm).

fronted with the isolated block of sediment at the centre of the lignite quarry, the prospects for any kind of "landscape archaeology" seemed remote. Fortunately, identification of the precise position of the site and consultation of historical maps together provided a topographical and geomorphological context for the site.

In the field it was quickly recognized that only deeper levels of limnic deposits had survived. Terrestrial areas of the site had been entirely destroyed, ruling out the possibility of locating intact settlement features such as dwelling structures or other zones of dry land activities. It was therefore not expected that plotting material recovered from off-bank limnic deposits would identify any meaningful spatial patterning. Unexpectedly, particularly in the case of faunal remains, spatial plotting did reveal meaningful distributional sorting. In combination with zooarchaeological analyses of the mainly large mammals this allows identification of locations of butchery and disposal for specific elements of the carcass and even recognition of repetitive processes.

The information obtained for the Bedburg site can be viewed at a number of different scales. At a macro-scale of kilometres there is the question of site placement in the geographical and human landscape. At a meso-scale of metres (within the area of the site) there is the information pertinent to behaviourally related activities and taphonomic factors before and during final deposition. Even at a micro-scale of centimetres it is exceptionally possible to identify very short-term or minor events, or indeed absence of secondary contextual modification.

Despite initial difficulties, spatial analyses of the Bedburg site can provide a meaningful contribution for the interpretation of site location, activities and depositional processes in hunter-gatherer waterside contexts.

Site location

Upon discovery of the Bedburg site all that remained at the centre of a huge area already stripped of overburden was an isolated triangular block of late

Pleistocene and Holocene deposits severely truncated in all dimensions by earth-moving activities (**fig. 2**). A first priority was therefore to establish any sort of geographical or chronological context for the encountered situation.

Reconstruction of the original geography of the Bedburg locality using historic maps (**fig. 3**) shows that the site was located at the northern edge of a meander of the River Erft, at the foot of gently sloping land bordering on marshland. It is at the narrowest point of the valley and sheltered from the north by a ridge of higher ground. Valleys draining into the meander from the North and West would have served as useful access routes between the valley bottom wetlands occupied by the site and the higher locations of the hinterland. They also possibly contained streams providing a source of fresh (clean and running) water for the site. The *Pielskamp*, a ridge of higher ground extending out into the valley, may have provided a natural causeway located strategically at a point suitable for hunting expeditions returning from the marshy valley floor. The advantages of the location for the exploitation of a range of resources are obvious.

Chronology

The surviving stratigraphy at the Bedburg site (**fig. 4**) comprised a sequence of deposits formed under initially sub-aquatic conditions in a palaeochannel of the River Erft (Behling 1988; Ikinger 1989; Behling/Street 1999). Basal coarse gravels were succeeded by finer sands grading into silts, all indicative of a process of channel infilling, probably as a result of the meander becoming cut off from the active Erft watercourse. A thin organic band (described as a sapropel formed at the top of the largely mineral deposit) represents a period of very warm temperatures (shown by high pollen values for *Typha latifolia*) and was itself overlain by calcareous and organic limnic deposits (gyttja) formed under still or very slowly moving water. This deposit enclosed the archaeological material. The sub-aquatic limnic sediments were themselves covered by peat formed during overgrowth of the now infilled channel, at the base reed peat followed by birch carr. The nature of the sedimentation process in this fluvial and wetland environment ensured optimal preservation of bone and some other organic materials. Pollen

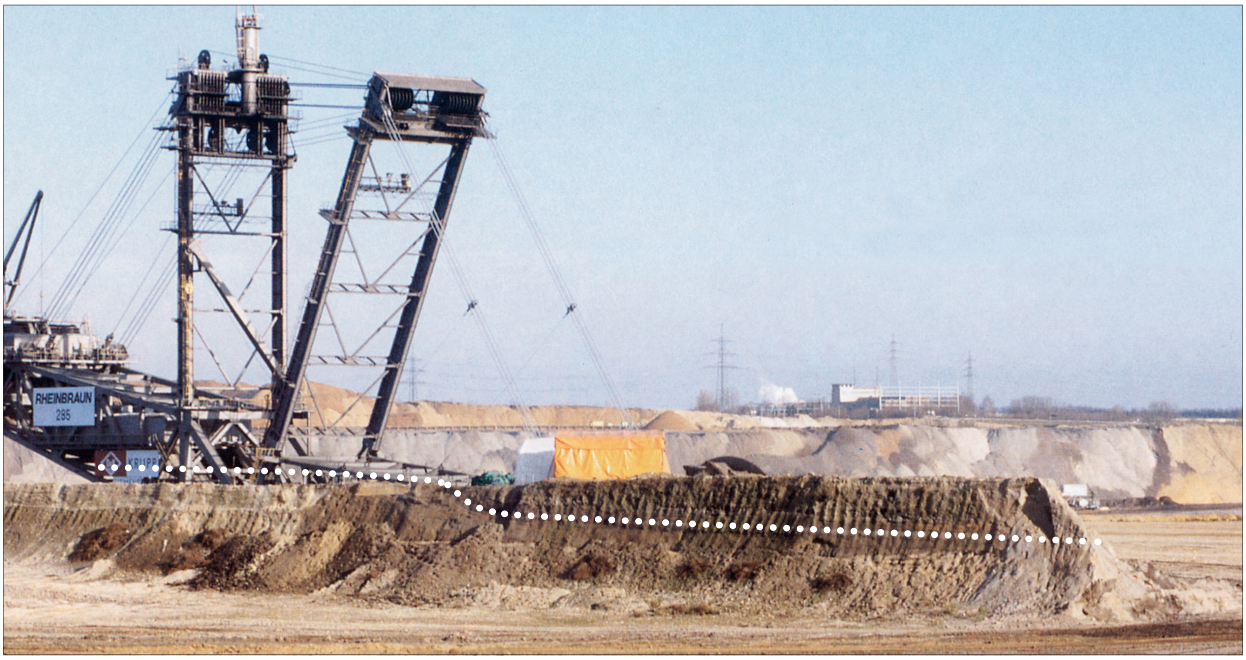

Fig. 2 Block of late Pleistocene and early Holocene sediments left by quarrying at the centre of the Garzweiler open cast lignite mine. The broken white line indicates the find bearing level.

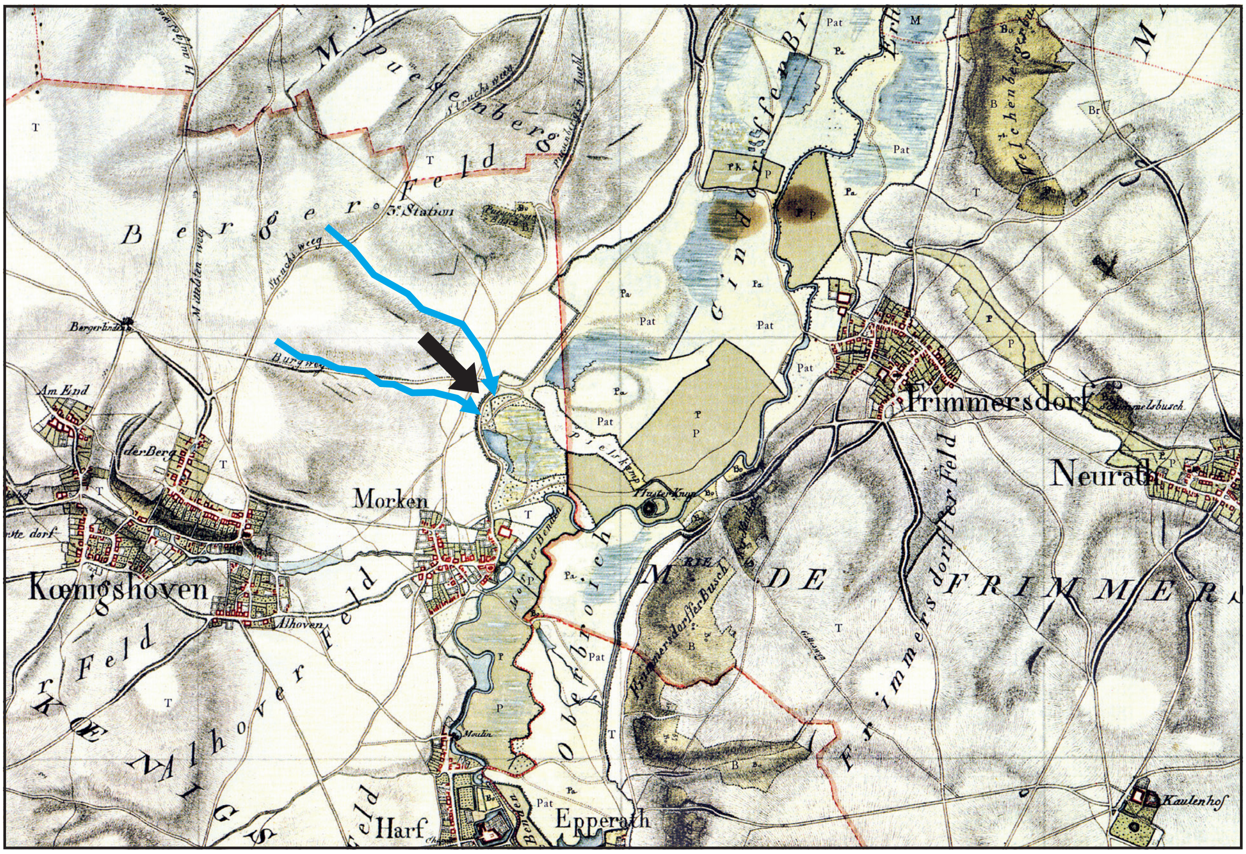

Fig. 3 Location (arrow) of the Bedburg-Königshoven initial Mesolithic site at the northern edge of a palaeo-channel of the River Erft, a tributary of the Rhine. Historic maps show valleys draining into the Erft meander close to the site. These may have served as routes between higher locations and the low-lying wetlands. – (Map taken from Sheet 59, Grevenbroich, of the "Kartenaufnahme der Rheinlande durch Tranchot und v. Müffling 1803-1820", Scale = 1:25,000. Landesvermessungsamt Nordrhein-Westfalen).

analysis and radiocarbon dates taken throughout the stratigraphic sequence provided an early Holocene age for the site (Behling 1988; Behling/Street 1999). The lowermost organic band provided two radiocarbon dates on small wood fragments which fell exactly at the Pleistocene-Holocene boundary. Dates for small wood fragments from the layer containing the archaeological lithic and faunal material gave a mid-Preboreal age, while the lowermost of the overlying peat deposits were dated to the late Preboreal. The date of Mesolithic human activity at the site thus seemed to be very precisely constrained to the middle of the Preboreal pollen zone.

Attempts to date faunal material directly using conventional radiocarbon measurement provided heterogeneous and highly anomalous results extending from the early Younger Dryas until the late Preboreal and younger and were rejected as unreliable, probably as a result of unknown contaminants. Recently obtained AMS results for a series of bones assigned to several distinct aurochs individuals (**tab. 1**; Street et al. in prep.) unequivocally assign the human occupation of the Bedburg site to the very beginning of the Preboreal at the time of the initial Holocene rise in temperature (**fig. 4**). This would make them contemporary with a dated organic band characterized by thermophilous plants, which is located below the gyttja containing the archaeological assemblage. This implies that the gyttja deposit must have formed subsequently to the activities represented by the faunal and lithic material. This represents a logical sequence of events since the gyttja would have been formed by the binding and precipitation of dissolved carbonate by water borne algae during the silting up of the meander. Most of the discarded remains of the Bedburg occupation appear to have been rapidly

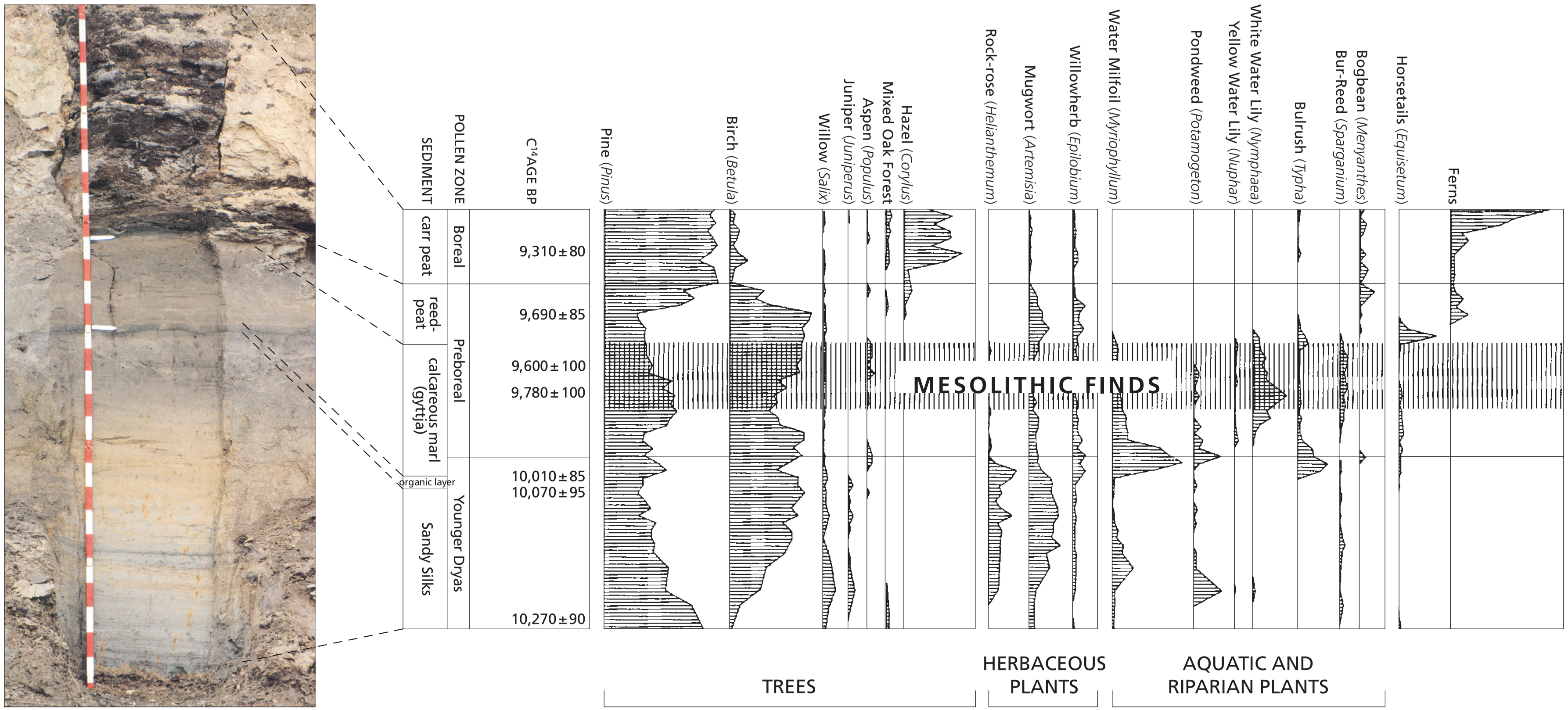

Fig. 4 Section at the Bedburg-Königshoven initial Mesolithic site and summary of palynological analysis (Behling 1988; Street 1989a). The top of the intact section is formed by 15-20 cm of dark brown compact and poorly decomposed late Preboreal reed (*Phragmites*) peat (immediately above the upper white arrow), overlain by strongly decomposed and compressed brown carr peat formations of Boreal age. Yellow deposits to the right are the infill of sub-recent peat-cuttings. Below the upper white arrow is a dark grey-green calcareous and sandy fine detritus mud (gyttja with *Chara oogonia*) which contains the archaeological material. The lower white arrow marks a dark, black-grey calcareous sandy fine detritus mud, which is dated to the initial Preboreal (10,010±85 14C BP and 10,070±95 14C BP) and contemporary with human occupation. This overlies a sequence of grey calcareous sandy mud with yellow sand lenses merging with increasing depth into calcareous yellow fine sand.

Tab. 1 Summary of radiocarbon dating for Bedburg-Königshoven (results calibrated with CalPal and OxCal 2016).
Conventional radiocarbon dates were obtained at the Cologne laboratory on plant remains sampled immediately after discovery of the site and during excavation. The latter were taken through the entire surviving Bedburg sequence (fig. 4) from the contact between terrace gravels and basal sands (Younger Dryas) to peat of Boreal and Atlantic age.
Subsequently five conventional 14C dates were produced for aurochs bone by the Cologne laboratory in the early 1990s. Results scatter widely, extending far back into the Younger Dryas, and this was interpreted as a result of unexplained methodological problems. The dates were and are rejected as unreliable indicators of the true age of the site, although the one plausible result (KN-4136) is reproduced here.
New direct dates on aurochs remains have been produced by the Cologne AMS laboratory. Although a number of results were initially rejected on methodological grounds, the repeat-dating following appropriate and more stringent pre-treatment protocols produced consistent results for all samples. The still unpublished dates (given here only as calibrated values) assign the hunting and butchery of aurochs to the very beginning of the Holocene warming episode.

Lab ID	14C date	SD	Context	Material	cal BC (CalPal)	SD	cal BC (OxCal)	Reference
KN-3883B	9540	120	Level B or C (preliminary sample)	peat	8933	190	9252-8611	Street 1991; 1993: Street/Baales/Weninger 1994
KN-3998	9600	100	101/103 Vt 3/4, level C1 (sample 4)	wood	8998	163	9260-8722	Street 1991; 1993: Street/Baales/Weninger 1994
KN-3883A	9660	120	Level B or C (preliminary sample)	peat	9038	177	9318-8711	Street 1991; 1993: Street/Baales/Weninger 1994
KN-4001	9690	85	93/105, level B (sample 7)	reed peat	9074	156	9290-8820	Street 1991; 1993: Street/Baales/Weninger 1994
KN-3999	9780	100	100/107 Vt4, level C1 (sample 5)	wood	9176	174	9461-8823	Street 1991; 1993: Street/Baales/Weninger 1994
COL 2669.2.1			87/108-4	bone, aurochs 4, *os petrosum*	9560	148	9700-9330	Street et al. in prep.
KN-3997	10010	85	83-85/106-110 (sample 3)	wood from organic band	9598	192	9981-9292	Street 1991; 1993: Street/Baales/Weninger 1994
COL 2674.1.1			85/105-3	bone, aurochs 9, metacarpus	9574	156	9768-9329	Street et al. in prep.
COL 2672.1.1			91/107-1	bone, aurochs 2, humerus, juvenile	9579	158	9772-9339	Street et al. in prep.
KN-4136	10020	100	96/108-1	bone, aurochs rib	9626	213	9892-9292	Street 1991; 1993: Street/Baales/Weninger 1994
COL 2680.2.1			104/102-1 (Streu 33)	bone, aurochs 8, *os petrosum*	9608	151	9805-9385	Street et al. in prep.
COL 2675.1.1			93/110-1	bone, aurochs 10, metacarpus	9617	158	9819-9368	Street et al. in prep.
COL 2948.1.1			93/106-2	bone, aurochs 7, skull, horn core	9641	161	9855-9394	Street et al. in prep.
COL 2673.1.1			97/107-3	bone, aurochs 11, metacarpus	9668	175	9877-9436	Street et al. in prep.
KN-3996	10070	95	83-85/106-110 (sample 2)	wood from organic band	9701	233	10043-9324	Street 1991; 1993: Street/Baales/Weninger 1994
COL 2671.2.1			97/107-4, 7	bone, aurochs 3, *os petrosum*	9758	191	10036-9647	Street et al. in prep.
COL 2974.1.2			93/106-2	bone, aurochs 6, *os petrosum*	9763	204	10045-9455	Street et al. in prep.
KN-3995	10270	90	(sample 1)	wood from basal sandy silts	10134	255	10466-9695	Street 1991; 1993: Street/Baales/Weninger 1994

removed from the influence of terrestrial weathering by intentional discard into water. It now seems very probable that the bed of this body of water was not, as previously concluded, already completely covered by the gyttja deposit (into which the material would have sunk) but will have been heterogeneous in nature depending on distance from the bank and the stage of vegetational development reached at this point in time and space.

The presence of humans merely represents a brief and fixed moment in time during the course of the dynamic process involving the silting up of an open body of water and its subsequent overgrowth by the time-transgressive development (sere) of a sequence of vegetation. This has implications for the interpretation of the site since contemporary finds might be recovered by excavation from quite different depositional units. Parts of the same animal bone would have been overgrown by reeds closer to the shoreline but might have laid initially uncovered among water plants in deeper water only a few metres away and subsequently been covered by gyttja. Indeed this very process is suggested by refitted fragments of bone material with clearly diverging taphonomic histories. Moreover, a spatially intermediate specimen might occupy a stratigraphic position within the body of an already accumulating gyttja deposit. This is perhaps counterintuitive for an archaeologist used to regarding sedimentological units as superposed, static, and perhaps chronologically distinct horizons. In the case of the sedimentary units at Bedburg the chronology of sedimentary units would move not only vertically but horizontally.

Interpretation of the Bedburg lithic (Street 1998) and especially faunal assemblages must therefore recognize that material derived from contemporaneous activities underwent quite complex and potentially divergent processes of dispersal and destruction/preservation over very small distances before and during their final burial within the offshore deposits from which they were recovered.

The overall small size of the Bedburg lithic and faunal assemblages renders many conclusions drawn by the present analysis anecdotal rather than statistically demonstrable. Arguably this is more than compensated by the excellent conditions of preservation of the material and, indeed, by the avoidance of complications often encountered due unquantifiable "palimpsest" effects by analyses of very large assemblages. The paper will present a number of "anecdotes" which may be of help for the recognition of similar anthropogenic or depositional factors or of use in teasing these apart within larger complexes of finds.

Lithic assemblage

Although fewer than 200 artefacts were recovered, the Bedburg lithic assemblage permits a number of conclusions to be drawn. 15 discarded cores and a high proportion of cortex flakes show that knapping took place at the site. The over-representation of cores in the sub-aquatic assemblage probably reflects their active discard into the body of water adjacent to the camp. The absence of micro-debitage is clearly due to the non-survival of the terrestrial areas in which lithics were actually knapped.

The important component of large laminar debitage at Bedburg is unusual for a Rhineland Mesolithic assemblage and might reflect a need for large flint blades for animal butchery. Used at the water's edge, the lithic butchery implements and larger waste faunal elements were subsequently discarded off-bank. The large laminar component might also be explained to some extent by the very early date of the assemblage since, while unusual for the Rhineland, the technology and dimensions of the Bedburg assemblage are typical of the early "Broad Blade" Mesolithic of the British Isles.

The presence of modified (retouched) lithic tools may be accounted for by analogous arguments. Scrapers may also have been used at the water's edge and actively discarded into the water, while the few microlithic points might represent projectile components passively discarded as "riders" together with the butchery waste. The composition and spatial patterning of the lithic assemblage can thus be explained as a result of interplay between intentional off-bank discard of larger and selected elements and

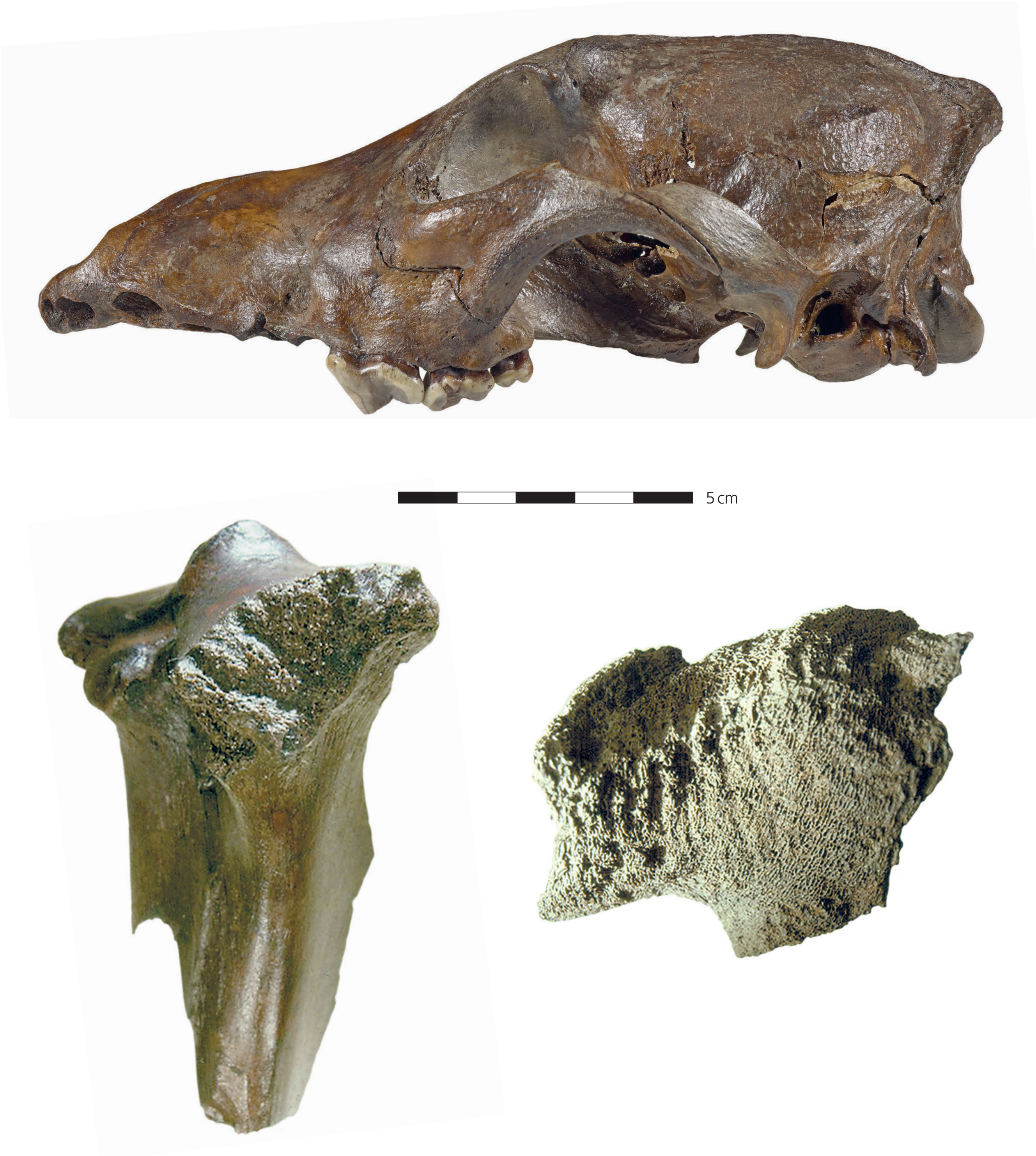

Fig. 5 Many bones in the Bedburg assemblage bear traces of gnawing by medium-sized carnivores: Proximal tibia of red deer (below left); distal femur of aurochs (below right). Dogs present during occupation of the site (above) clearly had extensive access to butchered material and both gnawed and ungnawed remains were subsequently discarded by humans into the adjacent body of water.

contextually determined absence of smaller waste elements. This can be seen as a variation on the classic "toss and drop zone" model of Binford (1983).

Faunal assemblage

The composition of the large mammal fauna reflects the early Holocene context within transition to postglacial woodland (Street 1993; 1997; 1999; Street/Baales 1999). Species typical of the open arctic landscape of Dryas III, such as reindeer (*Rangifer tarandus*), are no longer represented. Large mammal species indicative of a more temperate, forested environment, the cervids red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) and also wild pig (*Sus scrofa*) are already present. The presence of horse (*Equus* sp.) indicates that forest cover was certainly not closed and this might also be true for aurochs (*Bos primigenius*). Medium-sized mammal species are represented in the faunal assemblage by badger (*Meles meles*) and beaver (*Castor fiber*), the latter unsurprisingly in the lowland wetland context. Domestic dog (*Canis familiaris*) is present as an almost complete cranium and some postcranial bones. Indirect evidence for its presence is provided by the ubiquitous traces of gnawing on the bone assemblage (Street 1989b).

Small mammal remains are mainly those of species typical of the immediate wetland biotope (van Kolfschoten 1994) and cannot be linked to human activities. Many bird bones are identified as waterfowl (Street 1993). The ecological evidence of the large mammal fauna is supported by the presence of two bird species, white stork (*Ciconia ciconia*) and crested lark (*Galerida cristata*), which also require open conditions (Street/Peters 1991). The fish remains are mainly of species typical for the conditions of the still (or very slow moving) eutrophic body of water represented by the Preboreal Erft meander (Krey 1990). The bones of birds and fish indicate the availability of these resources at the site, although their exploitation by humans is not demonstrated by bone modification and any human role, if any, in the accumulation of this material is not clear.

Butchery

By contrast, the bone, tooth and antler of large and medium sized mammals recovered at Bedburg-Königshoven overwhelmingly represent material intensively modified by humans, particularly during butchery, and subsequently discarded into a body of water adjacent to the actual settlement area (Street 1990). Butchery was carried out according to a standardised system. Carcasses were exhaustively processed by removal of meat, marrow smashing of long bones, and partial fragmentation of cancellous bone, probably for the extraction of fat and grease.

By far the largest Number of Identified Specimens (NISP) among the large faunal material is assigned to the aurochs and at least 11 individuals are identified by combining the information provided by duplication of elements of the skeleton and ageing and sexing criteria (Street 1999). The representation of parts of the skeleton suggests that animals were hunted close to the site, but that the site itself is not the kill site.

Uniform treatment and spatial patterning of faunal elements, refitting of fragmented bone and artefacts across the site and consistently very close dates for several aurochs individuals suggest that the assemblage represents the accumulation of material from one longer stay, rather than from a series of unconnected events. Bones and teeth of young aurochs and remains of roe deer suggest occupation of the site in late spring or summer. Two red deer antler frontlets, probably not directly related to subsistence, may suggest activities more typical of a diversified longer-term residential site rather than of a sporadically occupied hunting camp.

Bone gnawing by dogs

Many of the Bedburg large mammal bones found throughout the limnic gyttja deposit, especially those of aurochs, show tooth marks left by scavenging animals (fig. 5), (Street 1989b; 1993). Both gnawed and ungnawed butchery waste was clearly discarded by humans into the body of water adjacent to their camp. Preservation of the gnawed and the non-chewed bones is identical and not suggestive of different taphonomic histories such as longer surface exposure to weathering and carnivore access.

Ravaging of a faunal assemblage by scavengers can be a major factor affecting the survival of bones. In order to evaluate the importance of this influence in Bedburg all bone fragments were examined for traces of carnivore gnawing following accepted methodologies (Brain 1981; Binford 1981; Legge/Rowley-Conwy 1988).

The development of various types of gnawing damage (e.g. Binford 1981) is very much conditioned by the character of the bone. *Crenellation* affects mainly thinner cancellous bones when the removal of short sections of bone gives the edge of the bone a scalloped appearance. *Furrowing* of cancellous bone, in this case usually the extremities of the limb bones, leaves distinctive irregular edges. *Punctures* on thin and cancellous bone represent perforation of the outer surface by a tooth, usually a canine or carnassial cusp, leaving a depression, often with a central plate of bone. They often occur in opposed pairs. Pitting and striation are also present on denser bone, such as the shafts of limb bones. The types of gnawing recognized at Bedburg on bones of *Bos primigenius* (several of which bear traces of more than one type of alteration) were counted and the proportional representation calculated relative to the total number of identified specimens of each bone element (Street 1989b; 1993). Of 336 identified bones of aurochs, 110 (32.74 %) show carnivore gnawing, an overall proportion well above that observed for the broadly contemporary Star Carr assemblage (Legge/Rowley-Conwy 1988). Nevertheless, gnawing damage was in many cases not severe and never prevented the identification and recording of a specimen.

The formation of a bone assemblage influenced by scavenging dogs (Brain 1981) provides a control for the degree of attrition of archaeological bone assemblages and was referenced in a revision of the Star Carr fauna (Legge/Rowley-Conwy 1988), which demonstrated that this assemblage does not resemble one ravaged by scavengers. This was in accordance with the observed low frequencies of carnivore gnawing on bones. Perhaps unexpectedly in view of the greater presence of carnivore gnawing on much of the Bedburg assemblage, the "Percent Survival" of each bone element is also not that of a ravaged assemblage; in fact certain elements with a low survival potential, such as the sacrum, proximal femur and proximal humerus, are quite conspicuous. The elements of the *Bos primigenius* skeleton recovered from the excavated Bedburg limnic deposit are thus still mainly representative of human influences and not activities of scavenging animals, no doubt because the examined material was removed from their influence before this could dominate the character of the assemblage. Carnivore access to fresh bones was clearly *quasi*-synchronous with settlement activities, which together with the size and morphology of the observed gnaw marks makes scavenging by or deliberate feeding of the medium-size dogs present at the site the most plausible interpretation.

Bjarne Grønnow (1987) describes ethnographically documented examples of the cleaning up of a butchering site involving the disposal of waste material into an adjacent body of water, which would seem to be the most plausible explanation for the presence and distribution of the bone assemblage at Bedburg. On this model at least some cleaning up of the Bedburg site only took place after butchering waste had been accessible to dogs, probably intentionally as the most rational way of feeding them.

Bone distribution patterns, refitting and site dynamics

Approximately 500 m² of surviving sediments at Bedburg were investigated, identifying and excavating the find-bearing horizon and recording the 3D-location of all identified finds within a grid system. This was not oriented exactly to compass north but was aligned to be relevant to the ancient topography of the site, parallel and at right angles to the edge of a palaeo-channel. The excavated surface (**fig. 6**) can

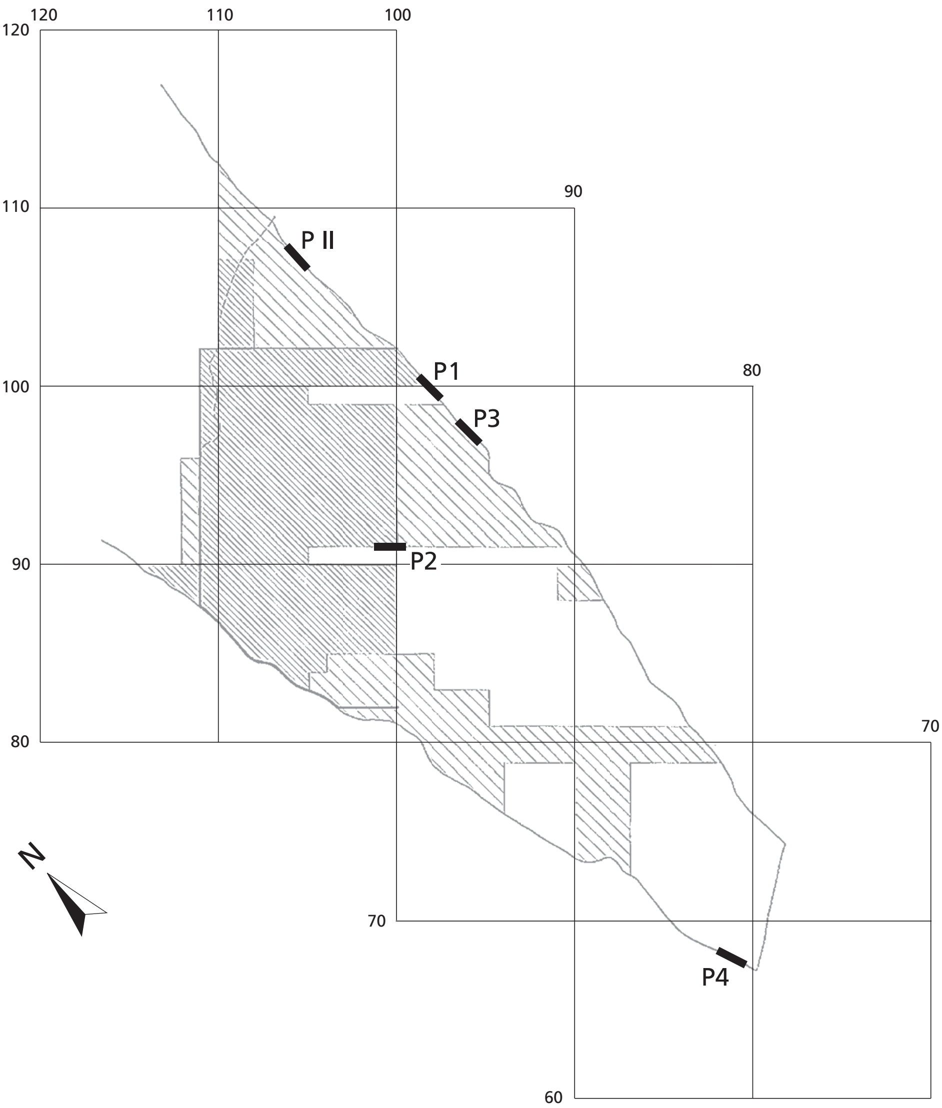

Fig. 6 Bedburg-Königshoven initial Mesolithic site: Plan of the excavation showing the extent of areas excavated using different procedures, and the location of palynological sections. Terrestrial sediments in higher-lying parts of the site (top of the plan) had already been destroyed in the 19th century and there was no hope of finding intact dry-land settlement structures. 190 m² of the immediate littoral area were excavated and finds recorded in 3D, with all sediment wet screened (narrow hatching). 180 m² of the off-bank area poor in material were excavated by test trenches but sediment was not screened (broad hatching). Some 150 m² of mainly sterile sediments could not be investigated (white). What remained of the site was destroyed by quarrying early in 1988.

be broken down logistically as follows: An area of 190 m² covering the immediately littoral area of the site was excavated and all of the removed sediment (a calcareous gyttja deposit underlying reed peat) subsequently wet-sieved, ensuring a contextualized recovery of any smaller material possibly overlooked during excavation. A further 180 m² of the off-bank area were excavated but since test screening showed sediment from this part of the site to be practically devoid of any contained lithic or faunal material the rest of it was not wet-sieved. Finally, some 150 m² of sediments located towards the middle of the palaeo-channel, which proved to be largely devoid of finds during test excavation, could not be excavated during the time available. Two 1 m baulks left standing as witness sections in alignment from bank to deeper water were recorded and sampled, importantly for subsequent site contextual analyses, but could not be fully excavated before what remained of the site was destroyed.

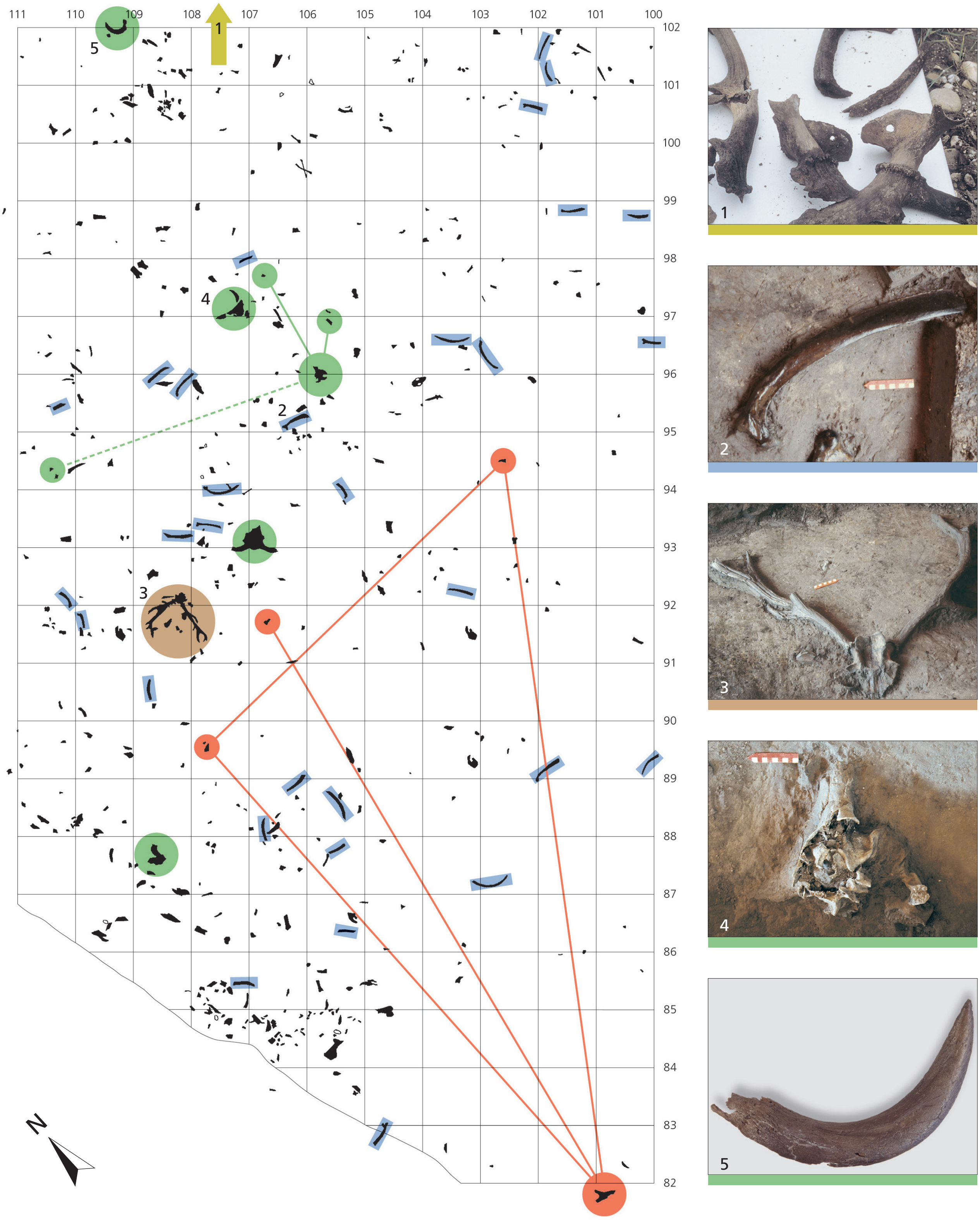

Fig. 7 Bedburg-Königshoven: Bone distribution patterns. Remains of the two "antler frontlets" of red deer (1, 3) and skulls of aurochs (marked green: 4, 5) lie approximately equidistant from the ancient river bank (to left of plan). Two aurochs M3 molar teeth 96/105-1 and 97/106-1 and the skull 96/105-2 (unbroken green lines) were originally discarded into the water as a unit. Anterior M1 and M2 (94/110-2, 4: broken green line) remained at the site of butchering and smashing the skull on drier ground several metres to the northwest. Aurochs ribs (marked blue) were found widely across the excavation and may have been moved by even weak underwater currents and so further disarticulated and displaced into deeper water. Fragments of a left aurochs pelvis (marked red) were dispersed across several metres. Pieces of the ischial blade 89/107-1 and 94/102-1 refit to each other and to the acetabulum 81/100-1, which also refits to the iliac blade 91/106-1.

Plotting the butchering waste discarded by early Holocene humans into the Erft meander shows distribution patterns influenced by a number of criteria. In a few cases the spatial patterning of refitted and rearticulated bone faunal remains provides more detailed insight into the dynamic processes of butchery and waste discard at the site. That the greater part of the assemblage was quickly covered by water and removed from the influence of scavengers and weathering is demonstrated by its good preservation. Subsequent movement of bones, for example by underwater currents potentially winnowing the assemblage, might not leave visible traces and cannot *a priori* be ruled out. This factor can at least be excluded for bones recovered in articulation, but there are in fact few bones which can be placed into this category.

Aurochs skulls and their fragments lay in a zone located between 2 and 5 m from the northern edge of the excavation (**fig. 7**), which equates approximately to the boundary between the surviving limnic deposits and the destroyed terrestrial part of the site. The location of the finds might primarily reflect the distance such heavy material could have been thrown into the water, although subsequent underwater movement would probably have brought the skulls down slope to rest on the flatter bed of the meander.

The relative locations of an aurochs skull and several maxillary teeth reveal both the final resting place of actively discarded waste and the original location of butchery, which involved fracturing of the anterior skull by blows immediately in front of the M3. The same considerations regarding distance from the bank may apply to the two humanly modified red deer antler frontlets, although in this case it should be considered whether they are merely discarded waste or alternatively material stored underwater for potential future use.

Aurochs ribs are found widely across the excavation and some specimens from neighbouring positions in the rib cage remain in broad spatial association, possibly indicating that they were originally discarded as larger or smaller slabs of rib cage rather than as disarticulated bones. However, once disarticulated this relatively light material has a high surface area to weight ratio, and could probably have been moved by even weak underwater currents. Much of it was therefore probably displaced downstream and/or into deeper water, as might be suggested by the quite even spread of ribs at distances of up to 10 m and more from the ancient riverbank.

The refitted fragments of an aurochs pelvis underline that material recovered widely dispersed across the site represents a single assemblage and provide an insight into butchering practises and the disposal of waste, i.e. the dynamics of human activity at the site. In any discussions of spatial interpretation it is important to note that the bank of the meander was at the left of the plan, with deeper water at right, while any flow of current still active enough to transport material underwater would have been from below to above on the plan.

The fragment of the pelvis furthest from the bank and hence in deepest water is also the densest and heaviest, the acetabulum. This refits to a fragment of the iliac blade and to two refitting fragments of the ischium. While the iliac blade might have been moved from the location of the acetabulum by underwater currents, it is improbable that this applies to the fragment of ischium, which would then have needed to be transported to a higher location. Equally improbable is that the acetabulum was moved by currents from the other elements, since this goes against direction of water flow.

It is improbable that the acetabulum should be eroded or washed more than 10 m from the other fragments, while the peripheral elements remained relatively close together. The logical original butchery site would be near to, or on, the drier land at the left of the plan, closer to the position of the ilium and ischium. The latter elements may have been discarded just off bank, with one fragment of ischium later transported down slope in the direction of water flow. Removed from the rest of the pelvis by fracture and possibly in articulation with the femur, the acetabulum was discarded separately "upstream" and came to rest in deeper water.

This distribution pattern was observed on other elements, with smaller fragments remaining close to

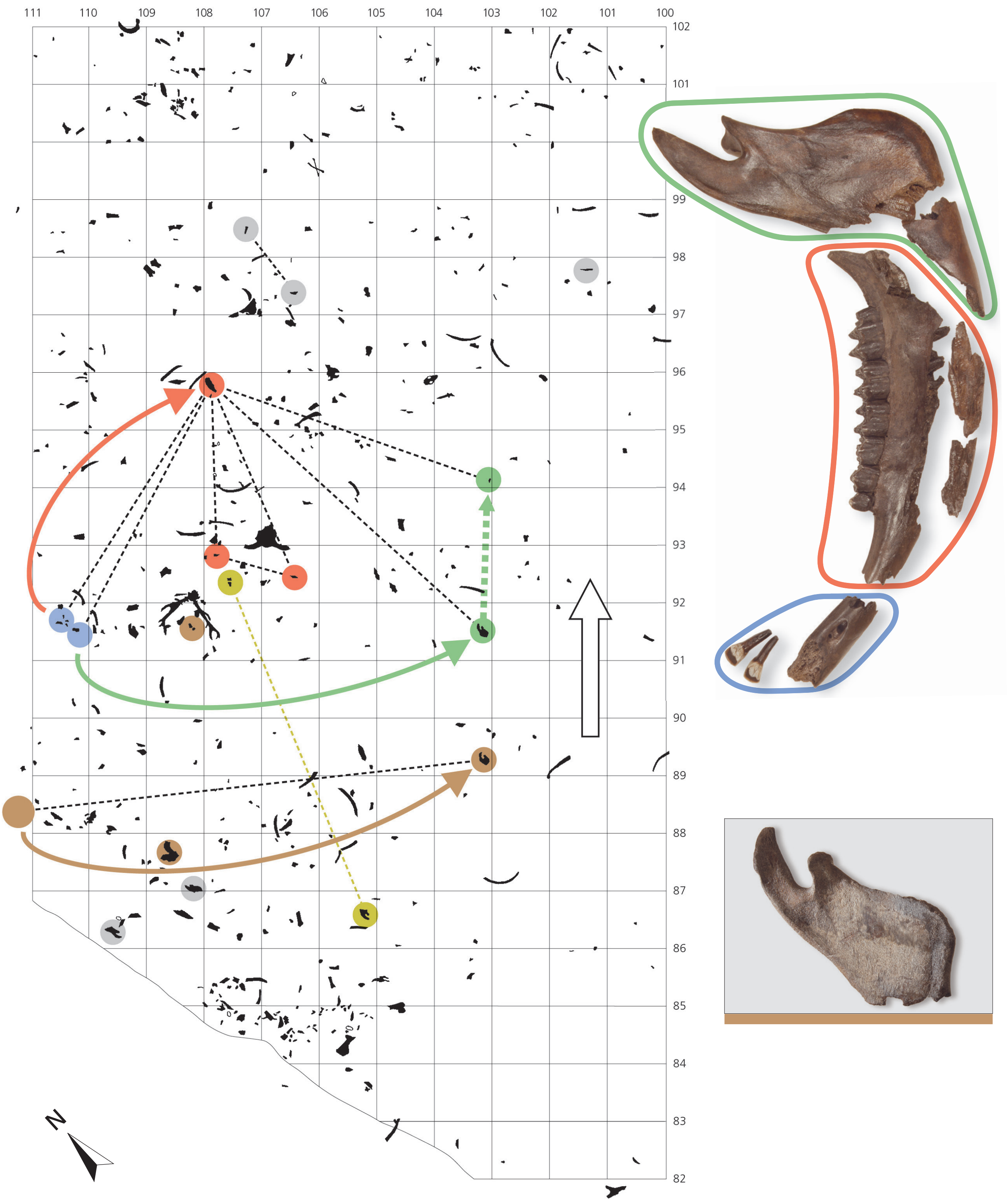

Fig. 8 Bedburg-Königshoven: Processing of aurochs mandibles. Detachment of the distal mandible and rostral teeth (marked pale blue) took place at the ancient river bank (at left). The ascending ramus was fractured off the left hemi-mandible and discarded into the water (unbroken green arrow) as two refitting fragments, the smaller of which may have been moved downstream by current flow (broken green arrow). The inferior margin of the horizontal ramus was removed to access the marrow cavity, producing a cleaned mandible with molar dentition and two detached fragments (marked red) also discarded into the water (red arrow). The positions and orientation relative to potential stream flow of the left adult element are mirrored by fragments of the right hemi-mandible of the same animal (identified by morphology, marked yellow) and of a left hemi-mandible of an immature aurochs (brown, brown arrow) the skull of which lies along the trajectory of proposed disposal.

the original the site of actual butchery while larger "selected" pieces are discarded into deeper water, a pattern which basically conforms to the "drop" and "toss" zone model proposed by Binford (1983).

An identical method of processing was recognized in the case of the deliberate fragmentation of aurochs mandibles, in some cases associated with spatial patterning (**fig. 8**). The exact dynamics of the distribution patterns are not fully clear; slope angle and water action have probably influenced the final position of the fragments which is thus the result of a combination of anthropogenic and subsequent natural processes. Nevertheless, the logical spatial association of sequentially fragmented butchering waste does suggest that the original locations of activity and disposal areas can be identified. Smaller bone pieces created by initial fragmentation of the mandible are generally found close to the water's edge (presumably at, or very close to the site of the bone smashing activity), while larger fragments subjected to further processing are located further from the shore. Were the distribution of refitted material primarily non-anthropogenic it would instead be expected that the smaller and lighter fragments would have been eroded and washed down slope, while the heavier elements remained *in situ*.

A first stage of processing saw the division of the lower jaw into two halves by smashing through the anterior mandible (containing the rostral dentition). The ascending *ramus* of each hemi-mandible was also removed by a blow to the posterior angle of the respective elements leaving the individual left and right horizontal *rami* for easier opening of the marrow cavities. The incisor teeth and small bone fragments from the initial fracturing operations remain where they drop in an upslope location on or close to the ancient river bank. The caudal parts of the mandible were discarded into the water. In some cases the ascending *ramus* was found as much as 8 m from the ancient river bank, either thrown that far by the butchers or due to subsequent movement of the disc-like flat bones by currents into deeper water. The desired element, the horizontal *ramus*, was broken open for the contained marrow by smashing away the lower margin of the bone. The detached fragments and the emptied *rami* were also discarded into the water, ending up some 3 m from the riverbank. Traces of gnawing on some mandible fragments suggest that they were only discarded into the water after first being accessible to the dogs present at the site (deliberate feeding?).

Humanly modified skulls of roe deer and domestic dog were found very close together (**fig. 9**). They are located at a distance of some 7 m from the northern edge of the excavation, which probably equates with the ancient river bank, and it is not clear to what extent their proximity (association?) so far out into the body of water might be a result of deliberate human action.

Similarly, a broken bone point and a chisel or burnisher made on a red deer radius, the only two formal organic tools (discounting the antler frontlets) found at Bedburg, lay adjacently some 10 metres from dry land and in this case must certainly have been carried together, perhaps tied or bound in a bundle, before their accidental loss or intentional discard. Similar associations of organic artefacts are known from other Holocene waterlogged contexts but by what mechanism or with what intention the Bedburg specimens were deposited remains unknown.

A quasi articulated radius and ulna of white stork probably represent an entire bird wing and their presence among human butchery waste may be the result of human discard or loss, although neither bone shows any modification. Other unmodified remains of small water birds (some in articulation) and fish probably reflect the natural background.

At the west of the excavated area an elongated area measuring some 3 metres in length from North to South contains a large amount of small-sized faunal material and an unusually high number of lithic artefacts. Material of equivalent small size is otherwise uncommon at the site, although wet-screening showed that smaller bone fragments are more numerous to the north of the site close to the water's edge. The heterogeneous lithic material includes both, well-made large blades and smaller lamellar forms, among them microlithic elements. The area yielded bone and tooth remains of the medium-sized mammal species beaver, badger and roe deer, among the latter a number of fragments of intentionally fractured roe deer limb bones. A scapula and femur of horse are among the few larger bones found close to this unusually dense scatter of bone at the west of the site. A complete articulated series of aurochs left carpal bones suggests that material was buried quite rapidly and demonstrates the lack of post-depositional disturbance in this part of the excavation.

The amount and range of material identified as roe deer in an area of less than 1 m² might also suggest remains of only one butchered individual and also underlines the rapid burial of material at this location. The sediment here was quite sandy, unlike the normally very fine gyttja matrix, and some of the fragmented long bones of roe deer are abraded. This and the linear distribution of the material suggest that the material was probably scoured from the bank and brought into the deposit as the filling of a small channel. Probably a small rivulet or stream flowed into the meander from the bank at this place and transported sediment and a selection of finds of smaller dimensions than those intentionally discarded into the water by humans. Possibly the valley extending into the meander from higher land to the north-west (**fig. 3**) drained water (perhaps seasonally) into the Erft valley at around the time the site was occupied. A source of fresh water may have played a major role in the choice of site location, while since occupation at Bedburg seems to have been in spring or summer, subsequent winter flooding of terrestrial areas and displacement of material is a probable scenario.

The heterogeneous "random sample" gives some idea of the range of material originally present in the terrestrial area of the site but lost due to recent destruction or perhaps much earlier due to weathering and other processes of site degradation. Furthermore, the close association of roe deer, badger and beaver with horse confirms the unity of the assemblage and demonstrates the contemporary ecological variation from woodland to more open grassland available to early Mesolithic hunters.

It is possible to identify a number of originally articulated associations of bone elements which have been moved apart underwater to a greater or lesser extent. The overall loss of material due to this process is impossible to quantify. The lack of strong currents indicated by the nature of the enclosing gyttja deposit might suggest that only small pieces are likely to have been seriously affected by winnowing. However, the recognition that material was probably discarded into the water at a time when infilling of the meander was not so far advanced leaves a period of unknown duration when scouring may have played a greater role.

Three carpal bones and a distal radius of *Bos primigenius* distributed over three neighbouring m² units show the movement of this articular unit subsequent to its removal from human influence.

Three semi-articulated cervical vertebrae of horse were found relatively deep in the gyttja horizon to the east of the site. A series of six red deer phalanges was found scattered over the same approximate area. It is unclear whether these finds might indicate the presence of another rapidly filled underwater channel and no anomalies such as different sediment matrix were noticed during excavation.

Site function and overview

The highly favourable nature of open swampland as feeding grounds for large ungulates has long been suggested as a major factor in the hunting strategies of early humans (e. g. Bay Petersen 1978). In the case of the aurochs, the largest terrestrial mammal prey species available to humans in the early Holocene, the etymology of the name (in German "flood plain" or "river meadow" ox) for this now extinct ancestor of domestic cattle would itself appear to betray the animal's ecological preferences. Moreover, various reconstructions of the ecology of the animal support this interpretation (e. g. Hall 2008; Van Vuure 2002).

Aurochs were certainly encountered, probably on a regular basis, by human hunters in the more open, flatland environments of river valleys. This is documented by a number of their skeletons recovered in various stages of completeness with clear evidence relating to human predation. Not

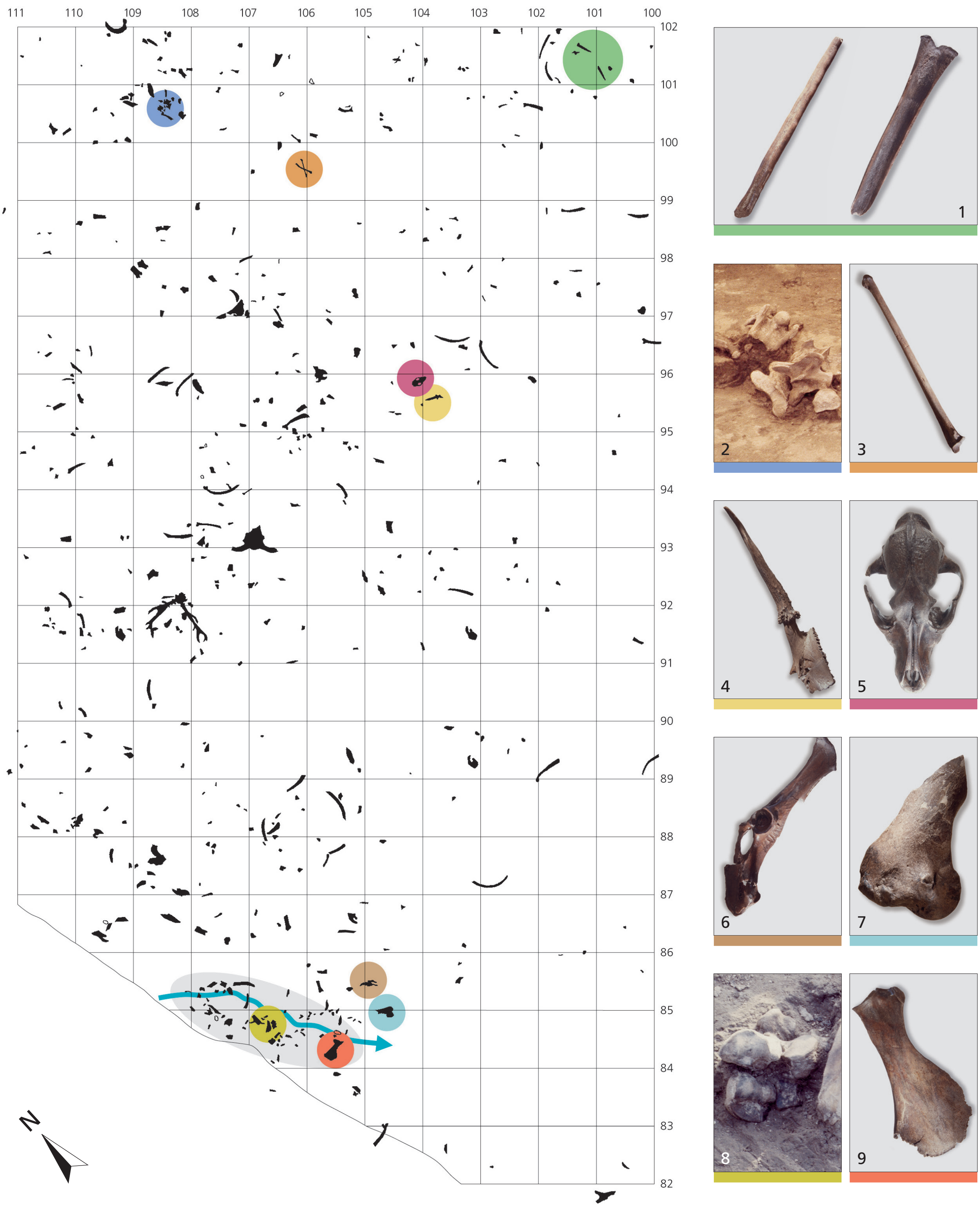

Fig. 9 Bedburg-Königshoven: Bone distribution patterns. Faunal remains in close spatial proximity represent primary anatomical associations or may in some cases reflect human activity or intention. Broken bone point and burnisher of red deer bone (1). Three articulated cervical vertebrae of horse (2) located close to six phalanges of a red deer foot probably disarticulated by water movement. The radius and ulna (3) of a white stork may represent human discard of an articulated wing. Close association of humanly modified skull bones of roe deer (4) and domestic dog (5) suggests they were discarded together. Other close spatial associations of material are probably due to rapid deposition, possibly caused by water run-off (blue arrow) from the bank (at left in plan). A small area of the excavation (grey shading) produced a collection of heterogeneous material including teeth and bones of roe deer (6), beaver and badger, articulated left carpal bones of aurochs (8), and a horse femur (7) and scapula (9).

all of these recorded episodes document successful hunts. Indeed, specific finds of entire aurochs skeletons associated with microlithic arrow points in early postglacial marshland deposits clearly represent wounded animals which evaded their hunters and died without being recovered. This is the case at the Danish sites of Vig (Hartz/Winge 1906; Noe-Nygaard 1973) and Prjelerup (Aaris-Sørensen 1984; Aaris-Sørensen/Brinch Petersen 1986). A complete aurochs skeleton reported from Holocene peat deposits in the Erft valley near Grevenbroich in 1912 (Krause 1912) might conceivably represent a similar episode located very close to the Bedburg Mesolithic camp.

The site of a successful early postglacial aurochs hunting episode was excavated at Schlaatz near Potsdam, where what remained of a butchered aurochs was found associated with a small number of flint blades (Benecke/Gramsch/Weisse 2002; Gramsch 1987; Gustavs 1987; Teichert 1987). The skull and axial skeleton of the massive bull were found in anatomical association and had undergone at most slight redeposition. All the limb bones and much of the rib cage were missing, and Schlaatz clearly represents the actual place of death ("kill-site"), from which the desired parts of the carcass have been removed.

The Bedburg faunal assemblage represents the next stage in carcass butchery (Street 1990), during which elements removed from the kill-site were further processed and the bones subsequently discarded as waste (Street 1989b). That so many elements of aurochs carcasses were transported to the Bedburg site indeed suggests that the animals were hunted and killed in the immediate vicinity at sites equivalent to Schlaatz, perhaps only some few hundred metres further out into the valley bottom marshland. Dismemberment of the prey and discard of elements too heavy to be transported took place before moving the required parts of the carcasses to the nearest dry land for further processing. This includes slabs of ribs fractured off the spinal column, whereby the proximal ends of ribs and vertebrae which are underrepresented at Bedburg correspond exactly to those elements found at Schlaatz.

There is some overlap of the elements found at the two sites, particularly the several aurochs skulls/mandibles at Bedburg. Their presence suggests that animals were killed close enough to the site to make transport of the detached heads profitable, since the brain, meat, tongue, marrow and horns were all desirable products. Nevertheless the skulls are only of much smaller cows and young animals and not of bulls equivalent to that at Schlaatz. This might suggest there was an upper weight limit for the readiness to transport elements, possibly also relative to the distance to the kill-site. Alternatively, the dominance of female and young animals might reflect the composition of targeted aurochs herds or higher potential risk in hunting larger males. Against these considerations would speak the clear presence of male elements among the postcranial material at Bedburg.

A number of further occurrences of early Holocene aurochs skeletons in varying stages of completeness are reported from equivalent river valley bottom contexts in the Rhineland and neighbouring regions (Auler 1999; Bos/Urz 2003; Lanser 1990; Prummel/Niekus 2011; Prummel et al. 2002; Richter et al. 2015; Urz 2000). It is probable that many of them are located along the spectrum extending from escaped prey of Mesolithic hunters to waste material discarded following their butchery of successfully hunted animals either at the kill-site or at a site occupied subsequently, perhaps for a number of other purposes.

The most plausible interpretation for the excavated part of the Bedburg-Königshoven site is as a waterside disposal area for butchering waste from a central residential camp occupied in spring/summer. The quantity of meat provided by the butchered mammals (at least 11 aurochs in addition to other species) would suggest a potential stay of at least two to three months over the summer by a group of e. g. eight adults and twelve children. This is implied by the heterogeneous character of the hunted faunal assemblage, the evidence for many episodes of lithic tool production, and the presence of a range of other items such as bone tools, tooth pendants and two antler frontlets. Indeed, the presence of the latter artefacts might suggest that the Bedburg site took on a role extending beyond the strictly economical into the social and/or spiritual and occupied a central position in the life of these early Mesolithic people, as has been argued for the early Mesolithic site Star Carr (Conneller 2004; Conneller et al. 2012).

Since the terrestrial land surfaces upon which prehistoric activities were primarily carried out will generally preserve faunal material poorly or not at all, it is self-evident that discard of organic waste into adjacent bodies of water will provide otherwise unavailable insights into butchery operations in the form of cut and impact marks which can show in detail how an animal carcass was processed. Material found in terrestrial contexts has by contrast a far greater potential for revealing the spatial dimension of the dynamics of human actions and activities.

The analysis of the early Mesolithic faunal assemblage at Bedburg-Königshoven, a site where no terrestrial deposits had survived, showed that an additional level of interpretation for butchering processes may in some cases be provided by meaningful spatial patterning even when the only surviving elements of the carcass are those that have been discarded into a sub-aquatic environment.

Clearly, in an ideal world we would hope to recover both the terrestrial and sub-aquatic parts of a lakeshore site and be able to examine their interaction in detail. When this is not the case, it appears that even the waste material discarded under water has its own tale to tell.

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