ÉVA DAVID · BERIT VALENTIN ERIKSEN

ANTLER TOOL'S BIOGRAPHY SHORTENS TIME FRAME OF *LYNGBY-AXES* TO THE LAST STAGE OF THE LATE GLACIAL

Abstract

The topic of this research paper is a discussion on the relevance of the sole use of absolute dating for the cultural attribution of bone artefacts. *Lyngby-axes* are an artefact-type indicative of a single culture of the Late Glacial, though radiometric dates suggest that a wider time period can be represented. It is discussed whether the direct dating of the utilised animal-based material always accurately reflects the age of the technology used to implement the artefact as a relevant cultural item. The technological approach used here points to the gathering of sub-fossil antler, targeted as a convenient raw material for this tool.

Keywords

Late Glacial, fossil antler, tool, technology, Hamburgian, Ahrensburgian, object biography

INTRODUCTION

The first Danish specimen recovered at Nørre Lyngby of a so-called *Lyngby-axe* (Fisher et al., 2013; Jessen and Nordmann, 1915; Stensager, 2004; see Degerbøl and Krog, 1959: 19, in particular "h", "i" and "p" for other possible *Lyngby-axes* from there), from the moment of discovery, served to define a new *fossil directeur* for the Late Glacial of the European Stone Age (Müller, 1901: n°1-2; Mathiassen, 1948: n°143 and 144). Perceived as bearing cultural value (Clark, 1936; Baales, 1996), this artefact-type was considered typically relevant of the Ahrensburgian archaeological culture when similarly worked antler pieces were discovered during excavations at the Stellmoor site in Germany (Rust, 1943). The original Stellmoor-publication records 46 Ahrensburgian *Lyngby-axes* from the upper horizon that date into the Younger Dryas. Only 18 specimens from this context were found again, and examined by us in the Schleswig-Holstein State Museums Schloss Gottorf. Tools made from reindeer antler resembling *Lyngby-axes* have also been reported from several Central-Eastern European settlement sites. Unfortunately, none of these tools from Eastern Europe are directly dated.

Some of the most recently published radiocarbon dates from *Lyngby-axes* (Clausen, 2004; Girininkas et al., 2016) suggest that this tool-type belongs to a chronological phase of the Late Glacial pre-dating the Younger Dryas. This contrasts with other dates from England (Gowlett et al., 1986; Jacobi et al., 2009), Southern Scandinavia (Hedges et al., 1993 and 1995; Stensager, 2006) and the South of the Baltic Sea regions (Goslar et al., 2006; Zagorska, 2012). Some of these dates are more reliable (AMS), indicating that these tools were particularly used during this r stage of the Late Glacial. The lower, i.e., Hamburgian cultural horizon of Stellmoor that dates into an earlier stage of the Late Glacial (Fisher and Tauber, 1986), provided a wide spectrum of cultural organic remains (Rust, 1943), casting doubts on the idea that *Lyngby-axes* are chronologically restricted to the Ahrensburgian, a perspective we would like to pursue in the following.

In: S. Gaudzinski-Windheuser · O. Jöris (Eds.), The Beef behind all Possible Pasts. The Tandem-*Festschrift* in Honour of Elaine Turner and Martin Street. Monographien des RGZM 157 (Mainz 2021). DOI: 10.11588/propylaeum.950.c12583

Fig. 1 Side views of the complete *Lyngby-axe* from Ahrensburg (Rust, 1943: Fig. 56-1). – (Photo: @ Schleswig-Holsteinische Landesmuseen). – Length: 51 cm; length from back-side to bez tine's active end: 11,2 cm; thickness to the shaft: 2,9 cm; angle between the bez tine and the shaft: 89°; maximal diameter of the medallion: 4 cm.

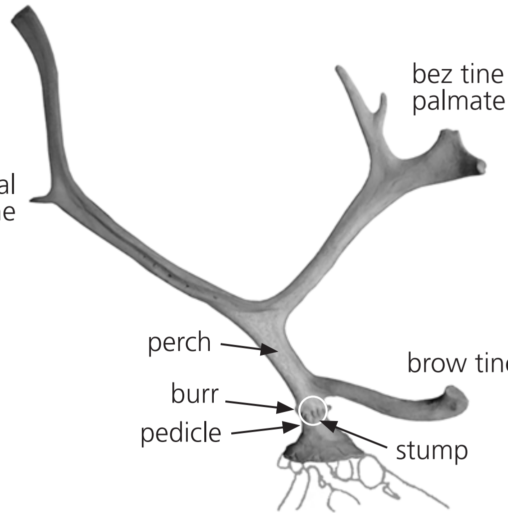

Fig. 2 Terminology used in the text on a worked frontal appendix of reindeer (unshed stag antler) in velvet from Stellmoor (Germany). – (Photo: É. David).

RESEARCH TOPIC AND METHOD

Although being used as *a fossil directeur*, *Lyngby-axes* were never properly defined as a tool-type. From the specimens we studied, the artefacts appear diverse in morphology and surface aspects, possibly due to the use of different types of antler materials or as a result of diverse uses. A recent study on marginally modified antler suggests that the relative chronological interpretation of surface modifications allows reconstruction of the artefact's biography (David and Ducrocq, in press). A comparative analysis conducted for these tools from the youngest and the oldest Late Glacial contexts was therefore considered, to test if differences in shape and/or the physical appearance of the surface (hereafter: *aspect*) would be relevant to any particular heuristic scenario. Due to the specificity of this artefact type, we assumed that the use of *Lyngby-axes* would have been either common or specific given the archaeological cultural context. We performed a 'biographical' analysis for three *Lyngby-axes.* The following specimens were studied: a tool from the Ahrensburgian from Stellmoor (Rust, 1943: Fig. 56-1), and two older specimens from the sites of Klappholz in Schleswig-Holstein in northern Germany (Clausen, 2004) and Parupé in Lithuania (Girininkas et al., 2016), both dated to the Allerød interstadial. The analysis of the latter artefacts is based on published high quality images, while the first tool was examined in person (Clausen, 2004; Girininkas et al., 2016).
The technological approach used here aims to reconstruct the tool's biography by studying how the raw-material was naturally modified and/or deliberately transformed into a tool. Therefore, taphonomical and histological variables must be taken into account when studying the shape, surface and structure of antler material to assess its initial *aspect*. Antler tool stigmata are usually examined with low magnification (from 4× up to 80×) and compared to reference collections for identification. Reconstruction of the artefact's biography takes the localisation, orientation, distribution, arrangement, and relation of observed stigmata into consideration as well as how these are patterned, contributing to the transformation of the antler in a certain order of time. The natural *aspect* of antler as raw-material for antler-tool production is known. This provides a starting point for the reconstruction of the successive "chronological events" (i.e., the palimpsest of observed taphonomical and technical patterns) as the osteological state of the animal-part can be mature or immature, fossil or fresh-collected or represent an extracted part of the

Fig. 3 Basal end of the Ahrensburgian *Lyngby-axe* viewed in cross-section. – (Photo: É. David).

raw-material: in this context antler (level 0). The observed anthropogenic-originated surfaces and traces that overlap on the recorded primary *aspect* constitute a succession of patterns ordered in steps (levels 1 to n). As mentioned above, recognised steps do not refer to human modification only, but include any other feature that characterises the object and thus, the object provides its own grid of analysis. In this way, the technological approach enables comparative analyses between the *Lyngby-axes* from the Ahrensburgian and the two older *Lyngby-axes* similar in appearance not in analogical (between comparable stigmata) but analytical terms (between comparable scenarios), on the conditions under which the osseous material modified in the course of use.

THE *LYNGBY-AXE* N°56-1 FROM THE AHRENSBURG LAYER OF STELLMOOR (GERMANY)

The piece is made of an unshed stag reindeer antler (**Fig. 1**). Antler morphology corresponds to reindeer antler uncovered at Stellmoor, described as quite large and circular (Gripp in Rust, 1943: 109, Fig. 3 and Fig. 2e) based on analyses of complete crania from the site. The antler surface of the tool is remarkably well preserved showing sinuous grooves of former blood vessels deeply imprinted on the surface, and with a remaining tuberous appearance for its highly pearled burr circle around the stump (**Fig. 2**).

The antler perch was chopped-off using the *nicking technique* and then straight-detached there from the palm in a *flexion break* (David, 2004). In transverse section, the outer antler layer is not clearly separated

from the spongy inner core. In mature antler the compacta should make up about two thirds of the entire antler diameter, but seems to be missing here (**Fig. 3**). There is no other noticeable change in porosity or colour between the two different tissues constitutive of the antler. Even if the piece was obviously restored, no form of chemical modification (hypothetically from a low pH in burial conditions) can be thought of to explain that the external compacta would otherwise appear so alveolar.
This eventually attest to the fact that the antler material was not entirely calcified when the antler piece was worked, regardless of whether the antler derived from a male or female (Bouchud, 1954: 341). As the surface *aspect* of the antler appear quite alveolar even in the stump area where the antler appendix merges with the bone material from the pedicle, the complete unshed antler piece was in the process of ossification (in velvet) when the animal was butchered. This stage of growth corresponds to when the frontal appendix is heavily irrigated with blood venules and arterioles crossing from around and through the various osseous tissues (**Fig. 4**). This is before the hormonal-based yearly cycle continues with ischemia leading to necrosis and final shedding of the antler (Bouchud, 1966: 79, Fig. 39). The vascularisation through the anterogenic periosteum originally located under the velvet skin must have been still in progress, at the time the animal died.

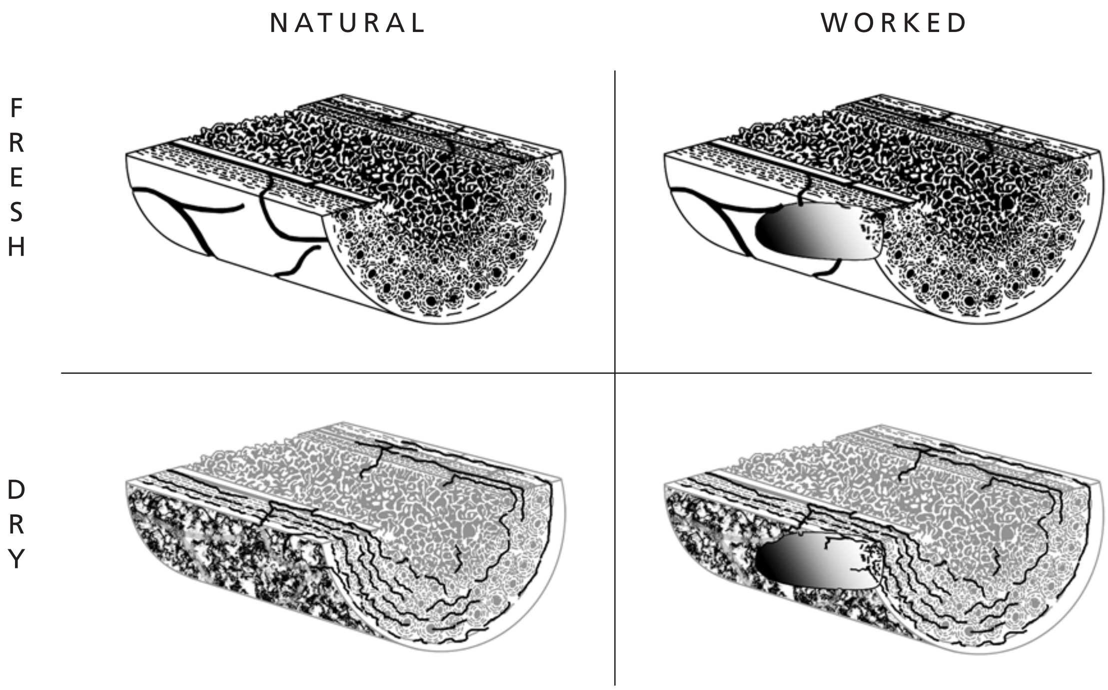

Fig. 4 The osseous (bone or antler) material consists of $^{1}/_{3}$rd trabecular hard tissue of spongy bone or spongy core that develops centrally (antler, flat bones) and at the extremities (limb and short bones). $^{2}/_{3}$rd of the material is represented by cortex or cortical hard tissue of compact bone or compacta initially protected with cellular derma and infra-derma periosteum (Bouchoud, 1966: 76). Once calcified, the compact bone is marked with prints (thick black outer lines) of former foramen and blood vessels and natural grooves through its numerous layers of *osteons* or *Haversian systems* – concentric nests of *lamellae* structures each constituted of *lacunae* and *canaliculi* (dotted circles) that encloses the central axial *Haversian canal* (central black hole) with its transverse-perforating *Volkmann's canals* (black deriving lines) – (Barone, 1986). The organic fraction of the bone reduces once the antler is shed or the animal is dead. Depending on burial and preservation conditions, desiccation lines may rapidly develop guided by the lamellar and alveolar structure of the two histological tissues, notably through their degraded interstitial (between the osteons) and circumferential parts (outer lamellae layer above the large dotted line). When worked (patch), the initial aspect of the osseous tissues used in artefact production remains in their most well-preserved surfaces, in how the distinct material precisely reflects the effects of mechanical constraints entailed in technical action. – (Drawing of mature bone viewed in axial and cross sections: É. David).

Fig. 5 Pedicle of the Ahrensburgian *Lyngby-axe* viewed from above, whose hard bone (circle), appearing as diversely vascularised (above and below dotted line), is marked from processing the frontal appendix with lithics (arrows). – (Photo: É. David).

The histology of the velvet skin differs from the cranial skin (Bouchud, 1966: 76), explaining why the pedicle appears subdivided into two zones: an upper zone with calcified bone patches (**Fig. 5**: circles) and a lower definitely ossified zone (Bouchud, 1954). The alveolar pattern is still discernable on the surface between the patches, clearly indicating that the antler including the upper zone of the pedicle was still covered in velvet skin to where it joins the cranial skin in a diffuse line almost at the bottom of the pedicle (**Fig. 5**: separation in zones with a dotted line).

This histological bi-partition of the pedicle surface is probably responsible for the different degree in which anthropogenic-originated impacts genuinely affected the bone material during working of the reindeer crania to remove the half-cranial carcass or 'trophy' (**Fig. 5**: some illustrated with arrows). In the upper (under velvet) part of the pedicle, impact marks appear torn and sunken, and as ripped into scars, whereas

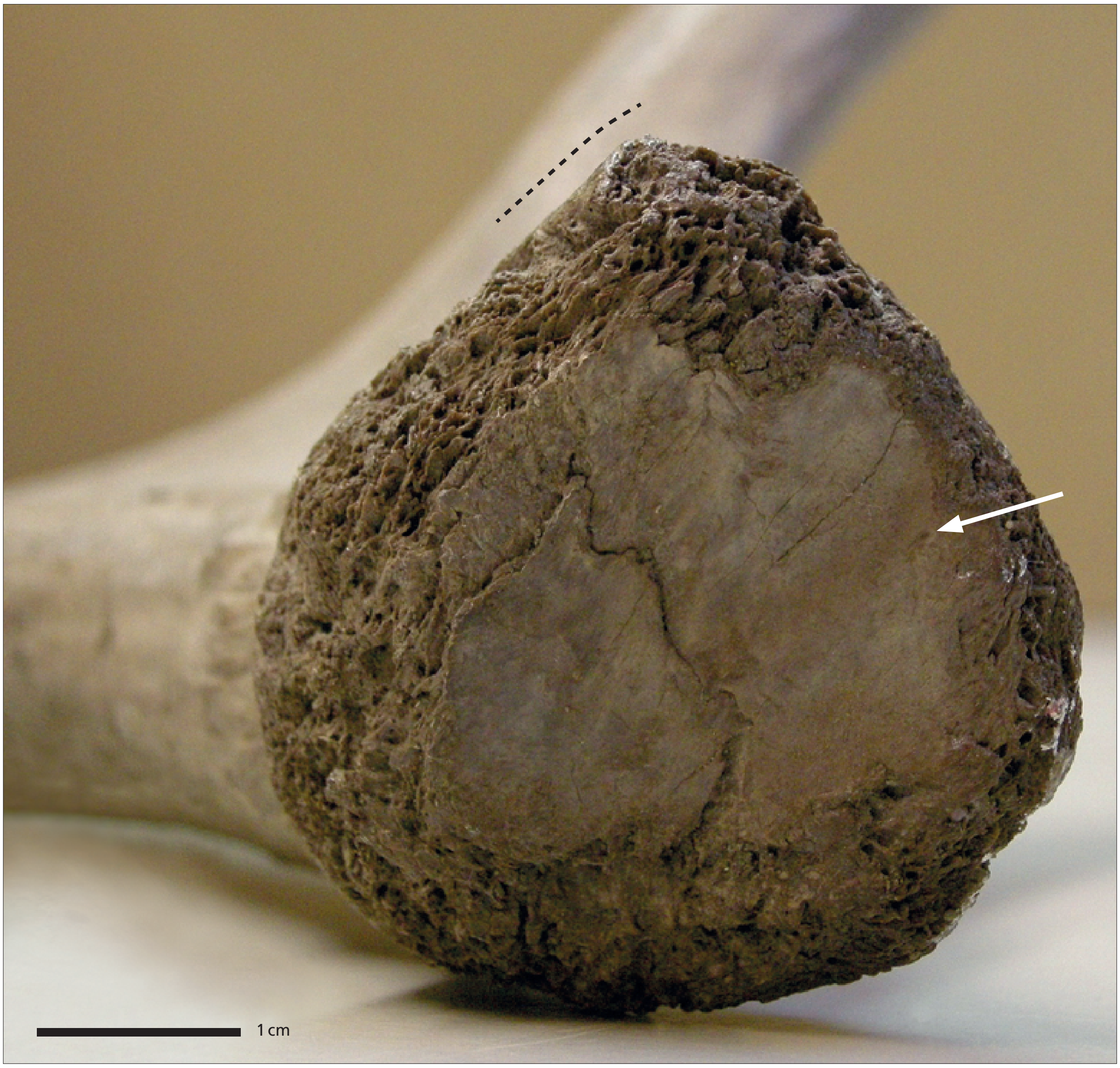

Fig. 6 Medallion-shaped skull cap of the Ahrensburgian *Lyngby-axe* viewed from its inner side, whose edge got partly smoothened (dotted line) with patinated cupule-shaped marks (one marked with an arrow) deriving from dog-gnawing. – (Photo: É. David).

in the lower zone of the pedicle impact marks are shallow and sometimes more sharply defined. Numerously observed spots with short incisions crossing each other arranged in two main rows along the edge at the bottom of the pedicle indicate similar repeated gestures, with which the front-parietal suture line had been modified. The slightly chipped-margin located below the straight-cut plane resulted from working the reindeer head or the cranium using the *nicking technique*: a lithic tool employed in direct percussion was used from the side with some precision, so that bone chips eventually detached in a mostly regular manner. The shape of these detachments developed in a row with no other distinction between worked and unworked bone parts, indicating the reindeer head was processed in fresh state (**Fig. 5**: front edge). The difference observed in the types of impacts (sunken *versus* sharp) might therefore not have been caused only by the histology of the bone matrix. It seems plausible to suggest that anatomy also determined the way the lithic

Fig. 7 Upper part of the Ahrensburgian *Lyngby-axe* viewed from a side marked with patinated cupule-shape mark (arrow) deriving from dog-gnawing. – (Photo: É. David).

cutting-edge marked the bone, where it had to be applied differently to work a narrower area of the pedicle towards the reindeer cranium. The straight-cut bone part is characterised by parallel lines and a column form, with incisions and scars above. This pattern resulted from the repeated incidental marking of the pedicle, while the front-parietal suture line was precisely aimed at, and was processed by direct percussion. Direct percussion was applied at various possible angles during repeated actions. All attest to processing for extracting the trophy rather than e.g., skinning, and perhaps also for gathering the rich proteinaceous substances from this opening of the reindeer head.

On the other side of the pedicle, the aspect of the trophy medallion suggests that the *nicking technique* was used, to shape the edge of the cranium into a regular disk-shape (**Fig. 6**). The processing was mainly from the side towards the inside of the skull cap, as shown by several occurrences of compact bone being partly torn off from the trabecular tissue. The shaped edge appears mainly brittle and with a brownish colour in the various occurring planes, all cutting through the whitish inner side of the skull cap but not always with a strict boundary.

In some places, the white patina overlaps broken parts and spongy bone parts close to where it is filled with some residual material. These cut-planes were otherwise not intensely modified. It might even be possible that their modification occurred incidentally and then were smoothed on a side (**Fig. 6**: dotted line) or crushed-in locally, as probably linked to using the piece as a tool. In their main aspect, the brownish planes appear evenly brittle as if fresh cut due to a recent damage of the skull cap from excavation or restoration techniques. However, the edge of the bone disk is genuinely ancient.

The residual material that still fills the trabecular tissue possibly acted as a protective deposit in some areas, and prevented irreversible damage to this particularly fragile edge of the disk before it eventually mostly dissolved during burial. This is indicated by the outline and colour of the un-damaged spongy bone situated in sharply indented reliefs, which would have changed colour or profile if recently altered and/or cleaned. Not altered so far with time, the regularised edge indicates the unshed antler piece was probably buried quite rapidly after the tool was used. As a consequence, the whitish "patina" on the unmodified inner side of the skull cap developed between the processing of the half-cranial carcass and when the antler was employed as a *Lyngby-axe*, most probably just after the shaping of the frontal appendix into a disk-shape. As a freshly extracted raw material, the utilisation of the piece as a *Lyngby-axe* before burial was anyway quite brief.

Gnawing marks inside the skull cap are rather white-patinated (**Fig. 6**: the largest one is marked with an arrow) as is the antler appendix of the piece (**Fig. 7**). Based on this observation, it can be argued that the white patina, as resulting here from an exposure to certain open-air conditions during a limited period of time, might have developed on the inside of the skull contemporaneously with the patina which had formed on the antler. This might have been even though scratching marks incidentally scattered across the antler surface in bands (**Fig. 8**: right side) show that one or two white-patinated layers already developed before scratching was performed by the carnivorous agent (the morphology of the gnawing marks suggests that reindeer or rodent were not the perpetrators – see Binford, 1981). Underneath the heavily damaged area the appearance of the scratches randomly changes from using the back-side of the tool depending on anatomy. Reduction in thickness due to repeated percussions by humans caused the brownish appearance of the impacted area on the back-side of the antler. Delimited towards the stump, the percussion marks

Fig. 8 Upper part of the Ahrensburgian *Lyngby-axe* viewed from the back (stump area towards the left). – (Photo: É. David).

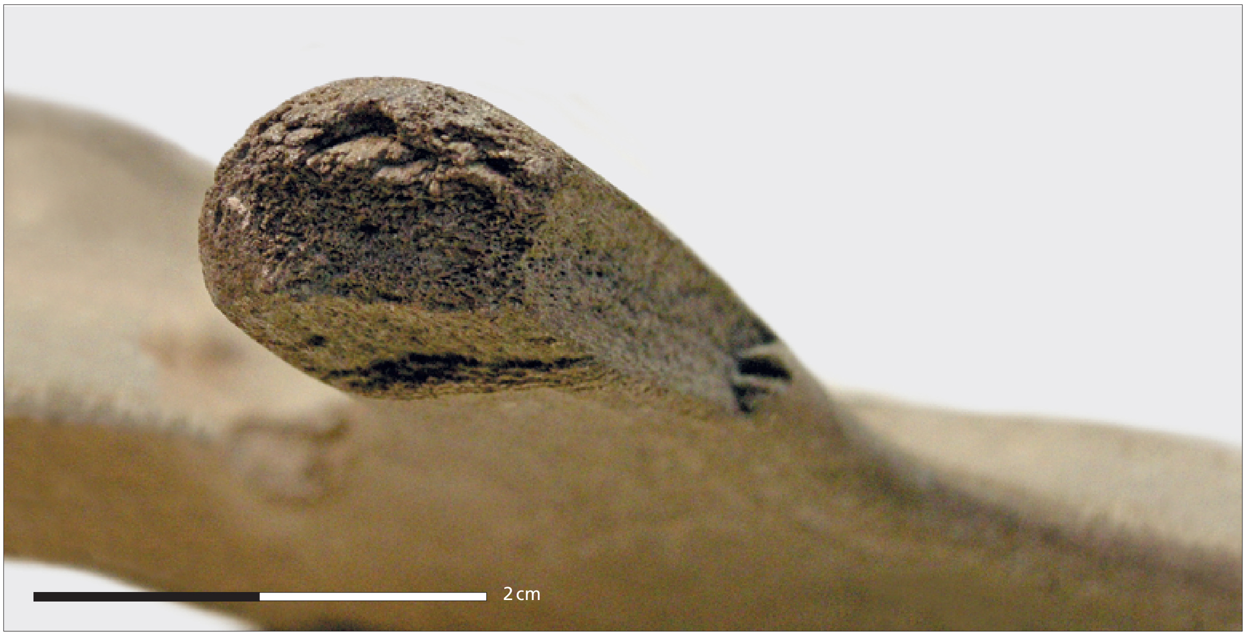

Fig. 9 Active part on the bez tine extremity of the Ahrensburgian *Lyngby-axe* viewed from above. – (Photo: É. David).

are shallower and on the impacted zone the white-patinated surface had completely been erased. This underlines that the patina must have been quite superficial, even though it probably developed in several successive planes over the antler surface (**Fig. 8**: left side).

If we agree that both the bone and the antler were anthropogenically-impacted during the same time slice, and gnawing occurred in equal patterning, the last white-patina developed on bone and antler during a short-term event, after the cranium was regularised and before the tool was last used.

The back-side of the tool, i. e., the posterior face of the antler, was subsequently transformed into a large though irregularly hatched area of randomly distributed blunt and "shiny" reliefs, sometimes sharply iterated, mainly orientated obliquely if not transversally (**Fig. 8**: middle). The deepest parts of the reliefs show a few scars singly attached to a percussion mark, regardless of their size or depth.

Sharp impacted reliefs overlay blunt or "shiny" reliefs and vice versa. These stigmata indicate that the area hatched by modifications was treated in an alternate manner using the sharp edge of a lithic tool (impacted-reliefs) and organic material ("shiny" reliefs) also as soft-hammer (club). As this off-white "shiny" use-wear pattern strictly overlaps earlier white-patinated surfaces also scratched and gnawed by the animal, it seems highly plausible that the antler was already de-velveted and in almost fully-grown condition, while partly immature in its osseous structure, when the trophy was extracted and used for a short slice of time, suggesting an interval of extraction during late summer (Bouchud, 1966: Fig. 37). The carnivorous animal was also involved in scratching the antler surface where the tool is blunt-hatched above and below percussion marks, suggesting that a dog as a companion to the hunter modified the piece in the duration of using the *Lyngby-axe*.

Repeated percussion of soft materials led to a drastic modification on the active area, which is located extending onto the bez tine (**Fig. 9**: see, the smooth reclining and crushed-in trabecular planes). Located at almost a right-angle to the main axis of the piece, the bez tine was heavily transformed, if not from the transverse removing of its digits (although this would have left no visible mark here as the bez tine may ini-

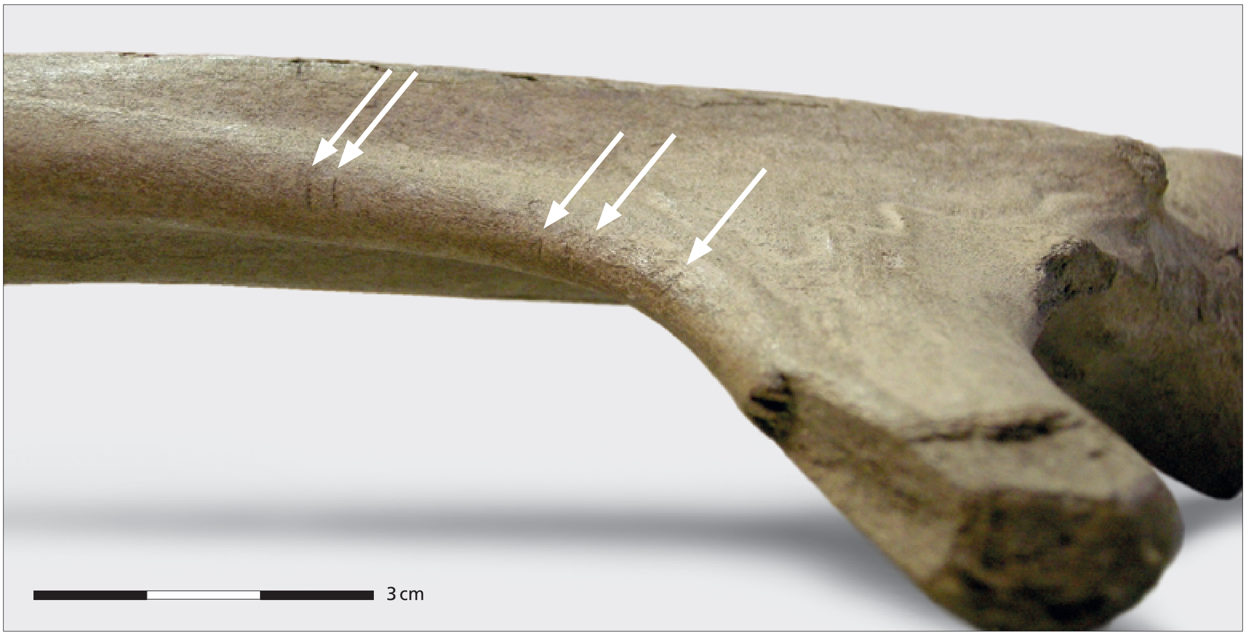

Fig. 10 Anatomical edge between the bez tine and the perch of the Ahrensburgian *Lyngby-axe* viewed from a side, with incised marks (arrow). – (Photo: É. David).

tially have been broken naturally), from using the reduced-bez tine directly as an active-part. As suggested from several long and deep damages occurring around its circumference and along both internal and upper faces, the active area was heavily peeled-off from use. These damages are slightly sinuous in their transverse profile (similar to the ventral side of a lithic blade from its prominent bulb area) and, in the lengthwise profile, their rough indented delineation indicates that a lithic artefact (the cutting-edge of a knapped blade or flake) has cut through in the axis of the alveolar tissue. Several percussion marks on the antler's natural curvature are otherwise located below, between the bez tine and the perch (**Fig. 10**).

These marks resemble one another, despite being independent in their location or orientation on this antler curvature. Thus, they probably result from a repetition of the same technical action. The reduced-bez tine was potentially used as a kind of club with a sharp lithic edge placed aplomb to the tine's main axis as an un-socketed active-end. These actions left these peeled-off damages on the tine edges as well as the below located impact marks when the percussion caused the lithic artefact to dislodge to one side.

Several differently angled scars, including the last ones, somehow truncated the active area from the side, indicating that the tool was last used in this uncontrolled manner. This is also evident from the active-area when viewed from above (see **Fig. 9**). The central area of the active-part is partially straight-split, resulting in blunt or "shiny" polish in most of its other parts where the alveolar tissue remained prominent. It seems that the two sharp sides constitutive of a lithic blade or flake had been used as a wedge on one side of the reduced-antler tine to split the worked soft materials with its other side, before hammering on the antler tool's back-side with another (wooden or antler) club. This could have led to the peeling of the bez tine, i.e., the split of soft materials leaving severe damages in return on the antler tine impacted surface. Due to the sideways sliding of the antler tool, in adjacent areas, repeated percussion led to the blunt crushing with incidental truncations and other scars on the antler curvature.

Needless to say, this heavy-duty work would have required craftsmen to perform together (there is no evidence that the lithic edge was firmly socketed to the tine). It is possible that the opposite working surfaces –

chronological events		Ahrensburgian *Lyngby-axe* n° 56-1 of Stellmoor
youngest	Level 8	antler buried as not-decayed material in cultural layer
	Level 7	antler used in direct percussion mainly (bez tine)
		antler used in direct percussion (back-side)
	Level 6	antler roughly reduced (nicking/flexion break)
		frontal appendix medaillon shaped (nicking)
	Level 5	bone/antler slightly patinated (short event)
	Level 4	bone/antler impacted (gnawing)
	Level 3	half-cranial carcasse (partly with nicking)
	Level 2	slaughtered reindeer
	Level 1	antler patinated/polished by reindeer's own action (de-velvet)
oldest	Level 0	immature fully grown antler in velvet (late summer)

human agent
non human agent

Tab. 1 Reconstructed biography of the *Lyngby-axe* from Ahrensburg (Rust, 1943: Fig. 56-1).

i.e., the back-side and the straight-cut bez tine – were used in the same way, though perhaps for different tasks, as the back-side offered a larger surface than the bez tine.

The damage patterns on the antler surface with impact marks and blunt or "shiny" areas are similar. These damages resulted from percussion of soft materials with a lithic cutting edge. The "shiny" convex areas are not planar as would be expected if caused by a smooth action. The soft materials worked with the *Lyngby-axe* must have been less dense (on the Mohs scale rating) than the osseous material, and it is most probable that wood was involved here. The same "shiny" appearance is evident for similarly worked planes on the pedicle. It is assumed that these modifications are caused by humans, although it is possible that these modifications are related to the reindeer scratching the antler velvet during the final period of antler growth, which may also result in some shiny polished zones on this material (Jin and Shipman, 2010). During use in percussion, the brow tine eventually snapped off, leaving a rough and familiar "shiny" area on the tool's edge, where the residual back tine would have otherwise remained.

Concerning the dynamics of use, two opposed working-ends can be recognized. The working-ends were probably in concomitant use to process soft materials (split wood) with a sharp lithic product used as an

Site	Country	Lab No.	^{14}C Age [BP]	Reference	Cal Age [cal BC]
Klappholz LA 63	Germany	AAR-2785	11,560 ± 110	Clausen, 2004	11,781 - 11,229
Parupé	Lithuania	Beta-403383*	11,170 ± 40	Girininkas et al., 2016	11,221 - 11,048
Mickelsmossen	Sweden	OxA-2791*	10,980 ± 110	Hedges et al., 1995	11,144 - 10,799
Odensee Kanal	Denmark	AAR-9298	10,815 ± 65	Stensager, 2006	10,940 - 10,750
Arreskov	Denmark	OxA-3173*	10,600 ± 100	Hedges et al., 1993	10,806 - 10,155
Mellupite	Latvia	KIA-42245*	10,399 ± 47	Zagorska, 2012	10,637 - 10,055
Earl's Barton	England	OxA-803*	10,320 ± 150	Gowlett et al., 1986	10,725 - 9,461
Murowana Goślina	Poland	Poz-15118	9,890 ± 50	Goslar et al., 2006	9,654 - 9,252
Nørre Lyngby, 7 *princeps* piece	Denmark	AAR-8919	9,110 ± 65	Stensager, 2004	8,542 - 8,233
Bara Lilla Mosse	Sweden	OxA 2793 (LUHM A)	9,090 ± 90	Larsson, 1996	8,560 - 7,966

Tab. 2 List of available AMS (*) and conventional radiocarbon dates directly obtained from *Lyngby-axes*.

intermediate piece. The back-side was used as club or soft-hammer (even to drive socket the lithic product in the bez tine of another *Lyngby-axe*). The bez tine was involved in driving the percussion. Further experiments using microscopic surface analyses are required to assign a more precise functional attribution. This is particularly true with regard to the development of the mentioned "shiny" aspect considering the relatively short duration of use (on/with frozen materials?).

As summarized in **Table 1**, the biography of the Ahrensburgian *Lyngby-axe* n°56-1 indicates that an almost fully-grown unshed stag antler was transformed when used with a lithic sharp edge as intermediate piece to work soft materials, soon after the reindeer was butchered. The tool was used as a heavy-duty tool and was then discarded and buried still in fresh state after having been used a further time.

THE "ALLERØD"-RELATED *LYNGBY-AXE* OF KLAPPHOLZ LA 63 (GERMANY), AS AFTER CLAUSEN, 2004

The *Lyngby-axe* from Klappholz is from shed stag antler that resembles the so-called "in sword" antler's natural morphology in reindeer species (Bouchud, 1966: Fig. 2-d). The piece is thought to attest to the oldest use of *Lyngby-axes* in the Late Glacial (Clausen, 2004, 152). However, this is difficult to confirm as according to our analysis, it was used as fossil antler.

The published photographs are very informative, showing that the worked parts of the antler are usually characterised by the same dark brownish colour, which distinguishes these areas from the overall white-greyish colour of the original surface (Clausen, 2004, 150). The different shades of colour derive from burial in a particular context, where weathering of the antler resulted in white-greyish colouring, and the crusted aspect of the antler surface was most evident for unworked areas. Since the marks related to the manufacture clearly overlap with the weathered natural areas of the antler in the observed intersecting planes, it seems that the osseous material was substantially degraded before the antler was used as a *Lyngby-axe*.

At the transverse-cut extremity of the perch for instance, cut-marks occur on the white-greyish upper portion of the hard tissue, resulting in scaling of the antler, and where similar cut-marks reach the underneath darker portion also made of the same hard bone tissue, resulting in shaving instead (Clausen, 2004: Fig. 6-1). This means that one technical action had different effects on the antler material depending on the stage of decay.

The overlapping of the different patterns on this single-action transverse-cut antler extremity – scaling/patinated/white-greyish turning to shaving/un-patinated/dark brownish – suggests that an extended period of time occurred between when the antler naturally decayed as a shed material, and when it was collected as a patinated antler piece to be used as a *Lyngby-axe*. Once used, the tool was buried, possibly quite rapidly. Otherwise the transverse-cut edge would also have had time to become changed and/or patinated. The hard tissue is thus either dark brown in its lower portion or white-greyish in its upper portion, with a strict boundary that precisely follows the circumferential lamellae structure of the compacta (see **Fig. 4**: fresh). The weathering effect only altered part of the piece, dependent on the differences in the otherwise unnoticeable histological composition between the outer lamellar and the inner osteonal/trabecular tissues. It is probable that the dark shade developed last, where the osseous structure was less mineralised than the discarded antler material and was subsequently discoloured in the peaty environment it was later excavated from (Clausen, 2004: 147).

The dark colouring is particularly developed in areas modified by the lengthwise- and/or sideways use of the bez tine; used surfaces occur dark only around the long blade-like edge with local striations caused by using this part of the tool in a smooth action (Clausen, 2004: Fig. 6-4). Considering the various orientations of the successive planes which constitute the long blade-like edge, which eventually merged into a single active-end, the same abrasion or repeated smooth action that was used to smooth the rough antler edges could have also been used here. Judging from the genuine white-greyish colour of the antler surface and apparent spongy core, it appears that when the antler was collected for use, the bez tine was originally truncated, having been broken in quite a straight manner in the natural state. The working-edge is therefore derived from using the antler, not from processing the antler tine as suggested in the original publication (Clausen, 2004: 149). Numerous specimens display a broken bez tine with a similar pseudo-blade shape as representing ordinary/unmodified reindeer antler material available in the Late Glacial natural environment (Degerbøl and Krog, 1959: Plate I, second row, fourth piece; Plate 1, last row, fourth & fifth pieces; Plate II, first row, first & fifth pieces; Plate II, second row, second piece; Plate II, third row, middle piece; Plate IV, last

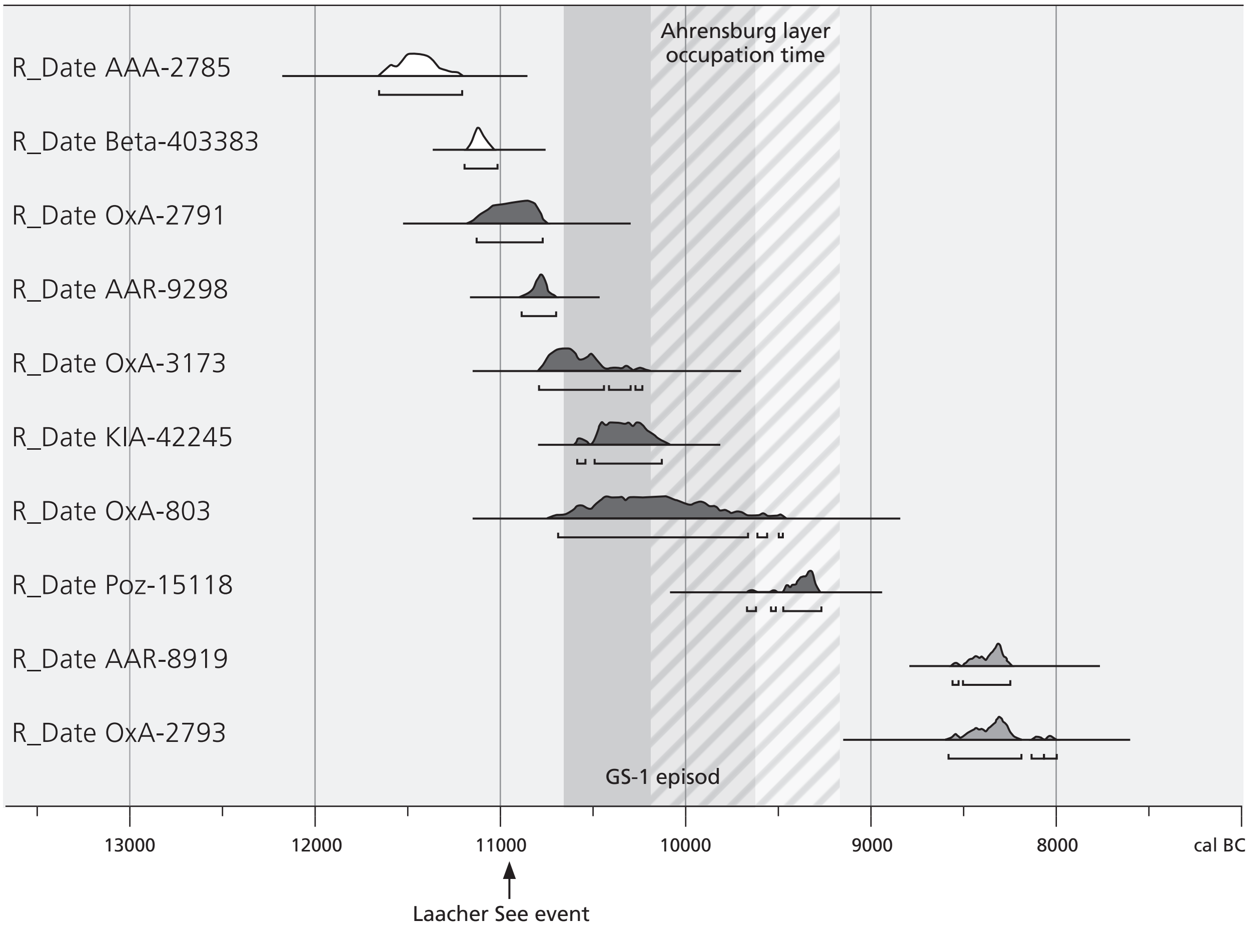

Fig. 11 Plotted available AMS (*) and conventional radiocarbon dates directly obtained from *Lyngby-axes* with presently (white) and anciently (grey) refuted range in age, which shortens time frame of *Lyngby-axes* from the Laacher See event (Baales et al., 2002) to the Ahrensburgian occupations from the Stellmoor site (Germany), mainly in the last cold GS-1 episode (grey column) from 10,750 to 9,620 cal BC (Weber et al., 2011). To plot the Ahrensburgian occupation duration at this site (hatched area), we used the nine published dates obtained from collagen material, discussed as representative in Fisher and Tauber, 1986: 11 (**Tab. 2**), dating to around 10,000 BP or 9,500 cal BC. Calibration (2σ: 95.4 %) using OxCal program v.4.4 with IntCal20 atmospheric curve (Reimer et al., 2020).

row, middle). The hunter possibly took advantage by collecting fossil antler pieces *in situ*, whose shape was close to that expected for the *Lyngby-axe*.
Although recently altered, a major scar located at the extremity of the truncation towards the perch is obviously contemporary with the use of the piece as a *Lyngby-axe*. Where smooth, the colour of the scar turns brown and is marked with three deep and short oblique scores towards a deeper and even darker area. In this precise zone, which is also the highest side of the long blade-like edge, the deepest part of the scar still displays a smooth aspect in line with the above successive planes, which are all constitutive of the long blade-like working-edge. This scored-smooth aspect might have derived from using the tool in a more radial motion, which caused the scores to develop where possibly the antler edge was less regular, with the effect of pulling out some indented part, and where the consequent scar was eventually smoothed from continuous use of the tool. Opposite the slanting smooth side, the chipped side of the scar detached, leaving a plate-like edge morphology typical for the desiccation cracks that commonly occur in dry antler. That this steep chipped edge derived from when the antler was used as a tool is evident from the white-greyish upper front, which is similarly smooth and weathered as other parts of the external surface of the piece here. This aspect of the desiccation-related plate shows that the antler desquamated during working and use. The active-edge was not altered further, excluding recent chipping on the margin of the scar, as shown by the lack of weathering in the particular deep and rough area developed in the length of the scar. So far, it was not important for the hunter to work with a fragile or dry antler raw material, as the bez tine was used for smooth actions, rather than for percussive actions. The arguments presented above show that two distinct consecutive taphonomic episodes can be reconstructed, with genuine technical events only associated with the later episode. The *Lyngby-axe* would be of a younger age than the date given by the radiometric dating of the shed antler material, as this must have starting fossilising some time before it was used. In consequence, the published radiocarbon date for the age of the *Lyngby-axe* is refuted, as it provides an age for the fossil antler only, not for its use by humans.

THE "ALLERØD"-RELATED *LYNGBY-AXE* OF PARUPÉ (LITHUANIA) AS AFTER GIRININKAS ET AL., 2016

The Parupé piece would attest to the oldest use of *Lyngby-axes* if it, too, was not directly used as a fossil antler material. This is apparent from the original publication with relevant pictures (Girininkas et al., 2016) illustrating that numerous inner desiccation lines had already occurred in the osseous structure of the shed antler when the piece was used as a tool; cracks have changed forms and/or size, and have somehow vanished locally, below the striations resulting from regularisation of the antler surface where the active-part is situated on the bez tine (Girininkas et al., 2016: Fig. 16, 21 and 22). In the case where the antler would have been shed "just" before use, e.g., in the form of sub-fossil material, worked planes and "shiny" areas on the truncated-edge (together with all the other natural surfaces of the piece) would have been altered evenly after a while. Here instead, two alteration phases can be distinguished. In phase one, the antler piece underwent a natural desiccation process and, in phase two, the anthropogenic-originated planes modified these decayed surfaces and were again affected by a further natural desiccation process. These processes affected the natural surface of the antler piece leaving two distinct patterns, that originated before and after the antler was collected including for the latter when it served as a *Lyngby-axe*. As already mentioned the first phase can be distinguished by cortical reliefs enclosing naturally developed inner splits which incidentally went downward, which then experienced flattening or surface-crushing in the second phase, regardless of their orientation or location due to working (Girininkas et al., 2016: Fig. 16, see the transverse crack). Histological canals structure the antler material and are visible in the form of tiny holes (see **Fig. 4**: fresh). These holes became inflected or obliterated by regularisation of the bez tine, causing striations which overlapped in surface and affected '*Haversian canal*' pits (if the illustrations in Girininkas et al., 2016: Fig. 14 refers instead to a close-up view of grid 1A, rather than of grid 1B; and Fig. 12 and 16, of grid 1B, rather than 1A or 2 respectively). Ultimately, black potentially manganese dots, which are distributed quite naturally on the unworked surface, look as if they have been erased, although are in fact still lightly remnant on the surface where the antler has been precisely transformed into the "blade-edge" (Girininkas et al., 2016: Fig. 13). This indicates that dots can be used to acknowledge with the un-erased ones on the original shape of the antler piece used as a collected material item. Dots form a regular pattern on the similarly slanted planes, which are all partly striated, indicating a working-edge (Girininkas et al., 2016: Fig. 12). Since these dots were not erased on the unworked panel below and laterally-located broken planes, versus erased from the above and centrally-placed worked panel, it indicates that this side of the bez tine was regularised, to form a single working-edge from a former (evenly black dotted) truncated broken bez tine. On the reverse side, the bez tine also shows that it was roughly regularised (perhaps only smoothed by use). Here, the antler tine was not shaped as a true bevelled-end tool; the inner and outer sides was planned to only converge for the use of this truncation in smooth action. It therefore seems that the shed antler piece was already provided with a singular broken bez tine when it was collected (for numerous occurrences of this kind in the Late Glacial see Degerbøl and Krog, 1959). More recently, large desiccation splits continued to develop, in parallel lines, cracking the antler material by lifting up most fragile cortical parts, including remnants of the formerly used worked plane (see Girininkas et al., 2016: Fig. 25 and 26). Based on these discussed taphonomic arguments which indicate a high degree of damage before the antler was implemented as a tool, the assumed age of the *Lyngby-axe* is refuted, with a younger age likely. This provides a useful reminder that radiocarbon dates show the age of the dead animal material, not the age of the tool.

CONCLUSION

This analysis shows that fossil antler was used as for tool production. Although taphonomic experiments that evaluate the decaying or patination time of antler have not been undertaken, the biography of the antler pieces presented here refutes the oldest time horizon proposed for tool use, and therefore restricts the time frame of dated *Lyngby-axes* to the last stage of the Late Glacial only (**Table 2**, **Fig. 11**). The consideration of other *Lyngby-axes* should be conducted in the same way, as the origin of the antler material might give new insights into human behaviour, with inference on later Late Glacial mobility patterning.

Acknowledgements

We are extremely grateful to the Centre for Baltic and Scandinavian Archaeology Foundation Schleswig-Holstein State Museums Schloss Gottorf who supported Berit Valentin Eriksen's project so that the archaeological artefact presented in the paper from Stellmoor was studied (É. D.) in 2009 in the best conditions. Our English was improved by Beatrice Cameron and Sophie Jørgensen-Rideout.

REFERENCES

Baales, M., 1996. *Umwelt und Jagdökonomie der Ahrensburger Rentierjäger im Mittelgebirge*. Monographien der Römisch-Germanischen Zentralmuseums 38. Verlag des Römisch-Germanischen Zentralmuseums, Mainz.

Baales, M., Jöris, O., Street, M., Bittmann, F., Weninger, B., Wiethold, J., 2002. Impact of the Late Glacial Eruption of the Laacher See Volcano, Central Rhineland, Germany. *Quaternary Research* 58, 273-288.

Barone, R., 1986. *Anatomie comparée des mammifères domestiques 1 Ostéologie*. Vigot, Paris.

Binford, L.R., 1981. *Bones. Ancient Men and Modern Myths.* Academic Press, London.

Bouchud, J., 1954. Dents de Renne, Bois de Rennes et migrations. *Bulletin de la Société préhistorique française* 7, 340-345.

Bouchud, J., 1966. *Essai sur le renne et la climatologie du Paléolithique moyen et supérieur*. Impr. Magne, Périgueux.

Clark, J.G.D., 1936. *The Mesolithic Settlement of Northern Europe: A Study of the Food-Gathering peoples of Northern Europe during the Early Post-Glacial Period*. Cambridge University Press, New York.

Clausen, I., 2004. The Reindeer antler axe of the Allerød period from Klappholz LA 63, Kreis Schleswig-Flensburg/Germany. Is it a relict of the Federmesser, Bromme or Ahrensburg culture? In: Terberger, T., Eriksen, B.V. (Eds.), *Hunters in a changing world: Environment and Archaeology of the Pleistocene-Holocene Transition (ca.11000-9000 B.C.) in Northern Central Europe*. Workshop of a UISPP Commission, Greifswald 2002. Verlag Marie Leidorf, Rahden/Westf., pp. 141-164.

David, É., 2004. Transformation des matières dures d'origine animale dans le Mésolithique de l'Europe du Nord. In: Ramseyer, D. (Ed.), *Industrie de l'os préhistorique, Matières et techniques.* Société Préhistorique Française, Paris, pp. 113-149.

David, É., Ducrocq, T. (in press). Biography of decorated antler adzes from Montières (France) suggests a magic function in Mesolithic art. In: Grünberg, J.M. (Ed.), *Mesolithic Art – Abstraction, Decoration, Messages*. International Conference Halle (Saale), Germany, 19th-21st September 2019. Landesmuseum für Vorgeschichte, Halle.

Degerbøl, M., Krog, H., 1959. *The reindeer (Rangifer tarandus L.) in Denmark: Zoological and Geological Investigations of the Discoveries in Danish Pleistocene Deposits*. Biologisk Skrifter 10, Det Kongelige Danske Videnskabernes Selskab. Munksgaard, Copenhagen.

Fisher, A., Tauber, H., 1986. New C-14 Datings of the Late Palaeolithic Cultures from Northwestern Europe. *Journal of Danish Archaeology* 5, 7-13.

Fischer, A., Clemmensen, L.B., Donahue, R., Heinemeier, J., Lykke-Andersen, H., Lysdahl, P., Mortensen, M.F., Olsen, J., Petersen, P.V., 2013. Late Palaeolithic Nørre Lyngby – a northern outpost close to the west coast of Europe. *Quartär* 60, 137-162.

Girininkas, A., Rimkus, T., Slah, G., Daugnora, L., Stančikaitė, M., Zabiela, G., 2016. Lyngby type artefacts of Lithuania in the context of the Stone Age in Europe: Multidisciplinary study. *Arheoloģija un etnogrāfija* 29, 13-30.

Goslar, T., Kabaciński, J., Makowiecki, D., Prinke, D., Winiarska-Kabacińska, M., 2006. Datowanie radiowęglowe zabytków z Kolekcji Epoki Kamiena Muzeum Archeologicznego w Poznaniu. *Fontes archeologici Posnanienses* 42, 5-25.

Gowlett, J.A.J., Hedges, R.E.M., Law, I.A., Perry, C., 1986. Radiocarbon dates from Oxford AMS system: archaeometry datelist 4. *Archaeometry* 28, 206-221.

Hedges, R.E.M., Housley, R.A., Bronk Ramsey, C., Van Klinken, G.J., 1993. Radiocarbon dates from Oxford AMS system: archaeometry datelist 17. *Archaeometry* 35, 305-326.

Hedges, R.E.M., Housley, R.A., Bronk Ramsey, C., Van Klinken, G.J., 1995. Radiocarbon dates from Oxford AMS system: archaeometry datelist 20. *Archaeometry* 37, 417-430.

Jacobi, R.M., Higham, T.F.G., Lord, T.C., 2009. Improving the chronology of the human occupation of Britain during the Late Glacial. In: Street, M., Barton, N., Terberger, T. (Eds.), *Humans, environment and chronology of the late Glacial on the North European plain: proceedings of Workshop 14 (Commission XXXII "The Final Palaeolithic of the Great European Plain").* RGZM – Tagungen 6. Verlag des Römisch-Germanischen Zentralmuseums, Mainz, pp. 7-25.

Jessen, A., Nordmann, V., 1915. *Ferskvandslagene ved Nørre Lyngby*. Danmarks Geologiske Undersøgelse II (29), Copenhagen.

Jin, J.J.H., Shipman, P., 2010. Documenting natural wear on antlers: A first step in identifying use-wear on purported antler tools. *Quaternary International* 211, 91-102.

Larsson, L., 1996. The Colonization of South Sweden During Deglaciation. In: Larsson, L. (Ed.), *The earliest settlement of Scandinavia and its relationship with neighbouring areas*. Acta archaeologia Lundensia 24. Almqvist & Wiksell, Stockholm, pp. 141-155.

Mathiassen, Th., 1948. *Danske Oldsager: I.* Ældre *Stenalder.* Natioɵnalmuseet, Copenhagen.

Müller, S., 1901. Nouveaux types d'objets de l'Âge de la pierre. *Mémoires de la Société Royale des Antiquaires du Nord* 1896-1901, 85-165.

Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, Ch., van der Plicht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A., Talamo, S., 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0-55 cal kBP). *Radiocarbon* 62, 725-757.

Rust, A., 1943. *Die Alt- und Mittelsteinzeitlichen Funde von Stellmoor*. Wachholtz Verlag, Neumünster.

Stensager, A.O., 2004. Nyt lys på gammelt fund. *Vendsyssel Nu og Da* 23, 38-43.

Stensager, A.O., 2006. Odense Kanal – et af Danmarks ældste fund. *Fynske Minder* 2006, 125-133.

Weber, M.-J., Grimm, S.B., Baales, M., 2011. Between warm and cold: Impact of the Younger Dryas on human behaviour in Central Europe. *Quaternary International* 242, 277-301.

Zagorska, I., 2012. Pirmā liecība par ledus laikmeta nobeiguma posma cilvēku Kurzemē. *Ventspils muzeja raksti* 7, 12-28.

Éva David
Paris Nanterre University
Department of Anthropology
CNRS ArScAn, Antet
Nanterre, France
21, Allée de l'Université
F - 92023 NANTERRE cedex
Corresponding author: eva.david@cnrs.fr

Berit Valentin Eriksen
Schleswig-Holstein State Museums Foundation
Schloss Gottorf
Centre for Baltic and Scandinavian Archaeology
Schlossinsel
D - 24837 Schleswig
Initiated the study and participated in recording the data