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Editorial

In the entertainment industry, there is a long-standing argument proclaiming the difficulty of making a sequel that is just as good as or even better than a successful first. We will leave it for others, you, to judge whether this paradigm also applies to academic publications, but feel that, at any rate, the launching issue of the *Danish Journal of Archaeology* has been a 'successful first'.

The reasons for this success are many, not least the considerable amount of work that has been put into getting our homepage up and running, as well as with finalising the printed version. New and old readers alike, as well as our many collaborators, will hopefully find the revitalised journal to their liking.

One of the advantages in having an online platform for publication and distribution lies in the possibility of getting a rapid and clear quantitative overview of the digital user behaviour; because *DJA* has, from the onset, published all articles following the principle of 'Rolling Publication', where the finished and typeset articles can be found online immediately, we have been able to monitor the traffic on our homepage at Taylor & Francis (www.tandfonline.co.uk/rdja). The amount of full-text downloads has, by the end of September 2013, reached just over 880, and there is a clear picture of progression, too, telling us that there is a steady increase in the number of readers visiting the homepage and downloading articles.

One of the main reasons for this positive trend must certainly be located in the expanded distribution network, which has accompanied the relaunch, and the increased number of libraries that host the *Danish Journal of Archaeology*. At present, there are almost 2000 libraries worldwide, which offer online access to the journal, and several of these also already have, or plan to include, the printed version as part of their holdings.

Important information can be found in the spatial distribution of download frequencies, which allows us to distinguish the geographic position of the more active locations. It can hardly come as a surprise that the libraries and institutions topping the list are Danish, and of these the Royal Library, the State Library/University Library in Århus and University of Copenhagen account for the three most active locations. Nevertheless, and most positive indeed, the following places are taken by institutions from most of Northern Europe with, for instance, the universities in Oslo, Lund, York, Utrecht and Gothenburg, as well as the Swedish Library Consortium on the list. Of course, we would have liked to see one or more German institutions represented in our 'Top 10 list' as well. These circumstances do, however, provide the editors with a clear incentive to increase our effort to promote the journal in this particular region, a marketing effort that started with the editorial team – with the first printed issue in hand – presenting and promoting DJA at this year's 19th European Association of Archaeologists' (EAA) Annual Meeting in Pilsen, Czech Republic. Speaking of presenting and promoting, the editors would like to thank the attendees for the positive feedback we received during (and after) the Book Reception held at the National Museum, a pleasant gathering, with a good number of authors, collaborators, editorial board members and reviewers coming together – and leaving with a printed copy!

But let us return to the download data. The reason for the diverse geographical distribution of downloads, can, with good reason, be attributed to two main factors: first, the wide-ranging collection of subjects and periods, which can be found in DJA vol. 1(1 + 2), and, second, the geographical distribution of the authors themselves. Regarding the content, the first volume of the journal presents articles ranging the Late Palaeolithic to the High Middle Ages, and covers subject matters as varied as Neolithic swidden rotation, the production of Bronze Age swords in the light of Baudrillard's theory on simulacra, as well as the clerical residences of the Middle Ages – a span of subject matters rivalled by only a few other archaeological journals. With regard to the authors, they together hail from seven different countries. That such a diverse group of authors has contributed to the first volume bears witness to the fact that the archaeology of southern Scandinavian holds a significant and desired research potential, but also that the *Danish Journal of Archaeology* has managed to fill a vacant quarter for methodological/empirical research publications, which, in the end, has invoked attention from most of Northern Europe.

In this respect, it is perhaps most important to emphasise that this tendency continues with *Danish Journal of Archaeology* volume 2(1 + 2) once again including a varied group of nationalities amongst the authors, and that the debates and periods focused upon in the current volume are rather diverse. Substantive *Research articles* and *Research reports* in issue 1 touch upon Late Mesolithic economy, Bronze Age weaponry and medieval church construction. A sneak preview of issue 2 offers –

peer-review allowing – treatments of Ertebølle ceramics, of Bronze Age chronology and cremations, of early urban Copenhagen and of Nordic grog.

As part of the volume 2(1) we also publish a further cluster of *Discussion articles*, this time focusing on one of the more hotly debated finds of the last decade – the small figurine from Lejre, Zealand. Despite its rather modest proportions (just over 4 cm^3), the figurine has attracted much attention, in part so because of the find location in the legendary Lejre, but also because the motive itself can be interpreted in relation to several of the written sources from the Middle Ages that describe the sagas and narratives from earlier periods.

Furthermore, the figurine is important because it stresses the circumstance that the main contribution and expansion of the understanding of the pre-Christian, ritual behaviour most likely will be based on archaeological studies rather than on written sources. The increase in basic data material is to be found almost exclusively within material finds and their related contexts, and only in a very limited fashion from written sources. In other words, research now begins to be able to specify and 'excavate' the narratives concerning pre-Christian religion. We chose to include the Lejre figurine because of its significance in this context, but also in order to try to broaden the interpretations regarding its character and composition by introducing several methodological viewpoints. The three contributions thus aptly showcase the disciplinary diversity found within contemporary archaeology. Furthermore, should our readers disagree with the presented ideas, or just wish to clarify or expand further on the interpretations of the Lejre-figurine (or any other article for that matter), we strongly encourage people to send in contributions to our *Discussion articles* section. It is one of our main goals to have and uphold a dynamic approach to current and future articles – and for that to happen it is critical to have 'active' readers.

In the same vein, we naturally invite readers to submit their manuscripts to the journal with reference to any of our article categories. This also includes *Brief communications* that have the intent of swiftly distributing concise information about events, finds and all things archaeology. Note also that although we normally endeavour to constrain the quantity of words and pages in the incoming articles, exceptions can be made. However, longer articles will only be taken into consideration if the author or authors, in advance, have made a clear and valid argument for why a lengthy article should be submitted. Likewise, it should be mentioned that we, so far, have not been so fortunate as to receive manuscripts about historical or contemporary archaeology. Therefore, if you should have a research article ready for publications, which takes up archaeological subject matters from the Reformation or after, we would be very pleased to consider them for the *Danish Journal of Archaeology.*

Throughout the process of revitalising the journal we have had to establish a series of procedures and practices, allowing us to handle the various and varied stadia of review, revision and production that each article must pass through. These procedures have continuously been adapted to our needs and we have now succeeded in streamlining the production pace to such an extent that the turnover from submitted manuscript to finished article has been reduced by more than 30% vis-à-vis volume 1. This entails that our readers will be able to find articles of current interest uploaded regularly, but also that the authors will be in contact with us and their manuscripts on a very regular basis. These factors will heighten the quality of the journal not only for the readers, but most certainly also with regards to the cohesiveness of the articles.

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Medieval church roof constructions in North Schleswig and Southwestern Jutland – examples of tradition and innovation

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Only few of the Danish medieval parish churches can be dated. This paper presents an attempt of doing so by the help of dendrochronology of a number of church roofs of different types. Results show this is possible although only in cases where original roofs are preserved in a sufficient degree. The typology of church roof constructions has been revisited and so has the general dating of types and their origins.

Keywords: church roofs; dendrochronology; dating; innovation; timber construction

This paper presents an attempt to date, by means of dendrochronology, some of the very well preserved, medieval church roofs of Southwestern Jutland and North Schleswig (Figure 1). One of the main theses of the project was that dating the roofs should also establish datings of the time of the erection of the investigated church and its building materials. This in turn could establish a somewhat more reliable basis for the dating of the occurrence of building materials such as tufa stones and bricks in the town deposits in the city of Ribe (Madsen 1993, 1994, 2007, cf. 2005a, 2005b).[1]

Although the interest taken by Danish scholars in medieval roofs had an early start at the end of the nineteenth century, represented by amongst others the Director of the Prehistory Department of the National Museum, Dr. Sophus Müller (Figure 2), the general conclusion was that most timber constructions in the medieval parish churches were the result of post-medieval rebuilding and repairs (Müller 1887, Storck 1890, Koch 1899, Schultz 1940). This view was finally changed when Elna Møller published her initial study of church roofs in South West Jutland and North Schleswig in 1953. She convincingly proved that roofs from the Middle Ages were far from an exception and that quite a lot of them seemed to be original and perfectly preserved constructions from the time of the erection of the church (Figure 3). In this first attempt to date and typologize Danish medieval church roofs, Møller emphasized the importance of timber numbers and numbering as indicators of medieval carpentry practice (cf. Moltke 1953, Møller 1953, 1963).

At the beginning of the 1950s of course no dendrochronology could be applied to her investigation and her terms and tentative datings had to remain unsupported until this method was taken into account by a new project in 1986. The initiative to combine Møller's investigating with dendrochronology was taken by Elna Møller, Hans Stiesdal and myself as a collaboration project between the National Museum and the Museum of Ribe, Den antikvariske Samling. Dendrochronological analysis were carried out by Wormianum or by NNU, the National Museum's Department of Natural Sciences.[2]

The first phase of the investigation was a series of limited dendrochronological samplings in fourteen selected village churches which, as far as roofing is concerned, were considered to be among the most interesting and best preserved in the country, while at the same time offering the potential for finding answers to the general questions posed by the project. Later on, more churches were added as part of the work of the Danish church inventory, Danmarks Kirker, forming an initial total of 23 church roofs (Figure 4). They are distributed fairly evenly over the Southwestern and Southern Jutland and North Schleswig region, with a certain concentration in the vicinity of Ribe, but on the whole corresponding in size, materials and architecture to the overall distribution of the village churches of the area.

The consistent use of timber numbers and the numbering of individual pieces of timber in order to indicate the proper placing of trusses and timbers formed the basis for analysing the roof constructions (Figure 5). The point of departure was the hypothesis that consistent, intact numbering would document the composition of the roof constructions in question. This hypothesis was confirmed, although this does not necessarily mean that every such roof construction dates from the time when the church was

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Figure 1. Map of Medieval Denmark and the Duchies of Schleswig and Holstein, the physical position of Ribe being within the boundary of Schleswig. In the Late Middle Ages the city became a part of the Kingdom of Denmark. Drawing: Merete Rude.

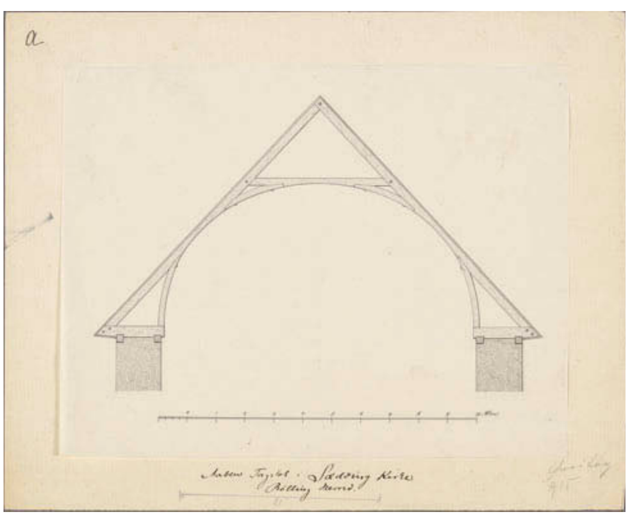


Figure 2. Roof construction above the eastern part of the nave in Sædding Church. After Müller (1887).

built and thus enables us to use dendrochronological analysis to date the building of the church accurately. The numbering systems observed were all applied by carving, chopping or scratching in the wood; no numbers made with either paint or chalk were observed, and in all cases they served to identify the position of the trusses in a predetermined sequence. Usually the number was applied to several or all of the timbers in the trusses, since the builders chose to combine the numbering with an indication of where and how the individual pieces were to fit together in the trusses. What we have is thus a combination of timber fitting marks and sequential numbering of the bays, a procedure that may turn out to have been characteristic of both the investigated roof constructions and their counterparts elsewhere in the country. The practice in the numbering area seems to correspond best to what we know from Germany, a similarity that cannot come as any surprise in the Southwestern Jutland and North Schleswig area, and which emphasizes that these regions should hardly be viewed as a relict area. On the contrary, the question must at present remain open whether, unlike here and the rest of Denmark, timber numbering can never, or can only later in the Middle Ages, be demonstrated in Finnish, Norwegian and Swedish church roofs (Hiekkanen 1989, 1995, p. 261, Binding 1991, p. 14 and 63, Sjömar 1992, 1995, p. 210/fig. 4, p. 212/fig. 7.l, Storsletten 1993, 1995, p. 153, 2002, Fischer-Kohnert 1999, p. 7 and 29).

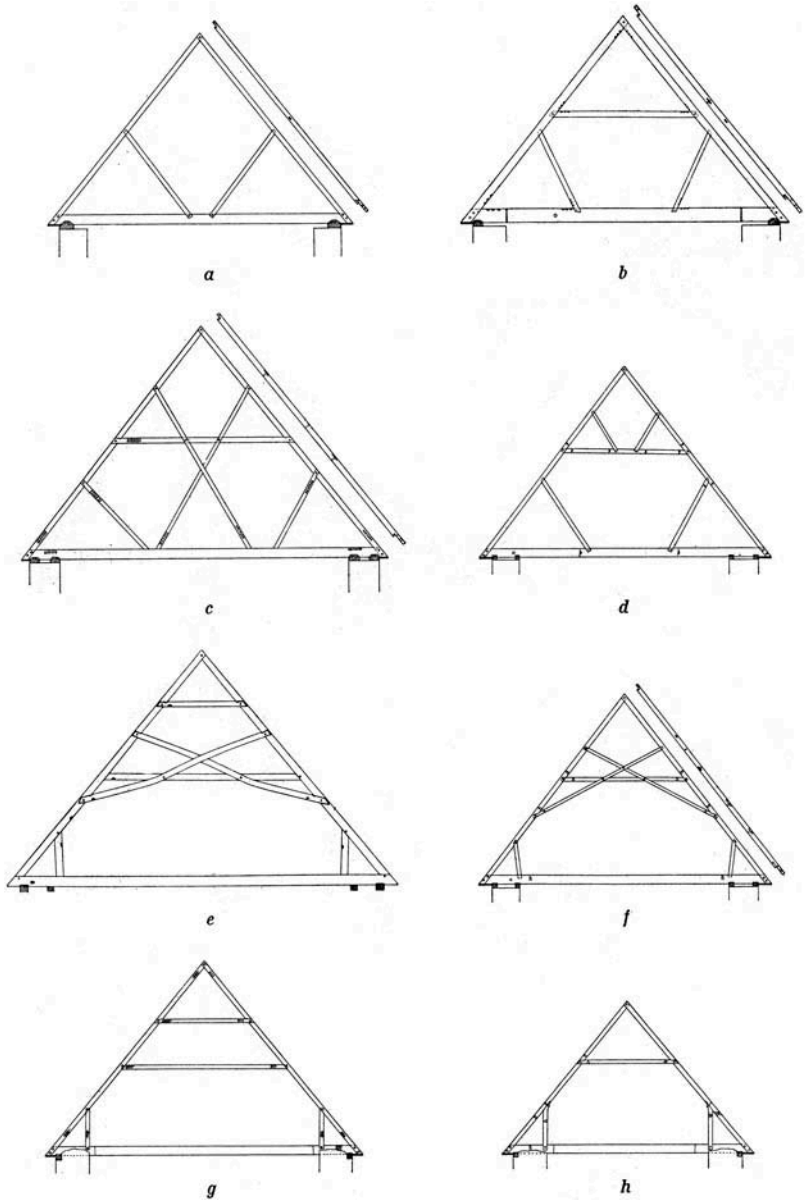


Figure 3. Elna Møller's classification of truss types from her paper in 1953. After Møller (1953).

From the outset, the investigation concentrated on the roofs over chancel and nave, since at first it was considered that the apse roofs offered limited potential. In general the project gave the highest priority to shedding light on the building date of the churches and their oldest construction history (Figure 6). Roof constructions in annexes to the churches were not included, not even for the possibility of demonstrating recycled timbers, something that was however investigated in the roofing of the oldest parts of the buildings, but without success. At first the sampling concentrated on the largest timbers with most growth rings, which were expected to produce the best results. As the work progressed, the smaller apse roofs also proved fruitful, and other pieces of timber could be included. This applies for example to the rafters, which unlike the tie beams and despite their often rather few growth rings may have preserved both the youngest growth rings and even the bark of the tree.

The project has produced several surprises in cases where roof constructions which were assumed to be contemporary with the erection of the church in question, and which had given their names to accepted type classifications, ended up being far younger than expected. This is

Figure 4. The 23 primarily investigated churches in Southwestern Jutland and North Schleswig. Drawing: Merete Rude.

the case with the church in Arrild some 15 kilometres south east of Ribe (Figures 4 and 7) (Danmarks Kirker 1953, p. 1264, cf. Danmarks Kirker 1963, p. 2700).[3] Elna Møller once called the truss type in the nave, with its two pairs of long struts, the Arrild type (cf. Figures 3c and 8). At the same time she considered this and a related type called after Arrild's neighbouring church Roager to be the oldest truss types exhibited by the churches of the area. However, it has been established that the timber in the roof structure of the nave of Arrild was felled in 1354 – but it should be noted that this was a renovated roof, which had replaced the original one of the same type after a fire. The Roager type too has turned out to have a considerably longer history than was thought, so we must assume that these types represent longer-standing regional features rather than chronological features alone and that they should not be considered as chronologically significant for any larger regions.

In the case of some of the churches where one could reasonably speak of contemporaneity of the building of the church with the preserved roof construction, a later construction date has been identified than traditionally suggested. In this respect the comparison is to some extent unfair, since the dating of churches in Denmark has almost exclusively had to be based on the wider framework of style-historical analyses, and in the present investigation we only have a geographically and otherwise limited segment of a very large body of material. When it comes to the building of stone churches in the western part of North Schleswig and in Southwestern Jutland, the transition between the almost unknown wooden churches and the standing stone churches, as proposed by Elna Møller, must have been relatively late – that is, in the period between c. 1200 and 1250/75 (Møller in Danmarks Kirker 1963, p. 2657, Møller 1979). This applies not only to the

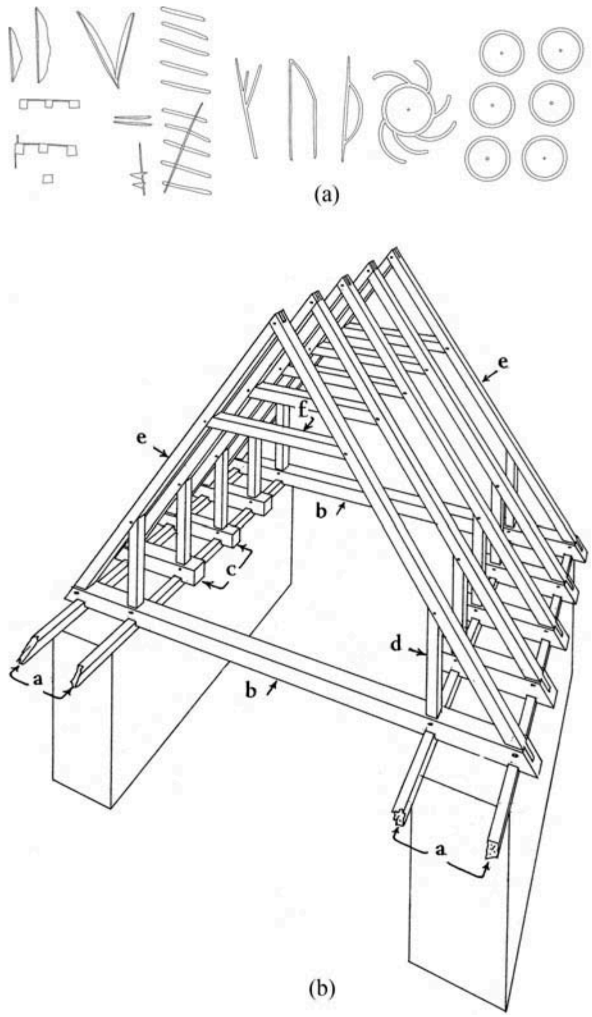


Figure 5. a. Timber numbers of various types, made with an axe, with a chisel or a knife. b. Designations for the most common parts of a medieval church roof structure. It consists on this drawing of five trusses on a set of double wall plates on each crown. a: wall plate. b: tie beam. c: truss – cut-off end of tie beam. d: vertical struts. e: rafter. f: collar beam. After Danmarks Kirker (1998–2000, p. 47).

stoneless areas to the far west, where imported calcareous tufa and brick may have been in use almost at the same time. Indirectly it emphasizes the unbroken importance of building in wood well into the Middle Ages which is also testified by other sources.

If the conclusion must be drawn with caution this is also due to the reservations attendant on the attempt to establish and especially to date the four different main types of truss: the Roager type, the Arrild type, the crossbeam type and the collar-beam type with which Elna Møller operated in the area investigated (Figure 3). The types can still be distinguished, but rather than a general development we may be dealing with regional preferences, and perhaps in the case of the Roager and Arrild types, of a relict-like character. As a partly alternative supplement attention has been drawn to the appearance of interior, short struts in the individual types (Figure 8). These struts and the rigidity in which they lock the truss, are seen as a crucial feature of the development in terms of controlling the stress exerted by the roof on the roof construction, and which the short struts help to propagate down into the core of the stone walls. For obvious reasons no parallels to this can be observed in timber architecture where only thin wall constructions appear. The use of the interior short struts should maybe be viewed in the context of the development of building with stone in medieval Denmark as it seems rather difficult to point out inspiration for this particular feature outside Denmark from before the time around and after c.

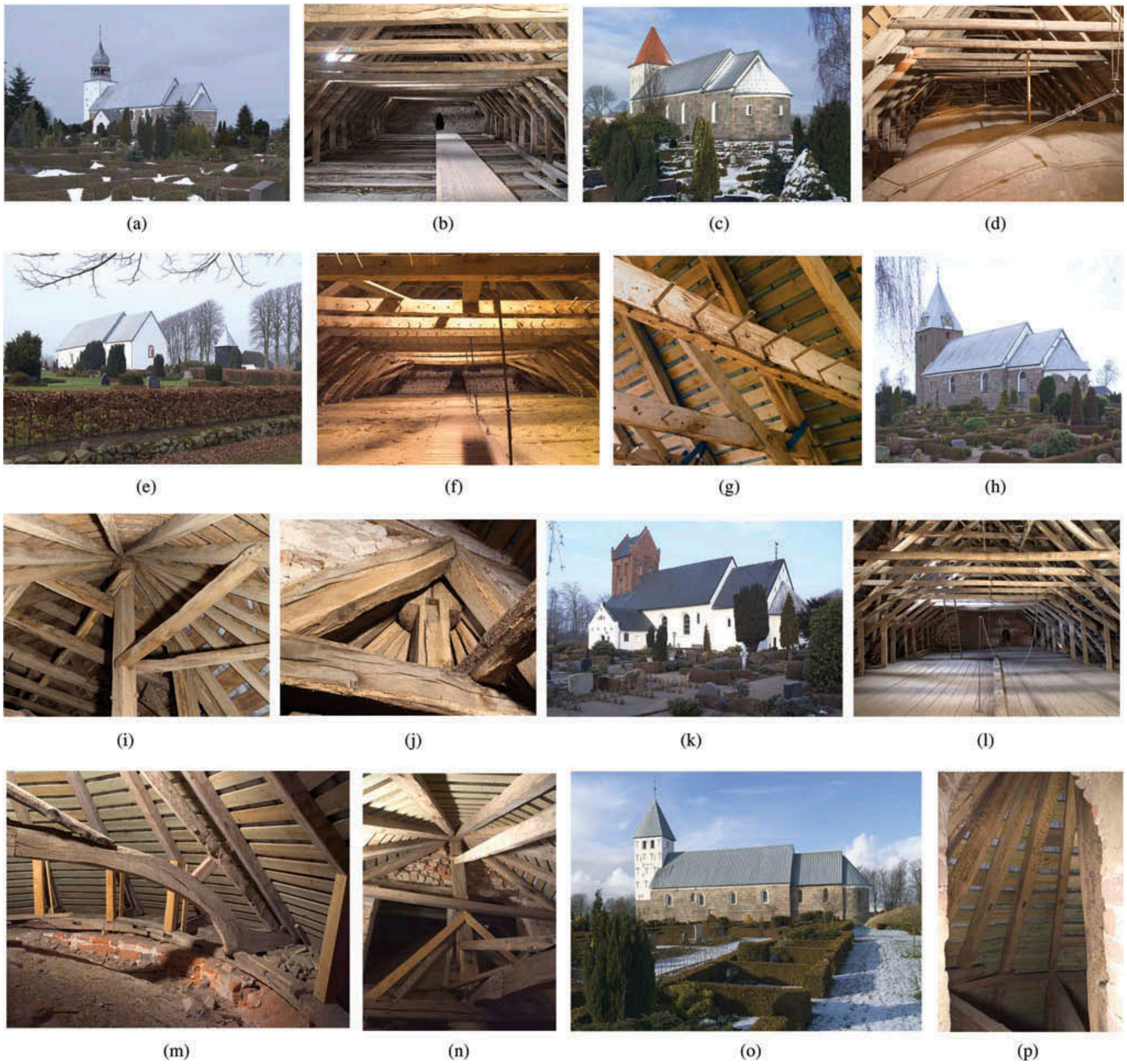


Figure 6. Some of the churches from the investigation. All exteriors from the south east. Photo Roberto Fortuna, February 2005. 6a–b: Andst Church, exterior and roof construction of the nave. 6c–d: Føvling Church, exterior and roof of the nave. 6e–g: Felsted Church, exterior and roof construction of the nave with inserted hooks used to hang up uniforms and weapons. 6h–j: Sdr. Hygum Church, exterior and roof construction of the apse with its kingpost. 6k–n: Bylderup Church, exterior and roof construction of the nave with the curved beam which runs across the vault of the apse and the roof construction of the apse. 6o–p: Brøndum Church, exterior and the partly preserved roof construction of the apse.

1200, when the oldest of the obtained datings of the *post quem* type and others are concentrated.[4]

All in all, for both chronological and technical reasons, one should refrain from calling any of the established truss types either Romanesque or Gothic. The technical development of carpentry will not have been associated solely with the churches, but would also have included the always far more numerous and undoubtedly equally complex solutions that non-ecclesiastical buildings required. One thinks of the possible relationship of the Roager and Arrild types to the presumed wall or head plate constructions that excavations of village houses and farms in both North Schleswig and Southwestern Jutland have demonstrated (Figure 9) (Madsen 1985 on head plate construction, Donat 1993, Sørensen 2003, p. 441, Smith 2004, cf. Smith 1982,

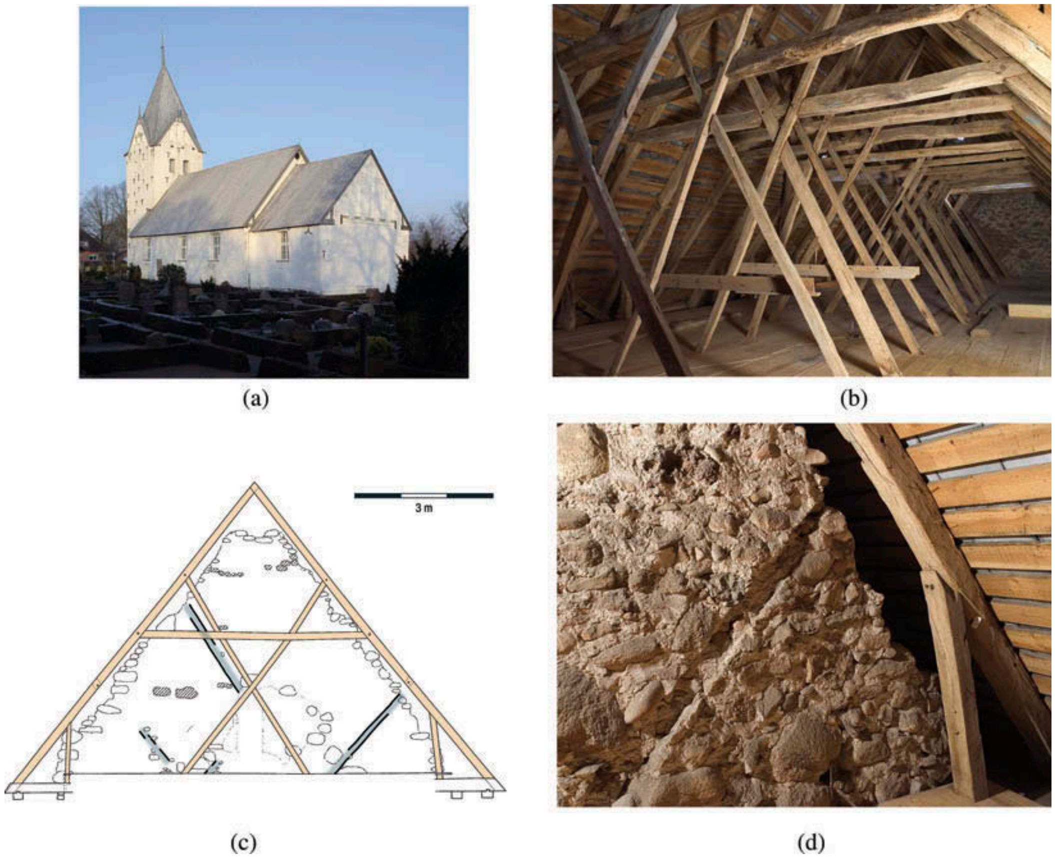


Figure 7. a. Arrild Church viewed from the south east. b. Roof construction of the nave viewed towards the east. c. Measurements of the west side of the gable between the nave and chancel. When the gable was built, the impression of a truss (shown in grey) of the same type as those found in the church today (shown in brown) was made in the masonry in front. d. The impression in the wall does not correspond to the empty hole from a similar strut in the standing truss in front of the gable. The nailed-on strut is of more recent date. To the right of the strut by the white slip of paper a sample was drilled out which showed that the tree in question was felled c. 1354. Measurements and drawing: Erik B. Fisker and Claus Feveile 2002. Photo: Roberto Fortuna, February 2005.

Søvsø 2012). Placing trusses on top of two parallel head plates in fact corresponds very much with the way that trusses and roofs are set on top of stone walls. No fixations between masonry and timber are used, the roof must stand supported by its own weight, nor does the placing of trusses in either of the two kinds of building need to follow either the row of posts or the architectural structure of the wall with window and door openings, etc.

On the other hand the upward dating of the types is not quite firmly established for exactly the two types of truss that used to be considered early, since both only passed out of use after c. 1400 – the Roager type perhaps as late as the end of the Middle Ages. The crossbeam trusses are underrepresented in the investigation, as they are normally associated with vaulted churches, but the type probably appeared in the investigated area as early as the 1200s. The collar-beam type is present from c. 1200, perhaps before, and in practice, together with the crossbeam type, becomes more and more dominant, and almost reigns supreme with the erection of new roof constructions in the churches of the area from the 1400s on, judging from the results of the investigation. Renewed, Late Medieval roof constructions of the crossbeam type on a number of the more substantial granite churches in the swathe from Ribe to the east do however shade the picture more subtly and shed light on the area's otherwise so little-known art of wood construction at the time. Although the crossbeam trusses in the stone churches are presumably associated most with vaults, it is not inconceivable that magnates in the area had carpentered houses with similar constructions, and that the renewal of a whole church roof with its considerable consumption of resources would have been an aspiration for a conscientious churchwarden.

The timber for the church roof constructions investigated is taken, as far as can be judged with a single exception, from the area in which the churches lie, and regional traditions would thus have been able to persist in

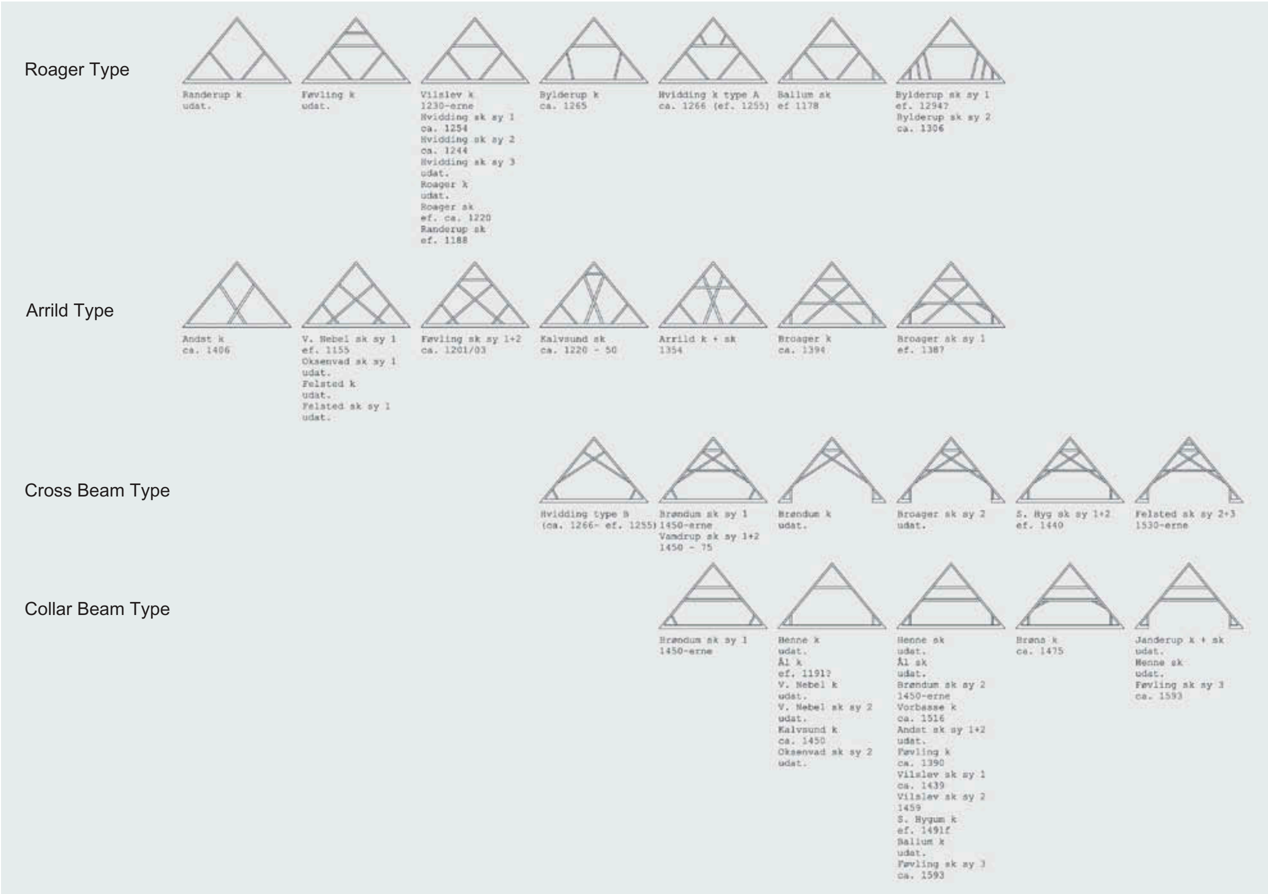


Figure 8. The truss types of the investigated church roof constructions arranged in the four types: Roager, Arrild, crossbeam and collar-beam type. Each type row is ordered on the basis of either the absence or presence of inside short struts. Truss types without short struts are in a group at the top left. They are only found in the Roager and Arrild types, which however are far from appearing only with struts. The crossbeam and collar-beam types always seem to be furnished with struts, but there is no basis in the material for claiming that roof constructions with struts came into use later than those without, although as suggested by the diagram they may be typologically younger. Trusses with or without struts appear from c. 1200 within all four truss types. The overlapping of types is long-lasting, and the Roager and Arrild types did not pass out of use until after c. 1400, unless the late examples from Andst and Broager are to be regarded as a kind of intermediate form between Arrild and the crossbeam roof constructions. With their association with the vaulting of the churches these are presumably underrepresented in the investigation, but probably the crossbeam trusses appeared as early as the 1200s. The collar-beam type is present from c. 1200, perhaps before. Drawing: Niels Erik Jensen.

Notes: Abbreviations: *ef.* after. *k:* chancel. *sk:* nave. *sy:* system. *udat:* undated. Brackets ( ) around a dating indicate that it has been inferred from another type of truss within the same closed system.

this field too. The extended forest Farrisskoven at the transition between Schleswig and the Danish Kingdom proper is the obvious supply source to point to, as well as the forest areas that could still be found right up to a very late date relatively far to the west in Southwestern Jutland. However, the preserved church roof constructions only represent a very limited segment of the production of medieval carpenters, and in the investigation we are furthermore talking about a body of material that mainly falls within the period from c. 1200 on.

In view of this, two churches from the vicinity of Ribe should be more carefully examined and compared. One is the church in Hvidding to the south west of Ribe (Figures 4 and 6) which tended to be considered as one of the first and oldest churches in the area built of calcareous tufa (Møller 1953, Danmarks Kirker 1957, p. 1133). Today its apse is a reliable reconstruction and only chancel and nave remain of the original building which shows a west extension from the end of the Middle Ages, but even earlier considerable alterations were carried out (Figures 10 and 11). Local magnates or churchwardens probably had the intention to adorn their church in a way that resembles the rede-sign of the building programme of the Cathedral of Ribe as it was carried out during the thirteenth century (cf. Krogh 1964, Madsen 1994). Correspondingly,

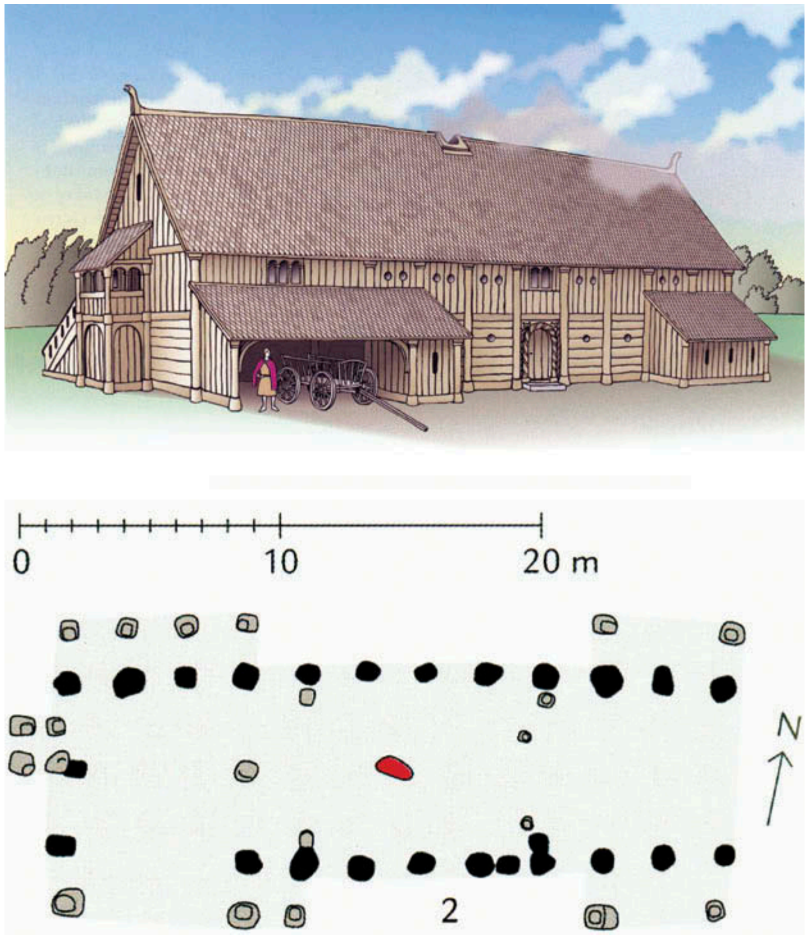


Figure 9. Excavation plan and reconstruction of a two-storey timber-built house in head construction from the excavation at the site Østergaard in North Schleswig, dated to the 1100s. Buildings of the same date with similar ground plan have been excavated just outside the city of Ribe. After Sørensen (2003).

dendrochronological datings from the roof of the chancel and nave in Hvidding seemed to indicate that the church was under construction during the first part of the thirteenth century and that its roofs were completed after the middle of this century.

The other example is the inland parish church of Kalvslund, some few kilometres east of Ribe (Figures 4 and 12). The dendrochronological dating of the roof structure and thus probably also of the completion of the nave of Kalvslund Church to c. 1220–50 – while no dating can yet be given for the chancel, except that it is unlikely to be much older – accords well with its former stylistic dating (Danmarks Kirker 1994–2003, p. 3345).[5] The church may be slightly older than Hvidding Church, and the similarity between the door design and the use of saw-tooth courses as decoration on both churches should be mentioned. While most of the building materials, i.e., the calcareous tufa stones for Kalvslund Church were bought and transported from as far away as the Rhineland, the granite in the interior was available from the eastern part of Jutland. As for the procurement of the timber, the analysis has shown that in Kalvslund oak from the Southern Jutland or North Schleswig area was used, and this applies almost without exception to all the church roofs in the area. Perhaps indeed the forest was not too far away, for toponymical research tells us that the very place name Kalvslund, like nearby Hjortlund and Hjortvad, is a 'forest clearance' name of fairly recent date and testifies to the spread of forest (*lund* = grove) – with deer (*hjort* and *kalv*) – rather closer to the west coast than was the case later (Hald 1975).

By all indications there was either originally or later thatched roofing on at least the nave of Kalvslund Church (Figure 13). This is suggested by rows of bored-in trenails in the tops of the rafters, which must be from the attachment of laths along the building. These would have borne the roof covering, which is thus unlikely to have been of lead, but may have been shingles, tiles or, as proven likely here, of straw thatch.

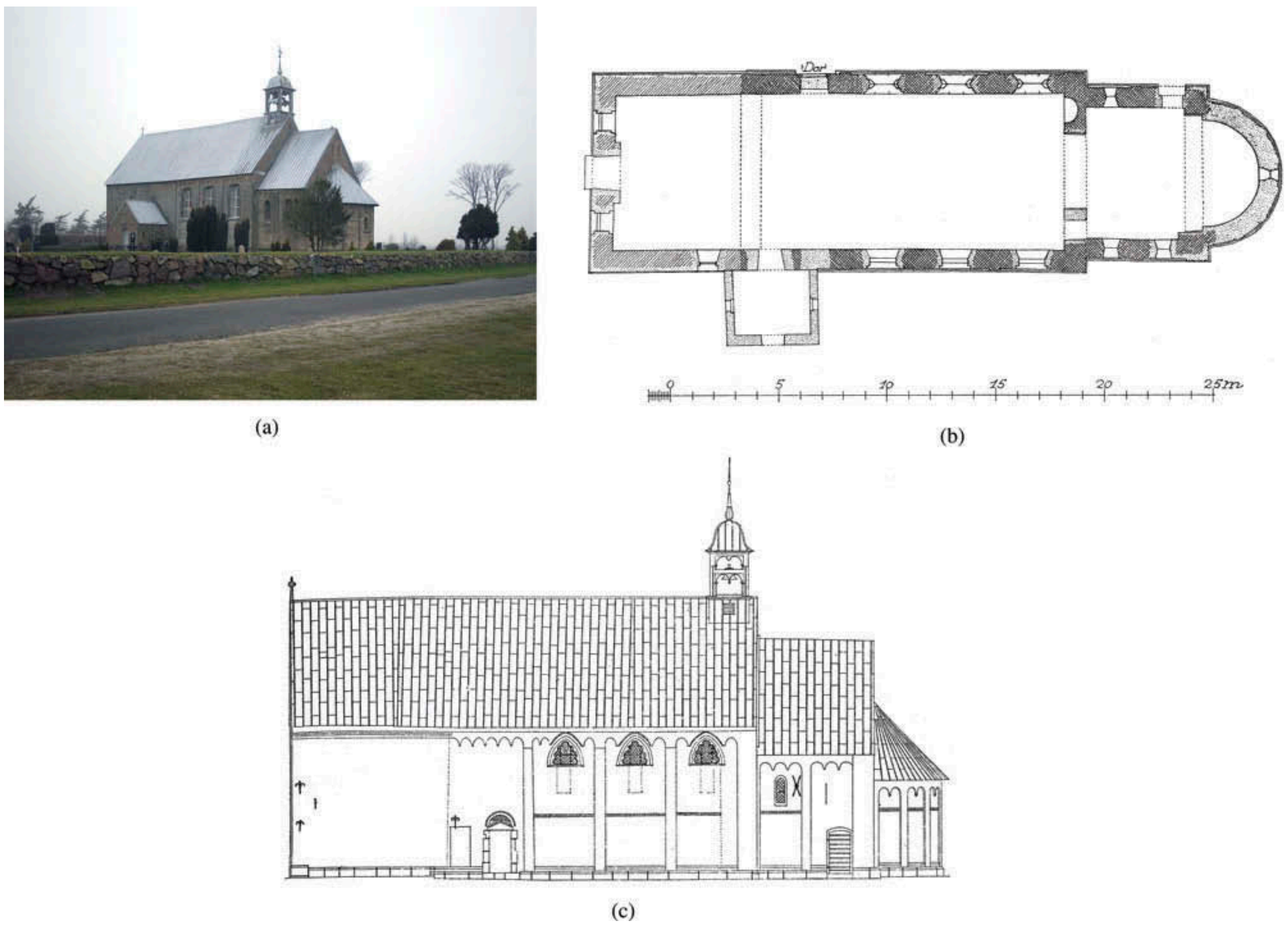


Figure 10. a. Hvidding Church, the church viewed from the south east. b. Ground plan of the church. c. Elevation of the north facade of the church. After Danmarks Kirker 1957, p. 1134–1135. Photo: Roberto Fortuna, February 2005.

The age of the thatched roof in Kalvslund may fall within the date range for the roof structure, if thatch, as suggested, was the first covering of the nave. The closest parallel to the thatched roof in Kalvslund is from the neighbouring church Hjortlund, where trenails have been observed in the rafters as in Kalvslund (Danmarks Kirker 1994–2003, p. 3345, Madsen 2005b). Østergaard 1961 and 1974 describes further parallels. Construction principles of thatched roofs have been described in detail by Rasmussen (1966). In addition, the two neighbouring churches are close parallels in terms of the construction of the gable between chancel and nave, which in both seems to have been of wood in the form of planks inset in the triangle formed by the gable truss (Figure 14).

Excavations inside the church in the 1950s led to the suggestion of a former wooden church at the spot which could perhaps also explain the quite flimsy joining of the nave and choir if the latter was raised against a still standing wooden church nave (Østergaard 1974, cf. Danmarks Kirker 1994–2003, p. 3345). This may still be possible, but the study of the roof has led to the conclusion that some of the special features of the extant building that might point in that direction perhaps have more to do with the construction of the roof. At all events any wooden church need not be older than c. 1200, while the nave of the stone church, judging from the dendrochronological investigations, appears to have been roofed in the period 1220–50. A transition from wooden church building to stone constructions at this time is far from unexpected in the western part of North Schleswig, and Kalvslund Church may, as pointed out, be approximately contemporary with the much richer church in Hvidding, lying close to the marshlands. The question is whether we should see this as evidence of, at the local parish level, a relatively late development in the form of intensified inland cultivation and settlement at the beginning of the High Middle Ages. Christianity and churchgoing in the Ribe areas can be traced considerably further back than around 1200, and the erection of stone churches in the city of Ribe is documented before 1200,[6] which does not mean that stone churches in the marshland parishes all came as

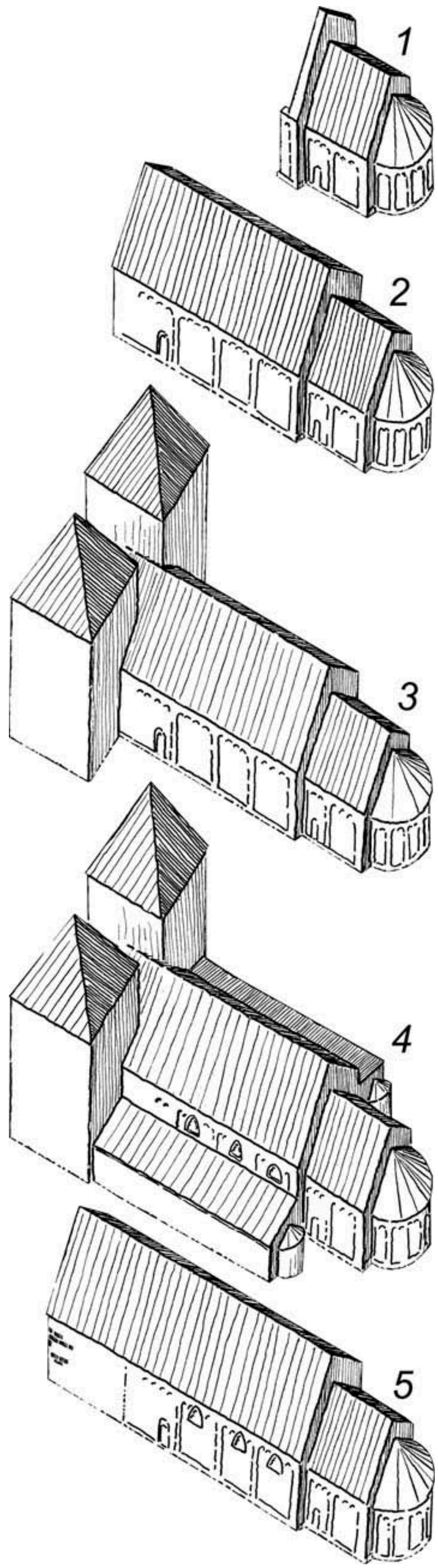


Figure 11. Hvidding Church, construction history. 1. Apse, chancel and the easternmost part of the nave including the rood gable. 2. The nave is finished. 3. A new western section, now disappeared, with two large towers and a vestibule in between is built. 4. The long walls of the nave are heightened, and trefoil windows are built in the heightened section, corresponding to the now restored state. The placing of the windows is due to plans for the erection of side-aisles, but it is not known whether these were ever realized. Any foundations have not been excavated. 5. The western towers collapsed and the nave was been lengthened with the present extension in brick. After Krogh (1964).

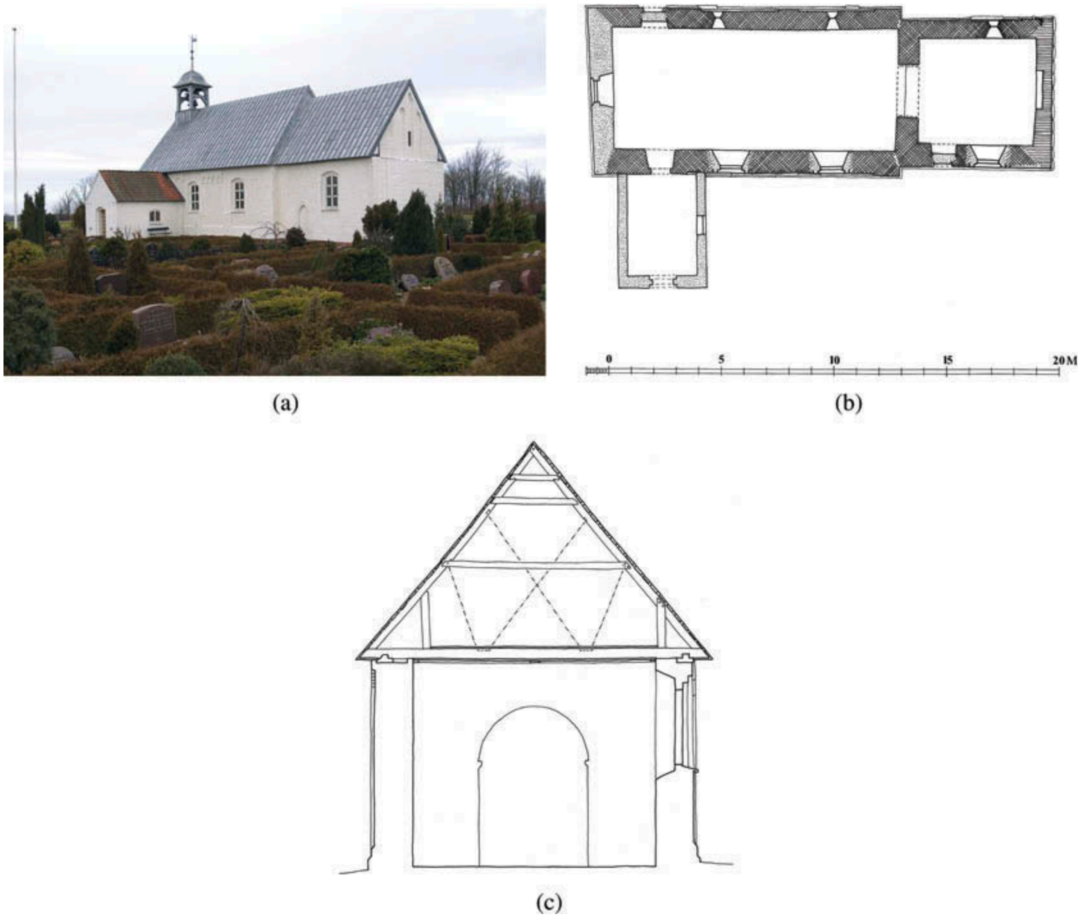


Figure 12. a. Kalvslund Church from the south east. b. Ground plan of the church. c. Cross-section of the church – the dotted line indicates the now-removed long diagonal struts. After Danmarks Kirker 1994–2003, p. 3347. Photo: Roberto Fortuna, February 2005.

early as that. At all events it may be that parishes which, like Kalvslund, lie inland, and whose resources, populations and church sizes always seem to have been smaller than those of the rich marshland parishes, only acquired their own church buildings from the 1200s on. The thatched roof of Kalvslund Church was not necessarily the result of inadequate funding – for as the predominance of calcareous tufa in the masonry clearly demonstrates, the builders of Kalvslund Church, like their fellows in the city and in the marshland parishes, were able to benefit from the supply of building materials from the Rhineland. But this meant that they were also subject to any fluctuations in the trade of i.a. lead.

One last example is the roof of the church in Sædding north of Esbjerg, lying some 60 kilometres from Ribe. This is in fact the church roof which Sophus Müller chose as his starting point for his paper from 1887, presuming that its nearly semicircular trusses represented the original roof of the church, being open to the nave (Figure 2). The closest parallels for this rather unique construction have been found in another three churches in Western Jutland and dendro-investigations simultaneously point to datings in the second part of the thirteenth century, or the first decades of the fourteenth century (Bonde and Madsen forthcoming). Nothing proves that this type of roof should be the original in any of the four churches, no matter whether it remained open to the nave or had the form of an oblong barrel vault with wooding clading on the trusses' bottom side. In either case the inspiration seems to have come from the similar roof constructions in Flemish or French ecclesiastical buildings as well as in vernacular houses in, e.g., Brugge and Ghent. Probably an open, barrel vaulted roof had to do with a wish for more light and space, giving room to new arrangements of the Rood Altar with for instance a tall crucifix which could then be placed above the Triumphant Arch to the choir. Anyway these few known examples of open or barrel vaulted roof constructions being built into West Jutland Romanesque parish churches in order to substitute their original roofs do reflect the main economic and cultural influences of the Late Middle Ages from Flanders to South Western Jutland.

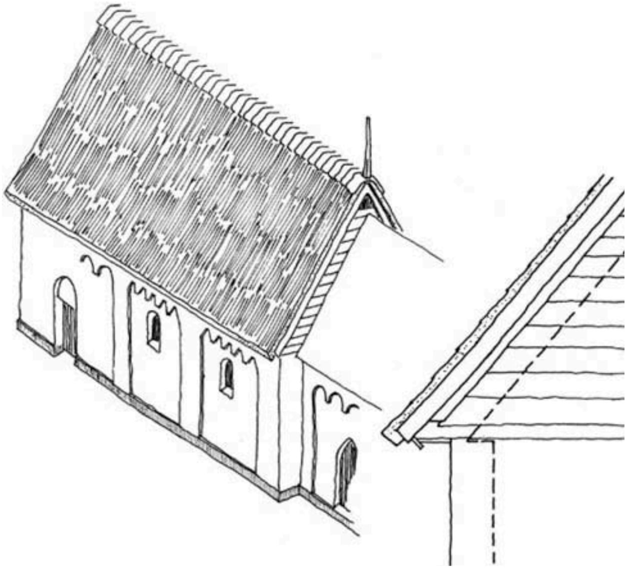


Figure 13. Kalvslund Church, suggested reconstruction of the covering of the nave with thatch and a ridge of turf as well as a vertical pole in the east gable. One can glimpse how the east gable of the nave may have been closed off with horizontal boards. How the chancel was covered at that time is unknown, so only its outline is suggested. A detailed proposal for the construction of the southern corner of the gable is also shown. The interior appearance of the gable construction is shown on Figure 14. Drawing: Niels Erik Jensen.

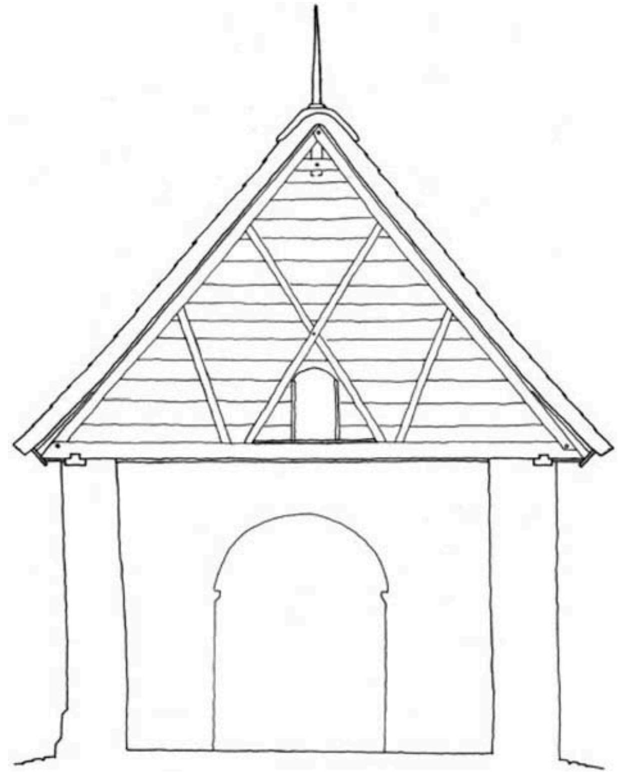
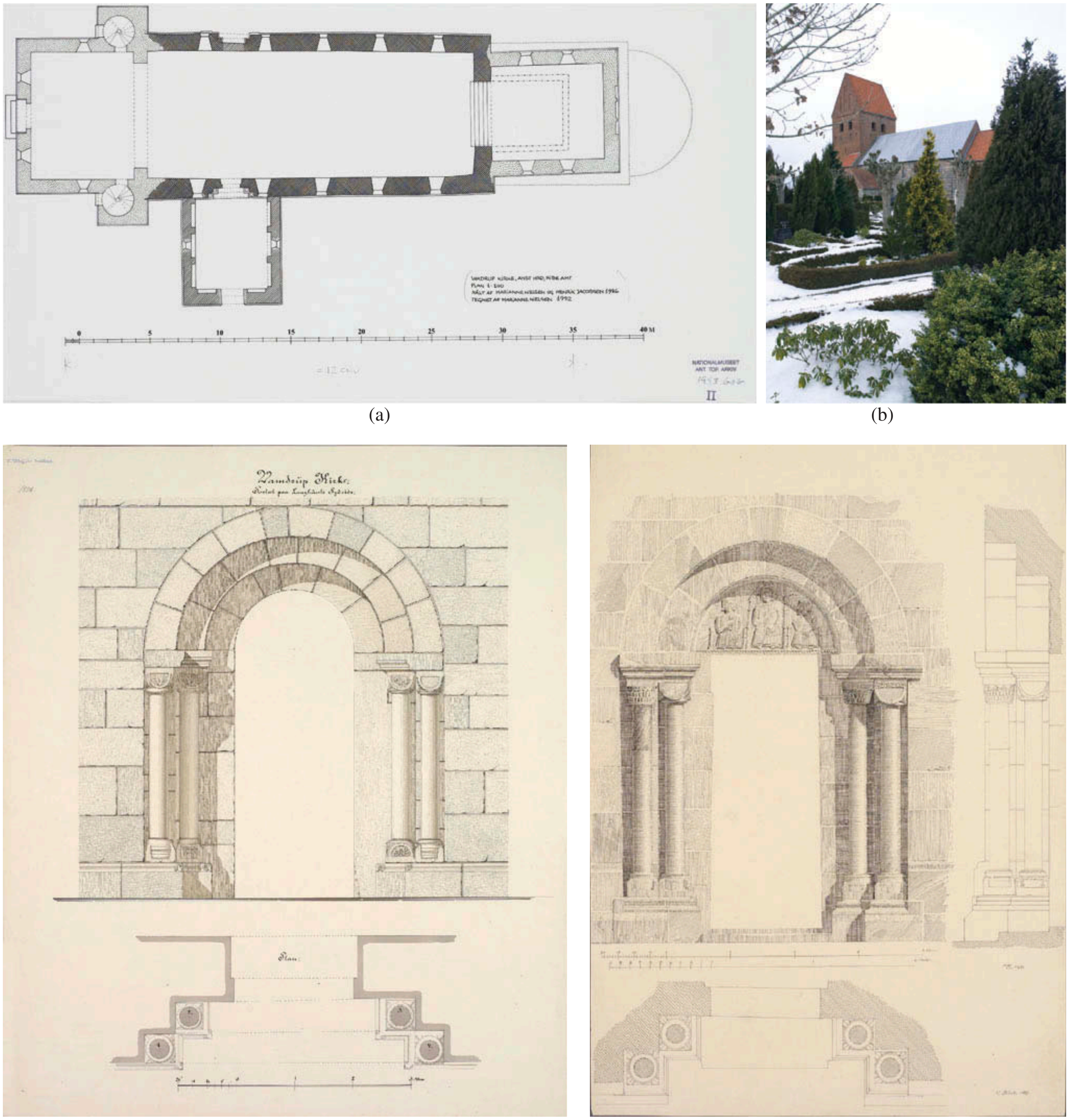


Figure 14. Kalvslund Church, sketched reconstruction of the eastern gable truss of the nave viewed from the west (that is, from ceiling of the nave) with added terminating boards and diagonal struts on the inside of the board wall. Figureshows that part of the gable which is visible from the outside. Drawing: Niels Erik Jensen.

Looking back on the whole project it has only been possible to a limited extent to fulfil the hope that the church roof constructions of the area would contribute, thanks to dendrochronological analysis, to the dating of the building materials of the church, that is of the granite, the calcareous tufa, the bricks and the succession in which they replaced one another. This limited success is partly because there are only a few cases where one can demonstrate contemporaneity of the discontinuity in construction and a change in materials in the masonry on the one hand and on the other hand in the roof constructions that must in practice be considered contemporary with the walls. But in some of the churches that have not yet been subjected to a major overall investigation, it may be possible to obtain results in this field. There is yet another perspective for continued investigation in the possible dating of the use of granite column portals in a number of granite churches in the time around 1200, for instance in Vamdrup (Figure 15) (Madsen 2007, p. 57+59, cf. Madsen 2000. Danish granit church portals are published by Mackeprang (1948). Ribe Cathedral too is graced with granite column portals (Figures 16 and 17), while the calcareous tufa churches in the close hinterland of Ribe have no column portals. In that respect the information on the age of the roof construction in the village churches of the Ribe area, as suggested by the investigation, may contribute further to the discussion of the age of Ribe Cathedral and its relationship with the architecture of the region in general. If we base our projections on the datings of the partial *post quem* type obtained, two possibilities emerge. One is that the erection of calcareous tufa churches is more likely to have taken place after than before 1200, and that the use of bricks began almost at the same time or only a little later. If the cathedral was the crucial source of the architecture and the choice of materials for the village churches, this raises the issue of whether its beginning should be pushed forward from the proposed period, 1150–1175, to the last quarter of the 1100s; or secondly, if the datings from the village churches are an expression of the revision of their architecture and of all-encompassing renewals of the roofing constructions investigated in the period after c. 1200 – then the start of the cathedral construction need not necessarily be affected, but at the same time the possibility is opened up that the calcareous tufa churches without portals either followed on from the cathedral in its first version or have their precursors among even earlier calcareous tufa buildings in Ribe. Given that there is probably a sisterly relationship rather than a subordinate mother–daughter relationship between the cathedral and the village churches, the first of the two suggestions here should be judged the most likely. Because of the extent to which the roof



(a) (b) (c) (d)

Figure 15. The two churches in Vamdrup and Andst are situated in the middle of Jutland east of Ribe (Figure 4). a. Vamdrup, ground plan. b. Vamdrup, the church from the south east. c. Vamdrup, south portal of nave. d. Andst, south portal of the nave. Photo: Roberto Fortuna, February 2005. Measurements and drawing: Danmarks Kirker 1991–1994, p. 2634+2636 and F. Uldall 1888.

constructions of the portal-decorated granite churches have been replaced, the potential for obtaining a further dendrochronological dating basis from these churches is relatively modest. As far as the calcareous tufa churches are concerned, though, there is still untested material available for an extended analysis of the age of the roofing of some more of these churches. And although, as the investigation has shown, we have regularly produced evidence for replacement of the roof construction, such a result also always gives us a deeper understanding of the church in question and the region to which it belongs, and thus, like the whole regionally based investigation of

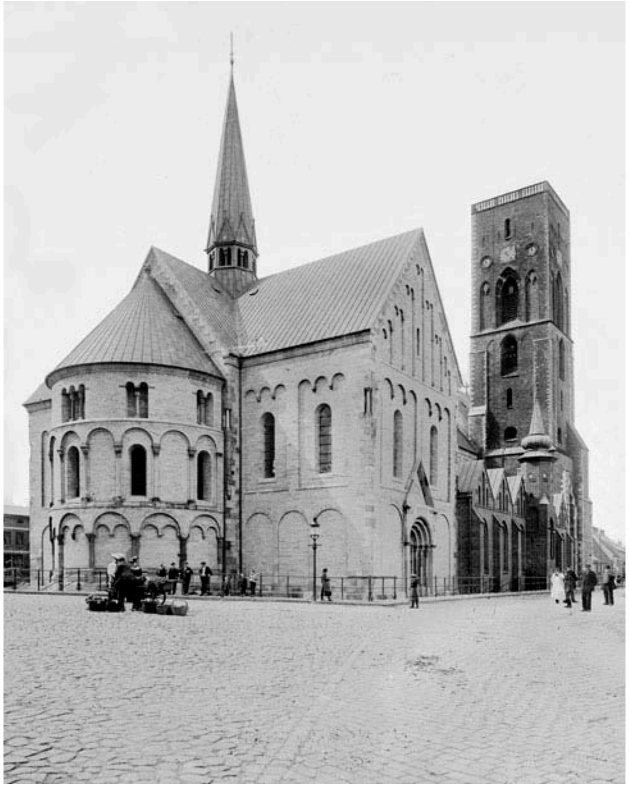


Figure 16. Cathedral of Ribe from the North East. The present look of the church is due to its latest restoration around 1900 which preserved the church's remaining Late Medieval additions, that is the brick built Great Tower to the North West and its two outer side aisles. The Romanesque basilical church with its protruding transept was erected by inspiration from the Rhineland using imports of Rhenish tufa stones and sandstones and some Jutish granite blocks. No choir was ever erected, and the apse is directly connected to the transept. A central tower on top of the crossing was planned but probably never raised and similarly only two slender west towers were built in order to flank a central tower of which only the massive and remaining ground storey was constructed. Photo: Hude, the National Museum, around 1900.

(a) (b) (c)

Figure 17. The portals of the cathedral in Ribe. a. Southern transept, the original portal with its slightly horseshoe-shaped arch and granite tympanum and its double set of columns originally ended horizontally. This was supplemented by adding the triangular sand stone relief on top of the portal arrangement, probably shortly after 1250. b. Northern transept and c. West entrance – the arch above the doorway is slightly pointed, probably dating from around 1225. Photo: Roberto Fortuna, 2005 and 2010.

Southwestern Jutland and North Schleswig roof constructions shortly presented here, underscores the need to continue with other, larger areas.

Finally it certainly also bears witness to the interdependent relationship between town and country and in this case, too, between an area which was on the one hand a prosperous innovation zone for the urbanizing influences from northwestern Europe, and on the other hand thereby becoming a part of the supplying hinterland of commercial centres such as Bruges (Madsen 1997, 2000). However, the same zone of South Western Jutland probably also maintained and further developed its traditions in the technical field of carpentry along with being open to inspiration from stone church building.

Acknowledgements

I wish to thank Dr. John Smith for his kind support and fruitful corrections. James Manley took care of the translation into English.

Notes

1. Final publication in Madsen (2007), with a catalogue of all investigated churches and their roofs including the dendrochronological results.
2. The project was granted by the Carlsberg Foundation, the Museum Councils of Ribe and Sønderjylland and the National Museum. Project files are kept in the museum of Ribe (Sydvestjyske Museer), and in the National Museum, cf. Madsen 2007.
3. Madsen (2005a) gives a detailed version of the investigation with references.
4. Madsen (2007, p. 39); Binding (1991, p. 49ff) dates the upcoming of interior struts in the Rhine-Mosel Area to the period from 1200 and onwards. In Westphalia they appear in the middle of the thirteenth century. Provided that these datings are reliable they seem to be later than the ones obtained from the investigated churches. This means that these German examples hardly were the ones to inspire the Danish carpenters concerning this important detail.
5. Madsen (2005b) with details and references.
6. About 860 Ansgar was granted permission by the king Harald Klak to build a church in Ribe. First mention of a stone church in the town implies its erection shortly before 1134 (Skovgaard-Petersen 1981, p. 39 and 60). The building of the present cathedral was initiated about 1150–75, cf. Madsen 2007, p. 63. The deserted parish churches in Ribe of Sts. Peter, Clemens and Nicolai were probably also of twelfth century date and were like the cathedral erected in calcareous tufa. Finds from new excavations south of the cathedral indicate that a stone church most likely was erected in the area prior to the present cathedral.

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Weapons, fighters and combat: spears and swords in Early Bronze Age Scandinavia

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This article deals with the use-wear analysis of 204 weapons of Period I of the Early Nordic Bronze Age. The analysed sample contained 154 spearheads and 50 swords and was made up of approximately one-third of the contemporaneous weapons in Southern Scandinavia. The use-wear analysis was undertaken with a source critical view on corrosion and other taphonomic processes. The information obtained was used to see how use-wear and taphonomic processes influence each other. Use-wear analysis was employed to evaluate statements regarding the functionality, or rather non-functionality, of Early Bronze Age weaponry. According to the results, spears and swords were not only functional but also very frequently used. Further deductions can be made from the material. Despite a difference in the scale of fighting, spears and swords show essentially the same kind of combat wear. It is argued that this relates to essentially similar styles of fighting that employ both cutting and stabbing movements and are perhaps most appropriately termed 'fencing'. This style of fighting possibly emerged from frequent encounters of sword and spear fighters in the closely interconnected world of Southern Scandinavia during Period I of the Early Bronze Age. In these engagements, a partial homogenising effect of warfare and fighting becomes visible. Yet, it is not the only effect that accompanies combat and war. Diversification and homogenisation are not mutually exclusive or contradictive. Accordingly, they took place simultaneously and helped develop fighting styles and weapon technologies.

Keywords: use-wear analysis; spears; swords; Early Bronze Age; Southern Scandinavia

Introduction

The Early Bronze Age of the Nordic sphere has a rich material culture and weapons are among the most spectacular finds. Period I is of special interest. It is a transitional phase rooted in the existence of specialised weaponry and a warrior ideal in the Late Neolithic (Sarauw 2007), but with newly introduced weapons, and the wider spread of bronze technology. The halberd of the Late Neolithic was probably replaced by the sword and the spear around 1800 BC (Horn in prep.). Simultaneously, a slow change of depositional practices took place. The halberds were mostly discovered as single depositions. Weaponry appears more frequently in graves in Period I of the Early Bronze Age (Lomborg 1965, Vandkilde 1996, Johansen *et al.* 2004, p. 43). However, this phenomenon is more closely associated to Jutland. Graves with weaponry become more frequent in Sweden and the Eastern Danish Islands in the subsequent periods. This suggests the transition varied in speed in different regions.

Studies of Bronze Age weaponry are mainly concerned with swords and neglect spearheads. It appears that swords are considered to be more important (Anderson 2011, p. 599). Only within the last 15 years, research is slowly catching up (Tarot 2000, Davis 2006, 2012, Bruno 2007, Laux 2012). This fact is reflected in publications concerned with use-wear analysis. The corpus of studies on swords following Kristiansen's (1978, 1984, 2002) works is impressive (Bridgford 1997, 2000, York 2002, Quilliec 2008, Bunnefeld and Schwenzer 2011, Colquhoun 2011, Matthews 2011, Molloy 2011). In contrast, papers analysing use-wear on spears are scant (Schauer 1979, Anderson 2011). Additionally, the cited accounts on swords mainly deal with swords of later periods neglecting the initial phase of this kind of weaponry.

It is possible that this is the reason why spears are still regarded as clumsy and inappropriate for fighting (Harding 2007, p. 76). If authors consider their use, they generally attribute it to fighting with throwing and thrusting manoeuvres (see Osgood 1998, p. 91, Osgood *et al.* 2000, p. 22, contra Molloy 2007, p. 102 and Anderson 2011, p. 599). In his analysis of the spearhead discovered in an Urnfield burial in Gau Algesheim, Germany, Schauer (1979) argued over 30 years ago for a more complex fighting style. This was later confirmed in a recent publication by Anderson (2011) on Late Bronze Age spearheads from Great Britain. However, early spears are usually regarded as not being fit for fighting and they are therefore interpreted as being employed for other purposes (Mercer 2006, p. 131). Similar claims are made against the swords of the Sögel-Wohlde-complex presumably because they are technically ill-constructed that limits them in their use in fighting (c.f. Fontijn 2005, pp. 146–147).

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This leaves the Early Bronze Age material with some interesting questions: were spears used at all in this early period? If so, how were they used? What is their relation to sword fighting in the same frame of time?

For the study, 154 spearheads and 50 swords of various types from Denmark, Northern Germany, Sweden and Norway were analysed (Figure 1). This sample represents approximately one-third (35%) of the total amount of the spears and swords of Period I (Kersten 1935, Hachmann 1957, Lomborg 1965, Jacob-Friesen 1967, Oldeberg 1974). This article examines the traces of use-wear with a source critical view on taphonomic processes.

Definition of use-wear and problems of recognition

Vandkilde (2003, pp. 135–136, 2011, pp. 374–375) criticised an element in the study of warriors and warfare. According to her, the idealised and heroic image of warfare in mythology and in rock art is overrepresented. Consequently, the ugly side of warfare is neglected, i.e. the actual fighting. Use-wear analysis is an apt way to

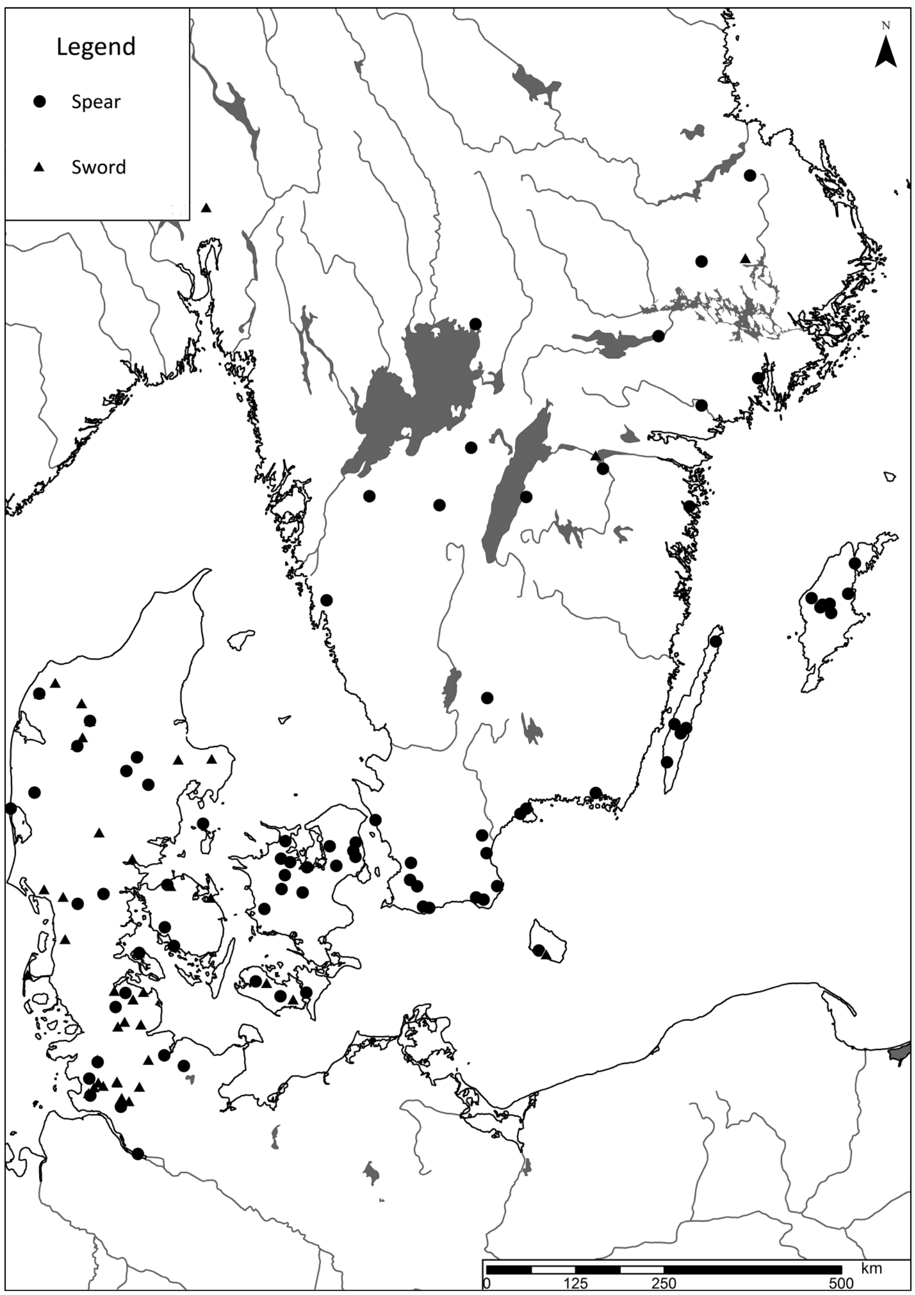


Figure 1. Map showing the find locations of the analysed spears and swords.

research the realities of combat on the weapons themselves (for other approaches, see Molloy (2007)). With this method, it might be possible to separate the warrior who presents an ideal and a myth from the actual combatant.

The material examined for this article is located in the National Museum in Oslo (NMO), the National Museum in Stockholm (SHM), in the Historical Museum in Lund (LUHM), the City Museum of Gothenburg (GAM), National Museum in Copenhagen (NMK), Moesgård Museum Aarhus (MM), Museum East-Jutland Grenaa (MEG) and the County Museum for Art and Cultural History Schloss Gottorf (LMSH). The examination took place macroscopically and microscopically with magnification up to ×300. For this purpose, a microscopic camera was employed (XLoupe G20, Lumos Technology Co. Ltd.). Documentation of the findings was carried out in writing, drawing and photography (macroscopically and microscopically). The results were entered into a database together with other relevant information.

In order to evaluate the observed use-wear, categories had to be built to qualify the results. The categories are based on literature concerned with the categorisation of use-wear (Kristiansen 1984, 2002, Bridgford 1997, 2000, Brandherm 2011, Molloy 2011). Results of experimental work are the base for the understanding of the mechanics of damage formation (O'Flaherty *et al.* 2008, Anderson 2011, O'Flaherty *et al.* 2011). All the observed damage was quantified with a number according to the frequency and intensity of the individual damage categories. The scale usually ranges from 0 to 3, with the exception of indentations; if these are present, they are usually very large and require more force to be created. Therefore, the number 1 was excluded for them. The range of numbers can be translated to 'no damage' (0) to 'highly/intensely damaged' (3). Finally, the numbers were added up. Due to the problems with repairs and corrosion described below, these numbers are of minor importance in the following considerations and are only presented in Table 1, for the sake of transparency and the convenience of the reader. However, the following damage categories have been defined based on previous work in use-wear analysis and experimental archaeology:

Notches have a v-shaped impact profile and are located on cutting edges (Figure 2(a)). Sometimes, notches contain information about the directionality of the blow. The bisection of the angle created by the impact gives the approximate direction of the blow. It is possible that most notches are caused by the edge of a bladed weapon, such as spears, swords or daggers and in some instances maybe also axes (for the mechanics, see O'Flaherty *et al.* (2011)). Some notches are very shallow, being below 5 mm in depth and are caused by a grazing impact. If the impacting blow comes in at a very flat angle relative to the longitudinal axis of the edge, the impacted metal can 'flake off' (Figure 2(b)). However, most notches are sharp and some intrude rather deeply. Sometimes, the notches lead to a material failure in their immediate surroundings or in areas directly connected to them (Figure 2(c)).

Indentations are parallel to notches in their placement along the cutting edge, but in contrast their impact profile is rounded (Figure 2(d) and 2(e)). Usually, they are wider than deep, so on average they are shallower. Due to their roundedness, the directionality of the impact is difficult to determine and in most cases it is not possible at all. Impacts of objects with a more rounded shape are responsible for dents, such as the sides of axes, handles or bones. Repairs give notches and indentations a very shallow and rounded appearance, which makes them hard to spot without other indicators, such as the striations of repair work (Figure 2(f)).

Material displacement is a plastic deformation around an impact zone (Figure 2(c)–(e)). Metal reacts to an impact in specific ways according to different factors: the force of the impact, the form of the impacting objects, their material properties, such as hardness and ductility and so on. An impact is able to leave damage, such as notches or dents on cutting edges, causing the metal of the impact zone to give way in accordance with the ductility of the material. If the ductility of the impacted material reaches its limits, a fracture will occur. Either the object gains fissures or it breaks entirely. The formation of material displacement causes massive stresses in the metal and subsequently the material displacement itself often breaks off. Thus, it can be assumed that the lack of material displacement does not mean that no impact took place. However, the presence of material displacement is a good indicator for an anthropogenic origin of the damage.

Blow marks, notches and dents are damage caused by impact, but blow marks are not located on the edge. They affect the flat side of the weapon (Figure 3(a) and 3(b)). The force of the impact is distributed more evenly due to a larger surface. Consequently, more pressure is relieved. Material displacement occurs less frequently and less significantly as a result. More rounded or oval scars may be attributed to tips (Figure 3(a)), while the edges of blades probably cause elongated damage (Figure 3(b)). Sometimes, it is difficult to distinguish between edge damage and blow marks (Figure 3(c)). However, reworked sinkholes can, in some cases, take on a similar appearance making it necessary to assess features carefully.

Tip pressure (Figure 3(d)) is visible as a flattened point on the weapon. This damage probably originated in an offensive manoeuvre. The point might have met with the side of another bladed weapon. In these cases, pressured tips may be complimentary to blow marks. Protective gear, such as armour or wooden shields, is perhaps another source for this damage (Molloy 2009, Uckelmann 2011, pp. 194–195), but archaeological evidence for such gear remains scant in the period under consideration. Tip pressure can perhaps account

Table 1. Results of the use-wear analysis.

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Algutsrum sn., Öland, SE	Single?	Spear (Valsømagle)	X	3	0	0	1	0	2	1	**7**	—	X	SHM 1304 (1842) 3
Allerup, Holbæk, DK	Single	Spear (Bagterp)	X	1	3	3	1	0	2	0	**10**	—	X	NMK 13315
Årup (I), Hassing, DK	Grave	Spear (Torsted)	X	?	?	?	2	0	1	1	**4**	X	?	NMK 13839
Årup (II), Hassing, DK	Grave	Sword (unknown)	X	3	0	0	1	0	2	1	**7**	—	X	NMK 13837
Assendrup, Vejle, DK	Single	Sword (Sögel)	X	3	0	3	2	0	2	0	**10**	—	X	NMK B938
Attemosegård (I), Copenhagen, DK	Hoard	Spear (Valsømagle)	—	0	0	0	0	0	0	0	**0**	—	—	NMK B670
Attemosegård (II), Copenhagen	Hoard	Spear (Valsømagle)		2	0	0	1	0	1	0	**4**	—	X	NMK B800
Bärbo, Södermanland, SE	Hoard?	Spear (Valsømagle)	X	0	0	0	3	0	1	0	**4**	X	?	SHM 2273
Björke sn., Gotland, SE	Single?	Spear (Valsømagle)	X	0	0	0	2	0	1	2	**5**	—	X	SHM 8400
Böda, Öland, SE	unknown	Spear (Valsømagle)	X	2	3	0	1	1	2	0	**9**	—	X	LUHM 12627
Bohnert (I), Rendsburg-Eckernförde, DE	Grave	Sword (Sögel)	X	0	2	2	1	0	1	?	**6**	—	X	LMSH KS16090
Bohnert (II), Rendsburg-Eckernförde, DE	Grave	Sword (Sögel)	?	0	0	0	0	0	1	?	**1**	X	?	LMSH KS12065I
Bohnert (III), Rendsburg-Eckernförde, DE	Grave	Sword (Sögel)	?	0	0	0	0	0	0	?	**0**	X	?	LMSH KS12101II
Bondesgårde (I), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	0	0	0	1	0	**2**	X	X	NMK B15101
Bondesgårde (II), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	0	1	0	0	0	**2**	—	—	NMK B15102
Bondesgårde (III), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	1	0	1	0	1	0	**3**	—	X	NMK B15103
Bondesgårde (IV), Torsted, Hind, DK	Hoard	Spear (Torsted)	—	0	0	0	0	0	0	0	**0**	—	—	NMK B15104
Bondesgårde (IX), Torsted, Hind, DK	Hoard	Spear (Torsted)	?	?	?	?	?	0	0	0	**0**	X	?	NMK B15109
Bondesgårde (V), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	?	?	0	1	0	1	?	**2**	X	—	NMK B15105
Bondesgårde (VI), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	2	2	1	0	1	?	**6**	X	X	NMK B15106
Bondesgårde (VII), Torsted, Hind, DK	Hoard	Spear (Torsted)	?	?	?	?	1	0	0	?	**1**	X	?	NMK B15107
Bondesgårde (VIII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	0	1	1	0	1	?	**3**	—	X	NMK B15108

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Bondesgårde (X), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	0	1	0	0	0	**2**	—	X	NMK B15110
Bondesgårde (XI), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	0	1	0	0	0	2	**3**	—	X	NMK B15111
Bondesgårde (XII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	0	1	1	0	1	?	**3**	—	—	NMK B15112
Bondesgårde (XIII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	0	1	0	0	?	**2**	—	—	NMK B15113
Bondesgårde (XIV), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	1	0	0	1	?	**3**	—	?	NMK B151114
Bondesgårde (XIX), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	3	0	0	1	0	**5**	—	?	NMK B15119
Bondesgårde (XL), Torsted, Hind, DK	Hoard	Spear (Torsted)	?	?	?	0	?	0	1	?	**1**	X	?	NMK B15146
Bondesgårde (XV), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	0	1	0	0	0	**2**	—	X	NMK B15115
Bondesgårde (XVI), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	0	0	1	0	0	1	**2**	—	?	NMK B15116
Bondesgårde (XVII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	1	1	0	0	0	**3**	—	X	NMK B15117
Bondesgårde (XVIII), Torsted, Hind, DK	Hoard	Spear (Torsted)	—	0	0	0	0	0	0	0	**0**	—	?	NMK B15118
Bondesgårde (XX), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	0	2	1	0	1	0	**4**	—	X	NMK B15120
Bondesgårde (XXI), Torsted, Hind, DK	Hoard	Spear (Torsted)	—	0	0	0	0	0	0	1	**1**	—	–	NMK B15121
Bondesgårde (XXII), Torsted, Hind, DK	Hoard	Spear (Torsted)	—	0	0	1	0	0	0	?	**1**	—	X	NMK B15122
Bondesgårde (XXIII), Torsted, Hind, DK	Hoard	Spear (Torsted)	—	0	0	1	0	0	0	?	**1**	—	?	NMK B15123
Bondesgårde (XXIV), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	1	1	0	0	?	**3**	—	?	NMK B15124
Bondesgårde (XXIX), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	2	1	0	0	0	1	**4**	—	X	NMK B15129
Bondesgårde (XXV), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	2	1	1	0	0	?	**4**	—	?	NMK B15125
Bondesgårde (XXVI), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	2	2	1	0	0	0	**6**	—	X	NMK B15126
Bondesgårde (XXVII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	2	0	1	1	0	0	0	**4**	—	X	NMK B15127
Bondesgårde (XXVIII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	0	2	0	1	0	**4**	—	X	NMK B15128

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Bondesgårde (XXX), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	2	0	1	0	1	1	**6**	—	X	NMK B15130
Bondesgårde (XXXI), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	2	0	1	0	1	?	**4**	—	X	NMK B15131
Bondesgårde (XXXII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	2	3	1	0	0	1	1	**8**	—	X	NMK B15132
Bondesgårde (XXXIII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	2	2	1	0	1	?	**6**	—	–	NMK B15133
Bondesgårde (XXXIV), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	2	1	1	0	0	1	**5**	—	X	NMK B15134
Bondesgårde (XXXIX), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	1	0	0	1	0	0	0	**2**	—	X	NMK B15145
Bondesgårde (XXXV), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	0	2	0	1	0	0	0	**3**	—	X	NMK B15135
Bondesgårde (XXXVI), Torsted, Hind, DK	Hoard	Spear (Torsted)	—	0	0	0	0	0	0	0	**0**	—	–	NMK B15136
Bondesgårde (XXXVII), Torsted, Hind, DK	Hoard	Spear (Torsted)	—	0	0	0	0	0	0	0	**0**	—	?	NMK B15143
Bondesgårde (XXXVIII), Torsted, Hind, DK	Hoard	Spear (Torsted)	X	2	0	?	0	0	0	1	**3**	—	—	NMK B15144
Bragby, Uppland, SE	Single	Sword (Apa)	X	2	0	0	1	1	0	1	**5**	X	X	SHM 14759
Briksbøl, Ribe, DK	Grave	Sword (Sögel)	?	?	?	?	?	?	?	?	**?**	X	?	NMK B9175
Brux, Rendsburg-Eckernförde, DE	Grave?	Sword (Sögel)	X	1	2	0	3	1	2	0	**9**	—	?	LMSH 9938
Buddinge, Copenhagen, DK	Grave	Spear (Valsømagle)	?	0	0	0	1	0	0	1	**2**	X	?	NMK B11946
Dildaelsgård, Frederiksborg, DK	unknown	Spear (Bagterp)	—	0	0	0	0	0	0	0	**0**	X	?	NMK B13640
Dithmarschen, DE	unknown	Spear (Valsømagle)	X	0	2	0	0	0	1	?	**3**	—	X	LMSH KS8814
Dystrup (I), Djurs, DK	Hoard	Sword (Apa)	?	0	0	1	3	0	1	0	**4**	—	—	MEG B17617
Dystrup (II), Djurs, DK	Hoard	Sword (Apa)	?	0	0	0	1	0	1	0	**2**	—	—	MEG B17618
Dystrup (III), Djurs, DK	Hoard	Sword (Apa)	?	0	2	0	1	0	0	0	**3**	—	?	MEG B17619
Dystrup (IV), Djurs, DK	Hoard	Sword (Apa)	?	0	0	0	1	0	1	0	**2**	—	—	MEG B17620

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Dystrup (V), Djurs, DK	Hoard	Sword (Apa)	?	0	0	0	1	0	1	0	**2**	—	?	MEG B17621
Dystrup (VI), Djurs, DK	Hoard	Sword (Apa)	?	0	0	0	1	0	1	0	**2**	—	—	MEG B17622
Dystrup (VII), Djurs, DK	Hoard	Sword (Apa)	-	0	0	0	0	0	0	0	**0**	—	—	MEG B17623
Dystrup (VIII), Djurs, DK	Hoard	Sword (Apa)	?	0	0	0	1	0	1	0	**2**	—	—	MEG B17624
Estvad, Ginding, DK	Grave?	Spear (Torsted)	X	1	0	1	0	0	1	0	**3**	—	X	NMK B10334
Everöd sn., Scania, SE	Grave?	Spear (Valsømagle)	X	0	2	0	0	0	0	0	**2**	—	—	SHM 7906
Falköping, Västergötland, SE	Single	Spear (Valsømagle)	X	0	2	0	1	1	0	1	**5**	—	X	SHM 4145
Falster (I), Maribo, DK	Hoard	Spear (Bagterp)	X	2	0	0	1	0	0	0	**3**	—	X	NMK 18588
Falster (II), Maribo, DK	Hoard	Spear (Bagterp)	X	2	0	0	1	0	0	1	**4**	—	X	NMK 18589
Flensburg, Schleswig-Flensburg, DE	Grave	Sword (Sögel)	?	0	2	0	0	0	0	?	**2**	X	X	LMSH KS11802
Flistad sn., Västergötland, SE	Single	Spear (Valsømagle)	X	1	0	0	0	0	2	1	**4**	—	X	SHM 10391
Främmestad, Västergötland, SE	Single?	Spear (Ödeshög)	X	2	2	0	0	0	0	0	**4**	—	X	SHM 13035
Funder, Viborg, DK	Grave?	Spear (Torsted)	X	1	0	0	0	0	1	0	**2**	—	X	MM FHM3646
Fur (I), Viborg, DK	Hoard	Dagger (Wohlde)	X	1	0	1	2	?	1	0	**5**	—	X	NMK B5254
Fur (II), Viborg, DK	Hoard	Sword (Sögel)	X	1	2	0	0	?	2	0	**5**	—	X	NMK B10036
Gislinge, Holbæk, DK	Grave?	Spear (Bagterp)	X	0	3	1	1	0	1	1	**7**	—	X	NMK B2402
Glemminge, Scania, SE	Single	Spear (Valsømagle)	—	0	0	0	0	0	0	0	**0**	X	?	SHM 2109:1758
Glüsing, Dithmarschen, DE	Grave	Sword (Sögel)	X	0	0	2	1	0	1	0	**4**	X	X	LMSH 8815
Gokels, Rendsburg-Eckernförde, DE	Grave	Sword (Sögel)	X	2	2	1	0	0	1	?	**6**	X	?	LMSH 11674
Gudendorf, Dithmarschen, DE	Grave	Sword (Sögel)	?	0	0	0	0	0	0	?	?	X	?	LMSH 13766
Guldbjerg, Odense, DK	Grave	Dagger (Apa)	—	0	0	0	0	0	0	0	**0**	—	—	NMK B5022
Haga, Gotland, SE	Hoard	Spear (Valsømagle)	?	0	0	0	1	0	0	0	**1**	—	X	SHM 14954
Hagstad sn, Östergötland, SE	unknown	Spear (Valsømagle)	X	0	0	0	1	0	0	1	**2**	—	X	SHM 14363:6
Halla, Gotland, SE	Grave?	Spear (Bagterp)	X	0	0	3	2	0	2	0	**7**	—	X	SHM 12374
Hälsingborg, Scania, SE	Single?	Spear (Valsømagle)	X	0	2	0	0	0	0	0	**2**	—	—	LUHM 16129
Halsted, Lolland, DK	unknown	Spear (unknown)	X	1	0	3	1	0	2	1	**8**	X	X	NMK B13551
Hammer, Aarhus, DK	Grave	Spear (Torsted)	X	2	0	2	0	0	1	0	**5**	—	X	NMK B12059

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Harresø, Vejle, DK	Grave	Spear (Bagterp)	X	1	2	0	1	0	1	1	**6**		—	MM 5286
Harritslev, Skovby, DK	Single	Spear (Torsted)	X	?	?	0	2	0	1	0	**2**	X	—	NMK B9512
Hindorf, Dithmarschen, DE	Grave?	Spear (Valsømagle)	X	0	0	1	1	0	3	?	**5**	X	?	LMSH KS13767
Hjälmared, Halland, SE	unknown	Spear (Bagterp)	X	1	0	0	1	0	1	1	**4**	—	X	GAM 47679
Hohenaspe, Steinburg, DE	Grave	Sword (Sögel)	X	2	2	0	2	0	2	0	**8**	—	X	LMSH 10800a
Hohenlockstedt, Steinburg, DE	Grave	Sword (Virringe)	X	3	0	0	2	1	1	1	**8**	—	X	LMSH 10802
Holmsland, Hind, DK	Hoard	Spear (Bagterp)	X	0	2	3	0	0	1	0	**6**	—	?	NMK 11337
Homfeld, Rendsburg-Eckernförde, DE	Grave	Sword (Sögel)	X	1	0	0	2	1	1	0	**5**	—	X	LMSH 8824a
Hüsby, Schleswig-Flensburg, DE	Grave	Spear (Bagterp)	X	2	3	0	3	1	2	0	**11**	—	X	LMSH B115.8
Hvarsta, Uppland, SE	Single	Spear (Valsømagle)	X	1	2	1	1	1	0	2	**8**	—	X	SHM 16381
Hvedholm (surroundings) (I), Sallinge, DK	unknown	Spear (Torsted)	X	1	2	0	0	0	1	?	**4**	X	?	NMK B1458
Hvedholm (surroundings) (II), Sallinge, DK	unknown	Spear (Bagterp)	X	?	?	?	1	0	1	0	**2**	X	?	NMK B1459
Hyby, Scania, SE	Single?	Spear (Bagterp)	X	2	2	3	2	0	2	0	**11**	—	X	LUHM 20548
Issehaved Bakker, Holbæk, DK	unknown	Spear (Bagterp)	X	1	0	0	0	0	1	0	**2**	X	X	NMK B10582
Itzehoe, Steinburg, DE	Grave	Spear (Bagterp)	X	2	2	0	1	0	1	0	**6**	—	X	NMK T10
Kerteminde, Odense, DK	Single	Dagger (Wohlde)	X	1	0	0	2	0	1	0	**4**	—	X	NMK 10578
Kisum, Ginding, DK	Grave?	Sword (Wohlde)	X	2	0	0	1	0	0	0	**3**	—	X	NMK B7830
Kokborg, Vejle, DK	Grave	Dagger (Sögel)	X	0	0	0	2	0	2	?	**4**	X	X	NMK B13483
Kragelund, Ribe, DK	Single	Spear (Bagterp)	X	0	0	2	0	0	0	?	**2**	X	X	MM 5786
Krumstedt, Dithmarschen, DE	Single?	Sword (Sögel)	X	2	3	0	1	0	2	0	**6**	—	X	LMSH 11675
Kyrkjuves, Gotland, SE	Single?	Spear (Bagterp)	X	0	0	1	1	0	1	0	**3**	X	?	SHM 15951:2
Liffride, Gotland, SE	unknown	Spear (Bagterp)	X	3	2	1	1	0	1	0	**8**	—	X	SHM 14776
Lilla Beddinge sn., Scania, SE	Single?	Spear (Bagterp)	X	1	3	1	1	0	0	1	**7**	—	X	LUHM 22266
Limensgård, Bornholm, DK	Grave	Sword (Sögel)	?	0	0	0	0	0	2	0	**2**	X	?	NMK B1648
Linköping, Östergötland, SE	unknown	Spear (Bagterp)	X	0	0	2	0	0	1	0	**3**	X	X	SHM 9170:1206

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Lintrup, Ribe, DK	Single	Spear (Valsømagle?)	X	0	3	3	0	1	1	0	**8**	—	X	NMK B561
Löderup, Scania, SE	Single	Spear (Bagterp)	X	1	0	1	2	0	2	1	**7**	—	X	SHM 5886
Løvskal, Viborg, DK	Single	Spear (Bagterp)	X	?	?	?	1	0	1	0	**2**	X	X	NMK B5040
Lund, Scania, SE	unknown	Spear (Bagterp)	X	3	3	0	2	0	2	1	**11**	—	X	LUHM 12718
Lunderskov, DK	Single	Spear (Ödeshög)	X	0	0	1	1	0	1	0	**3**	X	X	NMK B16874
Maglehem sn, Scania, SE	Single?	Spear (Valsømagle)	?	0	0	0	1	0	1	0	**2**	—	X	SHM 8722:814
Maltegård, Copenhagen, DK	Single	Spear (Bagterp)	X	0	0	1	1	0	2	0	**4**	X	?	NMK B18091
Mølgård, Viborg, DK	Grave	Sword (Sögel)	?	?	?	?	?	?	?	?	?	X	?	NMK 7717
Nättraby sn. (I), Blekinge, SE	Grave?	Spear (Bagterp)	X	0	0	0	1	0	1	1	**3**	—	?	SHM 4529
Nättraby sn. (II), Blekinge, SE	Grave?	Spear (Bagterp)	X	0	2	1	0	0	2	0	**5**	—	X	SHM 4529
Neuberend, Schleswig-Flensburg, DE	Grave	Sword (Virring)	X	0	2	0	2	0	1	0	**5**	—	X	LMSH KS9489
Nordborg (I), Sønderborg, DK	Grave	Sword (Sögel)	?	0	0	0	0	0	0	?	**0**	X	?	NMK Z1010
Nordborg (II), Sønderborg, DK	Grave	Spear (Bagterp)	X	0	0	0	1	0	0	0	**2**	X	X	NMK Z1011
Norra Möckleby, Öland, SE	Single?	Spear (Ödeshög)	X	1	3	0	1	0	2	0	**7**	—	X	SHM 1304 (1837) 81
Nørre-Bøel, Ribe, DK	Grave	Sword (Sögel)	X	1	2	0	2	0	2	1	**8**	—	X	NMK B4245
Nygårds, Gotland, SE	Single	Spear (Bagterp)	X	0	0	1	1	0	0	0	**2**	—	X	SHM 11686
Ödeshög, Östergötland, SE	Single?	Spear (Ödeshög)	X	0	0	0	1	0	1	1	**3**	X	X	SHM 11495:494
Ohrsee, Rendsburg-Eckernförde, DE	Grave	Dagger (Sögel)	X	0	0	0	3	0	2	0	**5**	X	?	LMSH 7380
Ölme, Värmland, SE	Single?	Spear (Bagterp)	?	0	0	0	2	0	1	0	**3**	X	?	SHM 8646
Øster-Gasse, Tønder, DK	Grave	Sword (Sögel)	?	1	0	0	0	0	0	?	**1**	X	?	LMSH 4962
Pahlkrug, Dithmarschen, DE	Grave	Spear (Torsted)	X	1	0	0	0	0	1	?	**2**	—	?	LMSH 13125
Rønnerud,Oppland, NO	Single	Sword (Apa)	X	0	0	3	2	0	2	?	**7**	X	?	NMO C54227
Rude Eskilstrup, Sorø, DK	Single	Spear (Bagterp)	X	1	0	3	2	0	0	0	**6**	X	X	NMK 14565
Russee, Rendsburg-Eckernförde, DE	Single	Spear (Bagterp)	?	2	0	0	0	0	0	2	**4**	—	X	LMSH KS14709
Rye, Copenhagen, DK	unknown	Spear (Bagterp)	?	?	?	?	?	0	1	0	**1**	X	?	NMK B10472
Ryssby sn, Småland, SE	Single?	Spear (Ödeshög)	X	1	0	0	3	0	0	0	**4**	—	X	SHM 1304:58

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Schafstedt, Dithmarschen, DE	Grave	Sword (Wohlde)	X	1	0	0	1	0	0	1	**3**	X	X	LMSH 11954.I
Schuby, Schleswig-Flensburg, DE	Grave	Sword (Wohlde)	?	0	0	0	0	0	0	?	**0**	X	?	LMSH 6998
Sengeløse (?), Copenhagen, DK	unknown	Spear (Valsømagle)	X	0	2	0	1	0	0	?	**3**	—	?	NMK B11350
Simris sn, Scania, SE	Single?	Spear (Valsømagle)	X	1	3	3	2	0	0	0	**9**	—	X	LUHM 27463
Smedby,Öland, SE	Grave	Spear (Bagterp ?)	—	0	0	0	0	0	0	0	**0**	—	?	SHM 23307
Søholt, Maribo, DK	Single	Spear (Bagterp)	X	1	3	2	1	0	2	1	**10**	—	X	NMK B14368
Sölvesborg, Blekinge, SE	Single?	Spear (Bagterp)	X	0	2	2	1	0	2	2	**9**	—	X	LUHM 20549
Sörup (I), Schleswig-Flensburg, DE	Grave	Sword (Sögel)	?	1	0	0	0	0	0	?	**1**	X	?	LMSH B23
Sörup (II), Schleswig-Flensburg, DE	Grave?	Sword (Sögel)	?	0	0	0	0	0	2	0	**2**	X	?	LMSH KS12587
Steinbergholz, Schleswig-Flensburg, DE	Grave	Sword (Sögel)	X	1	2	0	2	0	2	0	**7**	X	X	LMSH KS11405
Stenkumla sn., Gotland, SE	unknown	Spear (Valsømagle)	X	0	0	1	0	0	0	0	**1**	—	X	SHM 13457:1
Stora Bernstorp, Scania, SE	Single	Spear (Valsømagle)	X	3	3	0	3	1	0	0	**10**	—	X	LUHM 27042:25
Store Strandbygård, Bornholm, DK	Grave	Spear (Torsted)	?	?	?	0	0	0	1	0	**1**	X	?	NMK B1771
Tange, Viborg, DK	Single	Spear (Valsømagle?)	X	1	3	0	1	0	0	0	**5**	—	X	NMK B10902
Tåning, Skanderborg, DK	Grave	Spear (Bagterp)	X	0	2	2	1	0	1	?	**6**	—	—	MM 5135
Tensbüttel, Dithmarschen, DE	Grave	Sword (Wohlde)	X	0	0	0	2	0	1	0	**3**	—	X	LMSH B290
Thise (I), Viborg, DK	Grave?	Spear (Torsted)	X	1	2	0	2	0	0	0	**5**	—	—	NMK B13233
Thise (II), Viborg, DK	Grave?	Sword (Sögel)	X	0	2	0	1	0	1	0	**4**	X	?	NMK B13232
Thisted (near), Hundborg, DK	Single	Dagger (Sögel)	X	0	3	1	2	0	1	1	**8**	—	—	NMK B13409
Tinnum, Sylt, DE	Grave	Sword (Wohlde)	X	2	0	0	1	?	1	?	**4**	X	X	LMSH KS18092
Tinsdahl, Hamburg, DE	Hoard	Spear (Tinsdahl)	X	2	0	1	1	0	0	1	**5**	—	X	LMSH 6164
Torslunda, Uppland, SE	Hoard	Spear (Valsømagle)	X	0	2	2	1	0	0	1	**6**	—	—	SHM 208984
Tullgara, Södermanland, SE	unknown	Spear (Valsømagle)	X	1	2	0	1	0	0	0	**4**	X	?	SHM 8439
Ullevi, Öland, SE	Single	Spear (Bagterp)	X	0	0	0	2	0	0	1	**3**	—	X	SHM 4321

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Undløse, Holbæk, DK	Single?	Spear (Bagterp)	X	1	0	0	1	0	0	1	**2**	—	X	NMK 13874
unknown (1), Scania, SE	unknown	Spear (Valsømagle)	X	3	2	2	2	1	2	1	**13**	X	X	LUHM 3403
unknown (1), SE	unknown	Spear (Valsømagle)	X	1	3	2	1	0	2	0	**9**	—	X	LUHM 6658
unknown (10), Scania, SE	unknown	Spear (Bagterp)	X	0	2	3	1	0	0	0	**6**	—	X	NMK S135
unknown (10), SE	unknown	Spear (Ödeshög)	X	1	2	0	0	0	0	1	**4**	—	X	SHM 2899
unknown (11), Scania, SE	unknown	Spear (Bagterp)	X	1	0	0	1	0	0	0	**2**	—	X	GAM 2923
unknown (2), Scania, SE	unknown	Spear (Bagterp)	X	0	0	0	1	0	1	0	**2**	—	X	SHM 8970:146
unknown (2), SE	unknown	Spear (Valsømagle)	X	3	2	2	2	0	2	0	**11**	—	X	LUHM 8985
unknown (3), Scania, SE	unknown	Spear (Bagterp)	X	1	0	0	1	1	1	0	**4**	—	X	SHM no Number
unknown (3), SE	unknown	Spear (Valsømagle)	X	0	2	1	0	0	1	0	**4**	—	X	LUHM 10131
unknown (4), Scania, SE	unknown	Spear (Valsømagle)	X	3	3	2	1	0	1	0	**10**	—	X	LUHM 12911
unknown (4), SE	unknown	Spear (Valsømagle)	X	0	0	1	1	0	2	0	**4**	X	?	LUHM 11113
unknown (5), Scania, SE	unknown	Spear (Valsømagle)	X	2	0	3	1	0	0	2	**8**	—	X	LUHM 12913
unknown (5), SE	unknown	Spear (Bagterp)	?	0	0	0	1	0	0	0	**1**	X	X	SHM 2898
unknown (6), Scania, SE	unknown	Spear (Valsømagle)	X	1	0	0	2	0	2	1	**6**	—	X	LUHM 12915
unknown (6), SE	unknown	Spear (Ödeshög)	X	2	3	0	0	1	0	1	**7**	—	X	SHM 3937
unknown (7), Scania, SE	unknown	Spear (Valsømagle)	X	0	2	1	1	0	0	0	**4**	X	?	GAM 47590
unknown (7), SE	unknown	Spear (Bagterp)	X	0	0	0	2	0	2	1	**5**	—	X	SHM 17343:1440a
unknown (8), Scania, SE	unknown	Spear (Torsted)	X	2	0	3	1	1	2	0	**9**	—	X	LUHM 6657
unknown (8), SE	unknown	Spear (Bagterp)	X	0	0	2	1	0	1	0	**4**	X	X	GAM 2343
unknown (9), Scania, SE	unknown	Spear (Ödeshög)	X	1	0	1	1	0	0	1	**4**	—	X	LUHM 11111
unknown (9), SE	unknown	Spear (Valsømagle)	X	0	2	0	0	0	1	0	**3**	X	?	SHM 2893
unknown, Blekinge, SE	unknown	Spear (Bagterp)	X	1	2	0	1	0	2	0	**6**	—	X	SHM 9014
unknown, Lejrskov, Ribe, DK	Grave?	Sword (Sögel)	?	1	0	0	1	0	2	0	**4**	X	?	MM 5147
unknown, Ods H., Holbæk, DK	unknown	Spear (Bagterp)	X	1	0	1	1	1	0	1	**5**	—	X	NMK B10803
unknown, Värmland, SE	Grave?	Spear (Bagterp)	—	0	0	0	0	0	0	0	**0**	X	—	SHM 7577
Vallby sn, Scania, SE	unknown	Spear (Bagterp)	X	0	0	1	1	0	2	2	**6**	—	X	LUHM 11112

(*continued*)

Table 1. (*Continued*).

Find place	Context	Type	Use-wear	Notch	Indentation	Blow marks	Curvature	Twisting	Fractures	Tip damage	**Damage number**	Heavy distortion	Repair	Inventory no.
Valsømagle (I/I), Sorø, DK	Hoard	Spear (Valsømagle)	X	1	0	0	1	0	1	1	**4**	X	?	NMK B3952
Valsømagle (II/I), Sorø, DK	Hoard	Spear (Valsømagle)	X	0	0	0	1	0	1	0	**2**	—	—	NMK B7523
Valsømagle (II/II), Sorø, DK	Hoard	Spear (Valsømagle)	X	0	0	1	1	0	2	0	**4**	—	?	NMK B7524
Varpelev, Præstø, DK	unknown	Spear (Valsømagle)	X	1	0	0	1	1	1	0	**4**	—	—	NMK B8461
Virring (II), Sønderhald, DK	Hoard	Spear (Bagterp?)	X	2	2	1	1	0	1	0	**7**	—	X	NMK B3959
Virring (III), Sønderhald, DK	Hoard	Spear (Torsted)	X	0	0	1?	1	0	1	0	**2**	—	?	NMK B3961
Virring (IV), Sønderhald, DK	Hoard	Spear (Bagterp?)	X	0	2	1	2	0	1	2	**8**	—	X	NMK B3960
Virring (IV), Sønderhald, DK	Hoard	Spear (Rederzhausen)	X	1?	0	1?	1	0	0	2	**3**	—	X	NMK 3958
Virring (V), Sønderhald, DK	Hoard	Sword (Virring)	X	0	0	0	2	0	1	0	**3**	—	X	NMK B3957
Voldtofte, Odense, DK	Grave	Spear (Valsømagle)	X	0	2	0	1	0	1	0	**4**	X	X	NMK 25995
Vreta Monastery, Östergötland, SE	unknown	Sword (Sögel)	X	1	0	2	2	1	2	0	**8**	—	X	SHM 10419:211
Ysane, Blekinge, SE	Single?	Spear (Ödeshög)	?	0	0	0	1	0	0	1	**2**	—	X	LUHM 29767

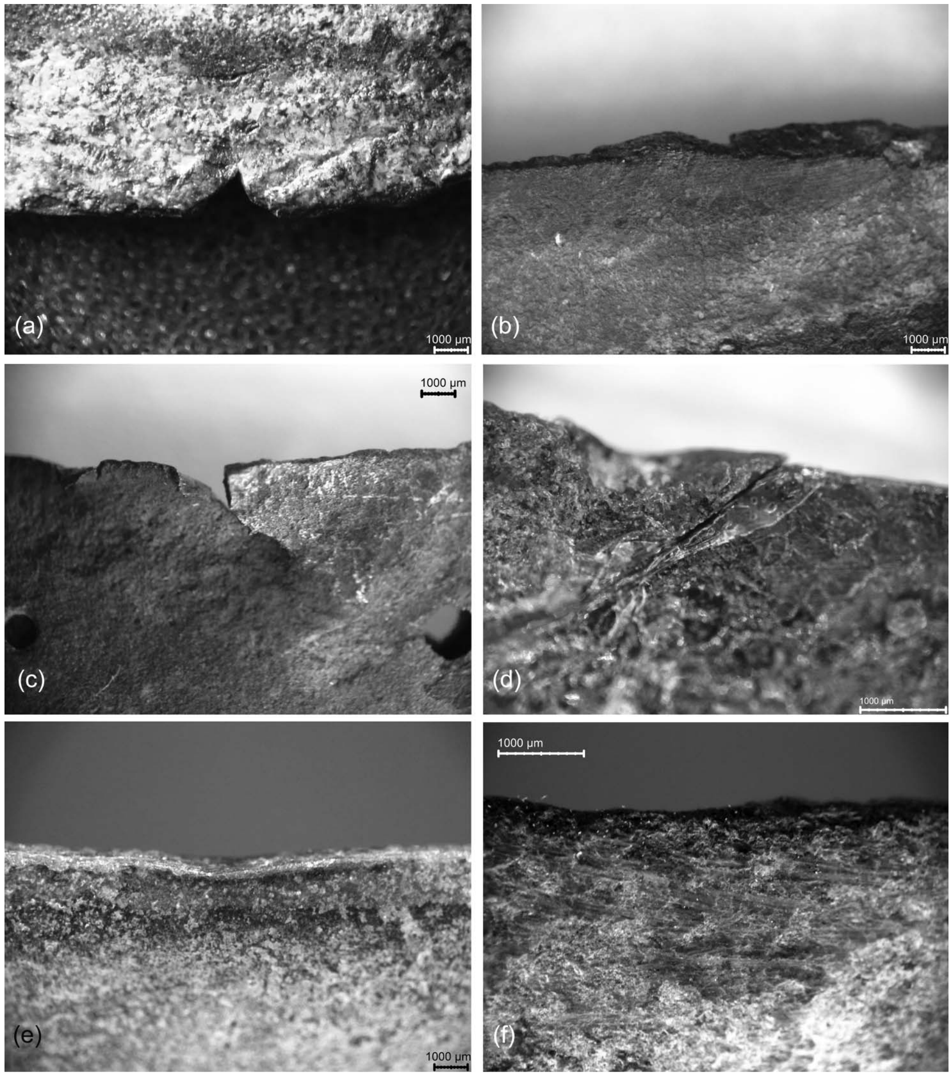


Figure 2. (a) Notch (NM K B 4245); (b) Grazing blow (NM K 9044); (c) Fissure caused by a notch (NM K B 938); (d) Fissure caused by an indentation (SHM 14776); (e) Shallow indentation and material displacement (NM K B 10902); (f) Repaired indentation and related striations (LUHM 20548).

as secondary proof for the existence of such protective gear, but this should not be overstated. It has to be kept in mind that bones or wooden weapons (see, for example, Jantzen *et al.* (2011)) could also have caused tip pressure.

Curvatures (Figure 3(e) and (f)) are caused by stress on the material due to force. The ductility of the metal allows such stress to be relieved by bending. Therefore, this damage is considered to be a plastic deformation. Curvatures usually affect larger portions of the weapon, for example, a tip receiving pressure might lead to a deformation of the upper third of the spearhead. This damage can affect a single part or the weapon as a whole. If a weapon shows just a very slight and even curvature over its whole body, it is attributed to earth pressure affecting the object post-deposition. Material displacement and curvatures are closely related, the main difference being the size of the damaged area.

Twisting is a plastic deformation along the longitudinal axis of the weapon. It is difficult to observe and to document because it is usually very weak due to the amount of force necessary to create it. This kind of damage was previously linked to the intentional destruction of weapons (Horn 2011). However, it could also be caused if the weapon became stuck somewhere, for example, between bones, and it was removed by force in a twisting motion.

Fractures (Figure 4) are caused when stress put on a material exceeds its ductility, ultimately leading to its failure. Such stress might, for example, occur when a tip receives pressure (Figure 3(d)). Complete material failure leads to a detached part and secondary fractures can develop in direct connection (Figure 4(a)). If nothing becomes detached, the fracture is termed a *fissure* (Figure 4(b)). *Hairline fractures* are invisible or barely visible macroscopically (Figure 4(c) and 4(d)).

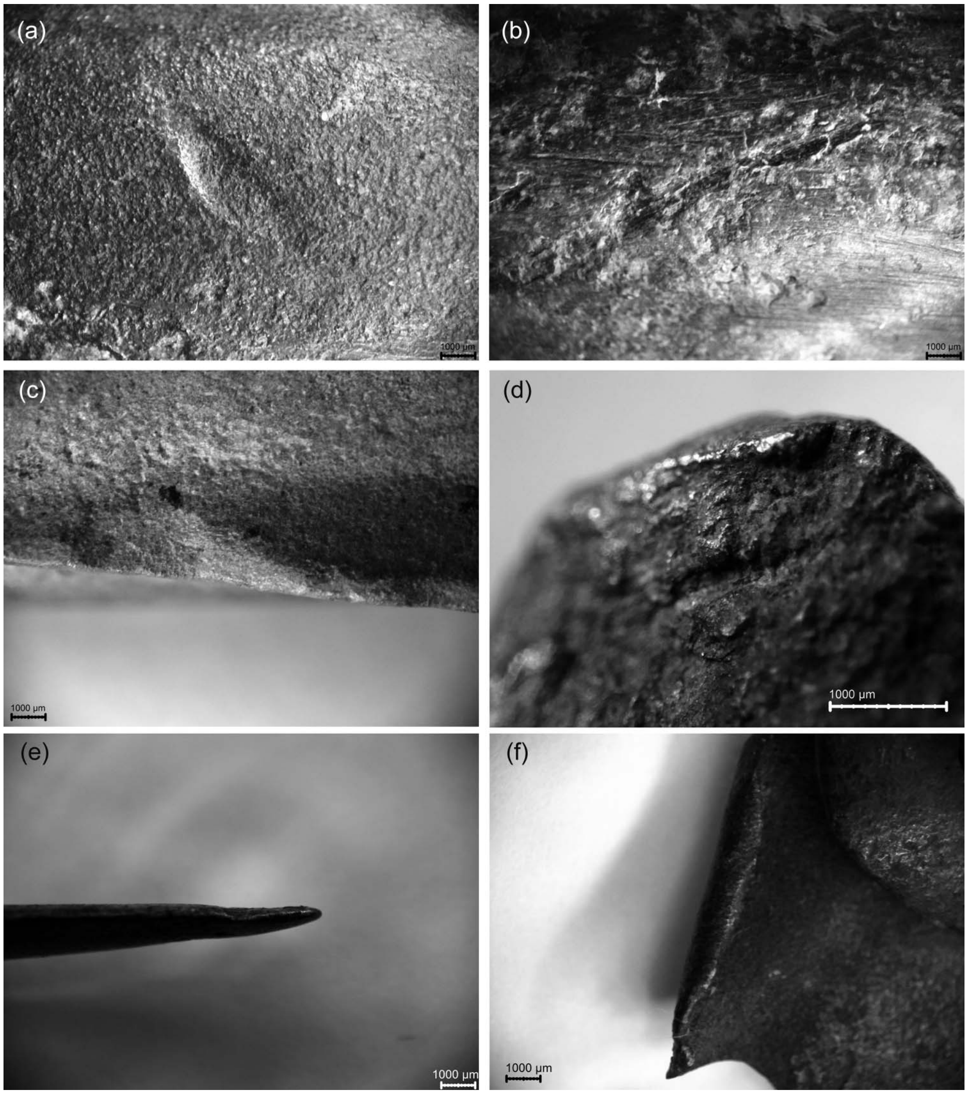


Figure 3. (a) Rounded blow mark (LMSH KS B 330); (b) Elongated blow mark (MM 5786); (c) Blow mark-indentation hybrid (LUHM 12740); (d) Fissure (spear tip) caused by pressure (LUHM 11112); (e) Curved tip (NM K B 10578); (f) Curved hafting plate (NM K B 10578).

Sometimes, it is difficult to distinguish between anthropogenic damage and that caused by corrosion. In these cases, a fracture associated with a curvature is a good indicator for a human origin of the damage (Figure 4(a)). However, not all breaks without a fracture at the apex of a curvature are due to post-depositional processes. An object's hardness, ductility and thickness are important properties preventing or facilitating fractures, curvatures and subsequently the ultimate form of the damage.

Shape reduction is not in itself use-wear damage (Figure 5(a)), because it may appear during production and repair. Despite the important and meaningful difference of which point in time this feature appears, its origin is difficult to distinguish. Both the outline and the cross-section are possibly affected. Several subtractive methods of treatment are known that may lead to shape reduction: *grinding*, *polishing* and *hammering* (Figure 5(b)–(f)).

Grinding has frequently been part of the post-depositional treatment after the objects recovery. Modern grinding is rather straightforward and cuts through patina. Usually, the aim of such grinding was to partially or completely remove patina (Figure 5(f)). Modern striations are often considerably deep and cause displaced material that is substantial, but usually remains on a microscopic level. The reasons for this removal vary and range from the desire of the amateur finder to distinguish the material of his new find, the wish to present the visitors of a museum with a shiny object (Bridgford 1997, p. 96) or the collection of samples by researchers.

In contrast, ancient grinding was probably done more carefully in order, for example, to preserve the sharpness

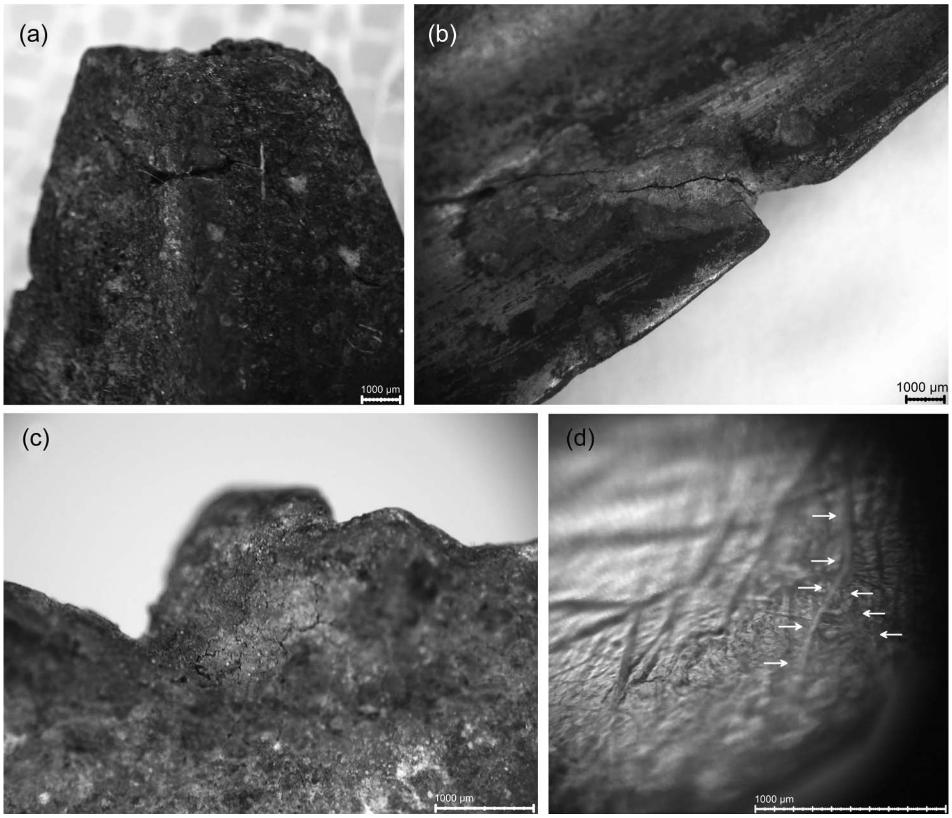


Figure 4. (a) Fissure (spear tip) caused by a curvature (SHM 14776); (b) Fissure (corrosion) induced stress next to a notch (NM K B 10578); (c) Material displacement affected by hairline fractures (corrosion) (LUHM 12627); (d) Hairline fracture (NM K B 15103).

of the edge of the weapon. Thus, ancient striations are probably weaker and take away less material at once. A weapon may be subject to repair more than once in its lifetime. Therefore, striations may be assumed to be less regular in direction. However, certain parts need certain treatment. A distinct directionality of striations can become visible (Figure 5(d)), but multidirectional striation patterns appear too (Figure 5(e)). Striations underneath patina suggest an ancient origin (Figure 6(a), Roberts and Ottaway 2003, p. 120). As grinding and polishing are subtractive, they affect ornamentation (Figure 6(b)). It is not likely that it was desirable to remove ornamentation. If disappearing parts of the decoration are patinated, they are a good indicator for ancient repair processes. However, it should be stressed that corrosion affects decoration too and can lead to its eradication.

Microscopic examination improves the chances of recognising weak striations (Figure 5(c)). However, it should be considered that objects were possibly polished very finely even after repair. For this reason, in a number of cases, no striations were visible up to 300× magnification. This exemplifies the problem of recognition, because there might be a number of cases which were repaired, but the traces of these repairs may not be visible to the modern observer. Assumedly, repairs were carried out from the coarse grinding to the fine final polish. The earlier this process was stopped in ancient times, the more likely it is observable.

A considerable margin of error exists in the assessment of striations, because they do not immediately tell at what point in time they were caused. In order to finish a cast metal object, it needs treatment, including grinding and polishing, for example, to remove casting seams (Binggeli 2011, p. 20). Cutting edges probably received an initial sharpness. So, the edges were ground and polished at least once before they are actually put in a situation where they would receive damage.

According to what has previously been mentioned, it is possible to interpret irregular, multidirectional, variable striations and those directly associated with corrected damage. If the cross-section is reduced severely or the outline is very asymmetrical, a repair process is assumed even without visible grinding or polishing traces (Kristiansen 1984, 2002). It is assumed to be unlikely that a high degree of asymmetry was desired upon production because that would reduce the weapons ability to cut on at least one edge.

The aim of ancient repair processes was presumably to keep the weapon in a usable state. Thus, repairs probably aim at making the transition between a preserved edge and to smooth damage in order to restore

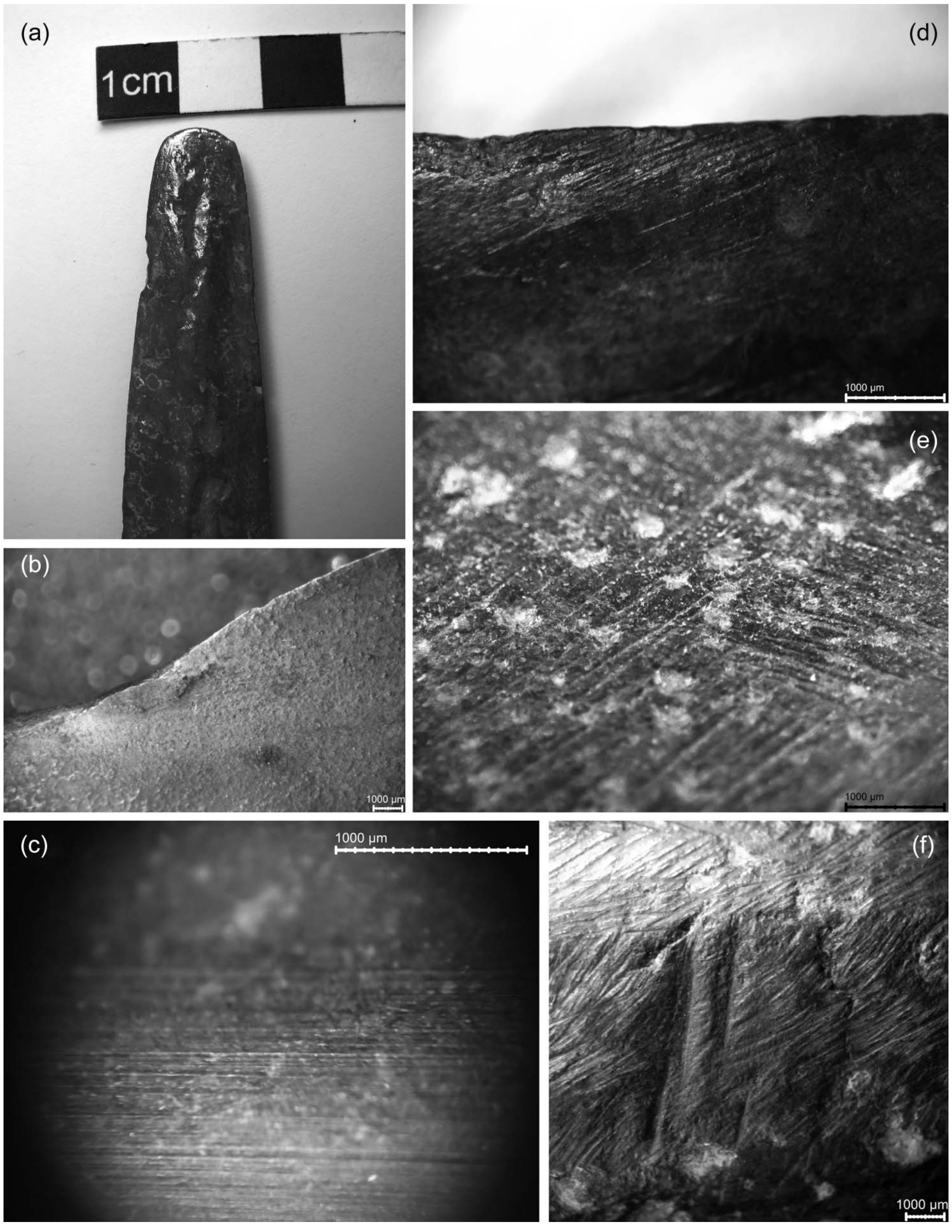


Figure 5. (a) Shape reduction (LMSH KS 11675); (b) Indentation potentially repaired by hammering (NM K B 10803); (c) Polish striation (NM K B 11946); (d) Resharpening striations (LMSH KS 11675); (e) Multidirectional striation pattern (MEG B 17620); (f) Modern grinding over ancient blow marks (SHM 9170).

the capability of the blade to cut. Additionally, this would prevent fissures occurring in sharp cracks jeopardising the physical integrity of the whole weapon. Thus, repairs lead inherently to the disappearance of damage. Accordingly, it should be kept in mind that not all damage received by a spear or a sword may be visible to the modern researcher.

Corrosion is another factor that has the potential to blur evidence for use considerably. It is a process that causes metal particles to oxidise and increase in size. This process puts stress on the microstructure (Spähn 2001, p. 203). Subsequently, the tension is relieved in fractures.

Chlorine and ammonia contribute to dissolving corrosion (Tylecote 1979, p. 350, Spähn 2001, p. 203, Table 1). Both substances are present in the human body, and decay sets them free. Mixed with bodily fluids and intruding water, it creates a highly corrosive solution. Thus, inhumations possess an environment very benign to dissolving corrosion. Sometimes, the corrosion induced by human decay is so severe that the metal dissolves completely into very brittle gypsum remains (Figure 6(c)). If the

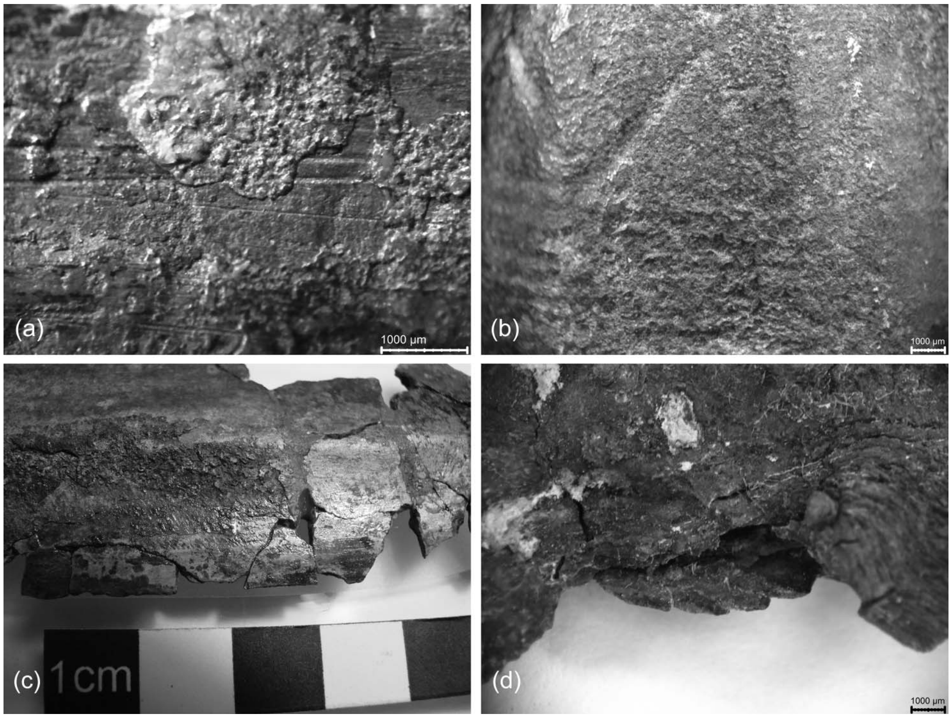


Figure 6. (a) Striations underneath patina (NM K B 5254); (b) Fading ornamentation (LUHM 6658); (c) Advanced stage of corrosion, metal transformed into gypsum (LMSH KS 11802); (d) Heavily corroded cutting edge affecting an indentation (LMSH KS 7380).

amount of pieces with heavy disturbances known from secure contexts is compared, graves (59%, 23) outnumber hoards (18%, 7) and single (23%, 9) finds by far.

Damaged areas are pre-weakened and, thus, more prone to corrosion. Consequently, these parts fracture and dissolve earlier than undamaged parts. (Kirchberg 2001, Spähn 2001). Due to their thinness, edges are especially predisposed to damage (Figure 6(d)). Edge damage exacerbates this, and post-depositional damage due to corrosion is intensified. The same is possibly true for ground parts because striations also provide a higher surface area. This facilitates even more danger to dissolve cutting edges because they provide a larger area for the corrosive elements to attack. In this way, corroded parts and those that received damage prior to corrosion become indistinguishable. This leads to the paradoxical situation that a specimen heavily damaged by past combat is not recognisable as such, because of its higher vulnerability to post-depositional corrosion.

All the remarks about repair and corrosion considered; a weapon might be grouped in the category 'no damage', despite having received damage in past combat. Thus, it has to be kept in mind that the category 'no damage' should be read as 'no damage visible'. For this reason, were heavily corroded weapons usually summarised under 'uncertain', even if they were recorded with 0 or 'no damage'. Unless, a weapon showed clear evidence that this particular damage was indeed completely missing. Moreover, if damage is visible it represents the final stage in the actual use of the weapon before it was discarded. Accordingly, it is very difficult to estimate how much fighting actually took place with a particular weapon, and we might never be able to. Furthermore, not all damage has to be seen as originated due to fighting. Perhaps, some damage comes from ritual practices as will be elaborated later on (see also Horn (in prep.)). Thus, any result has to be deduced carefully and interpreted with caution. In the following, the percentage for uncertain pieces is not always mentioned. If the percentage for the categories 'damaged' and 'no damage' does not add up to 100%, then the category 'uncertain' represents the remaining specimen.

Use-wear analysis of spears

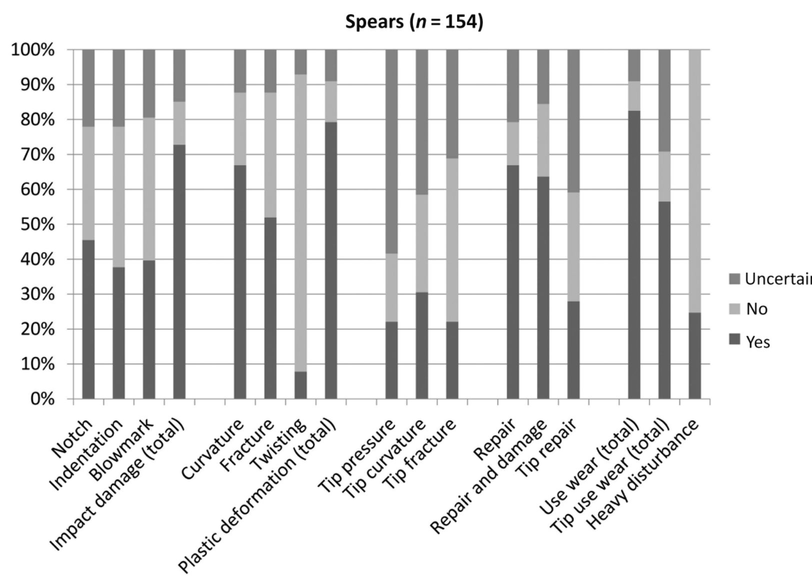
Among the 154 spears are 50 Torsted type, 49 Bagterp type, 39 Valsømagle type (two uncertain) and 9 Ödeshög type. Furthermore, two spears might belong to the Valsømagle type and two potentially to the Bagterp type, but all of them are uncertain in their classification. One spear could not be attributed to any type. Finally, a single Rederzhausen type spear and the spear from the Tinsdahl hoard were also analysed. All these spears belong to Period I of the Nordic Early Bronze Age.

All of the following results have been summarised in one chart and one table (see Figure 7(a)). A majority of the spears possess visible use-wear traces or traces of repair (83%, 127). Only 13 spears (8%) have no observable signs of use or repair, and 14 spears (9%) are too unclear to distinguish whether the damage is of anthropogenic origin.

Notches were observed on almost half of the analysed specimen (45%, 70). Such damages are not identifiable on a smaller number of spears (33%, 50). Indentations are exhibited by over one-third of the spears (38%, 58). Slightly more pieces (40%, 62) have no traces of indentations. 61 spears (40%) display blow marks that were not visible on 41% (63) of the examined pieces.

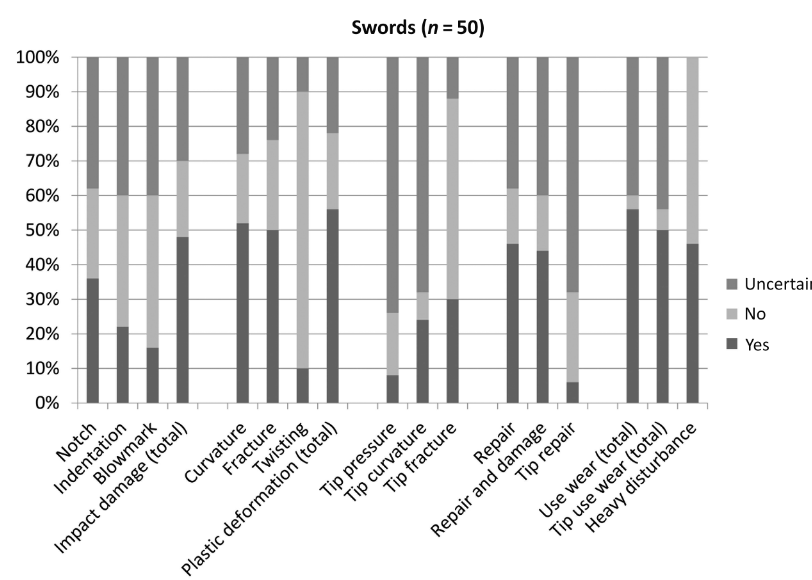
Notches, indentations and blow marks are summarised as ‘impact damage’ because their origin is probably directly connected to a more or less forceful blow from or to another object, which was very likely a weapon or another object used as such. In this regard, pressured tips could also be counted as impact damage, but since tips received special attention in the analysis they are left out. Almost three-quarters of the analysed spears (73%, 112) have observable traces of such damage. That means they were most likely used in hand-to-hand combat. The number would be even higher if pressured tips were to be

Spears (*n* = 154)			
	Yes	No	Uncertain
Notch	70	50	34
Indentation	58	62	34
Blowmark	61	63	30
Impact damage (total)	112	19	23
Curvature	103	32	19
Fracture	80	55	19
Twisting	12	131	11
Plastic deformation (total)	122	18	14
Tip pressure	34	30	90
Tip curvature	47	43	64
Tip fracture	34	72	48
Repair	103	19	32
Repair and damage	98	32	24
Tip repair	43	48	63
Use wear (total)	**127**	**13**	**14**
Tip use wear (total)	87	22	45
Heavy disturbance	38	116	0



(a)

Swords (*n* = 50)			
	Yes	No	Uncertain
Notch	18	13	19
Indentation	11	19	20
Blowmark	8	22	20
Impact damage (total)	24	11	15
Curvature	26	10	14
Fracture	25	13	12
Twisting	5	40	5
Plastic deformation (total)	28	11	11
Tip pressure	4	9	37
Tip curvature	12	4	34
Tip fracture	15	29	6
Repair	23	8	19
Repair and damage	22	8	20
Tip repair	3	13	34
Use wear (total)	**28**	**2**	**20**
Tip use wear (total)	25	3	22
Heavy disturbance	23	27	0



(b)

Figure 7. (a) Table and chart of the use-wear analysis of spears; (b) Table and chart of the use-wear analysis of swords.

added. Only 12% (19) and 15% (23), respectively, lacked impact damage or the traces were too unclear to identify them as being anthropogenic.

Curvatures, twisting and the fracture of weapons are termed ‘plastic deformations’ in this article. Even though notches, dents and blow marks are in a sense plastic deformation too, the scale of the deformation is larger and affects greater parts of the weapons when it comes to curvatures, twisting and fractures.

A large amount of the examined spears (79%, 122) possessed plastic deformations. If these are split up, then curvatures are the dominant damage exhibited on the spears by two- thirds of the examined material (67%, 103). Half of the analysed spears (52%, 80) have fractures potentially induced by anthropogenic action. Perhaps, the high amounts of damaged pieces for both curvatures and fractures point to a correlation between both.

Interestingly, the amount of fractures potentially caused by human activity in ancient times without association to a curvature is quite high (46%, 37). Conversely, 13 spears (16%) display both fractures on the apex of a curvature, as well as away from the curvature, and 26 specimens (33%) possess only fractures caused by curvatures. Deformations in a twisting manner are rare; just 12 spears (8%) display this kind of damage.

Examining the tips of the spears is difficult, because these tips are very frequently lost either due to human action or post-depositional processes. That takes away the possibility to see whether a break occurred in succession to the tip receiving pressure or after it had already been repaired. Therefore, the analysis of 90 spears (58%) could not lead to any feasible results whether they received pressure because the tips are lost or otherwise subject to heavy disturbance. Yet, it is still possible to make a judgement whether they are lost due to human impact or post-depositional causes.

The spears that received pressure to their tips and those without such damage are broadly balanced with 34 (22%) and 30 specimens (20%), respectively. On a general level, the amounts of tips with curvature repeat this picture, but a slightly higher margin exists between those spears affected by this kind of damage (30%, 47) and those not affected (28%, 43). The amount of spears with fractures, with clear indicators of human activity is surprisingly low (22%, 34). Just two spear tips (1%) were subject to a deformation caused by twisting.

If the use-wear on tips is summarised, we see that the majority of spears (57%, 87) probably received damage on their tips, while only 20 pieces (14%) were free of such damage. As already mentioned, spear tips, along with other parts of any weapon, can be affected by repair processes. These repairs will be addressed in the following.

Traces that point to repair processes have been discovered on almost two-thirds of the analysed spears (67%, 103). For 32 spears (21%), no decision about the origin of traces, such as striations and shape reduction, could be made. However, at least 19 pieces (12%) may show no signs of ancient secondary treatment.

For observation of repairs on the tips, the same difficulties stated earlier apply for tip damage if the tips are lost. Due to these problems, 41% (63) of the spear tips are unclear whether they were repaired in ancient times. Yet, over a quarter (28%, 43) of the analysed spear tips show traces that potentially suggests an ancient repair. However, 48 spear tips (31%) have no visible traces, such as striations or the traces suggest an origin in their production rather than during their repair.

Over two-thirds of all analysed spears (64%, 98) potentially possessed damage acquired in combat and traces of repair processes simultaneously. In this regard, specimens without or with unclear traces are represented with 21% (32) and 15% (24), respectively.

To end this section, we turn to post-depositional disturbances once more. In this regard, spears represent themselves in a distinctly different manner than swords, as we shall see. Only a quarter of the spears (25%, 38) were categorised as possessing heavy post-depositional disturbances. For the remaining 75% (116), it was expected that they are in a good enough condition that most of the use-wear present upon deposition should be visible.

Use-wear analysis of swords

All 50 analysed swords belong to Period I of the Nordic Bronze Age. According to their length, six blades should be classified as ‘daggers’, but morphologically they fit the known sword types very well. For this reason and for the sake of a statistical comparison, these six blades were included in the category ‘swords’. It possible to subdivide the analysed set of swords into Sögel (28), Apa (11), Wohlde (7) and Virring (3) type swords. One sword is not identifiable at all.

All of the following results have been summarised in one chart and one table (see Figure 7(b)). Slightly more than half of the swords (56%, 28) exhibit traces of use or repair and only two swords (4%, 2) are clearly lacking such evidence. The traces on the remaining swords (40%, 20) were not clearly identifiable as signs of ancient use. The different features are represented as follows.

Notches were visible on 18 swords (36%), while 13 blades (26%) were without them. Indentations were exhibited by 11 swords (22%). In total, 19 of the analysed pieces (38%) were without visible traces of indentations. Only 8 swords (16%) possessed observable blow marks. In turn, blow marks could not be detected in 22 cases (44%). If these damages are again summarised as ‘impact damage’, a total of 24 swords (48%) show such damage. A minority of the swords (22%, 11) had no visible traces of impact. Even more swords (30%, 15) were unclear after assessment.

Swords are affected by plastic deformations too. After the analysis, 26 blades (52%) seem to be curved by anthropogenic and not post-depositional influences. Only 10 swords (20%) were probably not affected by curvature caused by humans. The twisting of swords (10%, 5) occurs slightly more often than on spears (8%, 12), but it is still rare in Period I of the Early Bronze Age. A large amount of the swords (80%, 40) was most likely unaffected by this type of damage.

Fractures, whether fissures or broken off parts, have to be assessed cautiously, but 25 (50%) swords were possibly broken due to human action. The origin of the breaks of 12 (24%) swords is uncertain, and 13 (26%) blades are either broken due to post-depositional processes or not broken at all. Most of the fractures (60%, 15) deemed to be of anthropogenic origin occurred at the apex of the curve created during the physical action of breaking. In addition, nine swords (36%) exhibited multiple fractures. Some are connected with a curvature while others are not. In total, 28 specimens (56%) display plastic deformation possibly linked to human activity. In 11 (22%) of the cases, no such damage could be determined, and an equal number is too uncertain to identify.

Swords provide less opportunity to observe tip damage than spears due to the higher frequency of highly corroded pieces. This issue will be addressed later on. Accordingly, only four tips (8%) have clearly received pressure, while nine of the tips (18%) probably have not. The large majority of the tips (74%, 37) remain uncertain in the examination due to transforming processes, such as corrosion, fracture or repair. The result for curvatures on tips is slightly better because they might still be visible on adjacent parts even though the tip itself is lost. Still, the majority of the tips (68%, 34) are unclear in their definition. However, 12 swords (24%) possibly have a curvature of their tips. In respect of fractures, 15 of all analysed swords (30%) have a fractured and detached tip likely to be induced by human interaction. Just one tip was twisted by physical activity. According to this, it can be said in general that half of the blades under examination (50%) are likely to have received some kind of damage on their tips, and that 22 of the swords (44%) are uncertain in their interpretation. Only three tips (6%) could with some certainty be said to be free from any kind of damage.

Traces of repair were detected on 23 swords (46%). Due to the difficulties in distinguishing between grinding taking place during production and that applied as repair, over one-third (38%, 19) of the traces remain uncertain in their interpretation. In eight cases, the swords (16%) were in all probability never subject to a repair.

Repairs of the tips of the swords are again difficult to assess, and most swords (68%, 34) are uncertain in their interpretation. The reasons for that are yet again a result of the loss and transformation of tips due to other influences. Therefore, only three tips (6%) have traces that make an ancient repair probable. Overall, potential repair traces may coincide with combat damage on 44% (22) of the swords under examination. The unclear cases are almost as high with 40% (20). Only 8 swords (16%) are likely without such an association.

Finally, we have to turn our attention again to post-depositional processes, mainly corrosion but also modern grinding. Almost a half of the examined swords (46%, 23) have been blurred heavily by such processes. This problem will be discussed in the following section. However, such swords might still hold valuable information regarding their use, but it is difficult and improbable to make an accurate assessment.

Combat and fighting styles – discussion of use-wear

Perhaps, most of the damage on the spears and swords should be interpreted as combat damage. As will be discussed below, apart from two very special discoveries, any evidence for ritual damage is scant on the examined weaponry. Despite the problems of observing damage, which will also be discussed later on, the amount of present use-wear is impressive. Unfortunately, singular weapons rarely show the full array of possible damage, which makes it difficult to infer for an individual weapon all the different ways it was employed in combat. However, if they are looked upon as a group of weapons and all the damage that potentially occurs on them is described, as was done in the sections above, maybe then it is possible to infer some results. A comparison between the two weapon forms will aid this undertaking, because the damage profiles different fighting styles leave on swords are quite well documented (Bridgeford 2000, Molloy 2006).

Before proceeding, it should be considered that damage occurs involuntarily if not inflicted in a ritual (Molloy 2011, p. 75). It is difficult if not impossible for archaeologists to assess the perceptions and motivations of past individuals. However, when an individual engages in combat, we may assume that he is willing to win it. In this regard, fighting brings with it a certain task-specific rationality. Thus, a fighter would probably not risk the integrity of his weapon as that would put him at a disadvantage and makes it more likely that he will be defeated or in the worst case be killed. All things considered, all damage is accidental and therefore, even a single notch possibly contains valuable information about the style of fighting.

Roughly speaking, impact damage points to a cutting motion while tip damage can be attributed to thrusting and stabbing attacks. The location of the damage is important. Occasionally, a thrusting motion could be intercepted by a direct strike from the side leaving a notch, a dent or a blow mark. Yet, since parries usually make use of the trajectory and relative motion of an attack to divert it (Molloy 2011, p. 75), a thrusting attack would possibly be diverted along a horizontal trajectory. Thus, a parry like this would hardly generate enough force to leave damage behind. Plastic deformation relates to even more specific sets of manoeuvres. Curvatures and the subsequent fractures could stem from thrusting attacks. They would occur when such an attack meets resistance, which could be armour, like hardened leather, or the ground if the attack misses. However, it could also come from strikes in a cutting motion that hit a parrying weapon (Molloy 2011, pp. 75–76).

If the amount of use-wear found on swords and spears is compared, a difference in terms of percentage is apparent. However, a chi-squared test showed that the distribution of impact damage, plastic deformation and tip use-wear does not deviate significantly statistically between spears and swords ($p = 0.82275$). Since the sample can be considered to be large enough, the pattern could be seen as similar. Thus, it could be suggested that these similarities refer back to the way these weapons were handled and therefore demonstrate a related fighting style. However, there are some differences that will be addressed next.

The number of swords with observable traces of ancient use is considerably lower than the total number of spears with such traces. Especially surprising is the considerably lower percentage of blow marks on swords. Perhaps one reason is the quantity of pieces with heavy disturbances, which is, in most cases, induced by corrosion. This corresponds with the swords more frequently being found in graves. As previously mentioned, the inhumation graves generally provide a more corrosive environment (Tylecote 1979, p. 350, Spähn 2001, p. 203, Table 1). Coincidentally, swords are also usually thinner than spears. Therefore, they are more prone to corrosion and dissolve earlier. Corrosion peels off metal in layers from the surface down to the core. Consequently, the topmost layers are lost first which has a severe effect on decoration and weaker blow marks. The further this process advances, the lower the chance is of blow marks being visible.

In contrast to the swords, most spears were discovered in hoards or as single depositions and frequently placed in a boggy environment, which is more likely to create a protective patina layer (Tylecote 1979, Hassairi *et al.* 2010). Even if they are placed on dry land, corrosion is usually less aggressive. Finally, even if spears are part of grave assemblages, their position is usually further away from the body, which may also play a role. In contrast, swords have typically direct contact with the deceased. Accordingly, there is a big difference between swords and spears in the amount of pieces that are too distorted by corrosion to see any impact damage. The trend is repeated in other categories, especially when looking at visible repair. Yet, while the bad conditions of swords possibly account for some of this difference, they are most likely not responsible for all of them. Consequently, the spears under examination could have been used more frequently or in heavier fighting than the swords.

This is emphasised if we consider that the complete spear was a weapon with a more or less long wooden handle. This handle was possibly involved in fighting as well if we assume a fencing fighting style with the spear, as will be argued for below. The chance of hitting a spearhead to leave an observable use-wear trace is lower than a sword blade, because it is shorter and the metal part makes up less of the complete weapon. Thus, the tips of spears seem to be involved more frequently or heavily in combat as well. Yet, the missing tips of swords remain a source of doubt.

Tips are usually lost due to fractures and, as stated earlier, a curvature at the apex of a fracture is a good indicator for anthropogenic damage. This leads to a problem that needs to be addressed. It was observed that fractures and curvatures are more frequently associated with swords. A possible explanation is their dimensional properties. Swords are generally thinner than spears so that such plastic deformation occurs more easily. In contrast, the more sturdy spears do not deform and fracture that easily. Yet, the sheer amount of curvatures on spears is remarkable. Perhaps, the thickness of the spears causes the curvature to absorb the impact. It seems paradoxical, but it could be that the thickness of the spears leads to an either-or reaction to impact, because the impact has to be very high for fractures to occur. Perhaps, the scenario is as follows: the impact is either relieved in a curvature without a fracture occurring, or it is so strong and sudden that it exceeds the ductility of the material too quickly. Subsequently, the impact potentially leads to a snap-break leaving the spear with a fracture, but without curvature. Conversely, the thinner swords cannot maintain their material integrity upon impact even if they deform. Thus, swords tend to instead show a ‘one-and-the-other’ reaction to an impact.

Before the results are interpreted, we need to address the potential for deliberate destruction of weapons in a ritual process. The hoards from Dystrup (Wincentz Rasmussen and Boas 2006), and Bondesgårde, Torsted (Becker 1964) are unified in their uniqueness. Both provided a considerable amount of swords associated with the Apa type and spears of Torsted type, respectively. The number of individual objects in these hoards far exceeds those of any other discovery to date. There are more similarities; the specimens in both ensembles show a considerably lower amount of traces of use.

Furthermore, of the 40 spears discovered in Bondesgårde, 14 are fractured in the upper third below the tip. While this alone might be attributed to corrosion and the brittle nature of the material, all of these fractures are positioned approximately at the same height. Additionally, two are curved and six showed either a fracture on the cutting edge or a blow mark at the same position. This evidence points to a possible anthropogenic origin of these damages.

The damages in the hoard from Bondesgårde become even more intriguing considering that three of the swords in the hoard from Dystrup are broken in the same position, and two more possess suspicious fractures on their cutting edge in a parallel position. So, on both sites, roughly half of the deposited pieces contain such damage. Perhaps, a ritual background can be suspected for these damages, caused by the intentional destruction of a certain amount of the sacrificed weapons just prior to deposition.

These remarks considered, curvatures are potentially intentional destructions. Yet, they usually do not appear to be severe enough on either swords or spears. It has been argued elsewhere that twists along the longitudinal axis could point to such a process (Horn 2011, 2012). Very few spears (12, 8%) and swords (5, 10%) express damage that can be identified as twisting. An 'ecstatic killing' of the weapon by repeated blows against the same part also seems to be absent. In the case of Bondesgårde, it is quite certain that the spears were placed in the ground without their handles. They were discovered tightly packed with seven associated axes in a small rectangular stone setting. Additionally, they were probably put into what appears to be a basket (Becker 1964, pp. 117–118). According to Nebelsick (1997, 2000), depositing spears without their handle can also be seen as a deliberate destruction. There are frequently wooden handle remains present in the sockets in various cases. Yet, experimental archaeology shows that spear handles often break during combat (Anderson 2011). Thus, there is no convincing argument to be made to interpret the broken remains as evidence for a deliberate destruction of spears. In this regard, it is interesting to note that in Bondesgårde, where the spears were deposited without handles, such wooden remains are missing.

Apart from the observations in the hoards from Dystrup and Bondesgårde (Torsted), there is little evidence for an intentional destruction of swords and spears from other find contexts of Period I of the Early Bronze Age. This does not mean that nothing like it happened, but it is harder to prove as, for example, on halberds (Horn 2011, 2012), Late Bronze Age weaponry (Nebelsick 1997, 2000, Quilliec 2008) or on La Tene swords (Sievers 2010, pp. 68–69).

Weapons, fighters and combat – an interpretation

The results of the presented use-wear analysis of swords and spears of the Nordic Early Bronze Age Period I show them to be usable and used in prehistory, regardless of modern perceptions about technical design and functionality. They might appear clumsy or too weakly constructed to the modern observer, but the use-wear proves that they were used. Prehistoric combatants considered them fit for fighting, and ultimately, that is what counts in the research of prehistoric warfare and combat. These weapons were the best that was available at the time as the technological evolution of these forms was at its very beginning.

Furthermore, the results yield some light on the nature of prehistoric warfare and combat. There has been some debate over the definition of warfare, in general (Keegan 1994, pp. 3–12, Münkler 2007, pp. 24–28) and prehistoric warfare, in particular (Keeley 1996, pp. 3–24, Carman 1997, pp. 1–20, Peter-Röcher 2007, pp. 14–26, Ferguson 2008, pp. 502–505, cf. Wileman 2009, with older literature). Even though there are many difficulties to come to a simple definition, the following, admittedly oversimplified, definition shall be used for the interpretation of the use-wear analysed in this article:

Warfare is combat carried out by at least two parties in order to achieve an aim or resolve an issue with at least one group lacking the will, ability or opportunity to employ other means than violence. Both sides have to have the will to engage, even if this is only facilitated by the will to survive, in case one side is caught by surprise and defending. Engagement is a prerequisite to establish a state of combat and warfare. Knowledge and the use of technology is a key aspect of warfare and fighting.

Both, spears and swords were used in combat and the high amount of visible combat damage makes it likely that warfare occurred frequently and was intensive. The possibility that spears were more often or more intensely involved in fighting might foreshadow what is possibly the norm with the Early Iron Age hoard in Hjortspring. Here, the number of spears outranks swords indicating a 'hierarchy of weapons' that was maybe a reflection of the 'hierarchy of the warriors' (Randsborg 1995). Yet, this could only occur where spears and swords are simultaneously present, for example, in Jutland. In other regions, like southern Sweden, the common weapon appears to have been only the spear. So far, there are few discoveries of Period I swords in this region.

However, the simultaneous presence of impact damage on the cutting edges, plastic deformations and tip damage on spears is probably due to the use of these weapons in a fencing style analogous to the swords. Therefore, the results of the presented analysis confirm that the complex fighting style deduced for Late Bronze Age spears by Schauer (1979) and Anderson (2011) was also used with Early Bronze Age spears; even with the smaller spearheads of the Bagterp type. In this case, it also confirms that the dichotomy of cutting versus thrusting does not apply to spears as it does not apply to swords (Clements 2007). The length of the handles probably influenced the style of fighting (Davies 2012, pp. 22–25), but because they are usually not preserved we miss a considerable part of the weapon and with that of the information concerning the style of fighting.

The similarity in the fighting style between both weapon forms could be a result of frequent engagements between sword fighters and spear fighters. A spear tip, possibly of Valsømagle type, embedded in the pelvis of a deceased discovered in Over Vindinge (Kjær 1912) shows that fighting could have taken place with neighbouring groups, because the tip does not deviate from the general distribution. That many spears possess tip damage and that in this case it was a tip embedded in the bone cannot be seen as coincidence. It exemplifies a pattern. In contrast, cutting with a spear does not leave similar anthropological evidence.

Mauss (1950) convincingly showed how material culture necessitates a certain set of motions and is therefore embodied in its user. While Mauss was concerned with everyday objects, Warnier (2011) picked this idea up and applied it to weapons, which are highly specialised tools. Nonetheless, the techniques of the body are not unchangeable. The engagement with an enemy forces any given fighter to potentially adjust to the opponent's respective styles, and thus to act opportunistically. These adjustments probably happen to avoid defeat and to gain an advantage over the opponent. Consequently, successful manoeuvres are likely to be incorporated and effective weapon designs will be copied. The fighting styles converge and gradually develop with respect to each other to a certain degree. Thus, fighting and warfare in part homogenises and hybridises. This process could be responsible for the wider introduction of swords in Southern Sweden, which are more frequently discovered in Period II contexts.

However, every fighter is keen on getting an advantage over his adversary. Therefore, he will possibly invent counters, new moves and introduce new weapon designs. Consequently, warfare has a moment of diversification at the same time. Accordingly, both processes – homogenisation and diversification – are most likely not contradictory. Both could take place simultaneously and be seen as responsible for a gradual development in combat and warfare. Consequently, we can see combat with its motions of attack and defence, action and reaction, movements and countermovements, as creating a kind of communication. Here, fighting styles and weapon technology are negotiated in direct engagement between humans and material culture. A fighter could be seen as in an antagonistic dialogue with his opponent that is mediated not through language, but through material culture; their weapons.

Summary

In this article, use-wear analysis of 204 weapons of the Period I of the Early Nordic Bronze Age has been presented. Not only taphonomic processes intrinsic to deposition contexts, but also ancient repairs and modern grinding have been identified as disturbances. According to the results of the use-wear analysis, these weapons are likely to be functional weapons employed in frequent fighting. Even though swords are more often affected by taphonomic disturbances, spears still seem to be involved more frequently and in heavier fighting. Despite some differences in the scale of fighting between swords and spears, it has been argued, and supported by the results from the use-wear analysis, that they were used largely in the same style of fighting. This fighting was identified as fencing, involving cutting and thrusting motions.

Perhaps, the emergence of this style was due to frequent encounters of sword and spear fighters. Through these engagements, a partial homogenising effect is initialised leading people to take in successful strategies and technological solutions. Yet, diversification and homogenisation have both been taking place simultaneously and influencing fighting styles and weapon technique. In this sense, combat and warfare could be seen as providing room for an antagonistic dialogue in which the technologies of war are negotiated through engagement with material culture.

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RESEARCH REPORT

Flexibility and diversity in subsistence during the late Mesolithic: faunal evidence from Asnæs Havnemark

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In 2007, excavations at the late Mesolithic (Ertebølle) coastal site of Asnæs Havnemark recovered a wealth of flint, bone, and ceramic artefacts. A comprehensive analysis of the faunal remains resulted in over 50,000 identified specimens. Roe deer and gadids predominate, but there are a wide variety of other species represented. Stable isotope analyses of dog bones point to the importance of marine resources. Oxygen isotope analyses of otoliths indicate that fishing was conducted in multiple seasons of the year. Comparison with other late Mesolithic sites demonstrates that while generally the same species of animals were exploited everywhere, there are major differences in the relative abundances of species. The broad subsistence base available and flexibility in how it was exploited weaken arguments for a subsistence crisis brought on by environmental stresses as the causal mechanism for the adoption of domesticated plants and animals at the onset of the Neolithic.

Keywords: Ertebølle; Mesolithic; fauna; isotopes; seasonality; coastal settlement; fish; dogs

Archaeological background

The Ertebølle site of Asnæs Havnemark lies on the north coast of the peninsula of Asnæs near the town of Kalundborg in western Zealand, Denmark (Figure 1). The site is designated as Årby SB365 in the Danish national site catalogue. The landscape here is dominated by the end-moraine that is the Asnæs peninsula and the sea that is gradually changing the shape of the peninsula. There are a large number of prehistoric sites on this peninsula, discovered by various amateurs, landowners, and others. There are more than 100 prehistoric barrows from the Bronze and Iron Age along with substantial remains from the Mesolithic and Neolithic. The area is well known as a very good source of raw flint, particularly along the coast.

The deep waters of the fjord and the rich seas of the Great Belt between the Baltic Sea and the Kattegat created a rich environment for Mesolithic fisher-hunter-gatherers. In all probability, large runs of eels, herring, and other species of fish passed along the coast of Asnæs as is known to have been the case in historical times (Drechsel 1890). The sea is also eroding and building along the coast, a process, which has been going on for millennia. The archaeological site of Asnæs Havnemark today is in an active area of beach ridge construction and it is slowly eroding into the sea. The original size of the site is unknown.

The Ertebølle is the last period of the Mesolithic in southern Scandinavia, beginning around 5400 cal BC, and ending with the arrival of the Neolithic shortly after 3950 cal BC. Radiocarbon dates from Asnæs Havnemark document the occupation of the site at the end of the Ertebølle. Nine radiocarbon measurements from the site ranged between 5696 ± 63 and 5172 ± 60 years cal BP (Supplementary Information Appendix I) document the likelihood of at least two episodes of site use (ca. 4500 cal BC and ca. 4100cal BC) and the occupation of this site near or at the time of the transition to agriculture in southern Scandinavia.

The major focus of our project was the cultural layer that was exposed by wave erosion on the north coast of Asnæs, but we also uncovered an *in situ* deeper settlement layer at the same place on top of the moraine surface. The contents of the cultural layer and related deposits are the concern in the following pages. It appears that the original settlement was located directly on the beach ridge and that there may have been several episodes of occupation. The deposits are terrestrial, rather than waterlain, and a portion of the settlement area is intact.

The stratigraphy at the site was largely the result of the formation of two beach ridges at this location. Sediments were generally sandy with varying amounts of gravel and stones associated with the beach ridges. The younger beach ridge had buried the cultural layers that had accumulated on top of the older beach ridge. This beach ridge deposition at this elevation must have taken place during a time of higher sea level, probably

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Figure 1. The location of Asnæs Havnemark and comparison sites.

during the Littorina transgression at the end of the Atlantic climatic episode. This event fits extremely well with the radiocarbon dates available for the site and also provides important information on potentially significant environmental changes at the end of the Mesolithic period.

Beneath the beach ridges and at some depth there was a base of ground moraine beneath the older beach ridge. The cultural layers that accumulated atop the older beach ridge were divided into three strata, based on colour and content. The bottom of the cultural layer was black with many artefacts. The middle of the cultural layer was brown with shell and artefacts and the upper portion of the cultural layer was black with shell and artefacts. The presence of the shell was responsible for the good preservation of bone at the site. This cultural layer likely accumulated over a substantial period of time, perhaps several hundred years at the end of the Atlantic climatic episode. The cultural layer appears to represent a long-term series of occupations, lying between two episodes of beach ridge formation. Radiocarbon dates from the site suggest an occupation primarily between 4300 and 4000 BC with a few younger and older dates present.

Excavations in 2007 exposed ca. 22 m^2 of this rich cultural layer at the site. Water screening and fine mesh sieving of sediment samples was conducted that provided a glimpse into the contents of the site. Good preservation is one of the hallmarks of the archaeology of this region and the materials recovered at Asnæs Havnemark include lithics, faunal remains, ceramics, and some plant remains in the form of burnt hazelnut shells. The flint tools consist primarily of projectile points, cores, some distally concave truncated blade knives, a few borers, a very few scrapers, a very few possible burins, and a very few rough core axes. There were large numbers of stylistically homogeneous projectile points, distinctive flake axes, well preserved faunal remains including bone fishhooks and preforms, seal bones, large bird bones, and an extraordinary amount of fish. A quantity of pottery was recovered in the excavations, including both pointed-bottom vessels and oval lamps in different sizes from the late Mesolithic and several examples of Early Neolithic ceramics. The rich occupation layer with its diverse artefact content also included a fragment of a human mandible and several teeth, documenting a substantial residential settlement on the north coast of the Asnæs peninsula.

The studies reported here focus on the faunal remains from the site, which include both terrestrial and marine mammals, birds, as well as fish. These animals were taken for both food and raw materials and provided a rich resource base for the inhabitants of the site. Comparison of Asnæs Havnemark with other Ertebølle sites in the region documents the flexibility and range of these coastal peoples as well as raising doubts about the role of climatic change leading to the introduction of agriculture at the end of the Mesolithic period.

Taphonomy

In considering the bone material it is important first to discuss taphonomic issues relating to the assemblage in acknowledgement of the fact that not all of the bones originally brought to the site in prehistory were later recovered and identified for this project. While it is not possible to determine the precise degree of loss attributable to scavenging, bone degradation, method of excavation, etc., some observations provide insight into the likely representativeness of the data.

The mammal bone material from Asnæs Havnemark shows no signs of cracking or flaking, considered to be hallmarks of weathering due to exposure to the elements, although exfoliation has occurred on the surface of some of the bones and they appear to have lost some weight, i.e., they fall into Behrensmeyer's (1978) Category 0 index of bone weathering. The comparatively light degree of weathering suggests that the bones did not lie exposed on the surface for long after they were deposited. Quantitatively, over 70% of the mammal bones recovered by sieving through 4 mm mesh are between one and three centimetres in maximum length, indicating a high degree of fragmentation (Figure 2, Gron in press).

An estimate of taphonomic loss was only undertaken on the roe deer part of the mammal material as it is the best represented species and the single taxon for which it was possible to estimate the number of fragments resulting from the breakup of complete elements. Following Aaris-Sørensen (1983) and Noe-Nygaard (1977), the total taphonomic loss was estimated to be at a minimum 79%, based on an estimate of 375 fragments of bone per roe deer present at the site. It is acknowledged that the majority of the material of all species that was originally deposited was not recovered, although taphonomic losses of this magnitude are common at other Mesolithic sites (Noe-Nygaard 1977, Aaris-Sørensen 1983).

Fragmentation and preservation were assessed by different methods for the fish assemblage. An approximate assessment of the condition of the fish bones was created by comparing the weight of identified to unidentified bone. The 3113 g of identified specimens compared to just 488 g of unidentified ones (86% to 14% of the total weight) indicates an assemblage that is in good condition.

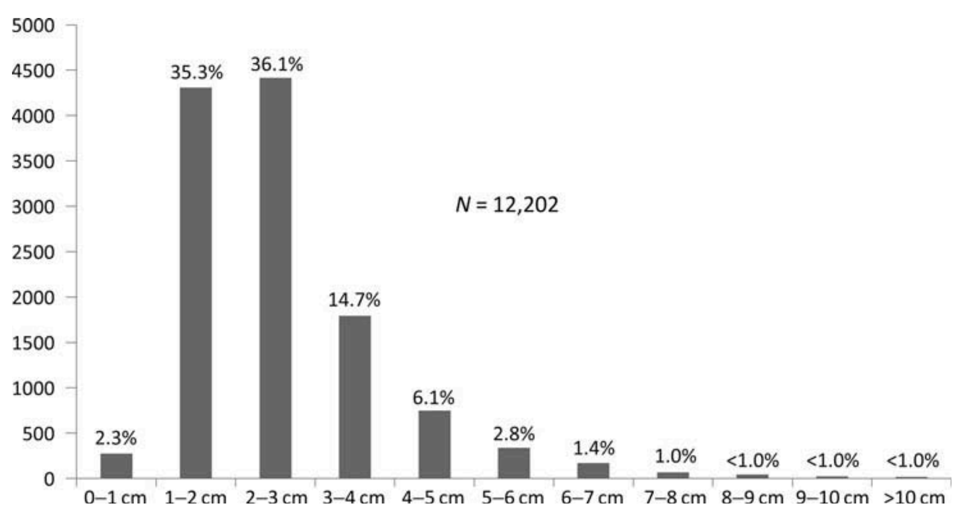

Figure 2. Degree of fragmentation (modified data from Gron in press).

A second approach to examining differential preservation in the fish assemblage focused on the presence of specific skeletal elements of individual species (see Russ and Jones [2009] for a complete discussion of the method). Vertebrae are present at between 65% and 73% of the values that would be expected, suggesting that not all of the ones that came to the site were preserved or recovered. Other elements are generally present at even lower levels, supporting the conclusion that some fish bones were lost (Supplementary Information Appendix II). Still, these results are generally higher than or equal to the percentages from other Ertebølle sites that have been checked by this method (Ritchie 2010), reinforcing that the taphonomic loss of fish bones at Asnæs Havnemark was relatively low.

Differential recovery of animal remains due to excavation technique is another aspect of taphonomy that can affect the final results. At Asnæs Havnemark wet-screening with 4 mm mesh sieves was undertaken on site, although not all of the excavated matrices were sieved. While this methodology was sufficient to recover enormous quantities of fish remains, smaller fishes are undeniably underrepresented in the assemblage because of the size of the sieves used (see below), although this bias does not seem to be so great as to nullify interpretations based on the data.

These observations indicate that the faunal data recovered at Asnæs Havnemark probably give a good, if not perfect, idea of what animals were exploited by the site inhabitants. The bone material can be used to answer questions about the subsistence economy if care is taken to consider some of the potential biases that may be present due to preservation and recovery issues.

Faunal assemblage

In total, the faunal material from Asnæs Havnemark consists of 50,005 identified bones. Of this, 47,760 (95.5%) are fish (Pisces), 2214 (4.4%) are mammals (Mammalia), 29 (0.1%) are birds (Aves), and 2 are amphibian (Table 1). Gadids dominate the fish bone assemblage (86%), while roe deer account for the vast majority of the mammal remains (67%). Despite the preponderance of these two species, the assemblage presents an impressive variety of other fish (18 families in all), mammals (at least 17 species), and birds (13 species). Overall, all classes of faunal remains from the site show uniformity in their relative abundances across contexts and therefore the assemblage is discussed as a whole (Supplementary Information Appendix III).

Fish

The fish bone assemblage from Asnæs Havnemark is remarkable because of its size – NISP (Number of Identified Specimens) over 47,700 – and diversity (18 different families of fish). Gadids dominate the assemblage with eel following at a distant second and other fishes contributing relatively minor amounts (Table 1; see below for the effect of smaller mesh-size on relative abundances). Freshwater fish are very rare (only eight cyprinid vertebrae), but diadromous fish include eel, shad, and trout/salmon. These results are very much in accordance with the site's location far out on the Asnæs peninsula with no major bodies of freshwater in the vicinity. Preservation of the fish bones was generally good and all of the skeletal elements seemed to have been discarded together (Supplementary Information Appendix IV), though not all elements were recovered and identified in equal proportions.

In order to evaluate the effect of sieve mesh-size on recovery rates of fishbones, 14 samples of mostly 2 litres each (31 litres total) were taken from several of the proveniences and washed through nested geologic screens of 4, 2, and 1 mm sizes (Supplementary Information Appendix V). The 2 mm fraction produced the largest number of identified specimens (1805 or 55% of the total), followed by the 4 mm fraction (1292 or 39%), and the 1 mm fraction (202 or 6%). This shows that a significant portion of the fish remains present in the deposits were probably missed using 4 mm screens during excavation. Considering relative abundances, gadids show a fairly large percentage decline with increasingly finer mesh sizes. Flatfish are little changed, perhaps because they comprise only a small percentage of the assemblage. Eel and other species characterized by smaller bones markedly increase in abundance when smaller mesh-size sieves are used (Supplementary Information Appendix VI). Mammal and bird bones that were recovered during the sieving tests were added to the rest of the materials recovered from these contexts, but the effects of screen mesh-size was not specifically evaluated for these classes of fauna. In general, it can be said that while the use of 4 mm mesh-size sieves affected which types of fish bones were recovered, even with much finer sieves the assemblage would still have been dominated by gadids.

Because of the enormous numbers of fish remains present in the deposits and a desire to sample a sufficient area of the site in the time available, fish bones were only sampled from arbitrarily selected proveniences to expedite processing. The matrices were hand-excavated and wet-screened in the field with 4mm mesh-size sieves. Because of the very large quantity of fish remains found in square 124E 135N, the contents of the screen after washing were emptied onto a white table and sorted. This resulted in exceptionally good recovery of fishbones from this square. All recovered fish material has been analysed.

Before examining the results of the analysis in more detail, it is perhaps helpful to add a few notes on the taxonomy of the fishes. Although some identifications

Table 1. Identified faunal remains.

Family	Species	Common name	NISP	MNI
Gadidae	*Gadus morhua*	Cod	675	
	Melanogrammus aeglefinus	Haddock	4	
	Merlangius merlangus	Whiting	46	
	Pollachius pollachius/virens	Pollock/saithe	9	
	Unspecified gadid	Codfish	38,103/2244*	
Gadidae total			40,347	856
Anguillidae	*Anguilla anguilla*	Eel	3849/598*	52
Pleuronectidae	*Platichthys flesus*	Flounder	(4 dermal denticles)	
	Unspecified pleuronectid	Flatfish	897/59*	
Pleuronectidae total			956	32
Cottidae	*Myoxocephalus scorpius*	Shorthorn sculpin	601/96*	27
Scombridae	*Scomber scombrus*	Atlantic mackerel	444/117*	18
Clupeidae	*Clupea harengus*	Herring	158/106*	5
Triglidae		Gurnard	136/5*	4
Belonidae	*Belone belone*	Garfish	45/–*	1
Squalidae	*Squalus acanthias*	Spurdog	40/1*	5
Trachinidae	*Trachinus draco*	Greater weever	34/9*	1
Zoarcidae	*Zoarces viviparous*	Viviparous Eelpout	18/12*	1
Clupeidae	Alosa sp.	Shad	13/–*	1
Salmonidae	*Salmo* sp.	Trout/salmon	13/2*	1
Cyprinidae		Carp family	8/2*	1
Callionymidae	*Callionymus lyra*	Dragonet	1/–*	1
Scophthalmidae		Flatfish	1/–*	1
Gasterosteidae	*Gasterosteus aculeatus*	3-spined stickleback	–/44*	2
Gobiidae	Gobius sp.	Goby	–/3*	1
Syngnathidae		Pipefish	–/1*	1
Fish total			**47,760**	**1011**
	Capreolus capreolus	Roe deer	1493	19
	Martes martes	Pine marten	65	5
	Sus scrofa	Wild boar	141	4
	Canis familiaris	Domestic dog	119	4
	Erinaceus europaeus	Hedgehog	12	4
	Cervus elaphus	Red deer	122	3
	Vulpes vulpes	Fox	43	2
	Castor fiber	Beaver	21	2
	Sciurus vulgaris	Red squirrel	5	2
	Lutra lutra	Otter	5	2
	Apodemus flavicollis	Yellow-necked Mouse	4	2
	Phocoena phocoena	Harbour porpoise	14	1
	Felis silvestris	Wildcat	2	1
	Clethrionomys glareolus	Bank vole	1	1
	Arvicola terrestris	Water vole	1	1
Phocidae		Seal	166	5

(*continued*)

Table 1. (*Continued*).

Family	Species	Common name	NISP	MNI
Mammal total			**2214**	**61**
	Penguinis impennis	Great auk	3	2
	Cygnus olor	Mute swan	6	1
	Pandion haliaetus	Osprey	4	1
	Hallieetus albicilla	White-tailed Eagle	3	1
	Aquila chrysaetos	Golden eagle	3	1
	Gavia stellata	Red-throated loon	2	1
	Podiceps grisegena	Red-necked Grebe	2	1
	Cygnus cygnus	Whooper swan	1	1
	Larus argentatus	Herring gull	1	1
	Mergus serrator	Red-breasted Merganser	1	1
	Podiceps cristatus	Great crested Grebe	1	1
	Turdus merula	Common Blackbird	1	1
	Turdus philomelos	Song thrush	1	1
Bird total			**29**	**14**
	Bufo bufo	Common toad	2	2
Amphibian total			**2**	**2**
Total fauna			**50,005**	**1088**

Note: * = screen test samples.

are to species level, the predominance of vertebrae (especially from gadids) means that most of the specimens are only identified to the family level. In order to avoid comparisons between different taxonomic levels, fish families are used to report results. Gadidae were represented by *Gadus morhua*, *Melanogrammus aeglefinus*, *Pollachius* sp. (*P. virens* or *P. pollachius*), and *Merlangius merlangus*. *Gadus morhua* (cod) are most common (at 75.1%, with 5.1% *M. merlangus*, 1.0% *Pollachius* sp., 0.4% *M. aeglefinus*, and 18.4% unspecified gadid – based on identifications of 899 otoliths). Flatfish were represented by *Platichthys flesus* (although *Pleuronectes platessa* and *Limanda limanda* may also be present) and *Psetta maxima/Scophthalmus rhombus*. Clupeidae remains consisted of both *Clupea harengus* and 13 vertebrae of *Alosa* sp. *(A. alosa* and *A. fallax* are both possible in Danish waters). The only other Ertebølle sites where shad bones have been recovered are Dragsholm and Henriksholm-Bøgebakken (Ritchie 2010, Enghoff 2011). None of the cyprinid vertebrae could be assigned to species, so it is not possible to say which fish are present from among the several options. Salmonids were also only represented by vertebrae, so it is not possible to state whether these are *Salmo salar* or *Salmo trutta*. Triglids (gurnards) could be either *Eutrigla gurnardus* or *Trigla lucerna*, but only *E. gurnardus* was definitely present. The single specimen that is attributable to dragonet (family Callionymidae) is of note as this fish has only been identified in one other Ertebølle assemblage (Norsminde, Enghoff 1991). Some fishes that are present in the assemblage (i.e., three-spined stickleback and pipefish) were only recovered because of the use of very fine (1 mm) mesh-size sieving.

Size information

The sizes of individual fish represented in the bone material were estimated based on regression formulas. For cod, measurements of otolith total length (OL) were used to estimate fish total length (TL) based on the formula (Härkönen 1986):

$$TL = -202.13 + 48.37(OL)$$

Summary data is graphically displayed in Figure 3. Estimates range from cod as small as 20 cm (with a weight of ca. 100 g) up to a maximum of 53 cm (weight ca. 1.5 kg), with an average of around 33–34 cm (weight ca. 300 g). Although the distribution is skewed to the right, this is likely the result of recovery issues related to sieve size. It should be noted that some specimens of other elements indicate fish of an even larger size than shown by the otolith estimates. There is little difference between the sizes of the fish in the various levels

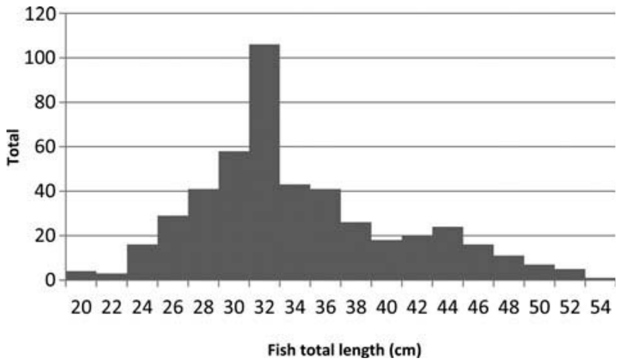

Figure 3. Total lengths of cod for all levels combined based on otolith total length. See Supplementary Information Appendix VII for data on individual levels.

(Supplementary Information Appendix VII), which accords well with the similarity in relative abundances seen earlier.

Eel total lengths (TL) were estimated from the width of the ceratohyal (K) according to the formula (after Enghoff 1987):

$$TL = 345.2232(K)^{0.7460}$$

Estimates of eel sizes ranged from 42 to 86 cm, with an average of approximately 61 cm (Figure 4). Although the shell layer does have slightly smaller eels on average when compared to the other layers (59 *versus* 62 cm), the small sample size for this layer and the similarity between the median lengths suggest that this variation is not meaningful (Supplementary Information Appendix VIII). The fact that most of the eels are greater than 50 cm in length implies that the majority of the catch was female eels (Muus, Dahlstrøm 1967).

Sizes of flatfish in the plaice/flounder/dab group were estimated based on the width (W) of first vertebrae according to the formula (after Enghoff 1991):

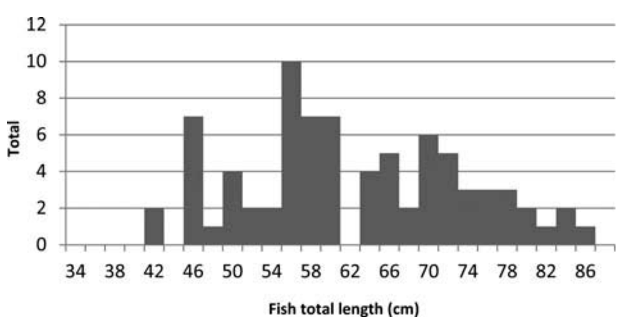

Figure 4. Total lengths of eel for all levels combined. NB. The apparent gap at 62 cm is most likely merely an artefact of rounding. See Supplementary Information Appendix VIII for data on individual levels.

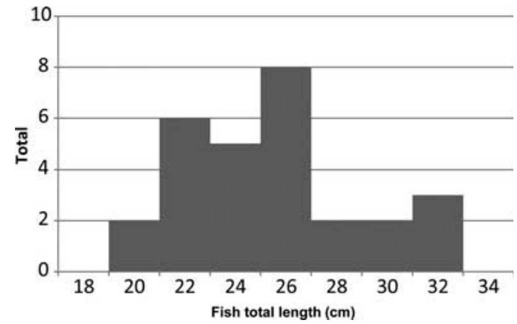

Figure 5. Total lengths of flatfish for all levels combined. See also Supplementary Information Appendix IX.

$$TL = 69.7268(W)^{0.9068}$$

The results shown in Figure 5 indicate that there was not a great deal of variation in the sizes of the flatfish, with an average length of about 25 cm.

The size estimates for the fish are similar to those from other Ertebølle sites in Denmark. Cod usually average around 30–40 cm, slightly larger at Lystrup Enge and Grisby. The largest fish at Asnæs Havnemark estimated from otolith length are not as large as the ones seen at many other sites, but as noted, there are some elements in the assemblage that indicate larger fish were caught. Eels from the site are similar in size to those seen elsewhere, although the absence of any specimens less than 42 cm is notable. The flatfish from Asnæs Havnemark are also similar in size to those found in other Ertebølle assemblages (Enghoff 1994).

The fish bone assemblage is interesting because of the high number of different fishes present, but also because of the clear dominance of gadids. Even when the use of finer mesh sieves increased the recovery of smaller fishes, gadids still comprised over two-thirds of the material. Eel were the second most common fish recovered, and the estimated lengths of the individual fish point to mostly female eels – perhaps caught during their fall migration. The fish bones represent an MNI (Minimum Number of Individuals) of 1011, demonstrating that fish were a significant part of the diet, even if their precise importance is difficult to quantify.

Mammals

The mammal assemblage from Asnæs Havnemark is also diverse, with at least 17 species represented. Highly fragmented assemblages are often difficult to interpret due to the relationship between the degree of fragmentation and zooarchaeological indices (Marshall, Pilgram 1993). In this case, however, the overall picture of mammal use remains similar regardless of what index is used. The assemblage is dominated by roe deer with a broad range of other species present in lesser numbers (Table 1 and Supplementary Information Appendix X). Measurements for individual specimens are given in Appendices XI and XII. All species are wild with the exception of the domestic dog, which is common at Stone Age sites (Aaris-Sørensen 1998). There are a minimum of three species of marine mammals, including at least two species of seal and the harbour porpoise. Much of the seal material was not identifiable to species, so seal specimens were assigned to the general class of 'seal'. However, this assemblage includes the grey seal (*Halichoerus grypus*) and at least one member of the genus *Phoca*. The particular taxon or taxa represented by the genus could not be confidently identified.

The most represented species is roe deer, comprising 66.5% of the identified material and a total of at least 19 individuals (MNI = 19). In order to establish MNI values, age classes were used in conjunction with the occurrence of elements in the mammalian body, as well as body side, to determine MNI in the simplest way possible, following Richter and Noe-Nygaard (2003). The next most common individual taxon is wild boar, making up only 6.3% of the assemblage and with a minimum of four individuals. Taken together, seals (Phocidae) comprise 7.4% of the identified material (MNI = 5), and are the second most common mammalian prey. Among the terrestrial mammals, six taxa which can be considered fur-bearing are found (beaver, fox, otter, pine marten, red squirrel, and wildcat), best represented by the pine marten. Martens are tied with seals for the second highest number of individuals with a total of five (MNI = 5).

Of the mammalian species, three (bank vole, water vole, and yellow-necked mouse) are often considered not to be archaeological remains when they are recovered at Mesolithic sites (Aaris-Sørensen, Andreasen 1995). In addition, these three species bear no evidence of human processing. The hedgehog represents a difficult case, as the species is one of the smaller mammals that may or may not have been utilized by man. At some Danish Mesolithic sites this species does exhibit clear evidence of human butchery (Aaris-Sørensen and Andreasen 1995, Gotfredsen 1998), but at Asnæs Havnemark they do not.

The only domesticated species in the assemblage is the dog, comprising 5.3% of the assemblage and an MNI of 4. At Asnæs Havnemark, dogs were probably kept as hunting companions, as was typical for the Ertebølle period (Aaris-Sørensen 1998, Richter and Noe-Nygaard 2003). In addition, however, one notable specimen is an arthritically fused right calcaneus and astragalus from a dog that would have been lame. This animal would have had limited utility in hunting and may be best interpreted as a favoured companion, or rather, a pet.

In total, 50 specimens of all mammal remains (2.2%) in the collection exhibit clear signs of being juvenile, determined by bone porosity, toothwear, deciduous teeth, or a body size clearly below the adult range. This number is surely an underestimate considering that not all parts of the mammalian body are useful for determining even approximate age.

The mandibular and maxillary remains among the collection were highly fragmented and when teeth were discovered *in situ*, they were most often single or few in number and the majority were loose teeth. It was not possible determine if most specimens were from different animals with any certainty, so in order to be conservative, it is possible only to say that a range of toothwear among the roe deer sample from Asnæs Havnemark is observed, from very little wear to very heavy wear. Therefore, a range of ages from young to old is present in the material.

Two wild boar individuals under 1 year old were aged based on known developmental rates of tooth eruption in conjunction with side-by-side comparison with specimens of known age at the Zoological Museum of the Natural History Museum of Denmark. One individual was around 5 months of age based on a first mandibular molar, which had just erupted (Matschke 1967), and the other was probably under a year of age given its unerupted second mandibular molar. This second individual was probably closer in age to its counterpart, given the extremely similar size and overall character of the specimens. Therefore, in all likelihood, this animal was between 5 and 8 months of age at death, although it could have been up to 1 year old. In addition to the tooth material, one roe deer calcaneus with undeveloped epiphyseal ends and extremely porous bone texture is indicative of a very young (less than ca. 3 weeks old) individual. Also among the material were the atlas and fused cervical vertebrae of the harbour porpoise, indicating an animal at least 6 years of age based on known rates of cervical fusion (Galatius and Kinze 2003).

A complete review of the biology, chronology, and uses of typical Ertebølle fauna has been published recently and is not repeated here (Richter and Noe-Nygaard 2003, Aaris-Sørensen 2009, Enghoff 2011). Overall, a notable observation with regards to the Asnæs Havnemark assemblage is that the wide variety of animals indicates diverse hunting techniques to procure animals for multiple purposes. The mammal assemblage is absolutely dominated by the presence of the European roe deer, a common species in Ertebølle assemblages, and also contains the other two large game species usually present at Ertebølle sites: the red deer and wild boar. In addition to the animals taken primarily for meat, at least six species of fur mammals (beaver, wildcat, red squirrel, otter, pine marten, and fox) would have been taken especially for their skins (Richter and Noe-Nygaard 2003).

Birds

Avian materials yielded 13 taxa (Table 1). Birds probably would have been hunted either with nets or with bow-and-arrow using specialized equipment such as birding arrows that have been found at other Ertebølle sites (Andersen 1985). The presence of each species of bird is evidenced by finds of single or only several elements. With the exception of the extinct great auk (MNI = 2), all bird species are represented by an MNI of one. The birds can be characterized as waterfowl or birds of prey. Birds were likely taken either as a source of meat (waterfowl) or in the case of birds of prey, to procure feathers for fletching or bone for specialized uses (Clark 1948).

Assemblage composition and stable isotopes

Any discussion of subsistence strategy must consider all the animals that were exploited. A major impediment to understanding the importance of various classes of fauna at Ertebølle sites (i.e., fish, mammals, and birds) is meaningfully relating them to each other. While zooarchaeological units such as NISP and MNI are useful shorthand for reporting assemblages in a standardized format, they are not necessarily directly useful for archaeological interpretations concerning the relative importance of resources in the human diet. So, abundance in the archaeological record does not necessarily directly equate to importance in the diet of humans. Because of the challenges inherent in using zooarchaeological data in this way, isotopic studies of human (and dog) bone have become increasingly popular and complement more traditional methods.

Isotopic studies are not without their own issues. One difficulty with this approach lies in the use of multiple localities by individual groups of Ertebølle fisher-hunter-gatherers, such that any isotopic studies of diet will reflect the average of visits to any number of sites over the course of the year. On a single-site basis then, it is probably impossible to determine how the overall diet relates to what is recovered archaeologically at an individual Ertebølle site. Nevertheless, carbon and nitrogen isotopic analyses were undertaken to two ends: to determine the environments from which various prey species were taken and to investigate human diets. The focus of the isotopic studies was on the bones of wild animals and domesticated dogs from the site. Dogs are generally considered to be a reliable proxy for human diet in Stone-Age southern Scandinavia and are similarly used here (Noe-Nygaard 1988, Clutton-Brock and Noe-Nygaard 1990, Eriksson, Zagorska 2003, Fischer et al. 2007). Results are presented in Table 2. All listed samples listed fall within acceptable range of atomic C:N ratios for bone preservation indicating a low likelihood of diagenesis (White et al. 2001).

All wild animals show values that are within the normal ranges for southern Scandinavia (Fischer et al. 2007). Terrestrial roe deer show highly consistent values, indicative of an herbivorous diet in very similar environments. The wild boar specimen indicates slight enrichment relative to the deer, probably due to its omnivorous dietary preferences. The grey seal is highly enriched, as expected for a marine carnivore. The dogs present isotope ratios that indicate they were eating an almost entirely marine diet similar to the single highly enriched dog found at nearby Smakkerup Huse (Price and Gebauer 2005). Further, the nitrogen values indicate at least one trophic level of enrichment compared to herbivores. The single human mandible recovered from Asnæs Havnemark did not yield sufficient collagen for the analysis of stable isotopic ratios or radiocarbon dating. Therefore, assuming that dogs are indeed a good proxy for human diet, the two individuals analysed here indicate that the people were subsisting almost entirely on marine protein. This does not necessarily mean that terrestrial resources were unimportant – the large amount of bone material from these types of animals proves that they had a role – but the dog isotope data underscores that marine resources were the staple part of the diet over the longer term.

Seasonality

The faunal remains from Asnæs Havnemark offer a compelling means of identifying the seasons when the site was in use. Multiple lines of evidence including animal behaviour patterns, oxygen isotope analysis of cod otoliths, and ontogenetic aging of select species indicate use of the site in all seasons of the year.

The presence or absence of migratory birds and fish at specific times of the year can be a useful tool for

Table 2. Stable isotopes of carbon and nitrogen from Asnæs Havnemark.

Number	Species	Lab #	%C	%N	Atomic C:N	VPDB	AIR
AH24-49	*Capreolus capreolus*	258,926	21.78	7.2	3.53	−22.99	4.76
AH40-19	*Capreolus capreolus*	268,260	16.41	5.24	3.66	−22.94	5.47
AH74-15	*Capreolus capreolus*	268,261	18.45	5.82	3.70	−23.07	5.90
AH70-14	*Capreolus capreolus*	268,262	20.07	6.58	3.56	−22.81	5.80
AH73-16	*Sus scrofa*	268,266	17.24	5.74	3.50	−20.90	5.18
AH84-1	*Sus scrofa*	284,462	35.46	12.70	3.26	−20.86	5.41
AH70-20	*Halichoerus/Phoca* sp.	268,269	18.88	6.37	3.46	−9.58	14.20
AH85-4	*Canis familiaris*	268,272	15.06	4.88	3.60	−11.94	10.13
AH83-10	*Canis familiaris*	268,273	14.30	4.60	3.63	−13.24	11.87

establishing the season of occupation at archaeological sites. Seasonal information for birds is restricted to the presence of individual species in conjunction with knowledge of their migratory patterns. The golden eagle, mute swan, white-tailed eagle, herring gull, red-breasted merganser, great crested grebe, red-necked grebe, and common blackbird provide no information about seasonality due to the possibility of their year-round presence in Denmark (Génsbøl 2006). The song thrush must similarly be treated as a year-round visitor, because while it is usually present from late February until around November, some individuals stay in Denmark all year (Génsbøl 2006). The osprey is present in Denmark in all seasons except winter. The whooper swan is an autumn, winter, and spring visitor to Denmark, present between September and April. Finally, red-throated loons seasonally migrate through Denmark between March and May, and again between late August and November (Génsbøl 2006). To be conservative, no conclusions are made about the seasonal presence of the extinct great auk due to the paucity of observations made by naturalists concerning its migratory patterns while it was extant (Bengtson 1988).

Based on these observations, the bird evidence provides the possibility of site use in all seasons. Due to the fact that most bird taxa are represented by a single individual, it is best to use the presence of seasonally migratory species to reinforce other, more concrete seasonal indicators.

Migratory behaviour is also important for the fish evidence, especially with regards to garfish and mackerel that are present in Danish waters from the late spring to early fall. The presence of bones from both of these species in the assemblage, albeit in limited numbers, strongly supports summer occupation at Asnæs Havnemark. Three diadromous fishes (eel, shad, and salmon/trout) provide some evidence for site use during spring and fall based on the idea that they were most easily caught during their migrations, but individuals could also have been taken at other times of the year (Muus and Dahlstrøm 1964).

In contrast with the evidence from migratory fish, the predominance of gadids in the assemblage (including large individuals of cod and haddock) may be evidence for winter occupation based on comparison with the Danish fishery in the nineteenth century (Drechsel 1890, Moustgaard 1987). To test this idea, a pilot study using a recently developed methodology was conducted on four cod otoliths to determine in which season these fish were caught. The method relies on three factors (1) that fish otoliths grow incrementally throughout the life of the fish, (2) that they incorporate isotopes of oxygen in ratios that reflect their surroundings, and (3) that the ratio of ^{16}O and ^{18}O in their aquatic environment varies in response to water temperatures (see Hufthammer et al. 2010 for full details of the methodology). Thin sections were cut from across the core of the otoliths and then a series of samples were milled from the sections with the aim of sampling the last year of the fish's life. A mass spectrometer measured $\delta^{18}O$ for each of the samples and, when plotted sequentially, these values should reveal the ambient water temperatures experienced by the fish during the period sampled.

By comparing the result from the sample taken from the outer edge of the otolith (the area being formed when the fish died) with the annual cycle of water temperature changes revealed by the complete series of samples, it is possible to determine at what time of year the fish was caught. Three of the four otoliths display clear patterns of cyclical variability that can be used to determine season of catch for the fish with confidence and one is less certain. The 48 cm fish was caught when water temperatures were just beginning to warm from their annual low, corresponding to a seasonality indication of late winter or early spring (Figure 6). One of the 49 cm fish shows a final reading midway between the coolest and warmest parts of the annual cycle, which indicates it was caught in the late spring or early summer (Figure 6). The smallest specimen, 35 cm, shows that it was caught when water temperatures were at their highest in the late summer (Figure 6). Because of two samples that were lost during measurement and the absence of a clear annual temperature pattern, interpretation of the results for the second 49 cm fish is problematic (Figure 6). Although not conclusive, the more positive measurements from the two samples closest to the edge of the otolith suggest a season of catch in the spring when water temperatures were just beginning to increase.

Although the sample size is small, these results show that while some cod were caught during the summer, winter and spring were also part of the fishery. It is of note that the one otolith that showed evidence for summer fishing was from the smallest of the fish that was sampled. From the growth rings evident in the polished thin-section of this otolith, the fish was aged at around 2 years – an age class that is known to remain close to shore during the summer months when the larger, older cod move into deeper waters in search of cooler temperatures.

Two lines of evidence are available for the estimation of season of occupation based on mammalian remains. The first is comparison of the antler casting stage of the archaeological examples of roe deer with the modern cycle in which roe deer cast their antlers in November and December (Richter 1982, Sempéré et al. 1992). Several roe deer frontal bones are present which represent different stages in the yearly antler casting cycle. Multiple specimens are present of skulls with uncast antlers and those that have recently cast their antlers. The skulls that have recently cast antlers have not yet started to regrow, and are therefore strong indicators of a November and/or December date of death. The uncast antlers are less useful for seasonality

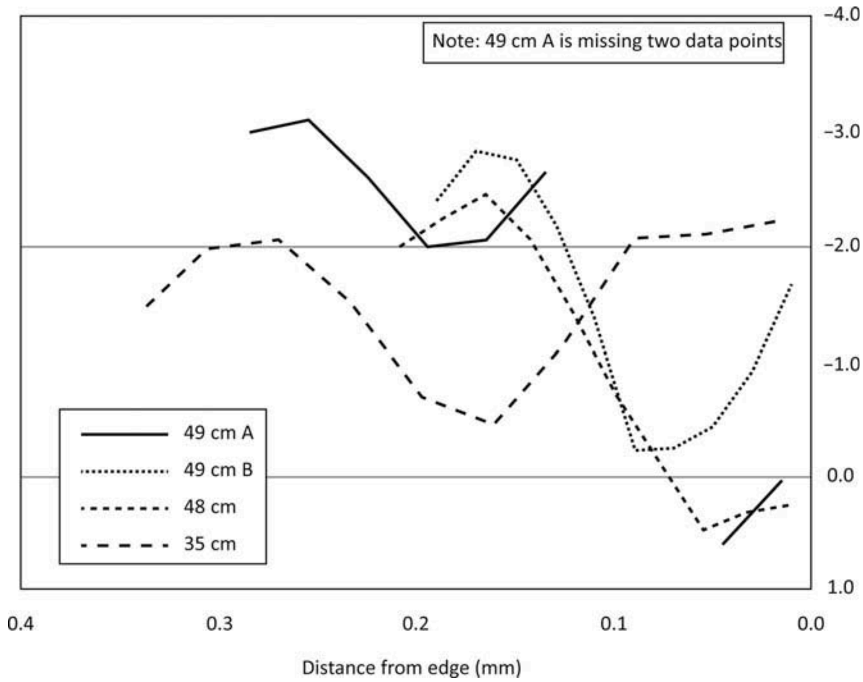

Figure 6. Results from cod otolith isotope analyses. Results higher (more negative) on the *y*-axis indicate warmer temperatures and readings farther to the right on the *x*-axis are closer to the time of capture.

determination, as the deer possess antlers for the majority of the year. The second seasonality indicator from the mammal remains is roe deer and wild boar individuals under the age of 1 year. One roe deer probably died in June, based on rates of calcaneus development and fusion, its bone porosity, extremely small size, and likely timing of roe deer births during the Mesolithic (Richter and Noe-Nygaard 2003). Wild boar were most likely born from mid-April to mid-May during the Mesolithic in Denmark (Noe-Nygaard and Richter 1990). Of the two individuals that were aged at less than 1 year, one was around 5 months old based on a first mandibular molar which was just erupting (Matschke 1967), and the other was under a year of age given its unerupted second mandibular molar. This second individual was probably closer in age to its counterpart, given their extremely similar size and overall character, in all likelihood between 5 and 8 months of age. This places their deaths at September to November, and somewhere between September and probably January, respectively.

Figure 7 summarizes the seasonality information from animal remains for the site. Cumulative seasonality information indicates use during most, perhaps all, of the year. However, it is not possible to state whether this was the result of year-round occupation of the site or instead consisted of repeated visits in different seasons over the course of many years. It is, however, apparent that hunting and fishing took place at the same times of year, as evidenced by the co-occurrence of mammal and fish indicators in the annual cycle.

Bone modifications

Food preparation

Burning, butchery and tool production are all in evidence as means by which animal bones were modified by human activities. Less than 1% of the mammal material is affected by burning, indicating that most cooking occurred after removal of meat from the bones. Burning is the principle manner in which the fish remains have been modified, although this should be understood as a fairly rare occurrence. Despite the fact that a total of 728 fish bones from the regular 4 mm sieving assemblage exhibit signs of burning (ranging from partial blackening to complete calcination), when considered in the context of over 44,000 identified specimens this is a small percentage (ca. 1.6%). Nevertheless, three observations need explanation: the discrepancy between abundances of fishes in the assemblage *versus* those that are burnt, the disproportionately high number of non-vertebrae elements that are burnt, and the spatial distribution of the burnt bones within the site deposits.

The large number of burnt bones from the gadid family (555 or 76% of the total) is unsurprising given the dominance of gadids in the overall assemblage (86%). Burnt eel bones (145) at almost 20% of the total are more numerous than would be expected from their

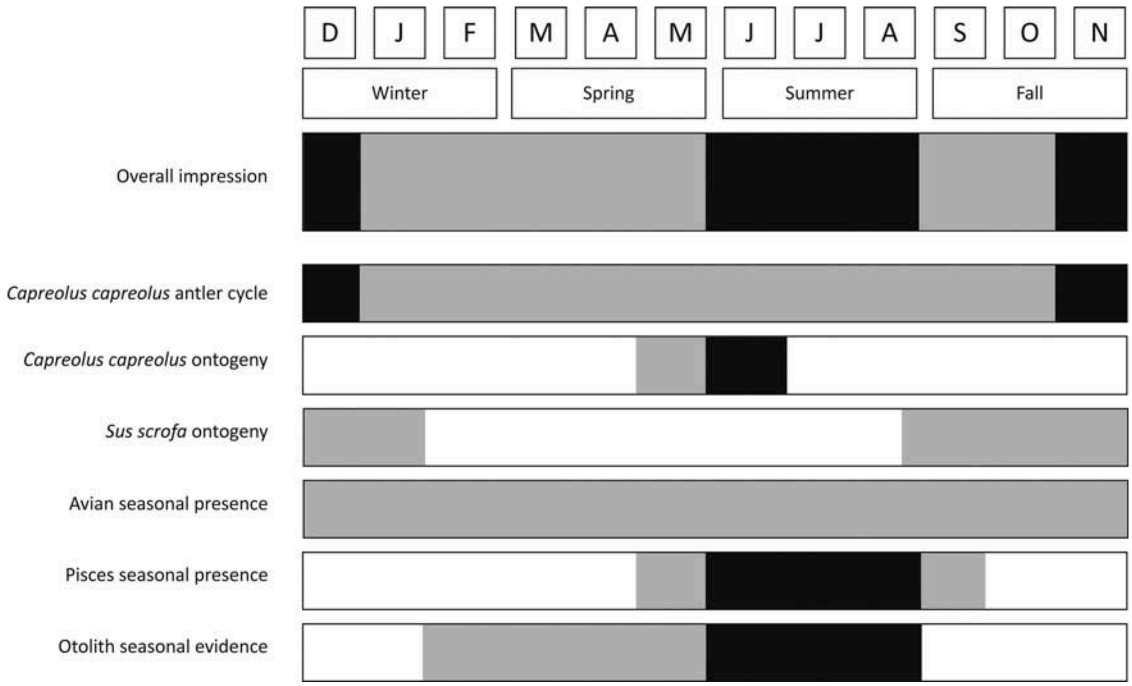

Figure 7. Seasonality at Asnæs Havnemark. Black indicates confidence, grey possibility, and white absence of indicators.

overall representation in the assemblage (9%), but still only roughly one out of every 27 eel bones is burnt. Eight bullrout, one herring, and one garfish bone are also burnt. These results do not seem especially meaningful on their own, but become more interesting when combined with the other two observations about burning.

More intriguing than the relative abundance of burnt bones amongst fishes is the distribution of burning between different skeletal elements. Specifically, while elements other than vertebrae comprise less than 15% of the overall assemblage, 561 (77%) of the burnt specimens are non-vertebra. Two possible explanations for the unexpectedly high number of burnt non-vertebra relate to the fact that these elements are in the head of the fish. Either fish were directly exposed to fire during preparation and the head elements were more likely to be scorched because they lacked the soft-tissue protection enjoyed by vertebrae, or fish heads were considered refuse and disposed of in the fire. Other scenarios can be constructed to explain the differential burning, but whatever the cause, the fact that almost 9% of the non-vertebra elements at the site are burnt *versus* less than one half of one percent of the vertebrae strongly suggests that much of the burning seen on the bones is the result of a deliberate decision by the site's occupants and is not merely the result of chance exposure to fire.

The spatial distribution of the burnt fish bones at the site is also of note, but here there is perhaps less reason to attribute the anomalous results to prehistoric behaviour. Vertical distribution of the burnt bones shows 182 from the shell layer, 193 from the culture layer, 342 from the brown layer, and eleven from other contexts. The large number of burnt bones in the brown layer represents almost 47% of the total burnt specimens, while this layer only makes up 10% of the total assemblage. About one in thirteen bones in this layer are burnt. Burning occurs on just over 3% of the specimens in the shell layer, but these 182 specimens constitute one quarter of the burnt bone total despite the NISP from this layer providing only 13% of the overall assemblage. At nearly three quarters of the total assemblage the culture layer is by far the largest, but with 27% of the burnt specimens it is underrepresented compared to the brown and shell layers.

Interpreting these differences is complicated by the limited number of squares that provided (burnt) fish bones from layers other than the culture layer. Of the two squares that have fish remains from the brown layer, only 124E 135N has burnt bones and it has a lot of them. Indeed, so do the shell and culture layers from this square. In fact, a total of 582 (80%) burnt specimens come from this single square. While a possible cultural explanation cannot be ruled out, in light of the general lack of variability in the deposits described above a more likely solution might relate to taphonomy. Specifically, the extraordinary care taken to recover fish remains from this unit may well have resulted in the recognition and recovery of many more burnt specimens than would normally have been obtained during excavation.

Evidence of butchery and tool production marks (including sawing, cut-marks, scrape marks, etc.) was present on some mammal bones (NISP = 94, 4.2%), although the location of most of these marks is not further interpretable due to the highly fragmented nature of the material and the relatively low occurrence of these modifications. Other than the previously described burning, osteological evidence for how fish were prepared for consumption is scant. There were almost no cut-marks observed during the analysis and skeletal element representation provides little additional information about butchery methods.

Nearly all of the appropriate mammal bones were fractured to gain access to marrow, in particular those of the roe deer, but also those from both wild boar and red deer. This is important to mention as it does not appear that differential overall representation in terms of relative abundance of red deer, roe deer, and wild boar is due to differential treatment of the bone; bones from all three species were marrow fractured to similar extents. Examples of fracturing include larger skeletal elements, such as longbones, as well as smaller elements, including first and second phalanges, which were snapped in half.

Considering the location of the site far out on a peninsula and the high frequency of roe deer in the terrestrial faunal material, it is important to establish whether individuals of this species exhibit any differential body-part representation which may indicate provisioning of the site from elsewhere. In conjunction with Minimum Number of Element (MNE) data, Minimum Animal Unit (MAU) data was calculated per element by taking the total number of elements, dividing by the occurrence of each element in the body, and then normalizing to establish %MAU (Gron in press), graphically depicted in Figure 8.

The relative abundances of each element in the skeletons of roe deer makes it clear that not all elements are equally well represented. However, there is no clear pattern that suggests only certain portions of the carcasses were brought to the site. Importantly, elements of the cranium are present, as are elements of the axial skeleton. Roe deer are most likely being butchered at the site, and therefore procured nearby (Gron in press). This assumes that a whole, unprocessed carcass would not have been carried to Asnæs Havnemark from any great distance, although the use of canoes for transport would render this conclusion moot. In any case, elemental representation data demonstrate that butchery of roe deer was one of the activities that took place at the site. Unfortunately, the small red deer and wild boar samples preclude similar analyses of these species, but among the available samples there is no clear evidence for any specific butchery pattern.

Tool production

In general, few bone specimens were unequivocally worked or prepared for the manufacture of tools (N = 14). However, one aspect particularly worthy of note is the number and placement of working traces found on domestic dog bones. Nearly every identifiable fragment of dog longbone is worked in an almost identical way, with minor differences evident between different types of bones.

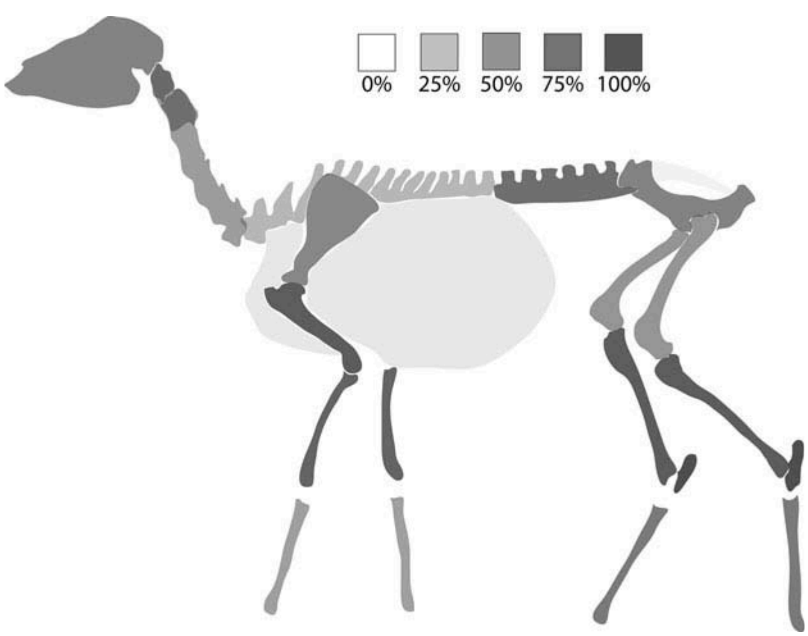

Figure 8. %MAU-roe deer. Carpals, tarsals, and other small elements omitted for illustrative purposes due to their small size (data from Gron in press).

In total, 119 fragments of bone are attributable to dog, comprising 5.3% of the identified material. Of the dog bone material, eleven fragments (9.2%) show unequivocal evidence of working for tool manufacture. Elements showing evidence of working include radii, tibiae, femora, and humeri, and belong to at least two individuals (possibly three). Both fused and unfused proximal femora are present, indicating both adult and subadult dogs were worked. In contrast, roe deer make up 66.5% of the recovered sample but less than one percent of the bones (ten specimens) shows definite or *possible* evidence of being worked in any way. None of the working traces are unequivocally for tool manufacture. However, 36.2% of the roe deer material (making up 24.1% of the entire sample from the site) shows clear evidence of fracturing to get marrow. No dog remains show evidence of such fracturing. Presumably, the size and density of comparable skeletal elements in roe deer and dogs are broadly similar. As such, they should have similar mechanical properties for the manufacture of tools. The high incidence of worked dog bones, coupled with the almost complete lack of evidence for the working of bones of similar-sized mammals, shows a clear preference in raw materials for tool manufacture. Ultimately, the reason for preferentially selecting dog bones for tools remains enigmatic.

Worked fragments usually consist of the end of the element, worked nearly up to the area of fusion at the epiphyseal end. Linear cuts are made on opposite sides of the bone, usually perpendicular to the flattest and straightest edge of the individual element in question (Figure 9). For example, considering the working pattern of distal tibiae, a groove is incised into the lateral and medial surfaces of the distal shaft of the bone providing an opportunity to separate and split the flat anterior and posterior surfaces of the bone, while cutting into the more rounded surfaces. Then, the flat segment of the long bone is thinned to provide a uniform and flat surface (Figure 10).

Figure 9. Working groove parallel to the longitudinal axis of dog tibia.

Figure 10. Perpendicular working so as to snap off a section of prepared flat surface.

Because of these traces of working and subsequent treatment to perpendicularly snap the prepared flat surfaces, it is suggested that such working is for the manufacture of fishhooks. A minimum of 21 whole or partial bone fishhooks and at least six preforms were recovered during excavation. Of special interest is the preform

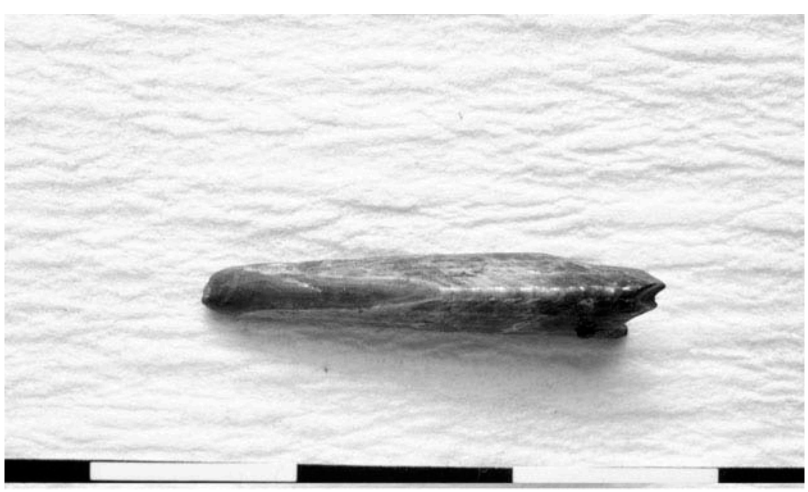

Figure 11. Spurdog spine showing probable traces of use/working.

fashioned from a swan ulna (*Cygnus* sp.), this being the first known evidence of the use of bird bone for fishhook manufacturing in the Danish Ertebølle.

Spurdog spines represent the only observed instances of fish remains that were used as tools. Of the ten spines that were recovered, one shows strong evidence (Figure 11) and three others show possible evidence of having been used as some type of tool based on wear of the ventral surface of the distal region of the spines (cf. Noe-Nygaard 1971). It is interesting to note that the ten spines indicate a minimum of five fish despite the fact that only 30 vertebrae were identified. While this could be the result of special treatment of the spines, it is also true that spurdog vertebrae are poorly ossified and do not preserve as well as the spines.

Interpretations

The site location, faunal assemblage, and tool technology all point to the conclusion that the people who lived at Asnæs Havnemark oriented their lives towards the sea. Isotopic evidence indicates that seafood was the most important part of the diet although the relative contribution of marine *versus* terrestrial foods is not completely clear. The overall impression of animal use at the site is one of both focus and breadth. In this sense, the diet of the inhabitants appears to be similar to the pattern known from many other Ertebølle sites. While the assemblage is strongly dominated by gadids and roe deer, there is a wide range of other species present.

In regards to the fish, the fact that at least 22 types of fish from 18 different families are present in the assemblage shows that there were many fishes available that the inhabitants could choose to target. While fishes were locally available in higher or lower numbers depending on the type of fish, the many bones of gadids (and to a lesser extent eel) demonstrate that they were the preferred catch. The rocky, exposed shoreline near the site, dominance of gadids (including large individuals of cod and haddock), and recovery of numerous fishhooks and preforms suggest that angling (possibly offshore in boats) played a major role in the fishery. This interpretation is supported by the very low incidence in the assemblage (0.1%), of weever, a species that is often used as a marker of fishing with stationary structures (Enghoff 1994). A further indication of the importance of the cod fishery is the otolith evidence showing that they were caught at different times of the year. That most of the eel are larger than 50 cm and thus presumably females, points to eel fishing in the fall when they were migrating from freshwaters into the sea (Muus, Dahlstrøm 1967). Some of the smaller fishhooks could have been used in this fishery, but it is also possible that nets, traps or spears were employed during this event. Access to good cod fishing grounds and migrating eels in the fall may have been the reasons behind why the site is located far out on the Asnæs peninsula, a setting that was the location of an important historical fishery for several different species (Drechsel 1890). With availability of these primary food sources ensured, other animals could be incorporated into the subsistence regime as opportunity presented.

The mammal assemblage is absolutely dominated by roe deer (ca. 2/3 of the identified fauna) although the reasons for their abundance are less than clear. These animals were probably killed on the peninsula and not butchered elsewhere and selectively transported to it, an assessment supported by the relative ubiquity of various skeletal elements and also by the rather tight distribution of isotopic values, which likely indicate that these roe deer lived in extremely similar, if not the same habitat. This is not to say that the possibility of transport of whole carcasses by boat to the site can entirely be excluded.

Based on their dominance in terms of relative abundance, roe deer were the most important terrestrial game. In terms of size, however, even assuming a deliberate and very generous underestimate of the ratio of overall body weight between a roe deer and a red deer (using values from Geist 1998), an adult red deer is at least four times heavier than a roe deer, indicating that the MNI values for roe deer (MNI = 19) and red deer (MNI = 3) are not that dissimilar in terms of meat content. The conclusion is that while they dominate the assemblage, roe deer were not necessarily the most important mammal species in terms of subsistence.

The location may also explain the rather lower numbers of red deer at the site relative to other Ertebølle sites in the region (Møhl 1971, Skaarup 1973, Noe-Nygaard 1995, Gotfredsen 1998, Price and Gebauer 2005, Enghoff 2011), as limited land area may have restricted the numbers of such a large animal (Geist 1998, Kamler et al. 2008). The location would have less affected the abundance of the much smaller roe deer, a species that often lives at higher population densities than red deer (see reviews in Gill et al. 1996, Kamler et al. 2008). In fact, aside from the large representation of roe deer, one of the most notable aspects of this assemblage is the markedly depressed occurrence of red deer. Meat importance aside, there are proportionally fewer red deer found at this site than in Ertebølle assemblages from elsewhere on Zealand.

Asnæs Havnemark is located near the tip of the Asnæs Peninsula, a finger of land jutting approximately ten kilometres into the Storebælt in western Zealand with a width of about one kilometre. The peninsula would have looked similar in the Stone Age, as even with a likely overestimate of sea-level rise of five meters during the Littorina transgressions the general outline and shape of the landform would have resembled today's peninsula (Noe-Nygaard and Hede 2006: 92). In fact, it may even have been somewhat longer.

Table 3. Families of fish present at six Ertebølle sites. Callionymidae, Cichlidae, Labridae, Rajidae, and Triakidae are omitted as they are each represented by only a single specimen.

	Anguillidae	Clupeidae	Cottidae	Gadidae	Pleuronectidae	Scombridae	Squalidae	Gasterosteidae	Scophthalmidae	Belonidae	Cyprinidae	Gobiidae	Salmonidae	Triglidae	Zoarcidae	Trachinidae	Esocidae	Percidae	Ammodytidae	Syngnathidae	Carangidae	Moronidae	Sparidae
Asnæs Havnemark	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X			
Bjørnsholm	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Nivågård	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X				
Smakkerup Huse	X	X	X	X	X	X	X			X	X						X	X					
Tybrind Vig	X	X	X	X	X	X	X	X	X			X	X		X					X			
Vængesø III	X	X	X	X	X	X	X	X	X					X	X	X							

The location of the site on this peninsula likely explains the presence of species that are not as common on Ertebølle sites, particularly the seals, as they generally prefer secluded locations when they haul out (Riedman 1990). Such localities may include islands or other isolated areas such as the end of long coastal peninsulas. The seal remains may be the result of clubbing seals while on land at a haul out location near the site, although hunting with harpoons from boats probably occurred as well. Of particular note is the number of seal remains and extensive cut-marks on some of the elements (NISP = 19), which indicate the importance of seals to the hunters at the site. Overall, this seal assemblage is broadly similar to that from Ølby Lyng in terms of relative importance of seals. Their presence at Ølby Lyng was interpreted to have been at least in part a deciding factor in the location of the site (Møhl 1971), and the same is probably true for Asnæs Havnemark.

Fur animals (beaver, fox, otter, pine marten, red squirrel, and wildcat) were found in numbers that indicate they were of considerable importance to the site's occupants. With at least five individuals of pine marten represented, obtaining these animals must be considered a significant economic activity. The purpose of taking these species was likely to obtain furs, a valuable resource for the cold winter months; a probability reinforced by finds of pine marten in appreciable numbers at other Ertebølle sites in Denmark. Unfortunately, there is no direct evidence for how this species was used.

Birds appear to have been taken opportunistically, as they are sparsely represented. Two general types of birds were taken, waterfowl and raptors, probably by different hunting strategies specific to the class of bird desired by the Ertebølle hunters. Birds were taken for food as well as possibly to obtain raw materials – feathers for fletching, and bone for other uses (e.g., decoration, fishhooks, bone awls/points). The large number of species is indicative of a lack of a clear interspecific focus on birding at the site.

Different skills and procurement strategies are required to obtain terrestrial game, fur animals, seals, raptors, waterfowl, and the various species of fish. The wide variety of animals represented in the Asnæs Havnemark assemblage indicates that the people who lived there were proficient in a number of different hunting and fishing techniques. The predominance of roe deer in the mammal material and gadids in the fish material does indicate a certain degree of economic specialization, but perhaps more of a *de facto* variety based on the unique set of circumstances accompanying the site's location. However, it is important to remember that the inhabitants of Asnæs Havnemark were not so much constrained by the availability of animals in the vicinity of the site, as drawn there because of the prey that was present.

Conclusions

We contend that a degree of variability is present in Ertebølle faunal use that has not generally been recognized. While the same species of animals are generally present in the assemblages, their ranking in terms of importance varies widely among sites. For comparative purposes, we selected five other sites from Denmark (Bjørnsholm on the Limfjord in northern Jutland, Vængesø III in east-central Jutland, Tybrind Vig on Funen, Nivågård in northeastern Zealand, and Smakkerup Huse in northwestern Zealand) that have reasonably large faunal assemblages and were excavated with methods appropriate for recovering a good sample of the faunal remains (Bratlund 1993, Price and Gebauer 2005, Andersen 2009, Enghoff 2011). The assemblages from these sites help to demonstrate that within the larger framework of available resources, broad differences in subsistence practices existed.

Examining the different families of fish makes it apparent that generally the same types of fish were caught (Table 3). Despite this exploitation of common species, the fisheries were actually quite variable when relative abundances are considered (Table 4). At most sites, a majority of the specimens are from one type of fish, but that type varies between gadids, flatfish, and eel (though it is most often gadids). The fact that mostly the same types of fish are found at Ertebølle sites throughout Denmark, but in widely varying abundances, points to fully developed fishing capabilities that were tailored to local conditions.

The same pattern is seen with the mammal assemblages. The same mammals are generally present at the sites (Table 5). Where dissimilarity does occur, it can often be attributed to the local availability of species. This is particularly true of the species locally absent on Zealand during the Ertebølle period such as badger, polecat, and lynx (Aaris-Sørensen 1980). However, the relative abundance of species

Table 4. Relative abundances of fishes at six Ertebølle sites.

	Total NISP	Gadidae	Pleuronectidae	Anguillidae	Other
Asnæs Havnemark	44,461	86%	2%	9%	3%
Bjørnsholm	11,490	10%	1%	56%	32%
Nivågård	4966	30%	56%	2%	11%
Smakkerup Huse	9332	70%	18%	2%	10%
Tybrind Vig	2423	77%	15%	1%	8%
Vængesø III	6478	49%	34%	0%	16%

Table 5. Presence or absence of mammals. Small rodents omitted except for *Sciurus vulgaris.*

	Canis familiaris	*Canis lupus*	*Capreolus capreolus*	*Castor fiber*	*Cervus elaphus*	*Erinaceus europaeus*	*Felis silvestris*	*Lutra lutra*	*Martes martes*	*Phocoena phocoena*	*Sciurus vulgaris*	*Sus scrofa*	*Vulpes vulpes*	*Bos sp.*	*Seal*	*Lynx lynx**	*Meles meles**	*Mustela putorius**
Asnæs Havnemark	X		X	X	X	X	X	X	X	X	X	X	X		X			
Bjørnsholm	X	X	X		X		X	X		X	X	X	X	X	X	X	X	X
Nivågård	X		X	X	X	X	X	X	X		X	X	X		X			
Smakkerup Huse	X		X	X	X	X	X	X	X		X	X	X	X	X			
Tybrind Vig	X		X		X		X	X	X	X		X	X	X	X			X
Vængesø III	X		X		X		X	X	X	X	X	X	X	X	X		X	X

Note: *species not present on Zealand.

Table 6. Relative abundances at six Ertebølle sites. Small rodents omitted except *Sciurus vulgaris*/all doubtful or mixed identifications omitted except for marine mammals/all *Sus* sp. considered wild boar.

	Total NISP	Red deer	Roe deer	Wild boar	Domestic dog	Fur mammals	Marine mammals	Other
Asnæs Havnemark	2208	6%	68%	6%	5%	6%	8%	1%
Bjørnsholm	364	28%	35%	24%	1%	9%	1%	1%
Nivågård	2469	36%	49%	10%	1%	2%	1%	0%
Smakkerup Huse	1787	41%	38%	16%	2%	2%	0%	1%
Tybrind Vig	1744	22%	8%	11%	3%	53%	2%	0%
Vængesø III	841	3%	11%	19%	9%	17%	42%	0%

is quite different at individual sites (Table 6), as with the fish remains. Variability is observed particularly among the three main terrestrial game animals (red deer, roe deer, and wild boar), as well as sea mammals and fur-bearing mammals. The faunal material from Asnæs Havnemark highlights this variability and underscores the reality of differences among certain classes of resources.

These comparisons show that within almost all classes of animals exploited by Ertebølle hunters and fishers there is a great deal of inter-site variability. While the same animals generally occur in all assemblages, the focus of subsistence at each site represents a specialized adaptation to local conditions. Recognizing and explaining this variability are key goals for understanding the late Mesolithic.

In the case of Asnæs Havnemark, the location of the site may explain to some degree the preponderance of just a few species in the archaeological material. However, a major caveat is that while this is the case, the range of animals utilized remains quite impressive, indicating an ability to employ multiple hunting and fishing strategies to fully exploit local resources. We take this to strongly indicate that in the face of either seasonal or atypical environmental stresses, Ertebølle fisher-hunters at Asnæs Havnemark had the knowledge and skills to readily switch between vastly different classes of resources as needed.

In other words, despite the preponderance of roe deer and gadid remains, the Asnæs Havnemark assemblage is the result of a highly flexible hunter-gatherer subsistence strategy able to adapt to local, seasonal, and longer-term shifts in resource availability. In turn, this means that environmental stresses would have less ability to create major changes in general subsistence patterns. Because of this flexibility, we contend that substantive environmental changes could not have been the major causal force for the introduction of agriculture at the end of the Ertebølle period. The evidence we have presented greatly weakens such arguments.

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A silver figurine from Lejre

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The current article describes in detail the Lejre figurine found in 2009, inside the mail hall-area at the settlement. The silver figurine depicts a small, anthropomorphic person seated on a throne, with a larger bird on each side. The description includes the context and circumstances of the find location – the aristocratic settlement of Lejre – as well as a thorough evaluation of the attributes of the figurine itself. In the article it is argued that the figurine presents a male personality, which presumably is of a noble status, dressed in a ritual garment and placed on a high seat, thus bearing similarities with the historic descriptions of the Norse god Odin. The garment might even be that of a coronation costume as it has been described and depicted in contemporary continental sources.

Keywords: Viking Age; Lejre; pre-Christian religion; Odin; aristocracy; rites of initiation; clothing customs

It's not that big – just 1.75 cm tall, 1.98 cm wide, and 1.25 cm deep, made of silver with niello inlay and weighing only 9 grams. But what the Lejre figurine lacks in size and heft, it makes up for in significance and in a wealth of unparalleled detail. At a glance, no one can be in doubt as to what it represents: a person sitting on a finely carved chair with a large bird on each armrest. The two stylized beast heads on the back of the chair pertain stylistically to the Viking Age and date the figurine to the period AD 900–950.[1] (Figures 1 and 2).

It was found one September day in 2009 at Roskilde Museum's excavations at Lejre, where an archaeological examination of the soil was underway.[2] The work in progress at that time had been preceded by a long, hot, bone-dry summer that had facilitated the excavation of some large and complex buildings, the biggest of which was a hall 60 meters in length. The ground linking the new excavation site to excavations that had been undertaken in prior years – work that had been broken off in the mid-1990s – was now to be investigated. It was here that the find was made, in between the two hall complexes (the older one that had been discovered in the 1980s and the new one that was being excavated in 2009), in a culture layer that lay between the arable soil and some underlying glacial deposits (Figure 3).

After the top layer of soil was removed by earth-moving machines, the field was explored by metal detector. Here many find-markers were placed into the ground, for – in distinction to the ground adjoining the newly discovered halls, where finds were scarce – numerous objects were found in these low environs, including gold and silver ingots, rare coins, and spectacular jewelry: so many items of interest that the workers who had been excavating the postholes of the hall came over to see the latest metal-detector finds. Whether it was the shout of 'Find!' or the subsequent dancing about that caused a crowd to form is unclear, but people started talking about it right away. 'Is it the King of Lejre?' 'No, it's Odin with his ravens.' 'Maybe, but isn't that a lady sitting on the throne?' And that is precisely the question: What – or, better, who – does the Lejre figurine represent? An answer to that question will be proposed in the following pages (Figure 4).

The figurine consists of three main components, each of which will be analyzed in turn:

- A finely carved high seat
- Two birds perched on the armrests of the chair
- The human-like figure seated in the chair.

The high seat

The high seat is designed as an upright chair whose four pillar-like legs are connected by inset pieces of wood or

The current article is a slightly revised English version of an article in Danish, which was published by the author in ROMU, Årsskrift for Roskilde Museum 2009. The reason for this English reprint is that the figurine has drawn a lot of attention by research worldwide and has been the topic of many a debate. By this article we, the editors, hope to have made available for a broader group of audience the description of the figure and the interpretation made by the head of excavation, Tom Christensen. Furthermore, by choosing the Lejre figurine as a subject matter for the debate section of our first issue, we also provide two additional interpretations by Ulla Mannering and Elisabeth Rudebeck, respectively. These two papers are intended to bring forth novel interpretation on the figurine.
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Translated by professor John Niles.

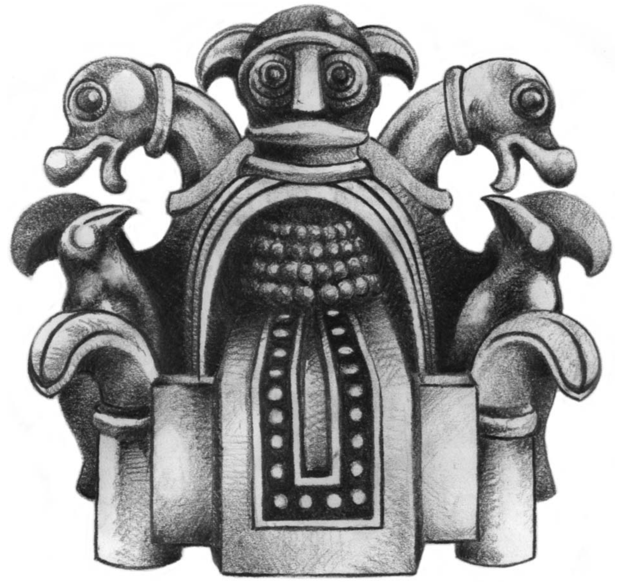

Figure 1. Drawing: Rune Knude/Zoomorgraphic.

Figure 2. The figurine is cast in silver with inlayed niello, a black copper- and sulfur-containing alloy that contrasts with the shiny silver. Photo: Ole Malling, Roskilde Museum.

panels. Each of the four corner posts is topped by a stylized beast head. These might be stylized griffin-heads or snake-heads, though the right front post is broken off. But first and foremost what gives the chair its character is its elaborately carved backrest. Markings or incisions on the rear face of the backrest, behind the seated figure, suggest that this is not to be construed as a smooth surface, but rather that it too includes carvings and decorations. The upper part of the backrest is adorned with two fantastic beast heads with sharply accentuated neck-collars and eyes, while the beasts' open mouths are biting down on the tops of the two rear corner posts. At the top of the backrest, there might also be depicted a smaller pair of stylized beast heads (Figures 5 and 6).

To judge from the seat's shape, with these details, one can infer that it is modeled on an actual item of furniture. Little furniture from this historical period survives, however, and among these remains, which are often fragmentary, there are no examples of high seats or thrones. From the Oseberg burial, which dates from AD 834, was recovered a fairly simple seat with a built-in chest for storing utensils (Brøgger et al. 1917–28). Also, worth noting in this connection are the so-called beast-head posts that

Figure 3. The place where the item was found, in between the two hall complexes. To the left, the 'old' Lejre hall is outlined in the terrain; to the right, one of the newly discovered halls is marked out in white. Photo: Roskilde Museum.

Figure 4. The Lejre figurine has just been discovered by amateur archaeologist Tommy Olesen of Osted. Photo: Roskilde Museum.

were found at this same site: five carved wooden figures, each one about 50 cm long, whose function is still unknown. When one takes into account the beast heads on the Lejre throne, it is possible that these Oseberg posts might have been parts of a high seat.

In any event, miniature chairs have been found at several Viking Age archaeological sites in Denmark and other parts of Scandinavia (Arrhenius 1961, pp. 149ff; Zeiten 1997, pp. 21ff). Most of these items are made of silver and seem to represent *knub-* or *kubbestole* – that is, chairs carved from a single block of wood. Most come

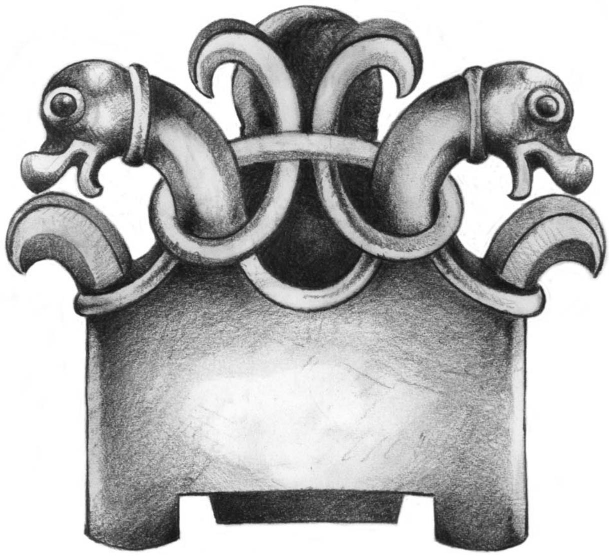

Figure 5. Drawing: Rune Knude/Zoomorgraphic.

Figure 6. The back side of the high seat. Photo: Ole Malling, Roskilde Museum.

Figure 7. The throne from Hedeby is the closest parallel to the Lejre high seat. There is every indication that a person was originally seated on the chair. The find was made in a woman's grave dating from ca. 900 at Hedeby near Schleswig. Photo: Hedeby Museum.

from hoards, but a few were found in graves. For example, one was found in a richly furnished female grave (grave 4) in the burial grounds near the Viking fortress at Fyrkat (Roesdahl 1977, p. 8). This little chair is fitted with an eyelet so that, like many of the other miniature chairs, it could have been worn as an amulet, either as an individual piece of jewelry or as part of a set.

But the find most pertinent to the one at Lejre is a small silver throne from Hedeby, one that was probably worn as an amulet and was found in a female grave (Zeiten 1997, pp. 41, 60) (Figure 7). This chair, which is 1.52 cm high and 2.5 cm wide, is similar to the Lejre piece in that it is shaped as an upright chair with four round corner posts and a backrest. At the armrests are two bird-like animals, swan-like in appearance (Petersen 2005, p. 66). The ends of the armrests possibly represent animal heads, perhaps lions or wolves. There was once a figure sitting on the chair, though now it is lost. The find is commonly known as 'Odin's throne'. The grave and thus the chair can be dated to ca. 900.

The chair from Lejre is a representation of a throne or a high seat (*há-sœti)*, as distinguished chairs are called in the sagas. In the *Prose Edda* of Snorri Sturluson as well as in skaldic poetry and the *Elder Edda*, mention is made of *Hlidskjálf*, Odin's high seat (Lindow 2001, p. 176). It has the property that when Odin sits in it, he can oversee all the worlds and take in everything that is happening.

The birds

On each side of the high seat is perched a bird whose attention is focused on the enthroned person that it faces. On the backs of the two identical birds, inlaid patches of niello highlight the

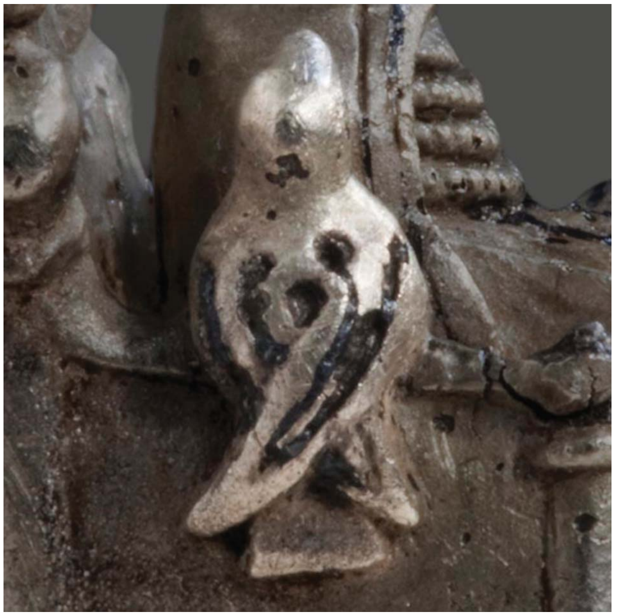

Figure 8. A raven on the armrest of the high seat. Photo: Ole Malling, Roskilde Museum.

pair of intersecting wings that cross one another over the bird's tail. The birds' sharp beaks, as well, help establish their identity as two ravens perched on the armrests (Figure 8). And indeed, depictions of ravens are well known among the colorful animal ornamentation that fills the surfaces of jewelry and other decorative objects of the late Iron Age and the Viking period. Certain types of jewelry are fashioned in the shape of birds, with ravens, among others, being clearly portrayed (Petersen 2005, pp. 64ff).

It is worth noting that the two birds on the Lejre figurine are not to be understood as parts of the high seat. While the beast heads on the backrest of the chair are portrayed in the stylized manner of carved wooden figures, the ravens, despite their small size, are presented as lifelike animals that are independent elements of the design.

The interpretation of the two birds is therefore obvious: they must be Odin's ravens Huginn and Muninn. The literal meanings of those two names are 'Thought' (bringing to mind) and 'Memory' (recollection) – qualities that were good for the birds to have, for their function was to fly out every morning into the worlds, whether of men or of gods, and in the evening to come back and tell Odin all that had happened.

The enthroned person

The long robe

The person sitting on the throne represents the figure's third element. The attire consists of a cloak; a long tunic, robe, or caftan; and, at the chest, a distinct outline of a piece of jewelry or regalia consisting of four rings or chains (Figure 9).

Figure 9. The Lejre figure's clothing. Among other details that can be seen are the bands that are superimposed on the garment. Photo: Ole Malling, Roskilde Museum.

Along the edges of the cloak are two parallel grooves with remnants of inlayed niello. On the robe, two vertical bands are conjoined at the bottom by a short horizontal band. The bands are adorned with small round ornaments whose silver hue stands out against the black niello. The person is wearing a hat or helmet with a clearly marked edge or shade.

We have information about late Iron Age and Viking Age clothing both from the archaeological record – primarily the remains of textiles from grave-finds – and from pictorial representations, whether these are freestanding figurines of wood or metal or, more commonly, pictures on metal in the form of jewelry. Most interesting in this connection are the pictorial images, for objects made of wood or metal are more likely to provide parallels to the garments of the Lejre figure (Figure 10).

In 1868, at the village of Trønninge in western Zealand, a small gold figurine was found of approximately the same size as the Lejre find (Mackeprang 1935, pp. 228–43) (Figure 11). It depicts a person wearing a cloak and a long article of clothing, reaching to the feet, on which bands are superimposed. In both form and ornamentation, this attire is similar to what we see on the Lejre figure. This find from Trønninge has been interpreted as a game piece for a board game, and – perhaps because of the ecclesiastical look of the garments – the suggestion has been made that this could have been a

Figure 10. The attire of this small (3-cm high) male figure from Gudme on Funen consists of sharply outlined bands, whose relation to the upper body is reminiscent of the bands to be seen on the Lejre figure. With reference to the Christ image on the large standing stone at Jelling, it has been proposed that this find from Gudme should be considered a Christ figure. Viking period. Photo: National Museum of Denmark.

Figure 11. This little gold figure from Trønninge disappeared during World War II and now can be studied only through photographs. Photo: National Museum of Denmark.

Figure 12. 'Freyja' figure from Stavnsager, near Randers. This bronze figure, 3.8 cm high, may be a mold for the manufacture of press blech figures. Photo: Randers Museum.

Figure 13. This figure from Rude Eskilstrup was found in a marsh in central Zealand approximately 75 m away from solid land. It is construed as a sacrificial gift. Around the neck and upper chest can be seen a piece of jewelry consisting of sharply outlined rings. The male gender of the figure is indicated by a prominent mustache. Photo: National Museum of Denmark.

bishop (Ramskou 1976, p. 45). However, the figure has a distinct hairstyle, a feature that has led to new interpretations. It is now thought to be a woman wearing a dress called a *seledragt* – a garment, typical of the Viking Age, that is characterized by superimposed bands. This type of costume seems to be associated with the more wealthy segment of society, but not the highest rank (Jensen 2004, pp. 353ff; Roesdahl 1980, p. 20).

By Stavnsager near Randers, Jutland, a bronze matrix was found depicting a person wearing a long garment with a knee-length ornament suspended from the neck (Nielsen and Højlund Fiedel 2001, pp. 82f) (Figure 12). Like other representations of people (particularly women) who tear out their hair, this image has been associated with the

Figure 14. Two gold foil figures from Sorte Muld on Bornholm, each approximately 1.5 cm high, depicting men in long robes, both of them with long hair and one with a beard as well. Photo: Cille Krause, National Museum of Denmark.

goddess Freyja. Among the Norse gods, it was Freyja and Odin, who were well versed in *seidr* or sorcery (Lindow 2001, pp. 265f). A term that is most readily used today as an equivalent to *seidr*, though not a fully adequate translation, is shamanism.

In a richly furnished woman's grave of the Viking Age located near Hägebyhöga Aska in Östergötland was found a small silver pendant that was once part of a large necklace (Figure 13). This item depicts a woman wearing a cape and a long robe, and so it bears comparison with the item from Lejre. On the chest are three well-defined chains that make up a large necklace. This Swedish find, too, is interpreted as a depiction of Freyja, here wearing the *Brisingamen*, a large gold necklace that was forged for her by the four dwarfs Alfrigg, Berling, Dvalin, and Grerr, who were called *brisingerne* (Arrhenius 2009, pp. 223ff).

It is not only women who are depicted wearing full-length garments and necklaces. A carved wooden figure, 43 cm long, from Rude Eskilstrup in central Zealand depicts a seated male figure wearing a long tunic or cloak. Around his neck can be seen a necklace composed of several broadly profiled rings. The enthroned posture, the long clothing, and the necklace all find their equivalents in the Lejre figure. The find has not been carbon-14 dated, but the composite necklace has actual parallels in pure gold from Swedish finds that date from ca. 500. A pin on the bottom of this item indicates that it was once mounted on a base – perhaps a pedestal or more likely a seat. One can imagine that what is depicted is a deity prepared to engage in ceremonial processions and cult activities (Ørsnes 1990, Jensen 2004, p. 106).

A 6.5-cm high bronze figurine or baton-end found at Søholte on Lolland similarly depicts a male person with a necklace or collar much like the one on the wooden figure from Rude Eskilstrup (Franceschi et al. 2005, p. 104).

Though of somewhat earlier date than the Lejre find, gold-foil figures are another source of information for the clothing of the period. These small paper-thin gold-foil sheets, which are believed to have had a religious or cultic context, often feature the stamped images of male and female characters. These images pertain to a numinous world and represent either mythological beings or a worldly elite that had religious functions. Among these figures are men dressed in knee-length or ankle-length robes or caftans, and likewise men wearing long cloaks (Watt 2003) (Figure 14).

Hat and facial hair

The face of the Lejre figurine is not particularly rich in detail with the exception of two eyes and a nose, while neither mouth nor ears are highlighted. While the surface of the nose and the left eye appears slightly brighter than the rest of the face, this difference may have resulted from

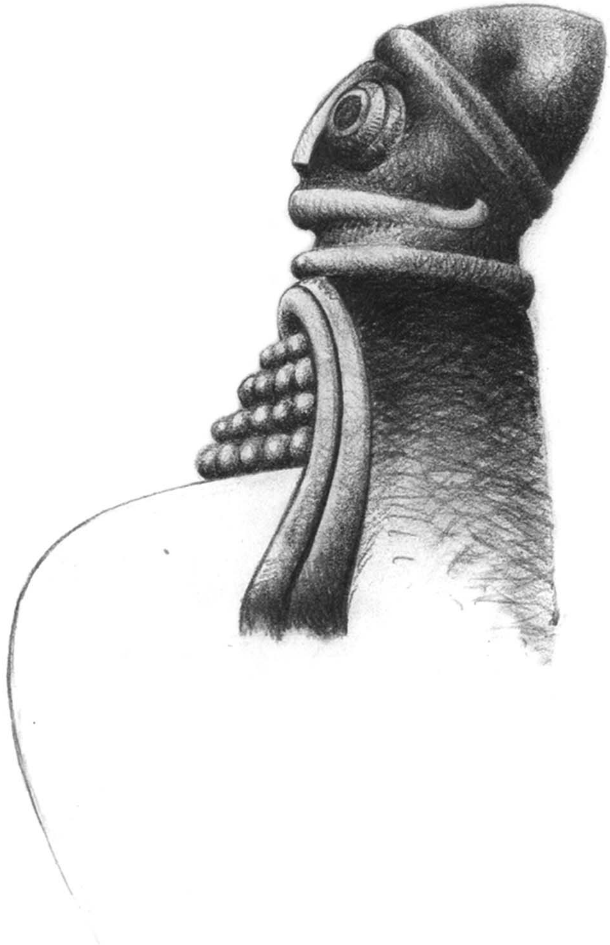

Figure 15. The drawing gives the headgear the character of a helm, and the mustache is almost of the handlebar type. Drawing: Rune Knude/Zoomorgraphic.

Figure 16. One of several male heads, carved in wood, from the Oseberg burial. The mustache is portrayed as a prominent double bulge. Photo: courtesy of the Museum of Cultural History, Oslo.

wear or damage accrued later. Directly under the nose can be seen a horizontal bulge that extends out towards the cheeks, where it diminishes (Figure 15). This can be interpreted as marking out a mustache. There are many examples of Iron Age and Viking Age artifacts where beards or, in many instances, mustaches are prominent on the representations of male heads. In the grave from Oseberg that has been mentioned above, several carved heads of men were found where the mustache is highlighted by horizontal ridges (Figure 16).

Around the neck of the Lejre figure there is another bulge, or rather a ring. It is clearly segregated from the upper edge of the cape and should not be construed as part of the clothing. It may be a representation of a heavy gold necklace of the kind that several of the Iron Age and Viking Age male figures are fitted with (Jensen 2004, pp. 105f) (Figure 17).

The figure's headgear is set off by a prominent edge or shade. Whether this feature is a cap, a helmet, or a hat cannot be determined upon first glance. Here it is natural to consider a number of bronze statuettes of the late Iron Age where such facial features as the mustache and hat or hairstyle are highlighted (Voss 1990, p. 138). With these objects, there is no point in trying to determine where the beard growth is located, whether over or under the chin; more important is to take into account the whole look of the head. In some instances the head is interpreted as having a bowl-cut hairstyle with the hair parted in the middle (Thrane 2005), but this could in other cases alternatively be construed as a hat or helmet. The figures are often single finds and dating them is a difficult enterprise, but there seems to be a consensus that they are depictions of gods and that they belong temporally to

Figure 17. The photo shows the bulge/mustache under the nose. Photo: Ole Malling, Roskilde Museum.

the fourth to sixth centuries AD (Voss 1990, p. 138) (Figures 18 and 19).

'Odin from Ribe' is the name given to a mask, made of lead, that was allegedly found in the oldest remains of Ribe (Jensen 1990, p. 178) (Figure 20). In addition to a mustache that can scarcely be overlooked, plus markings suggestive of a hat or helmet, a stylized bird can be seen on each side of the head. This find is construed as a representation of Odin with the ravens Huginn and Muninn. Similar finds are known from other locales.

To portray gods with beards and hats is not just a Danish or Nordic phenomenon. In the Slavic area, south of the Baltic Sea, there are similar examples of this practice (Gabriel 1991, pp. 279ff).

God of magic

Just as we see with the throne and the birds, the figure's clothing too is full of detail – and this is hardly accidental, but rather these details must symbolize features or characteristics of the person who is depicted. Thus we move into an area where religious power converges with secular power, and where male or female characters are depicted in special situations in which there was no need for them to be attired in easily recognizable gender-specific clothing.

Odin is a multifaceted god who pertains to many contexts and has a wealth of by-names, depending on what role he is attributed. As the supreme god of the Old Norse pantheon, he is called *Alfader* (All-father); and as he is a god of war, battle, and death, he is also called *Hærfader* (lord of armies) and *Valfader* (lord of the slain). The name Odin denotes 'the furious, the ecstatic one,' and this quality makes him a god of wisdom, magic, runes, and poetic inspiration. The fashion of his clothing, with its symbolism, can help to convey the particular mode in which he is represented. The Lejre figure represents him not as a god of war on his horse Sleipner, armed

Figure 18. This figure from Højby by Odense, which is 16 cm high, depicts a seated man with a mustache and hat that lend character to the face. Each hand is closed into a ball, the right one horizontally and the left one vertically. What he held in his hands is not known, but the figure was obviously made in a larger context, and he may therefore have been sitting on a chair or throne. Photo: National Museum of Denmark.

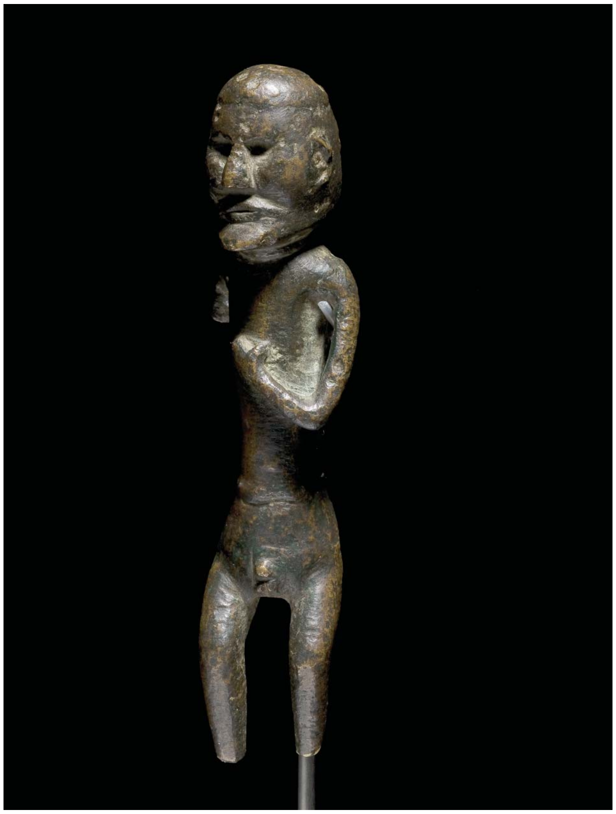

Figure 19. The Figure from Brejnebjerg, Funen, 12 cm in length, has a sitting pose and wears a heavy neck ring in addition to his beard and hat. Photo: National Museum of Denmark.

Figure 20. ‘Odin from Ribe’. The head is made of lead, which is an unusual material for jewelry and amulets; it is thought to be a model for a cast-metal worker. At the site of the same workshop in Ribe, 11 casts matching this figure were found. Photo: Museums of Southwest Jutland.

with his spear Gungnir, but rather as the god of wisdom, as is indicated by the high seat and ravens.

Many of the Gotland picture stones feature representations of scenes from Norse mythology. On a stone from Sora Hammers in Lärbro parish is depicted a man with a beard and long clothing who is hanging from a tree (Figure 21). On a stone from Garda Bote are depicted no fewer than seven men who likewise wear long robes and hang from the branches of trees. These scenes can be construed as representations of human sacrifice (Pesch 2005, p. 124). These visual images can perhaps also be related to the myth of Odin’s self-sacrifice. For nine nights, the god hung himself in the tree of life, Yggdrasil, in order to gain insight into the secrets of the underworld. If it is Odin, who is depicted on the Lejre figurine, reference is likely to one of those situations where he is represented as skilled in *seidr*.

Seidr is the Old Norse word for cultic rituals that traditionally were practiced by a special category of female cult leaders called *völvur* or *seidkonar* (women skilled in magic). In rare instances, these rituals could also be performed by men, but that was a potential cause for social opprobrium. Since, among his other attributes, Odin was a god of *seidr*, this endowed him with female attributes, and in certain situations, he had the capacity of donning women’s clothes. He can therefore be perceived as somewhat ambiguous as regards gender (Solli 2002).

It is therefore possible that a long garment with distinctive properties can be linked to the role of one who is skilled in *seidr*. In any event, the Lejre figure has a certain ambiguity as regards gender. Certain features suggest that a woman is represented, but substantial arguments can be made that it is a man, Odin, who sits on the throne. With

Figure 21. This detail from a picture stone at Stora Hammars on Gotland shows a hanged man wearing long robes. (Imer 2004, p. 60).

interpretations of the figure, we move into a sphere where, as was said above, the properties that pertain to deities are not always clearly defined as either masculine or feminine. Before the matter is finally resolved, what has been stated here provides at least one possible basis for interpretation.

Odin as majestas Domini?

If the figurine appeals to the viewer so strongly, perhaps that is first and foremost because it is easy to decode, even more than a thousand years after it was cast. Even without any background, we can understand it because we readily recognize its overall symbolism: the ruler on his throne. This is an image that is deeply rooted in our culture – roots that in large part lie in the ancient world, especially in the Byzantine Empire (330–1453), which grew out of the eastern part of the Roman Empire with Constantinople (present-day Istanbul) as its capital. The system of governance was imperial, and Christianity was adopted as the state religion (Figure 22).

When Caesar or Christ are depicted as rulers, they are often shown as frontally enthroned, a posture that signals authority. This same motif is known in Danish Romanesque church art, among other examples, in which Christ is seen represented on murals in the pose of *majestas domini* (the Lord in majesty), seated on a throne. Also, just south of the Danish border in the Carolingian kingdom, during the eighth and ninth centuries, the throne played a prominent role as a symbol of royal power. This motif is known not only from visual depictions, but also from surviving thrones or the parts thereof (Klæsøe 2003, pp. 101ff).

In many depictions – be they paintings, mosaics or reliefs – the enthroned ruler is wearing long robes whose individual components, ornamentation, and color have symbolic value. Along the outer edges of the Lejre figure's cloak can be seen sewn or woven bands, while the niello inlay on the lower part of the clothing seems to mark off a separate garment or ornamental bands. Particularly in the Byzantine Empire, a tradition developed – Roman in origin – whereby sewn or loose bands called *clavi* were attached to clothing. Originally associated with Roman senatorial attire as a sign of social rank, these bands were later depicted in early Christian and Byzantine art. The *omophorion* was another significant ornament of dress. This consisted of broad bands that were commonly worn as part of episcopal dress, similar to the *pallium* in the Roman Catholic church (Fleischer 2003) (Figure 23). Again, the question is the interpretation of the Lejre figure's clothing as being an unequivocally male or female attire. In its clearly emphasized details, there may reside a hidden significance that goes beyond simple gender and instead is attached to the office that the enthroned figure holds. Whether one can gain a greater understanding of this item by reference to parallels drawn from the costume culture of the Roman or, later, the Christian Byzantine era should not be decided here. Still, with all its harmoniously balanced symmetry together with its clearly defined symbolism of power, one gains the impression that what we are viewing is a pagan god fashioned in a classical/ Christian iconographic tradition (Figure 24).

Odin and Lejre

That a heathen god is depicted here, there can be no doubt; but is it Odin? While this question cannot be answered definitively, manifestly the throne or high seat Hlidskjálf is Odin's, even though, according to Old Norse sources, others dared to sit in it on rare occasions (Larsen 1991, p. 59). The two ravens Huginn and Muninn also pertain uniquely to Odin's attributes. The gender of the figure can be assessed with reference to its attire; in the present paper, I have emphasized an interpretation of the face as having a mustache and a hat. All in all, it seems most likely that it is Odin who is depicted here, by a skilled craftsman, in 9 grams of silver.

An amulet is an object that protects the wearer from injury and helps in difficult situations. This term is used for several of the miniature chairs mentioned above, but unlike them, the Lejre figurine is not provided with an eyelet, nor is evidence of wear visible at the hole in the center of the chair's back-support that could have been used for suspending it. An amulet can also be stored on the body in a bag or purse. The Lejre figure is, however, hollow. While its cavity might be no more than a product of the casting process, it could also be intended to help mount or secure the piece to a base. In this context, when one takes into account the figurine's subject matter, it is worth mentioning the so-called *völustafir* (cunning-woman staves) that are discussed in the Old Norse sagas

Figure 22. This ivory panel depicting the coronation of the Byzantine Emperor Romanos II (939–963), to the left, and Queen Eudokia, to the right, could be contemporary with the Lejre figurine. The coronation attire of the two royal figures is strikingly similar. (Mango 2002, p. 228).

and are also found in Viking Age graves. These were used in connection with the practice of *seiðr* and were employed in cultic rituals. The staves found in graves, which are made of metal, are most often associated with female burials, for instance grave 4 from Fyrkat (which is mentioned above), but they are also known from male burials (Pentz et al. 2009). The Lejre figurine might have been mounted on one of these staves or on some other symbol of authority. It is also conceivable, of course, that it could have been tucked away in a bag or purse and brought out on special occasions.

With the latest discoveries of large halls at Lejre, we venture to say that this center has been archaeologically proven to be one of the most important sites of Viking Age Denmark. Medieval written sources take it for granted that Lejre was the earliest royal seat of the Danes. Even though the stories of the kings of Lejre that circulated in later times have been shown to be historically unreliable, that fact should not obscure the significant point that Lejre in the year 1000 is referred to as a 'central' location and, in skaldic verse, is associated with Danish kingship (Christensen 1991, p. 18). Whether or not

Figure 23. The coronation of Harold Godwinson as seen on the Bayeux Tapestry. The king is depicted seated on his throne, wearing a symmetrically clasped mantle and a long robe that consists of several folds. To the right is the archbishop, who both wears the ribbon of office himself and stands with one in his hand; ca. 1075.

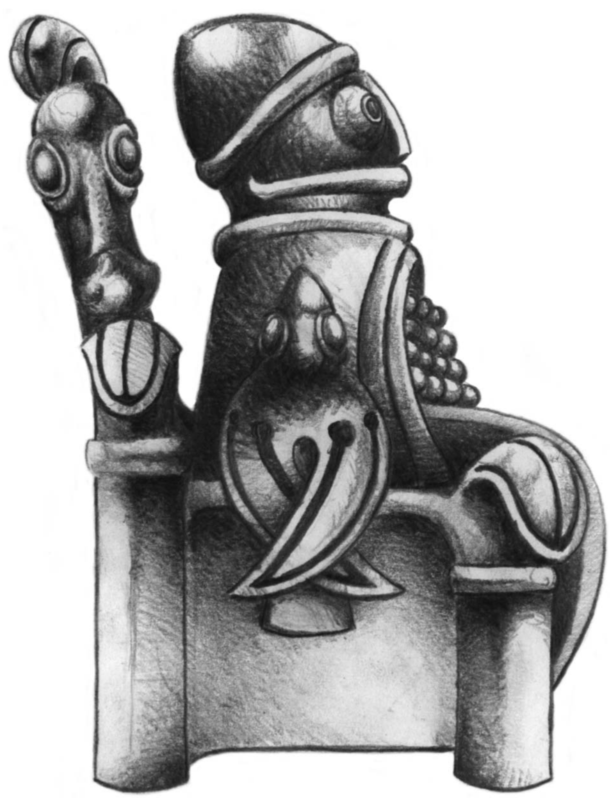

Figure 24. Drawing: Rune Knude/Zoomorgraphic.

Figure 25. Drawing: Rune Knude/Zoomorgraphic.

Figure 26. Photo: Ole Malling, Roskilde Museum.

actual kings lived at Lejre obviously cannot be proven. However, Odin was the king of the Norse gods and also the god of earthly kings, and he seems to have been worshipped among the upper ranks of society in particular. On the Lejre figurine, Odin is depicted in the posture of a ruler on the high seat Hlidskjálf along with the ravens, Huginn and Muninn, who bring him the insight and knowledge that make it possible to rule the world – features for which one or another of Lejre's residents must have had particular use (Figures 25 and 26).

Notes

1. Notwithstanding the short time, it has been on display as a museum exhibit, this little silver figurine has attracted attention and debate that is unlikely to cease any time soon. Future analyses, whether iconographic or technical in nature, will bring forth new interpretations of it. My colleagues at Roskilde Museum deserve thanks for their suggestions and comments, as does illustrator and graphic designer Rune Knude, who made line drawings of the figurine and has also been an inspiring discussion partner. Thanks are also due to museum curator Anne C. Sorensen and editor Christian Adamsen for their constructive suggestions.
2. Roskilde Museum journal no. 641. The excavations took place from June to October 2009 and were funded by the Foundation of 29 December 1967, which was established by Eilif Krogager.

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Man or woman? – perception of gender through costume

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Knowledge of Scandinavian costume history is based on information gathered from a large variety of sources. Actual costumes of skin and textiles are off course key finds but also prehistoric iconography offers a unique opportunity for comparative costumes studies. In this article quick guidelines for identification of male and female costumes seen on goil-foil figures dated to the Late Iron Age are presented. Further the recently excavated figuring from Lejre in Denmark is used as an example of how the guidelines can be used and applied to other find categories. Thus, the article offers an alternative interpretation of the figurine as a depiction of a female.

Key words: Archaeology; prehistory; iconography; costume; gender

Introduction

Textiles and costumes constitute important elements of our common cultural heritage. In Scandinavian prehistory, as in many past societies around the world, textiles were used for multiple purposes. Common for the time-consuming endeavor to produce textiles was first and foremost the wish to be comfortable and guard against the climate, but textiles also played a crucial role in expressing an individual's identity. Knowledge of our textile and costume history is hence a key to our understanding of a multitude of human issues and is vital for our interpretations of past societies (Barber 1991, Andersson Strand *et al.* 2010).

Scandinavia has a very long and impressive tradition for textile and costume research which has its starting point in the wide range of well-preserved archaeological finds originating from many different contexts and time periods (Geijer 1938, Broholm and Hald 1940, Hald 1980, Bender Jørgensen 1986, 1992, Østergård 2004). Information related to costume design and visual appearance is not equally well represented in all prehistoric periods. Especially when dealing with the Scandinavian Late Iron Age, it is necessary to include other sources for costume studies, such as prehistoric iconography. Fortunately, Scandinavia has a wide range of objects, primarily in precious metals and stone, which also include or constitute images of clothed figures. To date no single overview of all these images has been published, and in the archaeological literature, the diverse depictions are often presented individually or grouped according their material or type (Holmqvist 1960, Hauck 1978, Watt 1999a, Simek 2002, Helmbrecht 2011). Other more recent works have attempted to view the iconography with a specific theoretical or interpretational starting point thus reaching yet other conclusions (e.g. Göransson 1999, Danielsson 2007, Hedeager 2012).

In my PhD dissertation on iconographic costumes and depictions of clothed figures in Scandinavia, I took up the challenge to bridge the gap between archaeological textile research and research into prehistoric iconography (Mannering 2004, 2006, 2008). One of the chief conclusions from this study was that Scandinavian iconography depicting clothed figures can be used for costume studies as has previously been done in other countries (e.g. Müller 2003, Owen-Crocker 2010), and supplement information available from other archaeological sources, in particular, the textiles and costumes themselves.

Textiles and gender

Knowledge of Scandinavian costume history is primarily based on information garnered from a large variety of grave finds and, in some periods, also bog finds. The identification of the gender of the buried persons is, in most graves, based on the presence of gender specific grave goods like jewellery and weapons, and on rarer occasions on the anthropological analysis of the preserved skeletal material (Sellevold *et al.* 1984). On this background, it has been concluded that, in the Early Bronze and Late Iron and Viking Ages, costumes in general looked different for male and females (Broholm and Hald 1940, Hägg 1974, 1984, 1991, Iversen 1991), while in the Pre-Roman Iron Age and the Early Medieval period, it is more difficult to identify specific male and female garments. In these periods, it seems as if costume design focused less on segregating the genders (Østergård 2004, Mannering 2011).

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Based on the archaeological finds, it can further be concluded that, gender differences recorded in costume design are primarily based on differences in costume shape and drape, while the textiles used to produce these costumes within a specific time period are highly uniform; a phenomenon which can indeed be observed in the textile finds throughout the entire Scandinavian prehistory (Bender Jørgensen 1986). Especially in the Late Iron and Viking Ages, similar textile types were used for male and female costumes while differences can be recorded in the way various costume items were shaped, combined and worn, in the use of decorations and through the accompanying jewellery/fibulae and other accessories. Fortunately, these are large-scale characteristics that, in most cases, can also be tracked in the iconography.

In my work with the Late Iron Age dress iconography, I developed a methodology and an analytical tool which can be used to record and analyze the numerous details in the depictions, and enable a clear and easy description. This system was then related to features known from the archaeological finds denoting male or female such as specific costume shapes, hairstyles, jewellery and weapons, and thereby creating guidelines for gender and costume identification of iconographical figures.

The primary group of artefacts used for the development of these guidelines is gold-foil figures, which have their chronological peak in the sixth and seventh centuries AD (Watt 1999b, p. 138), but also clothed figures on the slightly earlier bracteates, and figures on contemporary or later weapons, jewellery and tapestries were included (Mannering 2006). Thus, it has been possible to make an iconographic costume sequence covering a period of more than 600 years from the fifth to sixth centuries that can be compared with the archaeological textile and costume finds.

Images and dress

Gold-foil figures may depict one or two figures. In double gold-foil figures, it is characteristic that one of the figures wears more and longer costume items and has longer hair than the other figure depicted. Combined with information on the occurrence of jewellery and necklaces, the following general characteristics may be listed:

- Women generally wear more costume items than men;
- Women generally wear longer costume items than men;
- Women most often wear dresses;
- Women often have long hair, and longer hair than men;
- Women can wear their hair in a knot at the nape of the neck;
- Women usually wear jewellery such as *fibulae* and necklaces;
- Men usually wear trousers or have clearly delineated legs;
- Men often have short hair.

Among the several hundred different double gold-foil figures, only very few display figures with similar features (Stamsø Munch *et al.* 2003, p. 249), while this occurs more commonly in the other object categories studied. When only a single figure is depicted, which occurs among the gold foils but also in the jewellery group, it is more difficult to determine costume and gender, but in general the same characteristics may be used. A noteworthy exception is a group of single gold-foil figures for which these guidelines are not sufficient to make a secure gender determination, either because the costume is not very gender specific or because the figure contains contradictory features. Thus these figures have previously been defined as gender neutral (Watt 2004, pp. 189–192). Their presence emphasizes that, the same object category may express different relationships to the body and various ways of depicting human figures.

A typical iconographic female outfit consists of an overgarment and an undergarment (Figure 1). Jewellery is occasionally seen as well. The overgarment consists of different types of capes or, in rare instances, a sleeved

Figure 1. Double gold-foil figure from Hauge in Norway showing a male clad in cloak and tunic and a female clad in cape and dress (© Ulla Mannering).

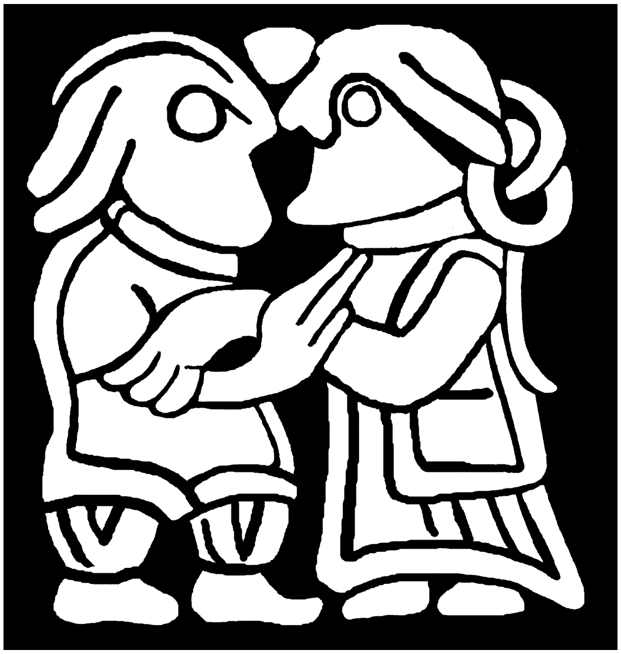

Figure 2. Double gold-foil figure from Helgö in Sweden showing a male clad in tunic and trousers and a female clad in sleeved jacket and dress (© Ulla Mannering).

Figure 3. Double gold-foil figure from Slöinge, Halland in Sweden showing a male clad in tunic and trousers and a female clad in blouse and skirt, and a cap on the head (drawing by Anders Andersson).

Figure 4. Single gold-foil figure from Sorte Muld, Bornholm in Denmark clad in caftan. Drawing by Sidsel Frisch.

jacket (Figure 2), while the undergarment usually consists of an ankle-length dress. In a few instance, skirts and blouses also occur (Figure 3). The female cape is almost always worn in a symmetrical manner resting on both shoulders which makes it open at the front, although it can be closed directly beneath the chin.

A male outfit generally consists of fewer components. The most common item is a hip-length or knee-length tunic with perhaps a pair of trousers with tight or wide trouser legs (Figure 3). If a man is wearing an overgarment, termed a cloak, the shape differs from those seen on women. The male cloak is most often worn in an asymmetrical manner resting on one shoulder which gives it a distinct pointed look (Figure 1). Another typical male overgarment is the caftan which is characterised as a sleeved garment with oblique front edges and a straight lower edge, and open in the front. The garment's edges are often decorated with wide patterned borders. The caftan is worn exclusively by male figures and is considered to be a warrior's outfit (Figure 4). The terminology chosen to describe the costumes recorded in the iconography is purely based on known modern words and is selected primarily to secure an easy description and identification.

Figure 5. The Lejre figurine (© Roskilde Museum/Ole Malling).

Based on the analysis of over 1000 depictions of figures clad in various outfits dated to the Late Iron Age and Viking Age, it is possible with this methodology and guidelines to evaluate and identify costumes recorded on other iconographic objects.

The Lejre figurine

In 2009, Roskilde Museum in Denmark recovered a remarkable find by means of a metal-detector during one of its many excavations in Lejre on Zealand (Figure 5). A three-dimensional figurine, a mere few centimetres tall, cast in silver that can be seen from all four sides (http://www.roskildemuseum.dk/Default.aspx?ID=306). The figurine depicts an individual seated on a square throne with legs, armrests, and a tall backrest. The back of the figure is placed close to the tall backrest but it is only the bent legs that touch the seat of the throne. The head of the person depicted is not particularly detailed and the face is indicated by two large round eyes and an almost square three-dimensional nose. The mouth is not evident, and instead, a ring passing from one side of the head to the other is seen where the mouth should have been. Underneath this ring at a slight distance is another ring which marks the transition to the torso, but it does not continue all the way around the back of the head (Christensen 2010a, p. 150). The forehead and the back of the head have a round finish without any further characteristics such as ears or hair indicated. The transition from face to forehead is marked by another ring which finishes where the upper face ring also terminates.

The body of the figure is divided into different zones with various patterns and shapes which most likely represent different elements of dress and possibly jewellery. The top garment rests on the shoulders. It is closed beneath the chin but from there it opens up and follows the sides of the figurine and covers the back. The front edge of this dress item is rounded. On either side of this garment, an incised line further emphasizes the edge, but otherwise, the surface is smooth. On the chest, visible beneath the top garment, four slightly curving lines of small dots lie one above the other.

The lower part of the body has quite a square shape which bends and follows the contours of the seat. At this part of the figurine the costume item has a smooth surface and ends in a straight horizontal line without any indication of shoes or feet. From the lowest row of dots and reaching almost to the lower edge of the garment, an oblong decoration/item is visible. This consists of a U-shaped border with a pattern of dots enclosed by a rounded edge. An inlay of niello further enhances the pattern. It is difficult to ascertain if this is a separate costume item or a decoration belonging to the lower garment. The figurine is without arms, with a bird seated on either side. This figurine is stylistically dated to c. AD 950 (Christensen 2010a, p. 143), and even though the figurine is three-dimensionally modelled, it is reminiscent of many other contemporary two-dimensional figurative representations dated to the same period.

Interpretation of the figurine as a male

Due to its unique character, from the outset, this figurine was the subject of much media attention. It was soon named ‘Odin from Lejre’, as the excavators interpreted the figurine as representing a man, or rather, the Nordic god Odin seated on his throne together with his two ravens (Christensen 2010a, b, c). Today, this name is firmly rooted and replicas are sold with this label.

In the first descriptions of the Lejre figurine, the identification of the figure was primarily focused on characteristics linked to the throne and the head. Depictions of human figures dated to the Late Iron and Viking Ages are iconic in the sense that they do not reveal personal details, and faces and limbs are rarely particularly detailed or even anatomically correctly depicted. Therefore, facial detail can only be used to differentiate between males and females on rare occasions, for instance where a clear moustache or beard is depicted. On the Lejre figurine, the upper face ring has been interpreted as a moustache. The upwards pointed end on one of the sides has been used as an argument for this interpretation (Christensen 2010a, pp. 149–150), but in fact this feature is not evident when the published photographs are studied. Compared to other depictions of males with a moustache, this execution is rather crude and not at all evident, and, in my opinion, this ring cannot be interpreted as a beard and thus is not a usable marker of the gender.

Another feature that has been utilized in gender identification is the shape of the head, which has been interpreted as that of a helmet (Christensen 2010a, pp. 149–150). A sketch published in 2010 (Christensen 2010a, fig. 8) also emphasises a pointed shaped head, but in this case too, the shape cannot be confirmed when compared with the available photos. The shape of the head is indeed much more rounded and does not justify comparison with a helmet. Regrettably, the Lejre figurine has no indication of hair, which in many other cases can be used as a marker of gender. On a group of gold-sheet figures found on the Slöinge settlement in Halland, Sweden (Lamm 2004), woman are sometimes depicted with a small cap or a hairnet (Figure 3). Based on this comparison, the Lejre figurine could just as easily be interpreted as wearing a cap. Therefore, no clear identification of the gender can be made based solely on the characteristics of the head.

A third argument that has been employed to identify the figure as a male is that it was said to be wearing a caftan or a long tunic (Christensen 2010a, pp. 146–149). According to the above-mentioned analyses, the caftan is a highly distinct item of costume which is only associated with a highly exclusive group of depictions related to the male sphere (Figure 4). On the other hand, the characteristics listed for the caftan do not match the appearance of this costume or any of the other costume items combined with this garment. The other option as a long male tunic is equally unlikely, as the costume clearly consists of several different items, which is a typical female feature, and as only in rare occasions are men depicted wearing long garments. Altogether, there are no clear features that support an interpretation of the costume, either as that of a caftan or as a long male tunic.

Interpretation of the figurine as a female

On the basis of the characteristics outlined above, I suggest that the seated individual on the throne is a woman. Most elements in the costume fit into the categories classified as belonging to women, whereas only the highly uncertain ones fit into the equivalent male categories. The overgarment accords in all aspects with the description of the typical female costume termed a cape, which may be closed under the chin, but always opens to the sides (Mannering 2006, pp. 22–30). In the gold-foil figures, which are most often shown in expanded profile, this type of cape is depicted with a triangular shape (Figures 1 and 6). Male figures, on the contrary, seldom wear overgarments such as cloaks or caftans, and these always have different shapes to the female overgarments, and are fastened in a different way (Figure 1).

It is less easy to identify the garment or garments seen beneath the cape, and several different interpretations are possible. Most likely, it is a dress, which is the most common female costume item in the iconography. Less commonly occurring in costume iconography is the combination of a skirt and a blouse (Figure 3), which is known from a few gold-sheet figures from Sweden (Mannering 2006, p. 215). Furthermore, the fact that the undergarment depicted on the Lejre figurine is so long that the feet are not visible, is yet another feature closely linked to female iconography, and especially seen on figurines dated to the Viking Age. Men, on the other hand, are usually depicted with visible legs/trousers and feet/shoes.

The costume item or decoration visible on top of the dress/skirt on the front of the figurine is an element which in iconographic costume terminology is termed an 'apron' (Mannering 2006, p. 215). This garment feature is known from a number of gold-foil figures from, for instance Slöinge (Figure 6) and Helgö in Sweden, and Sorte Muld in Denmark, and can also be compared with details seen on several Danish and Swedish figurine pendants (Melle 1725/1997, Watt 2001, Lamm 2004). The function of the apron is not fully evident and regrettably, a costume item that matches this position and use has yet to be identified among the archaeological textile and costume finds. There is no doubt, however, that the apron is an element that in Scandinavian iconography is restricted to women.

The transverse grooves evident on the chest of the figurine constitute a very clearly depicted element, but based on known iconographical comparisons, this probably does not represent a costume item. More likely, the dotted lines represent bead chains. Rows of bead chains are a characteristic feature depicted on many contemporaneous female figurines. A well-known example is seen on the pendant from Hagebyhöga in Sweden (Figure 7), where the chest of the woman is adorned with four lines of dots, interpreted as bead necklaces (Arne 1932, Axboe 1986). Bead necklaces belong to the group of female jewellery, which is well documented in the archaeological finds. On the other hand, it has been suggested that, on rare occasions, magnificent and intricate gold neck-rings like the one known from Ålleberg and Möne in Sweden (Holmqvist 1960, pp. 102–105) are also

Figure 6. Double gold-foil figure from Slöinge, Halland in Sweden showing a female clad in cape and apron, and a cap on the head, and a male clad in tunic and trousers. Drawing by Anders Andersson.

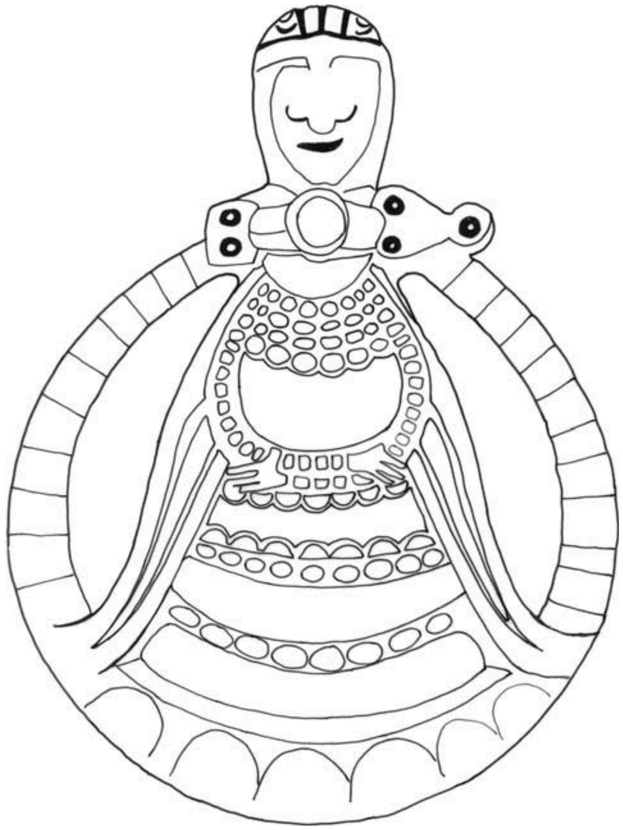

Figure 7. Pendant from Hagebyhöga in Sweden. Drawing by Pernille Foss, after Axboe (1986).

depicted on male figurines, as on the carved wooden statue from Rude Eskildstrup in Denmark (Kjærum and Olsen 1990, pp. 140–141). It has further been suggested that, the line/ring marking the top edge of the overgarment could be a heavy gold ring, but in my opinion none of these interpretations are fully convincing.

Finally, another, but less likely interpretation of the ornament on the chest is that, this indicates a kind of blouse linked to the occurrence of a skirt, or possibly a chain mail. Especially the last option is, in my opinion, highly unlikely as depictions of chainmail are never combined with other costume items, and secondly, the depictions are restricted to specific male warrior iconography as seen on the helmets from Vendel and Valsgärde in Sweden (Stolpe and Arne 1912, Arwidsson 1977, Hauck 1978), a setting which is not comparable to that recorded for the Lejre figurine.

Conclusion

Based on the afore-listed features and characteristics, I find it most likely that the figurine from Lejre is wearing a female costume, and therefore I also think it is most likely that the figurine depicts a woman.

That two researchers, viewing the same object, can reach such different conclusions is due to our analyses giving weight to quite different elements. The birds, who turn into *Hugin and Munin* (the ravens of Odin), and the chair, seen as *Lidskjalv* (the throne of Odin, from where he can see all nine worlds), are central elements in the identification of the figurine as Odin. An identification, which places it in a mythological universe where everything is possible (e.g. Andrén *et al.* 2006).

On the other hand, the signs of gender revealed by the costume cannot be considered secondary to the other details. Within Nordic mythology, there are many examples of strong and powerful women, who could also have been depicted in this way (Näsström 1998, 2009). A further and perhaps more provocative possibility could be that, here, we see Odin depicted in female attire. A disguise, both Odin and Thor were famed for using. Hence, we should even be open to the fact that other interpretations of the figurine than merely as Odin or a woman are possible. Further, it has been pointed out that in a prehistoric context it may be delimiting only to consider the presence of two genders and that the Lejre figurine as a 'performing object' can be used for many different interpretations (Danielsson 2010, p. 31).

Based on the presented evidence there is no doubt that a large part of the Scandinavian iconography depicting clothed human figures can be used for costume studies, and that they depict what was physically and visually available and preferred in Late Iron Age society. The majority of costumes identified in the costume iconography have also been identified in the archaeological textile record, and thus, the images constitute a reliable source for research in both iconographical and archaeological dress. In this way, the Scandinavian costume iconography contributes with crucial new information on chronological, regional, and social differences in costume traditions and lifestyles in the Late Iron Age which can be used by all researchers and applied to new finds.

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Negotiating normativities – 'Odin from Lejre' as challenger of hegemonic orders

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This article focuses on some bodily features of the figurine called 'Odin from Lejre'. Some corporal characteristics convey an ambivalent touch to the interpretation of the miniature. So, for example, shows the clothing close resemblance to the late Iron Age female dress. This, combined with facial attributes that have been interpreted as a moustache, can be seen as a negotiation of the contemporary hetero-normative gender order. Moreover, the eyes of the figure demonstrate certain irregularities, maybe signifying differences in the visual capacities of the eyes. This corporal exceptionality in relation to (today's) notions of body-normativity may imply that the Viking Age abled body sometimes was extended to include reduced visual capacity. The processing of both gender-normativity and body-normativity in one and the same precious item, may imply that the high-ranked setting of Lejre included performative practices that were negotiating both hetero-normative and body-normative hegemonic orders.

Keywords: Odin from Lejre; Scandinavian Viking Age; appearance; gender-normativity; body-normativity; intersectionality

Introduction

Sometimes new and surprising archaeological finds enter the scholarly scene, making us not only curious but also guide us in our search for novel and unexpected knowledge of the past. Such a find is 'Odin from Lejre', dated to the first half of the tenth century AD. The little silver miniature, depicting a human figure sitting in an honorary chair with a bird placed on each armrest and with the back of the chair decorated with two roaring beasts, shows us new facets of the connections between human beings – or maybe gods – animals, and accessories. The precious metal with its niello inlays and the figurine's wealth of details, regardless its small size, may deepen our insight into the skills of the silver craftsmen of the time. The well-documented archaeology of Lejre's special mixture as a magnate site with indications of trade, various craft workshops, and both mundane and ceremonial spaces (e.g. Christensen 2008, 2009) will provide a rich background for discussions of the figurine (Figure 1).

Already shortly after its appearance, the figurine stimulated eager discussions. Questions have, for example, targeted iconographic interpretations related to the figure's identity. Is it a man or a woman, or maybe a deliberately ambiguous gender-position that is articulated (Christensen 2009, 2010, Back Danielsson 2010, Mannering 2010)? Does the figurine represent a human being or a god? If the miniature depicts a god, is it Odin who shows his presence, or might the figure symbolize some other character of the Viking Age mythical universe (Christensen 2009, Mannering 2010, p. 28, Sonne 2010)? Is it perhaps a martial sovereignty, which is expressed (Sonne 2010, p. 35), an interpretation, which could be reinforced by Lejre's aristocratic milieu (Christensen 2008, 2009, pp. 18–22, 2010, pp. 24–25)? Maybe the practice of a seer or a seeress is reproduced? The find is indeed open for a wide range of interpretations.

Some analytical conceps

Here we see examples of plausible categories of identity, or positions of the subject, that are connected with the corporal articulation of the Lejre figurine. The position of the body, its shape, clothes, and other bodily attributes, the body's agential relation to the surroundings and its physical closeness to animal representations, are some of the themes that have been highlighted.

Over time the body in general has been an important field of study in archaeology, and maybe now the theme is more in focus than ever (see, for example, Joyce 2005, Boric and Robb 2008). For various categories of identity, like man or woman, young or aged, physically capable or incapable, sovereign or thrall, native or alien, or other relationally shaped positions of the subject, the body will be the node where identity is located and is given its particular physical reference. The body will comprise and situate various positions of identity, also understood as positions of the subject, in a web of interwoven or intersecting social orders, which are connected to, for example, gender, age, physical ability/disability, and rank. The sensing and acting body will also be the prime

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Figure 1. The Lejre figurine (© Roskilde Museum/Ole Malling).

locus where the positions of the subject through different articulations such as actions, attributes, and use of space, will be confirmed, strengthened, stretched, bent, or denied. The actions, reinforced by their accessories can be understood as performative practices in a continuous process where the situated body is negotiated and renegotiated. And vice versa, through the performative practices of the situated body, the social orders that are connected to a specific identity category will be confirmed or challenged. In a social dynamic, the body and its material references will obtain an agential position (Alberti & Back Danielsson http://www.springerreference.com/docs/html/chapterdbid/353662.html).

Categories of identity, such as gender, age, and so on, and the various positions of subjects that appear within such categories, are ascribed different values, which are based on the norms and values of a particular society. So, for instance, can the gender order that dominates our western society today, be described as a hetero-normative order. It can be expressed as an axis, where masculinity is placed on one end of the axis and femininity on the other. These two categories are usually distinguished through one or many significant makers (Hirdman 1988). This axis, or gender order, is often characterized by an asymmetrical hierarchy of values, where masculinity is ascribed a higher value and femininity a lower one. This asymmetrical construction can then be understood as a gender order of power, which is androcentric and hetero-normative.

Another example of categorizing identities is to ascribe norms and values to bodily abilities. In our society is the completely able body seen as a norm, and bodily variations that deviate and are placed far aside from the norm are often described as disabling, creating a handicap. Such a categorization is, however, a cultural construction. It can be understood as a position on an axis, where the completely able body is placed on one end and the body with total lack of abilities on the other (Thomson 1997). Adding a hierarchy of values, this will be understood as an ability/disability order of power (Sw. *funktionsmaktordning*).

Often we take both the contents of a gender order and the notions of what can be understood as an able body-norm for granted, seen as something obvious and natural. However, the notions of what characterizes masculinity, femininity, and other gender identities, as well as ideas of what constitute the bodily norm, the body-normativity, varies over time and between cultures. This also means that the hegemonic orders that are associated with them are negotiable social and cultural constructions (Arwill-Nordbladh 2012). The corporal characteristics of the little silver figurine from Lejre might broaden our knowledge of such social dynamics during Scandinavian Viking Age.

An ambiguous figure

As soon as the Lejre figurine was found, the discussion circled around its gender. A common way to approach a gender-attribution is to analyze the corporal appearance (Sørensen 1997). Here the costume is central. For many scholars (Mannering 2010, Sonne 2010) the clothing of the Lejre figurine appears as a female dress. There are, for example, many similarities with the Swedish pendant from Aska, Östergötland, which undoubtedly depicts a woman (Figure 2, 3). A cloak, an ankle-length skirt or a kind of

Figure 2. The Aska lady. A gilded silver pendant found in a woman's grave dated to 950 AD, Aska, Hagebyhöga parish, Östergötland, Sweden. Photo by Christer Åhlin, The National Historical Museum, Stockholm.

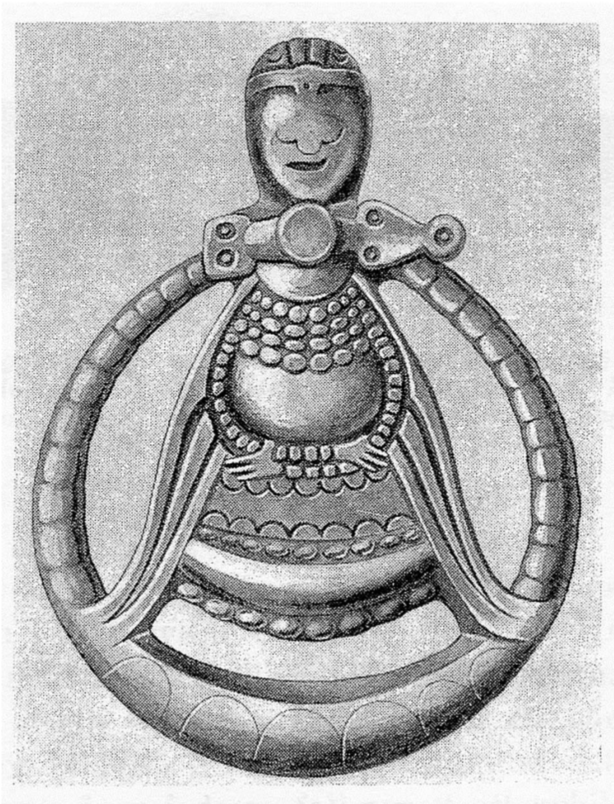

Figure 3. Drawing of the pendant from Aska. Drawing by Bengt Händel, ATA, Stockholm.

Figure 4. Gilded silver figurine from the magnate site of Tissø, Zealand, Denmark. Photo by National Museum, Copenhagen.

apron, and four rows of beads are similar for the two figures. A related apron-like garment is shown on the two figurines from Stavnsager, Jutland and Tissø, Zealand (Figure 4), both interpreted as women. The costume also resembles that of the figurine from Trønning, Zealand, which often is identified as a woman (in, for example, Jensen 2004, p. 353). Moreover, as Mannering demonstrates, has the clothing no clear similarities with the contemporary male costume. In those cases that a long cloak is part of a male outfit, the cloak's neck is not round, as here, but cut on the bias (Mannering 2010, p. 27). However, Christensen (2009, pp. 18–21) raises the idea that the costume could be inspired by contemporary clothing from the Roman or Byzantine church, where the officiating priests were dressed in ankle long costumes with long *stolae* or *palliae*.

Other features of appearance, signifying gender, are hairstyle and beard. The most common female hairstyle of this time, depicted on tapestries, carvings in stone and metal objects show either a knot-like coil ending in a long 'pony-tail', or a bun (Göransson 1999, p. 41). From this perspective, a gender attribution of the Lejre figurine is difficult. The coiffure, if any, is hidden under a helmet or maybe a hood, and will thus not be an unequivocal gender marker. It is true that Christensen (2009, pp. 16) refers to the male Højby-figurine's rounded cap, but also the woman from Aska wears a rounded helmet-like headgear. Two Viking Age figurines depicting men, 'Odin from Uppåkra' (Figure 5) and 'Odin from Lindby' (Vikingatidens ABC, pp. 188) are equipped with a horned helmet and a pointed hat, respectively. Regarding the miniature from Lejre, it seems that those, who designed it, refrained from the possibility of making a clear gender specification in relation to hairstyle and headgear.

Concerning beard, the Lejre figurine's gender attribution takes another turn. Ademption, presence and design of beard and moustache are cultural interpretations of corporal characteristics that distinguish the male body (Göransson 1999, p. 35; see, for example, the figurine 'Odin from Lindby', which shows a moustache). At the transition between head and body, the Lejre figurine is equipped with two torus-like rings that conceal the neck and the mouth. The lower one is often understood as a neck ring, something that Christensen sees as a masculine attribute (Christensen 2909, pp. 15–16). The upper ring, which seems to be not fully closed, is more difficult to explain – a more imaginative association is that of a gag. Christensen claims that this feature is a moustache, which is made explicit on several interpretative analysis-drawings (2009, pp. 15, 20). If the 'upper ring' is a moustache, the gender identification will be more

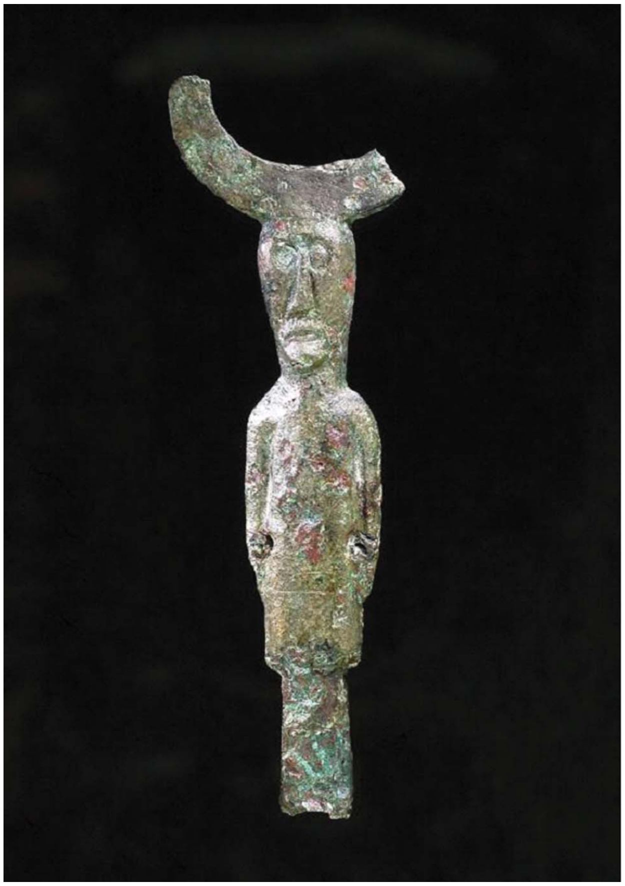

Figure 5. Bronze figurine, often called 'Odin from Uppåkra', found in the Viking age Cultural Layer of Uppåkra, close to Lund, Sweden. Photo by Bengt Almgren, Lund University Historical Museum.

complex. As Sonne states (2010, p. 36), one conclusion might be, that we see a man, who is dressed in a so far unknown man's dress. Another conclusion may be that we see a man dressed in a woman's costume.

The latter idea, that the figurine depicts a man dressed like a woman, has also been discussed, in particular on the web (see, for example, the blog Aardvarchaeology, http://scienceblogs.com/aardvarchaeology/2009/11/13/odin-from-lejre-no-its-freya/). References have been made to Old Norse texts that characterize Odin as a sorcerer and shaman (Hedeager 1999, Solli 1999, 2002). In the Old Norse texts, sorcery is described mainly as a female activity, and the fact that Odin devoted himself to this task added a feminine dimension to his character. Also Thor is connected to a narrative, which includes his dressing in female clothes as he was compelled to appear as the goddess Freya, while tricking his stolen hammer back from the giants (Näsström 1986). The dishonor, according to the Old Norse texts, that usually was connected to male femininity did not meet these gods. Odin's highly complex character and Thor's brute force and flammable fighting spirit when he was compelled to reveal himself, might have counterbalanced the disgrace of being associated with femininity. If the Lejre figurine puts an ambiguous gender attribution on display, this was most likely no shameful action. The precious material, the exquisite craftwork, and the find context quite close to the high-ranked setting of the Lejre Hall indicate that the ambivalent gender attributions were kept within decorum. As Back Danielsson (2010) suggests, this might have been a desired feature. If the costume designates femininity and the upper facial band represents a moustache and thus signifies masculinity, two contradictive gender markers are intersecting. Moreover, the possibility to choose a female coiffure or a distinctive male headgear has been avoided, in favor of a headgear that – for us – is more difficult to interpret, maybe being a more gender neutral cap or helmet. With this interpretation, the figurine from Lejre indicates that the heteronormative gender order where masculinity and femininity were clearly distinguished and separated, at least in some instances was open for negotiation.

The eye, eyesight, and vision

In connection to the Lejre figurine one feature, which so far has not attracted much attention, may be worth some awareness. That is the styling of the eyes. Photographs show that the two eyes in some way differ from each other. The right eye is circular with a staring pupil while the left eye seems more indistinct and diffuse. Christensen (2009, p. 15) observes this trait and suggests that the blank look might have appeared because of abrasion or later damage. However, it might not be impossible that a certain difference of the eyes could derive from the stage of production (see discussion in Arwill-Nordbladh 2012, p. 51). Still, this may seem as a very vague and uncertain observation, better left aside, if it had been unique. However, there exist a few examples of figurines and other depictions where a deliberate asymmetry regarding eyes, eyesight, and look seems to have been a desirable feature (Arwill-Nordbladh 2012). Good examples are the two Viking Age bronze statuettes from Uppåkra (compare Figure 5) and Lindby, where the men's faces show one 'ordinary' eye and one clear void on the place of the other eye (Larsson and Hårdh 1997, Bergqvist 1999; *Vikingatidens ABC* 1995, p. 188). Other examples are a man's face on a mold for a strap end from Viking Age Ribe (Price 2002, p. 387, Helmbrecht 2011, pp. 144, 168) and on a tool handle from middle of the eighth century Staraja Ladoga (Price 2002, p. 388). Yet an example, now a couple of centuries earlier, is the well-known bronze matrix from Torslunda, Öland, Sweden, depicting a so-called 'weapon dancer' (Figure 6). Here one of the eyes has been deliberately removed (Arrhenius 1994, pp. 212, 214). The same trait seems to appear on the approximately contemporary pin of a belt buckle from Elsfleth (Mückenberger 2012). These examples concern

Figure 6. Migration Age bronze mold from Torslunda, Öland, Sweden, showing a so called 'weapon dancer' with a horned helmet. Photo by The National Historical Museum, Stockholm.

depictions of men, but a few items depicting women imply a focus on eyes and vision also in connection to female gender. So, for example, appears the condition of the eyes of the earlier mentioned Aska lady to be particular. Just as for the Lejre figurine, it seems as if the eyes had been exposed for wear or abrasion, creating an erased gaze (compare Figure 2 and 3). Another example, perhaps a bit more uncertain, can be seen at the earlier mentioned figurine from Tissø, depicting a woman who shows an unusual and expressive gesture, perhaps tearing her hair. In this case there is no removal of an eye, but rather the opposite, as one eye appears as being exaggerated, implying a focus on the ocular theme (compare Figure 4). Once again it must be said, that some of the cited examples may be uncertain; the diminutive size makes analyzes difficult, pictorial reproductions may be vague, and damages and weathering over time may weaken the evidence. Hopefully, future finds and observations may reinforce this still tentative picture.

If such variations connected to eyes and eyesight, which have been discussed here, had been articulated for our contemporary time, we might most likely have interpreted such bodily deviations as examples of disabilities or handicaps. But, as Lois Briggs (1997, p. 166) states in the discussion of 'changing models of disability' in the Old Norse and particularly in the Irish medieval literature: 'Disabilities […] are individually defined by the culture in question and it is our task, as unintended readers of archaic texts, to suspend our own cultural notions and to determine, in so far as possible, the view of the culture at hand'. People, who today expose limited and handicapping bodily abilities versus specific competences, might in another society, with the same bodily exceptionalities, have been placed high on the ability/disability order of power. A specific corporal particularity could have been included in the concept of body-normativity, even gaining the subject extraordinary and socially desired capacities (Briggs 1997, pp. 165–166, Arwill-Nordbladh 2012, pp. 35–38). So, reminds us Briggs, for example, that blindness in some cultures was singled out as donating a specific capacity to bards and minstrels, priests, prophets, or shamans.

Anette Lassen (2003), who has studied the ocular topic of the eye, the gaze, and blindness in the Old West Norse literature, demonstrates the significance of this theme. The properties of the eye sometimes played a central role in characterizing different figures in the Old Norse narratives. As Briggs, also Lassen (2003, pp. 53–56), points out the blind gaze as a signifier to wisdom and prophetic ability. In particular, this was valid for the Odin-character (Lassen 2003, pp. 84–106). Moreover, the eyes could reveal both the personality and the social belonging of a figure. The look of kings and heroes were sometimes looking daggers, cutting like an edge, making the gaze difficult, and frightening to face. With a sharpened eye, the hero sometimes was able to 'bind' or deaden swords and thus be victorious in battles. The sharp and frightening look was also connected to the god Thor (Lassen 2003, p. 106). An eye as biting as a snake's eye, showed the world that the person was designated for war (Lassen 2003, pp. 39–40).

Sometimes, the look could reveal the identity of a hero, even if the subject changed his shape. In this connection, Lassen mentions an episode from the saga of Didrik of Bern that can be linked to an eye that was manipulated. The hero, who was planning to carry out revenge, was recognized and stopped to fulfil his plans. He then went to see a person skilled in medical tasks who 'broke out his eye'. When the wound was healed, he could approach in disguise and pursue his revenge. Lassen concludes that 'just as the eyes can reveal ones identity, even if you change shape or come in disguise, may the ademption of an eye serve as a disguise in itself' (Lassen 2003, p. 26). In the Saga of Didrik, we can thus see a very concrete example of a processing and changing of the eye and look. Is this not what we see also on the figurines, even if the contexts, and maybe meanings, are different?

Thus we can realize that eyes, sight, and looks were an important theme within the Old Norse text corpus. A special area was the manipulated and restricted sight. That this restriction not necessarily implied restricted capacities is also clear. Rather, it could mean changed and maybe extended and exclusive abilities.

Even if the archaeological material is sparse, it shows in a very manifest way that the ocular theme was part of various performative practices during late Iron Age in Northern Europe. Its significance, in the form of an exaggerated presence of eyes and looks in connection with the mortuary sphere, has been explored by Howard Williams and colleagues (Williams 2011, Nugent and Williams 2012). Prophecy, access to hidden worlds like the afterlife, or calling for ancestral attention maybe some of the reasons for this emphasis. The small figurines, which are the focus for the present discussion, indicate that the theme of gaze and eyesight was processed also by demonstrating limited or varied visual abilities. Just as Lassen shows that the early medieval texts present a number of meanings and contexts associated with eyes, eyesight, and look, so imply variations connected to visual capacities in the, admittedly scant, late Iron Age iconographic material, a more complex understanding of the ocular theme.

The exaggerated emphasis of eye and look that Williams and Nugent can show – maybe articulated on the figurine from Tissø – the one-eyedness and the removed eye at the so called Odin-figures from Uppåkra, Lindby, and Ribe and the somewhat older images from Staraja Ladoga, Elsfleth, and Torslunda, and the abraded and worn eyes on the Aska lady and on 'Odin from Lejre' indicate different contexts and meanings in relation to the overarching visual theme. The variability in relation to gender, material, expression, and contextual setting, suggests that in some specific social arenas, it was acceptable and maybe even desirable to articulate a limited visual capacity. Such negotiations of bodily abilities and disabilities demonstrate that corporal capacities were open for social and cultural interpretations within an ability/disability hegemonic order.

Conclusion

With its ambiguous gender attribution and with the different articulations of the pair of eyes and their looks, the little figurine from Lejre demonstrates how norms and values related to both gender and body may have been negotiated. Within one and the same item, variations connected to both the hetero-normative and the body-normative hegemonic orders are expressed. This may indicate that at least in some instances in Scandinavian Viking Age, such matters were structured in a broader way than our present-day concepts approve of. So in addition to the new knowledge about past times' social relations, interactions between man and animal, and craft, the Lejre figurine can also serve as a proof of past times' variability in connection to what we today often see as self-evident hegemonic orders.

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RESEARCH ARTICLE

New chronological research of the late Bronze Age in Scandinavia

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The concept of time dominating in archaeological science differs widely from that of prehistoric cultures. Still, 'time' is one of the most important criteria for the reception of cultural and historical processes. Compartmentalising time creates artificial breaches, used as methodical means of breaking down the continuum. This article analyses the currently valid chronological concept for the late Nordic Bronze Age created by Evert Baudou with the objective of finding possible toeholds for further subdivisions. Baudou's generous conception of the time periods IV–V makes the realisation of chronological adjustments very difficult. Using Baudou's catalogue of Danish grave finds, the author tries to further subdivide these time-horizons with the help of a correspondence analysis. By making use of several intermediate steps, it is possible to discern two more temporal subdivisions within the devolution of periods IV–V. The existence of these four phases is supported by ^{14}C-dates.

Keywords: Bronze Age; grave finds; correspondence analysis; chronology

Understanding time

The term 'chronology' etymologically derives from the Greek expressions 'chrónos' meaning time and 'lógos' generally translated as 'the study of' – both to arrive at 'the study of time'. However, the term 'chronology' – as used in archaeological science – relates to the study of chronological developments, an order of events, as well as to the establishment of time sequences and/or dates. It seems evident that the contemporary archaeological concept of time differs widely from that of former times and that an archaeologically established chronological order cannot possibly apply to the idea of measured time.

Western civilisation is generally known for being dominated by a linear concept of time. This linearity, however, includes various successions of cyclic elements: days, months and years, which continually revolve. Historiography and the application of a successive order to these cyclic elements results in the establishment of a progressive timeline (Nowotny 1995, Olonetzky 1997), so 'time' as used in our Western civilisation is strongly connected to a progression of singular events. Past time is lost forever (Weis 1995).

On analysing time concepts used by different cultures, one often realises the commingling of varying time concepts that have been developed according to certain rules. The agronomically determined circle (also part of religious belief) may be followed by a linear succession of history accompanied by political and religious power. On the whole, it must be stated that many different aspects of time circulate: the striving to understand the concept of time having persevered in prehistoric cultures can therefore amount to nothing but mere speculation (Bogacki 1999, 40 f., Hölscher 1999). The most important criteria to be taken into account while trying to reconstruct prehistoric time reception are climate and geographical position of the cultures in question. The succession of two to four seasons accompanied by a change of vegetation, winter and summer solstice, as well as astronomical changes of stellar constellations highly depend on the geographic latitude. They are essentials to the determination of the starting point of sowing (Meller 2004, p. 27).

The fabric of time described in this article consists of interwoven cyclical and linear points of view and mirrors the quality of human life. Time may be measured individually or determined by other biological patterns. It is not a given that time necessarily depends on a solitary cyclical system. However, the perception of linear time is only possible by the observation of a succession of events deemed crucial to a society. Nowadays, time may be measured arbitrarily and subdivided down to the smallest fraction of a second. By making use of this time scale, we are able to fix events in a certain order, arranging our immediate past. As van Rossum states, *Zeit hat mit Wahrnehmung zu tun und daher mit Geschichte* [Time relates to perception and therefore to history] (Van Rossum 2003).

Understanding chronology

Archaeological science feeds on quite a different understanding of time than has been hereto ascertained for prehistoric cultures or modern society. The concept of

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time is the major means of every archaeologist for evaluating structures of historical development. Artificially subdividing time into successive compartments is a purely methodical but nevertheless essential tool. As has been surmised by Manfred Eggert in 2001, archaeological science tends to break down the prehistoric sphere into individual time periods, assembled in a linear order. The Stone Age is followed by the Bronze Age and the Iron Age, but – different from what has been pointed out with regard to the circular calendar of modern times, which is divided into months, days, hours and minutes – it is not possible to observe any regularity as to the length of the established periods. Chronological order should be perceived as a structure made of inhomogeneous-sized blocks (or even as a tower of building bricks) reigned by absolute contemporaneity (Eggert 2001, 149ff.).

The archaeological timeline derives from the typological comparison of finds and their assemblage in a closed find complex, the best example still being Montelius' model of time periods: a particular ornamentation style circulates, predominates over a certain period of time and is thereafter replaced by new, equally temporary styles. The succession of such patterns provides the chronological structure of Montelius' time phases. Every individual style undergoes a certain development, from its early occurrence, followed by a time of frequent occurrence and subsequently ending in a gradual receding of occurrence. This model applies to nearly every article of daily use in human society and thus resembles today´s fashion trends. Finding several such objects deposited together in different closed complexes enables the archaeologist to establish a linear time order, as is – in a sense – also the case for statistical methods such as a seriation analysis.

Martin Trachsel lately examined the issue of establishing time phases with the help of typology (2004, p. 14–22). Contradicting Montelius, Trachsel states an acute difference between the period of production and the period of usage of an object. According to his model, the early form of an object is found together with older artefacts. These have been collected over a longer period of time. Therefore, the 'early' form does not necessarily possess a chronological relevance. The so-called 'late' forms of a pattern or an object have been used longer than the actual production time lasted. Montelius' concept corresponds to the Gaussian distribution, whereas Trachsel's model results in a gradient of steep beginning and a rather flat ending (Figure 1).

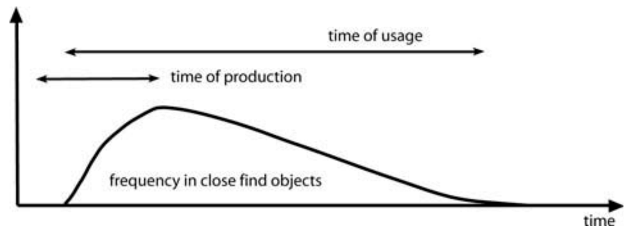

Figure 1. Diagram depicting the frequency of an artefact in relation to time (after Trachsel 2004).

The chronological analysis of grave finds holds further problems in store, as Trachsel's example of a mature individual found at Magdalenenberg (Central European Hallstatt epoch), Schwarzwald-Baar-Country (Figure 2), demonstrates: the production times of the different types of finds assembled in this grave varied considerably. The deceased acquired the burial objects at very different times throughout his life. The characteristic of this closed grave complex could therefore lead to the deceptive conclusion of a much longer lifespan than stands to reason. The aim of constituting time periods shorter than 50 years even carries the problem further if the individual lifespan has taken longer than 50 years.

As for the Nordic Bronze Age, Trachsel's assumptions only partly apply. First and foremost, the duration of the time periods IV–V each adds up to over 100 years and

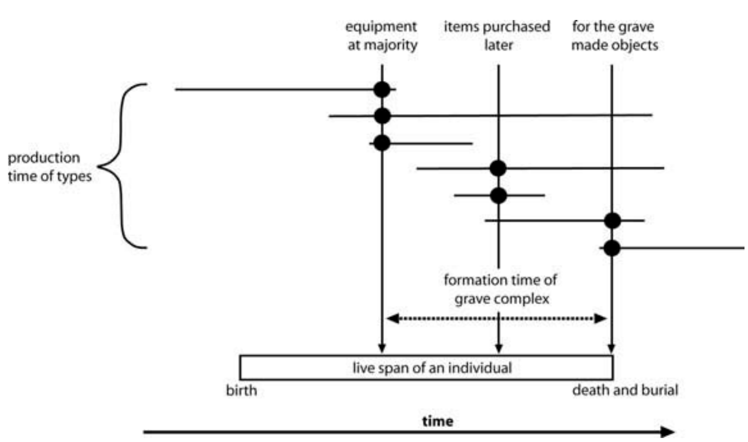

Figure 2. Diagram depicting the relation between the production time of different types of artefacts and the accumulation process of the grave inventory (after Trachsel 2004).

therefore outlast the usual lifetime of human individuals. Furthermore, Trachsel had the advantage of building his chronological tuning on richly provisioned burials common for the Early Iron Age of the South of Germany. Apart from grave finds, Trachsel's approach is barely applicable. Accumulative depositions of settlement debris in a pit are much more difficult to scrutinise than a limited number of finds within a grave. As for the dating of single finds, to determine a precise date within a given time range remains impossible. Therefore, the analogy of a tower of building bricks prevails as the best model for understanding chronological structures based on the assembly of objects along a given timeline. Within one time interval, the objects are absolutely contemporaneous.

Evert Baudou's chronology

Let us now turn to the practical example of the grave finds from the Nordic Late Bronze Age. The chronological framework of Evert Baudou is essential for research into the Late Bronze Age. The succession of types of artefacts established by Baudou with the help of closed find complexes remains valid to this day (Baudou 1960). A further subdivision of the chronological order of finds within the Period IV–V, however, has been fruitless – with the exception of only a few types (Baudou 1960, p. 112). In order to examine material for my doctoral thesis on the stratification of urns displaying anthropomorphic features throughout Northern and Central Europe (Kneisel 2012), the necessity for taking a closer look at these crucial phases arose: only on the basis of a finer chronology was it possible to make supra-regional comparisons. The methodical means of a correspondence analysis (CA) seemed more promising than a seriation, because it is based on the progressive order of groups of artefacts. This order comes closer to a real timeline than our archaeological time periods.

The following analyses presented in this article are based on Baudou's *'Die regionale und chronologische Einteilung der jüngeren Bronzezeit im Nordischen Kreis'* published in 1960. Baudou created a gradation of phases, which he – referring to Montelius – termed Period IV–VI. His results were based on the closed find complexes encompassing the region from Schleswig-Holstein up to Norway. A catalogue has supplemented his work. Baudou took both grave and hoard finds into account, but the analyses presented in this article relate solely to the burial finds. Hoards provide ample ground for discussions about their nature and the chance of determining the correct time of their deposition. Furthermore, this article excludes the finds north of Denmark in order to eliminate the occurrence of regional varieties as far as possible. At first, the data was based on the analysis of 436 graves from periods IV–VI in Denmark and Schleswig-Holstein. The types defined by Baudou are divided into artefact classes like razors, tweezers, pins, buttons, fibula, bracelets and pendants. There are more classes like celts or sickle, which do not appear in graves, but only in hoards. Some artefacts occur very rarely like the swords or knives. Only if the types exist in more than one grave and the grave contains more than one artefact are they included into the analysis. The main artefacts that occur in the following graphs are shown in Figure 3. All the type names used are similar to Baudou's typology (Baudou 1960, tables 1–18). The computing of the data was carried out using the statistical software application WinBASP (Bonn). The established dates for each grave, as have been stated by Baudou, are noted to facilitate a quick overview of the whole material.

First correspondence analyses

Running the first CA resulted in isolating the Period VI finds from the rest of the material (Figure 4). The find complex of Bordesholm, Schleswig-Holstein, (Baudou 1960, Kat. No 13) consisting of a disc-headed pin with straight shaft (TYP XXVB2b), is located between the per. IV–V finds orientated along the Y-axis and the per. VI graves relating to the X-axis. Pins representing this type are usually dated to per. V, but are also known from the occurrence in the per. VI find complex of Vesterby, Fuglsebølle sogn, Langeland herred (Baudou 1960, Kat. No 192). Except for this pin type, no connections between the types of Period IV–V on the one side and Period VI types on the other side occur, which means that in Period VI we deal with a completely new spectrum of types. A chronological progression in this CA is therefore very unlikely and the result of the analysis therefore lacks relevance. In taking this into consideration, the per. VI finds were excluded from further investigation, so that only the per. IV–V finds remained.

Second correspondence analyses

The analyses of the per. IV–V finds did not show any significant chronology (Figure 5).[1] A sequence of per. IV (black) and per. V (grey) can be made out along the second axis, but the burial objects of per. IV spread over a wide range along the X-axis. This scattering pattern can be pinned to several factors, as another figure featuring the same analysis and displaying the different artefact types should help to discern (Figure 6). The distribution of artefact types is marked by the different categories of finds such as razors, tweezers, bracelets, pins and buttons.

(1) The pins (TYP XXXVB1, H2, G1, G2) are fixed in the double positive area, far away from the main finds cluster.

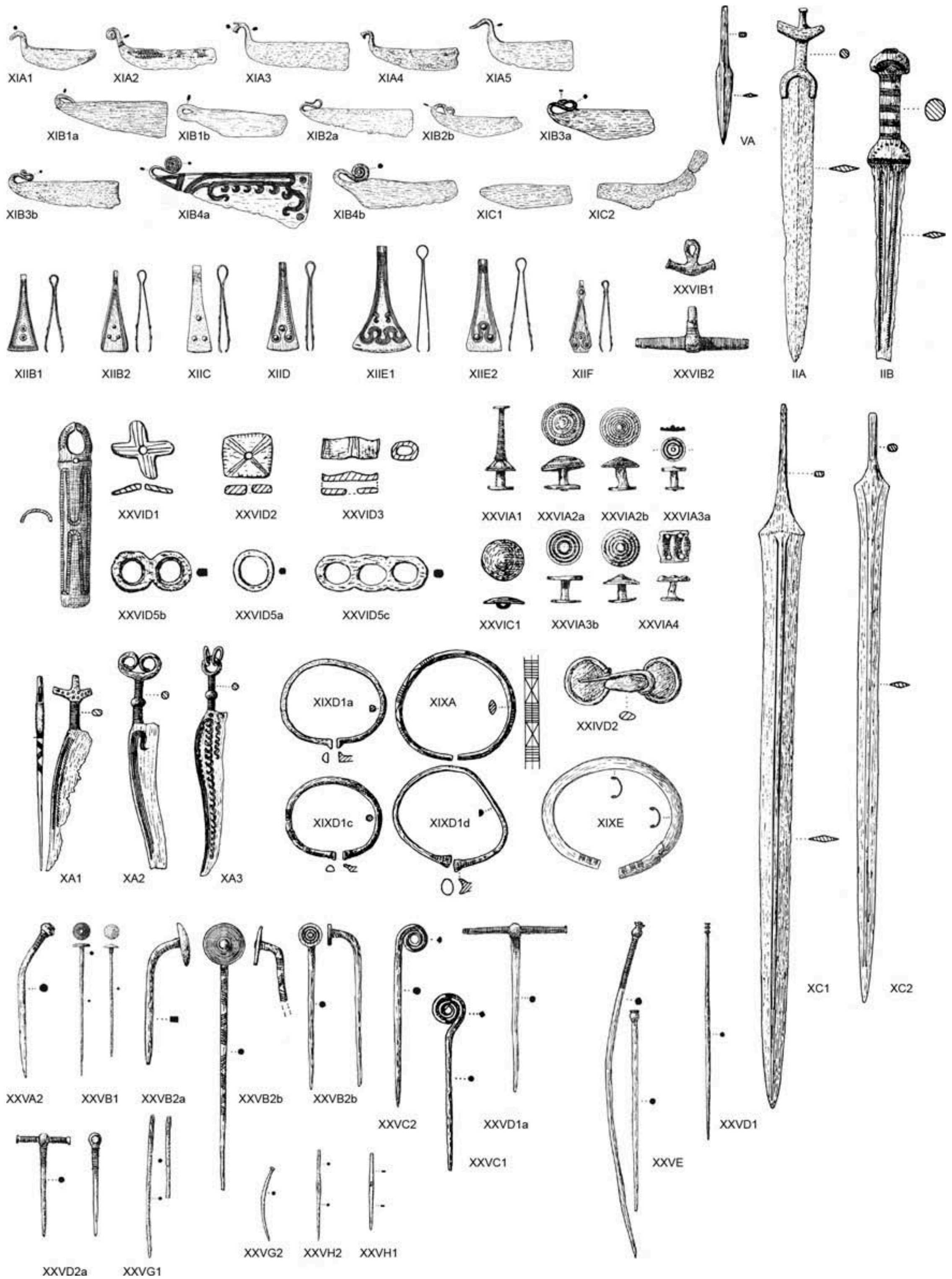

Figure 3. The types of Evert Baudou according the CA in this article Copyright Kneisel 2012. This image is based on Baudou's original tables (Baudou 1960, tables 1–18).

(2) In the lower right quadrant, the types of buttons are located (TYP XXVIC2, D1–D5), as well as the pendant belonging to type XXVII.

(3) The lower left quadrant is occupied solely by buttons belonging to type XXVI A1, A2a, A3–4.

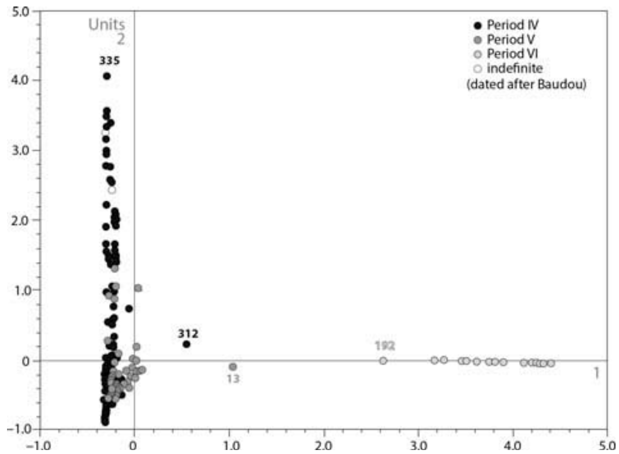

Figure 4. CA of closed grave complexes featuring Baudou's per. IV–VI finds (Baudou 1960). 1st in relation to 2nd eigenvector (Inertia 2.9 /2.7). The numbers refer to Baudou's catalogue.

The different types of buttons seem – with the exception of the button with a loop (TYP XXVIB) – to stay within the negative area of the Y-axis. The analysis of this group reveals that the buttons made of bone cluster on the right side of the diagram, whereas the metal buttons are located on the left. On re-focussing upon the groups of pins mentioned above, which are scattered around X 1.6–2.0 and Y 0–1.0, the noticeable dominance of bone types (three out of four) catches the eye. Therefore, it is more than probable that the X-axis may be interpreted as the division between the materials of bone and metal. However, this division does not necessarily result from chronological matters. Social and regional differences may also be the reason for this remarkable result. To ensure a chronological relevance of the material, social and regional differences have to be ruled out first.

To be able to determine the possible impact of social differences on the result of the analysis, the various combinations of grave goods have to be examined. The graph (Figure 7) displays burial inventories divided into those including buttons and pins made of bone and those containing only metallic objects. The specimens made of bronze (light grey) are listed at a percentage rate based on the total number of graves containing metallic objects. Showing a rate of 62%, razors are by far the most common burial good.[2] Forty graves contain bone pins (grey), which are frequently found together with bracelets, tweezers, buttons, pins, and of those the most frequent combination is with the disc-headed pin type XXVB1 (occurring 26 times). Twenty-four graves held bone buttons (black), which could be found combined with pins, buttons and – less frequently – with tweezers and razors. The most frequent combination of bone artefacts was together with other bone buttons or – as has been the case 11 times – with bone pendants.

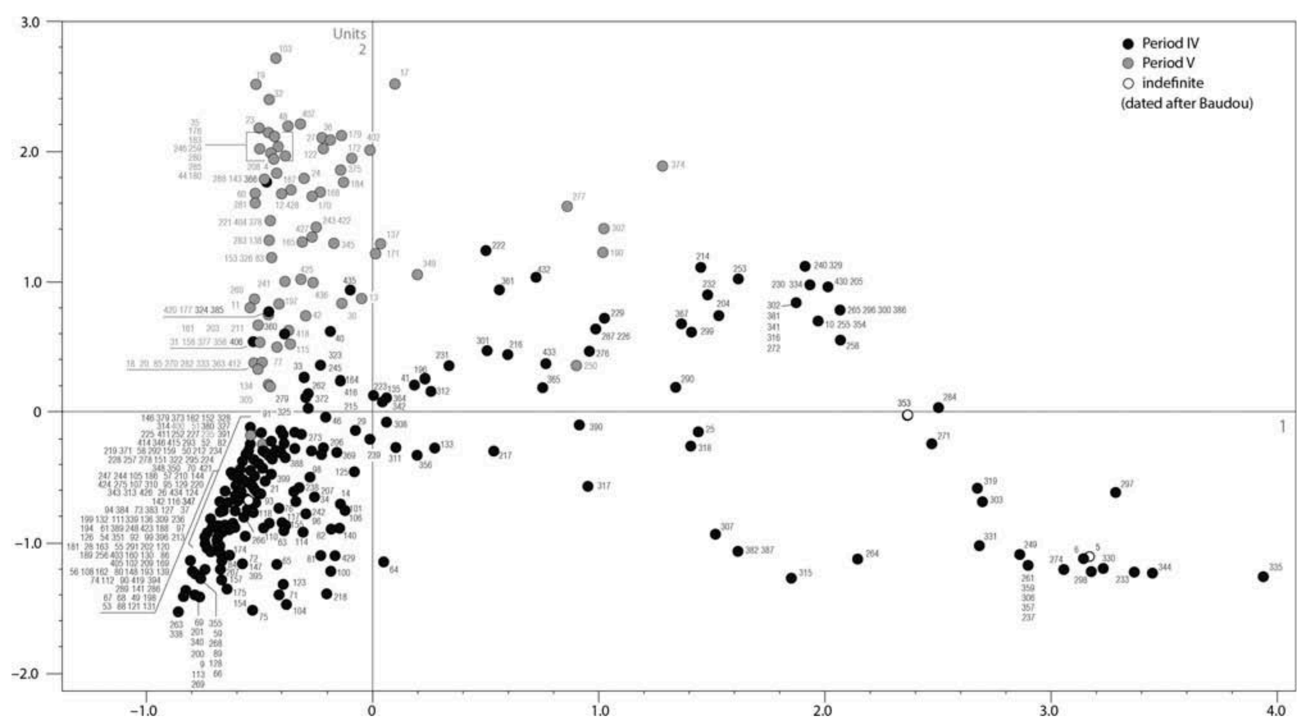

Figure 5. CA of closed grave complexes featuring Baudou's per. IV–V finds (Baudou 1960). 1st in relation to 2nd eigenvector (Inertia 3.0 /2.9). The numbers refer to Baudou's catalogue.

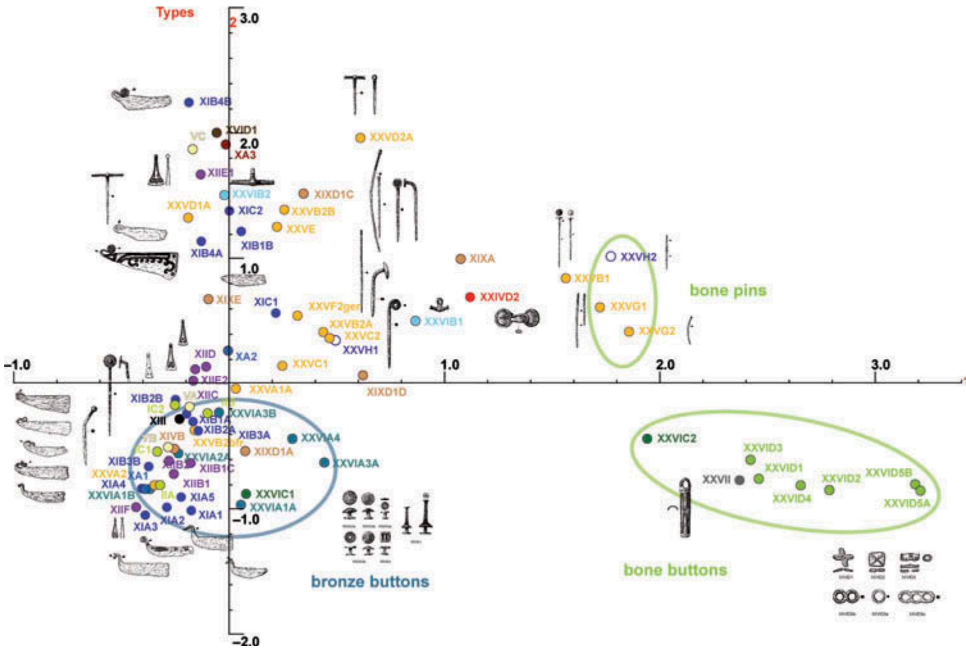

Figure 6. CA of closed grave complexes featuring Baudou's per. IV–V finds (Baudou 1960). 1st in relation to 2nd eigenvector (Inertia 3.0 /2.9). The colours mark the different types of artefacts.

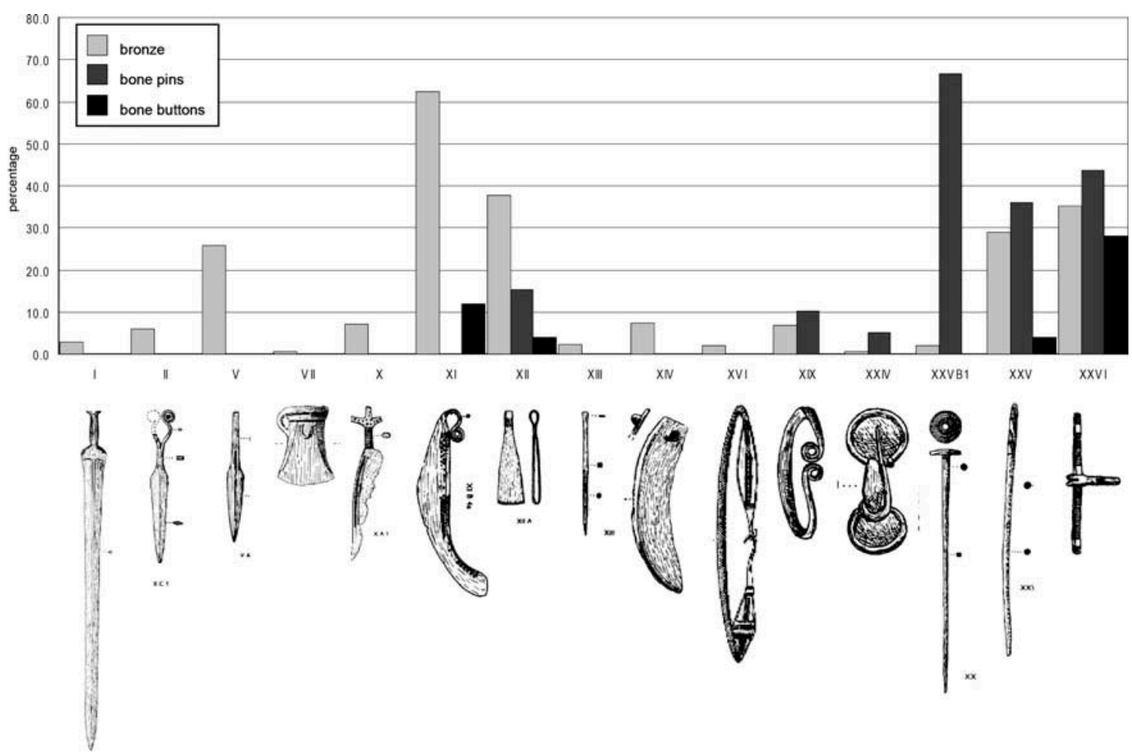

Figure 7. Quantitative distribution of the combination of bronze artefacts, bone pins and bone buttons with regard to the artefact types.

Jewellery seems to be lacking in graves displaying weaponry, a fact that seems to advance an explanation of social division, separating burials with jewellery from those containing weapons. At the same time, a clearly regional explanation seems to leave its mark on the results of the CA. One of Baudou's maps (Baudou 1960, map 51)

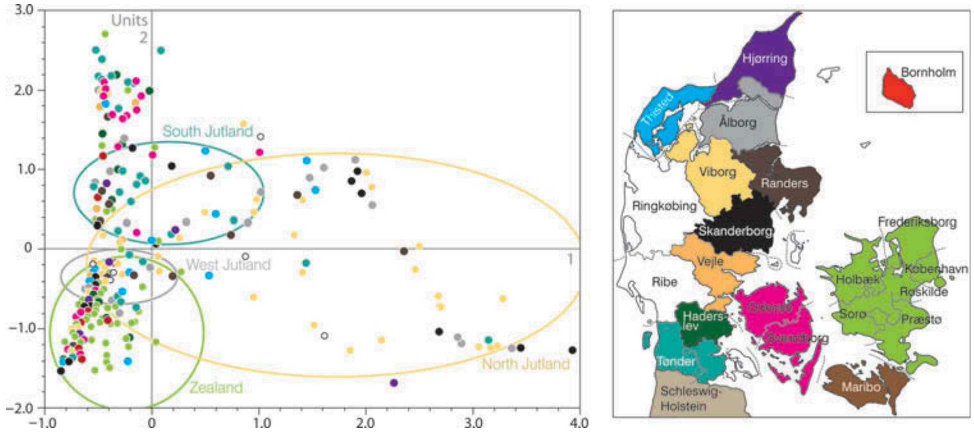

Figure 8. CA of closed grave complexes featuring Baudou's per. IV–VI finds (Baudou 1960). 1st in relation to 2nd eigenvector (Inertia 3.0 /2.9). Colours mark different (now defunct) Danish administration districts (*Amt*).

displays a striking accumulation of bone artefacts in Northern Jutland. In analysing the outcome of the statistical calculation, it is evident that both a social and a regional difference have to be considered.

In order to highlight the regional component, the finds were classified according to existing parish borders and marked by different colours as shown in Figure 8. Four more or less definite locations could be discerned. The buttons made of bone evidently separate the Northern Jutland-Group (right side). The agglomeration of the Zealand-group (bottom left) coincides with the main distribution of bronze buttons called type XXVIA (Baudou, maps 47–48).

On the whole, the following statements sum up the second analysis:

Material difference
- Bone and metal are divided by the X-axis.

Social difference
- The bone artefacts only appear in burials without weapons, thereby enhancing the separating effect of the X-axis.

Regional difference
- Bronze and bone buttons do not share the same areas of distribution. Zealand and Jutland are fairly separable along the X-axis. Several clusters of local groups mark the Y-axis.

The analysis implies an obvious difference between bone and bronze artefacts, defined by material, social, as well as regional aspects. These factors are closely related and emphasise the complexity of the find material.

Third correspondence analyses

It was not possible to state a chronological proposition based on the results of the second analysis. A third calculation was adjusted in order to eliminate the aforementioned aspects and thus had to exclude the buttons (TYP XXVIA, C, D), the bone pendants (TYP XXVII), as well as the bone pins (TYP XXVG1–1, H2). Consequently, the data was reduced to a number of 283 burials. The result displayed in Figure 9 shows an alignment of the finds along the X-axis. The negative range of X is occupied by the graves dated to per. V according to Baudou. The positive range holds the per. IV graves. Furthermore, the grave entities are scattered stray along the Y-axis. Focussing on the combination of the different types of finds (Figure 10), it is once again possible to distinguish between various groupings. One – located in the lower area of the graph – consists of a dominant association of razors and tweezers with pins. A grouping of pins with bracelets can be made out above the X-axis. The upper group mainly contains various types of pins. The second eigenvector (component) seems to correspond with the various patterns of burial equipment. A chronological relevance may be already assumed for the first eigenvector, but only the application of the fourth eigenvector helps to really clarify this quality, due to the inertia-values of the components. The inertia shows little distance variance; wider spacing can only be perceived between the second and third component. Further components only vary on a scale of one decimal place (inertia first axis 3.6; second axis 3.4; third axis 3.0; fourth axis 2.9; fifth to sixth axis 2.8). Therefore, the fourth eigenvector had to be introduced; resulting in a much clearer correspondence map with a nearly parabolic graph (Figure 11(a)). The different types of finds spread along the X-axis. The figure shows the distribution of razors along the two eigenvectors (Figure 11(b)). The early forms represented by types XIA3 and XIB3b dominate the bi-positive quadrant at the end of the curve, whereas the later per. V razors occupy the left-hand area of the graph. The distribution of tweezers or pins displays similar chronological successions.

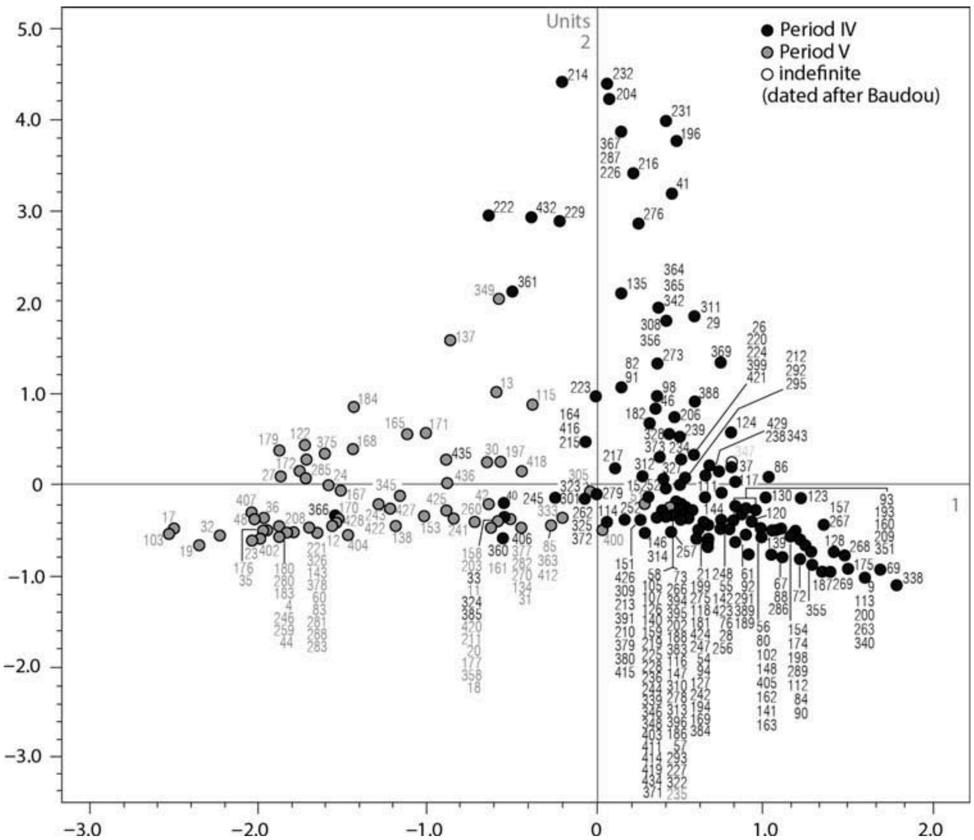

Figure 9. CA of closed grave complexes featuring Baudou's per. IV–V finds (Baudou 1960) excluding bone artefacts and the cluster of bronze buttons from Figure 6. 1st in relation to 2nd eigenvector (Inertia 3.6 /3.4). The numbers refer to Baudou's catalogue.

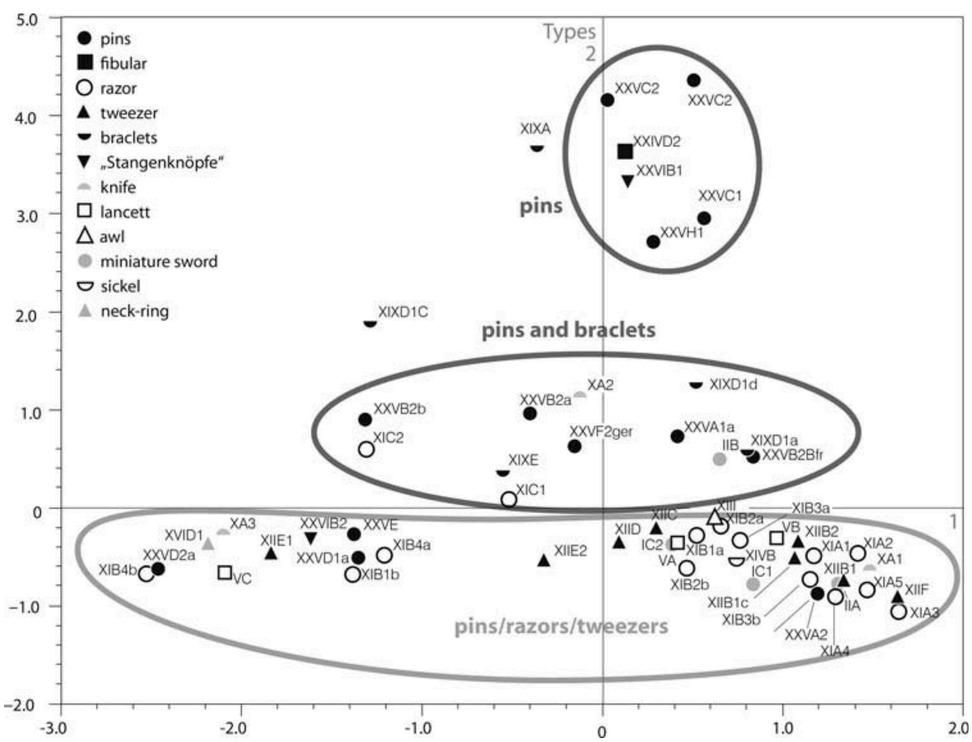

Figure 10. CA of closed grave complexes featuring Baudou's per. IV–V finds (Baudou 1960) excluding bone artefacts and the cluster of bronze buttons from Figure 6. 1st in relation to 2nd eigenvector (Inertia 3.6 /3.4). Colours mark the different types of artefacts.

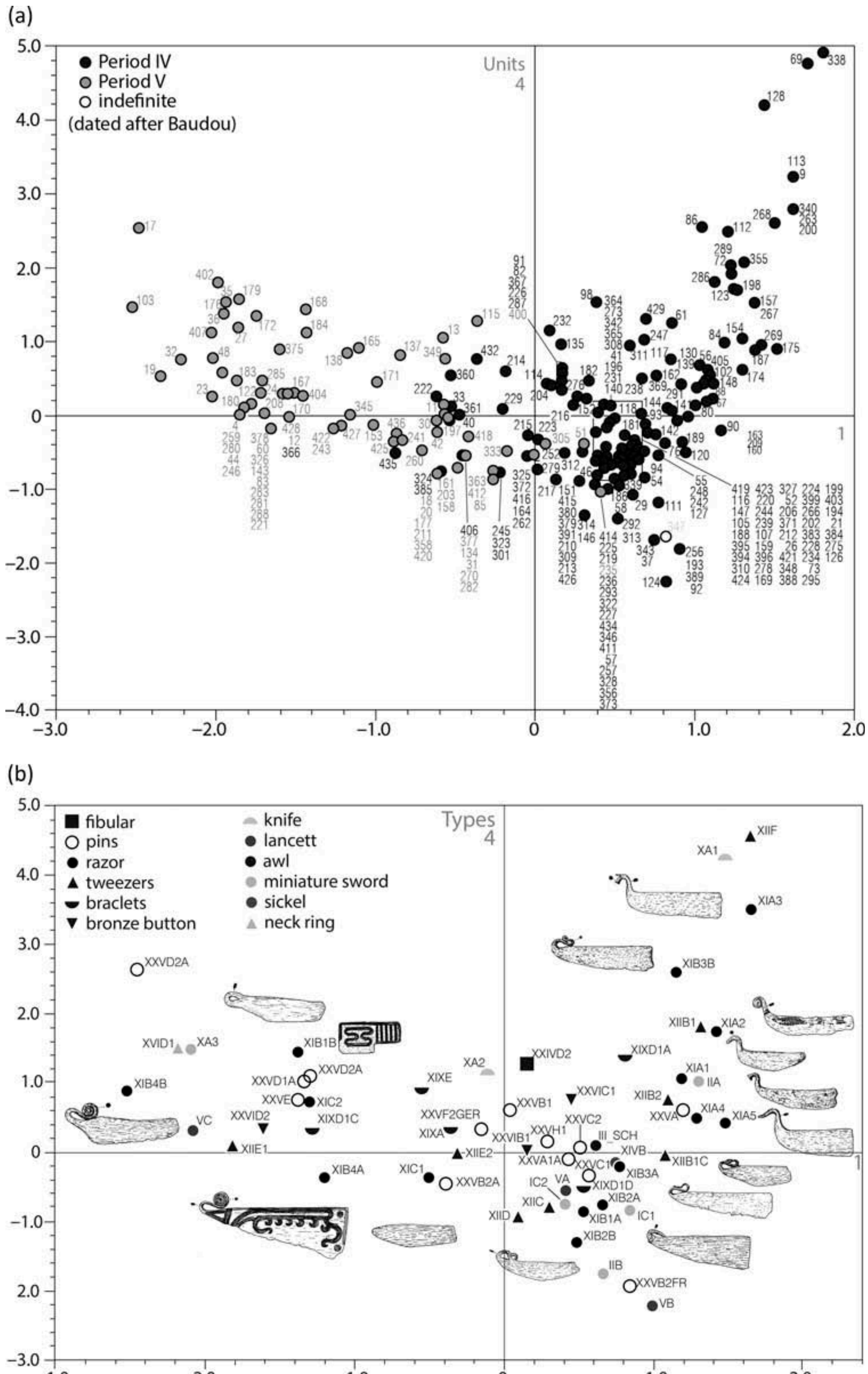

Figure 11. (a) CA of closed grave complexes featuring Baudou's per. IV–V finds (Baudou 1960) excluding bone artefacts and the cluster of bronze buttons from Figure 6. 1st in relation to 4th eigenvector (Inertia 3.6/2.9). The numbers refer to Baudou's catalogue. (b) CA of closed grave complexes featuring Baudou's per. IV–V finds (Baudou 1960) excluding bone artefacts and the cluster of bronze buttons from Figure 6. The distribution of different razors shows the chronological relevance of the parabola. 1st in relation to 4th eigenvector (Inertia 3.6/2.9). Symbols mark the different types of artefacts.

Furthermore, the application of the regional component did not result in an agglomeration along the axes. But still, the chronology had to be verified by independent dates.

Independent dating (^{14}C)

Several ^{14}C-dates are available located in the Scandinavian area of late Bronze Age. However, to ensure the highest possible comparability, only finds containing similar types to those presented and examined by Baudou may be taken into account. Unfortunately, some of the dates belong to Swedish finds, which have not formed part of the analysis. A new one is connected with the house urn from Fardume, Gotland (Sabatini 2007, p. 233). The data also includes the radiocarbon dates published by Vandkilde (Kneisel 2012, p. 56, table 2, Kneisel *et al*. 2013).[3] In addition, a few new dates have been applied: Nørre Dalgaard Syd (*AUD* 1999, p. 312); Rom (*AUD* 2001, p. 291); Lustrupholm (*AUD* 2000, p. 327, *AUD* 1998, p. 299) and Virkelyst (*AUD* 2001, p. 290). Recently published new dates by Hornstrup *et al.* (2012) are also taken into account. They are related to cremated bones and are well-published (see also Olsen *et al.* 2011, p. 265, table 1). Of all known ^{14}C-dates, 25 are applicable to the types of Baudou introduced in the CA (Figure 12 and Table 1). For calibration OxCal 4.2 with IntCal 09 was used (Ramsey 2009).

Context of the ^{14}*C-Dates*

The recently published graves with new ^{14}C-Dates are only briefly mentioned. For a more detailed description, see Hornstrup *et al.* (2012).

Grave of Bjergby, Jutland
See Hornstrup *et al.* (2012, p. 36, figure 25). The grave contains amongst others a button of Baudou's TYP XXVIB1.

Grave J of Gl. Brydegård, Odense
See Hornstrup *et al.* (2012, p. 37, figure 27). The grave contains several grave goods that can be compared with Baudou's TYP XIIE1 (tweezers), TYP XIB4A (razor), TYP XXVIB2 (button), TYP XXVB2b (pin) and TYP VC (lancet) and an iron awl (TYP XIII). Two ^{14}C-dates are taken, which have an R_combine date of 895–824 cal BC in 1-σ range.[4]

Grave B of Fardume, Gotland
The house urn contains a bronze double button, bronze tweezers with ornament lines and three knobs (TYP XIID) and a fragment of a razor, probably TYP XI B or C. The tweezers as well as the razor belong to per. IV or transition to per. V. The ^{14}C-date (St-8854 2525 ± 150 BP 804–431 cal BC) allows us – because of the Hallstatt plateau – only to date the burial into a wide time range from the eighth to the fifth century BC.

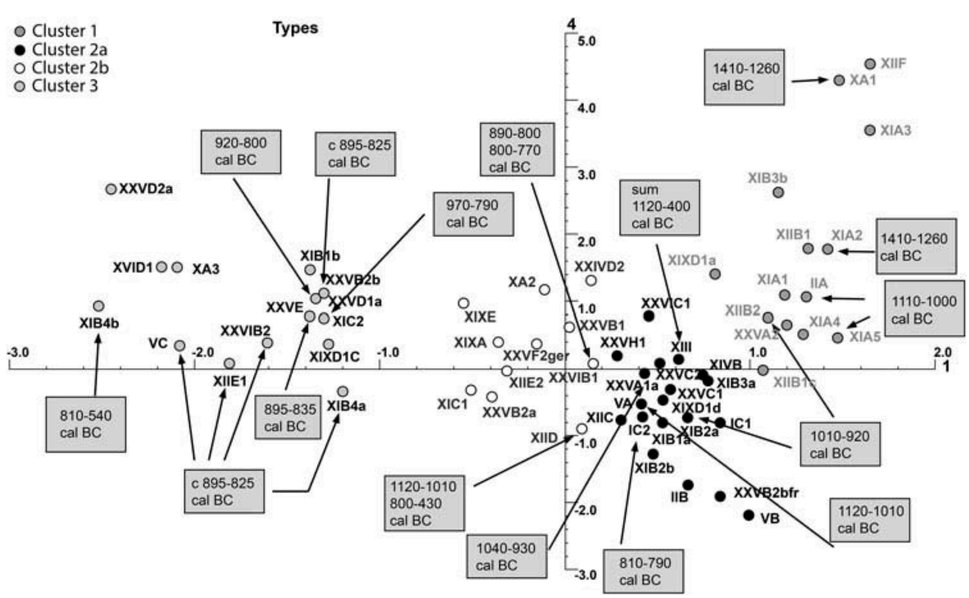

Figure 12. CA of closed grave complexes featuring Baudou's per. IV–V finds (Baudou 1960) excluding bone artefacts the cluster of bronze buttons from Figure 6 with correlation of the radiocarbon dates. First in relation to fourth eigenvector (Inertia 3.6/2.9). Grey-shading indicates the different clusters mentioned in the text.

Table 1. An overview of the dated graves and containing types. Bold, in CA; cursive awls, Type XIII.

Lab	Lab Nr.	Uncal.	Std.	68.2 BC	95.4 BC	Site	Type
AAR	9518	2583	34	-805-769	-820-559	Bjergby	**TYP XXVIB1**, *TYP XIII*
St	8854	2525	150	-804-431	-1005-233	Fardume	**TYP XIID**
AAR	9570	2706	35	-895-818	-914-805	Gl. Brydegård	**TYP XIIE1, TYP XIB4A, TYP XXVIB2, TYP XXVB2b, TYP VC,** *TYP XIII*
AAR	9576	2714	34	-896-827	-922-807	Gl. Brydegård	**TYP XIIE1, TYP XIB4A, TYP XXVIB2, TYP XXVB2b, TYP VC,** *TYP XIII*
AAR	9515	2837	39	-1044-930	-1116-904	Jattrup	**TYP XXVA1a**, *TYP XIII*
AAR	9520	2683	36	-892-805	-902-801	Jersild	**like TYP XXVIB1**, *TYP XIII*
K	3538	2690	80	-924-796	-1055-571	Lusehøj	**TYP IC2**
K	3539	2610	75	-894-567	-930-509	Lusehøj	**TYP IC2**
AAR	9575	2611	33	-813-787	-836-764	Lusehøj	**TYP IC2**
AAR	4620	2380	45	-517-397	-748-380	Nørre Dalgaard Syd	*TYP XIII*
AAR	9574	2867	33	-1111-998	-1187-927	Nyhøj	**TYP IIA, TYP XIA5**
Lu	444	3070	60	-1411-1263	-1491-1130	Nymölla	TYP IB, **TYP XA1, TYP XIA2**, TYP XXVIA1, TYP XXVIA2a
AAR	8786	2722	25	-895-835	-912-816	Øster Herup	**TYP XXVE,** TYP XXVH2
AAR	4681	2815	40	-1011-916	-1107-848	Rom (D1)	*TYP XIII*
AAR	8110	2805	45	-1012-903	-1085-837	Rom (D1)	*TYP XIII*
AAR	4682	2790	45	-1006-896	-1050-831	Rom (D2)	*TYP XIII*
AAR	8111	2882	47	-1127-981	-1209-929	Rom (D2)	*TYP XIII*
AAR	9524	2886	34	-1116-1011	-1196-941	Rom (D3)	**TYP VA, TYP XXVIA3b, TYP XIID**, *TYP XIII*
U	49	2650	80	-921-767	-1008-542	Simris (43)	*TYP XIII*
U	144	2690	80	-924-796	-1055-571	Simris (71)	**TYP XXVD1a** used as pin, TYP XIII
U	145	2560	90	-812-542	-892-410	Simris (79)	**TYP XIB4b**, *TYP XIII*
U	84	2690	90	-973-792	-1110-552	Simris (94)	**TYP XIC2**
AAR	9514	2805	43	-1009-906	-1075-837	Sundby	**TYP XIB2a, TYP XIIB2**
AAR	6097	2815	40	-1011-916	-1107-848	Virkelyst	*TYP XIII*
AAR	8112	2829	39	-1028-922	-1113-900	Virkelyst	*TYP XIII*

Grave Jattrup, Jutland
See Hornstrup *et al.* (2012, p. 33, figure 18). The grave contains several grave goods, such as a razor, tweezers (like TYP XIIB1 without any ornamentation), awl (TYP XIII) and some amber. But only the pin can sorted to Baudou's TYP XXVA1a.

Grave 5 of Jersild, Jutland
See Hornstrup *et al.* (2012, p. 36, figure 26). The grave contains, beside an awl (TYP XIII) and some bronze fragments, a button that M. Hornstrup compares with so-called 'Ringknebel'. This button looks very similar to Baudou's TYP XXVIB1, only a bit bigger in size.

Grave GX of Lusehøj, Funen
Several fragments of a sword blade, identified as Baudou's TYP I C2 by Thrane (Thrane 1984, p. 142) support this analysis. The charcoal samples from the pit fill from the central burial GX (K-3538 2690 ± 80 BP 926–794 cal BC; K-3539 2610 ± 75 BP 894–569 cal BC) indicate a 1-σ (R_combine) date of 893–790 BC (Thrane 1984, p. 78). A new date for the bones exists (Hornstrup *et al.* 2012, p. 37), which shows that the pit fill and inhumation are correlated (AAR-9575 2611 ± 33). Since for dating of charcoal old wood effects have to be taken into account, the date of the bones is the crucial date for the grave (813–787 cal BC).

Grave N29 of Nørre Dalgaard Syd, Jutland
The grave was set over a ritual place (AUD 1999, p. 312). This grave contains only an awl (TYP XIII) and a fragment of amber. The date of the charcoal is quite young but shows that the awls are used over a wide timespan. The date AAR-4620 2380 ± 45 belongs to the end of the sixth until fifth century (517–397 cal BC).

Grave Nyhøj, Funen
See Hornstrup *et al.* (2012, p. 33, figure 20). On top of the cremated bones were found, among others, a miniature sword (TYP IIA) and a razor (TYP XIA5).
Grave No. 4 of Nymölla, Scania
Beneath a packing of stone, an oak log coffin wrapped in birch bark emerged, holding the burnt remains of a mature individual. A sword with a hilt featuring little horns – *Hörnerknaufschwert* (TYP IB), a knife (TYP XA1) and a razor (TYP XIA2), as well as three double buttons (TYP XXVIA1, A2a) made of bronze could be retrieved beneath the burial (Petré 1961, 44ff.). The *Hörnerknaufschwert* and razors with a spiral handle clearly indicate per. IV,

whereas knives and double buttons derive from older per. III types. To assign the inventory of the burial to the beginning of per. IV seems more than plausible. The radiocarbon date (Lu 444 3070 ± 60 BP) points to 1412–1263 cal BC at 1-σ range.

Grave Øster Herup, Jutland
See Hornstrup *et al.* (2012, p. 36, figure 23). The grave contains some grave goods, but only a bronze pin (TYP XXVE) and one bone pin (TYP XXVH2) were of typological interest.

Grave D1–3 of Rom, Jutland
Three urns from the same barrow (D1–3) were found in the eastern part of the barrow.
Grave D1 was the larger one and held an awl (TYP XIII) and tweezers without ornamentation. The tweezers are chronologically irrelevant and are common in all periods (Baudou 1960, p. 40). The pitch (AAR-4682 2815 ± 40) and the bones (AAR-8111 2805 ± 45) gave a combined date of 1000–926 cal BC.

Grave D2
The smaller (D2) contained only an awl TYP XIII (Broholm 1946, Nr. 906–7). The lid seal – pitch – provided the sample AAR-4681 2790 ± 45 BP. With the dated bones (AAR-8110 2882 ± 47) the combined date for this cremation is 1025–929 cal BC.

Grave D3
The urn grave lay on the northeastern side of the barrow and was richly equipped with a razor of unknown type, tweezers (TYP XIID), a lancet (TYP VA), an awl (TYP XIII) and buttons (TYP XXVIA3b). The date AAR-9525 2886 ± 34 shows a little older date than the other two urn graves: 1116–1011 cal BC.

Grave Complex 43 of Simris, Scania
Other ^{14}C-dates could be retrieved from the cemetery of Simris (Olson 1961, p. 154–156). One charcoal sample was taken from a circle of stones encompassing four urns. The layer of charcoal covered the badly broken urns D and E and formed part of the surface layer for the urns A and B. Berta Stjernquist argued that the charcoal may have been laid down together with the burial of the vessels A-B (Stjernquist 1961, 14 ff.). Vessel A held an awl (TYP XIII), vessel D a razor with a spiral handle bent backwards (TYP XIB4b), grave E contained a double button and grave C an awl (TYP XIII) and one more bronze button. The ^{14}C-date reading U-49 2650 ± 80 BP (921–767 cal BC) therefore counts as *terminus ante quem* for the razor, putting it before the eighth century BC.

Grave 71 of Simris, Scania
One urn contained an awl (TYP XIII) and furthermore a rod-headed button with a retrieved ending, which had formerly been a pin of similar form. The pin relates to Baudou's TYP XXVD1a. The secondary usage may have led to a prolonged circulation. The ^{14}C-date (U-144 2690 ± 80 BP 924–796 cal BC) therefore only accounts for a *terminus ante quem*.

Grave 79 of Simris, Scania
This grave is a double burial, consisting of one urn inside and another one outside a stone cist (Stjernquist 1961). The latter (grave 79a) provided the ^{14}C-date (U-145 2560 ± 90 BP 812–542 cal BC). The inventory consists of an awl (TYP XIII), the tip of a knife, and once again a razor with a spiral handle bent backwards and a broad, trapezoid blade (TYP XIB4b).

Grave 94 of Simris, Scania
The vessel constituting the grave contained one more razor. It might belong to the form displaying a rectangular blade and hilt (TYP XIC2) which is usually ornamented. However, it could just as well belong to the Tackenberg-type common for the Elbe-Weser-area (Tackenberg 1961/63, p. 10, map 9, list 12). They belong to per. V. With the aid of the ^{14}C-date (U-84 2690 ± 90 BP 973–792 cal BC) the grave can be dated to the tenth century until the beginning of the eighth century BC.

Grave N1 of Virkelyst, Jutland
See Hornstrup *et al.* (2012, p. 35). The grave contains only an awl (TYP XIII) and a bronze spiral. Two dates – one of the pitch (AAR-6097 2815 ± 40 BP) and the other of the cremated bones (AAR-8112 2822 ± 39 BP) – were taken. The combined date is quite early and sets the urn in the tenth century (1005–930 cal BC).

The chronology of the curve

The radiocarbon dates were matched to the types computed in the CA (Figure 12). For graves with several dates, the combined date was used; this was the case for the graves of Gl. Brydegård, Rom and Virkelyst. For the grave GX of Lusehøj, only the bone date was taken into account. The slightly older charcoal dates might be affected by the old wood effect. If several dates were available, a sum calibration was used, which described quite well the time-span the artefact type might be in use. For example, for the awls 16 dates were available (Table 1, Figure 13),[5] which were nevertheless part of the database but set to 0 value in the correspondence analysis weighting. The ^{14}C-dates display a linear temporal course along the parabolic pattern, so that a chronological interpretation is probable.

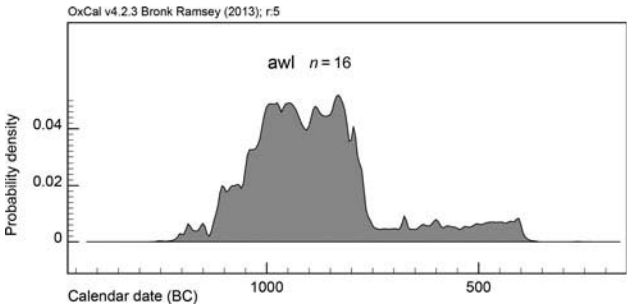

Figure 13. Sum calibration of awls. Older dates than Per. IV are also available for awls (see Hornstrup *et al.* 2012), but were not used for this graph.

After having applied the corresponding radiocarbon dates, three main clusters can be made out within the matrix of the CA (Figure 12).

1st Cluster (grey)

The date of Nymölla is located on the right-hand side in the upper quadrant, so this section is dated fifteenth to thirteenth century BC. The date seems uncommonly early, but since the sample originated from the birch bark deposited in the grave, this early date can hardly be pinned to the suggestion of secondary usage of older wood. This date of Nymölla must be viewed with some caution. Two other dates are available. The date from Kattebjerg, Skovby sogn, Odense amt, dated eleventh to tenth century. A third date from Stagstrup sogn, Thisted amt, seem a little bit too young and in fact it is connected with a Type of the second cluster (XIB2a). If the youngest type dates the grave, then this Type XIB2a is an older piece in the grave and could not be taken into account.

2nd Cluster (black and white)

The second cluster spreads around the centroid of the two axes and is quite well represented by ^{14}C-dates.

A razor from Sundby, Thisted amt of Type XIB2a represents the first part on the positive X-axis followed by a pin of Type XXVA1a from Jattrup, Ringkøbing amt, dating to the tenth to ninth century. The sword (Type IC2) comes from the burial of Lysehøj, which belongs to the end of ninth to beginning of eighth century. Another date exists for a lancet Type VA from Rom sogn, Ringkøbing amt, suggesting a date between the end of twelfth and end of tenth century. The many awls obviously belonging to this cluster cannot be taken into account, because they have remained largely unchanged over a long period of time (see Figure 13). For the second part on the negative side of the X-axis, four dates exist. A pair of tweezers of type XIID is known from two dated graves (Fardume, Gotland; Rom, Ringkøbing amt). The date of Rom is quite early and seems to belong more to the previous phase. The other dates are connected with a metal button type XXVIB1 from Bjergby, Thisted amt and from Jersild, Ringkøbing amt. The dates give a range for this subphase from the Beginning of the ninth to the eighth century.

3rd Cluster (light grey)

The left-hand side of the analysis shows several dates. Most of them came from a rich grave in Gl. Brydegård, Odense amt, containing type XIIE1, type XIB4a, type XXVIB2, type XXVB2b, type VC and type XIII. The two dates have an R_combine date of 895–825 cal BC in 1-σ range. Four more dates are available for this last phase. Two razors of type XIC2 and type XIB4b and a pin of type XXVD1a – all from different graves from Simris, Scania. A pin of type XXVE is from a grave from Øster Herup, Ringkøbing amt. The dates reach from the tenth to the middle of the sixth century. The long range is due to the *Hallstattplateau*.

Baudou's chronology encompassing per. IV and V has been thoroughly verified by the use of independent radiocarbon dates. In addition, the parabola of the distribution of types displays marked gaps, which may be interpreted in terms of further chronological subdivisions. Baudou has already suggested a possible two-stage development within per. IV (Baudou 1960, p. 112), which might be mirrored by the gap between cluster 1 and 2. Cluster 1 holds the typologically older forms, such as slender tweezers with straight ornamentation and the razor showing a

Table 2. The types of Evert Baudou separated according the CA; see Figure 12.

Period IV early	Period IV late	Period IV–V	Period V
Cluster 1	Cluster 2a	Cluster 2b	Cluster 3
IIA, XA1, XIA3, XIA1, XIA2, XIA4, XIA5, XIB3b, XIIB1, XIIB2, XIIB1c, XIIF, XIXD1a, XXVA2	IC1, IC2, IIB, VA, VB, XIB1a, XIB2a, XIB3a, XIB2b, XIIC, XIII, XIVB, XIXD1d, XXVA1a, XXVB2b, XXVC1, XXVC2, XXVH1, XXVIB1, XXVIC1	XA2, XIC1, XIID, XIIE2, XIXA, XIXE, XXVB2a, XXIVD2, XXVB1, XXVF2	VC, XA3, XIB1b, XIB4a, XIB4b, XIC2, XIIE1, XVID1, XIXD1c, XXVB2b, XXVD1a, XXVD2a, XXVE, XXVIB2

wire-like, bent-forward handle (TYP XIIB, XIA). They may clearly derive from the much older forms belonging to per. III.

Cluster 2 consists of slender tweezers with circumferential band incision ornamentation (TYP XIID), miniature fibulae (XXIVD2) and miniature antennae-swords (TYP XIC). Baudou has suggested, that these finds have to be placed within a later stage of per. IV and, as was his opinion, could have easily strayed into per. V as well. The finds of cluster 2 solely belonging to per. IV are located nearer the Y-axis (white). The transition from per. IV to V depicted in the CA and dated according to Baudou seems to be gradual. Most on the positive X-axis are per. IV, only three graves (Nr. 400, 51, 235) belong to per. V according to Baudou's definition. But on the negative side of the X-axis, the percentage of per. IV graves is more than one-third (Figure 11(a)). Find complexes belonging to both per. IV and V are located between the values X 0 and −0.6 and make a further subdivision of cluster 2 necessary: The first, belonging to per. IV, encompasses the scale of X 0.2 to 1.0 (cluster 2a, black), the second ranges from X 0.2 to −0.6 (cluster 2b, white). The third cluster mainly contains finds belonging to per. V (light grey).

To sum up the results of the analysis, it seems safe to suggest a four-stage gradation between the periods IV and V. Some inventories may have to be re-examined with regard to their assumed periodisation, but still it remains remarkable to be able to verify the hereto only assumed chronology for the first time. The four stages can be described as follows. A subdivision of per. IV with cluster 1 representing the older and cluster 2a the later phase. Furthermore, we may postulate a transition phase between per. IV and V (cluster 2b) and last but not least point out per. V (cluster 3) as clearly separating itself from the subsequent per. VI (Figure 4). The clusters represent artefact groups defined by similarity and frequency in grave contexts (Table 2).

The high number of ^{14}C-dates now available provides some more possibilities. The third CA shows, with the first against the fourth eigenvector, a chronological order of artefacts through their assemblage in graves. This change in grave goods is as close as possible to a readable linear timeline, a linear order of assemblages. This allows us to take the values of the first axis as values for time. But the distance between single points is not uniform. The distance in the middle of the graph is smaller than at the edges. This means 1 cm distance in the middle of the graph between types is not equal to 1 cm distance at the edge. Only a multidimensional analysis would give us an equal distribution between artefact types (Hinz and Müller forthcoming). Nevertheless, the order of artefacts and connected ^{14}C-dates allowed us to use Bayesian statistics. The relative order of the dates is a sequential order and can be calculated as a sequence (Figure 14). A few problems

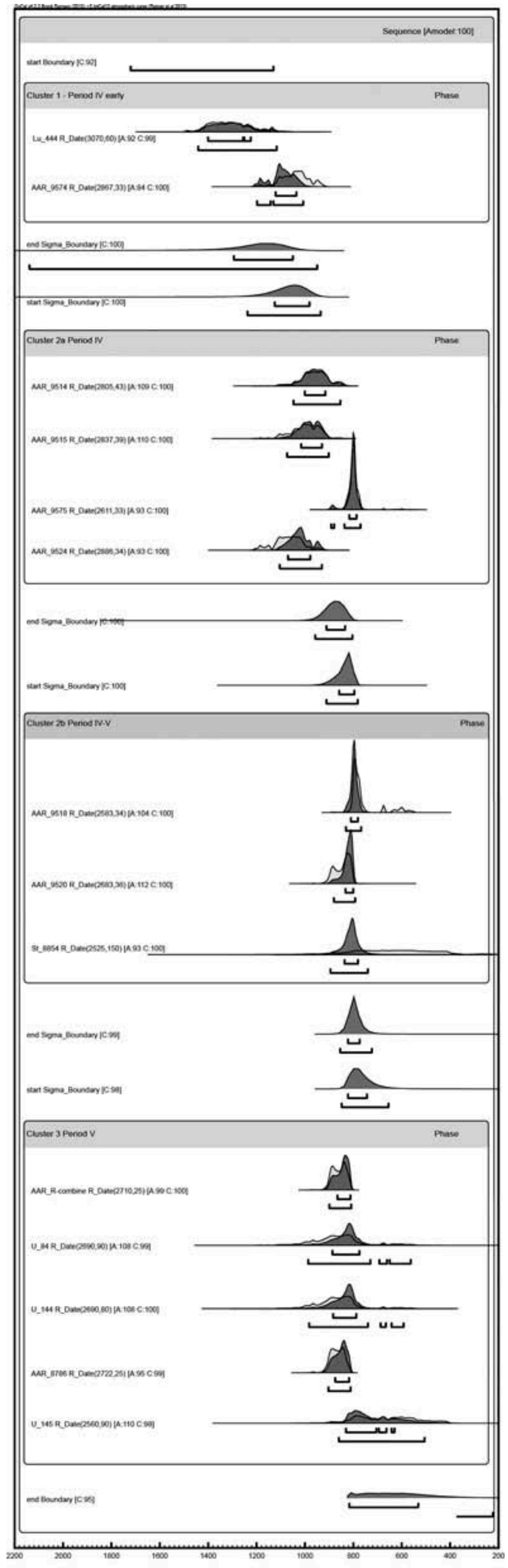

Figure 14. The chronological sequence of a Bayesian analysis performed with OxCal 4.2. The order of the dates follows the 1st eigenvector of the CA (see Figure 12). The results are shown in Table 3.

occur; several dates are connected with more than one artefact type, even in different clusters. Also, for the last cluster the most artefact types are associated with only one date, which is the combined date of grave J from Gl. Brydegård. Furthermore, some Swedish dates were used, even if those graves are not included in the CA. This needs to be considered if we want to interpret the results.

A Markov Chain Monte Carlo (MCMC) analysis with all dates in the sequential order, including repeating and overlapping dates, gave only poor results for an A_{model}. Therefore, a phase model was calculated (for details, see Ramsey 2009) and the duplicate dates were excluded.[6] The phases were separated by sigma_Boundaries to calculate a smooth transition in opposition to the aforementioned building brick model (Figure 14). The overall agreement of the A_{model} is 100.1%, which is far above the minimum acceptable level of A_{model} = 60.0%. Because data for an earlier phase than per. IV are missing, the beginning of per. IV is difficult to estimate, in part also because of the rather early date from Nymölla, Scania. But the phase per. IV early lasts until approximately 1050 BC. Period IV seems mainly fit into the tenth century and partly beginning of ninth century, while per. IV–V starts in the middle of the ninth century and lasts until middle of eighth century. The beginning of Period V can be assumed to be sometime in the eighth century; however, the ending is unclear because of the *Hallstattplateau* (Table 3).

The radiocarbon dates provide the basis for the absolute dating. Following Vandkilde's plausible argument (Vandkilde 1996; and newest Olsen *et al*. 2001, p. 271 figure 3), the beginning of per. IV may be ascribed to around 1100 BC. The end-boundary of the model suggests an end for per. V between 820 and 530 BC, which is too late according to the following per. VI and caused by the *Hallstattplateau*. The other feature is the fact that no date of the parabola strays younger than 540 BC, mirroring perfectly Vandkilde's thesis, which suggests – with regard to the settlement finds – an end of per. V at about 700 BC. Based on all dates it seems reasonable to have per. V (cluster 3) start around the year 820 BC. Cluster 2b (transition per. IV–V) would consequently represent the time between 950/20 and 820 BC, Cluster 2a (per. IV) between 1050 and 950/20 BC and Cluster 1 (per. IV early) the time of 1100–1050 BC. In comparison with the Bayesian model of Olsen et al., the timespans are slightly different for period IV and V due to new data sets and could be divided in two phases (Olsen *et al.* 2011, p. 270).

Table 3. Bayesian model according to Figure 14. A_{model} = 100.1%; $A_{overall}$ = 101.2%.

Name	Unmodelled (BC/AD)				Modelled (BC/AD)			
Sequence	1σ		2σ		1σ		2σ	
start Boundary					−1721	−1131	−5408	…
IV Early Phase								
Lu_444 R_Date (3070,60)	−1411	−1263	−1491	−1130	−1401	−1225	−1442	−1117
AAR_9574 R_Date (2867,33)	−1111	−998	−1187	−927	−1122	−1036	−1198	−1008
end Sigma_Boundary					−1294	−1050	−2139	−950
start Sigma_Boundary					−1125	−982	−1238	−936
IV Phase								
AAR_9514 R_Date (2805, 43)	−1009	−906	−1075	−837	−1001	−916	−1048	−854
AAR_9515 R_Date (2837, 39)	−1044	−930	−1116	−904	−1016	−930	−1075	−902
AAR_9575 R_Date (2611, 33)	−813	−787	−836	−764	−817	−788	−892	−771
AAR_9524 R_Date (2886, 34)	−1116	−1011	−1196	−941	−1071	−979	−1105	−931
end Sigma_Boundary					−911	−835	−958	−804
start Sigma_Boundary					−859	−796	−911	−782
IV_V Phase								
AAR_9518 R_Date (2583, 34)	−805	−769	−820	−559	−811	−782	−831	−768
AAR_9520 R_Date (2683, 36)	−892	−805	−902	−801	−833	−801	−881	−793
St_8854 R_Date (2525, 150)	−804	−431	−1005	−233	−837	−782	−895	−741
end Sigma_Boundary					−823	−774	−855	−724
start Sigma_Boundary					−823	−744	−849	−655
V Phase								
AAR_R-combine (2710, 25)	−895	−824	−905	−811	−865	−811	−898	−808
U_84 R_Date (2690, 90)	−973	−792	−1110	−552	−886	−774	−986	−562
U_144 R_Date (2690, 80)	−924	−796	−1055	−571	−883	−787	−982	−592
AAR_8786 R_Date (2722,25)	−895	−835	−912	−816	−874	−817	−903	−811
U_145 R_Date (2560, 90)	−812	−542	−892	−410	−830	−629	−859	−505
end Boundary					−817	−533	…	−223

Conclusion

In conclusion, the chronological system of Evert Baudou could be verified. The order of the types of artefacts shows a great variation based on regional, material and social differentiation. But it was also possible to outline a statistically proven chronological order of the artefacts. The parabola could be divided into three clearly separated clusters, which give a clearer insight into the combination of grave goods and their usage during the time periods of the Late Bronze Age.

The conclusions presented in this article have a new impact on the chronology of the late Bronze Age, but the material still needs to be reviewed and the results verified by including more recently published material and the hoards. The results of the analysis are based only on the grave finds published by Baudou and have been limited to the areas of Schleswig-Holstein and Denmark. It is necessary to include other graves and also the Swedish finds in order to examine the effect of an enlarged database on the present statements.

Even if this material is quite heterogeneous and includes mainly social and regional aspects, chronology is an underlying factor. The human individual of the late Bronze Age did not collect his burial objects with regard to 'modernity' – to him and his people it was much more of an issue to make a territorial or social statement. The two smaller gaps in the CA show the change of assemblages, but only at the passage of per. VI, when a completely new assemblage of different types is introduced to the burial ritual, a truly new era dawned.

To return to the prehistoric time concept, this article tries to divide the bricks of Montelius' Period IV–VI into smaller pieces. The choice of correspondence analysis opened the possibility for visualising the sequence of artefacts and artefact combinations on a timeline instead of as boxes. The sequence of artefacts given in Figure 12 shows that the differentiation between Periods IV and V is much smaller than that between the early and late parts of per. IV. The gap between per. IV/V and per. V means that a greater change in the artefact ensemble took place than between per. IV and V. We can also assume that the X-axis of the CA with the first eigenvector more closely approximates a timeline than the building brick model of periods with their concurrent types of artefacts.

Notes

1. Per. VI consisted of 26 grave finds and nine artefact types on the whole. The new database arrived at 385 artefacts. The statistical relevance depended on two types of artefacts per find and two locations per artefact type. Therefore, every grave containing only one burial object and singular artefact types had to be excluded from the database.
2. Awls have been excluded, because they are common at all times and have no part in altering the results (weight = 0).
3. Many thanks to Helle Vandkilde for letting me use her database, as well as Karen Margrethe Hornstrup for pointing out new dates to me.
4. All following dates are given in 1-σ range.
5. Older dates than Per. IV are also available for awls (see Hornstrup *et al.* 2012), but were not used for this article.
6. Many thanks to Marie-Josée Nadeau for helping me with the MCMC analysis of OxCal.

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RESEARCH ARTICLE

A biomolecular archaeological approach to 'Nordic grog'

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The combined archaeological, biomolecular, and archaeobotanical evidence from four sites in Denmark (Nandrup, Kostræde, and Juellinge) and Sweden (Havor on the island of Gotland) provide key reference points for reconstructing 'Nordic grog' from ca. 1500 BC to the first century AD. In general, Nordic peoples preferred a hybrid beverage or 'grog,' in which many ingredients were fermented together, including locally available honey, local fruit (e.g., bog cranberry, and lingonberry) and cereals (wheat, rye, and/or barley), and sometimes grape wine imported from farther south in Europe. Local herbs/spices, such as bog myrtle, yarrow and juniper, and birch tree resin rounded out the concoction and provide the earliest chemical attestations for their use in Nordic fermented beverages. The aggregate ingredients probably served medicinal purposes, as well as contributing special flavors and aromas. They continued to be important ingredients for many kinds of beverages throughout medieval times and up to the present.

The importation of grape wine from southern or central Europe as early as ca. 1100 BC, again chemically attested here for the first time, is of considerable cultural significance. It demonstrates the social and ceremonial prestige attached to wine, especially when it was served up as 'Nordic grog' in special wine-sets imported from the south. It also points to an active trading network across Europe as early as the Bronze Age in which amber might have been the principle good exchanged for wine. The presence of pine resin in the beverages likely derives from the imported wine, added as a preservative for its long journey northward.

Keywords: ancient medicine; beer; botanicals; biomolecular archaeology; mead; Scandinavia; wine

A simple question can be posed: What fermented beverages were drunk by the Bronze and Iron Age peoples of the northernmost habitable regions of Europe – referred to as 'Proxima Thule' by the Greeks? Until the advent of modern chemical, archaeological, and archaeobotanical techniques, the answer to this question was perforce based on later Greek and Roman descriptions of the 'barbarians' inhabiting the plains and river valleys north of the Alps (Nelson 2005). If classical writers were to be believed, binge drinking was the rule here by the late Iron Age. For example, according to Varro in his *Chronology*, the Gauls (a general Latin term for the Celtic people living in Europe at the time) were repulsed from the gates of Rome by a surprise attack when they lay in a drunken stupor after torching the city ca. 390 BC. Beer in particular was singled out for its foul smell by Dionysius of Halicarnassus in the late first century BC, who facetiously claimed that the Celtic brew was made from barley rotted in water (*Roman Antiquities* 13.11.1). Diodorus Siculus (*Bibliotheca historica* 5.28.3) drove home the point earlier in the century when he wrote that the rude farmers and mountain folk of the north drank their alcoholic beverages neat (i.e., undiluted) through tubes or with their moustaches serving as filters, obviously anathema to any cultivated Roman or Greek.

Sometimes, the literary sources provide greater and less contemptuous detail of the ingredients that went into a northern fermented beverage. Diodorus Siculus (5.26.2–3) also noted that Celtic beer included 'the washings of honeycombs, probably mead,' and imported wine. The latter beverage was a mark of the civilized human, at least in Greece probably for thousands of years, in central Italy by at least 700 BC, and in southern France by at least 500 BC (McGovern 2003/2007, pp. 296–298; McGovern 2009/2010, Ch. 5; McGovern *et al*. 2013). Fermented beverages made from honey, the most concentrated simple sugar source in nature, stood equally high on the list of high status drinks in this world and the next, as implied by the famous Greek *kykeon* of the Homeric epics and the Eleusinian Mysteries of the Hellenistic and Roman eras. If northern peoples were importing grape wine from the south and using honey in their fermented beverages, even if it were admixed with 'rotten barley water,' then at least they were partaking of the most prestigious southern beverages.

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This paper is affectionately dedicated to the memory of Eva Koch, a remarkable archaeologist of the ancient Nordic world. She was particularly fascinated by and contributed greatly to our knowledge of fermented beverages, whether made from honey, cereals, or fruits of the region. The archaeological world has indeed lost a very perceptive and productive scholar.

To gain a fuller and more accurate picture of the composition of these northern beverages before written records, our research group carried out a biomolecular archaeological study of well-preserved residues within vessels from tombs and hoards in Denmark and Sweden, extending over approximately a millennium and a half, from ca. 1500 BC to the first century AD (see Figure 1). In some instances, the archaeobotanical and palynological evidence, which is also presented here, expands upon and/or correlates with the chemical data and interpretations.

Archaeological samples chosen for analysis

Nandrup

The earliest sample examined was recovered from a tumulus (mound) tomb at Nandrup on the island of Mors in Jutland in northwest Denmark (Aner *et al*. 2001: Ke 5282, p. 144; Jensen 2002, pp. 299–300; Koch 2003). It dates to Montelius' Period II of the Nordic Bronze Age (ca. 1500–1300 BC). A single male warrior had been buried with his weapons and a jar, whose residue was the focus of our chemical investigation. The provision of both a bronze sword and a dagger, whose hafts and pommels are nearly identical in their geometric designs of interlocked spirals, roundels, and hatched horizontal lines, implies that the warrior belonged to an elevated social class (Randsborg 1974).

The Nandrup tomb can be compared to a contemporaneous grave at Bregninge in northwestern Zealand in which a male warrior had been buried in an oak coffin with a massively hafted bronze sword, battle-ax, and a jar which contained honey (likely mead) according to a palynological analysis by J. Troels-Smith in an unpublished document in the National Museum of Denmark (see Nielsen, 1977, 1978, 1988, Koch 2003, pp. 128–129). The very well-preserved cist grave at Ashgrove in Scotland of a slightly earlier period (ca. 1700 BC) provides another excellent parallel. A single male warrior with a well-fashioned dagger was buried with a pottery jar (beaker), which again most likely contained honey mead according to the palynological analysis (Dickson 1978; detailed below).

The rounded jar (Figure 2A) from the Nandrup tomb, with a wide mouth and slight vertical lug handles, had been placed at the foot of the man's body. An amber 'button' was recovered from inside the jar, which Koch (2003, p. 128) plausibly proposed was the knob for a lid made of an organic material, such as wood, that disintegrated.

The interior of the jar from its base up to mid-body was covered with a dark residue. Two small pieces (Danish National Museum [NM], sample M 2337), approximately 6 mm on a side (total of 0.25 g), were examined microscopically. They were relatively homogeneous in appearance with different colorations on the exterior (black) and in section (brownish).

Kostræde

A hoard of artifacts from a pit at Kostræde in southern Zealand (Thrane 1966), southwest of Copenhagen, included the only strainer (Figure 2B) yet recovered from the Late Bronze Age (Periods IV–VI, ca. 1100–500 BC) in Denmark. The bronze strainer was quite large, with a diameter of 30.7 cm and a reconstructed height (allowing for the missing base that probably was rounded off) of about 25 cm, comparable to a contemporaneous example of similar size and technological design from the site of Tiszavasvari in eastern Hungary (Thrane 1966). The

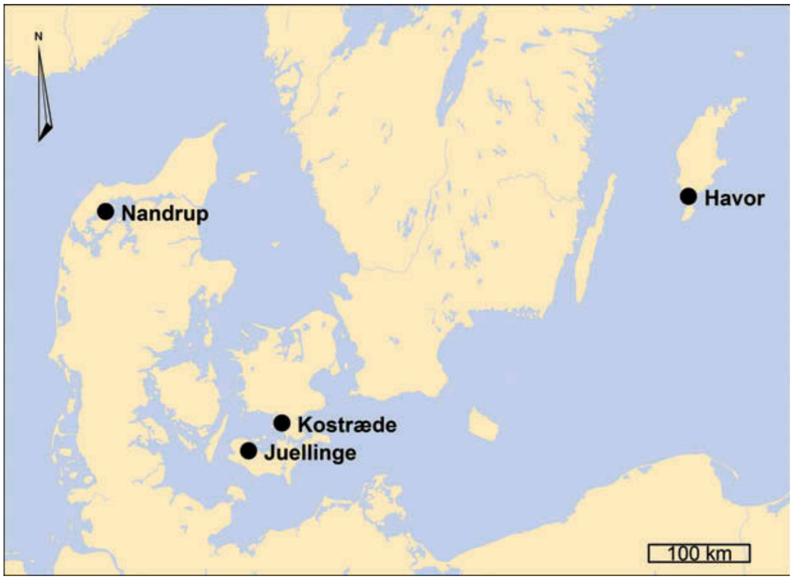

Figure 1. Map of southern Scandinavia, showing archaeological sites investigated.

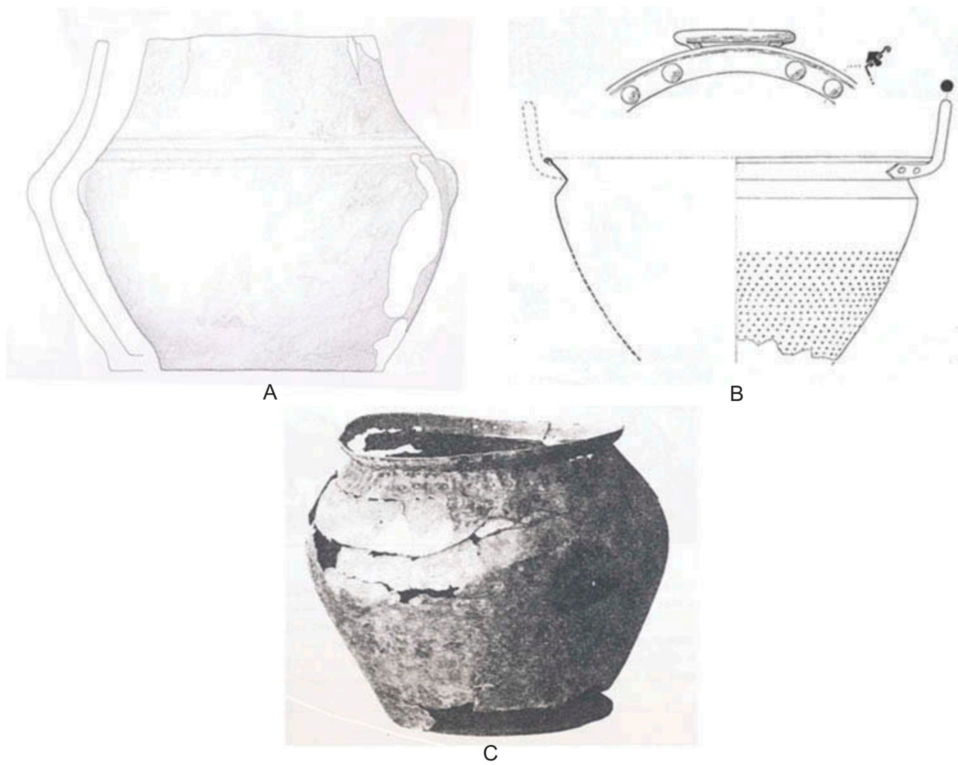

Figure 2. Artifacts with residues analyzed: Nandrup jar (A), Kostræde strainer (B), and Juellinge bucket (C). (Drawings and photograph, respectively, after Aner *et al*. 2001, pl. 70:5282, mid-body diam. 31 cm [ca. 1:3]; Thrane 1975, fig. 88, rim diam. 30.3 cm [ca. 1:3]; and Müller 1911: fig. 12, mid-body diam. 30.3 cm [ca. 1:3])

strainer was found together with a set of female belt ornaments and a pair of spiral gold earrings.

A small piece (NM, A4614), approximately 6 mm on a side (total of 0.25 g), was removed from one of the perforations of the strainer, evidently a residue from filtering a liquid. The piece was relatively homogeneous with a brownish cross-section and some surface mottling.

Juellinge

The tombs of four women, dating to the Early Roman Iron Age (ca. 200 BC), were found at the Danish site of Juellinge on the island of Lolland, south of Zealand (Müller 1911). Tomb 1, a wood coffin that held the body of a 30-year-old female, was exceptionally rich in finds. Besides cosmetic items and jewelry, the woman held a long-handled bronze strainer-cup, part of a standard imported Roman wine-set, in her right hand. In addition to two Roman-style incised glass beakers, a large bronze 'bucket' (Latin, *situla*) (Figure 2C), also part of the wine-set, was placed at her head, and a whole sheep was laid at her feet outside the coffin.

Inside the bucket was a long-handled ladle, another part of the wine-set. A dark, relatively homogeneous residue had collected on bucket's interior base. A small piece (NM, M18823), approximately 6 mm on a side (total of 0.25 g), was provided for analysis.

Havor

At Havor on the Swedish island of Gotland in the Baltic Sea, a hoard of a filigreed and granulated gold torque, a pair of bronze bells, and an imported Roman bronze wine-set of the Early Roman Iron Age (first century AD) was found buried against the inner face of the wall of a ring fort (Nylén 1962; Nylén *et al*. 2005). The wine-set was comprised of a 'bucket' (situla) (Figure 3), inside of which were three single-handled 'sauce-pans' or mixing/drinking cups, which were nested one inside the another, and a long-handled strainer-cup and ladle inside one another.

The interior of the strainer-cup had a built-up residue in and around its holes. A piece about a centimeter square and 3 mm thick was made available for analysis (see Isaksson 2005: fig. 1a–b). The residue was reddish-brown with dispersed greenish areas.

Archaeobotanical evidence

The botanical, especially palynological, evidence from excavated vessels (particularly 'beakers' and processing vats) in Scotland has proven very illuminating in defining a 'Nordic grog' (McGovern 2009/2010, Ch. 5), going back as early as the fourth millennium BC and continuing down to the second millennium when our earliest sample from Nandrup contributes data for Scandinavia.

Figure 3. Roman drinking-set, comprised of a bucket (*situla*), a ladle, and several 'sauce pans' or drinking cups, from a hoard under the floor of a settlement at Havor (Sweden) in the southern part of the island of Gotland in the Baltic Sea. (Photograph courtesy of E. Nylén and Statens Historiska Museum, Stockholm)

Very consistent results were obtained from the palynological analyses of the Scottish residues from regions throughout the country, including the western islands, and as far north as the Orkneys (Dickson 1978, Wickham-Jones 1990, Dineley 2004, Koch 2003). Honey, deriving mostly from the flowers of the small-leaved lime tree (*Tilia cordata*) and meadowsweet (*Filipendula vulgaris*) or heather (*Calluna vulgaris*), were attested in all the samples. Several vessels also contained cereal pollen. No fruit remains were reported, but since fruits carry minimal pollen compared to the amount and variety that is incorporated into honey as nectar, their presence cannot be excluded. The meadowsweet pollen could have originated from intentionally adding this herb to the beverage. Although some of the pollen evidence is open to interpretation, a good case can be made that the cups and large vessels originally contained a fermented beverage – whether it were a mead, sweetened ale, or a more complex Nordic grog with added herbs.

The palynological analyses of the residues from the Ashgrove and Bregninge warrior burials, with their evident similarity to the Nandrup tomb (above), should be especially noted as a preamble to our Scandinavian findings. The Bregninge jar yielded pollen from lime tree, meadowsweet, white clover (*Trifolium repens*), knotgrass (*Polygonum*), and flowers of the Compositae flower family. A profusion of lime tree, meadowsweet, heather, ribwort plantain (*Plantago lanceolatus*), and thyme (*Thymus*)/mint (*Mentha)* pollen had similarly infused the sphagnum moss and leaves covering the Ashgrove man's upper torso and arms. In both instances, the most convincing explanation was that the jars originally held a diluted honey beverage, which had spilled out onto the moss in the case of the Ashgrove beaker and which had evaporated inside the Bregninge jar. When honey is watered down to about 30%, natural osmophilic yeast in the honey become active and readily converts it to mead.

Nandrup

J. Iversen (Broholm and Hald 1939) made a very similar palynological finding to those at Bregninge and Ashgrove when he examined the residue inside the Nandrup jar, later confirmed by J. Troels-Smith in his unpublished document in the National Museum of Denmark. The residue was dominated by lime tree and meadowsweet pollen, with some white clover pollen, which are best explained again as deriving from a honey product. This was most likely mead, since the residue had the appearance of an evaporated liquid and was confined to the lower part of the vessel.

Juellinge

Our next botanical point-of-reference is the Juellinge residue, dated to ca. 200 BC. Based on his microscopic examination of the residue inside the situla, archaeobotanist B. Gram (1911) identified remnants of barley (Hordeum) grains, a fruit that was most likely bog cranberry (*Oxycoccus palustris)* which also accounted for numerous calcium citrate and malate crystals, lesser amounts of lingonberry or cowberry (*Vaccinium vitis-idaea*), filaments of bog myrtle (*Myrica gale*), and yeast cells. He concluded that the situla had originally contained a mixed beverage of barley beer and a fruit wine made of bog cranberries and lingonberries. Since he did not carry out a palynological analysis, it is not known whether a fermented, diluted honey/mead was also part of the beverage.

Unfortunately, archaeobotanical and/or palynological analyses of the temporally intervening sample from Kostræde, as well as the latest sample in our series from Havor, are yet to be done.

Chemical results

Ancient organic compounds were identified by a combination of chemical techniques: Fourier-transform infrared spectrometry (FT-IR), gas chromatography-mass spectrometry (GC-MS) following extraction, ultra-HPLC tandem mass spectrometry (LC/MS/MS) following extraction, and headspace solid phase microextraction (SPME) coupled to GC-MS (see Supplementary Information).

From earliest to latest, we obtained the following chemical results for our samples:

Nandrup

(1) The FT-IR spectrum of the sample has characteristic but small hydrocarbon peaks in the 2900 cm^{-1} region, indicative of organics, but it is mainly dominated by inorganic iron oxide peaks.

(2) The GC-MS results (Figure 4 and Tables 1 , 2) show odd-numbered n-alkanes C_{27} and C_{29} and even-numbered fatty acids from C_{24} to C_{30}, both characteristic of beeswax. However, the absence of beeswax esters, the C_{25} and C_{31} n-alkanes and the C_{32} and C_{34} fatty acids, together with only moderately intense C_{27} alkane and C_{24} fatty acid peaks, argue against beeswax. Possibly, the results are explained by differential degradation of beeswax compounds that were more susceptible to oxidation (especially wax esters) or were present in lesser amounts. Epicuticular plant wax can be ruled out, because plant sterols and internal diones are absent (see Juellinge, below).

(3) The presence of pristane and phytane, branched long-chain paraffins, are typical petroleum biomarkers (Eglinton and Calvin 1967).

(4) The isopropyl esters of the C_{12}, C_{14}, and C_{16} fatty acids, which have been reported in other ancient liquid containers (e.g., Corinthian 'plastic' vases: Biers *et al*. 1994, pp. 42, 50, 54, 55; a Minoan bowl: Beck *et al*. 2007, pp. 58–59), are likely volatile contaminants of human skin and/or saliva (Middleditch 1989).

(5) Manoyl oxide, a diterpenoid ether, has been reported (Biers *et al*. 1994, p. 24, with references) to occur in several Pinaceae and Cupressaceae family conifers, including juniper. The lack of evidence for other characteristic terpenes of these tree resins, however, implies that the manoyl oxide is most likely a contaminant.

The Nandrup sample was not analyzed by LC/MS/MS for tartaric acid/tartrate nor by SPME for volatile compounds.

Kostræde

(1) The FT-IR spectrum of the sample shows a mixture of inorganic (iron oxide and a 6-coordinate copper(II) complex) and organic constituents. The latter includes prominent hydrocarbon peaks in the 2900 cm^{-1} region. A doublet at 1730 and 1710 cm^{-1}, combined with a hydroxyl stretch absorption at 1455 cm^{-1}, can be attributed

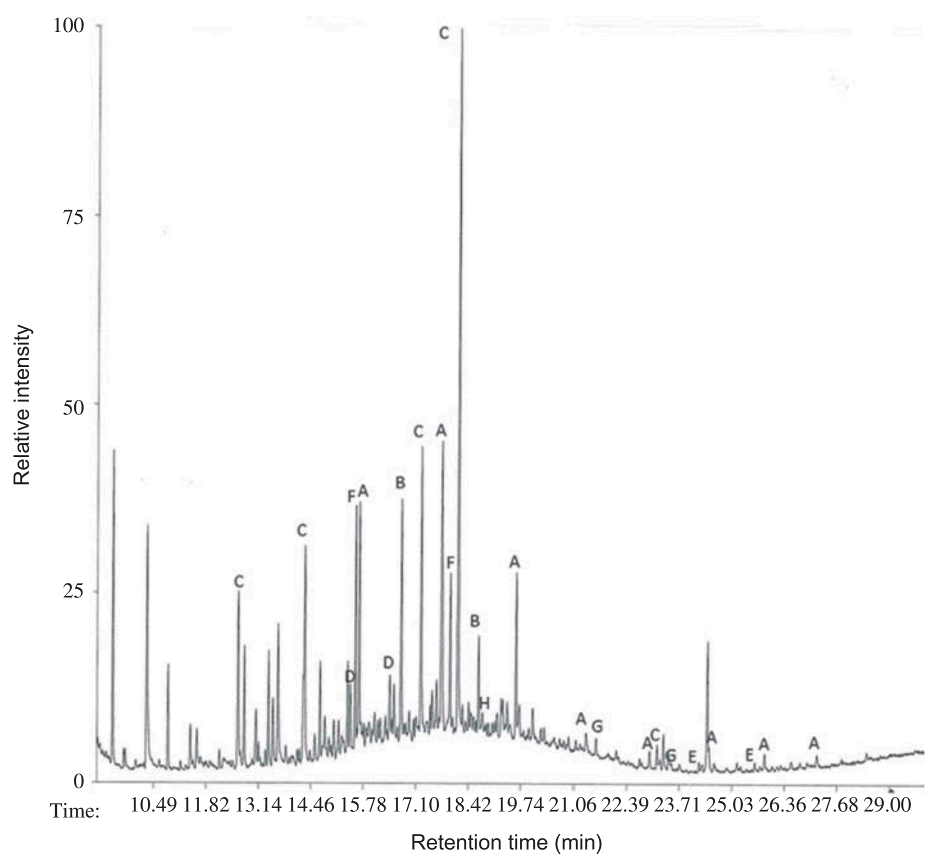

Figure 4. GC-MS chromatogram: Nandrup sample: (A) fatty acids (methyl esters); (B) fatty acids (isopropyl esters); (C) phthalate plasticizers; (D) pristane/phytane; (E) C_{27} and C_{29} alkanes; (F) antioxidants in plastic; (G) pine resin family; and (H) manoyl oxide.

Table 1. Chemical compounds identified by GC-MS for Scandinavian samples.

Sample identification	Nandrup	Kostraede	Juellinge	Havor
Pine (Pinaceae) resin diterpenoids				
Dehydroabietic acid	−	+	−	Trace
7-Oxo-dehydroabietic acid	−	+	−	−
Retene	−	Low	−	−
Manoyl oxide	+	−	−	−
Birch (Betulaceae) resin triterpenoids				
Betulin	−	+	−	+
Betulinic acid	−	+	−	+
3-Oxoallobetulane	−	+	−	+
Lupeol	−	+	−	+
Lupenone	−	+	−	+
Lup-2,20(29)-diene	−	+	−	+
Suberic dioic acids				
C_{16}	−	+	−	+
C_{18}	−	+	−	+
C_{20}	−	+	−	+
Plant sterols				
Sitosterol	−	−	+	−
Ergostanol	−	−	+	−
Stigmastanol	−	−	+	−
Stigmasta-3,5 diene-7-one	−	−	+	−
Wax esters of C_{16} fatty acid and C_{24},C_{26},C_{28} alcohols				
C_{16}/C_{24}	−	+	−	−
C_{16}/C_{26}	−	+	−	−
C_{16}/C_{28}	−	+	−	−
n-Alkanes				
C_{25}	−	+	+	−
C_{27}	+	+	+	−
C_{29}	+	+	+	−
C_{31}	−	+	+	−
Epicuticular plant waxes				
Hentriacontane-14,16-dione	−	−	+	−
25-Hydroxy-hentriacontane-14,16-dione	−	−	+	−
Fatty Acids				
Saturated	Up to C_{30}	C_{24} dominant	Higher C-nos. dom.	Up to C_{24}
C_{14}	+	+	+	+
C_{16} (Palmitic)	+	+	+	+
C_{18} (Stearic)	+	+	+	+
C_{20}	+	+	+	+
C_{22}	+	+	+	+
C_{24}	+	Dom.	+	+
C_{26}	+	+	+	−
C_{28}	+	+	+	−
C_{30}	+	+	+	−
C_{32}	−	+	+	−
C_{34}	−	+	+	−
Palmitic/Stearic ratio	>1	~1	>>1	>1
Oleic (C_{18})	−	+	Dom.	+
Azelaic (C_9)	−	+	Dom.	+
Isopropyl esters				
C_{14}	+	−	−	−
C_{16}	+	−	−	−
Petroleum biomarkers				
Pristane	+	−	−	−
Phytane	+	−	−	−

Note: + = Present; − = absent; dom. = dominant; C-nos. = carbon numbers.

Table 2. Retention times for compounds identified by GC-MS.

Retention time (min)	Compound name	Retention time (min)	Compound name
11.15	Heptanedioic acid, dimethyl ester	24.49	Tetracosanoic acid, methyl ester
12.46	Octanedioic acid, dimethyl ester	25.20	Pentacosanoic acid, methyl ester
13.65	Nonanedioic acid, dimethyl ester	25.45	Docosanedioic acid, dimethyl ester
14.83	Decanedioic acid, dimethyl ester	25.61	n-Nonacosane
14.57	Isopropyl laurate	25.90	Hexacosanoic acid, methyl ester
15.44	Pristane	26.55	Heptacosanoic acid, methyl ester
15.66	Tetradecanoic acid, methyl ester	26.93	n-Hentriacontane
16.55	Phytane	27.02	Lup-2,20(29)-diene
16.72	Isopropyl myristate	27.20	Octacosanoic acid, methyl ester
17.78	Hexadecanoic acid, methyl ester	28.04	Ergostanol
18.77	Manoyl oxide	28.45	Triacontanoic acid, methyl ester
19.44	Oleic acid, methyl ester	28.54	Sitosterol
19.65	Octadecanoic acid, methyl ester	28.61	Stigmastanol
20.60	Retene	28.78	14,16-Hentriacontanedione
20.76	Hexadecanedioic acid, dimethyl ester	28.97	Lupenone
21.42	Eicosanoic acid, methyl ester	29.13	Stigmasta-3,5 diene-7-one
21.65	Dehydroabietic acid, methyl ester	29.14	Lupeol
22.42	Octadecanedioic acid, dimethyl ester	29.68	Dotriacontanoic acid, methyl ester
22.99	Docosanoic acid, methyl ester	30.13	25-Hydroxy-14,16-hentriacontanedione
23.14	15-Hydroxydehydroabietic acid, methyl ester	30.58	3-Oxoallobetulane
23.53	7-Oxodehydroabietic acid, methyl ester	31.18	Tetratriacontanoic fatty acid, methyl ester
23.75	Tricosanoic acid, methyl ester	31.69	Betulin
23.98	Eicosanedioic acid, dimethyl ester	36.50	Palmitic acid, tetracosyl ester
24.21	n-Heptacosane	40.52	Palmitic acid, hexacosyl ester

to birch tree resin (see below); its strong absorptions mask any contribution by tartaric acid/tartrate, which is characterized by a doublet at 1740 cm^{-1} (major peak)/1720 cm^{-1} (shoulder) and hydroxyl stretch absorption in the 1450–1430 cm^{-1} region.

(2) Tartaric acid/tartrate is positively identified by LC/MS/MS (Figure 7).

(3) Beeswax was unquestionably present in this sample, based on the GC-MS identification of C_{25}–C_{31} n-alkanes, even-numbered C_{24}–C_{30} fatty acids with C_{24} dominant, and wax esters of the C_{16} fatty acid (palmitic) with C_{24}, C_{26}, and C_{28} alcohols (Figure 5 and Tables 1, 2).

(4) Pine resin is substantiated by dehydroabietic acid and 7-oxo-dehydroabietic acid.

(5) Birch tree resin is extremely well attested by characteristic triterpenoids of the lupeol and betulin families (betulin, betulinic acid, 3-oxoallobetulane, lupeol, and lupenone) and suberic C_{16}, C_{18}, and C_{20} dioic acids (Regert 2004 – compare Figure 5 and Tables 1, 2). Lup-2,20(29)-diene is a marker compound for heat-treated resin (Modugno and Ribechini 2009).

(6) Azelaic acid is most likely a derivative of oleic acid, also attested in the sample, since the latter is readily cleaved at its C_9 double bond and oxidized to the dicarboxylic azelaic acid. Oleic acid is widely distributed in the plant and animal kingdoms. It should be noted, however, that azelaic acid also occurs naturally in wheat, rye, and barley, which are highly appropriate ingredients for a Nordic grog.

(7) Volatile compounds are identified by SPME (Table 3) and their natural product sources are determined by standard bioinformatics searches of the available chemical literature (McGovern *et al*. 2009). Several compounds of the hydrocarbon, alcohol, ester, aldehyde, and lactone classes are consistent with grape wine (Bakker and Clarke 2011). However, benzaldehyde, 2-ethyl-1-hexanol, and nonanal could be contaminants (see Supplementary Information). Any ancient ethanol would have been metabolized by microorganisms.

(8) Juniper (*Juniperus communis*) extract, usually added as the cone (fruit), is a probable additive to the liquid filtered through the strainer. It is attested by fenchol, terpineol, and junipene (see Juellinge, below, for better attestation of juniper and herbs/spices in general).

(9) The herb bog myrtle or sweet gale, again as a probable additive, is indicated by fenchol, γ-cadinene, copaene, and other more common compounds.

(10) The natural source for the high level of eucalyptol (cineole) is uncertain; this compound is found in mugwort and other wormwood species,

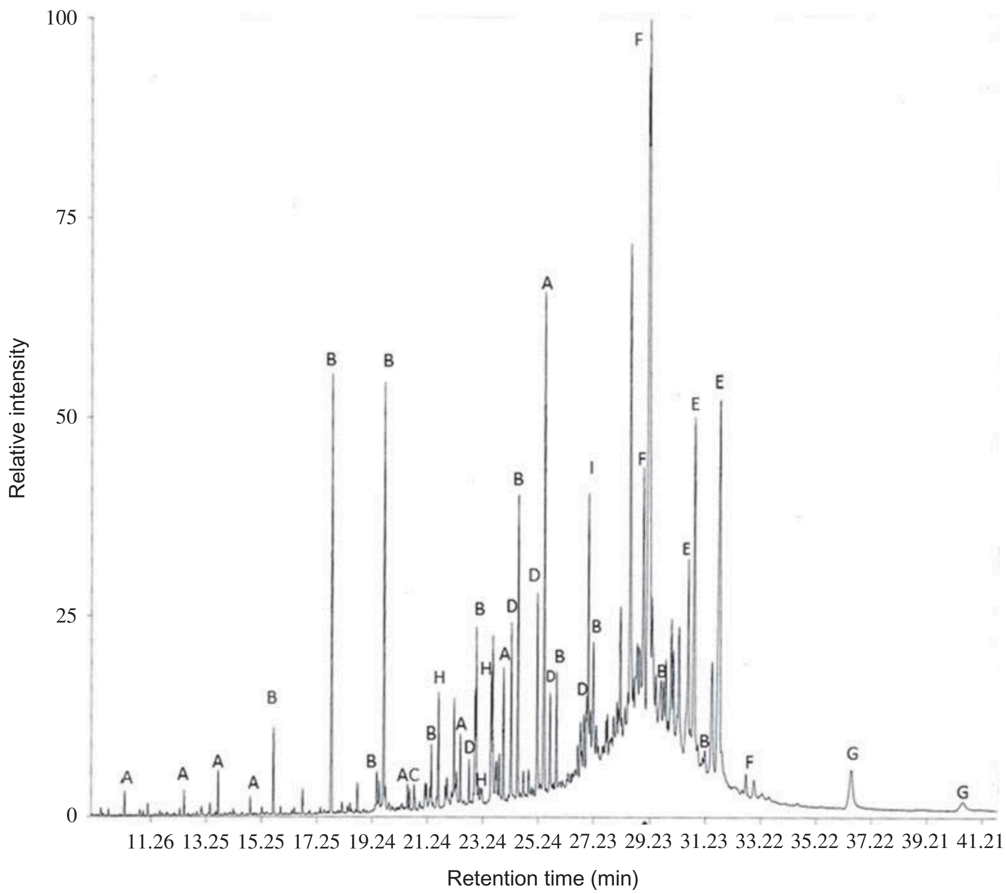

Figure 5. GC-MS chromatogram: Kostræde sample: (A) dioic acids; (B) fatty acids (saturated and unsaturated); (C) retene; (D) odd-numbered n-alkanes from C_{25} to C_{31}; (E) betulin birch resin family; (F) lupeol birch resin family; (G) wax esters of C_{16} (palmitic) fatty acid and C_{26} and C_{28} alcohols; (H) pine resin family; and (I) lup-2,20(29)-diene (heat-treated birch resin marker).

cranberry, and rosemary, which are known to have been additives to ancient European fermented beverages (e.g., Juan-Tresserras 1998, Stika 1996, McGovern *et al*. 2013).

Juellinge

(1) The FT-IR spectrum of the sample shows a mixture of inorganic and organic constituents, which are ill-defined.
(2) The LC/MS/MS data (Figure 7) are borderline positive for tartaric acid/tartrate.
(3) An epicuticular plant wax, which is common on the surfaces of fruits such as bog cranberry and lingonberry, is well attested by GC-MS (Figure 6 and Tables 1, 2), based on the presence of the plant sterols (sitosterol, ergostanol, stigmastanol, and stigmasta-3,5 diene-7-one) and large amounts of internal plant diones (hentriacontane-14,16-dione) and its associated hydroxyl compound (Evershed *et al*. 1991). A very high palmitic to stearic fatty acid ratio is also typical of plant products. Consequently and in contrast to the Nandrup sample (above), very similar peak intensity patterns of key odd-numbered n-alkanes and even-numbered fatty acids, coupled with the absence of wax esters and the C_{32} and C_{34} fatty acids, are better explained as deriving from epicuticular wax, rather than degraded beeswax.
(4) Azelaic acid is again most likely a derivative of oleic acid (see Kostræde, above), but a natural source from wheat, rye, or barley cannot be ruled out.
(5) Volatile compounds are very well represented by SPME (Table 3), including probable grape wine, juniper, and bog myrtle compounds, as already pointed out for Kostræde (above).
(6) Additionally, pine resin (Pinaceae) is attested by fenchone, terpineol, and possibly γ-cadinene; D-limonene and camphor might also derive from pine resin, but could be contaminants.

Table 3. Chemical compounds identified by SPME for Scandinavian samples.

Retention time (min)	Compound name	Relative intensity (%)			Probable source
		Kostræde	Juellinge	Havor	
2.64	1-Butanol, 3-methyl-	–	2.52	–	1
2.67	1-Butanol, 2-methyl-	–	1.02	–	1
3.01	Toluene	–	–	0.20	?
3.37	Hexanal	0.40	0.39	0.25	?
4.93	Heptanal	0.54	–	0.41	1
6.08	Benzaldehyde	3.86	5.24	2.05	1
6.20	Heptanol	0.97	–	0.77	?
6.37	Hexanoic acid	2.04	1.52	–	?
6.43	Phenol	1.05	17.02	–	?
6.56	5-Hepten-2-one, 6-methyl-	0.52	–	–	?
6.87	Octanal	0.80	0.50	0.48	1/6?
7.31	Benzene, 1,2,3-trimethyl-	–	–	0.41	6
7.39	1-Hexanol, 2-ethyl-	4.41	1.46	1.60	?
7.43	D-Limonene	–	0.54	–	1,2,3,5
7.51	Eucalyptol (cineole)	0.54	–	0.26	3
7.54	Benzyl alcohol	–	7.54	–	1
7.75	Salicylaldehyde	–	7.75	–	?
7.93	p-Cresol	–	7.93	–	?
8.09	Cyclohexene	–	8.09	–	?
8.24	Cyclooctane	–	8.24	–	?
8.25	1-Octanol	2.69	–	1.68	1
8.71	Fenchone	0.52	–	–	2,3 (as fenchol),5
8.71	2-Nonanone	–	0.64	0.27	?
8.96	Nonanal	1.13	0.88	0.54	1
9.06	Thujone	–	0.33	–	4
9.64	Pentanedioic acid, dimethyl ester	–	0.16	–	?
9.89	Camphor	–	0.82	–	2,3,4,5
10.05	Menhone	–	0.33	–	?
10.23	2,4,6-Octatriene, 2,6-dimethyl-	–	0.25	–	2
10.31	Octanoic acid	3.87	1.77	0.61	?
10.33	1-Nonanol	–	–	0.44	?
10.42	Menthol	1.82	0.84	0.49	?
10.6	Benzenemethanol, α,α,4-trimethyl	–	0.18	–	?
10.68	Naphthalene	2.36	3.78	0.72	?
10.78	2-Decanone	–	0.95	–	?
10.8	Terpineol	0.98	–	–	1,2,5
10.86	Octanoic acid, ethyl ester	0.51	–	–	1
10.89	Methyl salicylate	0.80	0.56	–	?
11.23	l-Verbenone	–	0.14	–	2
11.51	Benzothiazole	0.52	0.65	1.15	?
12.25	Nonanoic acid	2.13	0.57	0.72	?
12.78	2-Undecanone	–	0.59	–	?
12.82	Nonanoic acid, ethyl ester	0.39	0.48	–	1
12.88	Naphthalene, 2-methyl-	0.75	0.48	–	6
13.04	Undecanal	–	0.29	–	?
13.21	Naphthalene, 1-methyl-	0.53	0.28	–	6
14.09	Decanoic acid	0.46	–	–	?
14.15	γ-Nonalactone	0.52	0.34	–	1
14.27	1-Undecanol	–	0.16	–	?
14.49	Biphenyl	–	0.16	–	?
14.69	2-Dodecanone	–	0.11	–	?
14.76	Tetradecane	0.50	–	–	?
14.97	Naphthalene, 1,6-dimethyl-	0.98	–	–	6
15.07	Junipene	0.86	–	–	2
15.24	Naphthalene, 2,3-dimethyl-	–	0.10	–	1/6?
15.24	Naphthalene, 2,7-dimethyl-	0.46	–	–	1/6?
15.3	Naphthalene, 2,6-dimethyl-	0.40	0.19	–	1/6?
16.11	1-Hexadecanol	–	0.25	–	?
16.35	α-Cucumene	–	0.17	–	?
16.77	Pentadecanal	–	0.14	–	?
16.97	Dibenzofuran	0.74	0.28	–	6

(*continued*)

Table 3. (*Continued*).

Retention time (min)	Compound name	Relative intensity (%) Kostræde	Juellinge	Havor	Probable source
17.21	Azulene, 4,6,8-trimethyl-	0.38	–	–	?
17.48	Naphthalene, 1,2,3,4-tetrahydro-1,4,6-trimethyl	–	0.23	–	?
18.25	Hexadecane	0.69	–	–	?
18.48	Tetradecanal	–	0.16	–	?
18.89	Naphthalene, 1,2,3,4,4a,7-hexahydro-1,6-dimethyl-4-(1-methylethyl)-	–	0.27	–	5?
19.11	γ-Cadinene	–	0.48	–	2,3,4,5?
19.17	Copaene	–	0.16	–	2,3,4
19.32	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-4a, 8-dimethyl-2-(1-methylethylidene)-,(4aR-trans)-	–	0.30	–	?
19.64	Cadalin (Cadalene)	–	1.92	–	?
19.86	Heptadecane	0.64	0.14	–	?
21.26	Phenanthrene	1.08	0.30	–	1/6?
21.26	Anthracene	–	–	0.17	1/6?
23.81	1,2-Benzenedicarboxylic acid, butyl 2-ethylhexyl ester	– –	– –	– –	6
24.06	Octacosane	–	5.71	–	?
24.15	Eicosane	–	4.11	–	?

Notes: 1 = Grape wine (*Vitis vinifera)* constituent.
2 = Juniper (*Cupressaceae juniperus*) constituent.
3 = Bog myrtle (*Myrica gale*) constituent.
4 = Yarrow (*Achillea millefolium*) constituent.
5 = Pine (Pinaceae) resin constituent.
6 = Probable modern or ancient contaminant.

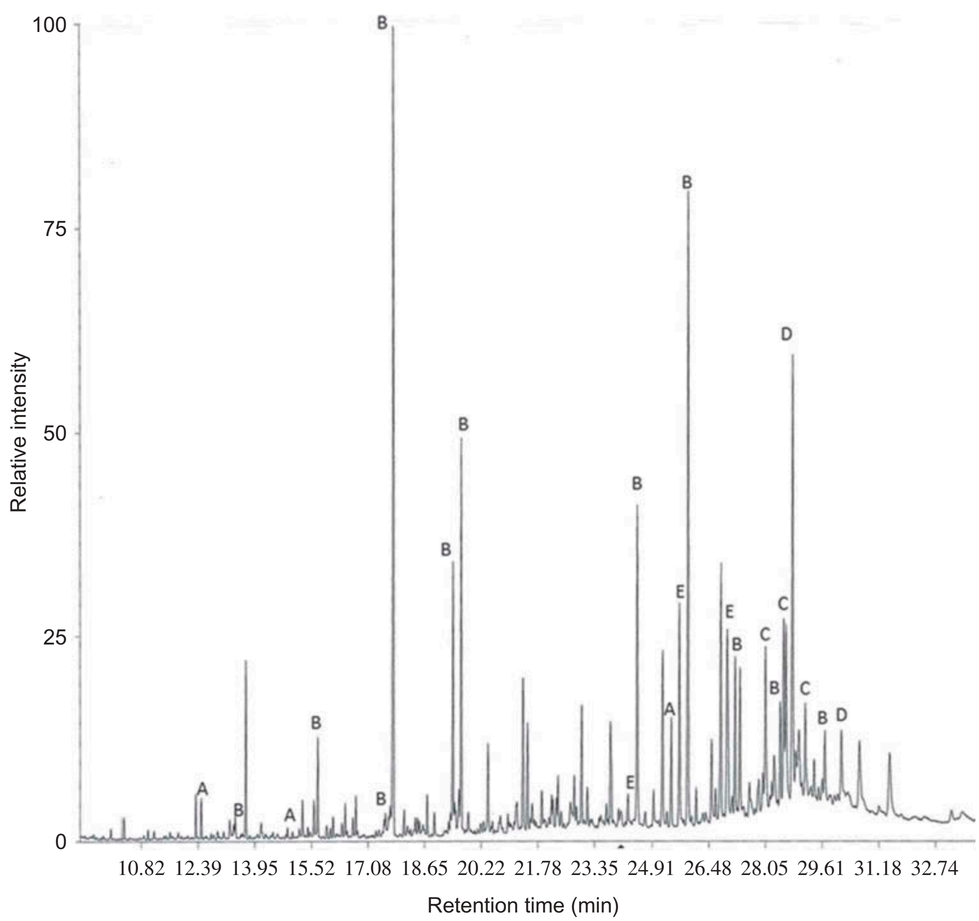

Figure 6. GC-MS chromatogram: Juellinge sample: (A) dioic acids; (B) fatty acids (saturated and unsaturated); (C) plant sterols; (D) epicuticular wax: hentriacontane-14,16-dione and 25-hydroxy-hentriacontane-14,16-dione; and (E) odd-numbered n-alkanes from C_{25} to C_{31}.

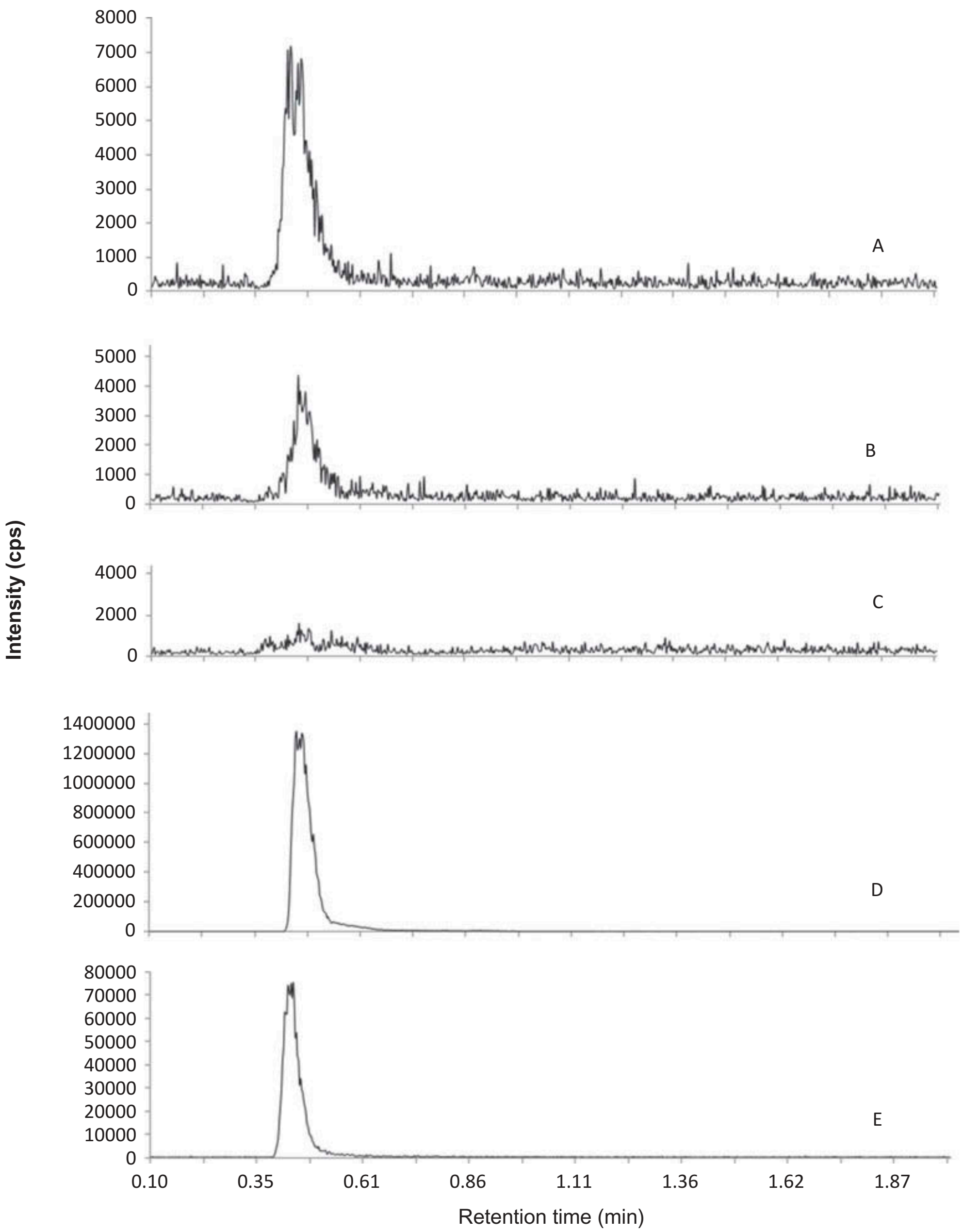

Figure 7. MRM LC/MS/MS traces of L-tartaric acid corresponding to *m/z* 149→87 molecular ion fragmentation for Kostræde (A), Juellinge (B), and Havor (C) samples, compared with standard solutions of L-tartaric acid (D) and modern generic red wine (E).

(7) The herb yarrow (*Achillea millefolium*) is indicated by copaene, γ-cadinene, and camphor.
(8) The presence of both terpineol and benzyl alcohol is consistent with bog cranberry, but weakly indicated.

Havor

(1) The absorptions in the FT-IR spectrum of the sample can all be ascribed to organic groups.
(2) Tartaric acid/tartrate is positively identified by LC/MS/MS (Figure 7). A Feigl spot test (Feigl 1966; see Supplementary Information) was also positive.
(3) According to GC-MS (Figure 8 and Tables 1, 2), the same suite of birch tree resin compounds are present in this sample as in the Kostræde sample (above). A trace of dehydroabietic acid is likely due to pine resin.
(4) Azelaic acid is again most likely a derivative of oleic acid (see Kostræde, above), but a natural source from wheat, rye, or barley cannot be ruled out.

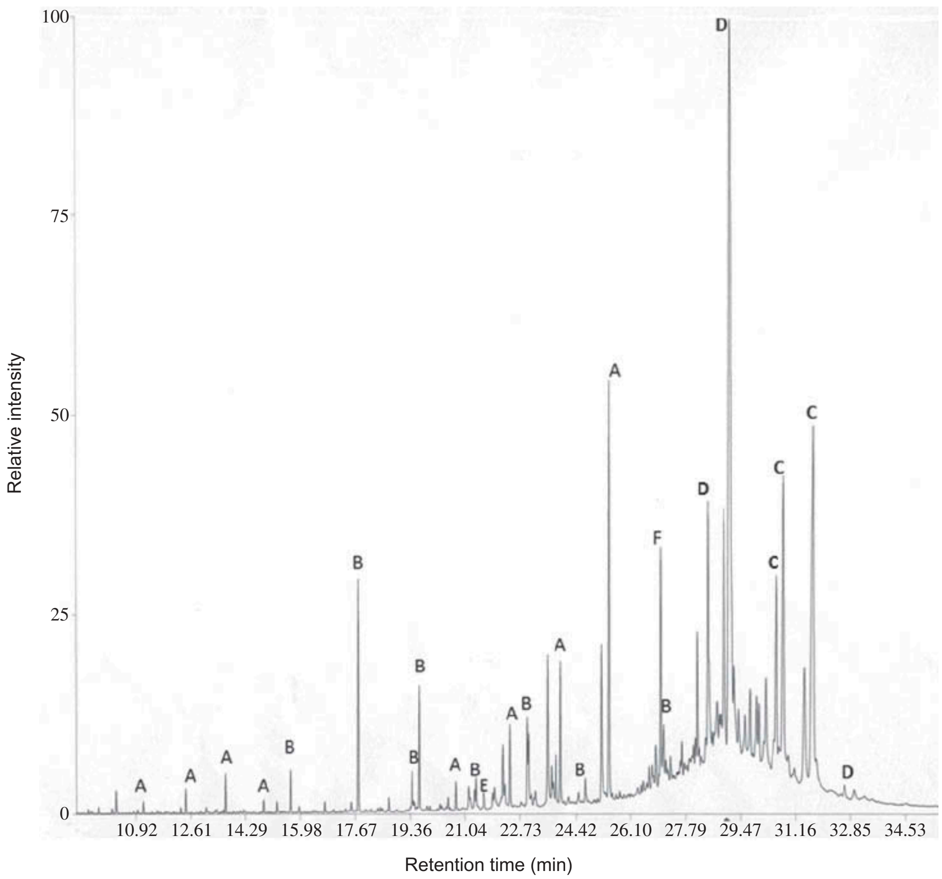

Figure 8. GC-MS chromatogram: Havor sample: (A) dioic acids; (B) fatty acids (saturated and unsaturated); (C) betulin birch resin family; (D) lupeol birch resin family; (E) pine resin family; and (F) lup-2,20(29)-diene (heat-treated birch resin marker).

(5) The high palmitic to stearic fatty acid ratio is typical of plant products. No cholesterol, characteristic of animal fats, was detected.
(6) Probable grape wine compounds are attested by SPME (Table 3), but herbal and pine resin compounds were absent.
(7) The natural source for the high level of eucalyptol (cineole) is uncertain; this compound is found in mugwort and other wormwood species, cranberry, and rosemary, which are known to have been additives to ancient European fermented beverages (see above).

Discussion and conclusions

The combined archaeological, biomolecular, and archaeobotanical evidence from four sites in Denmark and Sweden, stretched out in time over a millennium and a half (ca. 1500 BC to the first century AD), presents a coherent picture of how Nordic peoples conceived of and made their fermented beverages. In general, they preferred a hybrid beverage or 'grog,' in which various ingredients were most likely fermented together, including locally available honey, locally grown fruit (e.g., bog cranberry and lingonberry) and cereals (wheat, rye, and/or barley), and sometimes grape wine imported from farther south in Europe. Single batch fermentation, rather than separate fermentation of each beverage with subsequent mixing, best accounts for the uniformity of the beverage over time. At some stage in the process, locally available juniper, birch, and possibly pine (unless it had arrived via the grape wine from southern or central Europe), and/or herbs, especially bog myrtle and yarrow, might be mixed in. More of the fermentables might also have been added as sweeteners or flavorants after fermentation or when the beverage was served.

Nandrup

Our earliest sample from Nandrup might appear to be the most anomalous 'Nordic grog' in our corpus, because the residue inside the jar has thus far been shown to only comprise honey. This conclusion is based on well-attested palynological data, which are consistent with, but not proven, by the chemical data. The latter evidence thus far rules out any fruit being added. Herbal additives are also moot until a volatile organic analysis is carried out. Thus, the princely warrior in the Nandrup tomb, on current knowledge, most likely took an unadulterated mead to his death.

The case can be made that mead was the drink of elite northerners for millennia, whether in the Bronze Age (Koch 2003) or during Viking times (Husberg 1994). Honey is the most concentrated simple sugar source in nature, composed of 60–80% simple sugars, and procuring it in the wild (before hives were introduced, possibly as late as the first century AD) was difficult. As a relatively rare, expensive commodity, honey and its fermented beverage, mead, were likely the prerogative of the rich and powerful. The relatively high alcoholic content of mead of about 10–12% (alcohol by volume), like grape wine, contributed to its appeal. Other native fruits, grains, and natural products were lower in sugar and yielded lower alcoholic beverages. Such beverages might be enjoyed for their own sake or considered appropriate for the afterlife, as shown by barley beer in a beaker of the Single-Grave Culture, dated around 2600 BC, in a warrior burial at Refshøjgård on Jutland (Klassen 2005).

While mead might have been at the top of the Nordic drink pyramid, hybrid beverages were not far behind. The burial of a young woman in an oak coffin under a mound at Egtved in Jutland (Thomsen 1929), not far from Nandrup and of the same time period, is sufficient proof for this assertion. The woman's amazingly well-preserved attire, especially an open woolen skirt in which strings would have dangled from her hips, likely marked her as a priestess or ceremonial dancer. A large bronze belt disk at her midriff displayed interlocking spirals, which was a well-known entoptic symbol of the Nordic sun-god (Kaul 1998, 2005). Bronze Age female figurines from other Danish sites wear similar dress and jewelry, and are sometimes shown dancing with hands on their hips, arching their backs in acrobatic positions, displaying their breasts, and holding vessels. Dancers, amid spiral designs, are also shown on Scandinavian rock carvings executing backward flips, line or chain dancing, and doing the ancient equivalent of a 'jig' (conveniently illustrated in Koch 2003, see especially figs. 12.16, 12.17, and 12.18 [no. 15]).

Most importantly for the purposes of this study, a birch-bark container had been placed at the foot of the Egtved woman's coffin. The archaeobotanists B. Gram (Thomsen 1929, p. 20) and J. Troel-Smith (Christensen, Jensen 1991, p. 16) examined the container's contents and identified the remains of bog cranberries and cowberries, wheat grains, bog myrtle filaments, and pollen from the lime tree, meadowsweet, and white clover derived from honey. It was concluded that the Egtved woman likely belonged to the upper class. As such, she took to her death a special mixed fermented drink of mead, barley beer, and fruit, which might also have led to more inspired dancing during life. The bog myrtle would have given the brew a special flavor; it is still a popular additive to Scandinavian aquavits. Intriguingly, a flowering yarrow had been placed between the upper and lower halves of the coffin.

Kostræde

Our first probable evidence of imported wine in Nordic grog comes from the next sample in the chronological sequence, Kostræde, dated ca. 1100–500 BC. The chemical evidence was definitive for tartaric acid/tartrate (from the Eurasian grape, which did not grow in Scandinavia during this period), honey (likely as mead, which could more easily be filtered as a liquid than viscous honey), and birch and pine tree resins. Additives to the beverage probably included juniper and bog myrtle. Only very tentative chemical evidence was obtained for a cereal ingredient in the beverage. Archaeobotanical investigation of the Kostræde residue, yet to be carried out, might well shed light on whether a cereal, such as wheat, barley and/or rye, was also added to the beverage, making it a true hybrid beer/wine/mead.

The pine resin additive in the Kostræde beverage is not unexpected, since this tree exudate had long been used as a mastic, sealant, medicinal agent, etc., but in the case at hand, its antioxidative, preservative properties are likely the most important. Humans had discovered by the Neolithic period in the Near East that pine and other conifer resins helped to prevent grape wine from going to vinegar. The practice, along with viniculture itself, later spread to Europe. The *retsina* of modern Greece is the only modern carryover of this widespread practice of antiquity. Any wine that made the long trip to Scandinavia from southern or central Europe, such as that likely in the Kostræde beverage, might well have been protected by pine resin. Or it could have been added to the Nordic grog after it arrived.

The presence of the Eurasian grape in the mixed beverage is best explained as having been imported as wine from the south. The strainer itself was most likely made in central Europe (viz., Hungary: Thrane 1975), which might have been producing its own wine by this time or, if not, were in contact with regions farther to the south or east which were. Wine is an excellent candidate in exchange for amber in particular, since large deposits of the petrified resin occur along Baltic shores including Zealand in Denmark where Kostræde is located. The amber trade routes had already been in operation for centuries (Kaul 2013; also see Mukherjee *et al*. 2008 *re* the chemical identification of Baltic amber in a Bronze Age royal tomb in Syria).

Birch tree resin as an additive in any beverage would be intriguing, but its occurrence in the Kostræde beverage is so far the earliest chemically attested instance of such. Its use for a variety of other purposes – especially as a mastic to hold haftings onto weapons and tools and as a sealant – can be cited from northern and central Europe since at least Neolithic times. That the resin was considered fit for human consumption and might well go into a beverage is implied by the finding of lumps of it with human teeth impressions in Neolithic Swiss lake settlements and recently at a Neolithic site in Finland (Scientists find ancient chewing gum in Finland 2013). Apparently, it had been chewed as gum; since some of compounds in birch tree resin have anaesthetic and antibiotic effects, the goal might have been to alleviate pain or protect against tooth decay.

Raw birch sap, which flows in quantity from the trees in Spring, has a sugar content of 0.5–2% by weight. It can be concentrated down to much higher concentrations by heating, which appears to have been the case for the samples from Kostræde and Havor (below), based on the marker compound, lup-2,20(29)-diene. As such, it had considerable potential as a principal ingredient, or at least a fermentable adjunct, in Nordic grog. The use of lesser amounts for medicinal purposes and flavor enhancement is also possible. The common man's drink in Russia today, *kvass* (leaven), perpetuates this ancient tradition; in addition to leavened rye, wheat, or barley bread, which produce a mildly (1–1.5%) alcoholic drink, birch sap and various fruits are sometimes thrown into the brew to increase the sugar and resulting alcohol content.

Juniper might also be viewed as a curious additive to any beverage. Its unique flavor and aroma profiles, however, would have been incentives for its use. The spice was recognized for its medicinal value and flavor in Roman times (e.g., Galen, *De Alimentorum Facultatibus* [On the Powers of Foods], bk. 2) and probably much earlier. Even the invention of the popular, juniper-infused distilled beverage, gin, is attributed to a seventeenth century AD Dutch physician. More traditional Nordic beverages with juniper can be cited (also see Madej *et al.* forthcoming), including Finnish *sahti*, which like *kvass*, is made from barley, rye, wheat, and/or oats, often prebaked. On Gotland where the Havor sample (below) was obtained, the traditional beverage, *Gotlandsdryka*, is a barley beer spiced with juniper extract. Added sugar, often as honey, makes for a more powerful brew.

Bog myrtle as an additive to the Nordic grog was already known by the time of Kostræde, since it had been identified in the Egtved beverage, based on archaeobotanical evidence. Its combination with yarrow, however, is its first attestation by chemical methods. These two herbs are of special importance to European beer brewing in general. They constitute two of the principal herbs in medieval 'gruit,' which was used as the bittering agent for beers and other fermented beverages until it was displaced by hops in the sixteenth century AD throughout Europe (Unger 2007).

Juellinge

The evident association between women and the Nordic grog, which we have already seen illustrated at Egtved and Kostræde (above), is highlighted once again at Juellinge more than a millennium later during the Early Roman Iron Age (ca. 200 BC). Archaeobotanical and biomolecular analyses concur in the reconstruction of a mixed fermented fruit beverage of bog cranberry, lingonberry, and likely grape wine. The archaeobotanical investigation contributed additional information to the biomolecular investigation, viz., that barley was another main ingredient, and that the drink had clearly been fermented as shown by the yeast cells. The biomolecular investigation, in turn, provided new information that beeswax and thus honey were probably absent from the beverage. It also revealed that pine resin and juniper, together with yarrow and bog myrtle, contributed special flavors and aromas to the wine/beer concoction.

The Kostræde and Juellinge beverages are similar in other important respects: they both were made with imported, resinated wine, and both were spiced with bog myrtle and juniper. They differed in that the Kostræde drink was combined with honey mead and birch tree resin, whereas the Juellinge drink was a composite of barley beer and fruit wines made not just from grape but also native lingonberry and possibly bog cranberry.

Juellinge illustrates the pattern of importing special wine-sets in early Roman times that spreads out to encompass the rest of Denmark, southern Sweden (Scandia), Gotland, and parts of Norway and Finland in the centuries to follow. Increasingly, Roman and Greek wine-sets of large situlae, ladles, strainers, and drinking cups and horns, often of previous metals (gold and silver) and glass, were imported northwards (Hansen 1987). Indeed, the wine-set became a fixture of upper-class Scandinavian tombs, placed behind the head of the deceased. At Hoby on Lolland, not far from Juellinge and also belonging to early Roman times, a male chieftain was laid out in all his finery, which included the jug, ladle, and situla of a wine-set, a drinking horn, and two silver drinking cups with scenes from the *Iliad* (Johansen 1923). A wine-strainer, in particular, was a key item of any respectable woman's drinking repertoire for serving herself and her mate, as attested for the woman in grave 1949–2 at the wealthy, third century AD community of Himlingøje on Zealand (Hansen 1995, pp. 152–158).

The finding of the richest Bronze Age tomb thus far in Scandinavia at Kivik (Kristiansen and Larsson 2005), in the vicinity of Simris and contemporaneous with Nandrup, implies that connections between northern and southern

Europe had been in the making for over a millennium. The Mycenaean motifs (horse and chariot, boat, weaponry, sun-symbol of a cross within a circle, etc.) on the stone slabs of the burial cist at Kivik support this hypothesis in an extraordinary way, especially in light of the rich amber deposits on the nearby shores. Baltic amber is plentiful in Mycenaean tombs and palaces, and must have been exchanged for goods or items of commensurate value in the eyes of the northerners. The exchange mechanism of ideas and goods between northern and southern Europe, both direct and indirect, was complex at this time (Kaul 2013); it became more regularized in later periods.

Drinking-sets and wine might well have been two of the principal exchange commodities. Precedents for providing a drinking-set in the afterlife can be found as early as 1200 BC in the Urnfield culture of central Europe, when bronze buckets, handled cups, and strainers, like the one from Kostræde, were common items in burials. Imported drinking-bowls from central Europe, which had probably been inspired by Mycenaean prototypes, also made their way into bogs. Large 'cauldrons' or buckets were sometimes mounted on 'sun'-wheels, like those from Ystad in Scandia, Milavec in Bohemia, and Skallerup on the island of Zealand in Denmark (Rausing 1997). The later introduction of Greek and Roman drinking-sets into the continent elaborated upon this tradition, which eventually encompassed almost all of Europe.

What motivations lay behind these developments? Whether we call it elite emulation or conspicuous consumption, the rulers of Proxima Thule had much to gain by exchanging amber and other natural resources for imported goods from the south, beginning as early as the Bronze Age and reaching a crescendo by Roman times. They enhanced their status in the eyes of their subjects and the gods when they could provide them with grand feasts and offerings served up in quintessential drinking and serving vessels, which exhibited the consummate skill of the artisan. The northern rulers further set themselves apart, as much as any host of a Greek *symposion* or Roman *convivium*, when they served a more potent and distinctive version of Nordic grog, which might contain more valuable honey or imported wine than usual. The competition between Celtic chiefs to purchase only the best food and drink for their feasts and ceremonies was so intense that J. M. de Navarro (1928, p. 435) claimed that Celtic art owed its existence to Celtic thirst.

Havor

The Havor situla fits the pattern of importing both grape wine and the wine-set to go with it in Roman times. The wine was attested by multiple lines of evidence, including a Feigl spot test and, most definitively, LC/MS/MS. Since our earlier collaborator on this study, Sven Isaksson (2005), did not have access to these data when he published his analyses, he did not report the presence of tartaric acid/tartrate. There is agreement on the presence of birch tree resin compounds, which dominates the FT-IR spectrum and which, as we have already seen, laced the mixed beverage at Kostræde (above). Herb or spice additives are unlikely, based on the absence of SPME evidence. Traces of diterpenoid compounds of pine resin, which were not reported by Isaksson, show that the imported wine was probably resinated. No beeswax compounds from honey were detected, and lacking an archaeobotanical analysis, other ingredients, such as a cereal, cannot be determined. In short, the available evidence, including a very high palmitic to stearic fatty acid ratio and the absence of cholesterol (cf. Isaksson 2005), are consistent with the situla having originally contained an exclusively plant-derived product, viz., a resinated wine with added birch tree resin. It is highly probable that the 'dregs' of this beverage, which contained an elevated level of birch tree resin, was filtered through the strainer-cup, and better explain the built-up residue in its pore holes rather than its use as a censor (*pace* Isaksson 2005).

Far from having been the 'barbarians' that we might imagine them to have been from classical sources, the northern inhabitants of Proxima Thule exhibit the same innovation in making fermented beverages from a variety of natural sources that humans around the globe have shown since we came 'out of Africa.' They were not averse to adopting the accoutrements of southern or central Europeans in drinking their preferred beverages out of imported vessels of grand proportions, artistic finesse, and ostentatious materials. They were also not averse to importing and drinking the southern beverage of preference, grape wine, even if it were sometimes mixed with northern honey, fruits, herbs, and resins. To begin with, wine was a trickle, thus far first chemically attested at Kostræde (ca. 1100–500 BC). But its importation likely picked up momentum, as suggested by the results reported here from Juellinge and Havor and as will likely be filled out by future analyses, both earlier and covering the intervening time periods.

Once accepted as an alternative fermented beverage and fruit source, grape wine eventually took the northerners by storm, as a flood of the beverage was exported by amphoras and barrels up and down the principal river arteries of the continent, whose forerunners were the amber trade routes. When the Celts themselves had established a native wine making industry in southern France (McGovern *et al*. 2013), the process was inevitable.

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Supporting Information

FT-IR Analyses and Database Searches

The FT-IR data were obtained on Thermo Nicolet spectrometers, both by diffuse-reflectance on samples mixed with potassium bromide (KBr) or on neat (unmixed) samples run using a diamond cell. The primary FT-IR data are not presented here, because of limitations of space. Moreover, for the purpose of this paper, the pertinent compounds are much more exactly characterized by GC-MS, SPME, and LC/MS/MS.

FT-IR spectra were searched for "matches" against large databases of relevant natural products and processed organic materials, synthetic compounds, modern wine samples, and "ancient wine reference samples." The latter were residues from ancient vessels which likely originally contained wine, based on strong archaeological criteria or exterior inscriptions which recorded their contents.

GC-MS Extractions and Analyses

For the liquid-injection GC-MS analyses, the Nandrup, Kostræde, and Havor samples were pulverized and dissolved in a 2:1 mixture of chloroform and methanol, which was heated for 30-45 min at 60°C. The solubles were concentrated down by centrifugation and evaporation to dryness, followed by methylation with Alltech II Me-Prep. As an experiment, the pulverized Juellinge sample was put directly into Methyl Prep reagent and heated for 1 hr at 60°C. After filtering through a cotton-filled pipette, a heavier liquid had separated out; it was solubilized by adding dimethylformamide to the filtrate.

One microliter samples were injected splitless onto a 30 m x 250 μ x 0.25 μ film thickness HP-5MS column (5% phenyl methyl siloxane) of an Agilent HP 6890 GC, run at a 1.5 ml/min flow rate. An HP 5973 mass selective detector was used with the injector port at 325°C. The oven temperature was held at 50°C for 2 min, then programmed to increase at 10°C/min to 325°C where it was held for 10.5 min for a total run time of 40 min. The transfer line to the mass spectrometer was at 300°C. Compound identification was made by retention time and mass spectrum using NIST 05.

LC/MS/MS Extractions and Analyses

Approximately 10 mg samples were mixed in 5 mL of 1-2.8% ammonium hydroxide in water/methanol (80:20, v/v), stirred overnight, and ultrasonicated for 1 hr. Ammonium hydroxide enhances dissolution of tartaric acid in basic solution, so that the latter can be detected as the negative ion and its fragments. All aqueous extracts/suspensions were concentrated by evaporating the methanol and/or reducing the water content, followed by filtration through a 0.45 μm Nylon Acrodisc filter.

It should also be noted that short retention times are typical for ultrahigh performance LC methods, and present no problem in separating tartaric acid from other compounds that elute at later retention times. More importantly, our identification techniques relied on multiple factors, including retention times and accurate mass measurements that enable the unambiguous identification of tartaric acid.

SPME Analyses

Using freshly powdered samples, the headspace SPME analyses were carried out on an Agilent HP 6890 GC with a 5973 mass selective detector, equipped with an HP-5MS column (30 m × 250 μ × 0.25 μ film thickness) and Gerstel MPS2 Multipurpose Autosampler with a divinylbenzene/carboxen/polydimethylsiloxane 50/30 μm fiber. Fifty milligrams of sample were suspended in 1 mL of deionized water, to which 0.5 g of NaCl was added. The fiber was exposed to the headspace of the saline suspension at 70°C for 10 min, followed by 3 min desorption and splitless injection into the GC-MS at 250°C. To identify possible carryover compounds or contaminants, blank control samples, consisting of only the aqueous saline solutions, were run between the analyzed samples. The mass spectrometer was operated in the scan mode from 40 to 400 atomic mass units. The oven was heated for 29 min from 50°C to 250°C at 7°C/min, and a constant pressure flow rate of 1.2 mL/min was maintained on the column. The compounds were identified by matching scores of 80 or above to those in the NIST 05 and 08 mass spectral libraries (comprising more than 160,000 compounds).

Some of the compounds which were detected (Table 3), especially low-boiling compounds up to hexenal, might derive either from ancient and/or modern "background contaminants" due to groundwater percolation or sample handling (e.g., plasticizers and anti-oxidants from plastic, including compounds in the phthalate family).

SPME is of great utility in biomolecular archaeological studies. It requires only milligram quantities of valuable archaeological samples, and analyses can be performed rapidly, at lower detection limits, in an aqueous saline solution without prior extraction in an organic solvent.

Feigl Test

A Feigl (1966) chemical spot test for tartaric acid/tartrate, with microgram sensitivity, was used for only the Havor sample. A methanol extract showed a dark green fluorescence when irradiated by UV light; malic acid, one of the few cross-interfering compounds, gives a non-fluorescent greenish solution. The sample was tested together with blanks and solutions of the acids at low concentrations.

Tartaric Acid as the Principal Grape Biomarker in the Near East and Mediterranean.

Barnard *et al.* (2011) recently claimed that malvidin is a better biomarker than tartaric acid/tartrate for identifying the Eurasian grape and its products in the Near East and Mediterranean region, including Italy. However, a recent, very thorough bioinformatics search confirms the long-established and general reliability of Singleton's data (1995), viz., that the concentration of tartaric acid in grape (4000 mg/L) is twenty times that of malvidin (200 mg/L), as a conservative estimate. Natural sources for malvidin, as might be expected for a pigment, are also much more broadly distributed than plants with tartaric acid. They include pomegranate (*Punica granatum*), carrot (*Daucus carota*), apple (*Malus domestica*), whortleberry/bilberry (*Vaccinium myrtillus*), red clover (*Trifolium pratense*), and crocus (*Crocus sativa*).

Barnard *et al.* (2011) also incorrectly state that Middle Eastern hawthorn fruit has high amounts of tartaric acid. While the tartaric acid concentrations in two Chinese hawthorn species (*Crataegus pinnatifida* and *C. cuneata*) do exceed those of grape (McGovern *et al.* 2004), the chemistries of different species of the same genus in different regions of the world can vary enormously. Unless trade relations can be established by archaeological evidence between diverse regions at the time under consideration, other plants with high tartaric acid–e.g., tamarind from the Indian sub-continent, hawthorn fruit and star fruit from east Asia, or yellow plum from the New World–are irrelevant. For the period of this paper, ca. 1500 B.C. to the early 1st c. A.D. in Europe, no archaeobotanical evidence exists for these non-native plants.

Pomegranate is the only close contender to grape in having relatively large amounts of both tartaric acid and malvidin. Aarabi *et al.* (2008) state that pomegranate has about 600 mg/L of tartaric acid. But this fruit is also inconsequential for this discussion, since no archaeobotanical remains in association with European winemaking installations of the period in view have yet been reported.

Thus, if tartaric acid/tartrate is present in an ancient sample, together with alcohols, esters, aldehydes and terpenoids compounds characteristic of modern grape (as identified by SPME here), then the probability increases for a grape product.

Methodological Approach to Identifying an Ancient Grape Product as Wine

Assuming that tartaric acid/tartrate has been identified in an ancient vessel or utensil, then several other archaeological and enological factors must be assessed, to determine whether the intended product was wine and not another grape product. As argued above, the presence of the Eurasian grape in the mixed beverages is best explained as having been imported as wine from southern Europe. The grapevine did not grow in Scandinavia during this period. The admixture of pine resin in the beverages, a common preservative in ancient wines, supports this interpretation.

In terms of production of the wine in southern Europe, any grape juice there would not have remained non-alcoholic for long in a warm climate, given the slow pressing methods used in antiquity. Grape juice naturally ferments to wine in several days, because yeast (*Saccharomyces cerevisiae*) is always present on some grape skins. These microorganisms thrive in grape juice, which is an ideal medium of water and nutrients for their multiplication, and convert the sugars in the juice into alcohol and carbon dioxide.

Ancient Medicinal Wines and Mixed Fermented Beverages

Chemical analysis opens up a new perspective on ancient pharmacology, even preceding written texts, by providing contemporaneous data on the botanicals added to fermented beverages (McGovern *et al.* 2010). For example, adding a tree resin to wine, to protect against wine disease as well as for medicinal purposes and covering up off-tastes and off-aromas, was a popular and widespread practice throughout the ancient world (McGovern 2009/2010). Later literary references in Pliny the Elder, Strabo, Cato, and others make it abundantly clear that Etruscan wine from central Italy was often mixed with both fresh pine resin and processed pitch to make *vinum picatum* (Latin, "pitched wine") (Hostetter *et al.*, 1994), which left resinous splotches on sidewalls and accumulations on the bases of bronze wine cauldrons at sites throughout Etruscan and Ligurian Italy and Celtic Gaul as early as the fifth century B.C. (Bouloumié 1978). A metal such as bronze did not need to be sealed with tar, as became more customary for pottery amphoras and other containers in later periods. Resinated wines were still being made in the Middle Ages, according to the extensive agricultural and medical compilations based on classical writings, collectively known as the *Geoponica* (see Dalby 2011). The chemical evidence presented here for birch tree resin, juniper, bog myrtle, yarrow, bog cranberry, and lingonberry as adjuncts or additives in the mixed fermented beverages from Scandinavia implies that they were part of an emergent pharmacology there.

Other researchers have begun to report botanical and chemical evidence for herbal concoctions in alcoholic beverages from sites in central and southern Europe. For example, native rosemary, mint, and thyme were added to a fermented emmer wheat and barley beverage at Genó, near Barcelona in Spain, around 3000 B.C. (Juan-Tresserras 1998). Mugwort (*Artemisia vulgaris* in the wormwood family), also added to some of the early Spanish brews, was hypothesized as an additive, together with carrot, to a dark, sour barley beer (Stika 1996) at the settlement of Hochdorf of the late 5th-early 4th century B.C. This reconstruction was based on the archaeobotanical remains from probable malting and drying ditches, close to the earlier tumulus burial for the Celtic prince honored in death by a cauldron filled with mead (Vorwohl 1985). Significantly, the principal bittering agents in early medieval European beer were bog myrtle, yarrow, meadowsweet, and other herbs (Nelson 2005), which are already being used for this purpose for centuries, even millennia, earlier in Scandinavia.

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RESEARCH ARTICLE

New light on the early urbanisation of Copenhagen: with the Metro Cityring excavation at Rådhuspladsen (Town Hall square) as a point of departure

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Copenhagen's origin and early development have long been subject to study, and has since the nineteenth century resulted in numerous and sometimes conflicting theories. The dearth of large excavations in the old parts of the city in modern times has resulted in fragmentary archaeological evidence and a concomitant lack of synthesis of a more modern nature.

In connection with the current, large-scale, excavations connected to the Metro Cityring project (2009–), the Museum of Copenhagen has had the opportunity to conduct major excavations pertinent to the development of the medieval town. The site at Rådhuspladsen (the Town Hall Square) lies on the borders of the high and late medieval town, but in an area traditionally seen as located outside the earliest settlement. The preliminary results from this excavation, together with indications from excavations and watching briefs in recent years, enable us to update our hitherto knowledge and beliefs about the origins of Copenhagen. The discovery of a previously unknown cemetery at Rådhuspladsen, together with a large number of pits and wells backfilled with household refuse and waste from iron working, yields new information on the activities in the early town, and perhaps also clues to the organisation and power structure of the town's early phase.

This article sketches in broad outline the early medieval findings from Rådhuspladsen as well as some of the recent years' archaeological observations from around the city centre. Together, these form the background for a discussion on the organisation and character of Copenhagen in the early medieval period, and some preliminary hypotheses concerning the urbanisation process of the city.

Keywords: Copenhagen; early medieval; urbanisation; burials; iron working

Introduction

The question of how Copenhagen came to be is an old one, resulting in numerous and sometimes conflicting theories from historians and later on, archaeologists, from the nineteenth century onwards.[1] However, the source material has been scarce, both from a historic and an archaeological point of view (Frandsen 2001, p. 471ff.). A dearth of large excavations in the old parts of the city in modern times has kept the archaeological evidence fragmentary, a corollary of which is a lack of synthesis pertaining to the more recent archaeological evidence. Although archaeologists working in Copenhagen have been aware of the need to update the knowledge of the town's early history, this has not yet been done.

In connection with the current, large-scale Metro Cityring excavations (2009–) the Museum of Copenhagen has had the opportunity to conduct major excavations in areas pertinent to the development of the medieval town. The sites of Kongens Nytorv (*The King's New Square*; 2010) and Rådhuspladsen (*The Town Hall Square*; 2011–2012) lie on the borders of the high and late medieval town, but are traditionally seen as being located outside the earliest settlement (Gautier 1999, p. 67ff., Fabricius 2006, pp. 16–17). The preliminary results of these excavations, particularly Rådhuspladsen, together with those from the 2008 excavation of St. Clement's cemetery and a number of indications from small watching briefs around the city, allow us to update the story of the early development of Copenhagen.

Since the material is still undergoing analysis at the time of writing, the complete data from the excavation at Rådhuspladsen is not yet at hand. Therefore, this article should be considered an early presentation of preliminary results, with its main aim being to demonstrate the potential this material holds to illuminate the early urbanisation process of Copenhagen. These early findings indicate that the city's early development is a complex process with more phases and involving more agents than hitherto asserted. At present, there is insufficient empirical data to fully investigate this. However, the results obtained thus far provide some interesting insights, albeit in a preliminary form. Questions that spring to mind are: *What kind of place was early medieval Copenhagen? When and how did the town start to develop? Why did it develop as it did? And who were the people who settled here and lived their lives in the new town?*

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Figure 1. Copenhagen and the Øresund (the Sound) area, with important towns marked.

This article is part of a forthcoming larger study, treating questions on urbanisation and urbanity in medieval Copenhagen on a broader framework. The potential that this new information holds for enhancing our knowledge of Copenhagen's role in the Øresund (the Sound) area in this dynamic period is invaluable. Moreover, it would further our understanding of the general historical development in the eastern part of Denmark in the early medieval period (*c*. 1050–1200) (Figure 1).

Urbanisation and urbanity

The process of urbanisation and questions of urbanity are indeed topics central to the discipline of historical archaeology, as well as to other related disciplines, such as history, sociology and geography. It is a multidisciplinary research field, with a multitude of theoretical models and definitions attached to it.

'Urban', the key word utilised here, constitutes a central place both geographically and functionally (Andersson 2011, p. 370). A number of non-agrarian functions are placed in a specific location (a town), which has implications for the type of life and living conditions present in such a place (urbanity). Trade and craft are perhaps the most signficant of these non-agrarian functions. The location of the town is based on its communication possibilities (Andersson 2011, p. 381). The settlement is usually also characterised as being dense and organised in plots (e.g. Carelli 2001).

The process that leads to the development of a place into a town (urbanisation) is complex and differs from case to case, just as the functions of the specific town can vary (Carelli 2001, Andersson 2011). A common trait is that the town constitutes a centre of authority and organisation. Recent research has moreover focused on the possibility of urban functions, such as trade and administrative organisation existing, without a nuclear settlement which can be referred to as a town (Andersson 2011). A town also has to be considered in its wider context, as an actor in the landscape, interacting with its surrounding villages and countryside (Anglert 2006, p. 276ff., Andersson 2011, p. 371).

Previous research on Copenhagen's early period

Numerous theories abound as to how, when and where Copenhagen originated (summarised in Gabrielsen 1999, p. 9ff., Frandsen 2001, p. 471ff.). A brief overview of these theories is presented here.

Traditionally, the founding of the town is said to have occurred in 1167, when according to Saxo Grammaticus, the Archbishop Absalon is said to have built a new castle on the island of Strandholmen (Saxo Grammaticus, p. 338). Another contemporary written source is the letter Absalon received from Pope Urban in 1186, stating that King Valdemar I had given him the castle in Havn (the early name for København/Copenhagen) and what is interpreted as an estate or village of Havn (Nielsen 1877, p. 26; Jørgensen 1878, p. 293; Heise 1880–1881, p. 517; Zander 2010, p. 29). The meaning of the passages have been scrutinised by historians over the years, but there is little consensus on what Absalon was actually responsible for building, and what type of place Havn was at this time (summarised in Zander 2010, p. 29). The dating as well as

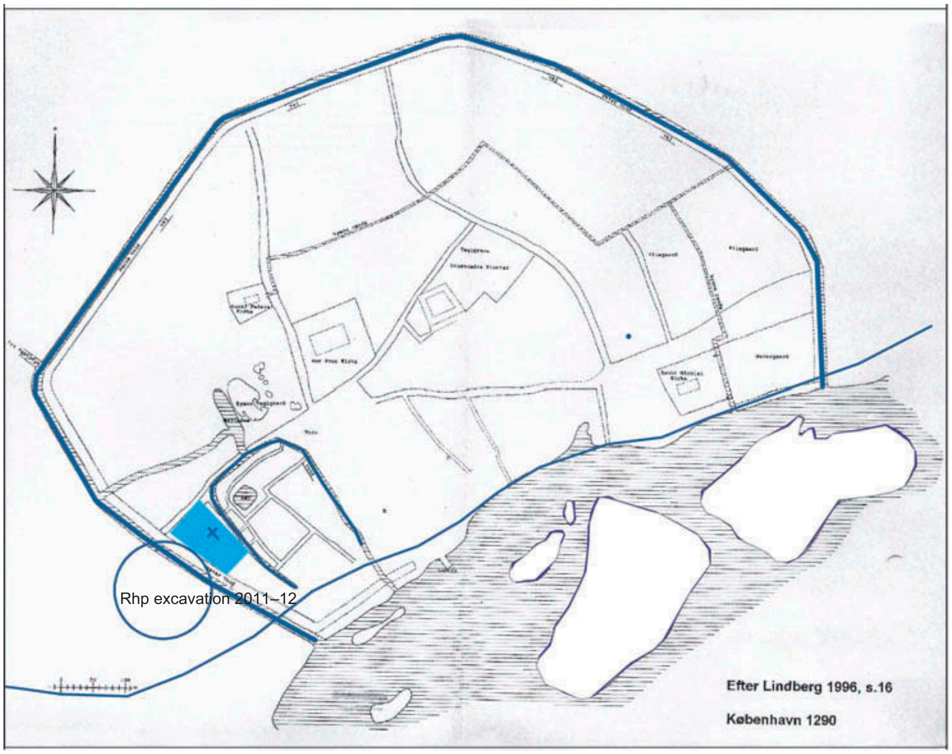

Figure 2. Small horseshoe-shaped enclosure and Skt. Clemens (St. Clement's) Church and cemetery on the background of the high/late medieval town.

the placement and function of the earliest settlement has also been subject to much debate. The general agreement though, among both historians and archaeologists, is that Copenhagen/Havn has a history predating Absalon (summarised in Gautier 1999, p. 67ff.). What kind of a place Havn was at this time, as well as the dating and placement of the earliest settlement/town, cannot however be said with certainty to have been agreed upon. The primary reason for this being the meagre archaeological source material.

The most established theory among scholars until recently has been that Havn was a seasonal marketplace, with fish as a main trading commodity, and that its importance grew during the twelfth century. The first settlement has been believed to have been located within a moat and rampart in a 2.5 ha area, with the church of St. Clement's placed outside (Skaarup 1999, p. 90ff.; Figure 2). Even with regard to these theories, however, much is uncertain: the date of the permanent settlement, the types of activities/functions, the existence of an eastern settlement and the dating of the earliest church in the town, for example.

New additions to the archaeological record

In the past 25 years, and particularly in the last 5–10 years, excavations and watching briefs around the city centre have piece by piece updated and added to the archaeological record, providing new indications on the dating and topography of the early settlement. There are, however, reservations as to the extent to which these highly limited and scarce remains can be considered as clear evidence. It is often only an isolated radiocarbon date or a few finds that constitute the grounds for dating. It is also uncertain, in some cases, as to what the archaeological source material from these excavations represents, i.e. if deposits should be seen as remains from activities at the precise location, or if the material has been transported from other places in the vicinity, to be used as infill.

With these caveats, the following map (Figure 3) and list show some of the most important locations where there are limited indications of early medieval activity, from west to east:

(1) Fredriksberggade, Vester Voldgade, Mikkel Bryggers Gade: Horseshoe-shaped ditch surrounding the enclosure: Recent ^{14}C-dating of a deposit in the ditch suggests an eleventh century date (Wozniak 2009).
(2) Vestergade 7, 1989: Clay floors and other cultural layers below the rampart – dated through pottery to the eleventh–twelfth century and stratigraphically older than the ditch (Skaarup 1999, p. 90ff.).

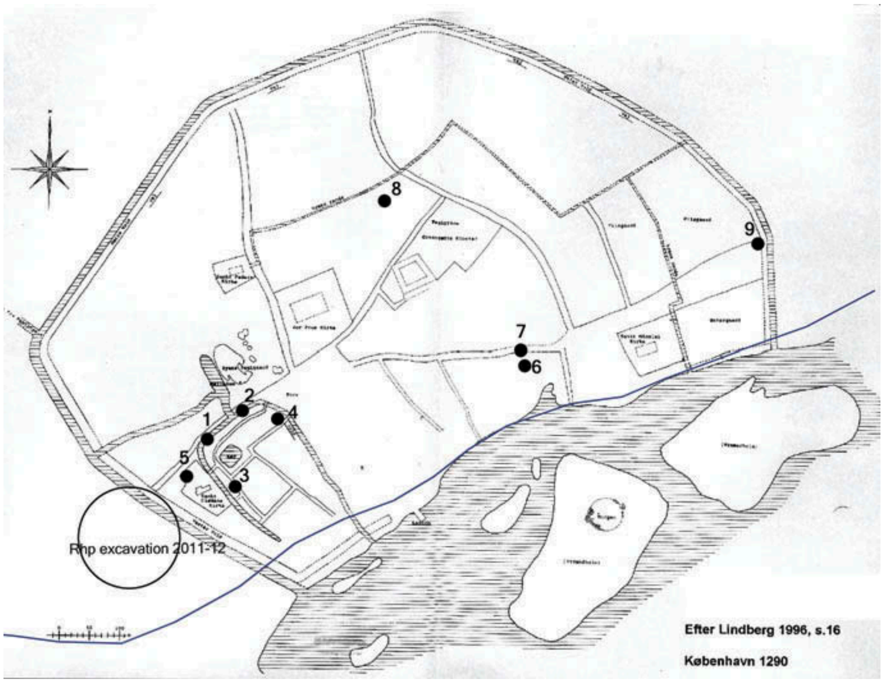

Figure 3. The medieval town. Shown here are some of the archaeological results that have enabled archaeologists and historians to rethink the dating and the extent of the early town. The map also marks the placement of the 2011–12 excavation at Rådhuspladsen (Town Hall Square).

(3) Mikkel Bryggers Gade 11–13, 1989: Cultural layers with traces of settlement and large-scale fishing, dated through pottery to the eleventh–twelfth century (Skaarup 1999, p. 84ff.).
(4) Gammeltorv 18, 2008: Cultural layers from the early medieval period, dated through ^{14}C of a charred seed. KBM 3535 (Grumløse 2008).
(5) Vestergade 29–31, 2008: Part of St. Clement's cemetery with 1048 graves from the eleventh to sixteenth centuries. Also wells and smithing activities from the same period. Early dating based on a coin reused as necklace, arm positions on buried individuals and grave types. KBM 3620 (Jensen and Dahlström 2009).
(6) Amager Torv/Højbro Plads, 1994: Cultural layers from the eleventh to thirteenth centuries, dated through finds of Baltic Ware (*c.* 1000–1200). They contained refuse from household and craft activities, and of animal husbandry. It is not certain, however, that the cultural layers were built up at the location. KBM 1213 (Johansen 1999).
(7) Amager Torv/Læderstræde 8, 2003: Five street levels were found. The deposit above the oldest one was dated with the help of ^{14}C to 1058–1156. It is, however, not certain if the layers were man-made or naturally deposited. KBM 2822 (Poilsen 2003).
(8) Regensen, 2012: Pit with ^{14}C-dating to 995 + −26 (Calendric Age, calAD; AAR-17445). At odds with this result was metallurgical analysis of a copper needle in the same pit, with a dating to 1200–1400. KBM 3824 (Winther 2012).
(9) Kongens Nytorv, 1999: Plot borders with backfills dated to 1055–1155 (^{14}C of animal bones). Containing refuse from large-scale animal husbandry. Find of a handle made of carved deer antler, typologically dated to the eleventh century (Kristiansen 1999, p. 100ff.).

The excavation at Rådhuspladsen

Although the archaeological evidence listed above attests that the extent of the early settlement appears to be different from what was previously believed, the excavation at Rådhuspladsen has given this a new perspective or dimension. Due to the location of the site outside the medieval town, it was thought to offer little potential for finding evidence of early medieval inhabitation. Contrary to this, however, a good deal of early medieval material was indeed encountered, indicating that the extent of the early medieval town goes beyond the town's later medieval borders towards the west. Yet perhaps more importantly, the excavation has produced empirical source material of such a scale that we now, with a new degree of certainty, have important information indicating the kind of place early medieval Copenhagen was.

The excavation area was placed in the north-western half of the square 'Rådhuspladsen'. It comprised of 1750 m^2 which was subject to excavation, and 2600 m^2 of watching briefs (see Figure 4). Due to intensive use of the area from the high medieval period onwards (for instance construction of multiple phases of moats and World War 2 air-raid shelters) a large part of the area was badly truncated, potentially removing early medieval cultural layers. Thus, almost all traces of activities from this period that remained were deep cuts and their fills. Therefore, we know very little of the ground level from that time, and the information we have about activities in the area is fragmentary.

The features in question were spread across the excavation area (see Figure 4). They consisted of pits, wells, simple buildings, roads and graves. From finds and

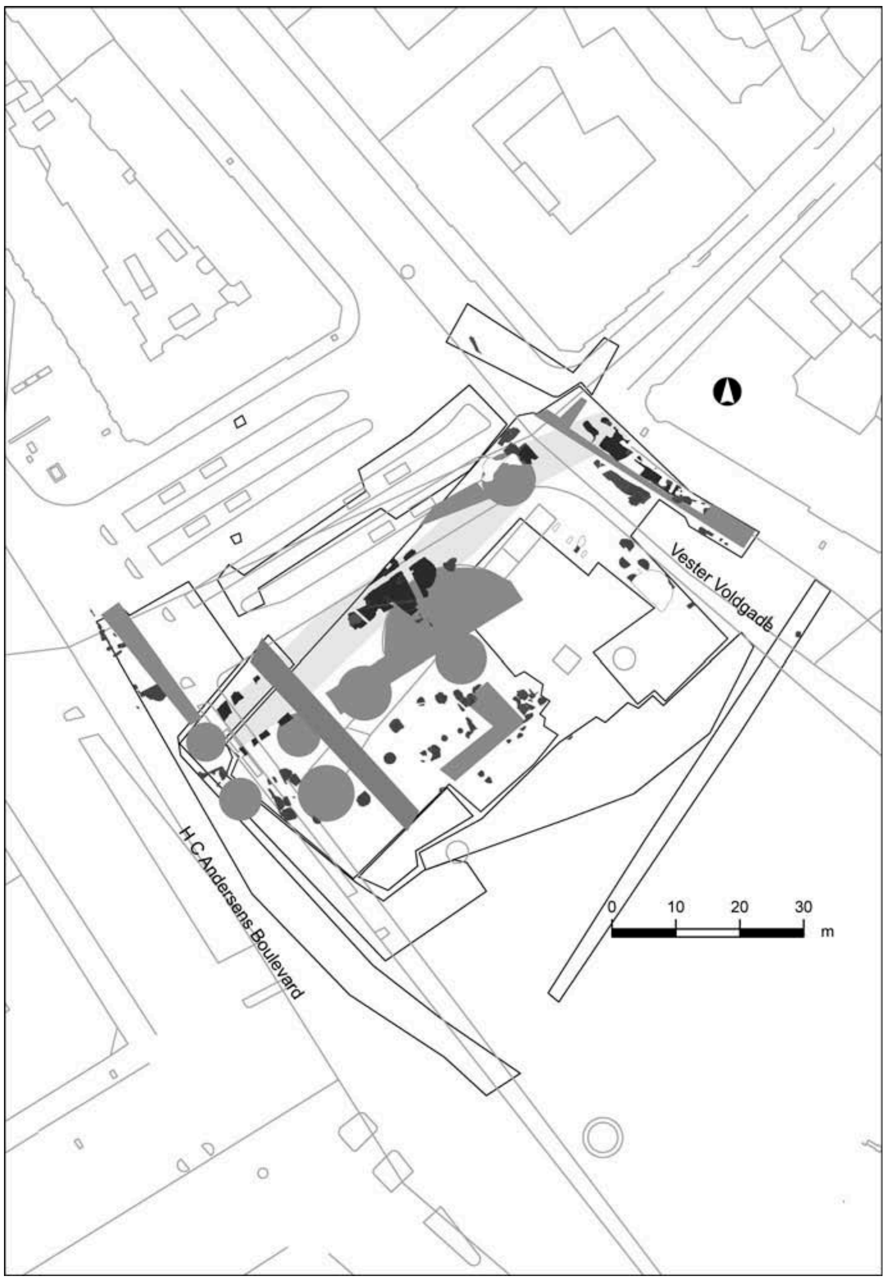

Figure 4. Plan of the excavation with all the early medieval findings highlighted in darker shading. The main truncations are marked with lighter grey. The circular, smaller, oblong features represent the WW2 air raid shelters. The diagonal lined feature in light shading is a reconstruction of the road discussed in the article, which is preserved in three different places (darker shading). The excavation trench is the large, central, rectangular figure where the modern toilet building makes up the missing piece. The watching brief trenches surround the excavation trench. It should be noted that, most of them had been dug up previously, and contained, to a large extent, disturbed soil.

stratigraphic relationships, we can date these features, in a preliminarily and broad fashion to the late eleventh–thirteenth centuries. From sometime in the fourteenth century, it is evident that most of the area has been used for other purposes. In the eastern part of the excavation area, the high medieval fortification with its moat and city gate 'Vesterport' were constructed, leaving huge cuts in the early medieval ground. No activity similar to the early medieval use of the area has been identified from the late fourteenth century onwards outside what is known as the town's high and late medieval borders (Dahlström and Lyne in prep.).

Early medieval production and settlement area

A large part of the area contained pits and well-like features that were preliminarily dated to the early medieval period through pottery and comb types found in their fills. The pits are believed to have been used for storage in connection with dwellings or productions – some might also have been used for specific purposes related to the iron production on the location (see below). There were 65 cuts interpreted as pits and 12 as wells, all but one located south of a possibly contemporaneous road running in a southwest-northeast direction across the excavation area. The road was preserved in, at least, two phases of usage, thus far broadly dated by pottery to the medieval period.

The pits and wells were situated quite close together, and contained similar fills. Some were subject to intercutting, which would suggest several phases of activity. Seen in plan view, it appears as though they were placed in a system, almost in rows at a certain distance from the road (Figure 5). This could suggest the idea of a pattern – for instance that they could be placed behind hypothetical houses that might have been located between the road and the pit/well area. This was one way of arranging household activities in medieval towns, with houses for dwelling and/or workshops/booths closest to the road, and other activities, including places for refuse disposal, placed behind them (Carelli 2001, p. 106ff.). There is also evidence, for instance from Lund in the twelfth century, that in this period with less regulated craft activities, workshops were placed far back on the plots (from Christophersen 1980, Carelli 2001, p. 144). However, no plot borders have been recorded at Rådhuspladsen. Furthermore, since the area which hypothetically would have contained houses was, to a very large extent, truncated by later activity, we do not have any archaeological data from that area – the apparent pattern of pits and wells could merely be imagined. The evidence uncovered suggests, on the one hand, that the area was mostly utilised for production and craft, and as such it would perhaps be of a less regulated character (ibid.). On the other hand, due to the large truncations, we cannot rule out the presence of dwellings and regulated plots. The find material in the deposits of the pits, both refuse from craft production as well as household refuse, also suggests the area may have been used as a combined dwelling and craft area.

The features interpreted as pits were generally quite large – one to one and a half meters in diameter and up to a meter deep. Since the edge of the cut was rarely preserved, it is difficult to know the true depth of the pit or well. The general shape of a typical pit was circular or sub-circular in plan, with vertical or evenly sloping sides and a flat base. In the primary fills, the finds were scarce, quite different from the later backfills of the pits. In some cases, it was possible that the pit had been left open for periods of time during the stage of disuse. The pits and wells had been utilised as refuse pits after the primary use had stopped. Many of the backfills contained craft-related refuse, with iron slag as a significant component. Many backfills also contained a substantial amount of fish bone

(a) (b)

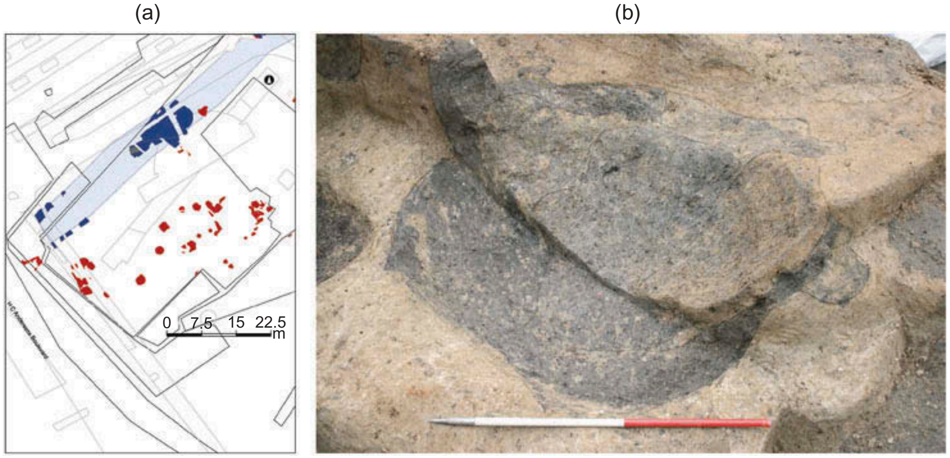

Figure 5. (a) Close-up of area with pits and wells. The reconstructed road is marked with diagonal lines. (b) Pit, pre-excavation. Photo: Museum of Copenhagen.

(a)

(b)

Figure 6. Part of a comb and sherds of Baltic Ware found in pit backfills at Rådhuspladsen. FO 200722 (a) and FO 220178 (b). Photos: Museum of Copenhagen.

and other bones. Other important find categories were pottery and bone combs (Figure 6(a) and (b)). The pottery was mainly Baltic Ware, which previously has been scarce in Copenhagen. Some pits also contained early redware and late greyware in the backfills. One pit contained a single Viking Age potsherd. Collectively, the backfills can be described as containing both craft-related and household material (Dahlström and Lyne in prep.).

The wells were between *c*. 0.6 m and 2 m in diameter, up to two meters deep and typically with vertical sides and flat bases. The distinction between pits and wells was hard to ascertain, and the interpretation was sometimes uncertain. In some of these features, the fills did not seem to be highly affected by water, and only one had an obvious lining in the form of a timber well lining. Alternative interpretations for some of these features could be some type of container – for instance a water cistern or a silo. Cisterns or silos were often placed in connection to dwellings or to other activities requiring the use of water or other storage, e.g. of grains (Karg and Lafuente 2007, p. 188ff.).

The key question concerning the original function of these finds is not conclusively answered, as yet. However, from their attributes, and the spatial relations already known, some thoughts and theories regarding their functions can be proposed at this stage. The regular shape of the majority of the finds – more or less circular, with vertical sides and flat bases – makes it plausible that they have functioned as storage (although some are definitely wells; see discussion on silos and cisterns above). This signifies that they could have been related to dwellings, even though we do not have much evidence of such structures. Pits were generally used as storage for food supplies, and they could be placed either outside the houses or under the floor indoors. The pits and wells could also have been useful for storage or specific activities related to different types of craft or production, for instance to keep raw material in a controlled atmosphere, and obviously for water which was needed for many purposes (Karg and Lafuente 2007, p. 188ff.). Furthermore, if the backfills of the pits and wells were to be seen as traces of the activities taking place on the location, it is more likely that the finds in question have been part of craft production activities. The evidence indicates that the site has been the location of iron working and possibly also of fish handling and other crafts, such as comb making. In the eleventh–twelfth centuries, craft activities were not very specialised, and generally spread across different areas around the town (Carelli 2001, p. 143, Scholkmann 2011, pp. 392–393).

As mentioned above, the pits and wells were situated south of the road running east-west. However, except for the burial area described below, almost no area to the north was available for the preservation of early medieval remains. Moreover, there were no borders or demarcations of the activities observed to the east or west in the excavation area. To the east, we know that St. Clement's Church and cemetery were situated, but we do not know how far towards the west the activities occurred.

The datings of these features rely on a combination of artefacts, stratigraphy and radiocarbon dating of seeds from primary pit fills and road layers. Since the early medieval period can be problematic to date via ^{14}C, it has to be weighed against the artefactual and stratigraphic evidence. It should be kept in mind that, the bulk of the datable finds were collected from secondary fills in pits, while radiocarbon datings mostly derive from primary deposits. Having said this, some preliminary ^{14}C-datings from primary fills of pits show a time span from the late eleventh century to the early fourteenth century. The oldest pits are dated to 1070 + −55 and thereabouts (Calendric Age, calAD, using 2 sigma; Lus 10669). The Baltic Ware pottery found in the backfills date preliminarily to the twelfth century (Figure 6(b)), while some later dated pits also had early redware and late greyware in their backfills. There are several combs of early medieval types, but they are, at this point, only preliminarily registered (Figure 6(a)). This gives an initial usage period of this area to the late eleventh to mid-fourteenth century, with the first half of this time span as the main phase.

In the eastern sector of the excavation area, closest to the central part of the town, some traces of simple buildings were found together with pits as those described above. This area was less disturbed by later activities, possibly because the rampart of the later medieval fortification may have built on top of it. Thus, some cultural layers and original topsoil were preserved. The traces of buildings consisted mainly of postholes, beam slots and fragments of clay floors. Since the undisturbed area was quite small, no complete buildings were identified. From preliminary observations there seem to have been several phases of houses. Some houses could be contemporary with the pits, but some clearly belong to different usage phases. With regard to the discussion of the kind of activities the pit-and-well-area represents, it could be argued that the better preservation conditions seen in the eastern part of the area, give an idea of how the whole of the area has been used – for dwellings and production in several phases. In this area, the Vesterport city gate was later built. Below the gate's foundation, was a stone paved layer, possibly part of an earlier road. A ^{14}C-dating from a seed found in between the stones dates to 1069 + −52 (Calendric Age, calAD, using 2 sigma; Lus 10635) (Figure 7).

Burials

Perhaps the biggest surprise of the excavation at Rådhuspladsen was the discovery of graves in the north-

Figure 7. Archaeologists from the Museum of Copenhagen working on early medieval features in Vester Voldgade. Photo: Museum of Copenhagen.

western corner of the square. A total of 18 east-west-orientated burials, and 22 individuals were registered in an area of approximately 30 m^2. The area was placed immediately north of the road which probably already at this point led into town. About 150 meters to the east, south of the same road, the church and cemetery of St. Clement's were situated from the eleventh century (Jensen and Dahlström 2009).

The graves at Rådhuspladsen were heavily truncated and disturbed by later activities. Of the 22 individuals, a total of 10 were recovered in situ, though none were complete. Some of the graves were seen only in the section towards the outer limits of the excavation area. This indicates that the burial area most likely continued both to the north and to the west.

The graves lay in up to three stratigraphic levels. On the basis of arm positions (A or B), a ^{14}C-dating of a coffin to cal AD 826 + −36 (Calendric Age, calAD, using 2 sigma; KIA 44988; in Dahlström and Lyne in prep.), as well as finds of Baltic Ware in the grave fills, the graves were preliminarily dated to the early medieval period. The early dating of the coffin timber was a surprise. Yet the wood used for the coffin could have had a considerable age when used, so no serious conclusions can be drawn from the date. At a later point, ^{14}C-samples were processed from almost all individuals (21), in order to provide more reliable information on the dating and usage period of the cemetery. The results of these confirmed the early dating of the coffin wood. It also called for further analysis of ^{13}C, to gain a more secure and relevant dating span. Depending on the amount of marine food intake by the individuals, the ^{14}C-datings need to be calibrated to be adjusted in this respect. The results of these are under analysis, but they point to a dating range of these graves to 1040–1126 (Calendric Age, calAD; preliminary report 1071, Institut for Fysik og Astonomi AMS ^{14}C Dateringscenter, Aarhus Universitet; in Dahlström and Lyne in prep.).

The remains of all individuals were analysed with regard to age, sex, height and basic pathology (Antropologisk Laboratorium, University of Copenhagen, report AS 37/2011). The analysis showed that the buried individuals consisted of women, men and children of all ages, suggesting this to have been a typical part of a settlement population. Nothing specific in terms of health or disease could be seen. The only information of particular note was the height of the two individuals where estimations could be made – a man of 179 cm, and a woman of 170 cm. No conclusions can be drawn from two individuals, but this indication is nevertheless curious in light of the fact that the individuals buried nearby in St. Clement's cemetery at about the same time were exceptionally small. Several women from the early phase of the St. Clement's cemetery (approximately dated to eleventh–twelfth centuries) were of a height of between 140 and 145 cm, and some individuals believed to be men were 162–165 cm tall (Harvig 2009). The average height of women during the Middle Ages was 160–162 cm, and the height for men 173 cm. During the Viking Age, the average heights were somewhat lower, for women 158 cm (Bennike and Brade 1999, p. 16). The individuals from St. Clement's cemetery and those from Rådhuspladsen are placed outside either side of this scale, although believed to be contemporary. The possible significance of this is worthy of investigation. Further analyses which could prove highly useful are isotope analyses which can provide information about diet, living environment and place of origin.

The layout of graves and the demographical indications can point to the burials belonging to a parish cemetery, most likely connected to a church or chapel. However, there is no information from written sources to suggest that a church was located here. In the historical records, there is no reference to more than one church during the early medieval period (KD IV, nr 125; in Zander 2009, p. 30, 76). The one church mentioned is interpreted as being the church of St. Clement's (Zander 2009, p. 76). From what we now know from the archaeological record, a new study of the references of the historical sources to churches during the medieval period would be beneficial.

The density of burials, which becomes higher towards the north, indicates that the centre of the cemetery is located in this direction, as well as the probable church. There are other indications of the full extent and placement of the cemetery. Approximately 25 m to the east, a pair of human shinbones was found at an earlier stage of the excavation, in a very small watching brief trench, which at the time was considered a stray find. Additionally, according to a note from 1954 in the museum's archive, skeletons were found outside the building which faces the north side of Rådhuspladsen, quite close to the graves found in 2011. The question then was if the skeletons should be considered as deriving from a modern murder or if they were historical (Archive note from 1954, KBM). After we checked with the police archives, it was evident that the skeletons were not modern. In view of this, it is likely that they may be a part of the newly discovered early medieval cemetery.

The stratigraphic conditions as well as the ^{14}C-results indicate that the usage period of the cemetery was fairly limited, but still more than a temporary feature. If the graves found at the Rådhuspladsen excavation were located towards the southern limits of the cemetery, and yet lay in up to three levels, that would suggest a well-established cemetery. Moreover, if these burials belong to the outer part of the cemetery, the central parts would be likely to have had a higher burial density and possibly older graves. However, since the cemetery, and its hypothetical church, is not known from written sources, it is likely that it was taken out of use quite early in the medieval period. It is tempting to see the cemetery and the activities in the pit area as a contemporary phase of activity which came to an end at one point and instead the high medieval fortification was built running through this area. Its signficance will be discussed later in the text.

In sum, the excavation at Rådhuspladsen has yielded crucial new information on the early history of Copenhagen. This information may be interpreted in the following way:

- Part of the settlement has been located further to the west than previously suggested, which could have several implications. The earliest town could have been larger in extent, or perhaps that the town's centre was located further to the west than previously believed – or that there were several settlement nuclei at this time.
- The findings seriously question the former theories about the horseshoe- shaped ditch and rampart east of St. Clement's and west of Gammeltorv as being the earliest extent of the town.
- It is likely that there has been a previously unknown church in the west – which was abandoned, possibly in the late twelfth or early thirteenth century. The presence of two churches points to social complexity, and the later abandonment of the cemetery and activity area suggests a change of organisation or power in the town (Andrén 1985, p. 33ff.; see discussion below)
- There is evidence of craft production – primarily iron working. Also significant is the occurrence of fish bone – which (depending on the scale of processing) could be seen in relation to trade.

The early settlement – or town – what type of place was it? What do the results imply about the early urbanisation of Copenhagen?

What does this new archaeological data, both from Rådhuspladsen as well as the earlier indications from around the town centre, suggest of *the type of place* Copenhagen or *Havn* was in the eleventh and twelfth centuries? Long-standing questions, such as when the oldest settlement can be *dated* to, where it was *situated*, *who* initiated the new settlement, and *why*, can now have new light shed upon them. This new information also enables us to ask questions about the people who moved to the town – about who they were, and why they settled down here. This will not be discussed in any depth, here, but left for future enquiry.

Dating, topography

Previously, it was assumed that the settlement developed possibly from the late eleventh century and onwards, but now we have more firm indications to suggest that Copenhagen could already have been a place with an urban character in the late eleventh century. The dates from St. Clement's cemetery, the ditch surrounding the horseshoe-shaped enclosure, dates from Mikkel Bryggers Gade and Vestergade as well as the ditch at Kongens Nytorv, all indicate substantial human activity already during this period, and over quite a large area. The ^{14}C-dates of the burials from Rådhuspladsen are, based on the preliminary analyses, among the earliest dates we have of activity in Copenhagen, and indicating a well-established cemetery at the turn of the twelfth century. Moreover, the dates from the production and settlement activities, starting from the late eleventh century add to the picture of Copenhagen as a busy place at the turn of the twelfth century.

The general picture of the topography of early Copenhagen may be interpreted in several ways. It may indicate that the early medieval settlement was placed along the beach in the rough shape of a long-stretched rectangle (Figure 8). Parallel to the beach, and later harbour, was a road running west-east, entering the location between the grave area and the production area at Rådhuspladsen, and ending at Kongens Nytorv. Along this road, the town developed. Alternatively, there could have been two or more nuclei, as nobleman's farms, each with its own church, cemetery and farm houses. These types of settlements from the late Viking Age and Early Medieval period have been brought to notice in recent Scandinavian research. These places often had different functions, some with specialised craft activities (e.g. Hedwall *et al.* 2013.

Towards a new 'map' of early medieval Copenhagen – a hypothesis

With the archaeological data outlined above, together with the theories presented, a new map can be suggested for how the town might have looked in the early medieval period (Figure 8). The physical map, too, has significance for the 'map of power' in the town, which will be discussed later.

What earlier was believed to be the first fortification and extent of the town could instead have been a protected marketplace, or possibly a fortified/enclosed king's or nobleman's estate. Immediately to the west, the church of St. Clement's could have been built already in the eleventh century, or early twelfth century at the latest (Jensen and Dahlström 2009, p. 55ff.). And to the west of the church (at present-day Rådhuspladsen) there seems to have been a combined production/dwelling area. North

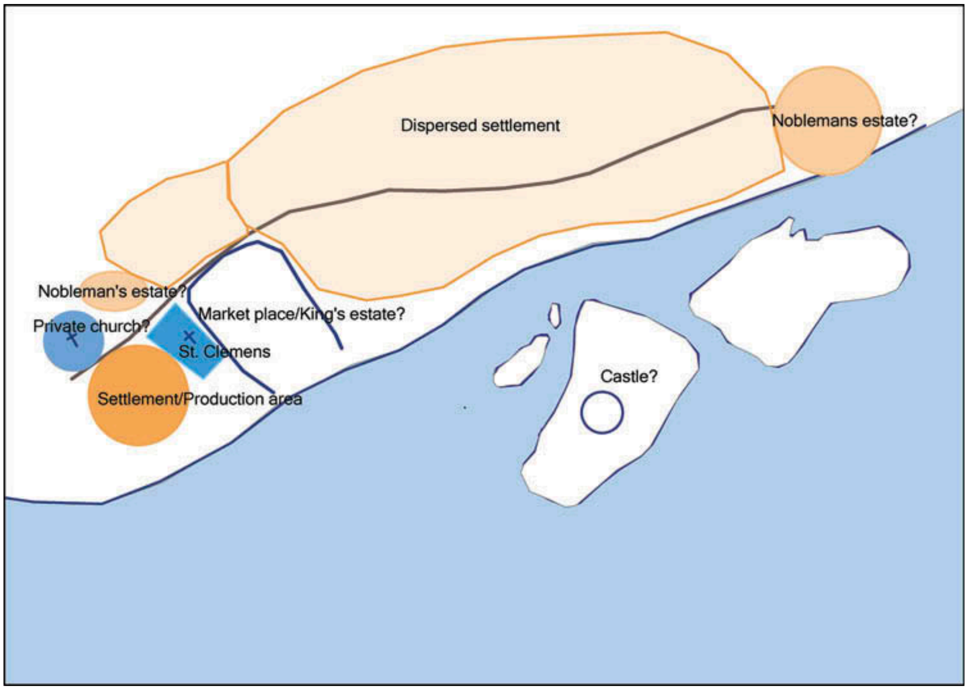

Figure 8. Map with suggested placement of different activities.

of these activity areas, a road ran in an east-west direction. North of the road adjacent to the production/dwelling area was a second cemetery. The possible church connected to the cemetery probably lay further to the north, since the grave density increased in this direction. Assuming this would probably be a private church, there could have been a nobleman's estate next to it – according to frequently used archaeological theories (Hedwall *et al.* 2013) – no archaeological evidence of this is presently at hand. In the area towards the east, from Gammeltorv all the way to Kongens Nytorv, the archaeological evidence attests that there has probably been sparse settlement activity here, much like farms, which constituted the typical layout of the early medieval town settlement, e.g. in Lund (Carelli 2001, pp. 107–108). Finally, in present-day Kongens Nytorv, plot borders and animal bones possibly from the eleventh century suggest a settlement or an estate at this location. Taking into account that this would be a logical place for docking ships coming to the town, it is also feasible that there would be some point of control here, monitoring the incoming ships. Considering the contemporary topography, the area of present-day Rådhuspladsen was then quite close to the shoreline, which could be another reason for the seemingly active use of this area – perhaps there was a second harbour or place for docking boats here?

An alternative hypothesis is the possibility of two – or more – centres in the area from present-day Rådhuspladsen (or even further towards the west) to Kongens Nytorv, in the form of several large nobleman's farms or estates. This is seen in other comparable towns, like Viborg in Jutland (Carelli 2001, pp. 119–120), Wrocław in Poland (Andersson 2011, p. 376) and Skänninge in Östergötland, Sweden (Hedwall *et al.* 2013) amongst others. The centres in early Copenhagen could have had different functions, forms of organisation and rulers. These could eventually have grown together or been merged under a common town ruler.

Activities

It has long been assumed that fishing was the dominant economic factor in the origins of Copenhagen, something which is all the more likely due to its placement by the coast and its proximity to the emerging herring market in Skanör and Falsterbo (Ersgård 1988). In many places in the town, archaeological material attests that fish was an important source of nutrition. At a few locations, for example Mikkel Bryggers Gade, fish bones have appeared in such numbers and in such a way as to suggest the handling of fish on a larger scale (Skaarup 1999, p. 88, El-Sharnouby and Høst-Madsen 2008). The clay-lined pits in Kongens Nytorv dating from the thirteenth century are another example of the economic importance of fish in Copenhagen in the medieval period (Jensen in prep.). At Rådhuspladsen, large amounts of fish bones were found in many of the pits, which initially have been interpreted as primarily storage pits, backfilled with household and production refuse. The current analysis of the type of fish bone refuse may help in assessing the scale and type of fish handling represented, and thereby provide a more nuanced and well-founded interpretation of the role of fishing in the town's early urbanisation.

The excavation at Rådhuspladsen has also yielded information about other early medieval activities. The refuse in the many pits suggests a considerable amount of iron working. The iron working refuse material is presently subject to analysis. The preliminary report, however, reveals a versatile and non-specialised production, with several active workshops. Both primary and secondary smithing have been taking place. The quality of the iron and the skills of the smiths seem to be average. The raw iron has its origin in Norway or Sweden (Jouttijärvi in prep.).

Analyses of iron smithing in Lund have indicated a shift in metal working praxis and organisation sometime in the twelfth century, when it went from being less regulated and non-specialised, with workshops all over town – to becoming a more specialised profession with its activities gathered in the same area, close to the street with its trade facilities (Carelli 2001, pp. 150–151). Seeing the iron working activities at Rådhuspladsen in the light of this, one could argue that it is the first of these phases which is seen here – non-specialised production, probably not localised in any particular area and not in close proximity to trade facilities.

When the analysis is completed, it may reveal more about the scale of the production and changes over time. This could perhaps provide clues as to whether the production was only for local use in the town or for wider distribution. The results could be a key to understanding the kind of place that Copenhagen was in the early medieval period, and if iron working was something which helped decide the further development of the town. Iron may well have had an important role for the town, which could have been a place where the raw material was taken and distributed further to the rural surroundings or other towns in Zeeland. A possible distribution route for the raw iron or iron ore could have been from Skåne, via Øresund (the Sound) to Copenhagen, where the raw iron was worked into artefacts and distributed further into Zeeland. The indications that the raw iron at Rådhuspladsen derived from Norway or Sweden show connections to other regions, direct or indirect.

There is not much evidence of other craft-related activities in early medieval Copenhagen. There is, however, one pit at Rådhuspladsen that stands out in this respect. The pit was filled with what seems to be household refuse material, although it also contained at least six combs or parts of combs (Dahlström and Lyne in prep.). The pit also contained the only sherd of Viking Age pottery from the site, along with a fair amount of Baltic Ware sherds, (Langkilde 2013). The feature was placed in the western part of the excavation area, fairly close to the burial area. Could the deposits in the pit represent some type of craft-related refuse? There was seemingly no typical production waste present, which might contradict this interpretation. Nevertheless, a find assemblage containing so many combs is unusual at the least.

Initiative and control over early medieval Copenhagen

Organisation, power and the significance of two churches

How organised were the initial activities of fishing and craft, and what trade was there and how was it organised? How much centralised control was there in early medieval Copenhagen? What can the churches reveal about the organisation of the place? What reasons might there have been for the hypothetical second church to be never mentioned in written sources? Is it possible to interpret the archaeological remains as evidence for some type of competition or power struggle in the early medieval period? These are all questions that arise when dealing with the recently recovered archaeological source material for the early urbanisation of Copenhagen.

An important key to understanding the early urbanisation of Copenhagen naturally lies in its functions – what kind of a place was it, and what occurred there? It may be argued that early medieval functions in Copenhagen, such as production and distribution of iron as well as fishing would have been under the king's control. However, there would have been local noblemen involved, who were present in the town and kept the activities and income under control. It is their presence that might be revealed by the possible existence of two churches.

Churches dedicated to St. Clement are believed to have been built by the king sometime in the mid-eleventh century. Twenty six St. Clement's churches existed in Denmark, which is by far the most in Scandinavia. St. Clement is the saint of metalworkers, blacksmiths and seamen and the churches were often built in coastal towns and there placed close to the waterfront (Cinthio 1968, Crawford 2006, p. 238). The placement and dating suggestion for the St. Clement's Church in Copenhagen to the eleventh century would fit well with these theories. It can therefore be argued that the king was in control of Copenhagen at an early stage. But what about the hypothetical second church? All in all the ^{14}C-dates suggest that this church could have been older, but still partly contemporaneous with the church of St. Clement's. What does this mean in terms of power and control over early Copenhagen?

The finding of the graves belonging to a second church is significant for several reasons. Firstly, they indicate dates that show that there has been activity in this location possibly as early as the late Viking Age. This in turn has potential to provide new information about the process of the Christianisation of Denmark. More importantly, the findings also reveal more about the type of place Copenhagen might have been during this period. If the hypothesis of two contemporary churches is correct, that would suggest more than one source of power present, with interests in the town in its early stage. This conclusion is drawn on the basis of theories that have been dominant in recent decades, which suggest that the early medieval churches were mostly private churches built by noblemen, or by kings and bishops (Carelli 2001, p. 235ff.). Moreover, when there is a reference to parishes in the Early Medieval period, many scholars believe that they should be seen in a social and economic context, rather than a territorial one, representing a group of people connected to a leader/person with power (Andrén 1985, p. 33ff., Carelli 2001, p. 235ff.). This could signify that before the king obtained control of Copenhagen, there might have been a nobleman present in the town. The nobleman might have built a church and was in that case most likely involved in the economic activities of the town at this time. However, there is nothing to suggest that there were not other actors like this in Copenhagen. Hypothetically, there could have been several different interests on several organisational levels present at the earliest stage of settlement.

Noteworthy in light of this, is the seemingly sudden change of use of the area which is now Rådhuspladsen sometime in the High Medieval period from being a busy area with craft/production activity, possibly dwellings and a church and cemetery, to a more or less unused place where the town's fortification is placed, leaving most of the former busy area outside the formal borders of the town. Could this abandonment have been the result of a decision made by the town's ruler? Should it be seen as a deliberate erasing of a competitor's territory? Is that also why the hypothetical church is not mentioned in any historical sources? Recent studies on the theme of abandoned medieval churches in Denmark show that a large number of churches possibly existed during this period which did not survive into the High/Late Medieval period (Kieffer Olsen in prep.). One example of a town with churches abandoned in this period is Slesvig (present-day German Schleswig). A historical source from the twelfth century speaks of two churches, which later did not exist, and there is archaeological evidence of even one more church, which is not mentioned at all.[2] It would be interesting to examine and compare the situation in Copenhagen in this context. The questions surrounding the churches and the role they may have played in the early urbanisation of Copenhagen is an aspect which is definitely worthy of further study before new theories can be properly formulated on the subject.

A hypothesis regarding the development of the early medieval churches in Copenhagen could be thus explained: The church to the north of Rådhuspladsen, possibly slightly older than St. Clement's, might have been a nobleman's church, belonging to a nobleman who was in control of the trade or parts of the trade over the Sound prior to the king's involvement. This nobleman perhaps later continued to be a force in the town, allied with the king, and taking care of the king's interests. Sometime in the late twelfth century, perhaps when the town was given to Bishop Absalon, his services would no longer have been required, and he would have lost his power. This could be why the hypothetical church and the cemetery were abandoned, and the area for production as well. The new ruler of the town, Absalon and his successors then began the work of constructing a town fortification which went right through this area, symbolically and physically leaving the earlier lord's land outside town.

Copenhagen – a politically strategic place in the twelfth century

It has been argued in this paper that the key to understanding the kind of place Copenhagen was, is the different activities we now have evidence for, or that from our current understandings we can assume to have taken place – craft, fishing, and most likely trade. It must be reiterated that the possibility of the existence of two mostly contemporaneous churches, too is highly significant. Combined with its central location in the Øresund area, it is quite possible that already by the early to mid-twelfth century, Copenhagen played a key strategic role in the region. It is likely that the town was some kind of hub for trade and travel, for instance between nationally important towns like Lund and Roskilde. Copenhagen was probably also a politically strategic location. It must have been increasingly important for the central powers in the early medieval period to have control over the passage between Sjælland and Skåne, both for political and economic reasons.

A town?

When did Copenhagen become a town? There seems to have been a gradual and perhaps fluctuating development in the eleventh and twelfth centuries. The *process* is more interesting than an actual founding date, which would be a simplification. My view is that at a time when fishing, iron working and presumably trade were important functions in Copenhagen, and when there is likely to have been two churches in existence controlled by two different power figures, then there is an urban character to the place Copenhagen, with a primary function as a logistical, political and economic node in eastern Denmark.

The excavation at Rådhuspladsen has produced substantial empirical data to enable us to form new theories about the earliest phase of Copenhagen, as well as allowing us to re-examine old source material and established theories in a new light. Perhaps more importantly, it urges us to raise more questions to help us further explore the society of early medieval Denmark.

Notes

1. All radiocarbon datings presented in the article are calibrated using: http://www.calpal-online.de/index.html.
2. Jakob Kieffer-Olsen, personal communication, 31 May 2013.

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RESEARCH REPORT

The introduction of ceramics in the Ertebølle Culture

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Pottery production has long been viewed as an integrated part of the Neolithic package. Instances of ceramic production in hunter-gatherer contexts have been explained by influences from early farmers. This has also been the case for the ceramics of the Ertebølle Culture. Recently, however, the discussion has become more nuanced and alternative explanations have emerged. This article argues that a focus on the life cycle of the early ceramics as well as an understanding of technology transfer as a process of cultural transmission can potentially broaden the perspective on the uptake of ceramics technology by the hunter-gatherers of northern Europe. The chaîne opératoire of the Ertebølle ceramics is analysed and a model of how a technology moves from one social setting to another is presented. In the light of this work, different approaches to the introduction of ceramics in the western Baltic are discussed. It is argued that important elements of the Ertebølle pottery tradition came from the east via Baltic exchange networks. However, the tradition was not directly transferred, and important elements appear along the way. Whether some of these elements can be ascribed to agro-pastoralist groups in the south is still uncertain.

Keywords: mesolithic; neolithisation; early ceramics; Ertebølle Culture; chaîne opératoire; technological transmission; cultural transmission; Baltic

Introduction

From the onset of the investigation of the Ertebølle Culture (EBK), ceramics have been recognised as part of this culture's inventory. Early on, it was suggested that the subsistence at the Ertebølle-type locations had been based on wild resources (Worsaae 1862, p. 62–63). As the use of ^{14}C dates spread, it was shown that the culture should mainly be placed before the onset of farming (Tauber 1971, p. 126–129, 1972, p. 109–120). Therefore, the Ertebølle ceramics came to represent a challenge to the concept of the so-called 'Neolithic package', i.e. the firm association of domesticates and ceramics.

In spite of great popularity in Western archaeology, the concept of the 'Neolithic package' has not played any major role east of the former iron curtain. Within Soviet archaeology, a radically different definition of the Neolithic developed. Here the presence of ceramics is one of the necessary criteria whilst farming is not (Dolukhanow *et al.* 2009, p. 238, Jordan and Zvelebil 2009b, p. 35, Gronenborn 2011, p. 68). This kind of Neolithic has been termed boreal Neolithic as opposed to agro-pastoral Neolithic (Davison *et al.* 2009, p. 10). For long, the confrontations between the two traditions were sparse because of political and linguistic barriers. However, within the last decade and a half, a number of scholars have suggested that there could be a connection between the hunter-gatherer associated ceramics traditions of Western Europe and the boreal Neolithic of Eastern Europe, bringing ceramics all the way from the Urals and maybe even from the Far East (Timofev 1987, p. 221, 1998, p. 225–228, Van Berg and Cauwe 1998, p. 468–470, Klassen 2004, p. 111–114, Hallgren 2004, p. 139–141, Dolukhanov *et al.* 2005, p. 1453–1456, Davison *et al.* 2009, p. 17, Jordan and Zvelebil 2009b, p. 36, 69–72, Dumpe *et al.* 2011, p. 436).

In recent years three major volumes on the origin and spread of ceramics in the context of hunter-gatherers in northern Europe and Eurasia have been published, making the debate take a major leap forward (Jordan 2009a, Vanmontfort 2010, Hartz 2011). Focussing on the EBK ceramics, a number of different hypotheses on the origin of the craft tradition are now present. They can be summarised as follows:

- The Ertebølle ceramic tradition is, along with the ceramics of the Swifterbant culture of the Netherlands and Belgium, a result of inspiration from Linear Band Keramik Culture (LBK) and post-LBK groups, combined with an indigenous coiled basket tradition and maybe similar functional demands on hunter-gatherer vessels. Though the two ceramics traditions are thought to have originated in roughly the same way, they are not related (Louwe Kooijmans 2010, p. 36).
- The Ertebølle ceramic tradition is a result of a creolisation happening when influences from the

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Boreal Neolithic and from the Agro-pastoral Neolithic met in the north-western-most Europe (e.g. Dumpe *et al.* 2011, p. 435, Hallgren 2004, p. 131–141).
- The Ertebølle ceramic tradition has its primary roots in the eastern forager-related ceramic traditions of the south-eastern Baltic, and thus in the Boreal Neolithic (e.g. Klassen 2004, p. 111–114, Gronenborn 2011, p. 68, Andersen 2011, p. 209).

While disagreement on the nature of the process can hardly be greater, new data on the production and use of the vessels have qualified the basis for addressing the introduction of ceramics in the EBK considerably (e.g. Craig *et al.* 2007, 2011, Philippsen *et al.* 2010, Glykou 2010, Dumpe *et al.* 2011, Saul *et al.* 2012).

In evaluating the introduction of a new technology like ceramics, it must be taken into consideration that pottery is not just an idea or a type of utility. Pots are the result of a process demanding skilled action upon matter, and the resulting product becomes involved with further processes, most commonly the production of food. Furthermore, the movement of the craft and related practices from one group of people to another entails cultural transmission. Therefore, I propose that examining the whole production sequence of the Ertebølle ceramics as well as viewing the process in the light of a model of technology transfer can potentially shed light on the introduction of ceramics in the Ertebølle Culture. In the following, I will review the production sequence of the Ertebølle ceramics. Then I will introduce and discuss a model of technology transfer and finally I will discuss the three viewpoints outlined above as well as new data on the spread of ceramics technology in the Baltic region in light of that model.

The Ertebølle ceramics

The area of the EBK includes present-day Denmark, the Swedish province of Scania and parts of Blekinge as well as parts of the German Schleswig-Holstein and Mecklenburg-Vorpommern, including the island of Rügen. The area of distribution in present-day Germany is still not fully established (Jennbert 1984, p. 142, figure 79, Klassen 2002, p. 306–307, 2004, p. 27 Abb. 4).

It is generally accepted that the first ceramics appeared in the western Danish area as well as in Mecklenburg-Vorpommern around 4800–4600 cal BC, around the middle of the EBK period (Richards *et al.* 2003, p. 288, Hartz and Lübke 2006, p. 64, Andersen 2010, p. 168, 2011, p. 207–208). Based on dates from food crust from vessels from the inland site of Schlarmersdorf LA 5, it has been suggested that EBK ceramics appeared substantially earlier in the inland of Schleswig-Holstein, as early as the last centuries of the sixth millennium cal BC (Hartz *et al.* 2000, p. 140, Klassen 2004, p. 109–110, Hallgren 2004, p. 136). However, a freshwater reservoir effect of significant magnitude has recently been shown to exist at Sclarmersdorf as well as in the Danish Store Åmose. This reservoir effect is called the hardwater effect (Philippsen *et al.* 2010, p. 995). It is due to fossil carbon in the ground slowly being dissolved and flowing with the ground water into the freshwater systems. The hardwater effect is in part determined by local geological and hydrological conditions. It varies through the year and between different organisms in the water, which makes a general estimation of the hardwater effect very difficult, even within a single site (Philippsen and Heinemeier 2013, p. 1091–1098). In Store Åmose, a hardwater effect of between 100 and 500 ^{14}C years has been demonstrated to exist in Mesolithic material. At Schlarmersdorf, the effect seems to be even larger. At both locations, the hardwater effect was examined by comparing dates from fishbone with dates from terrestrial material and dates from food crusts on ceramics (Fischer and Heinemeier 2003, p. 456–457, Philippsen *et al.* 2010, p. 996). The existence of the hardwater effect on the Schlarmersdorf site makes it probable that the dates of the ceramics here fall into the established time range of ceramics use in the rest of the EBK area (Hartz and Lübke 2006, p. 64). Another concern is that there is a lack of dates for the onset of ceramics production in Scania and Zealand. Whether this happens at the same time as in the rest of the area is therefore not known (Andersen 2010, p. 168, 2011, p. 208).

The EBK ceramics can be divided into two main forms, point-based vessels and low oval bowls (see Figure 1). The point-based vessels have conical lower parts, which end in a point-shaped base. The vessels' wall profiles can vary between cylindrical without any marked transition from neck to body, to distinctly S-shaped. The rim is normally everted, but straight rims are common, and incurving rims have also been found. The bases come in a number of different shapes. Some of them vary regionally whereas others coexist spatially (Prangsgaard 1992, p. 30–32, 2013 p. 283, Glykou 2010, p. 182–183). An example of the latter can be seen at the site of Neustadt LA 156 in Schleswig-Holstein where four different point shapes have been identified (Glykou 2010, p. 182). While the bases in most of the EBK area are variations of a simple conical shape, the bases found in southern Sweden and the island of Bornholm have a cylindrical ending to the cone (Prangsgaard 1992, p. 32).

The point-based vessels vary in size between small cups with a height as small as 8 cm up to very large vessels with heights up to 50 cm. Generally, the small vessels are not as common as the larger ones (Prangsgaard 1992, p. 30–31, Andersen 2011, p. 199). The low oval bowls have rounded bases and the ends can be round or pointy. Their size varies with lengths between 8 cm and

Figure 1. Examples of EBK vessels of various sizes. The upper three are point-based vessels while the lower two are lamps (reproduced from Andersen 2011, figure 2, with permission).

30 cm and widths between 3.5 and 11 cm. There does not seem to be a fixed relationship between length and width. In general, the vessels are shallow with heights up to 5.5 cm (Prangsgaard 1992, p. 37, Glykou 2010, p. 184). The low oval bowls are often interpreted as blubber lamps. This has recently been verified by lipid analysis of crusts from such bowls (Heron *et al.* 2013).

The life-cycle of Ertebølle ceramics

Within technical ceramics studies it has been emphasised that an understanding of the single elements of the ceramics must be based on knowledge of the whole life cycle of the ceramics, including production, use and discarding/disposal (Tite and Kilikoglou 2002, p.4, Tite 2008, p. 228). Here the concept of chaîne opératoire can be helpful. Chaîne opératoire is defined as a sequence of actions transforming one or more materials from their natural form into artefacts (Lemonnier 1992, p. 25–26). Although the process of pottery-making can vary a lot between different traditions, some basic stages are shared, dictated by the physical properties of the clay. In the following, I will go through the basic steps in the pottery chaîne opératoire of low-fired pottery with focus on the EBK ceramics.

Raw materials

The first stage in pottery production is to procure raw materials. These are clay and in some instances tempering material. For the purpose of making pottery, a certain content of non-plastic material in the clay is beneficial.

This can enhance the workability of the clay and help homogenous drying as well as increase resistance to thermal shock under firing and use and toughness of the finished vessel (Kilikoglou *et al.* 1998, p. 261–262, Tite *et al.* 2001, p. 303–315, Rice 2005, p 51–53). Toughness is an expression of how much energy it takes to break a piece of pottery. The ability to dissipate the energy in an emerging crack is an important component in the toughness of a ceramic ware (Kilikoglou *et al.* 1998, p. 261–262, Tite *et al.* 2001, p. 303–315, Rice 2005, p. 51–53).

The EBK potters used non-calciferous fine to coarse clays for the pointed base vessels, while fine calciferous clays often seem to have been used for the lamps (Hulthén 1977, p. 25–45, 1984, p. 201–202, Stilborg and Bergenstråhle 2000, p. 30, Dumpe *et al.* 2011, p. 434, Prangsgaard 2013, p. 288). The preference for non-calciferous clays for the pointed base vessels may be due to avoid spalling and crumbling of the ware caused by decomposed calcite (Rice 2005, p. 98), though this would normally not be a problem because of the low firing temperatures (see below). For the lamps, fine calciferous clays were probably chosen to achieve low permeability (Hulthén 1977, p. 26).

When found in nature, clay is rarely pure; it will normally contain some non-plastic elements such as sand, pebbles, other soil types or even organic material. Therefore, the addition of temper is not always necessary, and some cleaning of the clay will often be performed (Rice 2005, p. 52).

In examination of the temper used in EBK vessels, the presence of crushed granite has been observed in the majority of instances (Prangsgaard 1992, p. 35). The angled shape of the granite particles suggests that the stones were burned before they were crushed (Koch 1987, p. 108, Glykou 2010, p. 179). Burning makes it significantly easier to crush the stone. Also, the use of burned stone may point to a reuse of cooking stones as temper (Prangsgaard 1992, p. 35). Apart from granite, observations of sand, crushed feldspar, crushed quartz, grog, plant material and crushed flint as temper has been reported as well as the absence of added temper (Hulthén 1977, p. 27, table 2b, 42–48, 1984, p. 202, Andersen 2009, p. 147, Glykou 2010, p. 179, Prangsgaard 2013, p. 278). Hulthén has observed instances of grog tempering in EBK ceramics dispersed throughout the EBK area (Hulthén 1977, p. 25–49, 1984, p. 202–206). In order to positively recognise grog as temper, thin section analysis has to be performed (Koch 1987, p. 108) and since such analyses are few in number, it is hard to say how common the use of grog was.

The choice of tempering material can potentially be significant in how the clay body behaves, especially during and after burning, but also in how the process of ceramic production is perceived (Dietler and Herbich 1998, p. 253–254, Gosselain 1999, p. 218–219, Tite *et al.* 2001, p. 316–317, Tite and Kilikoglou 2002, p. 1–2). The tempering materials observed in EBK ceramics have very different characteristics with regard to both physical properties and possible cultural connotations. Experiments have suggested that the crack dissipation abilities of grog-tempered ceramics are not as good as those for ceramics tempered with quartz, sand and marble (West 1992 cited Tite *et al.* 2001, p. 316–317). As quartz makes up a significant proportion of granite, the same could be expected from granite tempering. It must also be mentioned that the concentration of non-plastic particles is an additional important factor for the properties of the ware (Kilikoglou *et al.* 1998, p. 266–276).

With regard to the possible cultural connotations linked to the use of temper, grog is different from other tempering materials in that it involves the recycling of old vessels. The use of burnt stone and plant material may also have contributed with their connotations to the perception of pottery and pottery production. The possible reuse of cooking stones seems interesting in this respect. Burnt stone was a well-known feature in EBK domestic contexts, stemming from cooking stones and stone built hearths, and it is possible that burnt stones had cultural connotations beyond their functional merits.

Preparing the paste

Preparing the clay paste aims at getting a paste with the desired qualities and consistency. Apart from the concern with wanted and unwanted contingents of non-plastics mentioned above, this involves getting the moisture level of the clay paste just right. The latter is often achieved through drying and/or soaking of the clay and subsequently adding water during the kneading, wedging or treading of the paste (Sillar 1996, p. 265, Rice 2005, p. 118–124).

Manufacturing techniques

In manufacturing a point-based vessel, the walls were built by coiling while the base was either coiled or made by pinching one or two lumps of clay into the wanted shape (Koch 1987, p. 109–110, Glykou 2010, p. 179–180). Traces of manufacture clearly show that the vessels were built from the base up (Koch 1987, p. 109–110, figure 6). This is significant as building the vessel starting from the rim would probably provide more stability of the vessel in the process and more freedom for the potter. The fact that the vessels were started from the base probably tells us something about how the vessels were conceptualised. According to Andersen (Andersen 2010, p. 170), the building technique may reflect an association with basketry as a similar procedure is used making coiled basketry. The lamps were made either entirely by pinching or by a combination of pinching and coiling (Glykou 2010, p. 181).

In principle, three different coiling techniques have been recorded for EBK pottery, the so-called H-, U- and

N-techniques (Andersen 1975, p. 57, Hulthén 1977, p. 25–35, figure 15). When using the H-technique, a coil is added to the base or the previous coil by applying pressure with a finger to the coil at even intervals, and smoothing the sides of the coils, normally downwards. The finger pressure will leave imprints of finger-tips, which can be visible when the pot breaks. The U-technique is very similar to the H-technique, with the exception that not as much pressure is added and therefore no finger impressions are present. Despite the fact that thin coils are used, the unidirectional forces exerted when coiling and smoothing will tend to result in vessel walls that are quite thick. Using the N-technique, the coils are smoothed in opposite directions at the two sides of the vessel wall, which forces the coils into an oblique shape (Koch 1987, p. 109–113).

A number of variations and intermediate forms of the three techniques have been observed. Even within the same vessel, the appearance of the coils can be different according to the part of the vessels that they form. In these cases, it appears to be a combination of non-oblique and oblique coils, the oblique coils occurring where the profile of the vessel changes from rim to belly or from belly to base. The oblique forms of the H- and U-technique may not only be related to transitional parts of the vessels, however (Koch 1987, p. 110, Stilborg and Bergenstråhle 2000, p. 33, Glykou 2010, p. 180, Andersen 2010, p. 170). Because of the more complicated picture emerging, it has been suggested that in evaluating fashioning techniques, not only the individual coil joints must be considered but also what part of the vessel they made up. Additionally, how base and rim are fashioned as well as how variations occur in the vessel wall should ideally be included (Glykou 2010, p. 180, Dumpe *et al.* 2011, p. 429). Very few analyses taking these points into consideration have yet been made. For a want of suitable alternatives, coil-joining techniques will therefore take a prominent position in the discussion of fashioning techniques below.

For the sites where the manufacturing techniques of the ceramics have been analysed, the U-technique appears at all of them, but the occurrence of two or all three techniques at the same site is common (Prangsgaard 1992, p. 34, figure 7, Glykou 2010, p. 181). In the southern Swedish area, the H-technique appears to be more frequent and common within assemblages than is the case in the central and southern parts of Jutland where the U-technique appears dominant. At the site of Neustadt in Schleswig-Holstein, the H-technique was dominant (Prangsgaard 1992, p. 34, Glykou 2010, p. 181, Andersen 2011, figure 10). At the site of Ringkloster in Jutland, a gradual change in the relative frequency of the techniques has been observed: while the U-technique was dominant throughout the sequence, H-technique was more frequent in the lower parts and N-technique in the upper parts of the stratigraphy. It was therefore suggested that the H-technique is an early feature, while the N-technique is late (Andersen 1975, p. 57–64). Yet, it also seems that no technique was absent at Ringkloster at any point in time. As H-technique is dominating the material from the site of Neustadt, which does not cover the earliest centuries of EBK ceramic-making (Hartz 2005, p. 77, Glykou 2010, p. 181), it should be taken into consideration that changes and variation in fashioning techniques could be due to a range of factors other than chronology.

Decoration

After the vessels have been shaped, they need to dry. Decoration can be applied at all stages of the drying process, giving different results and demanding different tools. The most common kind of decoration on EBK pots is ornamentation on top of the rim. This often takes the form of finger or nail impressions in the rim. Glykou has pointed out that this type of decoration follows naturally from coil building a vessel using the H-technique. The last coil is simply treated like all the other coils (Glykou 2010, p. 181).

For the lamps, rim impressions are the only known type of decoration. On the point-based vessels, decoration of the vessel walls and bases can also occur. The most common motif seems to be small pits or stab impressions placed in bands or other patterns (Prangsgaard 1992, p. 36). The band variant seems to be the only vessel wall decoration present at the sites in Schleswig-Holstein and Mecklenburg-Vorpommern (Glykou 2010, p. 183). In the southern Swedish area and the island of Bornholm, a motif consisting of large low pits covering the whole surface in no apparent order has been found. Apart from that, incised lines were also used. These can be sub-parallel or in a cross-hatched pattern (Prangsgaard 1992, p. 36, Casati and Sørensen 2006, figure 27). While decoration of the vessel walls is very sparse or totally absent in most of the area, there are local exceptions where more emphasis on decoration developed. This is the case in the eastern part of the area including the Swedish parts and Bornholm. In Scania, up to 40% of the sherds of a site can be found decorated (Stilborg and Bergenstråhle 2000, p. 34). In eastern Jutland, there is a limited group of sites featuring vessels with decorated walls in certain patterns. Here the ornamented sherds make up only a minor part of the ceramics (Andersen 2011, p. 201, figure 12).

In general, the decoration of EBK vessels suggests that this was executed immediately after the shaping of the vessel. The motifs appear to be embedded in the local art style of the time (Klassen 2004, p. 117, Andersen 2011, p. 204).

Drying

Drying the vessels is important because a rapid heating of water inside the vessel wall during firing will cause the vessel to explode. Also, too quick and uneven drying can cause cracks, and therefore drying the vessels in direct sunlight is often avoided (Rice 2005, p. 152–153). However, Rice suggests that this is not as much an issue for vessels manufactured from coarse paste (Rice 2005, p. 152), which probably means that EBK vessels could be dried in direct sunlight. The frequent rains, which appear at all times of a year in the western Baltic area, would probably pose more of a problem in drying the vessels. The drying of a vessel in temperate climate will normally take weeks (Rice 2005, p. 152), and therefore it seems likely that the vessels were put to dry in some kind of roofed structure that could shelter them from the rain. This could be within the dwelling structures or in a structure built for drying.

Firing

The firing of EBK vessels was probably performed by rapid open firing (Koch 1987, p. 113). Hulthén has observed that the vessels seem to have been fired at a temperature of around 500–600°C (Hulthén 1977, p. 26–45). In general, the temperature control of an open fire is poor, and although this can be alleviated by the way the pots and the fuel are arranged, the temperature range and magnitude vary substantially for different parts of an open fire (Gosselain 1992, p. 248–257, Rice 2005, p. 153–158). This means that there is a relatively high risk of vessel breakage during firing.

Managing the metaphysics

In sum, there are a number of different technological processes that have to be mastered in ceramic production. In addition, most ethnographically observed cases exhibit a range of social practices bound up with the technology that also has to be mastered. Rice (2005), for instance, mentions that raw material procurement in particular and shaping, drying and firing in general are stages of ceramics production, which are often the focus of rituals and taboos. She explains this as a reaction to the fact that many things can go wrong during these stages (Rice 2005, p. 115, 124). According to Gosselain (1999), people in non-Western societies will seek to control the technological process not just through technological means, but also by social means. In his study area of southern Cameroon, an unexpected failure is always explained by the breach of a prohibition, and will in general not be connected to natural causes (Gosselain 1999, p. 209, 217).

The use of point-based vessels

Points from point-based vessels have been found sitting *in situ* in hearths (Becker 1939, p. 263, Andersen and Malmros 1985, p. 81). This indicates that at least one use of the vessels was as cooking pots in direct heat as opposed to indirect heat, or stone boiling. Recent experiments involving cooking with replica vessels in open fire have shown the vessels to be quite effective cooking pots (Philippsen 2009, p. 10).

The occurrence of food crusts on EBK sherds is fairly common. These are typically situated near the bottom on the inside of the vessel and outside the rim, and sometimes contain fish remains like scales or bone fragments (Andersen and Malmros 1985 p. 84–85, Glykou 2011 p. 283). On the basis of recent lipid analysis and carbon isotope analysis of residues from two inland sites and five coastal sites, it was found that the vessels were predominantly used for processing aquatic resources. A smaller number of the residue samples had $\delta^{13}C$ values that fall within the range of ruminant adipose tissue, i.e. fat (Craig *et al.* 2007, p. 142–143, 2011, p. 17, 911–17, 912, figure 4).

Pollen analyses from food crusts may indicate that ribwort plantain and broadleaf plantain were cooked at the site of Ronæs Skov. At the same site, the find of macro remains of mistletoe leaves in food crust showed that this plant was used (Andersen 2009, p. 151-153). Recently a new method of analysing starch extracted from archaeological material has been tested on samples from food crusts on pottery from the submerged site of Neustadt (Saul *et al.* 2012). The authors are cautious in making their conclusions as the method is new and a bigger set of reference material is needed. All the samples analysed contained starches similar to that of acorn. This suggests that the processing of acorn possibly formed a major part of cooking that also involved pottery at Neustadt. In addition, it was found that sedges and reeds might also have been important plant foods. For acorn to be edible, toxic tannins have to be removed. This can be done by repeatedly heating the crushed acorn in water (Saul *et al.* 2012, p. 3489–3490) and pottery could potentially have eased this process significantly compared to other cooking technologies. Furthermore, existence of phytoliths from garlic mustard seed have been proven in food crusts on pots from Neustadt and the Zealandic inland sites of Åkonge and Stenø, indicating a practice of spicing the food in late EBK and early Funnel Beaker contexts (Saul *et al.* 2013).

The analysis of food crusts on EBK pots show exciting potential for revealing aspects of prehistoric cuisine otherwise hard to investigate archaeologically. At present, the evidence from lipid analyses as well as starch and phytolith analyses suggests that a variety of foodstuffs were processed in the vessels. Analytical challenges remain, however, as the preparation of stews with many ingredients may result in the mixed signals commonly observed, while repeated use of the same vessel for cooking different dishes probably also played a role.

The social dynamics of adopting a new technology

In evaluating the process of adoption of new technologies, it must be realised that technology is fundamentally a social phenomenon, and the cultural transmission involved will likely influence the adopting society in a broader sense (Lemonnier 1986, p. 147–153, 1992, p. 4).

Within the field of Development Studies it was realised early on that the success of the introduction of new technology is highly dependent on social factors and often has unintended social implications (Spicer 1952, p. 13–20). Working with the implications of this insight, it has been suggested that a holistic concept of technology is needed that is ontological universal and takes social factors into consideration. Within development studies, this has been intended to 'decolonise' the concept of technology (Müller 2011, p. 11). Regarding the study of prehistoric and ethnographically observed technologies, a similar concern with the Western-centric notions of the concept of technology has been voiced (Ingold 2000, p. 296–299). Using a well-defined but fairly open definition of technology may offer a productive avenue for seriously taking these concerns into consideration. I therefore focus on one of these attempts to decolonise the concept of technology within development studies. Müller (Müller 2003, p. 29) defines technology as follows:

> *Technology is one of the means by which mankind reproduces and expands its living conditions. Technology embraces a combination of four constituents: Technique, Knowledge, Organisation and Product.*

The first part of the definition is very broad and tells us that we are dealing with something of importance and necessity for all humankind. In addition, it relates technology to living conditions. At face value, the second part of the definition is the more interesting. Here the elements of technology are listed. The first element is technique, which here is perceived as the way the individual steps in the process are carried out and the physical items involved. Knowledge is seen as conscious as well as unconscious. Organisation is how the process is organised, while product signifies the material as well as the immaterial outcome. It is emphasised that the product is an embedded part of the technology. A technology is not only chosen on the basis of the desired qualities of the product but also based on qualities of the other parts of the technology.

The four elements are illustrated as pieces in a jigsaw puzzle. It is argued that a qualitative change in one element will lead to changes in the others. If this does not happen, the initial change will not be sustained. Furthermore, the analogy of the jigsaw puzzle is used to illustrate how the elements of technology are connected to other elements of society, e.g. social capital, economic organisation and ecological conditions. Changes in these external elements will therefore have the potential for changing the technology (Müller 2011, p. 14–15). An important point in Müller's work is that when a technology is moved, the technology as well as the new social context has to be adjusted to fit each other. This is the only way the technology can be successfully integrated. Neither technology nor society can stay the same (Müller 2003, p. 72).

Social carriers of technology

In order to investigate the processes involved in the introduction of new technology, it is essential, according to Müller, to focus on the relationship between actor and structure. To this end, he introduces the concept of 'the social carriers of technology'. A social carrier of technology is an actor in the form of a person or a group of people who engage in promoting the adoption of a new technology. On the basis of this concept, he builds a model of how a technology is integrated in a given society (see Figure 2). The original model is clearly concerned with modern society with access to complex technologies. Nevertheless, the underlying principles make a potentially fruitful tool for understanding the introduction of a new technology also in past societies.

The model prescribes that the introduction of a technology demands more than one social carrier of technology. The carriers form a so-called task network. I will return to this below. Six necessary conditions have to be fulfilled by actors within the task network for them to become social carriers of technology. The six conditions described as applied to a prehistoric context are as follows: (1) interest in the technology; (2) power to pursue this interest; (3) organisation for facilitating adoption of the technology; (4) information about the different technological options; (5) access to the necessary raw materials; and (6) knowledge, here taken to mean mastering the technology. The first three conditions are seen as primarily social, while the latter three are seen as being to a greater extent related to technology (the potential ones and the ones already used by the society). The six conditions are necessary but not sufficient for the adoption of a given technology.

Society or 'structure' is represented in the model by three entities: institutions, social division of labour and infrastructure. The notion of the 'task network', which essentially is what makes the system dynamic, binds these elements together. They are networks of social carriers of technology working together to promote their interests related to the new technology. Unlike the entities

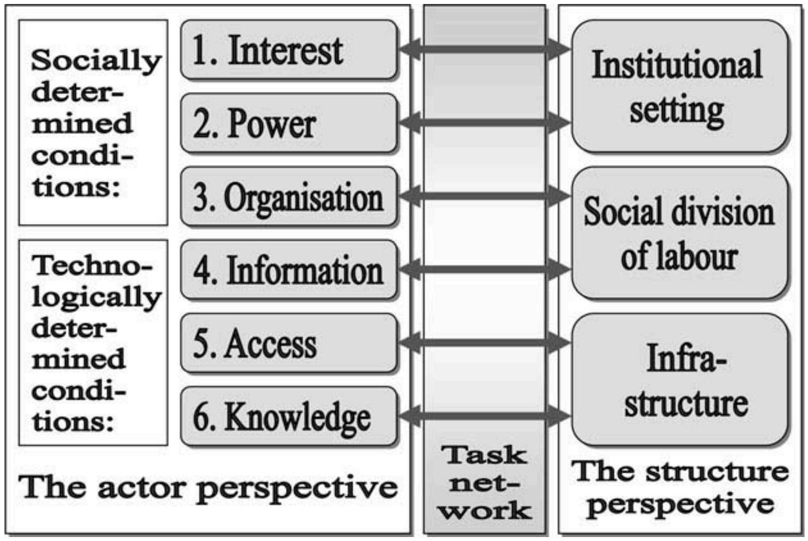

Figure 2. Müller's model for the integration of a technology into a new social setting. J. Müller 2003 © reproduced with permission. Central to the model is the relationship between actor and structure. The actor perspective is represented by six conditions, which have to be fulfilled for a social entity to become a social carrier of technology. The first three conditions are seen primarily as socially determined, while the final three are seen as primarily determined by the relevant technology. The structure perspective is represented by three aspects of society. Social entities form ad hoc task networks in order to introduce new technology into their society. In turn, these changes affect the social entities and the way they fulfil the six conditions, creating a feedback system with technological as well as social repercussions.

representing structure, the task networks have an ad hoc character linked to the new technology. Through the different ways, the six conditions are fulfilled within the task network; the social carriers of technology succeed in affecting the institutions, the social division of labour and the infrastructure. Hereby the new pieces of technology are fitted into the jigsaw puzzle of society, to use Müller's analogy.

An important characteristic of the model is that technology is not present directly but appears indirectly through the engagement of the actors. It is not 'technology meets society' but rather 'society is adjusted to fit in a new technology by the goal-directed interactions of the actors'. The model is a proposition of how the adjustment of society to a new technology can be viewed. However, the question of how technology is adjusted to fit a new social environment is not dealt with. In addition, the only actors in the model are those, which act to the benefit of the new technology. In most cases, a new technology will probably also have opponents trying to keep the social carriers of technology from changing the social structures accordingly.

To clarify how the model may be applied, I will go through in the context of the introduction of the Ertebølle ceramics. I will start with Müller's six necessary conditions.

(1) *Interest in ceramics*. It can be difficult to discern what motivates the actions of the living. Concerning prehistoric people, these difficulties are exacerbated. Obvious motives for having an interest in producing and using ceramics could be that ceramic containers can be used for cooking in direct fire, that food prepared in the vessels is associated with something desirable, or that the process of production in itself opens for something socially propitious.

(2) *Power to pursue the interest in ceramics*. This will probably relate to social position and the ability to persuade others to share the interest, or at least to not work against the adoption of the technology.

(3) *Organisation for facilitating adoption of ceramics*. This condition is linked to the former but emphasises that the social carriers of technology have to organise in a task network to achieve changes in the way activities are performed in the society. In the case of Ertebølle ceramics, other activities may have had to be rescheduled to fit in with ceramic production and use.

(4) *Information about the different technological options*. In the case of prehistory, the available technological options will often have been quite limited. Nevertheless, a new technology will always have had a precursor in an old technology and the way things used to be done. Furthermore, the Ertebølle people may have been aware of the southern LBK-associated ceramic tradition as well as the ceramic traditions east of the Baltic.

(5) *Access to the necessary raw materials*. Clay, tempering and firewood.

(6) *Mastering the chaîne opératoire of ceramics production*. Alternatively, sufficient knowledge of this process to reinvent it at home. In both cases, knowledge of how to use the vessels is also included in the condition.

The term 'institutions of society' is here taken to mean the ways in which life is organised with regard to economic, social and spiritual activities (which of course cannot be wholly separated). This could, for instance, be seasonal mobility or general worldview. The social division of labour in Ertebølle society was probably based primarily on gender and age. In addition, studies of flint knapping suggest a certain specialisation of demanding crafts (Sternke 2005, p. 158). Infrastructure is in this context viewed as the way information, artefacts and people move between groups. Prestige systems could be an example. Knowledge of the existence of a certain technology has to travel through the existing social infrastructure. The task network would consist of different individuals and groups who directly or indirectly work together to make room in the jigsaw puzzle of Ertebølle society in order to fit in the new pieces: ceramics.

The introduction of ceramics in the Ertebølle Culture could be summarised as follows. Through the pre-existing infrastructure, knowledge of ceramics is available. At some point, a number of actors within the Ertebølle society become interested in this technology. The model does not cover how this interest emerges in the first place. The interested actors will start influencing each other and organise to facilitate the interest. As part of this process, these actions influence and change the social structures. These changes will then influence the strategies of the actors. In this way ceramic production would have influenced a range of aspects of EBK society, including the planning of everyday tasks; the manner in which food was prepared; how information, artefacts and people moved around in the area; and how aspects of the world are perceived.

Technology transfer and learning

The model of social carriers of technology leaves room for various scenarios of how ceramic craft was transferred into the EBK area. To evaluate whether the craft was obtained in the form of skill or the form of inspiration, it would be useful to isolate aspects pertaining specifically to learning relationships. A study of the relations between technology, learning and ethnicity made by Gosselain (1998) amongst non-industrial potters in Southern Cameroon may be of help here. Gosselain found that whereas the techniques of most stages of the chaîne opératoire appeared to vary randomly, fashioning techniques largely followed ethnic boundaries. As the great majority of the potters in the area had learned the craft within their extended family, he ascribed this pattern to the position vessel fashioning techniques have in becoming a skilled potter (Gosselain 1998, p. 92–99). Fashioning a vessel demands the building of specific motor habits and in a sense becomes a part of the physique of the potter once acquired (see Ingold 2000, p. 351–361). Although all stages of the pottery chaîne opératoire demand skill and may be a part of the technical identity of the potter, he or she may choose to change technical behaviour at some point. According to Gosselain, the stages of pottery production most prone to post-learning change are stages that involve public actions and cooperation with others and do not to a significant degree rely on motor habits. This means that where fashioning technique seem to be related to initial learning, the techniques involved in raw material procurement, preparation of paste, firing and post-firing treatment may be related to other factors. These could be linked to the display of some form of affiliation or to the integration of the potter into a new group (Gosselain 1998, p. 100–102). Gosselain emphasises that the distribution of fashioning techniques does not necessarily correspond to ethnic or linguistic groupings, but in reality mirrors learning networks, which can occasionally transgress such boundaries (Gosselain 1998, p. 103–104).

As the training of motor habits is necessary in order to achieve the ability to build a vessel, it can be assumed that the special status associated with the fashioning techniques is common to all pottery traditions. However, Gosselain (2008) later revised this position: potters are able to modify or change their fashioning technique if they find it advantageous. He suggests that the correlation between ethnic boundaries and fashioning techniques in his study area is due to the fact that fashioning techniques are perceived by the potters as something they inherited from their teacher/predecessor. Because techniques are perceived as inheritance, they must be cherished (Gosselain 2008, p. 169–170). This special status of the fashioning techniques can be due to the fact that whereas most stages of pottery production are learned informally as the prospective potter helps out during the process, the fashioning stage is characterised by direct instructions. Often the trained potter will lead the hands of the apprentice to teach the right movements (Gosselain 1998, p. 94–95).

So, does this mean that the fashioning techniques cannot be used to establish learning relationships more generally? In my opinion, this stage of pottery production still holds a special position because of the difficulties that have to be overcome to build appropriate motor habits. However, it is an important point that potters can make changes at all stages of production if they want to. The propensity of making changes at different production stages will likely be related to the organisation of the craft in the relevant society. In the opinion of Dumpe *et al.* (2011), too much emphasis has been put on different coiling techniques in the discussion of the EBK ceramics. Rather they suggest that a wider approach to analysing the building of the vessels would be fruitful (Dumpe *et al.* 2011, p. 429–430). They caution that the H-technique should be seen as "a marker of a specific craft" (Dumpe *et al.* 2011, p. 436). From the present data, it seems that the H-technique is a phenomenon very limited in time and space compared to N- as well as U-technique (Hulthén 1977, p. 46, Koch 1987, p. 109–113, Dumpe *et al.* 2011, p. 436, Raemaekers 2011, p. 495). It must therefore be seen as plausible that potters using this technique were passing it on via detailed instruction. This would not prevent a potter from changing technique later in her or his career. Nor can it be ruled out that potters initially trained in other techniques could change their ways and adopt the H-technique.

Discussion

The three different hypotheses on how the EBK ceramics originated presented in the Introduction have quite different implications when it comes to the process of cultural transmission.

Inspired reinvention hypothesis

In the first scenario – that the EBK ceramic tradition is the result of inspired reinvention instigated by contacts with farmers – the process of cultural transmission is addressed directly. Louwe Koojimans addresses the subject in depth. He is mainly concerned with the ceramic tradition of the Swifterbant but states that he sees the process for the EBK ceramics as similar (Louwe Kooijmans 2010, p. 36).

The Swifterbant ceramic tradition of the Netherlands and the westernmost part of the German province of Niedersachsen appears around 5000 cal BC. When it was first discovered, a relationship with the EBK ceramics was proposed (De Roever 1979, p. 23, Raemaekers 2011, p. 485–486). Recently, however, the nature and closeness of the affiliation has been questioned based on differences in morphology, decoration, tempering and the absence of lamps in the Swifterbant assemblages (Andersen 2010, p. 174, Raemaekers and de Poever 2010, p. 146). Most germane to the reflections on learning relationships above, it has been shown that the assumption of similar coiling techniques appeared to derive from a conflation of terms between the research traditions of southern Scandinavia and the Netherlands. What is termed H-technique within EBK research is not present in Swifterbant ceramics (Raemaekers 2011, p. 493–495).

Louwe Kooijmans's proposes that the adoption of ceramics technology was sparked by the desire for new foods/food preparation modes. The general idea was transferred from farming societies, while the reinvention was partly based on these general ideas and partly based on known container technology, i.e. coiled basketry (Louwe Kooijmans 2010, p. 35–36). Along the same lines, Crombé *et al.* (2011) suggest that the pointed base of the hunter-gatherer ceramics is not a result of affiliation but merely a functional adaption of the vessels to transport and life in temporary camps (Crombé *et al.* 2011, p. 478).

Following this approach, cultural transmission takes on a mixed character as old traditions transmitted from generation to generation are transformed by new ideas transmitted without direct contact between the practitioners of the craft traditions. Loouwe Kooijmans suggest that the males brought home the knowledge of pottery – containers made of fired clay for cooking (in direct heat) – while the females made the transformation of the techniques of coiled basketry into a production sequence for pottery (Louwe Kooijmans 2010, p. 35).

Creolisation hypothesis

The second hypothesis is that the EBK ceramics tradition is the result of creolisation of eastern and southern ceramics traditions. Dumpe *et al.* 2011 have outlined how this could have played out. They base their proposition on a new and thorough study of Latvian Narva pottery from two sites and compare the results with those of older studies of Scanian EBK ceramics. The onset of the Narva pottery tradition is set to the second half of the sixth millennium cal BC, and the tradition continues into the fourth millennium cal BC (Dumpe *et al.* 2011, p. 412). Similarities between the Narva and the EBK pottery regarding the pointed bottoms and the presence of lamps have earlier been pointed out (e.g. Hallgren 2004, p. 139–141, Timofev 1998, p. 227). As the existence of soot traces on the Narva lamps has recently been verified, an association seemed even more likely. Yet, there are also marked differences in the tempering materials used: While shell and other organic material are dominant tempering agents in Narva ceramics, these are absent (shell) or almost absent (plant material) in EBK ceramics. Also, it is found that the technique of thinning the walls of Narva pots with a comb-like instrument after building and the adjustment of temper particle size to vessel dimensions sets the tradition apart from the EBK, where such thinning and adjustment has not been observed (Dumpe *et al.* 2011, p. 434–436). Therefore, the authors propose that shape and function of the EBK vessels were inspired by the eastern ceramic traditions – ultimately a circumpolar forager related tradition – while the technological knowledge was procured from a Western European ceramics tradition such as the LBK or Swifterbant. Furthermore, they argue that knowledge on choosing temper and clay types along with how to fire the vessels and the principles of coil building was passed on directly from members of an established pottery tradition. In contrast, the detailed knowledge on how to knead the paste into a homogeneous mass and how to join the coils was not passed on. This resulted in a comparably heterogeneous paste in the EBK ceramics along with the H-technique (Dumpe *et al.* 2011, p. 434–436).

Evaluating the potential mix of eastern and southern influences in hunter-gatherer ceramics of the Baltic, data from the Southern Baltic must be taken into consideration. In northern Poland, a few sites featuring point-based vessels and lamps have been uncovered (Nowak 2009, p. 454, Kabaciński and Terberger 2011, p. 372–374). The site of Dąbki 9 north-east of the city of Koszalin in Pomerania is the one most extensively researched and published so far. The site features rich layers of refuse thrown into a former lake. According to dates from worked bone material, occupation at the site appears to have started at around 4900/4850 cal BC and ended more than a millennium later. Ceramics are present from the start of the sequence. Around the middle of the sequence, funnel beaker ceramics begin to appear. No traces of domesticates or cultigens appear before around 3900 cal BC. The early ceramics of the site features weakly S-shaped profiled point-based vessels as well as low oval bowls interpreted as lamps. The tempering agents are mineral, mainly granite (Kabaciński and Terberger 2011, p. 362–371, Czekaj-Zastawny *et al.* 2013a, p. 198–201). Similarities with the EBK have previously been pointed out (Ilkiewicz 1989, p. 31). Of particular interest is the observation that the fashioning techniques (H-, U- and N-coiling) appeared to be similar to those of the EBK ceramics (Kabaciński and Terberger 2011, p. 372).

Yet, a recent in-depth analysis of the pottery reveals a different and more complex picture. The point-based vessels of Dąbki were made using flat, wide coils added at an angle to each other, which makes the cross-section of a vessel wall resemble that of EBK N-technique. The coiling at Dąbki was, however, applied from the inside of the vessel, whereas it is observed that in the EBK the N-coiling was done from the outside of the vessel (see Figure 3). In addition, the coils of the Dąbki vessels in general appear wider than the typical EBK coil (regardless of coil application mode), although the wall thickness of the vessels are about the same or a bit thinner at Dąbki

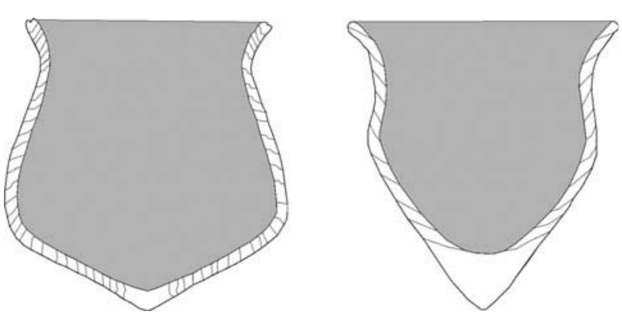

Figure 3. Schematic drawing of the fashioning techniques of the EBK ceramics (left), and Dąbki ceramics (right). After Czekaj-Zastawny *et al.* (2013b, figure 6). Used with permission.

(Prangsgaard 1992, p. 34, Czekaj-Zastawny *et al.* 2013b, p. 414–416). To find out whether or not EBK vessels with N-technique were always built from the outside will require a detailed scrutiny of the EBK assemblages. At any rate, the coiling techniques used at Dąbki and in the EBK ceramics do not appear intimately related.

Interestingly, the differences pointed out by Dumpe *et al.* between Narva and EBK ceramics seem to also differentiate Narva and Dąbki pottery: at Dąbki the vessel walls were apparently not thinned after building. Whether adjustment of tempering particles to vessels dimensions was practiced is uncertain, but the clay paste is described as heterogeneous. The tempering agents are also wholly different (Czekaj-Zastawny *et al.* 2013b, p. 414). Therefore, the same kind of process of technology transfer as suggested between Narva and EBK for ceramics can also be envisioned between Narva and Dąbki. Concerning the relationship between the ceramic tradition of Dąbki and that of the EBK, the form, function and temper appear similar. This could suggest that these elements were transferred from northern Pomerania into the EBK, while fashioning techniques were either reinvented within the EBK or transferred from somewhere else.

Following Dumpe *et al.* the process of transmission demands more intensive interaction between groups of people with different cultural affiliations than is the case for the scenario put forward by Louwe Kooijmans. For the prospective potters of the EBK (or northern Pomerania) to learn how to choose raw materials and fire the vessels, they would need to be in direct contact with the technical donors and witness quite closely the process of pottery production, albeit not necessarily as apprentices.

At Dąbki, contacts with other groups are visible throughout the sequence mainly as sherds of alien pottery. In the late Mesolithic horizon, these derive mainly from the post-LBK group of Brześć Kujawski of the Lengyel Culture, but LBK, Stroke Band Pottery culture and the EBK are also represented by a few sherds. The import ceramics from agro-pastoral groups were all thin-walled ware, and cooking pots do not seem to be represented (Czekaj-Zastawny *et al.* 2011, p. 45–46, 2013a, p. 203–204). It is suggested that people from these respective groups who frequented the site as an important node in the exchange networks of the region brought foreign pottery to the site (Czekaj-Zastawny *et al.* 2013a, p. 207). So how close were the connections between the people at Dąbki and these foreigners? And were they sufficiently close for technical elements of ceramics production to be transmitted?

Within the areas inhabited by early farmers, studies of strontium isotopes indicate that forager women of local descent joined early agro-pastoral societies (e.g. Bentley *et al.* 2003, p. 802). Likewise, a recent genetic study has shown that forager women married into farming communities, while the movement of women the other way was limited (Bollongino *et al.* 2013, p. 480–481). It has been suggested that the socially and economically complex hunter-gatherer societies of the coastal zones may have been able to build more equal intermarriage relationships with farming groups (Zvelebil 2004, p. 50).

For the hunter-gatherers of the Baltic shores, Hallgren (2009) has suggested that far-reaching social networks including the exchange of marriage partners were maintained in order to negotiate access to marine hunting. This is based partly on historical sources underlining the importance of such negotiations in the Baltic, and partly on ethnographically observed marriage structures in tribal societies. Hallgren states that exchange of spouses would probably imply visiting and feasting, increasing the possibility of craft transmission (Hallgren 2009, p. 387–388).

The relationships between foragers and farmers, and between groups of foragers, must have varied across time and space. The distances from Dąbki to the known sites of the cultural groups represented by ceramics there are considerable (<400 km; Czekaj-Zastawny *et al.* 2013a, p. 207). Whether marriage relations or other relations sufficiently intimate to facilitate the transfer of detailed technical information were upheld across these distances is difficult to discern. If such transfer did happen, the absence of agro-pastoral cooking wares at Dąbki may indicate that foragers observed pottery production at the farming villages.

A major concern when evaluating the processes involved in the origin of the earliest indigenous pottery tradition of coastal Pomerania is that it is not certain if we know anything much about the start of this tradition. As ceramics are present from the start of the sequence at Dąbki, the tradition may well be older. How the tradition originated will ultimately have to be decided by further fieldwork and detailed studies of the ceramics of the potential donor cultures. Influences from the farmer contacts incorporated later could potentially have affected the EBK ceramics.

In the EBK area, no site with so massive indications of contacts with agro-pastoral groups as that of Dąbki has been found. The evidence of contact here consists of stone axes and a few ceramic sherds manufactured in post-LBK contexts found in the EBK area, shared bone artefacts and a special flint tool that appears to share wear traces with flint implements of the LBK (Juel Jensen 1994, p. 50–58, 65–67, Klassen 2002, p. 308–313, 2004, p. 119–133). In principle, the relationships here could have been sufficiently close for detailed craft transmission to take place, making a further creolisation between east and south possible.

Eastern origins hypothesis

In the third hypothetical scenario, the EBK pottery has its primary roots in the eastern forager-related ceramic traditions of the south-eastern Baltic, and is therefore more related to the Boreal Neolithic of the east rather than the agro-pastoral Neolithic of the south. The craft travelled from the eastern Baltic via the social networks connecting the coastal areas of the Baltic Sea (Klassen 2004, p. 111–116, Andersen 2011, p. 209). The proponents of this hypothesis have not yet given much attention to the details of the cultural transmissions involved. This leaves room for various different interpretations. Mechanisms of transmission are in principle like those of the two former hypotheses, and can be envisioned alongside a version, where pottery craft travels as a package transferred by detailed instruction on all aspects of ceramics production between individuals. Although there are similarities between the EBK pottery and the slightly earlier and contemporary pottery of the eastern Baltic, there are also marked differences (Dumpe *et al.* 2011, p. 434–435). The latter version of the transfer of pottery technology touches upon one of the long-standing problems with identifying the origins of the EBK pottery: If pottery arrived as a package, why then is it so hard to establish where it came from? Following Müller's thoughts, the explanation could be that a great deal of modification of the technology was necessary for this new element to be fitted into the jigsaw puzzle of the EBK.

Evaluating the hypotheses

As mentioned above, the evaluation of whether inspired reinvention or creolisation was the main process leading to the EBK ceramics basically relies on the nature of the contacts of the involved cultural groups. Hallgren stresses that close contact does not necessarily lead to technological transmission. However, occurrences of ceramics with similar traits in groups, which appear to be connected, suggest that technological transmission between the groups did take place. The EBK sherds from Dąbki show that contacts between people here and those west of the river Oder existed at least around 4500 cal BC (Czekaj-Zastawny *et al.* 2013a, p. 204). It is tempting to assume that such contacts also existed earlier on and could have facilitated craft transmission. Another thing that seems to pose an argument against isolated inspired reinvention of the EBK ceramics is the existence of lamps in the southern and western Baltic from the Narva to the EBK. If the lamps were independently invented, there must have been a predecessor made from organic material. Furthermore, these would have been quite similar across the Baltic – again suggesting contact. All in all, I do not deem an independent inspired reinvention of ceramics likely for the EBK. Whether this model fits the Swifterbant record more aptly is beyond the scope of this article.

At present, the emerging picture indicates that form, function and maybe also temper of the EBK ceramics derived from the east. Yet, the study of fashioning techniques cannot support a notion of unbroken learning from the east. The tradition seems to break between the Narva and that of Dąbki, and again between Dąbki and EBK, though it must be remembered that fashioning techniques can essentially only support an assumption about the nature of learning relationships when sufficient likeness is observed – not the contrary. The H-technique seems almost certainly to originate within the EBK, and if not used by the first EBK potter then it became part of that tradition very early on. The question of whether any of the other coiling techniques observed in the EBK, or other aspects of vessel fashioning, could be derived from the Swifterbant or early post-LBK groups in the south cannot to be excluded at this point. A detailed technological study in line with that suggested by Dumpe *et al*. of the ceramics of different cultural groups in the area would probably have the potential of shedding new light on that particular question. Such studies may also provide new insight into the relationships between groups of the North European Plain, especially how they interacted regarding the transfer of ceramic technology. As present, it is not possible to discern whether the origin of the EBK ceramics is to be seen as a process of creolisation of eastern and southern influences, or rather eastern influences combined with local reinvention against a background of known technology.

In conclusion, I suggest that the EBK ceramics tradition owes important traits to ceramic traditions east of the area. Whether influences from the south or south-west also played a part in the beginning of the tradition is still unclear. I consider it most probable that the tradition took its beginning somewhere at the German Baltic coast, probably in the east. After pottery craft was taken up and consolidated (to a certain degree) in the German area, it spread along the Baltic coast and uplands to the whole of the EBK. During this process, the new technology had to undergo a process of adaption in principle every time it entered into a new social unit. This may in turn account for the variations in vessel morphology and decoration found within the EBK area. How fast this process of ceramisation took place cannot be established from the available dates. ^{14}C dates on the start of the ceramic sequences in Scania and Zealand would be informative to this end, along with more data from Mecklenburg-Vorpommern in general. As ceramics seem to appear simultaneously in Jutland and Funen, the spread of the technology here was probably rather rapid (Andersen 2011, p. 208). A rapid spread of the technology would indicate either that the advantage of producing and using it were obvious or that ceramics in some way got tied up with the prestige systems in the EBK.

It has been suggested that the large coastal sites of the EBK functioned as congregation camps, probably central to the exchange in the area (Johansen 2006, p. 205, Jennbert 2011, p. 101). In this respect, these large sites may have played a key role in the transmission of ceramic technology.

Incorporating ceramics into the seasonal cycle

Traditionally, sedentism along with a certain level of group size have been stressed as being of critical importance for the adoption of pottery (Eerkens *et al.* 2002, p. 200). The degree of sedentism in the EBK has been a matter of debate within the last decade (Carter 2003, Johansen 2006, Brinch Petersen 2006). Whether sedentism amongst coastal EBK groups is accepted or not, it is clear that inland sites and small sites in use only seasonally also contain pottery (Andersen 1979, p. 40–41, Hartz 1997, p. 178–183, Skousen 1998, p. 44, Kramer 2001, p. 157–159). This poses the question of whether the EBK groups that took up pottery had to change their seasonal cycle to accommodate the production of the vessels.

An archaeological study of non-sedentary hunter-gatherers in the Great Basin (USA) found that even comparably mobile groups were able to incorporate ceramic production into their annual movements. Pottery appears mostly to have been made on the spot where it was needed, and to a lesser extent carried during movement from camp to camp (Eerkens *et al.* 2002, p. 219–224). A significant difference between the Great Basin and the western Baltic with regard to pottery production is that the air humidity is considerably higher in the western Baltic (Christiansen 1999, p. 54–55), which would probably make drying of the vessels take longer, thereby prolonging the total production sequence. The faunal data from the smaller EBK sites does not allow an estimate of whether seasonal movements were frequent or only occurred a few times a year (Johansen 2006, p. 204–205).

Two models for how pottery production was incorporated into the seasonal cycle of the EBK can be proposed. The first is that production took place during the summer and enough vessels for the whole year were produced in one or a few larger batches. If the group was sedentary, the vessels were stored. If they had one or more seasonal residence changes, the pottery was transported.

The second possibility is that a few vessels were produced whenever there was a need for new vessels throughout the year.

Moving pottery around may seem inconvenient, but a common feature of EBK settlement is the location near waterways (Mathiassen 1959, p. 19, Pl. XV, Andersen 1977, p. 14–16, Jennbert 1984, p. 102–105, figure 65 and 66, Fischer 1993a, p. 59, 1993b, p. 19–35, 1997, p. 63–65). Camp movement would probably have taken place by boat. The pottery would be put into the boats during moves along with other goods and people. Producing pottery in large batches would potentially leave large amounts of sherds when misfires happened, thereby creating an archaeologically observable trace. However, the taphonomic processes of repeated site use may have obscured such concentrations. A detailed scrutiny of the published and unpublished data on some of the sites with well-stratified living floors may provide the possibility of resolving this specific problem.

It is possible that the heterogeneous paste observed by some scholars (Dumpe *et al.* 2011, p. 434) was due to pottery production being undertaken on an ad hoc basis. On the one hand, if only a few vessels were made at the time, a few times a year, it may conceivably have been harder for the potter to achieve a high level of skill. On the other hand, the fashioning of the large vessels would have been quite demanding, showing that the craft was taken to a certain level.

Whether the pottery production was worked into annual rounds of movement according to the first or the second model, it would have demanded planning in accordance with other activities. If the pottery was made on the spot of its use, the movements may have had to be scheduled so that the production sequence could be completed before it was needed for a specific task. Whatever the seasonal cycle looked like before pottery was incorporated and regardless of how the production was organised, it would probably have caused the new users to reschedule in some ways and thus to change their attendant habits.

Why go through all the trouble?

One of the explanations put forward for the invention and adoption of pottery in general is that it could have constituted a prestige technology primarily associated with ritual use. The vessels would then be used for displaying food during feasting, or otherwise forming parts of rituals (Hoopes and Barnett 1995, p. 3, Rice 1999, p. 12–14). However, it has also been suggested that such ritual pottery would be likely to receive embellishments (Rice 1999, p. 13). Although some parts of the EBK area show a higher occurrence of decorated vessels, the general impression is that decoration was not very important (Prangsgaard 1992, p. 35–36, Stilborg and Bergenstråhle 2000, p. 34–35, Glykou 2010, p.183–184). A related prestige hypothesis, which is not as dependent on the appearance of the vessels, is that they were used to prepare or store prestige foods (Hayden 1995, p. 261).

It has been pointed out that one of the advantages of pottery relative to other non-industrial container technologies is that it can be produced in large batches at a time, thus reducing the cost of the single container (Eerkens *et al.* 2002, p. 201). This virtue could be an advantage in scenarios where abundant resources were exploited in a short window of time (Jordan and Zvelebil 2009b, p. 58). At some EBK sites, this seems to have been the case. For instance, 63% of the fish bone material found at the shell midden of Bjørnsholm was from migratory species, some of which would occur in large quantities within very limited time periods (Andersen 1993, p. 88–89). Pottery would then be convenient in that a large number of vessels could relatively easily be produced immediately before the migration was expected to occur (Jordan and Zvelebil 2009b, p. 58).

Another advantage of ceramic vessels is that they are well suited for detoxification and for preparation of small food items, thereby having the potential to broaden the diet of the people obtaining pottery craft (Rice 1999, p. 8). It has been suggested that the late Mesolithic saw a broadening of the diet to include more plant foods (Andersen 2010, p. 174–175, Prangsgaard 2013, p. 287). Cooking in ceramic vessels would be an effective way to break down starches to make plant foods more nutritional. In this context, the finds of Saul *et al.* of what appears to be starch from acorn in all of the analysed food crusts from Neustadt is particularly interesting. On the basis of ethnographic observations, Saul *et al.* suggest that acorns were ground, heated in several changes of water and dried to make a storable, non-toxic food source rich in starch and fat. A population of the relevant species of oak produces a large amount of acorns at two- to four-year intervals but virtually nothing in intermittent years (Saul *et al.* 2012, p. 3490). In that way, the processing of acorn would have the same purpose as suggested for the storage of migratory marine resources – to get the most out of a periodically abundant food source.

Whether or not the utilisation of migratory marine species or acorns was part of the reason for taking up ceramics in the EBK, this new technology for preparing food would have introduced new cuisine, new ways of making and consuming foodstuffs. Cross-culturally, what you eat and how you prepare your food inevitably play a role in how identity and group affiliation are signified (Belasco 2008, p. 15–33). This aspect of the new technology must have played a part in the motivation for taking it up and in the negotiations associated with making it fit with other aspects of EBK society.

Unlike the point-based vessels, the lamps were probably not directly associated with food preparation. Cooking would formerly have been undertaken using different technologies such as boiling in soft containers and roasting. Likewise, there could have been organic predecessors of the lamps, which have left no archaeological trace. If such lamps did exist, a new version made in a hard and durable material seems to be quite an improvement. On many sites, lamp sherds are very few compared with sherds of point-based vessels, while at some sites the lamp sherds are totally absent (Andersen 2010, p. 173, 2011, p. 206). In comparing these vessel types, it should be taken into consideration that the lamps are considerably smaller than the point-based vessels and sometimes a careful examination is necessary to identify the lamp sherds. Therefore, it cannot be ruled out that the wish for this new light source could have been a major or important additional incentive for taking up ceramic production.

The rise and introduction of the EBK ceramics

In summary, I propose that important aspects of ceramic technology were carried by and through the networks of the Baltic coast from the south-eastern Baltic, over the southern Baltic and into the western Baltic. Along the way, aspects of the technology appear to have changed at least twice, which indicates that traditions were not only changed to fit into new contexts, but also that a direct learning chain was not upheld. Whether elements of agro-pastoral ceramics were worked in along the way remains unclear.

Adopting ceramics technology would probably have played out as numerous negotiations between individuals advocating the new craft and individuals in favour of keeping things as they used to be. Through these negotiations, aspects of the EBK way of life were changed so that the new element could fit into the routines, dietary customs and metaphysics.

Concerning cuisine, it would be very interesting to examine if the high frequency of acorn starch in the Neustadt food crusts represents a general trend within the EBK. Further analysis of food crusts from the southern and eastern Baltic would be very interesting, potentially shedding light on the degree to which the cuisine followed the containers. The content of the vessels is an important aspect of pottery, which potentially could further qualify the discussion of the spread of ceramics along with the physical properties. Considerations of the latter have hitherto made up the foundation of the evaluations of the topic.

Can the adoption of ceramics in the EBK be viewed as part of a neolithisation process? From the present evidence, it seems clear that the EBK people were not 'trying out' a part of an agro-pastoral Neolithic package before 'buying the whole thing'. The concepts of the agro-pastoral Neolithic and the boreal Neolithic carry within them notions of increased social complexity and sometimes also sedentism (Davison *et al.* 2009, p. 10, Dolukhanow *et al.* 2009, p. 237–238). The matter of sedentism is a contested one. Different use patterns may have existed in different types of landscapes in the late EBK (Johansen 2006, p. 207–208). The general picture of the EBK indicates an overall stability throughout the time period in question. Yet, during the late EBK, the numbers and sizes of the settlements seem to increase (Andersen 1995, p. 48, Johansen 2006, p. 218). Increased evidence of contact with farming communities in the south in the form of imports and shared material culture characterise the late EBK (Klassen 2004, p. 109). It has also been suggested that exchange networks in the Baltic became of increased importance during this time (Timofev 1998, p. 228–234, Zvelebil 2006, p. 180–184). If population density increased, it is likely that social complexity did alongside. The increasing evidence of exchange with other cultural groups may be connected to the mediation of such increased complexity. If the adoption of pottery is seen as connected to these processes, we are left with a picture of neolithisation in the boreal sense.

Some have suggested that in the fifth millennium cal BC, the northern fringes of the North European Plain was characterised by agro-pastoralists and foragers mutually advancing their material cultures to each other, eventually amongst others resulting in an agro-pastoral life style suitable to large parts of the hunter-gatherers of northern Europe (Louwe Kooijmans 2005, p. 269, Bogucki 2008, p. 62–63, Czerniak and Pyzel 2011, p. 350–356). If ceramic traditions of agro-pastoral origin contributed to the ceramic traditions along the Baltic coast, such contributions must be viewed as one element within a wider framework of technology transfer processes that, when taken together, led to the eventual agro-pastoral neolithisation of the northern fringes of the North European Plain.

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RESEARCH REPORT

Cereal cultivation in east-central Jutland during the Iron Age, 500 BC–AD 1100

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This article aims at presenting a cereal cultivation history for the Iron Age (500 BC–AD 1100) in east-central Jutland (Vejle and Århus County).

The developments in cereal cultivation are presented based on recent investigations of material from the Iron Age sites of Gedved Vest and Kristinebjerg Øst, as well as a compilation of 10 previously analysed sites.

The combined data show that barley (*Hordeum vulgare*) was the dominant cereal throughout the period, with a seemingly rapid shift from naked barley (*Hordeum vulgare* var *nudum*) to hulled barley (*Hordeum vulgare* var *vulgare*) around the year 1 BC/AD. Rye (*Secale cereale*) is present in archaeobotanical assemblages throughout the period, but secure evidence of its cultivation exist only from the end of the second century AD onward. From the fourth century AD onward, the record indicates that rye may have been utilised as a dominant crop alongside barley.

The cultivation of subdominant cereals, hulled wheats (*Triticum dicoccum/spelta/monococcum*), naked bread wheat (*Triticum aestivum*) and oat (*Avena sativa*), is also discussed. A reappearance of naked barley during the fourth to sixth century AD is also elaborated upon.

Agricultural strategies are assessed based on the material and an interpretation is put forward that cultivation from the fifth century BC to at least the third century AD took place on manured, spring sown fields, which were slowly rotated between cultivation and fallow. The shift toward crop-rotation of barley and rye is also investigated; tenuous evidence of which are dated to the late second century AD and secure evidence occurring from the ninth century onward.

The article also addresses issues of archaeobotanical interpretation, and a way of increasing the resolution of archaeobotanical investigations is illustrated by examples from Gedved Vest where plant macrofossil analysis was combined with geochemical (phosphate analysis and analysis of soil organic matter) and geophysical (magnetic susceptibility) methods.

Keywords: cereal cultivation; Iron Age; Jutland; Denmark; south Scandinavia; archaeobotany; plant macrofossil analysis; phosphate analysis; magnetic susceptibility; settlement archaeology

Introduction

Since its introduction, around 4000 BC, cereal cultivation has been one of the primary components of the subsistence economies of southern Scandinavia.

The discipline of archaeobotany, with a history of research in south Scandinavia spanning over a hundred years, has since its very beginning pursued the study of cereal cultivation as one of its main research areas (Robinson 1994, Grabowski 2011, and therein presented historiography). The ongoing accumulation of archaeobotanical data has provided archaeology with numerous insights about cereal cultivation and its links to other facets of prehistoric societies.

The always fragmented nature of the archaeological record, as well as the changing geographic, methodological and theoretical focus of archaeologists has, however, resulted in the insights of archaeobotanical research being unevenly distributed. This particularly applies to geographic and chronological coverage, with some areas and periods being notably underrepresented in scientific publications (Robinson *et al.* 2009, Grabowski 2011). There are also numerous phenomena connected to cereal cultivation which, although being well researched, are still in need of further data gathering, interpretation and discussion.

Aims

The primary aim of this article is to present a cereal cultivation history for east-central Jutland covering the Iron Age, that is circa 500 BC–AD 1100.

The main investigation area has been delineated to the former amts (counties) of Vejle and Århus. This area has previously been noted as an underrepresented region in archaeobotanical research (Robinson *et al.* 2009).

Within the PhD-project of which this article is part, two sites have recently been analysed at the Environmental Archaeology Laboratory at Umeå University:

(1) HOM 2247 Gedved Vest, a large site with settlement continuity spanning from period V/VI of the Bronze Age to the Viking Age.

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(2) VKH 7087 Kristinebjerg Øst, with one analysed house dating to approximately AD 800.

The data from these sites is used as the main empirical material of the presented study, along with a compilation of all hitherto analysed relevant archaeobotanical assemblages from the investigation area (see Table 1).

A second aim of this article is to discuss and address some of the complexity inherent to archaeobotanical inference in Scandinavian prehistoric settlement contexts. The analysis of Gedved Vest is therefore also presented as a case example of how archaeobotany may be correlated against geochemical and geophysical methods in order to achieve a better understanding of the material under study (see also Grabowski and Linderholm 2013).

Previous research

General overview of interpretations of Iron Age cereal agriculture in southern Scandinavia

Results from archaeobotanical investigations have over the last hundred years been accumulating in the form of reports of analysed sites and single finds of specific interest, interspersed by occasional attempts at regional syntheses of available data (e.g. Hjelmqvist 1979, Engelmark *et al.* 1992, Robinson 1994, Regnell 2002, Robinson *et al.* 2009, Grabowski 2011, Jensen and Andreasen 2011). Numerous studies from the former category have provided in-depth insights into specific aspects of cereal cultivation, while the latter category has allowed for identification of larger scale geographic and/or chronological trends.

Generalising broadly, south Scandinavian cereal cultivation may be seen as having gone through two main transformations during the last two millennia of prehistory, that is *c*. 1000 BC–AD 1100.

Early Iron Age: intensification of cultivation, possible beginning of manuring, and the establishment of hulled barley as a dominating crop

Cereal cultivation during the latter part of the Bronze Age and the earliest phases of the Iron Age was developed from a long agricultural tradition established during the Neolithic. This earlier agriculture was based on two main groups of cereals: barley of the naked variety (*Hordeum vulgare* var *nudum*) and hulled wheats; emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*) and spelt (*Triticum spelta*) (Robinson 1994, 2003, Engelmark and Viklund 2008, Andreasen 2009).

Evidence about the modes of cultivation during the Neolithic and early Bronze Age is scarcer than for most periods, and what has been obtained is often difficult to interpret. Numerous interpretations of available data have proposed that the abovementioned crops were cultivated on unmanured fields within a framework of an area-extensive agriculture utilising wandering fields in a woodland meadow setting otherwise used for animal grazing (Hedeager and Kristiansen 1988, Gustafsson 1998, Robinson 2000, Göransson 2001, Welinder 2004, p. 136, Andreasen 2009). Arguments for such cultivation are the availability of land during the early periods of agriculture and a lack of traces from permanent or semi-permanent cultivation in the landscape-archaeological record dating to the Neolithic and early Bronze Age. This perception has, however, increasingly been questioned based on new data, some researchers calling for the possibility of both permanent fields and manuring already during the Neolithic (for Scandinavia see Regnell and Sjögren 2006, p. 134 and therein cited references). Combining the current sources of evidence, one may argue for a Neolithic and early Bronze Age agriculture utilising both area-extensive and more permanent solutions in a flexible manner, adapting to local ecological and social conditions.

The first of the mentioned agricultural transformations was a shift away from the presumed area-extensive way of cultivating crops towards more permanent fields typical of the mid Iron Age. Physical evidence of more permanent cultivation can be seen in the archaeological record in the form of fossil fields, areas with stone clearance cairns (primarily in southern Sweden), field enclosures and changing settlement patterns (Hatt 1949, Lagerås and Bartholin 2003, Welinder 2004, p. 136f, Widgren 2010).

This transformation appears on a general level to have coincided with some major changes in the choice of crop species. The hulled wheats appear by the beginning of the Iron Age to have assumed a distinctly marginal role, together with naked bread wheat (*Triticum aestivum*) which, although present from the early Neolithic onward, always appears to have been cultivated on a limited scale. Naked barley also decreased, seemingly being replaced by the hulled variety (*Hordeum vulgare* var *vulgare*), which over the course of the Iron Age became the dominating crop (Engelmark *et al.* 1992, Robinson 1994, Robinson *et al.* 2009).

Numerous interpretative models have been proposed on the intensification of cereal cultivation at the shift from the Bronze to the Iron Age, about the changing role of crops and about the possible causal links between these phenomena (for a detailed overview of the recent discussion see Hedeager and Kristiansen 1988, Lagerås and Regnell 1999, Regnell 2002, Mikkelsen and Nørbach 2003, Robinson 2003, Regnell and Sjögren 2006, Robinson *et al.* 2009, Grabowski 2011). Most important is perhaps the discussion surrounding the timing of when manuring was introduced and its possible link to hulled barley.

Engelmark *et al.* (1992) proposed that the two phenomena are interconnected based on hulled barley's better tolerance to over-manuring and the suitability of its straw

Table 1. List of previously performed archaeobotanical analyses in east-central Jutland with a summary of the results.

Site no	Site/feature name	Context type	Chronology	Plant finds other than cereal grains	Reference
1	Randers, Frederiksdalvej, Pit CET	Pit with presumably mixed secondary/tertiary depositions.	Stratigraphically, pre-Roman Iron Age (*c.* 500 BC–AD).	Spring-annual arable weeds, *Camelina sativa*, grassland and wetland plants, heather and hazelnuts.	Robinson and Petersen (1994)
2	FHM 4862, Grenåvej, House 2	Longhouse, most likely not burnt. Samples derive from two roof-supporting postholes.	Typologically, early pre-Roman Iron Age (*c.* 500–250 BC) and 14C: 749–208 BC (2σ).	*Persicaria lapathifolia* (spring annual arable weed).	Andreasen (2008), Moesgård Database
2	FHM 4862, Grenåvej, Pits	Cluster of pits, presumably containing mixed secondary and tertiary deposits.	Typologically and by association to other settlement remains, early pre-roman Iron Age (*c.* 500–250 BC).	Spring-annual arable weeds, *Camelina sativa, Linum usitatissimum*, grassland and wetland plants and hazelnuts.	Andreasen (2008), Moesgård Database
3	Århus, Børglumvej, House I	Longhouse, most likely not burnt.	Typologically (house type and pottery), later pre-Roman Iron Age (*c.* 200 BC–AD).	Spring-annual arable weeds, possible grassland taxa and heather.	Aaby *et al.* (1994)
4	Århus Søndervold, House CME	Pit-house, presumably burnt.	Typologically, later Viking Age (*c.* 900–1100).	Spring-annual arable weeds and autumn-annual and perennial arable weeds.	Fredskild *et al.* (1971)
4	Århus Søndervold, House OU	Pit-house, presumably burnt.	Typologically, later Viking Age (*c.* 900–1100).	Single *Poaceae* seed.	Fredskild *et al.* (1971)
6	SBM 983, Kildebjerg I, Kiln K21	Kiln, deposit from active period of feature, may consist of repeated carbonisation events over an undefined period of time.	Typologically and by association to other settlement remains, pre-Roman Iron Age (*c.* 500 BC–AD).	Spring-annual arable weeds, *Camelina sativa* (large find, hundreds of seeds meted into 'lumps') and single find of *Carex* sp.	Jensen and Mikkelsen (2006), Moesgård Database
6	SBM 983, Kildebjerg I, Pit A4851	Pit with presumably mixed secondary/tertiary depositions.	Typologically and by association to other settlement remains, pre-Roman Iron Age (*c.* 500 BC–AD).	Spring-annual arable weeds, possible grassland taxa and *Lolium perenne.*	Jensen and Mikkelsen (2006), Moesgård Database
7	SBM 1101, Golf 11, House K11	Longhouse, unknown whether burnt or unburnt, only a single sampled posthole.	Typologically, late Roman Iron Age (*c.* AD 200–400) and 14C: AD 255–532 (2σ).	Spring-annual arable weeds, hazelnuts.	Andreasen (2011, 2011), Moesgård Database
7	SBM 1101, Golf 11, Iron furnace JP484	Iron extraction furnace.	Typologically *c.* 200 AD–1000 and C14: AD 133–326 (2σ).	Spring- and autumn-annual arable weeds, *Lolium perenne,* cereal straw (cf. *Secale*).	Andreasen (2011, 2011), Moesgård Database

(*continued*)

Table 1. (*Continued*).

Site no	Site/feature name	Context type	Chronology	Plant finds other than cereal grains	Reference
7	SBM 1101, Golf 11, Iron furnace JP485	Iron extraction furnace.	Typologically *c.* 200 AD–1000 and C14: AD 255–405 (2σ).	Spring- and autumn-annual arable weeds, *Lolium perenne,* cereal straw (cf. *Secale*).	Andreasen (2011, 2011), Moesgård Database
8	HOM 1892, Galgehøj, Pit A3402	Pit, presumably containing mixed secondary and tertiary deposits; however, a major portion of the deposit appears to derive from accidentally charred, cleaned, barley cache deposited post-burning inside the pit.	Association to surrounding settlement and pottery, early pre-Roman Iron Age (*c.* 500–250) and 14C: 387–50 BC (2σ).	Spring-annual arable weeds.	Jensen (2009a), Moesgård Database
9	HOM 2288, Møllersmindevej, Pit A317	Pit with presumably mixed secondary/tertiary depositions.	Pottery, early pre-Roman Iron Age (*c.* 500–250 BC) and 14C: 405–207 BC (2σ).	Spring-annual arable weeds, *Camelina sativa, Linum usitatissimum*, grassland and wetland plants.	Jensen (2009b), Moesgård Database
10	HOM 2295, Kværnbæksgård, Pits	Numerous pits with presumably mixed secondary/tertiary depositions	Pottery, pre-Roman Iron Age (*c.* 500 BC–AD).	Spring-annual arable weeds, grassland and wetland plants and hazelnuts.	Grabowski (2009), Moesgård Database
5	MKH 1588, Viuf Vesterby 2, Pit-house III	Deposit inside pit-house. Unknown whether burnt or unburnt. Unknown whether grain is a primary, secondary or tertiary deposit.	Typologically and through settlement context, Viking Age (*c.* AD 550–1100) and 14C: AD 888–1024 (1σ?).	Spring-sown arable weeds.	Andreasen (2010), Moesgård Database

Notes: The compositions of cereal grain finds from the listed sites are presented in Figure 2. The site numbers in this list correspond to the ones in Figures 1 and 2. For detailed data on the composition of each assemblage, refer to Supplementary material 1.

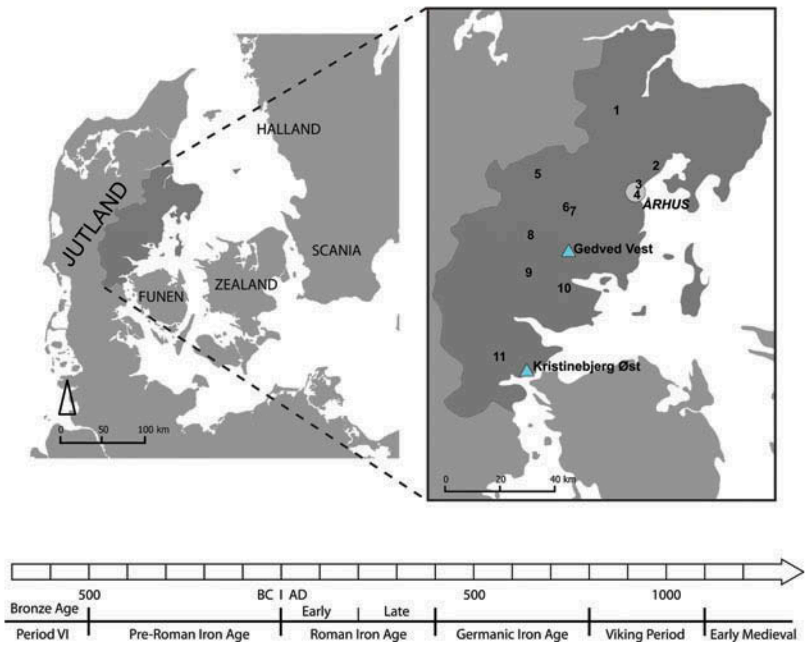

Figure 1. Map of southern Scandinavia, showing regions mentioned in the text as well as an outline of the main investigation area. The close-up map shows the location of the analysed sites of Gedved Vest and Kristinebjerg Øst, as well as sites from which previously analysed archaeobotanical assemblages have been compiled (numbers 1–10, cf. Table 1).

as animal fodder. A correlation between the appearance of hulled barley and nitrophilous weeds (preferring manured soils) in archaeobotanical assemblages and the contemporaneity between hulled barley and byre-indicating evidences in settlement-archaeological data have been proposed as a link between the two phenomena.

The identification of byres and other stabling indicators in the settlement-archaeological record is, however, an active and not completely resolved topic amongst archaeologists and may be seen as a weak link in the Engelmark's model (e.g. Viklund *et al.* 1998, Carlie 1999, Lagerås and Regnell 1999, Ethelberg 2000, Streiffert 2001, Peterson 2006).

The manure-hulled barley connection has also been questioned on the basis of some of its theoretical assumptions; the most commonly cited being whether the increase of nitrophilous weeds truly indicates changing field conditions rather than altered harvesting and processing techniques (e.g. Lagerås and Regnell 1999, Robinson 2003, Regnell and Sjögren 2006). A hypothetical, but archaeologically unsubstantiated, change from hand plucking of cereals close to ears to sickle-based harvesting close to the ground (in order to bring in the straw as fodder) may for example have radically changed the quantities of weeds, making their way into the charred archaeobotanical assemblages. Thus, manuring could have been in use prior to the end of the Bronze Age, invisible in the archaeobotanical carbonised material (Regnell and Sjögren 2006).

The use of weeds as indicators for field conditions on anything more than a general level has also been put into question (Bogaard *et al.* 2013). An alternative approach utilising analysis of the isotopic signature of carbonised cereal grains has been presented as an alternative method of investigation and may in the near future begin to complement the indications obtained from analysis of weed finds. These analyses are, however, in the early stages of method development and application on prehistoric archaeological material and thus currently unable to provide solid clues about the timing of manure introduction in south Scandinavia (Bogaard *et al.* 2013, Kanstrup *et al.* 2013).

The growing corpus of archaeobotanical results also challenges the connection between hulled barley and manuring because the transition from the naked to the hulled variety appears to have been less rapid and later in many parts of southern Scandinavia than in Scania: the region that provided the empirical material for the hulled barley–manure hypothesis. Currently available evidence indicates that hulled barley was introduced on a large scale at the end of the Bronze Age in Scania and Zealand, areas where it dominates most but by no means all botanical assemblages already during pre-Roman Iron Age. In other areas such as northernmost and southernmost Jutland, Halland and, to some extent, also Funen, however, naked barley appears to remain in cultivation as one of the primary crops well into the Roman Iron Age, long past the date when other segments of the archaeological record indicate at least partial use of animal stabling and manuring (Engelmark *et al.* 1992, Robinson 2003, Robinson *et al.* 2009, Grabowski 2011, Jensen and Andreasen 2011).

Other proposed hypotheses for the introduction and eventual domination of hulled barley include resistance to increasing humidity and other environmental change (Helbæk 1957), suitability for beer brewing (Mikkelsen and Nørbach 2003), tolerance to more efficient but forceful harvesting techniques with new iron implements (naked barley grains are comparatively loose, which may result in significant loss of grain if they are harvested forcefully; Hillman 1984, Mikkelsen and Nørbach 2003) and changing food habits (Skoglund 1999). All of these hypotheses are difficult to substantiate on the basis of currently available data, neither can they be refuted, and must therefore be considered as possible causal factors in future research.

Regardless of which choices and processes prompted the shift away from hulled wheats and naked barley, it is clear from the investigated material that hulled barley by the middle of Roman Iron age was the main crop across the south Scandinavian region (Robinson *et al.* 2009, Grabowski 2011). The weed flora accompanying the cereals in archaeobotanical assemblages, as well as other types of archaeological data, also indicate that manured, so called *permanent*, fields were in use across most of the region (Engelmark *et al.* 1992, Gustafsson 1998, Robinson 2003).

The term *permanent field cultivation*, commonly used in archaeobotanical literature (e.g. Engelmark *et al.* 1992, Gustafsson 1998, Grabowski 2011), is perhaps slightly misleading and could for the sake of clarity be termed as a *slow rotation semi-permanent cultivation utilising manure*.

Manuring of the Iron Age fields would have allowed for a replenishing of the nutrient content, extending their active use to several years or possibly decades. Eventually, however, cultivation would most likely have become unsustainable because of increasing problems with weed and insect infestation (Engelmark *et al.* 1992). A presumed solution to this problem would have been a slow rotation of fields between active use and fallow. The fallow fields in such a system could have been utilised as pasture or meadow spaces, providing a portion of the fodder necessary to feed the manure producing animals. Additional sources of fodder could have been obtained from wetlands unsuitable for cultivation and from leaf fodder from coppiced or pollarded trees.

It should be noted that the archaeological evidence from the first halves of the Iron Age in most of southern Scandinavia does not indicate a fully developed infield–outfield system, such as that known from later periods, although some tendencies towards a division of the landscape along similar lines may already have begun (Fabech and Ringtved 2009). It is likely that the rotation of fields between active use and fallow would have created a patchy and somewhat extensive distribution of cultivated land and foddering space. A source of evidence for this may be seen in the physical traces of the fields themselves. The remnants of the so called *celtic fields* in Sweden and Denmark have often been discussed from the perspective of ownership, inheritance and land regulation (e.g. Hatt 1949, Widgren 1997, p. 32, Holst *et al.* 2010), but their size and distribution may also be a partial result of a rather complex sequence of clearance, use and fallow, each cycle spanning several decades (cf. Lang 2007, p. 105). At the very least, any regulated division of land in connection to inheritance events must have taken into account the quality of the fields as productive units within the existing agricultural system. The stone clearance fields common in some areas of southern Sweden can be interpreted along similar lines and have been proposed as indicators for a semi-permanent cultivation (e.g. Lagerås and Bartholin 2003, Widgren 2003).

Late Iron Age: appearance of crop-rotation, infields–outfields and rye as new staple of south Scandinavian agriculture

The introduction of a more defined infield–outfield landscape organisation was presumably one of the main components of the second transformation of Iron Age cereal agriculture.

Historical as well as archaeological evidence shows that agriculture at the beginning of the medieval period was distinctly different from that practiced during the middle of the Iron Age (Myrdal 1999, Fabech and Ringtved 2009). The infield–outfield concept can broadly be defined as a binary division of land into an intensively worked space close to the settlement, containing the majority of the cultivation and fodder generating areas (primarily meadows for hay gathering), and a less intensively used surrounding area utilised for grazing, fodder collection, wood resources and gathering of wild plants (Christiansen 1978, Fabech and Ringtved 2009). It should, however, be noted that the prehistoric record in south Scandinavia shows significant variation with regard to archaeological remains, indicating management of the landscape along infield–outfield principles (Pedersen and Widgren 2004, Fabech and Ringtved 2009). Näsman (2009, p. 106), among others, argues that:

> *One should be open to the possibility that a distinct infield–outfield system was only established on better soils, and that a more loosely structured grazing practice continued in western Denmark (my translation).*

A possible scenario is that the trend toward a division of land into spaces utilised at varying intensity and the thereof resulting fixation of cultivation (and possibly also settlement) took place at varying pace in different parts of the south Scandinavian region. The resulting landscape arrangements would as a result range from distinctly developed infields–outfields to a loose adaptation of the same principles in which earlier strategies could have remained more or less intact or where alternatives to strict infields–outfields could be developed.

Because the infield–outfield concept requires a more fixed and permanent siting of arable fields than the preceding semi-mobile agriculture, the problems with nutrient depletion and weed-pest infestations must, however, be solved by new cultivation strategies. Strategies that became dominating across southern Scandinavia throughout the entire medieval period were various versions of crop-rotation systems. In such systems, the problem of increasing infestation was solved by dividing the arable land into sections. Some of these were cultivated with spring sown crops, in Scandinavia traditionally hulled barley, while others were used for autumn sown crops. Commonly, a period of fallow was also incorporated in each rotation cycle. The alternation between spring and autumn sowing in such system disturbs the life cycles of the pests, decreasing their competitiveness on the fields, while the period of fallow followed by intensive tilling destroys the root systems of existing weeds (Engelmark *et al.* 1992, Mikkelsen and Nørbach 2003, p. 132).

The crops cultivated by the farmers of the early and middle Iron Age were most likely all spring sown, an indication deduced by the predominance of spring annual arable weeds in the archaeobotanical assemblages (Engelmark *et al.* 1992, Viklund 1998, Andreasen 2009). Therefore, in order to function, the three-partite rotation of the medieval period necessitated the introduction of an autumn sown crop. This role was filled by rye (*Secale cereale*), which towards the end of the Iron Age and throughout the medieval period complemented hulled barley as the staple crop of the region. Ryes' lower demand on soil nutrient content also meant that the fields only needed to be fertilised once per rotation cycle as opposed to each year, or every couple of years, when cultivated exclusively with hulled barley (Engelmark 1989, Mikkelsen and Nørbach 2003).

Similarly to the first of the mentioned agrarian transformations, the introduction of autumn rye, crop-rotation and infield–outfield organisation is not easy to date and trace across the region. Archaeobotanically, the presence of rye has been one of the most widely used indicators, although it is far from an unproblematic one. This is because rye initially spread to the south Scandinavian region as a weed, growing unintentionally with planted crops. This is reflected in the archaeobotanical material as small inclusions of rye grains in assemblages, otherwise interpreted as clean barley or wheat harvests; the earliest occurrences dating to the end of the Bronze Age (Behre 1992, Robinson 2003, Regnell and Sjögren 2006).

After this initial period of weed presence, rye may have been grown for a period of time as an independent crop, in ways similar to the dominating barley, that is spring sown and not within a fully developed rotation system.

Behre (1992) suggests that it was ryes' ability to compete on lower nutrient fields that prompted the Iron Age farmers to adopt it as a crop in the first place. If ryes' ability to outcompete other cereals on certain types of soils was as obvious as presumed by Behre, the initial period of independent cultivation may have provided Iron Age farmers with observations necessary for the formulation of concepts and botanical understanding necessary for its subsequent inclusion in a crop-rotation regime. Alternatively, if crop-rotation was inspired from areas outside the south Scandinavian region, the initial period of cultivation may have demonstrated the suitability of rye cultivation under the specific conditions prevailing in southern Scandinavia. Although difficult to prove by archaeobotanical means, rye could through experimentation and experience have ended up being grown on either soils, which were too poor or sandy for barley and wheat cultivation, or on fields in a stage of the slow rotation sequence best suitable to its requirements (Engelmark *et al.* 1992).

The presumed independent cultivation of rye is one of the reasons why the introduction of rye–barley rotation is difficult to delineate in time and space. Traditionally, the presence of rye in quantities on par to those of barley has been proposed as evidence for crop-rotation (Engelmark *et al.* 1992, Regnell 2002). The interpretative problem lies in the fact that the archaeobotanical record in most cases is the end result of complex formational and taphonomic processes. In many cases, the record is an amalgamation of events, which cannot be separated by means of available methodology. Thus, it is impossible to say whether an approximately similar amount of rye and barley on a site truly represents the conditions in the fields.

For that reason, two additional archaeobotanical strategies have been used to distinguish autumn sown rye. The first is identification of weed taxa, which are historically and ethnographically documented in autumn cultivation. The two most commonly cited species are *Agrostemma githago* and *Centaurea cyanus*. The first of these appears in south Scandinavian assemblages from the sixth century AD, while the second appears at the end of the Viking Age and the beginning of the medieval period (Jessen and Lind 1922, Grabowski 2011). A third species cited in literature is *Bromus secalinus*, which thrives in autumn sown rye fields (Kroll 1987, Mikkelsen and Nørbach 2003). This species is, however, also tolerant to other environments and appears even to have been periodically cultivated for its seeds. It is recovered from various archaeobotanical contexts throughout most of prehistory, thus making it a problematic indicator for delineating the beginning of autumn sowing (Hillman 1981, Korsmo *et al.* 1981, Engelmark *et al.* 1992, Gustafsson 1998, Robinson 2002, Regnell and Sjögren 2006).

Based on the reasoning above, the beginnings of crop-rotation and autumn sowing, and by extension possibly the shift to an infield–outfield landscape utilisation, have been placed to sixth to seventh century at its earliest, with clear evidence being available from eighth to tenth centuries onward.

Recent findings from Denmark have, however, put the above model into doubt by questioning the link between *Agrostemma githago* and *Centaurea cyanus* and the earliest autumn rye cultivation. Neither of these species is native to Scandinavia, and although they have historically been linked to autumn sowing, there is no evidence that this was the case in prehistory. Mikkelsen, for example, argues that these species may very well have been introduced to the region after crop-rotation was established as a result of an unrelated process, possibly the growing grain trade in the Baltic region, which presumably started at the very end of the Iron Age (Henriksen 2003, Mikkelsen and Nørbach 2003).

Recent studies have therefore attempted to circumvent some of the problems of archaeobotanical material from settlement contexts by analysis of a specific type of feature, namely the iron extraction furnace.

In such furnaces, organic material, occasionally cereal straw, was used in the smelting procedure. On occasion, unprocessed cereals were utilised, presumably collected in nearby fields directly prior to use. This appears in the material as finds of complete cereal plants, often with soil still clinging to the roots, accompanied by a clearly unsorted weed material. Since the iron extraction furnaces were single-use features, Mikkelsen argues that the unprocessed cereal material found within some of them must represent single harvests. Statistical analysis of such features containing clean barley and clean rye finds have shown that the weed flora differs significantly for each respective crop, something that would not be the case if they were both spring grown within the same slow rotation system. By means of statistical analyses, Mikkelsen has defined new criteria for identification of autumn sowing from weed data, one based on changed numerical relationships between existing taxa rather than the appearance of completely new species. Some of the increasing species defined as particularly important are *Rumex acetosella, Lolium perenne* and *Triplospermum perforatum* and *Polygonum* aviculare. The furnaces which produced indications for autumn sowing have, on basis of site typology, artefacts and ^{14}C-data, been interpreted as being in use around AD 380–540. Mikkelsen thus argues for an establishment of autumn rye and crop-rotation as early as the Roman Iron Age (Mikkelsen and Nørbach 2003).

The identification of autumn sown rye and crop-rotation through analysis of iron furnaces is, however, not without problems. Although the majority of the furnaces analysed by Mikkelsen contained unthreshed material, this is not always the case. If furnaces are interpreted as being filled with processed straw, the same limitations of archaeobotanical interpretation apply to this material as to any derived from settlement contexts. Furthermore, the practice of filling furnace pits with cereal straw is limited in space and time; all the hitherto analysed furnaces are located in southern Jutland and all are dated to the Roman and Germanic Iron Age. This chronological and geographic distribution makes it difficult to evaluate the representativity of the results on more than a local scale. That caution is needed can be argued by reference to the most basic of archaeobotanical data, namely the relative percentages between cereal species. There is a discernable trend of rye appearing in larger quantities early on in western and southern Jutland and in Halland, but later in Scania, Zealand and to some extent Funen (Regnell 2002, Robinson *et al.* 2009, Grabowski 2011, Jensen 2012). Thus, the interpretation of early crop-rotation based on material from iron furnaces in south Jutland may well be true for that particular area, where it corresponds with the rye–barley numbers, while the model of a late introduction could still apply to other parts of the south Scandinavian region.

Previous plant macrofossil analyses in east-central Jutland

As previously mentioned, east-central Jutland is one of the underrepresented regions in archaeobotanical publications (Robinson *et al.* 2009). During the last decade, however, a number of sites have been analysed.

To avoid inclusion of archaeobotanical material with poor representativity, a condition for including a previously analysed assemblage in this study was that it should contain at least 50 carbonised plant remains (see discussion in Robinson *et al.* (2009, p. 121)). This resulted in the compilation of 15 unique assemblages (i.e. spatially and chronologically delineated botanical units, for example: a single house, a specific pit, etc.) distributed across 10 sites.

The material is unevenly distributed throughout the Iron Age, with nine contexts dating to pre-Roman Iron Age, three to late Roman and early Germanic period and three to the Viking Age.

Pre-Roman Iron Age

The material from pre-Roman Iron Age shows that naked barley dominates in seven out of nine assemblages.

The hulled variety of barley was only retrieved in larger quantities in two assemblages, both derived from

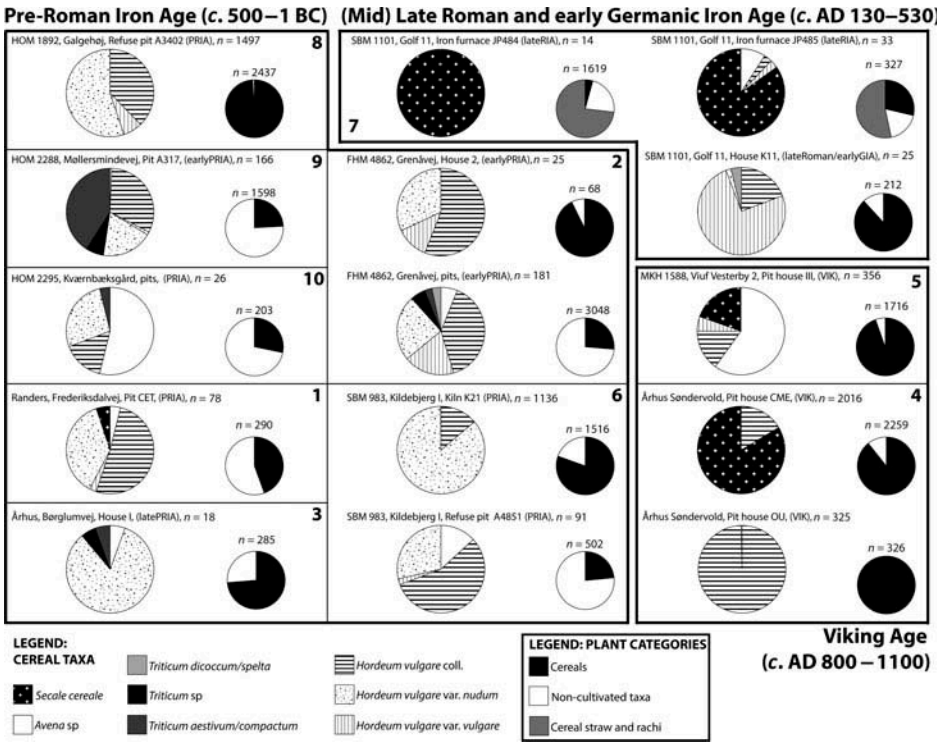

Figure 2. Overview of archaeobotanical assemblages from east-central Jutland dating to the Iron Age. The assemblages are presented grouped into three chronological segments: pre-Roman Iron Age 500 BC–AD 1, mid/late Roman and early Germanic Iron Age AD 130–530 and Viking Age AD 800–1100. The composition of each assemblage is presented as ratios between cereals, weeds and straw/chaff (small pie chart, representing entire sample) and ratios of identified cereal species (large pie-chart, identified cereal fraction only).

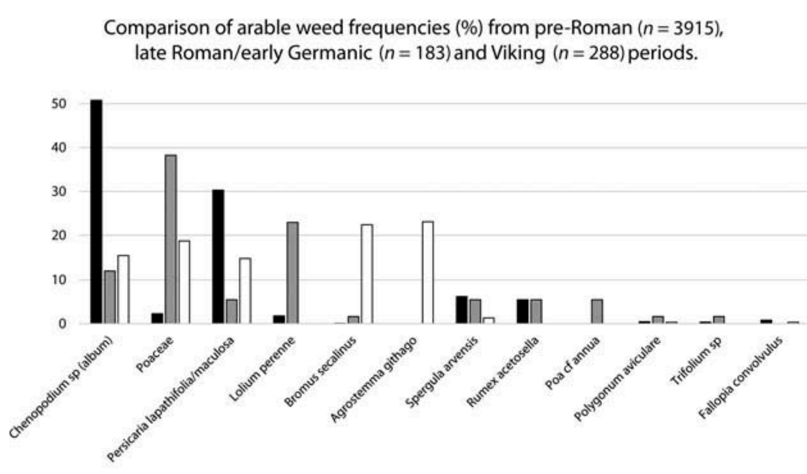

Figure 3. Weed frequencies over the course of the Iron Age in the compiled archaeobotanical assemblages from east-central Jutland. The material is, similarly to Figure 2, divided into three chronological segments representing pre-Roman, mid/late Roman and early Germanic Iron Age, and the Viking period.

the site of Grenåvej. The contexts in which the hulled barley was found are of different type; one assemblage deriving from two postholes of an unburnt longhouse, the second from a cluster of refuse pits. This distribution in contexts formed by two unrelated events may indicate that the hulled barley was a significant crop on this site, rather than being the result of an isolated and unrepresentative circumstance.

Other sites where hulled barley was retrieved were Galgehøj, Møllersmindevej, Randers Frederiksdalvej and

Kildebjerg, where it was found as small inclusions of no more than a few percent. Since most of these finds derive from presumably mixed contexts, such as refuse pits and unburnt houses, interpretation of the origins of these finds is problematic. They may represent cultivation of the crop on a very small scale, but could perhaps also be explained as unplanned inclusions in naked barley cultivation. Since hulled barley was likely cultivated during this period on at least some sites, as indicated by the material from Grenåvej, it is possible that the crops used in the region were not completely pure. An admixture of hulled barley in naked barley seed would have been almost impossible to remove through sieving or similar techniques because the two plants are morphologically almost identical. Any purification would therefore have been undertaken by hand (Hillman 1984, Jones and Halstead 1995), a time consuming process which may have prompted the acceptance of a level of crop mixing in otherwise monocultural cultivation. That this is possibly the case may perhaps be seen in the assemblage from Galgehøj, where hulled barley made up 13% of the barley grains determined down to variety. Although derived from a pit, the sampled layer contained such a high concentration of clean grain that it was interpreted as belonging to an accidentally burnt crop cache, which was deposited in its entirety inside the pit, presumably representing a single harvest (Jensen 2009a, p. 3f).

The third most commonly appearing cereal was oat (*Avena* sp.). Oat is a problematic plant for archaeobotanists since it occurs in arable environments both as a cultivated crop (*Avena sativa*) and as a weed (*Avena fatua*/*strigosa*). Distinction between these species can be made only if the floret bases are preserved (Jacomet *et al.* 2006), which is rarely the case in carbonised assemblages. Therefore, the definition between cultivated and wild oats has previously mainly been made by identification of large and clean finds. This is a problematic approach, since small scale cultivation of oat could theoretically have taken place whilst being archaeobotanically interpreted as weed presence due to low frequencies in the material.

In the record from east-central Jutland, oat appears in six out of nine pre-Roman assemblages. In all contexts but one, the oat appeared as a small inclusion only. The only percentually large find was derived from Kværnbækgård where oat made up >50% of the cereal total. The entire assemblage of cereals determined down to species was, however, comprised of only 26 grains, and despite the high percentage, this find cannot be used as evidence for cultivation.

Wheat was present in four out of nine assemblages. Three of the occurrences were very insubstantial and may indicate either limited purposeful cultivation or accidental inclusion in other crops. In the fourth assemblage, at Møllersmindevej, naked bread wheat made up just under 50% of the total species-determined assemblage, which as a whole consisted of 166 grains. The material was retrieved from a pit in which material presumably accumulated over a longer period of time and is thus of unknown representative value. Still this comparatively large find of wheat may indicate limited cultivation in the region.

Late Roman and early Germanic Iron Age

After approximately 1 AD, there is a gap in the archaeobotanical material from east-central Jutland.

Dating to the latter part of Roman Iron Age and the beginning of the Germanic period are three contexts from the site of SBM 1101 Golf 11.

Two of the contexts comprise of iron extraction furnaces, while the third was recovered from a presumably unburnt longhouse. All three contexts differ strikingly from the ones dates to the pre-Roman Iron Age.

In House K11, almost all identified grains consisted of barley and the ones which were in a good state of preservation were predominantly determined to the hulled variety. This shows that the transition from naked to hulled barley most likely was completed by fourth and fifth centuries AD as the house provided a cal. 2σ ^{14}C-date spanning AD 255–532.

The iron furnaces were possibly somewhat older, providing cal. 2σ-dates of AD 133–326 and 255–405, respectively. The composition of the botanical material recovered from them differed drastically from the house. The amount of recovered grains was small in both furnaces, but was dominated by rye. The presence of rye was also indicated by large amounts of straw fragments. These were determined as likely belonging to rye (cf *Secale cereale*). The combination of grain and straw finds must be seen as a convincing indication that rye was independently cultivated at this site. Therefore, cultivation of rye in this area should, based on available data, be seen as commencing at the latest during the second or third century AD.

Since the barley and rye were recovered from two unrelated contexts, it is impossible to interpret how they were cultivated in relation to each other. Rye may have been cultivated on independent fields, in certain stages of a slow rotation agriculture or even in some form of crop-rotation. The presence of *Lolium perenne*, interpreted by Mikkelsen as an autumn rye indicator, in one of the furnaces could be a tenuous indication of rotation. Since the species was only found in one of the furnaces and since the material is so small as to prohibit further in-depth analysis, the issue must, however, be seen as unresolved.

Germanic Iron Age and Viking Period

After the transition from late Roman to Germanic Iron Age, there is another gap in the material, the chronologically subsequent assemblages dating to the Viking Period.

All three of these assemblages were derived from pit houses. Two of these, from Søndervold in Århus, have been typologically dated to the Viking Age. The third, from Viuf Vesterby, has been radiocarbon dated to AD 888–1024 (1σ?, BP-date not reported). The three assemblages are in this overview considered as contemporaneous.

The material from both houses at Søndervold consisted of large and clean finds of grain indicating storage. Interestingly, each house was dominated by a different crop; house CME contained mostly rye with approximately 20% barley, while house OU contained an almost clean barley crop with only a single grain of rye. The find in house OU was also almost completely clean of weed inclusions, indicating a well processed produce, the only inclusion being a single grass seed (*Poaceae*). The weeds in house CME were somewhat more numerous and very informative as they contained *Agrostemma githago*, which has already been discussed as an autumn rye indicator, and *Centaurea jacea*, which has a life cycle similar to that of autumn sown rye. The comparatively large presence of rye brome also points towards this store being autumn sown. Thus, the find from Søndervold is a clear indication that not only rye was cultivated, but also crop-rotation was in use. A point of caution is, however, the archaeological context of the find. Since Århus Søndervold represents an urban setting, it is possible that the cultivation of the recovered plants took place somewhere else than in the Århus area, as extensive trade networks are most likely to have existed during this late period of the Iron Age (see e.g. numerous articles in Mortensen and Rasmussen (1991)).

The functional interpretation of the material from Viuf Vesterby was somewhat ambiguous. Its composition and siting inside the house did not provide clear evidence about its formation. It is thus unclear whether it is a storage find carbonised in situ or whether it ended up in the house fills as a secondary or tertiary deposit. Andreasen (2010) also explored the possibility of the material being brought into the house as floor covering, although without reaching a conclusion. Regardless of its origins, this assemblage provides some information about possible agrarian practices.

Hulled barley and rye were present in almost equal proportions. This could indicate crop-rotation. The presence of *Lolium perenne* adds further support to this interpretation, which would be chronologically consistent with the results from Søndervold.

More important, however, is the fact that the assemblage was dominated not by barley and rye, but by oat, and that some of the oat husks were preserved sufficiently to allow their identification as *Avena sativa*. Thus, Pit House III from Viuf Vesterby provides the first, and so far only, evidence of oat cultivation in east-central Jutland during the Iron Age.

Weed finds

The large number of weed taxa and their diversity with regards to seed production, dispersal modes and seed preservation qualities make this type of archaeobotanical remains more complex to assess than cereal finds, although under certain conditions weeds may also be more informative than the cultivated plants.

The composition of weed seeds in archaeobotanical assemblages cannot be seen as representative for the actual flora of the fields. Rather, the weeds should be used qualitative proxies providing general insights about field conditions (Engelmark 1989).

The material from east-central Jutland is also small, with only the finds from pre-Roman Iron Age occurring in larger quantities.

With these reservations in mind, a summary of the most commonly occurring weeds (Figure 3) shows three tendencies.

The first of these is one of continuity. Nitrophilous weeds, interpreted previously as indicators for manured fields (Engelmark 1989), such as *Chenopodium album* and *Persicaria lapathifolia/maculosa* are among some of the most commonly appearing taxa in the assemblages from all periods. They do decrease in the graph during the late Roman/early Germanic and Viking periods, but this decrease should be seen in light of the graph showing relative occurrences within each period, the decrease in the graph corresponding to an increase in taxa not present during the first period.

The new taxa are *Lolium perenne, Agrostemma githago* and *Bromus secalinus.* All three have been previously interpreted as possible indicators for autumn sowing (Kroll 1987, Mikkelsen and Nørbach 2003).

Lolium perenne increases sharply in the graph already from later Roman Iron Age, but this increase is based on a single material only, the iron extraction furnace from SBM 1101 Golf 11. The uncertainty of its representativity for autumn sowing has already been discussed above.

The finds of *Agrostemma githago* and *Bromus secalinus* increase during the Viking period and have also been previously mentioned as much more secure indications of crop-rotation.

There is also a trend of decrease in the material, seen mainly in *Spergula arvensis* and *Rumex acetosella*. These taxa are associated with lower-nutrient soils, and their decrease could possibly indicate that poor soils were used to a lesser extent during the latter part of the Iron Age. The material is, however, far too limited to substantiate such a hypothesis.

Archaeobotanical interpretation: issues and possibilities

As seen from the overview above, the archaeobotanical material has provided numerous insights into how cereal cultivation may have been practiced during the Iron Age. It has, however, also illustrated numerous aspects of complexity inherent to studies based on carbonised plant material.

The plant macrofossil analyses at Gedved Vest and, to a lesser degree Kristinebjerg Øst, were therefore planned not only as means of providing additional input to the corpus of archaeobotanical data, but also to attempt to test and evaluate analytical strategies, which may enhance the interpretation of carbonised materials from settlement sites (Grabowski and Linderholm 2013).

Complexities of the archaeobotanical source material

The archaeobotanical study of cereal agriculture during south Scandinavian prehistory has to date been primarily based on analysis of carbonized plant macrofossils from rural settlement contexts (Engelmark and Viklund 2008, Robinson *et al.* 2009). Although the technical aspect of plant macrofossil analysis is comparatively straightforward, the interpretation of this material presents a high degree of complexity due to a number of factors.

The composition of archaeobotanical assemblages is the result of both anthropogenic and natural transforming processes (Schiffer 1972, 1976).

Non-human filters include the properties of the plants themselves, particularly those which affect their chances of preservation through carbonisation. They also encompass the dynamics of the sediments into which botanical material is deposited (Engelmark 1989, Boardman and Jones 1990, Gustafsson 2000, Branch *et al.* 2005).

The anthropogenic filters shape the archaeobotanical material mainly as a result of the sequential actions involved in refining harvested or collected plants into usable end products (Dennell 1976, Hillman 1981, 1984, Jones 1987, Viklund 1998). This series of transformations is termed as *operational sequence* (cf. *chaîne opératoire,* Schlanger 2005, *behavioural chains,* Schiffer 1975, *systemic and archaeological context,* 1972).

Unlike many types of material culture, which are created by joining components into artefacts, plant resource operation is commonly characterised by separation of material retrieved jointly from a specific habitat into separate units intended for different utilisation.

Figure 4 shows a typical operational sequence of cereal processing. As the harvested crop progresses along the sequence, actions such as threshing, winnowing, flinging, sieving and hand sorting achieve both the removal of weeds and the separation of the harvested crop into functional units (Hillman 1981, 1984, Viklund 1998).

In theory, the original material collected in its growth biotope may through these actions be subdivided into a number of separate assemblages. Cleaned grains may be stored and eventually consumed. Weed residues from cereal cleaning may be used as fuel, left in situ or re-deposited in a number of ways as an effect of waste management. There are also some indications in the archaeobotanical material that weeds were, at least on occasion, collected and consumed (e.g. Behre 2007). Other parts such as the ears of cereals may be treated similarly to the weeds, while the straw may be used as fuel, as animal fodder, in construction and manufacture, and so on.

Important for archaeobotanical interpretation is the fact that some actions are more or less unavoidable for a given crop and that these have to be performed in a specific sequence, for example threshing prior to winnowing and flinging and coarse sieving prior to fine sieving (cf. Jones 1984).

Botanical material can be preserved by carbonisation at numerous stages of the operational sequence (Hillman 1981, 1984), but the nature and chances of the carbonisation events are also variable. Active use of fire, for example during parching in order to loosen the glumes, presents

Figure 4. A schematic illustration showing a possible operational sequence of cereal processing. After Hillman (1981) and Viklund (1998).

an increased chance of carbonisation. Small portions of botanical material may become charred in connection to everyday accidents around heat sources, resulting in the accumulation of plant remains over longer, often archaeologically undefinable, periods of time. In contrast, uncontrolled fires may occasionally result in the carbonisation of large quantities of plant material: assemblages representative of singular events (Viklund 1998).

Once carbonised, most plants are no longer of use to humans. Thus, the process of carbonisation results in an irreversible movement of the material from an operational to an archaeological context (cf. Schiffer 1972). This may occur through abandonment of the material at the location of its carbonisation or consist of numerous stages of deposition and re-deposition (see Figure 5).

Based on the reasoning above, most archaeobotanical research performed since the 1970s has acknowledged that a good foundation for archaeobotanical interpretation may often only be attained through delineation of the operational context of the investigated assemblages (e.g. Hillman 1981, 1984, Jones 1984, Van der Veen 2007).

Defining the operational context of botanical assemblages presents several challenges. The exact structure of the operational sequences performed during prehistory is rarely known, although clues may be attained from ethnographic studies and historical documentation. Ultimately, the operational sequences must be inferred from the prehistoric record itself, either through analysis of the internal compositional variation within the botanical material under study, by correlation to non-botanical archaeological data (feature morphology, artefacts, etc.), or through analysis of the sediment matrix from which the material was recovered by additional non-botanical methods. Another problem is that it may be impossible to identify some stages and fully define the sequence. The available methodology may not be able to attain a sufficient level of resolution to separate one stage from another. The various stages themselves may also have created more or less suitable conditions for preservation of botanical material. Some stages may be significantly underrepresented or even lacking completely in the material, others may be impossible to separate from each other because of the phenomenon of *equifinality*; that is similarities in archaeobotanical outcome may not always represent similarities in starting conditions or operation.

The known aspects of Iron Age settlement structure indicate that plant resource refinement, as well as numerous other activities, were confined to specific areas. Thus, the definition of the functionality of spaces is an important step in delineating the operational context of a related plant assemblage. The assemblage itself may, however, also provide clues about the functionality of the space from which it was recovered. Therefore, the process of delineating functional spaces and defining an operational botanical context may be seen as a multidirectional interpretive process.

Multiproxy functional analysis as a way of evaluating carbonised botanical assemblages

At the Environmental Archaeology Laboratory at Umeå University in Sweden, botanical analysis has been integrated into a more comprehensive multiproxy strategy where archaeobotany is correlated against a set of geochemical and geophysical methods (Grabowski and Linderholm 2013). These analyses are performed either on separate samples, collected from the same archaeological contexts, or on sub-samples extracted from the soil which is sampled for plant macrofossil analysis.

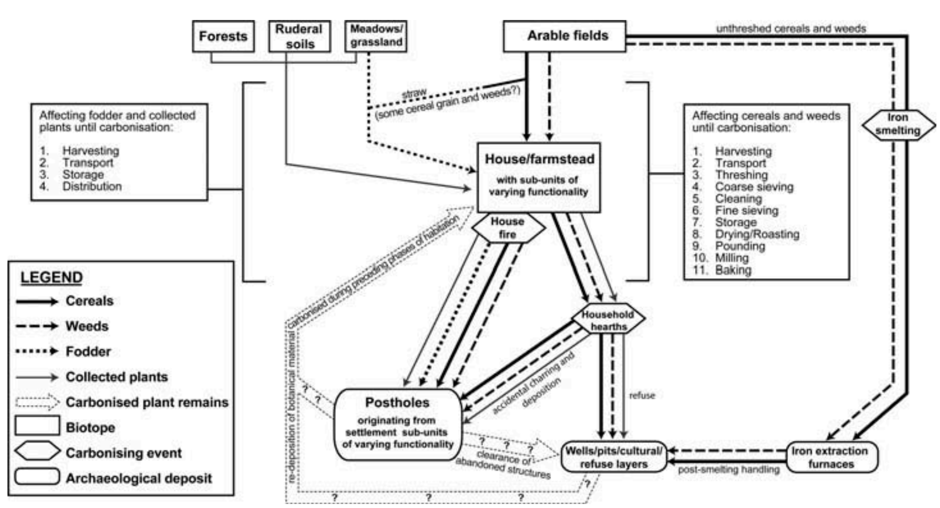

Figure 5. Flow chart showing the plausible pathways of movement, deposition and re-deposition of carbonised botanical material at an Iron Age settlement site (the herein presented chart being modelled on HOM 2247, Gedved Vest).

The development, previous application and technical specifics of the method are described in a separate article (Grabowski and Linderholm 2013, and therein cited references).

In short, the procedure can be described as follows:

Plant macrofossil analysis is performed on material retrieved through floatation (0.25 mm smallest mesh size). The theoretical preposition is that different actions of plant utilisation will result in variable botanical compositions. Under favourable conditions, this variation should be indicative of the operational context of cultivated plants and/or functionality of the space from which the samples were retrieved. This is presumed to apply in particular to samples from postholes, since the depressions created by the removal or destruction of posts should have filled up quickly with eroding sediment. This process is assumed to have created protective environments for botanical assemblages indicative of activities performed around the posts.

Magnetic Susceptibility analysis is performed on the samples to differentiate between soils previously exposed or not exposed to heat. In some cases, the field evidence is inconclusive about whether a context, such as a house, is burnt or not. A definition of this aspect is important for archaeobotanical interpretation, since it illuminates the formation process of the material and gives an indication of whether it is resulting from an accumulation over a longer period of time or whether it represents a singular event.

Phosphate analysis is used to delineate areas of increased input of phosphorous material. This material can originate from numerous sources. Therefore, a separation is made between phosphates bound in inorganic and organic compounds. Concentrations of inorganic phosphates are presumed to be indicative of household waste, primarily bones, while organically bound phosphates are presumed to be indicative of manure. In visualisations of phosphate data, it is sometimes illustrative to also express the relation between organically and inorganically bound phosphates (phosphate quota), with higher quota corresponding to higher levels of organically bound phosphorous material.

Loss on ignition is performed to measure the organic content in the samples. High organic content may be indicative of a number of different types of depositions. One of these is long term input of manure. In this study, the results were correlated to those of the phosphate analysis in order to provide evidence about the presence or absence of manure.

Material

HOM 2247, Gedved Vest

Site overview

Gedved Vest is situated in east-central Jutland, 33 km south-west of Århus and 8 km north of Horsens. The site was investigated between 2008 and 2010 by Horsens Museum in connection with an industrial development project (Hansen 2012).

The area is characterised by a gently undulating topography. The relatively flat topography of the site is mirrored by a comparatively homogenous geology. The subsoil was primarily made up of glacial silty clays with admixtures of sand and gravel. The overlaying topsoil was made up of clayey loam.

The excavation of Gedved Vest resulted in the documentation of a large amount of archaeological features, mostly of settlement character (postholes, pits, wells, enclosures, refuse/activity layers, etc.). More than 350 constructions were recorded on the site, many of which have been ^{14}C dated, showing activity from the latter half of the Bronze Age (oldest dates at 808–551 BC, cal 2σ) to the Viking Age (AD 885–1013, cal 2σ). The radiocarbon data corresponds well with the typological chronology established during excavation (Hansen 2012). For a plan of the site see Figure 6.

Presented contexts

A total of 879 samples were retrieved from Gedved Vest. Botanical analysis was performed on all samples. Geochemical and geophysical methods were thereafter strategically applied to features qualitatively assessed as suitable cases for the identification of operational cereal processing context and functionality of settlement spaces.

The space constraints of the article format do not allow for a presentation of all results from Gedved Vest. Instead, the presentation focuses on cases where functionality and/or operational context was to some extent elucidated. This applies in total to 12 assemblages from 10 archaeological features. Since these contexts were not evenly distributed in time, the herein presented data spans approximately AD 1–550.

The illustrations below present data only relevant to the discussion of the material. A full table with archaeobotanical and geochemical/geophysical data is presented as Supplementary material 2 (Table 2).

Kristinebjerg Øst

Site overview

Kristinebjerg Øst, situated a few kilometers from Little Belt, between the towns of Kolding and Fredericia, was excavated between 2007 and 2009 by Vejle Museum. The excavations, which were performed in connection with rezoning of the area, resulted in the identification of archaeological remains dating to the Neolithic and the Iron Age, as well as the medieval and modern periods (Bjerregård and Iversen 2013).

Table 2. [14]C-datings from Gedved Vest for the archaeological features presented in the article.

Locality	House	Lab nr	Dated material	Age ^{14}C	Cal 1σ	Cal 2 σ
21	A11402	Poz-44610	cf Secale cereale	1905 ± 30 BP	AD 26–128	AD 25–212
		Poz-44611	Secale cereale	2015 ± 30 BP	47 BC to AD 23	97 BC to AD 64
		Poz-44612	Hordeum vulgare var vulgare	1925 ± 30 BP	AD 53–124	AD 2–134
	A11404	Poz-44614	Secale cereale	1900 ± 30 BP	AD 69–130	AD 28–214
		Poz-44,615	Hordeum vulgare var vulgare	1850 ± 35 BP	AD 126–223	AD 79–240
		Poz-44616	Hordeum vulgare var vulgare	1895 ± 30 BP	AD 70–132	AD 33–215
	A11412	Poz-44617	Hordeum vulgare var vulgare	1910 ± 30 BP	AD 67–126	AD 21–210
		Poz-44618	Hordeum vulgare var vulgare	1875 ± 30 BP	AD 78–210	AD 70–225
		Poz-44619	Hordeum vulgare var vulgare	1845 ± 30 BP	AD 130–215	AD 85–239
09-Nov	A11312	Poz-44684	Hordeum vulgare var vulgare	1565 ± 35 BP	AD 436–561	AD 428–582
		Poz-44658	Hordeum vulgare var vulgare	1585 ± 35 BP	AD 383–529	AD 342–535
		Poz-44686	Hordeum vulgare coll	1585 ± 30 BP	AD 415–532	AD 397–540
	A11320	Poz-44687	Hordeum vulgare	1625 ± 30 BP	AD 392–531	AD 352–537
		Poz-44688	Hordeum vulgare var vulgare	1590 ± 30 BP	AD 426–533	AD 411–534
		Poz-44689	Hordeum vulgare	1625 ± 30 BP	AD 392–531	AD 352–537
13	A11220	Poz-44700	Hordeum vulgare var vulgare	1620 ± 30 BP	AD 397–532	AD 357–539
		Poz-44702	Hordeum vulgare var vulgare	1605 ± 30 BP	AD 415–532	AD 397–540
		Poz-44703	Secale cereale	1656 ± 35 BP	AD 434–540	AD 434–540
	A11071	Poz-44722	Hordeum vulgare var vulgare	1550 ± 35 BP	AD 435–555	AD 424–584
		Poz-44723	Secale cereale	1575 ± 30 BP	AD 435–535	AD 417–552
19	A11107	Poz-44717	Hordeum vulgare coll	1545 ± 30 BP	AD 436–561	AD 428–582
		Poz-44718	Hordeum vulgare coll	1635 ± 30 BP	AD 383–529	AD 342–535
		Poz-44719	Hordeum vulgare var vulgare	1605 ± 30 BP	AD 415–532	AD 397–540
	A11123	Poz-44724	Secale cereale	1505 ± 35 BP	AD 536–610	AD 435–639
		Poz-44725	Hordeum vulgare var vulgare	1485 ± 35 BP	AD 548–613	AD 443–649
		Poz-44726	Secale cereale	1565 ± 30 BP	AD 434–540	AD 422–561

Note: See also the ^{14}C calibration graph in Supplementary material 3.

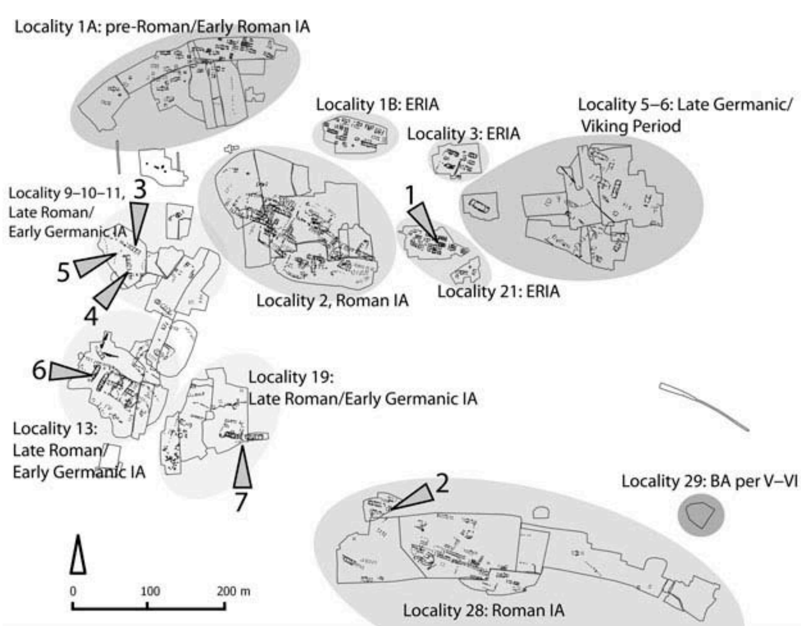

Figure 6. Site plan of Gedved Vest, showing the location of the context presented in the article. 1, locality 21 (houses A11402, A11404 and A11412); 2, pit A35875; 3, house A11312; 4, house A11320; 5, well A30223; 6, house A11220; 7, Locality 19 (houses A11107 and A11123).

The site topography was characterised by a gently undulating moraine landscape, with an underlying soil consisting primarily of sandy clay.

House DG

In the western part of the site, a concentration of 12 houses from the Viking Age was excavated. Chronological control of these houses has been achieved through house and artefact typology.

Several of the houses were sampled for archaeobotanical studies but preliminary analysis of the material showed that only one building, house DG, contained substantial amounts of carbonised plant remains.

House DG is one of the smaller buildings dated to the Viking period. The typology of the building indicates a date around AD 800. It has been interpreted as a likely barn or outhouse to one of the larger longhouses situated nearby (Bjerregård and Iversen 2012).

Only archaeobotanical analysis was performed on the material from house DG since the samples were floated on site and no soil remained for additional analyses. Complete data from the analysis of house DG is available in Supplementary material 4.

Analysis of Gedved Vest

Functional interpretation of Locality 21: houses A11402, A11404 and A11412

Locality 21 consisted of a cluster of at least 32 houses of varying sizes, typologically dating to the early Roman Iron Age. Many of these structures overlapped, indicating recurring phases of construction, reconstruction and renovation. Since the individual postholes of the houses only occasionally cut each other, it is impossible to reconstruct a relative chronological sequence for these phases.

Among these houses, three stood out during excavation with clear traces of house fires; A11402, A11404 and A11412. These were the only houses which were sampled during excavation. On the basis of their size and siting in relation to larger 'habitation-type' longhouses, the three constructions have been interpreted as outhouses. All three appear to have had at least three separate phases, and in all three cases, only one phase appears to have been destroyed by fire. The presumed burning of the houses was evidenced during excavation as highly charcoal rich fills, with significant inclusions of burnt clay and charred grain.

Relating to Figure 5, which shows the possible pathways of a botanical material on an Iron Age site, Locality 21 does not present an optimal case for archaeobotanical studies, as there is a possibility of material moving between chronological phases due to redisposition of soil.

Because of this complex archaeological situation, geochemical and geophysical analyses were not performed on this locality, and the interpretation below is based solely on botanical data.

There were, however, also factors favouring the inclusion of this material into the study.

First, each of the overlapping houses appears to have been constructed similarly to its predecessor, resulting in dimensionally comparable structures on top of each other. Such similarity may be an indication of a functional continuity. Any mixing of plant material between chronological phases should thus not affect the final interpretation of function.

Second, the excavators noted that the postholes of the sampled houses had much darker and charcoal rich fills than those of the overlapping structures. This observation was confirmed during the archaeobotanical analysis. Locality 21 displays the by far highest concentrations of carbonised plant material on Gedved Vest (57.5 remains/litre compared to an average of 13.4). The fact that the three sampled houses were burned and the overlapping ones were not may be argued to have created an assemblage where the majority of the botanical remains likely originated from the burning event. Identified patterns should therefore reflect the contents of the structures at the time of the fire. A signal from activities before the fire is likely embedded in the material as well, but its effects on the composition of this assemblage should be limited.

All three houses have been ^{14}C-dated, providing similar cal. 2σ-spans, ranging from AD 2 to 240. Only one sample out of nine provided a slightly divergent date of 97 BC to AD 64. These structures could have been contemporaneous and possibly destroyed as the result of the same event.

Figure 7 illustrating the results of the archaeobotanical analysis shows striking differences between the three structures. Most obvious is the diametrically opposite relationship between cereals and non-cultivated taxa in A11402 and A11412. In the former house, non-arable plants (predominantly arable weeds) make up 80% of the material, oil plants 10% and cereals 10%. In the latter, house cereals comprise over 90% of the material with a small inclusion of oil plants and almost no weeds. This indicates that these two structures, regardless of whether they are contemporaneous or not, filled a different role in the processing of cereal produce. The most readily available explanation is that A11402 was used either as a cereal cleaning space or a space where cereal cleaning residues were stored, resulting in an accumulation of weeds not meant for human consumption, while A11412 was a storage space for cleaned grain at the end of the operational sequence.

House A11404 is somewhat more difficult to interpret. The relationship between cereals and non-cultivated taxa is 80–20%, respectively. This mixing of the two categories

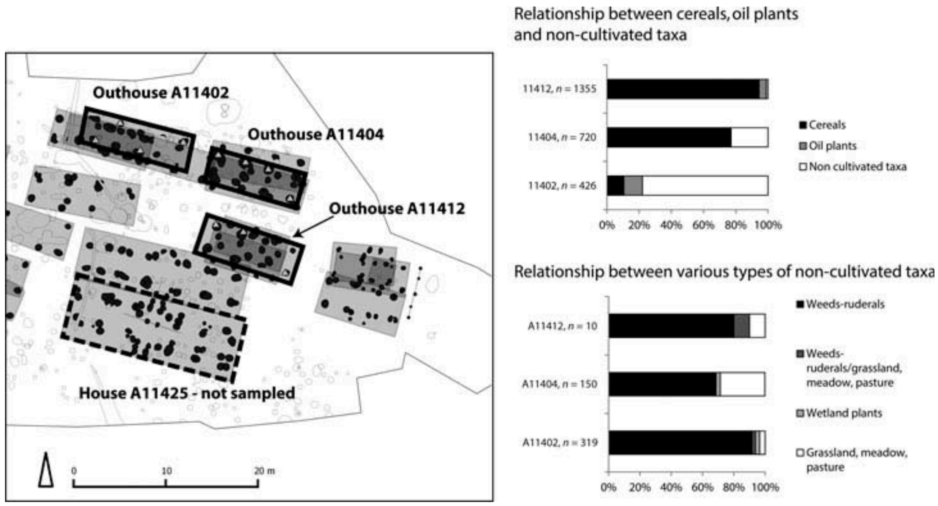

Figure 7. Site plan of locality 21 at Gedved Vest and the composition of the archaeobotanical material from houses A11402, A11404 and A11412.

of plant material could indicate a more diverse functionality of the house. It could also, in the event of all three houses being contemporaneous, indicate intermediate storage of partially cleaned grain. A third explanation may possibly be seen in the composition of the non-arable category of plants. Both in A11402 and A11412, this category was composed almost exclusively of weeds-ruderals. In A11404, the weeds still dominate, but there is also a presence of possible fodder plants, amounting to 30%. Accordingly, an alternative interpretation of this structure could be that it was a fodder storage space and that the fodder comprised of both meadow plants, such as grasses and weeds, and cereal straw with some grains still attached. There is also the possibility that all of the abovementioned functions were true and that the house was used in a flexible manner.

Functional interpretation of Locality 28: pit A35875

A35875 was a small pit, 64 cm in diameter and 50 cm in depth (Figure 8). Three layers were identified inside the pit, two rich in carbonised material, possibly indicating primary use, and an uppermost layer which appears to have eroded into the pit after abandonment.

Pottery fragments of Roman Iron Age-type were found inside the pit and two adjacent features, a longhouse and an iron extraction furnace, have provided ^{14}C-dates with a span of AD 70–409 cal. 2σ.

Only macrofossil analysis was performed on the samples from A35875.

The results of the analysis show distinctly different composition of each of the sampled layers. The uppermost fill (A) contained few plant seeds or charcoal. This supports an interpretation that the layer represents infilling of the pit after its active phase. Layer (B) contained a large concentration of charcoal, but a comparatively limited amount of plant seeds, while the lowermost layer (C) showed a reverse situation with a smaller amount of charcoal but high concentrations of plant seeds.

The relationship between plant categories in this pit was 12% cereals to 88% non-cultivated taxa. The former category was made up predominantly of grains, but several rachis fragments were also recovered. The latter category consisted almost exclusively of arable weeds.

Based on the available data, a plausible interpretation of the feature could be that it was some form of hearth where both wood and cereal material was used as fuel. The distribution of the charcoal above the cereals may possibly indicate that the latter was used as kindling and that this material was a residue from cereal threshing and cleaning, indicated by the predominance of weeds and the presence of inedible cereal parts such as the rachi. The fact that the layers display clearly divergent botanical signatures also indicates that the entire material most likely represents a single firing event, with limited succeeding mixing or disturbance. It is unclear, however, whether the feature was a one-use construction or whether it was utilised repeatedly and cleaned prior to its final use.

Functional interpretation of Locality 9–11: houses A11312 and A11320 and well A30223

Locality 9–11 was another cluster of settlement remains identified during the excavation of Gedved Vest. The cluster was typologically and artefactually dated to late Roman and early Germanic Iron Age.

Two longhouses, A11312 and A11320, were sampled in sufficient detail to allow for an in-depth interpretation based on analysis of posthole fills (Figure 9). Because of the relatively clean siting of both houses, all methods

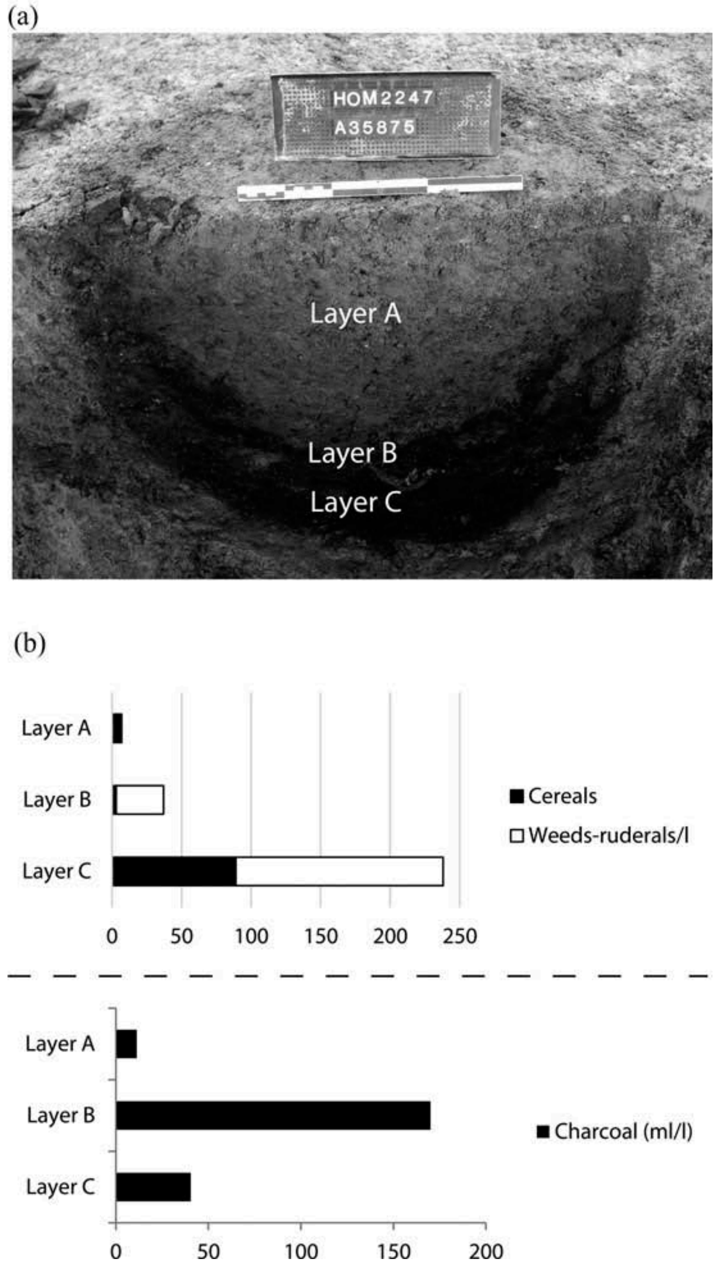

Figure 8. Photograph of pit A35875 at Gedved Vest (a) and the composition of the archaeobotanical material in the three layers documented and sampled inside the feature (b).

outlined in the method section above were applied on the material. Both houses were ^{14}C-dated, showing a cal. 2σ-span of AD 342–582 for A11312 and AD 352–537 for A11320, corresponding with the preliminary typological designation of the locality. In this presentation, the houses are treated as roughly contemporaneous.

A well, A30223, situated in close proximity to both houses, was also sampled and analysed in detail (Figure 11). The well has not been securely dated by relative or absolute methods, but its special siting indicates a likely association to one or both houses.

Magnetic susceptibility analysis of the postholes indicates that both houses were burnt. This is supported by the archaeobotanical results, which show presence of carbonised material along the entire length of both constructions, with the exception of a single posthole pair at the easternmost end of A11312.

Although present in all sections of the houses, the botanical material shows a heterogeneous composition in different parts of both houses.

In A11312, there is a clear separation between finds of arable weeds and cereals. The former are concentrated to

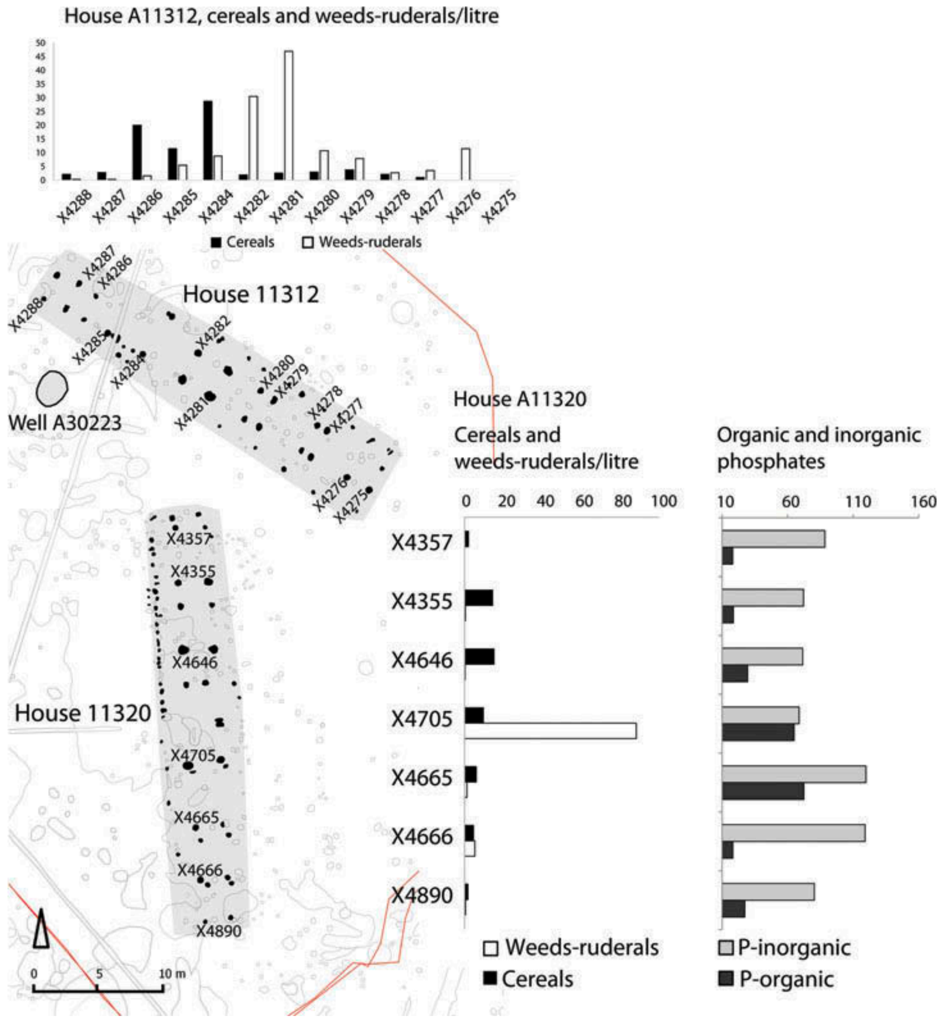

Figure 9. Site plan of locality 9–11 at Gedved Vest and results of the multiproxy analyses of houses A11312 and A11320, showing the composition of the recovered archaeobotanical material for both houses and the results of geochemical analyses for house A11320.

an area around two posthole pairs (X4282–4281), while the latter were found further west, around posthole pairs X4286, X4285 and X4284.

A similar pattern was detected in A11320, where the cereals were predominantly found in the northern part of the house, around posthole pairs X4355 and X4646, while almost all weed finds were recovered from posthole pair X4705, situated directly to the south.

This pattern may be interpreted as an indication for the presence of two areas with different function in each house, the finds of more or less clean cereals indicating cereal stores and possibly a kitchen/living spaces and the weeds indicating cereal cleaning areas.

To test this hypothesis, measurements of the cereal grains from each respective area were performed. All known cereal sorting procedures, such as sieving, winnowing and flinging, are based on weight, size and the aerodynamic properties of the plant remains. Thus, in theory, the cereal grains meant for consumption or cultivation should be larger and heavier than those which may have been discarded during cereal cleaning. The results of the measurements, presented in Figure 10, show that the cereals in the presumed cereal cleaning spaces were on average a full millimetre shorter than those in the presumed storage areas, with a smaller but notable difference in height and width. Although a difference of only 1 mm could, if presented on its own, be interpreted in numerous ways, for example as a difference in sieve size used in the processing of different cereal caches, in relation to the results from the other measurements applied at Locality 9–11, the results seem to indicate different stages of operation and not separate assemblages processed differently.

It should be noted that the cereal finds in the presumed storage sections, although consisting of clean grain, were not comparable in quantity or concentration to carbonised

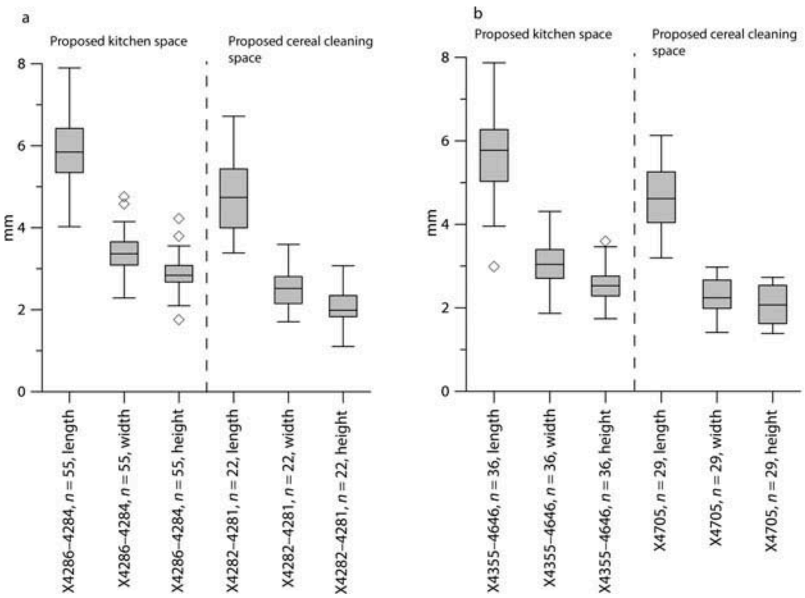

Figure 10. Grain sizes in the proposed cereal cleaning areas and kitchen/storage spaces, respectively, of houses A11312 (a), and A11320 (b).

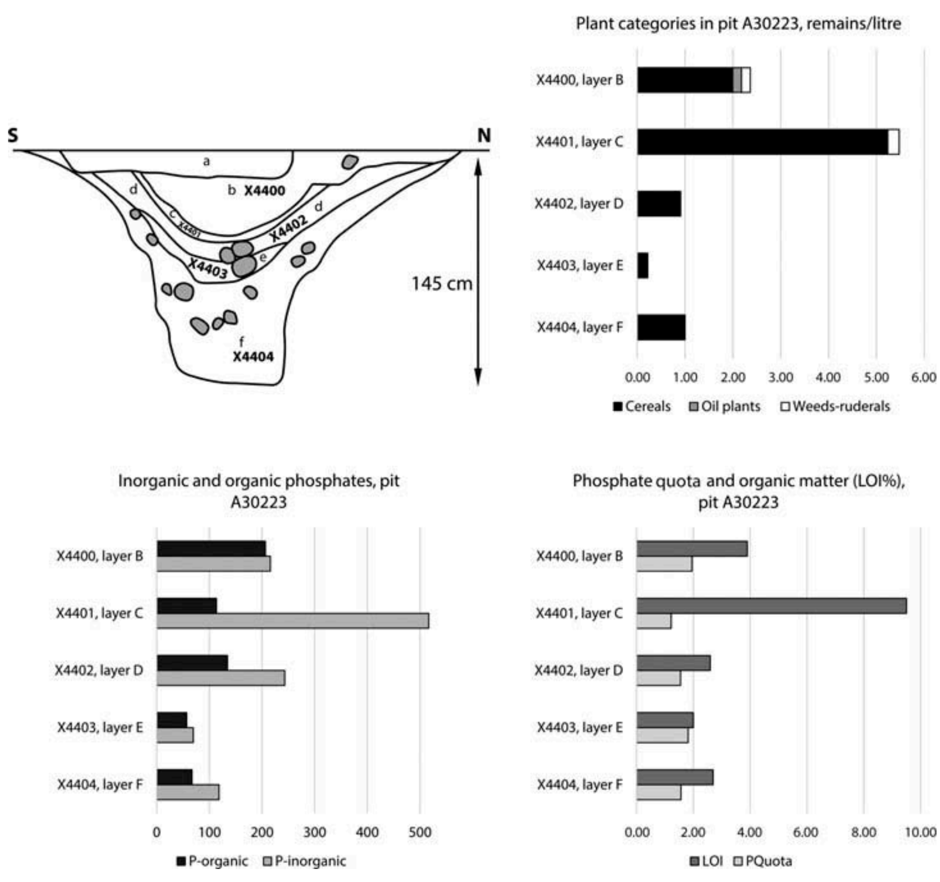

Figure 11. Section drawing of well A11320 and the results of the archaeobotanical and geochemical analyses.

bulk storage finds from other parts of south Scandinavia, or even to house A11412 presented above. It is therefore possible that the main cereal store of the farmsteads represented by houses A11312 and A11320 were situated somewhere else, possibly in an outhouse, and that the material presented herein represents smaller caches of grain brought into the houses in connection with final processing and consumption.

The phosphate and loss-on-ignition measurements in these houses showed diverging results. In A11312, the LOI and phosphate levels were relatively even along the entire length of the house. In house A11320, two different areas could be defined, one corresponding spatially to the finds of cereal grains in the northern part of the house, where almost all phosphate was bound in inorganic compounds most likely representing animal refuse (bones), and one with high levels of organic phosphate and organic matter (LOI) localize to the southern half.

Thus, a possible functional interpretation of A11320, based on herein presented data, is that it contained a byre in the southern half and a cereal storage and likely kitchen area in the north, with a cereal cleaning space situated in-between.

The interpretation for A11312 is similar, with a cereal storage space and kitchen in the west and a cereal cleaning area in the middle, but no evidence of a byre space.

Well A30223 consisted of six layers, of which all but the topmost were sampled and analysed. The results from all methods are strikingly consistent. Low concentrations of plants as well as limited evidence for input of phosphate rich material in the lower layers D, E and F indicate that these layers represent deposition due to the collapse of the walls of the well. These layers were also noted during excavation as containing large stones, which could originally have belonged to some form of lining or structural support. In layer C, the amount of recovered botanical remains increases sharply (consisting almost exclusively of cereal grains), as does the amount of organic matter (LOI) and the amount of inorganically bound phosphates. In the chronologically subsequent layer (B), the input of anthropogenic material decreases again.

A plausible interpretation for this pattern is that the well was, during its lifespan, kept clean with limited input of waste and rubbish. After its abandonment, the well began to collapse (layers D–F) and was after some time taken into secondary use as a refuse pit. The dominance of cereal grains in layer C along with a phosphate signature consistent with animal matter indicates that this waste most likely derived from kitchen activities. It should also be noted that A30223 is situated less than 3 m from the presumed kitchen section of A11312, literally within throwing distance.

The overview of the two houses and the well at Locality 9–11 have thus resulted in the identification of several functional spaces as well as two, or arguably three, categories of operationally delineated botanical material: cereal cleaning residues in houses A11312 and A11320 and end-stage grain finds in the kitchen areas of the same houses as well as well A30223.

Functional interpretation of Locality 13: house A11220

Locality 13 consisted of a cluster of structures of varying size, as well as remains of wells, pits and post-built enclosures, most of which have been ^{14}C-dated or typologically estimated as belonging to the late Roman and early Germanic Iron Age.

One house, A11220, was sampled in sufficient detail to allow for an in-depth functional analysis (Figure 12).

Three ^{14}C-samples were analysed from this house, showing a 2σ-span of AD 357–540, which corresponds to the general chronological interpretation of Locality 13.

The house was a longhouse, approximately 27 by 7 m, aligned along a southwest-northeast axis. The house structure was well preserved in comparison to most houses at Gedved Vest, allowing for a documentation of not only the

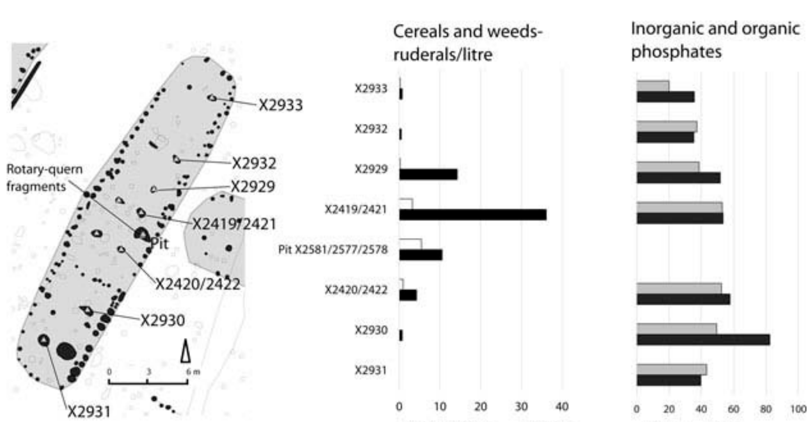

Figure 12. Plan of house A11220 at Gedved Vest and the results of the archaeobotanical and geochemical analyses.

largest roof-supporting postholes, but also details of the walls and internal divisions. The internal arrangement of postholes indicated that at least one wall had been present inside the house, separating the southernmost third from the rest of the building. Another internal detail interpreted as being connected to the house was a pit at the centre of the structure, which contained parts of a rotary quern. This find resulted in the preliminary interpretation of this space as a milling area.

The magnetic susceptibility measurements of the samples from A11220 show that the soil was most probably not exposed to heat, indicating an unburnt structure.

The distribution of botanical material in the house strengthens this interpretation, showing only one area with significant concentrations of carbonised remains. These remains consisted predominantly of cereals, with a smaller admixture of weeds and ruderals, and were recovered from the centre of the house: from the pit with the rotary quern and the posthole pairs on either side of it.

This combination of material evidences strengthens the interpretation of the centre of the house being a mill, but also expands it. In an unburnt house, carbonisation of botanical material should in theory take place primarily around heat sources such as hearths. In most such cases, the carbonisation is accidental and usually limited in volume. The concentration of cereals at the centre of A11220 is, however, comparable to finds from burnt structures, indicating that charring occurred not only of grains which accidentally fell or where thrown into a fire, but rather of a larger cache of grain. Relating to the presumed operational sequence of grain processing (Figure 4), established on the basis of ethnographic, historical and archaeological evidence, a possible explanation may be that this part of the house was not only used for grinding grain into flour, but also for the preceding stage of roasting: one of the few stages involving both fire and large quantities of grain.

The phosphate analysis of this house sheds further evidence about its internal functional arrangement. Both the central and the southern third of the house show higher phosphate levels than the northernmost section. The southernmost section does, however, also display elevated levels of organically bound phosphates around posthole pair X2930.

Summing up the evidences from house A11220, a functional interpretation may thus be that the southernmost third was a byre with animals, or at least a manure storage space. The central space was most likely an area where milling took place, as well as roasting. The comparatively high levels of phosphate may also indicate deposition of various type of animal and organic waste. Thus, this area may also have functioned as a kitchen and possibly also as a living space.

The northernmost space is clean of both botanical remains and phosphates and may have been used for activities which do not leave traces detectable by the methods applied in this study.

Functional interpretation of Locality 19: houses A11107 and A11123

Houses A11107 and A11123 were two longhouses discovered in close proximity to one another at the edge of Locality 19 (Figure 13).

Three ^{14}C-samples from each structure were analyzed, showing a calibrated 2σ-span of AD 342–582 for A11107 and AD 434–649 for A11123.

Based on the large and similar size of these two houses, as well as the fact that A11123 provided slightly earlier ^{14}C-dates than A11107, these houses were preliminarily interpreted as two separate farmsteads; A11107 proposed as the direct successor to A11123 (Hansen 2012). It should be noted, however, that the ^{14}C-data does not preclude these houses being contemporaneous.

The chronological background for houses A11107 and A11123 necessitates the consideration of two possible interpretative scenarios: either that the houses were contemporaneous and possibly part of a single farmstead unit or that they were chronologically separate but, based on their constructional similarities and spatial association, possibly representing succeeding phases of occupation.

Because of the large amount of analysed postholes, the material from these two houses is presented grouped into 12 sections.

The magnetic susceptibility analysis indicates that both houses were destroyed by fire. This indication is supported by the comparatively high concentrations of carbonised plant material in all sections of the houses.

A review of plant concentrations in individual postholes shows that some postholes of A11107 did not contain any carbonised material. This is presumably a result of the constructional history of the building. The plan of the house shows numerous postholes clustered in close proximity to one another. This phenomenon is commonly observed on Scandinavian Iron Age sites and is usually interpreted as the consequence of house maintenance. When a post began to rot, it would be replaced by a new one, resulting in a new posthole next to its predecessor. Since A11107 was probably destroyed by fire, a plausible interpretation is that the ‘empty’ postholes were sealed prior to the fire event.

A comparison between A11107 and A11123 shows that cereals were dominating in all sections of the former house except for no 5. The relation between cereals and non-cultivated plants in this house was 88–12%. The reverse is true for A11123 where non-cultivated (primarily weed-ruderal) taxa dominated all sections except for no 8. The total assemblage of the house shows a relation of cereals to non-cultivated plants of 28–72%. This result

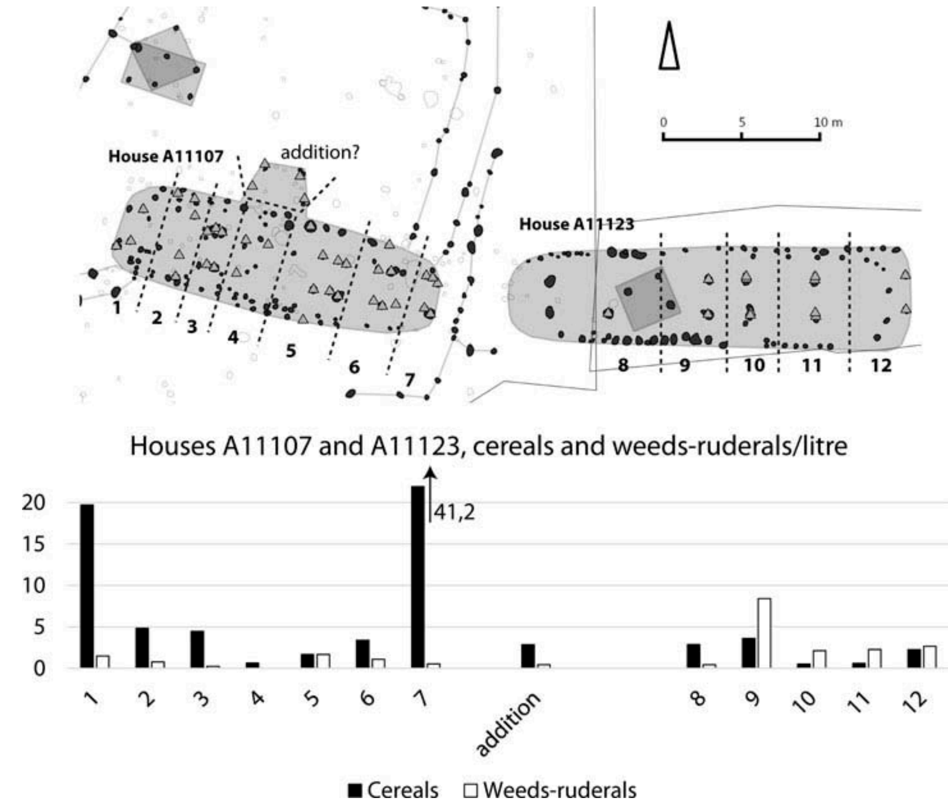

Figure 13. Plan of houses A11107 and A11123 and the results of the archaeobotanical analysis. Note that the samples from the houses have, for the sake of presentation, been grouped into 12 sections.

alone indicates a difference in functionality. A possible interpretation of the variations in the plant assemblages is that A11107 contained predominantly stored grain, from the later stages of operation, while A11123 contained a cereal cleaning space where weeds and cereal residue could accumulate.

Another result indicating different functionality of these buildings was obtained from the phosphate analysis and loss on ignition measurements (Figure 15). The total phosphate levels were higher in house A11107, while the fraction of organic phosphate as well as soil organic matter was higher in A11123. The close proximity of these two houses, as well as the uniform underlying soil conditions, suggests that this variation should be interpreted as a result of anthropogenic processes rather than natural variation. In this particular case, a plausible explanation is that A11123 housed a byre for farm animals, or at least a storage space for manure, while A11107, with high concentrations of inorganic phosphate, could have housed a space where animal products were processed, the most probable alternative being that it contained a kitchen.

Another difference between these houses is the average size of the cereal grains (Figure 15). Grains from A11107 were longer, thicker and broader than those from A11123. The smaller size of the grains in the latter house may represent grain which was sorted out of the main cereal assemblage along with weeds. The grain measurements are thus in agreement with the above interpretation of plant macrofossils, phosphates and LOI.

The multiproxy analysis indicates that these two houses were used for different activities and that they were possibly contemporaneous. The latter interpretation is based on the fact that each structure displays complementary functional aspects expected on an Iron Age farm.

The cultivated crops at Gedved Vest

The functional analysis of archaeological features shows that, with the applied methodology, the botanical material from Gedved Vest can be classified into at least two broad operational categories.

Residues from cereal cleaning were identified in outhouse A11402, pit A35875, specific sections of houses A11312 and A11320, as well as longhouse A11123. The material in these houses may be argued to provide a good foundation for studying the composition of arable weeds at Gedved Vest, since it should be less sorted and modified by human action than weeds in storage finds.

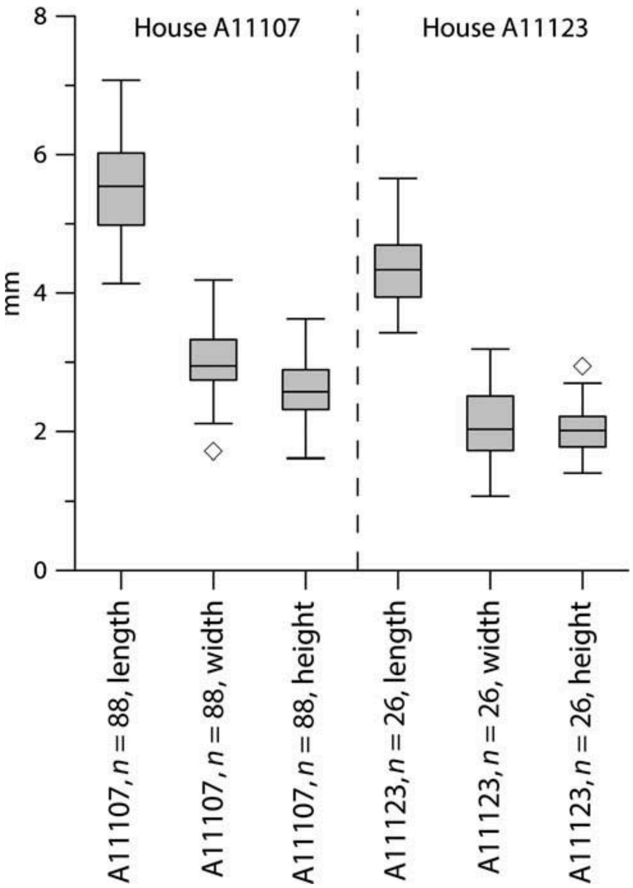

Figure 14. Grain sizes in A11107 and A11123.

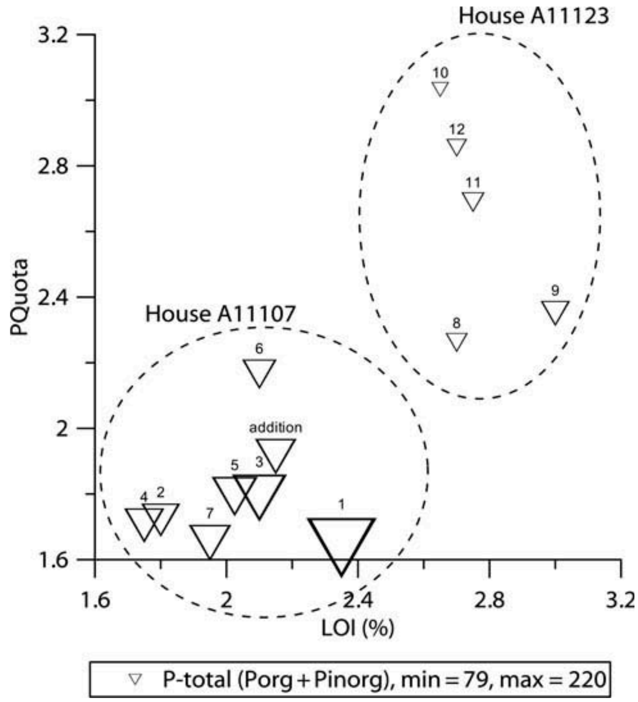

Figure 15. Results of the geochemical analyses of house A11107 and A11123 expressed as a 'bubble graph'. The *Y*-axis shows the relationship between inorganic and organic phosphate (higher quota = more organic P), the *X*-axis shows the amount of organic matter in the samples, as measured by loss on ignition, and the size of the triangles corresponds to the total amount of measured phosphate.

Cereal finds of storage and/or consumption character, in the later stages of cereal processing, were obtained from outhouse A11412, specific spaces in A11312, A11320 and A11220, in pit A30223 and also the entire longhouse A11107. This material is interpreted as providing a good indication of which plants were desired or acceptable for final consumption.

A somewhat ambiguous material, of cereals, weeds and fodder plants, was also recovered from longhouse A11404.

Figure 16 displays the relative cereal composition in the various operational categories (*Y*-axis) sorted in chronological order (*X*-axis). The chronological span of the figure is early Roman Iron Age to late Roman/early Germanic Iron Age. As such, Gedved Vest contributes to filling in a significant gap in archaeobotanical data identified in the overview of previously analysed sites.

The figure provides several insights into the cultivation history of this site.

There appears to be a significant stability in the choices of cereals at Gedved Vest. The assemblages interpreted as meant for consumption all show a distinct dominance of hulled barley. The barley finds dominate already in the earliest assemblages. If Gedved Vest is representative for the region, this could, in combination of the results of the other investigated sites from east-central Jutland, indicate that the shift from naked to hulled barley occurred around the turn of the first millennium AD. If this is the case, this could mean that this region follows a trend similar to Funen, situated to the east (Jensen and Andreasen 2011, Jensen 2012), while diverging from the main trend observed in southern, western and northern Jutland.

Naked barley, although being mostly replaced by the hulled variety, does not disappear entirely. It is present in small amounts in house A11404 and A11312. These occurrences are, however, so small that they could be interpreted as impurities in crop stocks rather than purposeful cultivation. More interesting is perhaps the somewhat larger occurrence in houses A11220 and A11107, both houses displaying almost identical composition of their end-stage cereal assemblages. In the latter case, naked barley comprised only 6% of the cereal material in the house, but a full 50% in the two adjoining postholes from which it was recovered. This indicates small scale cultivation and separate storage of this cereal at the shift from Roman to Germanic Iron Age. This result is interesting as it once again points toward a trend of crop

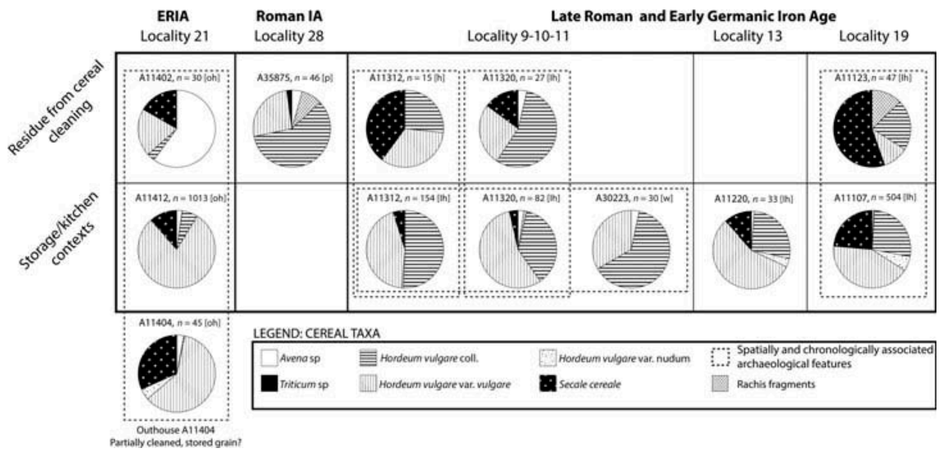

Figure 16. Overview of archaeobotanical assemblages from Gedved Vest. The assemblages are ordered to operational context along the *Y*- and chronologically along the *X*-axis. The type of assemblage is noted next to each assemblage: oh = outhouse, lh = longhouse, p = pit and w = well. Spatially and chronologically associated features are bounded by a broken line.

choices similar to Funen where naked barley is replaced by hulled barley but, deeming from the results of recent investigations, reappears on a small scale during this period (Jensen 2012).

Wheat does not appear to have been grown at Gedved Vest. The occurrences of wheat occur predominantly at Locality 28 and 2, both dated to the Roman Iron Age, but never as more than single occurrences.

Oat was most likely not cultivated either. Oat appears occasionally in the material, but always in very small quantities. Only three grains on the entire site could be determined down to species and these were all *Avena fatua.* Another indication that oat was not cultivated is that appears predominantly in assemblages interpreted as cereal cleaning residues, indicating that it was actively sorted away from the material meant for consumption.

Finally, the assemblages from Gedved Vest contain notable presence of rye. This presence displays a pattern of higher occurrence in cereal cleaning assemblages than in those interpreted as storage and/or consumption finds. For example, rye made up only 4% of the cereal category in the storage find in house A11312 but 40% in the cereal cleaning residue. A similar trend was seen in house A11320 with 3.5% rye in the kitchen space and 15% in the cereal cleaning residue, while longhouse A11107 at Locality 19, interpreted as a habitation space, contained 21%, while the nearby house A11123, interpreted as a barn, showed rye presence of 45%.

Thus, there is a trend of rye presence throughout the investigated periods, increasing somewhat in the later periods, but also of rye generally being localised to areas with cleaning residues rather than spaces with end-stage grain. An exception to this pattern is house A11404 at Locality 21. Being dated to the early Roman Iron Age and interpreted as at least partially cleaned grain, this assemblage stands out as an early and numerous find of rye at Gedved Vest.

The tendency of rye appearing in cereal cleaning residues rather than storage/consumption finds could be the result of rye being a free-threshing cereal, and thus more prone to detaching from the straw than the hulled barley. It could, however, also be, to some extent, an effect of a conscious removal of rye from barley seed.

Based on the results presented in Figure 16, it is difficult to determine how it was cultivated on the site and also when purposeful cultivation may have begun. The complexity involved in such interpretation, as well as the possibility that it may have been consciously removed from the assemblages, is discussed in the summary chapter of this article below.

The weeds at Gedved Vest

Figure 17 presents the relations between weed taxa from the investigated periods of Gedved Vest. This figure is based solely on material from assemblages interpreted as cereal cleaning residues, based on the reasoning that these assemblages should contain the most ‘complete’ weed compositions in relation to what was presumably growing in the fields. The presence of both small/light- and medium-sized/medium weight weeds in all of the interpreted cereal cleaning residues is furthermore interpreted to represent not one but probably several stages of cleaning, for example coarse sieving, followed by flinging or winnowing (cf. Viklund 1998, p. 63).

The results in the figure are similar to the overview of weed-finds in east-central Jutland as a whole (Figure 2). Arable weeds preferring manured environments, such as *Chenopodium album* and *Persicaria lapathifolia*, dominate the material, but are complemented by species

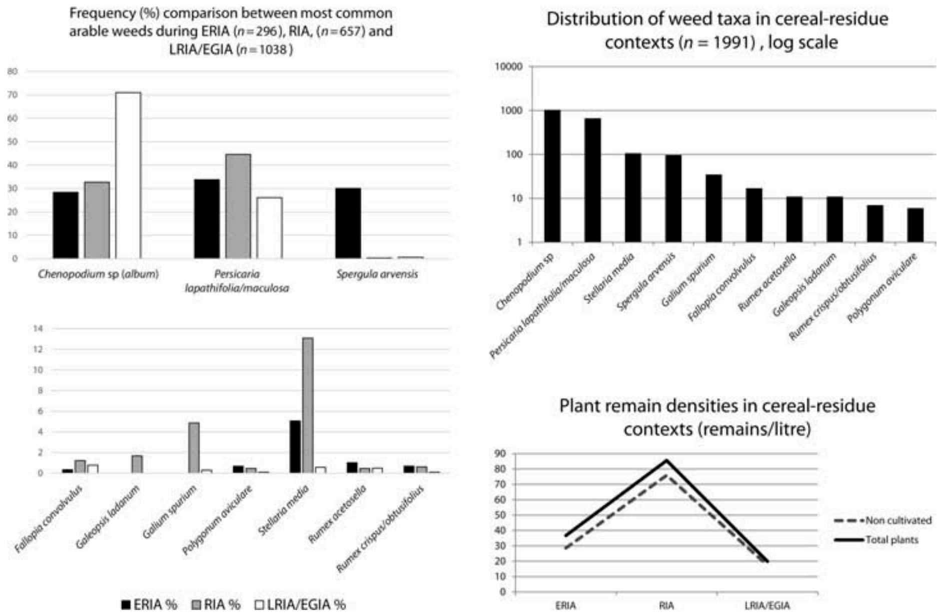

Figure 17. Weed frequencies at Gedved Vest. The material is divided into three chronological categories: early Roman Iron Age (*c*. AD 1–200), Roman Iron Age (*c*. AD 100–400) and late Roman/early Germanic Iron Age (*c*. AD 350–600 [650 in house A11123]).

tolerant of lower nutrient environments such as *Polygonum aviculare, Spergula arvensis* and *Rumex acetosella*. Similarly to the region-wide overview of weed finds, the low-nutrient species appear to decrease sharply over the course of the Iron Age. This could possibly add support for the previously mentioned hypothesis that poor soils were used to a lesser degree during the latter part of the Iron Age or that the manuring regimes became more consistent.

There were no weeds indicative of autumn sowing in the material.

Fodder plants at Gedved Vest?

In the herein presented, overview of botanical material from Gedved Vest references have been made repeatedly to arable weeds and cereals. Hypothetically, however, an Iron Age site should contain botanical material from other biotopes as well, such as fodder plants or collected taxa.

With the exception of house A11404, which contained a moderate presence of grassland species possibly indicative of hay, remarkably few traces of foddering were found at Gedved Vest.

A possible explanation for this fact could be that storage of fodder within the domestic spaces of the settlement was limited. Karin Viklund (1998) has previously noted a distinct difference in the amount of fodder plants in southern and northern Sweden, respectively, arguing for the possibility that the animals in the south were only stalled for short periods of time each year. The milder climate in southern Scandinavia could have allowed for outdoor grazing to a much higher degree than in northern Scandinavia. Interestingly, the analysis of Locality 9–11 showed that only one of two analysed houses contained a phosphate signature consistent with a byre space. This could therefore perhaps be an indication that stalling of animals was not practiced in all farmsteads of the settlement or at least that it in some cases was limited.

Since most of the investigated houses were burnt, there is also a possibility that the houses burned during a time of the year when little or no fodder was stored indoors or that fodder was generally not stored inside the longhouses but maybe in smaller ancillary constructions.

A third possibility could be that the grasslands were mostly used for pasture and that the animals were fed with alternative fodder sources during the stalling period. One such source could be leaf fodder from pollarded trees. Such material would result in a carbonised botanical signature consisting of charcoal and would thus be essentially impossible to distinguish from charcoal derived from the structure of burnt houses.

Analysis of Kristinebjerg Øst

Functional analysis of house DG

House DG was already during excavation noted for its large amounts of charcoal and visible cereal grains indicating destruction by fire (J. Westermann, personal communication, September 2013). This was confirmed by the archaeobotanical analysis, which showed high concentrations of cereals in all sampled postholes and wall-trenches.

The botanical material consisted of almost pure grain. After subsampling, the large samples , a total of 3168 plant remains, were recovered from the house. Out of these, only 143 belonged to non-cultivated taxa. It may thus be concluded that this material represents well cleaned stored grain.

The grain was present in all parts of the house, indicating that the entire area of the house was used for cereal storage. This function does not, however, preclude that the structure had other functions since the cereals could have been stored on a loft (cf discussion in Rowley-Conwy (2000)). Such ancillary function would, however, not have involved plant material traceable through standard archaeobotanical methodology.

Cereals in house DG

The grain assemblage in house DG was composed of four crops: hulled barley, rye, bread wheat and oat. Interestingly, all of these were found in separate parts of the house, thus indicating both monoculture cultivation and separate storage. As seen in Figure 18, only the mixing of crops appears to have occurred at the boundaries between the crop concentrations, possibly resulting from movement of grain during the destruction event. The otherwise intact signature of separate storage indicates limited disturbance after the event.

The cleaned nature of the grain means that the diagnostic floret bases of oat were missing in the material, but the clean large find indicates that it was cultivated at this site, since wild oat would likely not be collected and stored in large quantities. This is also chronologically consistent with the data from previous investigations in east-central Jutland, such as Viuf Vesterby.

The finds of hulled barley and rye are also consistent with previously established understanding of late Iron Age cultivation in Denmark.

Finds of weeds indicating autumn sowing, such as *Agrostemma githago* and *Bromus secalinus* together with the concentration of rye, also indicate crop-rotation of these species.

Most interesting, however, is the large find of bread wheat. This is thus far the only secure storage find of this crop in the region and one of a few in the entire south Scandinavian region. As such, it is a rare material providing evidence about how this crop may have fitted into the existing agricultural system.

A review of the weeds accompanying the wheat in house DG (Figure 19 and supplementary material 4) shows that it likely is grown on manured fields, indicated by presence of *Fallopia convolvulus, Galium spurium, Persicaria lapathifolia/maculosa* and *Stellaria media*. The concentration of wheat did, however, also contain the majority of the *Agrostemma githago* finds from house DG. Although there is a possibility that this occurrence is contaminations deriving from rye cultivation, the evidences pointing toward a minimal disturbance of house DG after the burning also necessitate the consideration that it was growing in the fields together with the wheat. If this is the case, this may indicate that the wheat was

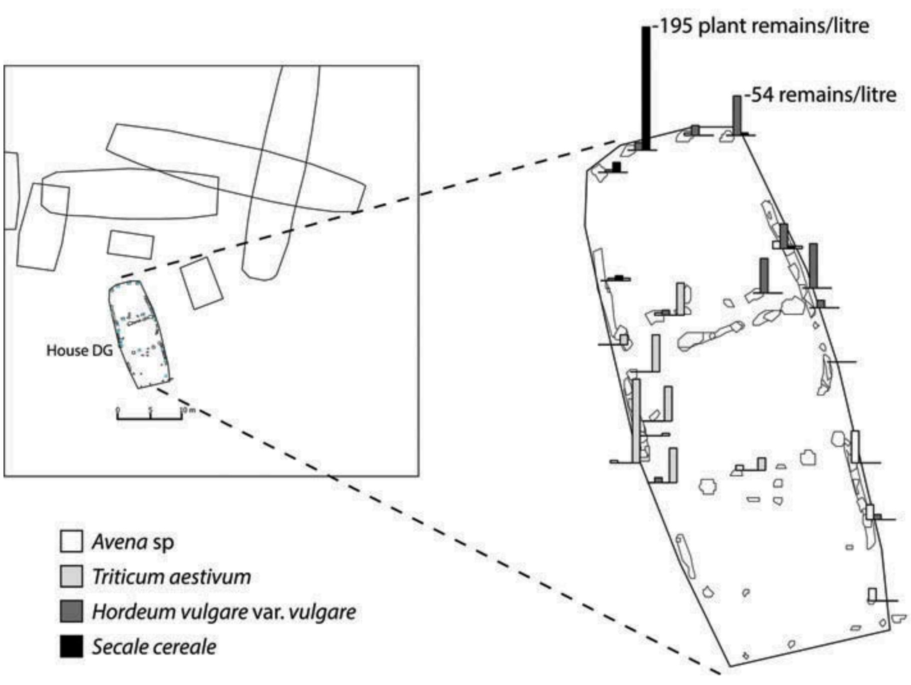

Figure 18. Site plan of Kristinebjerg Øst and close-up of house DG showing the distribution of cereals.

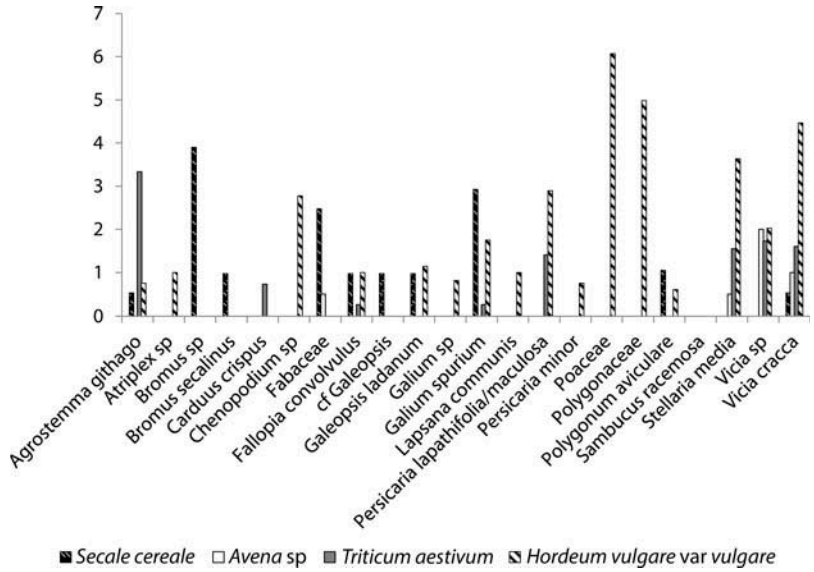

Figure 19. Graph showing the number of various weed taxa in each of the four concentrations of cereals containing relatively clean rye, hulled barley, bread wheat and oat, respectively.

autumn sown similarly to rye. The higher nutritional demand of wheat may, however, have necessitated a slightly different manuring regime for wheat than for rye. This find of wheat thus opens up for the possibility that the rotation agriculture of late south Scandinavian Iron Age may have been more complex than previously indicated by archaeobotanical finds. In the least, the possibility of wheat being autumn sown should be considered in future research as more large finds of bread wheat become available.

Interpreted cereal cultivation history of east-central Jutland based on currently available data

The chronological span of the material presented in this article from previously performed archaeobotanical analyses, coupled with the recently acquired results from Gedved Vest and Kristnebjerg Øst, allows for the establishment of a region-specific cultivation historical overview for the Iron Age in east-central Jutland. This cultivation-historical outline is illustrated in Figure 20.

Consistent with previously proposed models for other areas of south Scandinavia, the Iron Age agriculture in the investigated region appears to have been distinctly dependent on barley, which dominates or makes up a fundamental component of almost all botanical assemblages. The compiled data for east-central Jutland also indicates that the transition from naked to hulled barley, previously mentioned as occurring at different times in various parts of south Scandinavia, can be dated to around the first century AD. Comparing this result to the adjoining regions, east-central Jutland appears to follow a trend more reminiscent of Funen than the rest of Jutland.

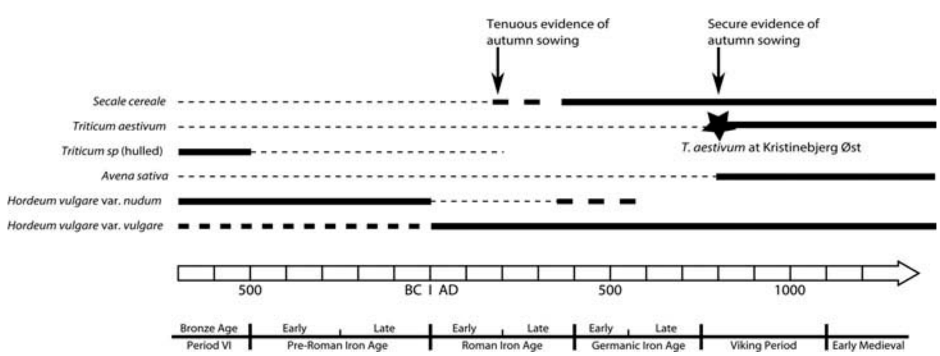

Figure 20. An attempt to visualise the cereal cultivation history of east-central Jutland, based on a qualitative assessment of material from Gedved Vest, Kristinebjerg Øst and the eleven previously analysed sites. Thin broken line, possible cultivation; thick broken line, secure evidence of cultivation but, based on current data, limited in scale; Thick unbroken line, clear evidence for cultivation; star, marking, for the region, the exceptional bread wheat find at Kristinebjerg Øst.

That the main barley cultivation, already at the start of the Iron Age, was performed on manured fields also appears to be clearly indicated by the investigated material. The weed flora (presented in Figures 3, 17 and 19) is similar in almost all assemblages, with nitrophilous, manure indicating weeds being among the most numerous taxa throughout the investigated period.

There are, however, also dissimilarities in the weed material dating to different periods of the Iron Age, the most significant being the decrease over time in taxa which thrive predominantly on poorer soils, such as *Spergula arvensis, Rumex acetosella* and *Polygonum aviculare*, and an increase in taxa indicating autumn sowing such as *Agrostemma githago*. Both of these changes are consistent with a proposed model of early and mid-Iron Age semi-mobile cultivation gradually being transformed into a more fixed infield–outfield utilisation of landscape, where the infields were cultivated in accordance to crop-rotation principles.

The exact dating of this transformation is, however, elusive. The weed assemblages are at this stage not sufficient in quantity and chronological coverage to date the process satisfactorily. Thus, the best archaeobotanical indication for the establishment of crop-rotation, and by extension the presumed infields–outfields, must be sought through a convincing identification of autumn sown crops. In the case of south Scandinavia, the most significant of these crops is rye.

Strong evidence for autumn sowing of rye were found at Kristinebjerg Øst, analysed in connection to the project of which this article is a part, and on the previously analysed site of Århus Søndervold. There was also a more uncertain indication of autumn sowing at the site of Viuf Vesterby. All of these sites are dated to AD 800 or later.

The only earlier clean finds of rye were reported from the site of SBM 1101 Golf 11, where it was recovered from two iron smelting furnaces. There is, however, no way of confirming or disproving whether this rye was autumn sown or not, a situation common to many analysed sites in south Scandinavia.

There are several aspects to rye which make it a particularly difficult plant to interpret.

The first of these is that rye most likely spread to northern Europe as a weed in other cultivation. This weed was, however, not a wild progenitor of cultivated rye, but rather a cultural plant in its own right; a plant that had developed all traits of cultivated cereals in order to increase its chances of dispersal by human action. Therefore, weed rye and cultivated rye are impossible to distinguish by morphology; they are not separate species, but rather different utilisations of the same plant (Behre 1992).

Second, the fact that weed rye already possessed the traits of cultivated cereals distinguishes it from many other weeds by not being necessarily harmful to the cultivation as a whole. Behre notes that farmers in some documented cases display a tolerance to weed inclusion of rye:

> *All over Anatolia and also in north Iran, north Iraq and north Syria, non-brittle types of rye are conspicuous, tolerated weeds in wheat agriculture. They are usually not weeded out by the farmer, and are harvested and threshed together with the wheat* (Behre 1992, p. 149).

Another relevant study of the mixing of crops has been presented by Jones and Halstead (1995). In their publication of the attitudes of the farmers on the Greek island of Amorgos towards monocultural cultivation, maslins (cultivation of several species on a single plot) and the thereof deriving produce, the authors showed that the perception of the purity of a crop was not fixed, but could both be assessed differently by individual farmers – some being more careful in their processing than others – and also influenced by the context in which the plant was utilised; a ‘pure assemblage’ being judged variously in situations of foddering, consumption, trade and selection of seed for sowing.

The complexity of situations in which rye may have figured during the Iron Age could have been comparable to the cases observed and documented by ethnographers.

In a case such as Gedved Vest, rye could have been grown on separate fields, utilising soils unsuitable for barley. It could also have been utilised on fields which had previously supported barley cultivation, but were being transformed into fallow. The rye could also have grown as a weed in spring sown barley fields.

Another factor to take into consideration is that rye could have had more than merely culinary uses. In an ethnobotanical overview of rye use in Denmark, Brøndegaard (1979) lists many types of craft and manufacture utilising rye straw, ranging from basketry to roof thatching, while in Sweden rye has been documented as being cultivated on small plots in barley dominated areas, its straw used as binding material for the harvested sheaves of the main crop (Dahlstedt 1999).

The factors outlined above makes it necessary to consider whether rye should be discussed in terms of a *weed* versus *cultivated crop* at all, at least when referring to the period preceding its adaptation into a rotation system. The conceptual spectrum of the Iron Age farmers may not necessarily have been one of a binary division into a wanted or unwanted plant. Rye could have been perceived as an individually unique botanical phenomenon, not a weed and not a cereal crop, but rather a species with properties which could be utilised flexibly in order to meet both the needs and desires of the farming community as well as the preconditions for agriculture, such as access to manure and soils in a state suitable for cultivation. Such a situation would account for the difficulty of establishing a precise date for its large scale cultivation.

On a site such as Gedved Vest, flexible utilisation would account for the chronological variations in occurrence; rye being present during the earliest Roman period, disappearing during mid and late Roman Iron Age and reappearing at the shift to the Germanic period.

A flexible utilisation of rye would also account for the trend of rye appearing in some but not all end-stage assemblages from Gedved Vest and for the higher frequencies in cereal cleaning residues, since these could possibly be an amalgamated result of its free-threshing nature and occasional conscious removal from barley stock in which a high level of purity was desired.

Overall, one could argue that rye, even after a review of numerous assemblages, remains a difficult plant to interpret; its mode of cultivation being mostly speculative. The certain conclusions regarding rye are that it played a role in Iron Age agriculture in the investigated region from as early as the first century AD and that its significance likely increased over time. Independent cultivation is indicated from the second and third centuries AD by the iron smelting finds at SBM 1101 Golf 11, while crop-rotation is convincingly identified from the Viking Age onward.

Oat, similar to rye, most likely appeared in south Scandinavia as a weed. Although the weed species *Avena fatua* and *Avena strigosa* differ from the cultivated *Avena sativa* in terms of some morphological traits, these traits have not been preserved in any assemblages except at Viuf Vesterby, where some grains were positively determined as the cultivated species. At Kristinebjerg Øst, the clean and large find, although not positively determined down to species, also indicates cultivated oat. Both sites are dated to the Viking Age. All earlier finds from east-central Jutland are numerically small, pointing to weed inclusion rather than cultivation. This result is somewhat unexpected as assemblages of oat have been interpreted as cultivated in other parts of Denmark from as early as the pre-Roman Iron Age (Robinson *et al.* 2009). Therefore, although oat cultivation cannot be securely established in this region before the Viking Age, one should be cautious about precluding its cultivation prior to the end of the Iron Age. A factor to take into consideration is that oat has historically, at least in some areas, been linked to the feeding of animals, primarily horses (Langdon 1982, Myrdal 1999). If this was true for the prehistoric periods as well, oat may be significantly underrepresented in the archaeobotanical record, since it would likely run a smaller chance of becoming charred by accidental contact with household fires. If the fodder was not stored in structures containing hearths, it would also run a smaller chance of preservation due to accidental house fires.

The modes of oat cultivation cannot be deduced from the small finds presented herein, but historically it has been cultivated both as a spring sown crop in three crop-rotation systems and on permanent slow rotation fields, either independently or following barley. Oat is more resistant to humidity than other cereals, and historical references for Halland have documented the latter method as being applied on wet soils, where little other cultivation was possible (Mikkelsen and Nørbach 2003, Pedersen and Widgren 2004, Grabowski 2011, p. 490 and there listed references).

The last of the four main crops identified in the archaeobotanical material from east-central Jutland is wheat. The various types of wheat have a long history in south Scandinavia; the hulled varieties being in cultivation for several thousand years during the Neolithic and the Bronze Age as a staple in human subsistence, and the naked bread wheat, with its ability to provide fine flour for yeasted white bread, seemingly being cultivated as a secondary crop and known in historical medieval documentation and oral tradition as something of a luxury or special-event product (Grabowski 2011,p. 492 and there listed references).

During the Iron Age, however, wheat is another crop presence eluding a comprehensive interpretation. It occurs constantly throughout most periods and both hulled and naked types are present in the material, although the hulled wheats do gradually disappear over the course of the Iron Age. The sparse presence in botanical assemblages makes it difficult to discuss possible modes of cultivation for wheat or its role in the rotation-systems established at the end of the Iron Age. The find from Kristinebjerg Øst must in this context be seen as significant, since the weed flora accompanying the wheat points towards autumn sowing. The size of the material at Kristinebjerg Øst also indicates that it was, at least on this site of significance, comparable to barley and rye. It is impossible to determine, however, whether this significance is representative for a wider area or even the site from which it was recovered, since the burnt house DG most likely represents a single event in the history of the site. Future archaeobotanical finds of wheat should therefore seek to understand both the relative importance of wheat to other cultivation and attempts to establish whether it was autumn or spring sown.

Concluding remarks

The overview of previously conducted archaeobotanical analyses presented at the beginning of this article focused on a discussion of two previously identified transformations of cereal cultivation over the course of the Iron Age: first from an extensive agriculture of hulled wheats and naked barley on possibly unmanured fields to an intensified cultivation of hulled barley on manured fields, shifting at unknown intervals between cultivation and fallow, and second, one from the intensified but still semi-mobile cultivation of hulled barley to rotation of spring sown hulled barley and autumn rye within a more fixed infield–outfield system.

The initial overview showed that the archaeobotanical material seems to support such a sequence of developments, but only when viewed at the general level of the entire region. The accumulation of archaeobotanical results from analysed and published sites increasingly accentuates differences between various parts of south Scandinavia as much as similarities.

The addition of data from Gedved Vest and Kristinebjerg Øst further accentuates this view, showing, in combination with the previous analyses, that the cereal cultivation history of east-central Jutland followed a general set of developments observed in archaeological data for the south Scandinavian region as a whole, while, on closer inspection, displaying several area specific traits. This particularly applies to the timing of some agrarian transformations, such as the establishment of hulled barley as a primary crop and the establishment of crop-rotation.

As a consequence, the asynchrony and geographic dispersal of the deduced agricultural strategies can be used to question whether Iron Age agriculture should be conceptualised in terms of phases and transformations at all or whether the entire period could be seen as one complex and drawn out process of agrarian intensification and invention culminating in the agricultural system of the medieval period.

In a discussion about Iron Age agrarian landscape developments, based on archaeological and geographic data, Pedersen and Widgren have previously argued that:

> *Agriculture was everywhere based on a combination of crop and animal husbandry. Most farmsteads had three-aisled longhouses with stabled livestock* [and] *manured fields.* […] *The produce from the fields made up at least half the food.* […] *Arable fields provide approximately 10 times more energy per unit of space than pastures or meadows. Therefore, crop husbandry played an important role even in the most livestock oriented areas* […].
>
> *To some extent one can therefore speak of a typical Iron Age farm.* […] *However,* [if one travelled through the Iron Age countryside] *one would see a richly varied landscape. House types and enclosure materials varied between regions. Enclosure systems formed different patterns in the different areas. In that sense there was no typical Iron Age farm* (2004, p. 270, my translation).

In a subsequent discussion, Widgren (2000) further elaborated this view by defining the natural conditions of each region, the locally prevailing culture and social structure, and the global context of south Scandinavia as three perspectives necessary for an understanding of the development of Iron Age landscapes.

It is my conclusion that the herein presented study conforms to the perception of Iron Age agrarian societies as both regionally structured and simultaneously following local developmental trajectories. I also fully agree that numerous perspectives are necessary to extend the value of archaeological studies beyond observation and towards interpretation and understanding; an understanding to which I hope this article contributes with its archaeobotanical perspective.

Supplemental data

Supplemental data for this article is available via the supplemental tab on the article's online page at http://dx.doi.org/10.1080/21662282.2014.920127

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