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Research Article

How Bone Technology points to Cultural Lineages in Prehistory? New Insights from Danish Late- and Post-Glacial Weapons' Heads

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Abstract

The analysis provides a novel understanding of the technological details of the bone and antler manufacture in the 9th and 10th millennia before present as a proxy to emphasize contemporary Late-Glacial-originated versus Early Mesolithic bone technologies in Denmark. This paper contributes to the knowledge of newly dated bone weapons from Sjælland, Lolland and Bornholm's islands in the Late Paleolithic (Late Glacial, Federmesser, Ahrensburg cultures) and the Danish Early Mesolithic (Maglemose culture).

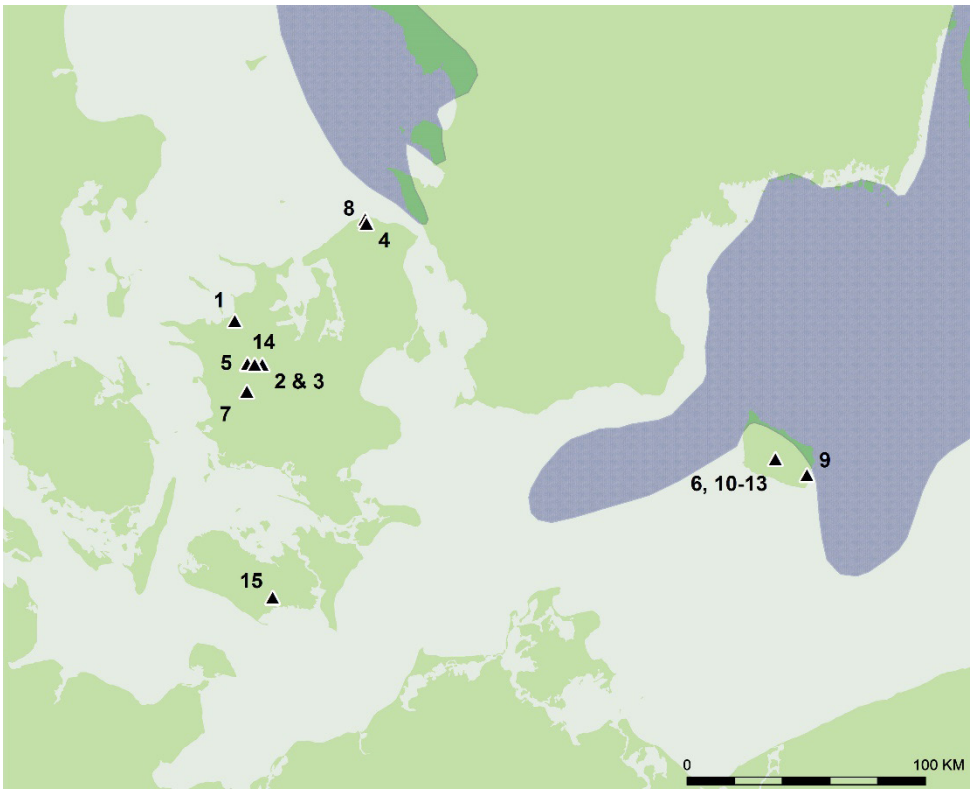
Keywords: Cultural evolution, Technical lineage, Harpoon, Leister-prong, Manufacture

Introduction

This last decade, developments in prehistoric archaeology opened a discussion on epistemological issues about reconstructing cultural evolution [1]. A novel paradigm arises as a new way to think the analysis of material cultures. If how every day's objects were made and used is relevant enough to reconstruct technical behaviors in order to identify ancient cultural groups based on a same technology, it must be conducted with taking a step back. A new and non-evolutionary perspective from lithic studies derives in this way from taking a larger framework in the technological approach which, not only considers the prehistoric product but also how to pursuit its examination [2]. According to that, the reconstruction of non-writing ancient populations in prehistory is no longer be limited to being perceived as a chronological suite of technology replacements, some to the detriment of others due to assimilated «progress», but as trees of various trajectories that last longer through bodies of similarly-manufactured implements with a transcultural effect, themselves repeated in a single materiality and/or artefact forms over millennia as if particularly adapted to a single environment [3]. The way we, ourselves, see stone or bone tools that have at once no meaning to us would have a direct impact on the way we interpret technical change in prehistoric archaeology. Represented by the weaponry of the last prehistoric hunters, it is the bone industry that is explored in the following pages to reveal whether using the technological approach might be different to help unearth cultural affiliation through the common use of daily practiced techniques albeit the bone tools morphologies, as for the lithic, might be either similar or different. This way, our knowledge may be based on a solid empiric analysis in order to give methodological clues about discussing archaeological cultures in terms of diversity versus evolution. To settle the study case within a particular chronological time span and geographical area where all the discussed items are framed, the presentation is supported with results from unpublished and newly acquired radiocarbon dates.

Research Background and Perspective

Eventually lost during various hunting and fishing, Stone Age weapons in the form of bone and antler armatures have been retrieved in Northern Europe as intact stray finds from paleolake or sediment deposits of ancient shoreline, sometimes by thousands [4]. Their exceptional preservation with pitch residues and/or binding fibers still attached to their stem enables to highlight the past know-how and ergonomic principles used in composing the projectile points [5]. Since intact implements are less represented as complete shapes in dwelling sites, the cultural attribution of these well-preserved stray finds often retrieved as bone and antler harpoon-heads is therefore quite important in prehistoric research, which is why these finds were particularly involved in dating programs [6]. However, relying on the chronological setting obtained from the sole absolute dating made some of these dated weapons directly serving as "fossiles directeurs" [7] and this prevented us from considering the value of this material in order to propose clues for exploring cultural attribution [8] and affiliation [9]. Given that various contemporary technologies or technical ways to achieve a material production might have occurred independently, there is a great potential in joining how the hunting and fishing equipment was traditionally manufactured with a range of time and space. Possibly inscribed within a single technical lineage [10], any gear similarly implemented might indicate the occurrence of specific cultural groups whose evolution relates to that of their material culture [11]. In this regard, it is expected that a Mesolithic technology in the Post Glacial would derive from an earlier Late Glacial technology if it belongs to the same tradition of tool-making, not because they are in chronological order but because both share the same principles used in the production design during a certain period which possibly is encompassing two distinct climatic episodes. If not, these technologies would be distinct in either time or space with no other correlation than they occurr in the same region. In order to emphasize such a technical lineage, the technological approach used here [12] examines the newly dated, so-called "Late" and "Post" Glacial types of bone harpoon-heads and leister-prongs from eastern Denmark (Map).



Map. Location of the oldest indented bone armatures (harpoons, leister-prongs) of Denmark, map with coastlines of the Ancylus lake period [59], ca. 8500 calBC [61]: 1–Skippinge Mark; 2-3–Sandlyng Mose; 4–Tammosegård; 5–Skellingsted Bro; 6–Vallensgård Mose; 7–Skaftelev; 8–Tormose; 9–Hundsemyre; 10-13–Vallensgård Mose; 14–Mørke Enge; 15–Skottemarke. All in Sjælland, except n°6 and 9-13, in Bornholm, and n°15, in Lolland islands. The labels refer to the inventory numbers in Table 1. CAD, L. Sørensen.

Late and Post Glacial archaeological material made of hard organics from Northern Europe is particularly interesting to conduct the technological approach since the bone points dated to this chronological frame (the transition phase towards the Holocene from the 9th to the 10th millennia calBC, i.e. before Christ in calibrated years - see [62] are always represented as remains of hunting/fishing equipment with more than half of the used production found discarded at a settlement site ([13]:Tab.33]). From more refined contexts, bone armatures were recovered amongst vestiges of animal carcasses still in anatomical connection

with a skeleton of elk [14] or pike [15,16]. These records thus indicate that the same armatures were used to acquire large size animal resources but for distinct game, mammalian versus fish. Some indented attributes such as barbs or notches (Figure 1) were therefore manufactured on the osseous points so that the weapon head, once shot, would stick into the animal body for possibly preventing lose the prey when trying to escape. Thus, these attributes may have played a role in "picking and carrying back" any game shot in an aquatic milieu regardless of the hunting techniques applied [17]. As grouping of points decayed in situ suggested that different types of bone armatures could have been used in mounting a single weapon [18], no obvious correlation can be drawn between a bone type and a singular function either-see [19]. The recorded diversity of shapes can hardly be explained by the material constraints of using a particular osseous matter or matrix for manufacturing these armatures for a single (detachable) hafting system: barbs made of antler can also be large even though these made of bone involve quite divergent barb-morphologies compared to those made of antler whose shape is squatter (Figure 2:3 compared to n°10). If not, from the archaeological context then, nothing seems to establish that a bone armature would have functioned like any other armatures unless specific analogies can be found in their use-wear patterns see [20] (Figure 2).

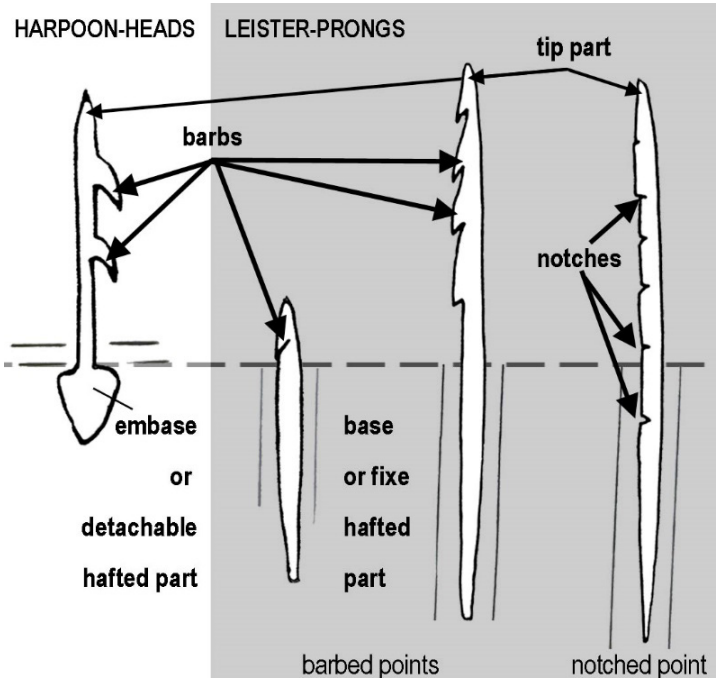


Figure 1: Terminology used in the paper. Sketch drawn by É. David.

Moreover, a previous chronological study of indented armatures indicates that, over time, barbed attributes slowly substituted for notched ones in the same tradition of tool-making [21] as if this evolution would obey an intrinsic pattern that a given technology would display over the long term [2]. From the observed diversity in osseous armature-types [13]: Tab.35], a single tradition in tool-making emerges as a result based on transmitted knowledge in crafting bone in Northern Europe from the 9th to the 8th millennia calBC, whereas some resembling tools might originally be rooted in diverse material cultures [22]. This is why our study of bone artefacts is now developing on the principles of the evolution of material culture based on the technical conception of industrial productions including stylistic variation and characters of innovation [23]. In our effort to formalize the links between past human groups and phenomenological-perceived, distinct archaeological cultures [24], we agree that this research perspective would contribute to approaches similarly developed on the lithic [25] to better reconstruct anthropological dynamics from the recording of systematic ways in which productions have been technically achieved, adorned and (re)invented and whose choices in implementing bone for daily use intrinsically endorse a cultural value.

Advanced research hypothesis

The apparent lack of harpoons from Late Glacial dwelling sites, even when bone is preserved suggests that osseous weapons would possibly have been left or lost in areas less systematically excavated because distant from the (invested) zones recovered as archaeological sites [26] to the effect that only the latter would be providing material with a cultural-bearing value. As a result, the fragments of bone harpoons found in there were more or less automatically attributed to the Late Glacial phase by morphological analogy to resembling types classically attached to pre-Holocene contexts [27]. In contrast, Early Mesolithic dwelling sites relative to the Early Maglemosian occupations (9,300-7,300 calBC) are usually filled with notched or barbed points mounted as leister-

prongs [28]. There, harpoon-heads are indeed poorly represented as formal types ([13]Tab.48). Therefore, it was classically assumed that harpoons would be Late Glacial and leister-prongs, Mesolithic. This being said, recent AMS radiocarbon dates of several of these harpoons from eastern Baltic retrieved as stray finds now indicate that this category of weapons can be of Mesolithic age in date [29]. This is in line with the new results obtained here from Danish material with contemporary ages c. 9,000 calBC i.e. also Mesolithic in date. But, as a surprise, some of the five newly dated harpoons supposedly representing Late Glacial types are of same age or even younger than the two other newly dated Mesolithic leister-prongs (Table 1).

Table 1: From oldest to youngest harpoons and then leister-prongs newly dated from Denmark (n°1, 2, 5 and 7 are AMS, the others are conventional). Calibration (with no correction): 95.4% confidence, OxCal version 4.4.2 [57] with IntCal20 atmospheric curve [62].

Inventory numbers	Provenances	Identifications						Related technologies with lithic and/or *bone armatures*		Radiocarbon dates			REF	Labels/ Fig. in this paper
	Finding areas or settlement sites*	Artefact categories	Dated materials	Length (mm)	Thick (mm)	Width (mm)	Barb depth (mm)	Lab. code		Age in 14C (BP)	2s range (calBC)			
A 39773	Sandlyng Mose	Harpoon-head	Antler	95	7.8	13.3	4 to 5	Lateglacial	*Federmesser*	AAR-9296	9905±65	9661-9255	a	3
A 42895	Skellingsted Bro	Harpoon-head	Antler	136.6	7.2	19.9	3 to 6	Lateglacial	*Federmesser*	Ua-54134	9835±37	9360-9247	a	5
Gim 991x1	Tammosegård	Harpoon-head	Antler	136.1	7.9	20	3 to 7	Lateglacial	*Federmesser*	not dated			a	4
A 31965	Skippinge Mark	Harpoon-head	Antler	118.3	8.8	20	5 to 6	Lateglacial	*Ahrensburgian*	Ua-54135	9735±36	9283-9159	a	1
A 22394	Vallensgård Mose	Harpoon-head	Antler	166.1	4.9	20	3 to 5	Lateglacial	unidentified	AAR-9404	9585±55	9199-8785	b	6
A 39782	Sandlyng Mose	Harpoon-head	Antler	114	7.8	19	4 to 6	Lateglacial	*Ahrensburgian*	Ua-54132	9533±35	9131-8753	a	2
A 38715	Skaftelev	Harpoon-head	Antler	252.2	5.5	19	4 to 6	Lateglacial	unidentified	Ua-54133	9218±35	8547-8312	a	7
A 22393	Vallensgård Mose	Harpoon-head	Bone	183	7.9	21.7	8 to 12	Lateglacial	unidentified	AAR-9297	9280±65	8702-8312	b	11
A 2175	Vallensgård Mose	Harpoon-head	Bone	191.8	9	18	5 to 8	Lateglacial	unidentified	AAR-13136	9145±55	8540-8270	c	10
Gim 563x3	Tormose	Harpoon-head	Bone	242	8.2	22	11	Lateglacial	unidentified	not dated			a	8
A 2176	Vallensgård Mose	Leister-prong	Bone	209	9	19.9	4 to 6	*Lateglacial*	*unidentified*	AAR-13137	9250±60	8621-8308	c	12
A 22392	Vallensgård Mose	Leister-prong	Bone	215.8	7.9	17.9	4 to 5	*Lateglacial*	*unidentified*	AAR-13133	8875±65	8242-7761	c	13
A 54546-n°X	Mørke Enge*	Leister-prong	Bone	not illustrated				Mesolithic	Maglemosian phase 0	AAR-9407	9605±65	9226-8793	a	not fig.
A 54543-n°VII	Mørke Enge*	Leister-prong	Bone	130	7	11	nc	Mesolithic	Maglemosian phase 0	AAR-9408	9595±65	9222-8787	a	14
A 20371	Skottemarke*	Leister-prong	Bone	115	6	10	nc	Mesolithic	Maglemosian phase 0	OxA-4864	9570±100	9246-8654	d	15right
A 20364	Skottemarke*	Leister-prong	Bone	not illustrated				Mesolithic	Maglemosian Phase 0	OxA-5528	9310±90	8768-8303	d	not fig.
BMR 1121x1	Hundsemyre	Leister-prong	Bone	293	4	16	2 to 3	*Mesolithic*	*Maglemosian*	not dated			c	9

Legend: nc-not concerned; REF-Princeps references: a-this paper; b-[6]:31; c-[63]:55; d-[58]

.According to the results obtained from the 17 discussed weapon heads, the two distinct categories of gear—harpoons versus leister-prongs—would match with the Maglemosian-phase "0" i.e. the earliest phase of the Danish Mesolithic based on the analyses of cultural remains retrieved from secure contexts [30,31]. If two of the dated weapons found in typical Early Maglemosian sites record the expected notched shapes, two others of a same age in date resemble harpoons, eponym of the last culture of the Late Glacial (Figure 2:1 and 2) typical to the Ahrensburgian culture [32]. However, when Maglemosian culture emerged, this Late Glacial culture is supposed to have completely disappeared with the dawn of Post Glacial in Denmark [33]. Thus, the two leister-prongs of Maglemosian-phase 0 and the two antler harpoons of Ahrensburgian-style, both found in Denmark with similar age in date c. 9,000 calBC in average, raise the question of whether human populations bearing different (Late Glacial-related versus Maglemosian) technologies would have inhabited the same (Danish) territory during Post Glacial or if human groups with a single crafting tradition in manufacture would be changing implements depending on the kind of hunts: large game shooting with harpoons versus fishing with leister-prongs using the same (Maglemosian) method(s) of manufacture (Methods "D" or "F" [21])?

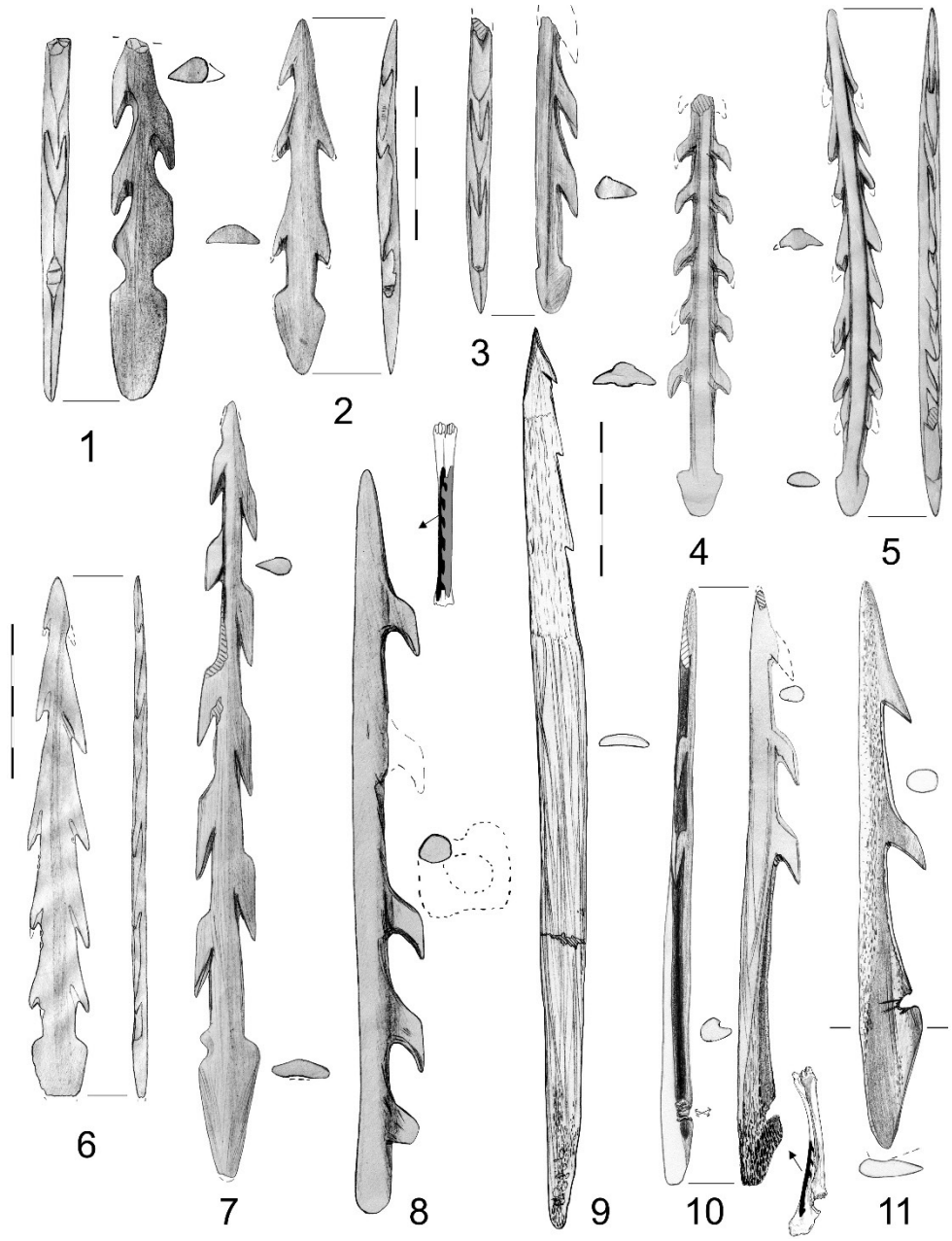


Figure 2: Indented bone armatures found as stray finds in Denmark: n°1-11–harpoon-heads, except n°9–leister-prong. Other than antler (n°1-7), the bones utilized refer to a metatarsal bone (n°8), a rib (n°9) and an ulna (n°10), all possibly from the elk, and an osseous material (limb bone?) from an unidentified (sea? horse?) large mammal (n°11). Barbed point n°9 shows degradation in zonation on the upper part of the stem (on both sides) possibly deriving from that the bone material decayed there in a different way, as if gastric juce of fish would have participated to this differential alteration of the bone (see Figure 4-photo). Scale subdivision, in cm. Drawings, É. David.

Apart from the problem evoked above (the artefacts representativeness depending on the kind of archaeological sites invested), there is no reason not to think Maglemosian hunters have not inherited an Ahrensburgian technology through factors of transmission [25], unless their technology was drastically divergent, not transferable then in equal terms, perhaps due to technical or material constraints. But their technology was not divergent since harpoons and leister-prongs—even though these probably account for the diverse hunting/fishing techniques of acquiring large size animal resources—both implied manufacturing indented attributes with lithic tools in the form of uni- or biserial series of notches or barbs regardless of the hafting systems required (detachable for harpoons versus undetachable for leister-prongs, supra Figure 1). Therefore, a comparative analysis was conducted between attributes how these were technically achieved in order to support a possible distinction between Late Glacial and Maglemosian technologies. Regarding the oldest specimens dated, there was a possibility that these could be Federmesser in chronology (Figure 2: 3 to 5) since they resemble the one from Kettig [34].

It is assumed here that if populations crafted their hunting gear themselves, they will have done so with their ancestral techniques regardless of the hunting/fishing techniques employed. So, if a Maglemosian method has been used to produce the barb's attribute of some Danish harpoons dated c. 9,000 calBC, this would mean that these weapons would have been made by Maglemosian craftsmen or with a Late Glacial-originated Maglemosian tradition, except if these particular harpoons could not be technically manufactured in a way other than the leister-prongs. In case harpoons would display (a) different craft(s) that would not be due to material constraints, one may conclude that this gear could belong to (an)other cultural group(s) based on similarities with types from abroad dated by means of absolute or relative dating (perhaps contemporary to Maglemosian) and possibly left or lost with no other tangible records in Denmark at least in settlement sites, during episodic or less easy archaeologically recordable events (shore hunting? in running water? on ice core?). It was hoped the way barbs were technically produced would give new insights into distinct cultural groups who crafted bone in Denmark at transition Late to Post Glacial for fishing and/or harpooning large game/fish [35,36].

Animal material-based weaponry

Amongst the available skeletal elements used to manufacture the newly dated weapons of large ungulates, metapodials certainly represent commonly transformed postcranial elements in artiodactyls: see in particular one specimen whose anatomical origin was identified by one of us (É.D.) thanks to the very long protruding osteological relief marking the harpoon where it reminds of the natural divided line of an elk metatarsal (Figures 2:8). Others, which concern the leister-prongs, also involved this same anatomical element (infra Figure 4:14 and 15-the two specimens) or the same animal species (Figure 2:9 and 10). The rest of the collection reflects the use of other anatomical parts (Figure 2:11), as rib (Figure 2:9), but mostly antler for harpoons (Figure 2:1-7). The bone material used in manufacturing harpoons and leister-prongs is particularly identifiable for the natural medullar canal which opens on a large heterogeneous and scarcely developed trabecular tissue was only low transformed in each case (infra Figure 4:12 and 13). Except for one harpoon-head whose thin cortex-ring on an homogenously distributed trabecular tissue but large in size reminds of the red deer antler (Figure 3:6c and d)—its cross-section also is quite large once reconstructed, suggesting the use of the beam or basal part—the reindeer antler was identified (É.D.) for almost all of the other harpoons by their un-pearled relatively straight outer surface opposing a denser trabecular tissue uniformly disposed on the inner side under a thick layer of hard bone. All these osseous material resources are in line with the range of animal species then available in Denmark [35].

As expected, various taphonomic aspects are recorded from the outer aspects of the studied specimens since the material was retrieved from diverse archaeological contexts attesting to the multiple origin of the collection. Each specimen displays a single color and porosity regardless of where it was worked or left rough. Therefore, none would have been made of fossil material for instance. However, two specimens have been processed after the antler became fossilized as observed from a real discrepancy between the original osseous surface and the worked planes whose difference in color or aspects probably derived from recent actions: in one case, the artefact has been freshly re-cut transversely (Figure 3:1a) (sampled for dating?), and in the other case, a series of recent depressions in the material along a modern cut shaping the barb (Figure 3:7c) is also particularly distinct in color and porosity from the antler stem, suggesting a Late Glacial antler material (indeed dated here to c. 8,500 calBC) had recently been used to replicate the shape of a Late Glacial harpoon. Consequently, this specimen is not included in the discussion on techniques (Figure 3).

Figure 3: Details of harpoon-heads from antler (n°1-7) and bone (n°8). Photos (magnification x20), É. David. [1–Skippinge Mark; 2-3–Sandlyng Mose; 4–Tammosegård; 5–Skellingsted Bro; 6–Vallensgård Mose; 7–Skaftelev; 8–Tormose].

Weapons with similar attributes but distinct in use

Each of the weapon heads presents barbed or notched attributes. These are mainly uniserial and made of bone (Figure 2:8-11) and biserial of antler (Figure 2:1, 2, 4-6) and, in the latter case, either symmetrical or asymmetrical (Figure 2:1). In order for harpoons to be detachable during use, their basal-end, namely the embase, was fashioned with a protrusion devised for attaching a binding system (string with buoy possibly) in a way as to anticipate for the possible pursuit of the injured prey [37]: the harpoon is less made to kill than to remain in the body of the animal once shot in order to make it bleed profusely and weaken it, until it is found again and slaughtered. Therefore, the embase was shaped for ergonomic reasons in the axis of the overlying series of barbs (Figure 3:8d, 2e, 4e and 6e) either with a slightly asymmetrical bi-shouldered tanged shape (Figure 2:1-6) or in the form of an auxiliary tongue fashioned on a side of the tang (Figure 2:8), or even through a deep notch implemented crosswise using the sawing technique (Figure 2:10 and 11). In contrast, the basal-end of the leister-prong was shaped in the continuation of the stem as to adhere to the shaft and to remain undetachable (Figure 2:9). Thus, the hafted part is usually revealed in this case not from the presence of an embase but because it was shaped at the extremity to be conformable to the hafting and/or from the location where adhesive residues remain and/or from singular differences in its use-wear patterns [38]. Among this

category of undetachable weapon heads, the notched points differ from the barbed points in that the finest attributes (the notches) distribute not only at the tip-end of the point (this is the case of barbs) but also along the stem and sometimes the tang too (supra Figure 1). The notches can be perceived as participating as much in the hafting as in serving to injure the animal game. If harpoons always have barbs, conversely barbed points refer to either a detachable or undetachable system (thus a distinctive practice of hunting or fishing). Since bone harpoons (Figure 4:10 and 11) here show barb morphologies similar to those on bone leisters (Figure 4:12 and 13), the techniques of barbs production regardless of the kinds of barbed points are comparable with more certainty than when comparing the distribution, size or kinds of attributes which would be relative only to how grip was assisting the binding system for instance or to how using broken points anticipated being turned on the shaft in the other way round (Figure 4:14).

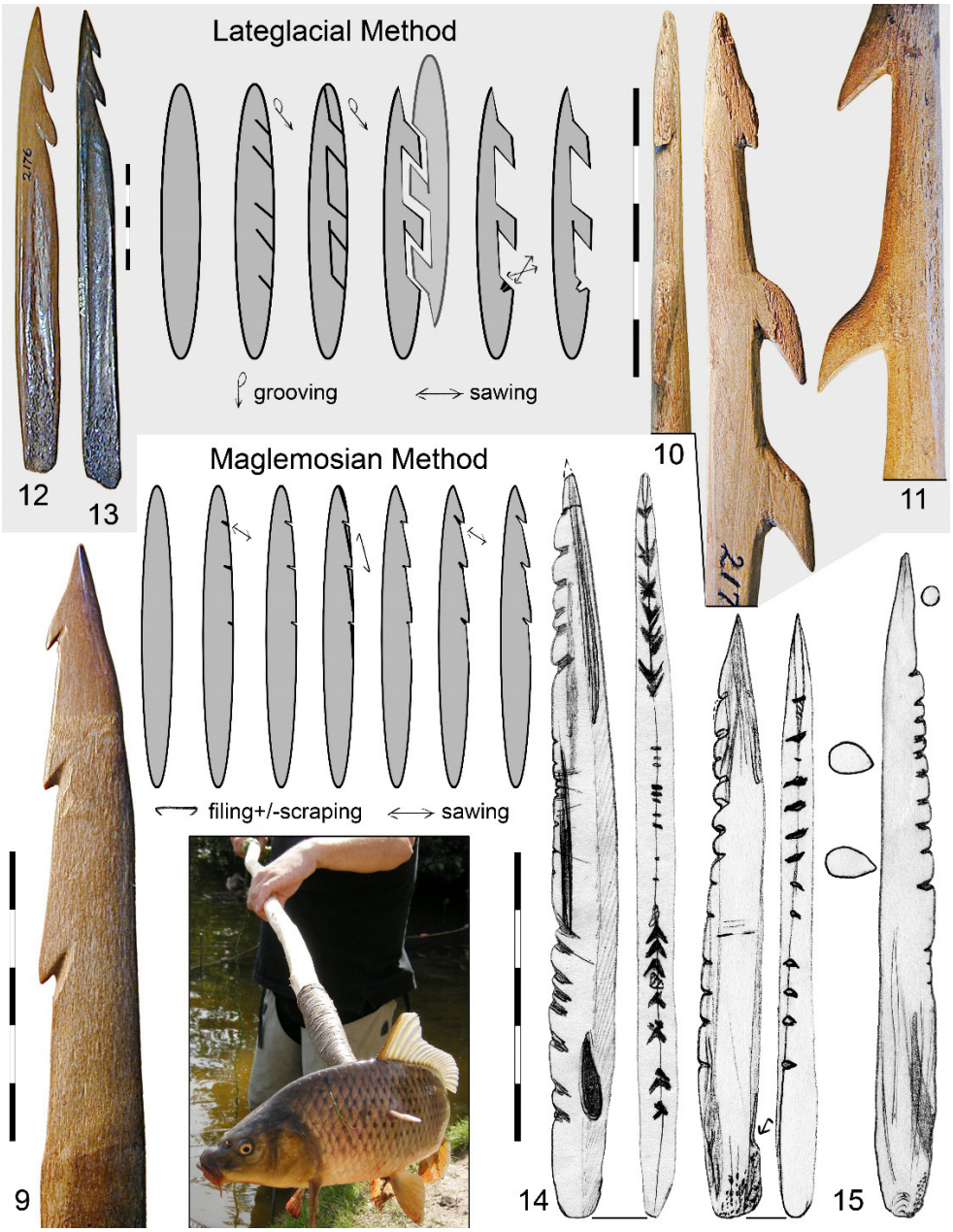


Figure 4: Manufacturing methods used to implement the indented bone armatures identified, regardless of their use as harpoons or leister-prongs and suggested function of Maglemosian barbed points made of mammal ribs experimented as a fishing gear with similar use-wear patterns as the archaeological ones [17]. The labels refer to the inventory numbers in Table 1 with addition n°15-left, from Skottemarke (n°A20439). Scale subdivision, in cm. Photos and drawings, É. David.

Detachable and undetachable systems for long-lasting use and style

Each of the weapon heads displays a more or less important symmetry in regards to being ballistic-compatible. However, the elaborated shapes suggest different "degrees of investment in manufacture" [39] which concerns the scope of the comparative analysis: barbs may have been manufactured differently for the purpose of a short versus long-term use for instance. Regarding the leister-prongs, these can be considered as resulting from a practical shaping of elongated splinters, notably when the basal-end is not distinctive (Figure 4:15 right and left) or because the point was only sharpened at the tip-end which precisely indicates that only the pointed part of the weapon was supposed to snap off if broken during use while the rest of the bone point would remain whole attached onto the (wooden) shaft (Figure 2:9). In regards to the practical use of ribs transformed into barbed points which also show a greater numbers of barbs however less deep than when of limbs ([13] :Tab.10 and 11), the underlying barb might have been produced in anticipation of the apical damage and the then resharpening of a tip at the broken-end so that the point could be properly reemployed "as a cutter", therefore taking advantage, as often as needed, of the great length of the costal bone once rebound on the shaft. So, the barbed point was meant for a long-term use, which notably explains the observed particular acute angle and large variations in the length forming the resharpened tip-ends in the archaeological material ([13]:Pl.24 and Tab.12). And it also explains the straight stepped-pattern of numerous active-parts broken at the level of the barb and the singular triangular flat fragments that were possibly torn off during impact at the meeting point between the bone surface and the shaft [17].

Regarding the harpoons, these show more often broken barbs than broken parts, which therefore probably continued to be used as damaged weapon heads as long as the ergonomy was not drastically changed from losing the barbs; much like continuing to use a hair comb with missing teeth. Differing in conception though, this last weapon was then also meant for a long-lasting use.

This being said, the way all these weapon heads were achieved in details might draw specific styles which, for now, find no particular explanations, if not, for the scale of the study itself; from the more or less pronounced protruding aspect of barbs, stylistic variations would either indicate particular craftsmanship (local scale), group (regional scale) or tradition (supra-regional scale) depending on the focus. This is particularly true for barbed points with a particular slender shape on a generous belly, which are associated to the Maglemosian culture in Northern Europe as well as to local styles in Denmark [40]. Styles have become part of the cultural identification to distinct between groups producing similar or resembling material shapes when techniques were not identified but technical patterns visibly recordable from specific profiles of artefacts [41]. This is also true for antler morphologies with a shouldered form of embase whose distinct cultural attribution follows that given from associated lithic material: Ahrensburgian versus Federmesser. When the antler stem remains plain-triangular in the crosswise profile upon a long "paddle-like" shaped tang in the first case (Figure 2:1 and 2), it is raised round in a low champlevé from grooves both-sided and aligned upon a shorter "tongue-like" shaped tang in the second Federmesser-style (Figure 2:3, 4 and 5). This variation, —see Figure 3:1c (plain) compared to Figure 3:3b, 4c and 5c (champlevé)—, might however reveal distinct hunt or a particular kind of animal game since barbs also stylistically diverge: whereas the "plain-style" with individualized protruding barbs occurs as a single type in the Northern parts of Germany ([34]:395) such as at Stellmoor in the eponymous Ahrensburgian horizon ([13]:Pl.12), the other "in champlevé-style" with tapered rows of round-barbs only is found in Rhineland with the Kettig Federmesser harpoon [42]. Unless both kinds were to be found on a single site in association with a single lithic material culture, these two styles of harpoons infer two cultural types regardless of their absolute dating [43,44].

Resembling barbs, but distinct know-how in crafting

If not relying on the diagnostic of the lithic production, the cultural attribution of osseous weapons is now based on techniques more than on types, although, as it will be seen again, from the latter may be recorded stylistic patterns that eventually provide with technical, therefore cultural markers. This approach is used here so that the differences observed in the aspect of the barbs can be established not as reflecting a different ability in crafting or stages in use but as typical shapes initially made different (Figure 4) and also, so that resembling shapes continue to be discussed based on the knowledge of the genuine ones in order to emphasize possible interactions between groups [45,46] (Figure 4).

Here, two methods enabled the manufacture of barbs after the osseous blank was first produced and mostly pointed by means of a convergent grooving as suggested from consequent axial planes on the outer edges (Figure 3:2a and b):

I. by cutting out (Palaeolithic-originated or Late Glacial Method), as first described by Dauvois ([47]:81) for the Magdalenian.

II. by reduction in abrading planes (namely the D and F Methods grouped here as Maglemosian Method), as first described by David ([13]:196 & 675).

Contrary to the carving technique only [48] or to the cutting out method whose related edges are quite straight in all profiles (Figure 3:3a, 5a, 8a, 4band 5b), reducing with the Maglemosian Method led to a relatively smooth convex-shape in all profiles with a particular short indentation just beneath the barb on both sides of the splinter (Figure 4:9). The reduction method consisted in sawing the bone or antler splinter's edge crosswise for implementing one or several transverse or oblique notches and filing them below until the expected depth is obtained for each barb. It sometimes ends up into a small cortical leftover matter which corresponds, when not removed by filing, to an accidental pattern left by the additional axial scraping with a flint edge for regularization with a 'down to up' motion and, because the flint edge is generally thick, it cannot really reach the underside of the barb. As a genuinely Maglemosian-made leister-prong, the barbed point found at Hundsemyre made of an elk rib (Figure 2:9) has been produced and shaped exactly the

same way as in the Mesolithic from Sjælland 8th millennium calBC. Albeit not radiocarbon dated here, this Danish find from Bornholm is clearly linked to the classic Maglemosian (M2) as this type of weapon is most representative of princeps contexts ([21]:91). Besides, as the Maglemosian method also served at producing a harpoon made of a rib with a deep barb (8mm) at the Lundby Holmen II site ([13]:251), it is comparable to the other method recorded below that was used to manufacture deep barbs.

The cutting out method consists in incising the shape of the whole point on a blank matrix (Dauvois' traçage) prior to grooving until the shape formed in negative is extracted by cutting it out "au découpé" (Figure 3:1c): see, in particular, the flat side of barbs resulting from the grooving before detachment (Figure 3:2c, 3a and 5a) if not from regularization (Figure3:4b). This is then a definitive shape with morphologically achieved barbs that was extracted using the "Late Glacial" Method (Figure 4-grey) for which the blank initially may have been used reversely i.e. the tip of the harpoon pointing either to the upper- or the anatomically distal-end of the bone [6]. The curvature of the barb in the crosswise profile indicates the use of the natural divided line of large cervid metapodials as a potential mid-barbed line leading to manufacturing twin harpoons once placed upside down; see Figure 2:8, with a production scheme that is then similar to the Løjesmølle's harpoon [49]. The harpoon stem made this way takes advantage of the thickest anatomical relief of either the anatomical cranial or caudal half of the bone. This production process of harpoons in pairs inscribes divergently-oriented grooves on the osseous surface due to having to work one or the other way around (Figure 3:8c to e), which therefore is responsible for the great variation observed in the barbs' morphology of a specimen. This gave a higher technical constraint in bone working and made the barbs even wider than these of antler where not drilled for shaping the barb from a possible perforation enlargement [50]; see the diverse aspects of the inner barbs' edge attest to the only grooving that was applied as the main manufacturing technique (Figure 3:3a to 8a). Since these points have been used with missing barbs, the exact process used, which would have possibly damaged some barbs during extraction, remains difficult to assess so that a technical affiliation between the studied harpoons and the Magdalenian ones could also be drawn. Since no cut off pieces have remained as archaeological material, it is most probable that pairing of harpoons was a common procedure, if not, produced from using a particular anatomical bone edge having for effect a slight twisting of the barbs in their delineation (Figure 2:10) and for which the method was eventually enriched with a lot of carving (reduction in removing planes); see the facetted aspect of the stem in achieving shaping the barbs (Figure 4:10 and 11) that conjoins with cut-off marks properly done for enabling to slim down some of them in particular (Figure 3:3d and 4c). In this respect, complementary studies are required to understand whether the double grooves marking the round-stem harpoons either of their faces (Federmesser-style) would possibly have a particular function since, in its delineation, each barbed edge appears as if obtained from a singular layout subsequent to barb production (groove and cleaving?), (Figure 3:4c and 5c). This stands out from the other harpoons whose barbs adhere most to the shape of the prior used or produced edge (Figure 3:1c and 2c).

In this sense, the "Late Glacial" Method is understood as a global mode that is possibly grouping diverse schemes in production which might therefore have required using techniques in specific ways (know-how), the harpoon being appreciated for its production out of a single splinter as a single product, double, twin, intertwined as uniserial on either side of another biserial, there arranged in the transverse cross section face to face, one over the other, in quincunx, with use of the anatomical divided line (metapodial) or imprints of blood vessels (antler) or not, etc. Further investigations are required to unearth such expectations from the dimensions, the very precise anatomical origin and shapes of larger collections of harpoons. As of now, the grooving technique itself is well identifiable from sets of parallel striations lying in grooves overlying one another under each barb with a different orientation due eventually to working in a convergent manner below and on the sides when forming the barb (Figure 3:4d and 6b). The barbs implemented this way were also incidentally incised from slipping outside of the groove when working on them in depth with an axial or transverse motion (Figure 3:5d/e and 8a/b). To implement the tang, the grooving technique is also recorded from convergent straight-cut planes in the lengthwise or crosswise profile with similar slipping markings on the bone or antler (Figure 3:2e, 4e and 6e). In some areas, the operation of extraction was performed after grooving the blank similarly on its inner however spongy side in vis-à-vis (Figure 3:6c, 6d); see the edge showing opposing grooves that have conjoined under a barb where not regularized (Figure 3:2d). Remaining unreached cortex was possibly removed by scraping or carving locally (Figure 3:4b and 4a, 3e respectively). As said, grooves might have sometimes been enlarged in surface to get less stubby barbs (Figure 3:1c and 5b). Less deep, these are made the same for manufacturing two leister-prongs (no embase) of bone splinters, whose size actually corresponds to harpoons (Figure 5:12 and 13). The concave shape between barbs each deeply marked by differently oriented grooves indicates the use of the cutting out method although, here, it is restricted to shaping up two barbs only at the tip-end. These last specimens indicate that leister-prongs could have been implemented in the same way as harpoon-heads, meaning that both types of barbed implements have a value for comparative analysis.

Discussion on the Contemporary Technologies

From our study, no morphological evolution could be unearthed from harpoons to leister-prongs or, in other words, there is no linear evolution from the Late Glacial to the Post Glacial types in chronology as formerly assumed for Danish assemblages [51]. On the contrary, the dates show that all categories of points already occurred in the region in the 9th to the 10th millennia calBC (Figure 5).

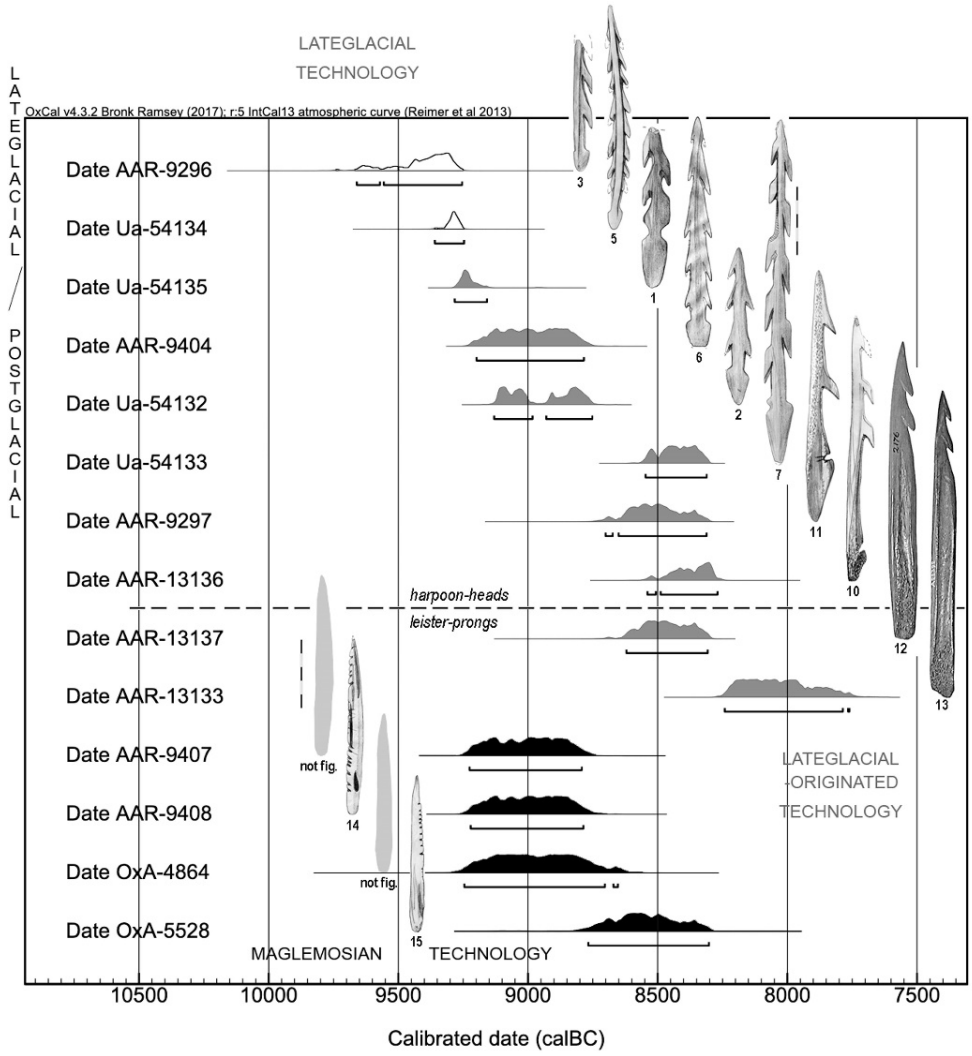


Figure 5: Oxcal plot showing the calibrated dates (see Table 1) for 8 antler and bone harpoon-heads (n°1-11) and 6 bone leister-prongs (n°12-15) showing these manufactured with a Lateglacial or Lateglacial-originated technology (grey, possibly all with an Ahrensburgian-style when of antler, except, in white, with a Federmesser-style), or Mesolithic (Early Maglemosian phase 0) technology (black, n°14-15). Scale subdivision, in cm. Drawings, É. David

The sensible shift in the choice of raw material from antler towards bone for the earlier to the later specimens of harpoons might correspond to a decline otherwise recorded in the richness of animal species due to climatic and environmental change [59], which included the reindeer in the region ([35]:39). In regard to the manufacturing of harpoons, the use of the other available cervids such as the red deer would have been favored, which could be transformed according to the same terms (Figure 5:6). Harpoons continued to be implemented when leister-prongs appeared and large barbs are found with similar aspects regardless of the raw material that was used. However, certain styles occurring in antler (champlevé) would wait (long?) before being seen again for armatures in the Latvian Preboreal for instance besides several mainly bone harpoon-heads ([45]:242-8). This being said, as developed above, the manufacturing methods used to shape the barbs were drastically distinct with a clear opposition between the Late Glacial(-originated) and the Maglemosian styles regardless of the armatures-types involved.

Since only small barbs are then made preferentially [21], the Maglemosian reducing method in abrading planes appears as an (Early) Mesolithic concept. The method is not recorded so far in the Upper Magdalenian although barbed points are available with such small size in depth since the «Gourdanian» (Magdalenian IV) at the Mas d'Azil Piette's excavations (France), for instance (David, ongoing research). During the Post Glacial, as if it was coming from (a) different crafting tradition(s), the cutting out method and the reducing method in removing planes seems relevant to the Late Glacial or Late Glacial-originated technologies, as suggested from other evoked finds in the Northern Europe where it is recorded for similar types found in various non-Maglemosian contexts, but a complete study of the barbed bone and antler points of the so called back- and tanged-points groups has to be undertaken in order to perhaps attribute the evoked methods and styles to a more particular lineage or region. Pending for the other known harpoons and leister-prongs attributed to Late Upper Palaeolithic and Late Glacial traditions to be reinvested for the technology they would

bear, we hope that we have presented here further that will help distinguish between the various technologies possibly involved. By now, these Danish stray finds show a noticeable homogeneity in regards to technology, regardless of the diverse cultural affiliation proposed (a paradox?). This makes the human groups behind these finds in close relationship although individually possibly using similar hunting areas [52].

Finally, our specimens here that are recording Late Glacial-originated and Maglemosian technologies in the same large chronological episode may refer to contemporary resilient and novel forms of expression regarding the technologies relative to main subsistence. Since recent discoveries identified the presence of one (Ahrensbourgian) of these Late Glacial complexes further north in Sweden and Norway all the way to Finnmark [59] and up to the Preboreal [54], we presume that human groups traditionally related to former Late Glacial technical traditions might have occurred lately in certain regions in parallel with when the Maglemosian bearing populations used antler or bone leister-prongs in their pioneer phase from c. 9,600 to 8,800 calBC (starting with Star Carr). Being principally wild boar hunters [55], these really were not familiar hunting with osseous harpoons. This is eventually supported here by the technology and the newly dated chronology of the finds: whereas a first set of earlier dates associates the oldest chronological frame with both the typical Maglemosian leister-prongs (Figure 5:14 and 15) and Ahrensburgian/Federmesser harpoons (1, 3, 5 and 6), the second and later series of dates concern again some (Late) Ahrensburgian harpoon (2) with other either Late Glacial-originated harpoons and less typical harpoon-sized leister-prongs, as if transferred from Maglemosian (?) to resident Late Glacial-related population (10 to 13).

Conclusion

The present paper discussed the technology of ten harpoon-heads made from bone or antler, and seven bone leister prongs mainly found as stray finds from Sjælland and Bornholm in Denmark. Four harpoons have been newly AMS dated (n°1, 2, 5 and 7). If we agree that the dating results fit with the Preboreal chronozone c. 9,300 calBC, the harpoons are synchronous to the Danish Early Mesolithic (Maglemosian). According to our technological analysis, coupled with a consideration of the records from contemporary contexts, the harpoons holders were not Maglemosian but (a) group(s) practicing a Late Glacial-originated technology, the described Ahrensburgian- and Federmesser-styles included, which probably lasted longer in this western facade of the Baltic area. The latter supports evidence of a particular cultural lineage through practicing a unique technology opposed to another (Maglemose) locally clustered in the same region in Denmark, regardless of the tools final morphologies. As a main result, Late Glacial-originated and Early Mesolithic bone technologies occured contemporary in Denmark 9,300 calBC.

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Conflict of Interest

No conflict of interest

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