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Editorial

Velkommen til, or rather *welcome* to the first issue of the *Danish Journal of Archaeology*! After many months of behind-the-scenes negotiations and work, we are pleased and proud to be able to present the first of many exciting volumes on what is moving and shaking in the discipline in Denmark and beyond. We, the editors, are not the only ones who have noticed a distinct lack of English-language, peer-reviewed outlets for Danish archaeology. Luckily, the Danish Agency for Culture agreed with us, and with their generous pump-priming funding, we are able to launch this new publication.

Archaeology in Denmark is rooted locally but at the same time can be said to be a strong and global brand. Most, if not all, archaeologists around the world have learnt that the earliest antiquarian efforts by Danish scholars such as Thomsen and Worsaae laid the foundation for archaeology as a modern discipline. Texts about Danish archaeology feature on many a university reading list, and cultures or sites such as Ertebølle, Hjortspring, Trelleborg and Lejre are known – despite their occasionally awkward names seen from a non-Scandinavian perspective – by many. Yet, as a discovery – as well as a theory-driven discipline, archaeology is constantly evolving. In most European countries, legislation is such that developers must, in advance of building projects, see to the adequate investigation and documentation of archaeological remains in the construction area. Years of booming global economy have meant that the frequency and scale of archaeological field investigation have reached unprecedented heights. However, the period of reflection following the widespread economic downturn has led many governments – including Denmark's – to realise that excavation and documentation alone simply are not enough. Now, the publication of findings is being given increasing priority. Coupled with the move towards a publication-based reward system for university departments, the eagerness, need and readiness of commercial units, museums and academic archaeologists to publish findings in article format have perhaps never been more marked.

In order to meet this demand, the *Danish Journal of Archaeology*, which builds on the legacy of the *Journal of Danish Archaeology,* will fill the niche for an up-to-date English-language journal for scholars conducting research in and around Denmark and provide a peer-reviewed publication with a strong web presence.

The *Danish Journal of Archaeology* is dedicated to the presentation, discussion and interpretation of the archaeological record of the Scandinavian, Baltic and North Atlantic regions in their international, regional and local contexts covering all time periods and all kinds of archaeology that have relevance for the Scandinavian area or to the discipline as such. The journal's aim is to provide an international platform for publication and debate for professionals from the museum and heritage sectors as well as from the universities. Our focus is on empirically-grounded studies and our aim to tap into the strong tradition of excellent empirical work carried out by Scandinavian archaeologists, while remaining receptive to theoretical and conceptual papers. Additionally, the *Danish Journal of Archaeology* will provide, we hope, the ideal publication platform for the presentation of new finds and outstanding discoveries from the field – and the Scandinavian area is rich in these! The geographic and institutional scope of the *Danish Journal of Archaeology* is wide: Southern Scandinavia and its universities, museums and research centres constitute the central element, while the Baltic and North Atlantic regions make up the broader sphere of contact and influence. It is our hope and aim that the journal, as was the case with its predecessor, will be drawn on in university courses across Northern Europe, at the very least.

The *Danish Journal of Archaeology* publishes two online issues and one printed volume annually. Thanks to our collaboration with Taylor & Francis all articles will appear online as soon as manuscripts are accepted in their final form, which will, we hope, offer opportunities for dynamic and rapid publication and of engaging debate about recent findings and current debates. The professionalism and international marketing experience brought to the journal by Taylor & Francis also means that the *Danish Journal of Archaeology* will be available at all the relevant international conference, and thereby further promote Danish archaeology as the globally excellent brand that it is. The *Danish Journal of Archaeology* includes original research articles, news and discoveries and discussion pieces with the intention of fostering open debate in print about the archaeological record of Southern Scandinavia in its broadest sense and the position of archaeology as a discipline in the modern world. A broad portfolio of formats for contributions is offered: *Research articles* (regular analytical, theoretical or methodological contributions), *Research report*s (longer research articles with a stronger empirical or descriptive aspect), *Brief communications* (find or field reports and short notes) and *Discussion articles* (comments on previously published work or on special topics and finds). For further details and guidelines, see http://www.tandfonline.com/rdja. The instructions for authors can be found in the menu on the left-hand side stating 'Authors and Submissions'. It is also there in the menu 'Subscribe' where you can find information on how to make sure that you receive every issue of the journal. Also, note that we have negotiated very favourable rates for many institutions, including museums!

The journal's first issue attests to this deliberate diversity of contributions. This first batch of articles ranges widely both chronologically and in their approaches. We have made space not only for the presentation of important sites but also for shorter contributions and discussions. In addition, we are very happy to announce that every single back issue of our predecessor, the old *Journal of Danish Archaeology*, is now available online to subscribers. Needless to say, all articles (with the exception of the willingly 'uncensored' *Discussion articles*) are peer reviewed by at least two expert colleagues from Denmark or elsewhere. We now heartily thank our corps of reviewers for their very important contributions. We also thank the members of our international Editorial Board who provide vital support and backing to the kind of project that this journal is. Last but not least, we thank our authors who have chosen to support this new publication venture here in its infancy – thank you all. We look forward to many years of fruitful collaboration and collegial exchange across national and disciplinary boundaries with both our reviewers and the Editorial Board.

The *Danish Journal of Archaeology's* first editorial team is made up of Felix Riede (Aarhus University), Eva Andersson Strand (Copenhagen University & The Danish National Research Foundation's Centre for Textile Research) and Mads Dengsoe Jessen (National Museum of Denmark). We cordially welcome new and old readers and we would encourage you all to contribute to this important new platform for Danish archaeology – we look forward to receiving your manuscripts!

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Prologue

Ad multos annos….

Archaeology has a long history in Denmark and one of its foremost and most enduring concepts is Christian Jürgensen Thomsen's (1788–1865) division of prehistoric material into Stone Age, Bronze Age and Iron Age periods. Thomsen presented his ideas in a paper titled 'Brief Review of the Monuments and Antiquities from ancient times in Scandinavia' (Kortfattet Udsigt over Mindesmærker og Oldsager fra Nordens Fortid) in the book 'Guide to Scandinavian Archaeology' (Ledetraad til nordisk Oldkyndighed). The Danish version was published in 1836 and was already translated into German by 1837.

Thomsen's springboard was the establishment of 'The Royal Commission for the Preservation of Antiquities' which, with its roots in the royal collections, was the forerunner of the existing National Museum of Denmark. Not only were his ideas practiced in the museum, but their publication in both domestic and international fora, made it possible for contemporary scholars to understand, discuss and criticize them. And this is how it should be; archaeology embraces both prehistory and the middle ages, the renaissance and modern times with archaeologists working both on dry land and underwater. Furthermore, for over 100 years the collaboration between the natural and conservation sciences and archeology as well as between the archaeological museums and the universities has been mutually rewarding.

As most of todays' excavations are triggered by construction projects, it is often these that determine where we excavate and how. It is thus even more important that all archaeological activities are built upon on a common, long-term research strategy in collaboration with the archaeological museums and ensuring that both research excavations and construction-led excavations produce high quality results to an international standard.

One of the consequences of the latest Museum Act, effective from 1 January 2013, is the reduction of the total number of Danish archaeological museums to 27 viable units which can deliver relevant research. The research quality should be equal to the highest international standards, a focussed effort should be made to attract international researchers and projects should be grounded in frontline research questions. International research assessments for both 2009 and 2013 have emphasized a need for additional research in both terrestrial and marine archaeology in Denmark.

One of the ways in which we can promote these objectives is with this journal. Made possible by financial support from The Danish Agency for Culture, the *Danish Journal of Archaeology* (*DJA*) aims to be among the foremost of its type in archaeological research and welcomes articles within its geographical and editorial framework from all, regardless of the authors' position.

The *Danish Journal of Archaeology* is therefore a deliberate name change from the *Journal of Danish Archaeology* (*JDA*) which was published between 1982 and 2006 and successfully sought to play a similar role. Despite the name change, *DJA* follows in *JDA*s footsteps. The former facilitators and editors deserve thanks for completing 14 volumes, all of which were alongside their usual responsibilities. Then as now, collaboration between the archaeological museums and the universities lays behind the journal and now the Danish Agency for Culture has demonstrated its commitment to safeguarding the quality and internationalisation of archaeological research by ensuring a secure economic basis for the *Danish Journal of Archaeology* for its first four years.

The range of the editorial team and their desire to encompass a wide variety of archaeological topics, both geographical and professional, will be a central characteristic. In addition, collaboration with an international publisher such as Taylor & Francis ensures a digital future for the *Danish Journal of Archaeology* and also for the published content of the *Journal of Danish Archaeology* which is already available online for all subscribers.

It is my hope that this initiative will prove its strength for many years to come, that past and future subscribers will continue their support and that the *Danish Journal of Archaeology* will grow and live.

Crescat et vivat!

Per Kristian Madsen
Director General, National Museum of Denmark

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The Bishop of Ribe's rural property in Lustrup

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In 1996, an archaeological trial excavation prior to an expansion of the Viking Centre in Lustrupholm led to the discovery of among other things a 54-m long, approximately N–S-oriented post-built house from the Middle Ages. The find gave rise to continued investigations, and in subsequent years the remains of a – by Danish standards – very extensive series of buildings were excavated. This can be identified from written sources as a farm site belonging to the Bishop of Ribe. The article presents the results of the archaeological investigations up to 2007. One or two large houses from the 1100s were succeeded around 1200 by a two-winged post-built complex which was expanded in later years with a brick-built house and a number of other large buildings apparently constructed according to a great variety of principles. The complex appears to have been demolished before the end of the thirteenth century.

Keywords: Ribe; Bishop; magnate farm; 12. century; 13. century; cavalry

– *a magnate farm from the age of the Valdemars*[1]

Introduction

Lustrupholm is the name of a small manor house situated near the stream Haulund Bæk just 2 km SSE of Ribe.[2] The modest whitewashed buildings were erected around 1770 and today house the administrative functions of the Ribe Viking Centre, which was established there in 1992. Throughout the 1990s, in the areas south and west of the manor house, full-scale copies of houses from the Viking Age have been built on the basis of house sites excavated in and around Ribe.

Within this anachronistic framework, from 1998 until (so far) 2007, the Antiquarian Collection in Ribe has excavated extensive remains of a medieval magnate farm which is known, on the basis of written sources from the thirteenth century, to have belonged to the Bishop of Ribe (Figure 1, excavation picture). The complex of buildings, which grew large over time, probably had its origins in two largish farms from the 1100s which were succeeded around 1200 by a two-winged structure around which a number of impressive buildings were erected in subsequent decades, with a total area approaching 1400 m^2. This included a brick-built house with cellars. The useful life of the magnate farm was short, and there are no signs of activity after c. 1260.

So far only provisional descriptions of the farm and its history have been published.[3] It is the aim of this article to present the – not uncomplicated – archaeological data from the excavations, so that future research on this and other magnate farms and their role in the society of the Middle Ages can rest on firmer ground. But not all questions about the Bishop of Ribe's complex in Lustrup can be answered at present. Various earthworks, afforestation and recent building work have removed or concealed parts of the complex. Nevertheless, there is little doubt that the excavated buildings make up the best Danish example of how a magnate farm belonging to the absolute elite of society could look.

We do not know the historical motives for the erection of the so-far unique complex, but against the background of the information about the farm in the written sources, linked with historical knowledge of the role of the bishops in among other areas the military organization of the country, it is proposed that the farm may have served – at least – two purposes: one as a nodal point in the administration and maintenance of the flow of duties, primarily paid in kind, to the bishop's seat; while a second purpose, equally important in the period, may have been as a supply station for the King's mounted troops, who were extremely active in the first part of the thirteenth century.

The History of the Excavations

When the Viking Centre was established in 1993 on the gently ascending terrain, south of the manor house, a copy of the "Viking Age" market place was reconstructed with a background of the excavations of the market place of the eighth and ninth centuries in Ribe. There was no preliminary investigation of the area. In 1998, plans emerged to expand the centre with a number of buildings located on the slightly higher-lying area to the south. Prior to this construction work, the Antiquarian Collection carried out a trial

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Figure 1. Past meets past. The excavations at Lustrupholm were conducted between Ribe Viking Centre's reconstructions of present-day ideas about the past. Here we see a corner of the market place in Ribe in the year 720 temporarily destroyed by the search for the northern part of the farm features from the twelfth century.

excavation and subsequent rescue excavations in 1998–99. These were followed by our own and foundation-supported research excavations in the years 2000, 2002, 2003, 2006 and 2007.[4] The orientation and position of the excavation fields had to allow for the Viking Centre's use of the area, which in conjunction with limited funding for the investigations was the reason for the apparently unsystematic location and delimitation of the excavation fields[5] (Figure 2, campaign overview). The excavation method was the one most frequently used in Denmark, where the topsoil was cleared with excavating machinery until untouched subsoil appeared, after which the earthfast features were drawn and to a certain extent sectioned. As a minimum, the interpreted structures are sectioned and to a very great extent also sieved, and this has ensured a large body of artefact material. The non-threatened features were investigated carefully and an attempt was made to preserve the non-sectioned half of the features with careful covering. Specimens were only taken for scientific analysis to a limited extent. In all, an area of 10,178 m^2 was excavated.

Topography

The flat West Jutland landscape took on its rounded forms during the melting phases of the last ice age, when enormous masses of water as well as wind and weather levelled the contours of the landscape and created the wide heath plains and hill islands that make up the basic forms of the landscape today. In this flat context, Lustrupholm, as the name suggests ("holm" = islet), is a striking element in the form of a small headland that

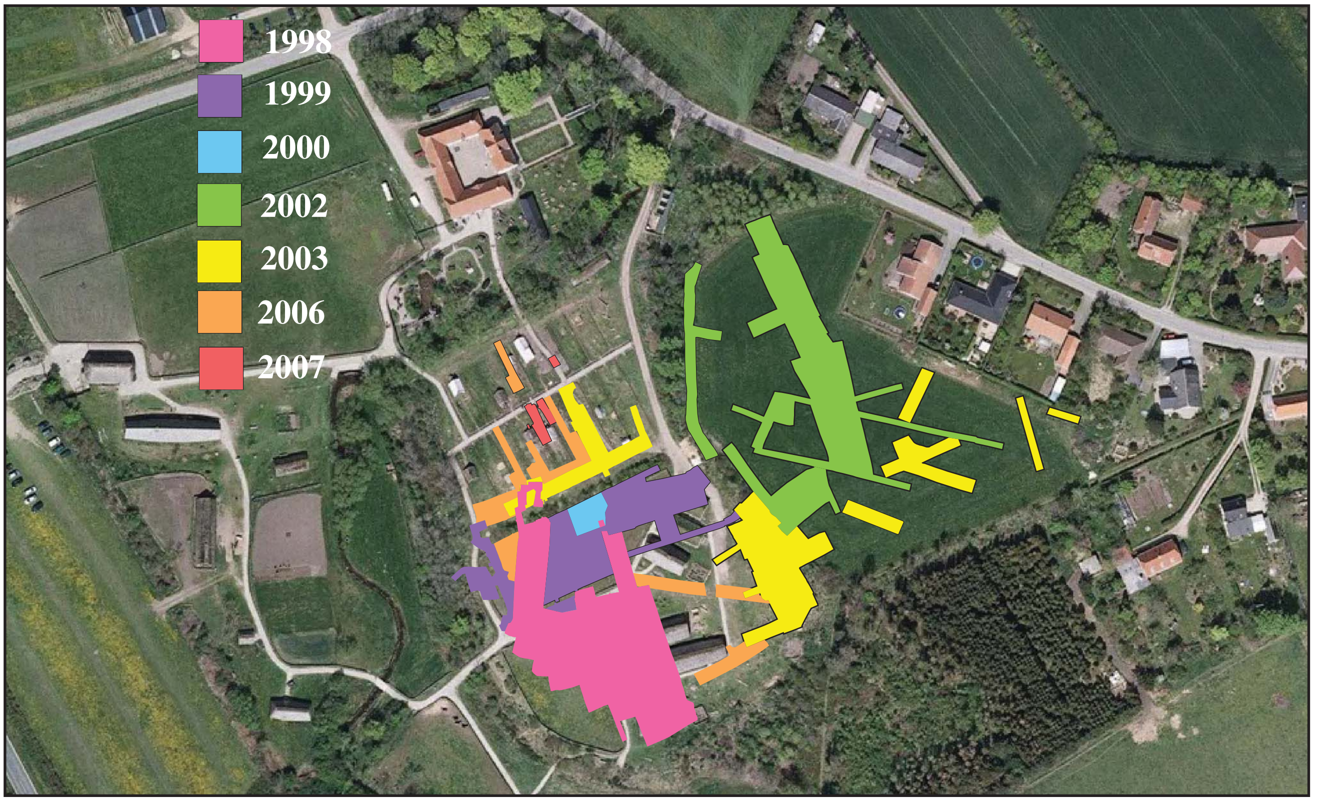

Figure 2. The present use of the area and limited funding have together produced this patchwork of excavation fields which shows the extent and sequence of the excavations.

stretches out into the lower-lying wetlands around Haulund Bæk, which surrounds the area to the north, south and west. Towards the east, the terrain continues evenly in the direction of the present-day village of Lustrup. The landscape surface on the point lies between 8 and 10 m above Danish Normal Zero (DNZ), and the subsoil at the place is fine yellowish sand entirely free of rock. The ploughsoil layer all over the area was very thin and only in a few places reached thicknesses over 40 cm. The ploughing depth seems always to have been modest, and the preservation conditions for the earthfast features must be described as good. In the sandy soil, organic material was much decomposed. Only animal bones were preserved in some cases in the medieval features.

The striking, naturally protected location in the landscape must have appeared attractive to both hunters and farmers through several periods of prehistory. Besides the features from the Middle Ages discussed here, Mesolithic flint from the Maglemose period has been found in the excavations, as well as traces of settlement from several periods of the Neolithic Funnel Beaker Culture and the Single Grave culture, a settlement and burial site from the Bronze Age and several farms from the period Late Roman Iron Age to Germanic Iron Age.[6]

From the point Lustrupholm, the area of which was formerly around 2 ha, there are good views towards the north, south and west, and it is worth noting that the southward road to Tønder runs only 500 m to the west, while the eastward highway over towards the old military road Hærvejen and to Haderslev runs less than 1 km to the north. Both roads must be supposed to have existed as early as c. 1200, and viewed in the context of Ribe's harbour potential the farm must be said, in the overall traffic perspective, to have been located at a central intersection (Figure 3, VSK outline map).[7]

Today, the transition between the point Lustrupholm and the meadows around Haulund Bæk runs down over a marked slope descending about 3 m. This feature is not original, but has emerged with sand-quarrying and the establishment of a meadow irrigation system at some time in the interval 1870–1937. With this excavation work the northwestern tip of the point, which, judging from older height contour lines, must have been very striking, disappeared. At this point in the 1860s, the city historian of Ribe, J. Kinch, could see "a thrown-up bank surrounded on two sides by Lustrup Bæk, and on which there undoubtedly stood a fixed tower in ancient times."[8] It is no longer possible to verify Kinch's observations, but

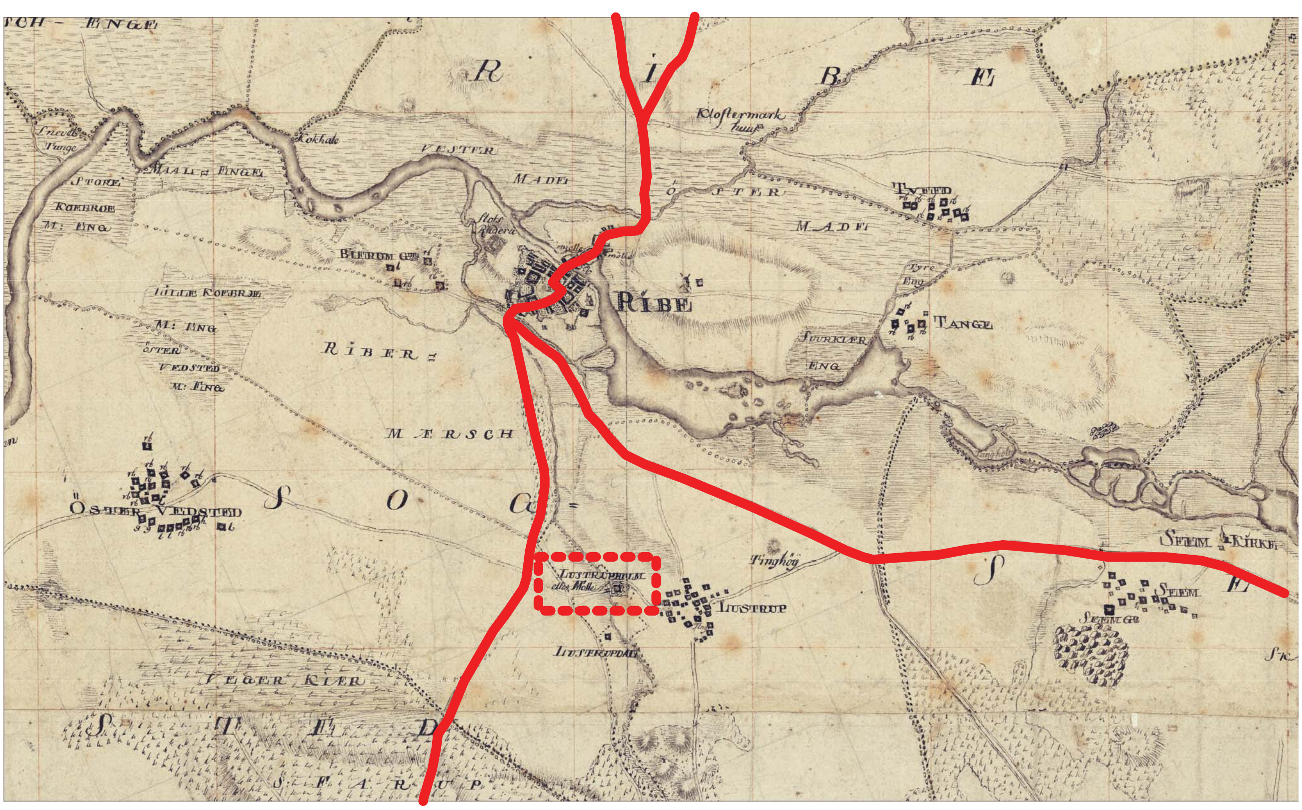

Figure 3. On the outline map from the Royal Danish Society of Sciences and Letters from 1794 the highways towards Ribe are marked here in red. The Bishop's farm lay close to both the southbound road to Tønder and the roads to the south east towards Hærvejen and Haderslev.

Figure 4. By combining the oldest preserved cadastral maps with the height contours from the Topographical Maps from surveys around 1850, one can reconstruct the earlier appearance of the landscape. As is evident, the northwestern part of the point was formerly a striking element, but the area west of the broken line has today been removed by sand-quarrying and a meadow irrigation system. On the point there was an artificial bank, known from a description in the 1860s. This may have been an earthen wall belonging to the northern farm. The placing of the excavation fields is marked in yellow. From the cadastral map of 1839 with additions by the author.

it is likely that there was a rampart belonging to the northern farm from the twelfth century (see below).

By studying the oldest preserved map of the area and earlier height contours, it is possible to reconstruct the appearance of the landscape around 1800. Although there may also have been changes earlier, it is far from unlikely that this picture of the landscape shows us a situation like the one when the buildings of the magnate farm occupied the site on the point at Lustrupholm (Figure 4, original landscape).

Written Accounts of the Bishop's Farm

Of the legal documents from the end of the eleventh century that were instrumental in the regulation of Danish society, and among other things stipulated the legal basis for taxation and property ownership, very few have survived until the present. Most of them are from the Late Middle Ages, and the number of sources declines rapidly the further back in time one goes. Given the paucity of sources, it is striking that today we have knowledge of a whole three sources from the 1200s that mention the Bishop of Ribe's interests in Lustrup. In itself this is indirect evidence of the importance of the place – especially in view of its short functional lifetime.

In 1233, Bishop Gunner of Ribe confirmed a settlement between farmers from "Tønder" and the later-vanished Andaflyth Parish.[9] In the agreement, which does not give further details of the original dispute, and whose wording is known from a transcript in *Ribe Oldemoder,* a number of provisions are stated regarding the distribution of the duties that the farmers were obliged to pay to the Bishop. The passage which mentions Lustrup translates as follows: "Each of them is also obliged to drive oat [duties], to wit oxen and bishop's gift, to Lustrup at his own expense." What was in Lustrup is not described in detail, but it must be assumed to have been important that the farmers delivered their oat duties precisely there in Lustrup, more than 40 km away. Only the oat duties are required to be delivered in Lustrup, while the destination of the other duties is not specified. As early as 1233, the Bishop's seat had major possessions around Møgeltønder, and it is likely that already at that time there was a predecessor of the Bishop's Møgeltønderhus – the later Schackenborg – in the area.

In Nyborg on 14 March 1255, King Christoffer I and Bishop Esger of Ribe effected an exchange of property where the King took over the Bishop's meadows in Lustrup, which damming for the King's water mill in Ribe had left under water.[10] In exchange, the Bishop was given Harboøre. The property exchange must give us an approximate date for the King's mill and the creation of the dam, whose effects are still visible today upstream from Ribe. On the face of it, this seems to be a particularly good transaction for the Bishop. In King Valdemar's Cadastre, Harboøre was an independent *skiben,* with an area today of c. 3000 ha, which must have been substantially decimated since 1255 by coastal erosion. The value of the meadows in Lustrup does not seem to have been proportionate to that of Harboøre, and one might ask whether one possible reason for the size of the compensation might be that the loss of the meadows also meant that the operating potential of the Bishop's farm on Lustrupholm was thus considerably reduced. A second and perhaps more important possibility might be that the King, with the exchange of property, was ensuring the support of the Ribe Bishop in the power struggle with Archbishop Jakob Erlandsen which was to affect the political history of the country in the subsequent decades.[11]

The last known mention of the Bishop's estate in Lustrup is a letter signed by Bishop Esger at "Our residence in Tønder" on 8 September 1258, which is also known from a transcript in *Ribe Oldemoder*.[12] In the letter, the Bishop entered into an agreement with his tenants in "Tønder," from which it is evident that the farmers are "obliged to bring the duties to our butler (*cellarius*) with their own wagons to Lustrup." The mention of Lustrup shows that it still must have been important that some duties were delivered there, where there appears to have been a butler who may have managed the Bishop's household.

The present manor house of Lustrupholm seems to have arisen in the Late Middle Ages, but neither the written sources nor the archaeological finds suggest that there may have been continuity back to the Bishop's farm.

Division into phases and dating

At Lustrupholm, the earthfast remains of a number of buildings and other features have been excavated, and are presented in this context divided into five phases covering the interval from the twelfth century until around 1260. The division into phases has the function of showing the dynamic development of the farm throughout its short useful lifetime, but it is not straightforward, since the number of stratigraphic relations between the medieval buildings is limited. In other cases, it could be documented that a given feature was later than prehistoric features, or it could be assigned to the medieval phases by virtue of the find material. But even when all the stratigraphical, dating and interpretational information is gathered, it is far from obvious how the expansion of the Bishop's estate at Lustrupholm developed. The finer division into phases has therefore to a certain extent been done on the basis of the author's ideas of how it may have happened, and which buildings must be supposed to have stood at the same time. But a number of factors are uncertain. The slender basis for the division into phases is used here in a feature matrix showing the registered stratigraphic relations (Figure 5, feature matrix). The more detailed basis for the assignment to phases and dating is described under the individual buildings.

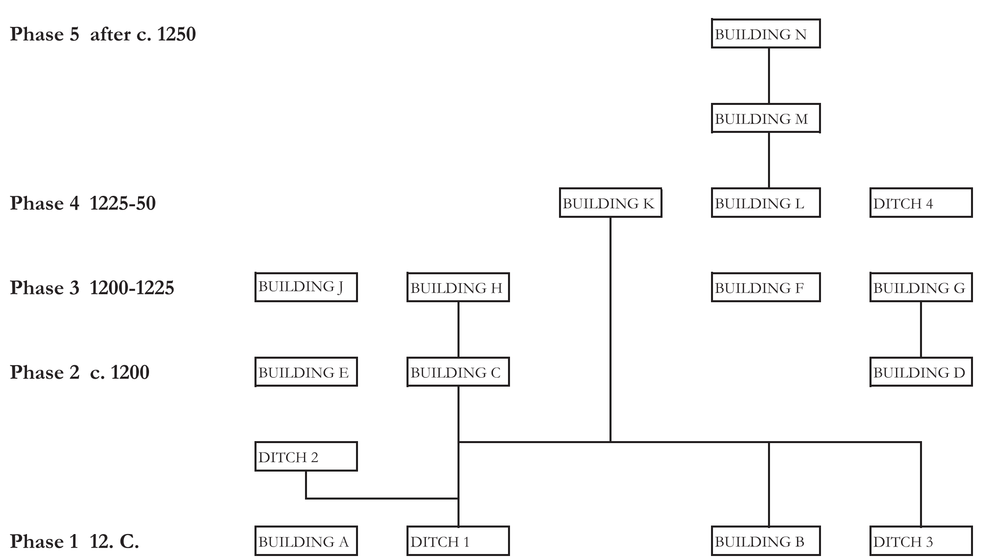

Figure 5. Feature matrix showing the division into phases and the stratigraphic relations on which it is based.

Phase 1: twelfth century

By all indications, in the oldest medieval phase two large farms were built on the point Lustrupholm (Figure 6, Phase 1). Both farms had curved long walls, but they were of different sizes. This might suggest that they were not built at the same time, and in that case the northernmost farm, Building A, must presumably be regarded as the first to be built. South of Building A, a collection of medieval post-holes may mean that there was yet another medieval building, but a belt of shelter planting prevents further investigations at present. This may have been a building that belonged together with Building A, as the course of the large Ditch 1 may also indicate. There is little possibility of determining with certainty whether one or two farms lay at Lustrupholm in the twelfth century. They are regarded here as two contemporary units on the basis of the convergence between Trenches 1 and 3, which seem to respect each other, but this may be coincidental. The northernmost farm looks like the most important one, both because of the size and number of the buildings and because of the surrounding ditch, but it is unfortunately also the one most destroyed today.

Building A

Sand-quarrying and terrain regulations have transformed the area where Building A lay, so much so that the possibility of its existence was not realized until after the excavations in 2006. These were followed up by limited surface stripping in 2007, which was not made easier by the fact that the Viking Centre's market place uses the area at present. The western end of the building has been destroyed by sand-quarrying, and only the bottom centimetres of the post-holes of the south wall were preserved. However, this was enough to establish that there has been a building with curved long walls, whose width in the middle had exceeded 9 m. The building does not seem to have had projections; it consisted of two rows of roof-bearing wall post-holes. In these two potsherds were found; one of the rhenish Paffrath type and the other of local grey-fired ware. From the east gable a ditch started, Ditch 2, which is discussed below. Buildings with curved long walls consisting of just two rows of roof-bearing wall posts are well known in the archaeological material. They are known from Vorbasse and a number of other sites and are dated in general to the eleventh/twelfth centuries.

Figure 6. Phase 1. Buildings and ditches belonging to Phase 1 of the medieval settlement from the twelfth century. Building A has two circular post symbols against the background of an accurate sketch made during the digging of a pit-house at the Viking Centre market place in 1993.

Ditch 1

A substantial ditch between 2.3 and 3 m wide in the excavation surface. Its curved course cut off Building A and the northwestern part of Lustrupholm from the open countryside towards the east. Its depth was up to 1 m below the excavation surface. Towards the east there was a 4-m wide opening approximately opposite Building A. There were no traces of any rampart, but this is not surprising, since the subsequent construction work around 1200 must already have removed most of it. There were no traces of support for the sides of the ditch, which had collapsed in and partly filled the ditch before the formation of visible growth zones or humus layers.

The course and size of the ditch suggest very strongly that it was conceived as a fortification feature, perhaps dug together with the possible rampart on the northwestern corner of the point during the civil wars of the 1100s. The quick filling of the ditch suggests a short useful life. The Chronicle of the Bishop of Ribe, written around 1230, says of Bishop Helias (1142–62) that “for his protection he built many fortified places, of which there are still traces on the episcopal estates.”[13] Perhaps Building A was one of these?

Ditch 2

An E-W-oriented ditch, whose width in the excavation surface varied between 0.6 and 1.2 m. It has been assigned to Phase 1, since it seems to start at the gable of Building A, and is interesting because it cuts through the fill layers of Ditch 1, which must thus already have been wholly or partially filled in when Ditch 2 was dug. The function of Ditch 2 is unknown.

Building B

Building B was excavated in its entirety, and was a well preserved, approximately E–W-oriented, post-built long-house with roof-bearing posts placed in the slightly curving long walls (Figure 7, Building B). The length of the building was 27 m, and the span between the long walls was 5.5 m at the gables, while the span at the middle of the building was approximately 7.2 m. At the eastern end the building was equipped on both sides with a 2.2-m wide projection that took the overall width of the building up over 10 m. The western end of the building seems to have constituted an independent section of the structure, which was open to both north and south. A function as a wagon shelter or threshing floor is a possibility.

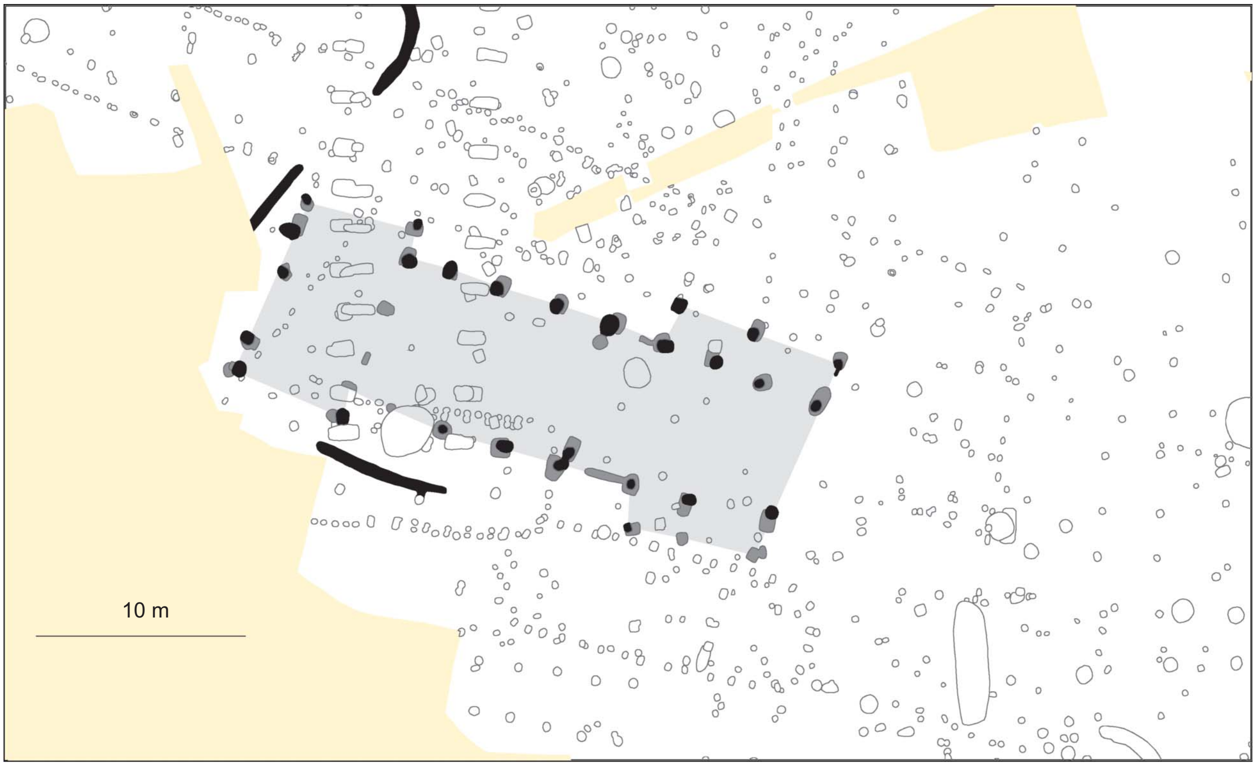

Figure 7. Building B was a 27-m long post-built house with slightly curving long walls. At the eastern end both walls had projections, while the western end of the building is occupied by a building section whose function has not been clarified. The grey shows Phase 1 of the building, while the black post-holes show Phase 2.

In the way the posts were set, a number of differences could be seen which may reflect a further partitioning. In the central segment, the posts were set in pairs opposite one another, forming four bays with post-intervals between 2 and 3 m. The pairwise rhythm ended towards the east with a set of posts standing in the interior of the building close to the walls. East of these the posts did not stand opposite one another. Against this background, it is possible that Building B was divided into three main sections. No remains of fireplaces or other features definitely associated with Building B were found in the interior of the building.

The find material from Building B is scanty. It consists of 19 body sherds from local grey-fired globular pots, where the small body sherds cannot be dated more precisely than the interval c. 1000–1300.

Building B, with its dimensions, the curved long walls, the division into three sections, and especially the distinctive western section, is a building type of which excavations over the past 25 years have produced a number of examples. A close parallel is Building C from Vilslev, which was not fully exposed when Stig Jensen published the provisional results in 1987.[14] The similarity between the building from Vilslev and Lustrup is so great that they can reasonably be viewed as built according to the same template. The published buildings from Vilslev were regarded by Stig Jensen as contemporary and from the eleventh century, but against this one can argue that overlapping house remains and several buildings with straight long walls were also found at the site.[15] Against this background it is more reasonable to view the Vilslev site as in several phases and perhaps extending all the way into the 1200s. Building CLXXII from Østergaard, only about 30 km east of Ribe, is best known for the find of two particularly prestigious gold and silver brooches in one of the post-holes of the building. This has been dated to the 1100s and fits into a sequence of similar buildings.[16]

Buildings like Building B from Lustrupholm, but with straight long walls, are also known. The best known was excavated in 1982 at Nr. Farup near Ribe and has been dated to the second half of the 1100s.[17] From excavations in the city of Ribe, we know post-built houses with straight long walls and projections. They have likewise been dated to the second half of the 1100s on the basis of the dendrochronology of related wells and a large body of find material.[18] There is thus much to indicate that buildings with straight long walls, projections and the special gate/barn space at one end were already known in the second half of the 1100s, but it is still too early to say whether this also means that the corresponding buildings with curved long walls are all older, or whether there may have been a long period when the two construction types existed side by side.

Despite these reservations, the erection of Building B must be dated to the 1100s and probably to the time before rather than after 1150.

Ditch 3

This is an overall designation for a total of three smaller ditches whose width in the excavation surface did not exceed 1 m. The course of the ditches, but also the openings in between them, seem to have respected Building B. Parts of the ditch are stratigraphically younger than the settlement traces from the Iron Age and the long Building K. Its function cannot be specified in more detail.

Phase 2: around 1200

In Phase 2, a number of buildings were erected which, particularly in view of their later successors, can be interpreted as the oldest phase of the Bishop of Ribe's farm in Lustrup. From the beginning the residence seem to have consisted of two large post-built houses and a four-post structure; the latter has been proposed against the background of a find configuration interpreted as the remains of a small forge (Figure 8, Phase 2).

Building C

Building C was a poorly preserved E–W-oriented longhouse consisting of two parallel rows of post-holes. The width was 7.8 m, but the length is not known, since the later brick building, Building H, had removed part of the southern wall; but there may still be posts from the north wall of the building beneath the unexcavated shelter planting. The north wall could be followed over 18.3 m.

Finds only emerged from one post-hole belonging to Building C; in this a piece of brick was found as well as two grey-fired side sherds from globular pots and two pipeclay sherds of the material type Green Rouen, probably from a jug imported from the northern French region.[19]

How Building C was constructed above the ground we cannot say with certainty, but the posts do not form sets across the building, and we must probably imagine that the wall posts had a head or wall plate on which the roof structure rested. Whether this actually took the form of a so-called "head" where anchoring beams brace the structure crosswise, or a roof where the rafters and a tie-beam formed a fixed triangle cannot be determined.[20] The roof construction and lower part may have made up two separate sections of the building, which may be a reasonable assumption inasmuch as the lifetime of the roof construction must be expected to have exceeded that of the earthfast posts in the lower part.

Despite the incomplete preservation, there is little doubt that Building C must be regarded as a predecessor of Building F.

Building D

This is a relatively poorly preserved NNW–SSE-oriented post-built longhouse with projections on the western side

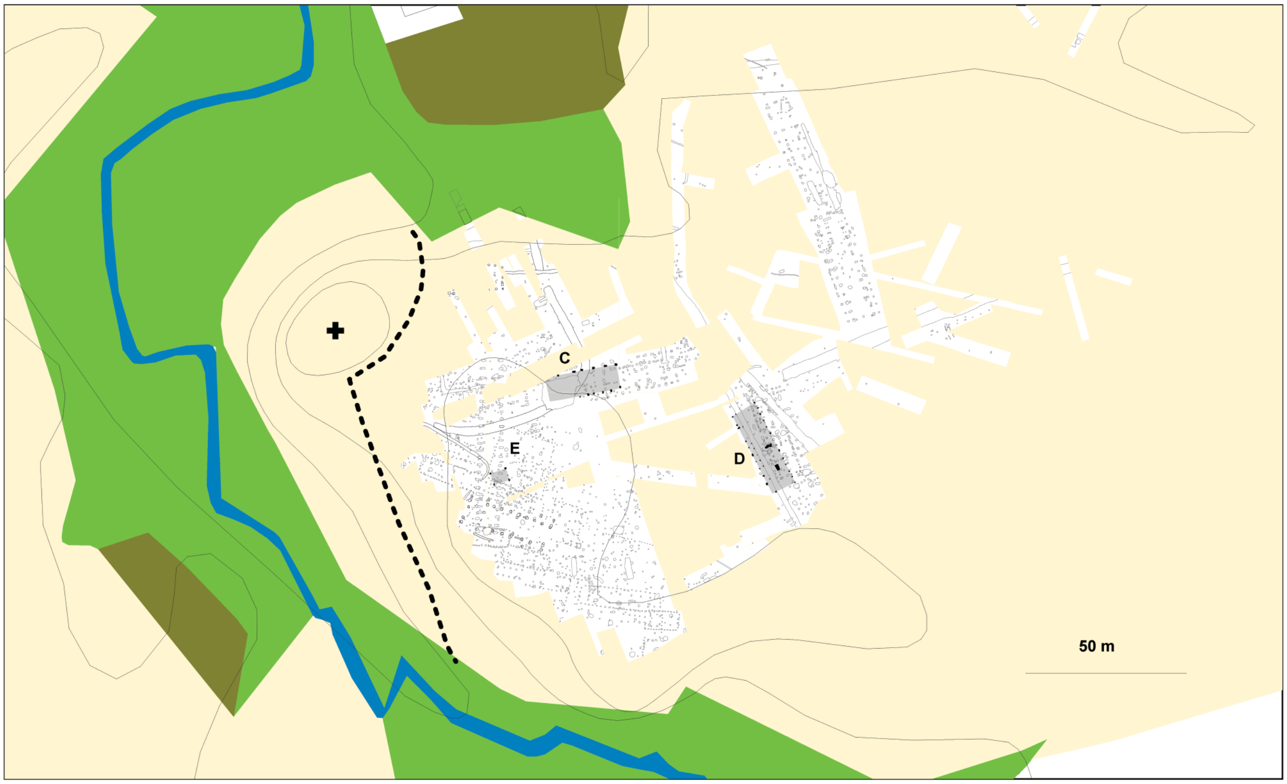

Figure 8. Phase 2. Appearance of the farm c. 1200. The complex consisted of two 8 m wide post-built houses and a probable four-post feature, Building E.

throughout the length of the building. The northern part of the west wall was excavated in the 1999 season, while the other parts of the building were identified and excavated in 2003. The full width of the building was 7.9 m, of which the projection took up 1.2 m. The length of the building was 27.6 m. No finds emerged from the post-holes.

Inside the building, a number of pits were found which probably belonged to Building D. This assumption is strengthened by the fact that in the next, almost identical Building G, pits were found similarly placed in the building. In all three cases, these were rectangular pits with almost vertical sides and a flat bottom which was dug down deeper than the posts of the building. There was no trace of wooden constructions or other features in the pits, but the sides must have been supported in some way – otherwise they would have collapsed. In all three, a complicated but structurally identical layer sequence was registered; it had arisen because organic fill material in the pits had collapsed and pulled the layers above down into the pit. The succession of the layers in the pits could thus tell us about the appearance and character of the otherwise ploughed-away surfaces inside the buildings. The majority of these layers seem to have belonged to the succeeding Building G and are described there. The function of the pits cannot be more specifically established, but the fact that similar pits were positioned in the same way in the succeeding Building G shows that it is more likely to have been a deliberate rather than a random feature.

Building E

A so-called four-post construction forming a rectangle of 5 × 3.7 m situated approximately 30 m SW of Building C. In the southeastern post-hole, an iron nail and a forge-stone were found – the latter a waste product from forging, part of the clay slab that protected the bellows from the heat of the forge. Usually four-post features are described as hay barns, but the find material included a small amount of slag and forge-stones, concentrated around the two demonstrated four-post features, Buildings E and J.[21]

Phase 3: first quarter of the thirteenth century

In Phase 3, the two oldest buildings on the Bishop's property were rebuilt. Building C was succeeded by the equally wide Building F, displaced 18 m to the east. This may have been because the erection of the brick structure Building H was also planned at this time. Building D was also replaced by the apparently identical Building G, which partly overlaps the older site (Figure 9, Phase 3).

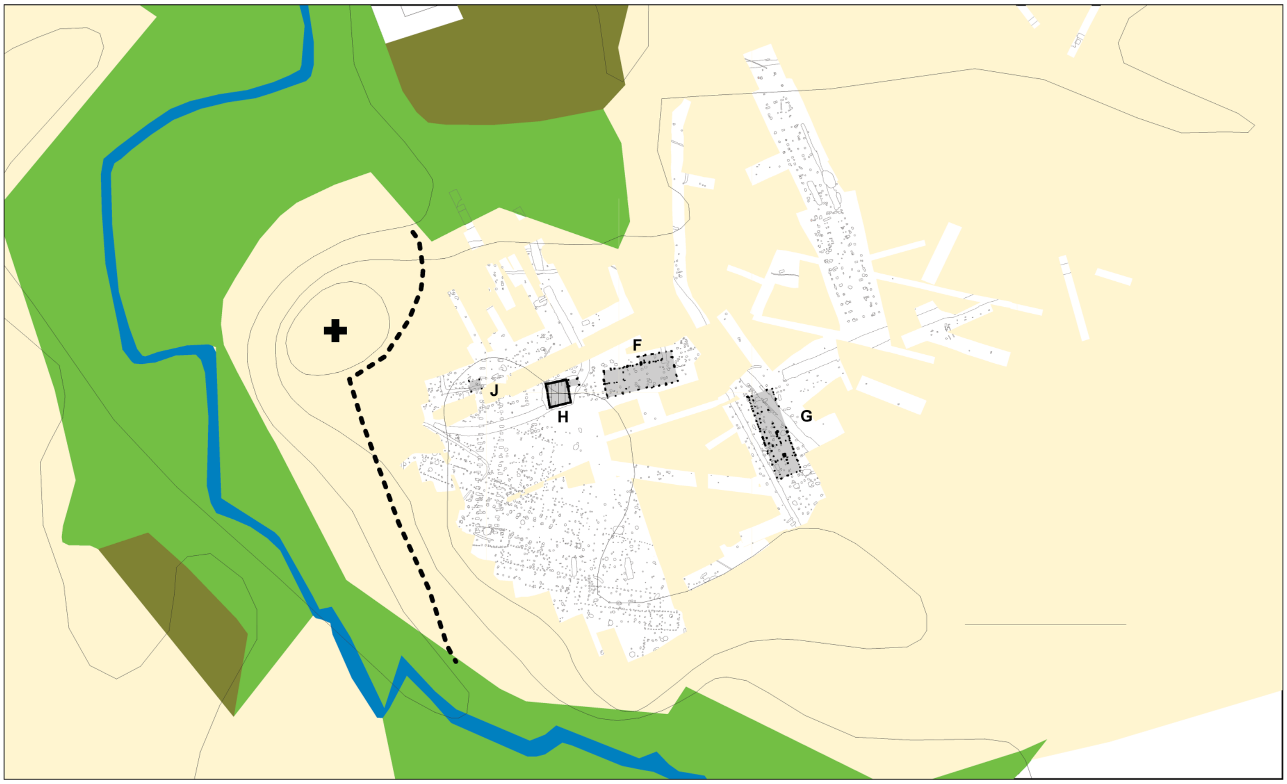

Figure 9. Phase 3. First quarter of the 1200s. The oldest set of buildings at the farm are replaced by two new ones, and the prestigious brick house with the wood-built stairwell is erected. To this phase a four-post feature probably also belongs.

Building F

E–W-oriented longhouse whose post-holes mark a well-defined ground plan where the placing of the individual post-holes was strikingly unsystematical. This feature recurs in its predecessor, Building C, but contrasts with the precision of the placing and orientation of the post-holes in the other wing of the complex, Buildings C and F.

Building F is 22 m long and 7.8 m wide (Figure 10. Building F). Along the eastern half of the north wall the building was equipped with a projection that brought the overall width up to 9.9 m.

The find material from the post-holes consists of brick, small iron fragments and 30 potsherds, 27 of which come from local grey-fired globular pots, while one is of the rhenish Paffrath ware type, one of rhenish proto-stoneware and the last is an imported pipe-clay sherd with peeling glaze which cannot be identified in more detail.

In the interior of the building, a number of post-holes have been interpreted as traces of partition walls, but in the rest of the building, a whole row of medieval post-holes was found which has not been specifically interpreted. Besides the post-holes, no other dug-down elements could be found that could be associated with Building F. The function of the building cannot be identified, but its closeness to the brick Building H makes it most likely that Building F was used as a residence.

The unsystematic placing of the posts suggests that the wall posts held up a head or wall plate on which the roof construction rested. The fact that the building is of the same width as its predecessor might indicate that the roof construction was re-used from the latter? During the lifetime of the building, there may have been a number of repairs, but they seem to have been effected by digging down new posts in the wall line rather than complete replacement.

Building G and related structures

Building G is a well-preserved NNW–SSE-oriented post-built building with projections on the west side along its whole length (Figure 11, Building G). It is the best preserved post-built house site of the excavations, partly because the building had burned down. Another reason for the good state of preservation was that most of the house site was located beneath the dike that formed the boundary between the property associations Lustrupholm and Lustrup. Prior to the establishment of the earth wall, there had been a phase when the area was ploughed, which was discernible over the fire place from clearly charcoal-filled plough traces in the original brownish-grey soil layer.

Figure 10. Building F was a very clear but atypical medieval house site where the gables are also marked by large posts. The individual posts had been placed with a striking lack of precision which recurs in its predecessor, Building C, but which differs clearly from the other buildings at the site.

The ploughing had removed all traces of surfaces in and around the building. The fire was the reason why it was possible during the excavation to observe clear charcoal-filled post traces in most of the building's post-holes. In these, large quantities of fired mud-wall were found. The charcoal is thought to have ended up in the traces from the posts after the rotting-away of the burried part of the burnt-down posts. The post traces provided an unusually precise snapshot of the way the posts had been set in the building.

Building G seems to have been an exact copy of its predecessor, Building D, and the similarities are so striking (cf. the pits mentioned blow) that there must have been a template or survey behind it. The similarities must also mean that the erection of the younger Building G came immediately after the demolition of the older Building D, and as has also been proposed for Building C/E the roof construction from Building D may have been re-used in Building G.

The length is 27.4 m and the width is 8.0 m, with the projection taking up 1.2 m. Post-holes and traces mark the placing of three transverse partition walls that divided up the interior of the building, but possibly not the projection, into four rooms. The larger central room and the southern room may have been further subdivided by posts standing on the central axis of the room. At the partition wall between the two middle rooms, a clearly heat-affected section was found that marks the position of a fireplace. That the fireplace is by a partition wall suggests that there had been a secondary stove fed from another room.[22]

From the building come several thousand fragments of fired mud-wall with impressions of straw on the back. Precisely this mud-wall type is a well-known find group from the Ribe of the 1100s and 1200s, and it must have been in general use in house-building. The distribution over the whole site of Building G shows that it was used all over the building (Figure 12, mud-wall).

The other find material from the building consists of pottery and a small quantity of brick. From the fire layer come half a horseshoe and an iron lug from a cauldron. Besides these, a few small lumps of melted lead were found.

How the house was constructed above ground we cannot say with certainty. There is a tendency for wall posts to form pairs across the house, but it is not consistent, and it is equally important that the central partition wall of the house with its secondary stove was not located at a pair of posts. This suggests rather that the pairs of posts were not joined by transverse tie-beams but bore a longitudinal wall plate on which the roof construction,

Figure 11. Thanks to very clear post traces (marked in black), the burnt-out Building G provided a precise "snapshot" of the positions of the posts in the building, which was divided into four rooms and had projections on the west side. Inside the house, as in its predecessor, a number of pits were found whose function is not known. On the eastern side of the house towards the north, one can see a four-post feature and towards the south the post-holes from the possible post-borne plank road. The arrow inside the house marks the position of a fireplace, while the arrow beneath the plank road marks the position of the pit with the crushed pottery and the coins.

Figure 12. On the thousands of burnt mud-wall fragments from Building G impressions of straw are the only traces of what they had been applied to. In the panels such straw mats must have been mounted, but how they were attached to the wooden skeleton of the building we do not know. The actual clay layer is usually less than 1 cm thick.

which may have been re-used from the preceding building, rested.

As in its predecessor, Building D, in Building G too there were a number of rectangular pits approximately in the middle of the building. Thanks to the pits in the preceding Building D, remains of Building G's floors were preserved. This was so because the fill in the older set of pits had collapsed and had drawn the layer above down with it and beneath the depth of the plough (Figure 13, cross-section of pit with fine layering). The fill in the older set of pits was all sealed in by a fire layer with mud-wall material, and beneath this in all three pits remains of mortar flooring were found as well as laid-out layers of heath turf.

The secondary stove and the floor-layer remains show that the house was furnished as a dwelling – perhaps for the butler mentioned in 1258, who was probably responsible for everyday operations?

Constructions associated with Building G: Abreast of the north end of the east wall of the building there was a four-post feature consisting of four small post-holes forming a rectangle 1 × 1.5 m. The interpretation is uncertain.

Figure 13. Section of the pit A345, which formed part of Building D. Originally the pit was filled with an organic layer that has wholly decomposed and now consists only of the brown streak at the bottom. In the process, the overlying floor layers, which belong to Building G, were pulled down under the plough layer and form the only preserved floor layer from Building G. There are traces of both a mortar floor and a layer of laid-out heath turf.

Along the east side of Building G and further south, a number of large post pairs were found, recalling the post-borne plank roads which in the first half of the 1200s formed continuous paving on most of the streets of Ribe. Such posts had lengthwise sills on which the plank floor had been nailed.[23] This may also have been the case here. Beneath this plank road, the possibly recovered coin hoard mentioned below was found (Figure 22).

Building H

In the 1999 field, a large irregular fill layer approximately 9 × 12 m was registered. In the two southernmost corners the sections were dug, and in both places intact masonry emerged. In the subsequent excavation of the complex in 2000, the wall remains proved to come from a large brick structure. The uncovering and registration of the ruin was done carefully. No intact masonry was removed, and in the excavation of the room the digging at first only went down to the top of the youngest surface-covering floor layer; a sand layer that was probably the underlay for a surface-covering cobblestone layer, Floor 3. After this, 30% of the underlying floor layer was excavated (Figure 14 with plan of investigated areas in the cellar plus the stairwell). All fill layers from the ruin were sieved.

The original structure: The excavated wall remains form a cellar whose outside dimensions were 7.9 m N-S × 7.4 m E–W. The walls stood on a foundation of fieldstones and were built of brick in monk bond set in shell-tempered mortar.[24] In terms of masonry technique, this was a cofferwork wall where the core consisted of alternate layers of medieval brick fragments as well as some tuff and a few pebbles. The thickness of the wall varied between 65 and 75 cm, and the inner dimensions were 5.9 m E–W × 6.6 m N–S – approximately 39 m^2.

At the northern end of the eastern wall the remains of a door opening were found. This was an outwardly bevelled opening whose width, measured in the outer alignment, had been 1.4 m. Inside, the opening was surrounded by half-brick filleting which at some later juncture had been cut way in the preserved north side of the door opening. In the sixth course of the cut-away filleting a now-decomposed piece of wood had been mounted, in which the lower of the door pintles had been mounted. It had thus been a left-hand door and opened into the room, as was also shown by the shape of the youngest wall bench. In the door opening a granite ashlar had been laid as a threshold stone. The first stage of the laying of the oldest Floor 1 had been a 10–12 cm thick layer of marine clay, which must have functioned as damp proofing, and over this a mortar floor just 1 cm thick was poured, which, probably thanks to the frost-free depth, had preserved its hardness. The mortar floor was 1.9 m beneath the surface at that time.

On this floor, round along all four walls, a one-brick wide wall bench was laid; at the door opening it functioned as the bottom step of the stairs into the room. The wall bench was later removed and was only evident from a few remains and the impression in the mortar floor. The construction ended with the pouring of a wearing course on the floor consisting of mortar tempered with crushed brick, making the floor appear in a warm red colour – almost like a tennis court. In the mortar on the floor gutters were made, a few centimetres wide and deep, which, judging from the excavated section, seem to have been N–S oriented. Perhaps they led to an unexcavated sump? On this floor a thin layer of dirt was found, but no finds emerged from the excavated parts of the layer.

Later rebuildings: Before the laying of Floor 2 of the cellar, the wall benches along all four walls were removed. Then, first, an underlay of grey marine clay was laid, followed by a layer of crushed brick and mortar, and finally a layer of mortar which, like the oldest floor, had preserved its hard surface. On this floor, but only along the north wall, a one-brick wide, three-course high wall bench was built, which was fully preserved. Towards the east, where the door opened, the wall bench was built up of diagonally laid stretchers – probably so as not to be in the way of the door (Figure 15, wall bench behind the door). In the first layer on Floor 2 or the overlay a coin was found that had been minted in the reign of Valdemar II, and which was in circulation in the time before 1234.[25]

Floor 3 is marked by a sand layer up to 20 cm thick. In this the remains of an otherwise removed cobblestone covering were found. The youngest registered floor of

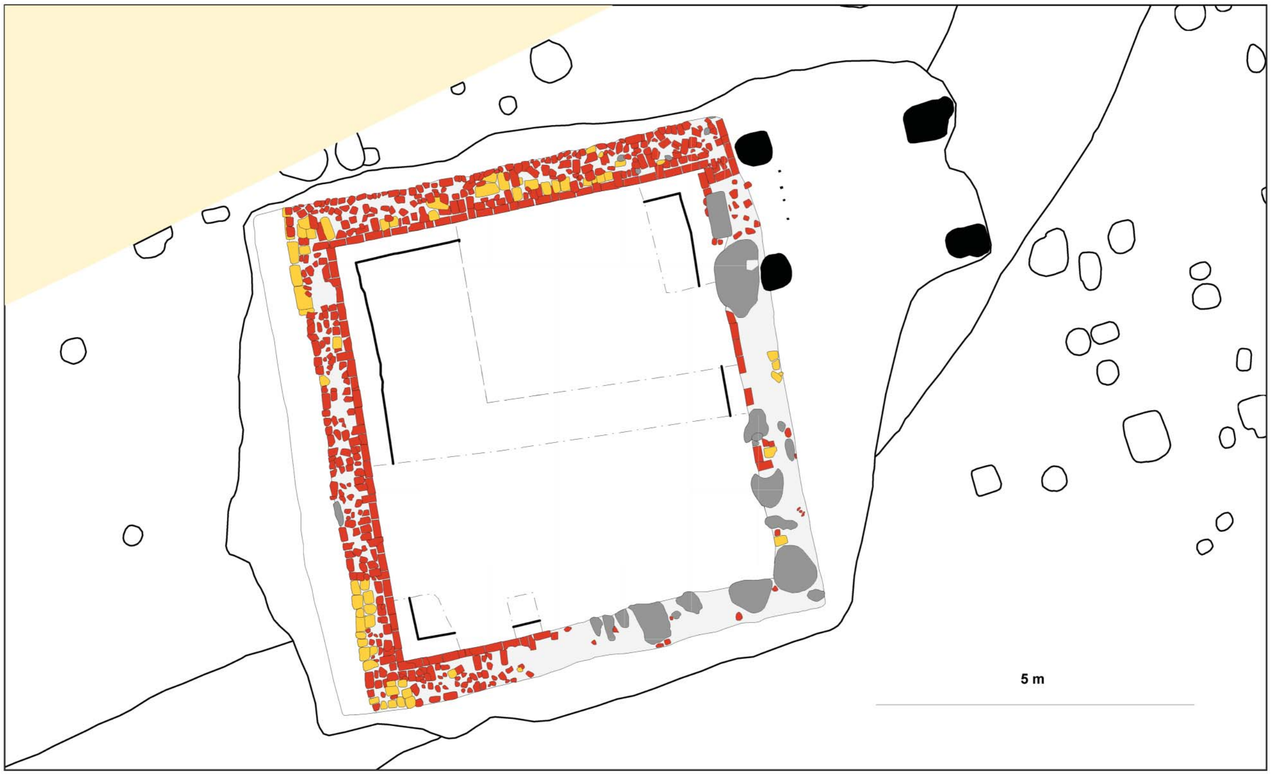

Figure 14. The registered wall remains from the cellar beneath Building H. Tuff stone is marked in brown, while fieldstones are grey. At the north end of the east wall, one can see remains of the bevelled door and the stone threshold. Outside this we see the four massive post-holes from the wood-built stairwell and, in a row, the four iron nails that were part of the wholly decomposed stairs down to the cellar. The investigated areas of the floor layers are marked, and a line marks the course of the oldest wall bench.

Figure 15. The northwestern corner of the cellar seen from the southwest. The door jamb and the younger wall bench can be seen. Where the door opened, the bricks are set diagonally, and the primary function of the wall bench was probably to conceal and seal in front of projecting foundation stones.

the cellar, Floor 4, was represented by a 6- to 10-cm-thick heterogeneous/stirred-up marine clay layer, above which a decomposition layer was found. In the marine clay layer, a coin minted in Ribe during King Abel's brief reign in 1250–52 was found.[26] (Figure 16, digitalized profile w. floor layer)

The wood-built stairwell: Just outside the cellar entrance a largish fill layer was found which concealed several large post-holes, once the basis of a large, wood-built stairwell with estimated outside dimensions of 3.4 m E–W × 2.45 m N–S. Within this structure a wooden stairway down to the cellar had been placed. The stairwell itself was borne by four particularly substantial posts. The two eastern ones had been dug 1.3 m down under the ground surface while the two western ones had been dug a whole 2.2 m down. We cannot say with certainty how the actual staircase up to the upper floor was designed, but the spacious stairwell suggests several possibilities. The most likely is a stairway with straight fliers just 2 m wide, which even at a gradient of less than 45° would end more than 3 m up the wall. If we reconstruct the stairs like this, the building must have had at least two floors above the cellar. There were no certain traces of any replacements of the stairwell posts.

Type, dating and function of the building: There are unfortunately few possibilities for clarifying how the building looked above ground level. Its demolition –

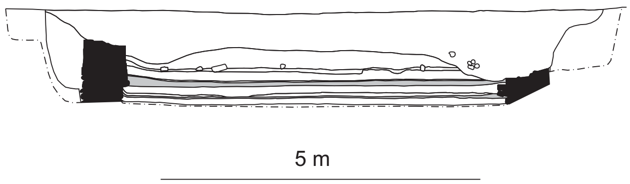

Figure 16. Section through the cellar ruin with floor and fill layer. The intact mortar floors, Floors 1 and 2 are marked in grey.

besides the preserved wall remains – had only left behind small amounts of rubble that cannot be used to provide much information on the fixtures of the building, but comparison with the known secular brick buildings around 1200 in northwestern Europe makes it seem likely that the upper floors of the building were also brick-built.[27] There were neither moulded nor ribbed bricks in the ruin, nor were there demolition layers. Since brick was clearly preferred in the preserved interior facades, there can be little doubt that the exterior of the building also appeared as a brick construction. From the excavations come two limestone fragments with traces of dressing, one of which is equipped with a bevelled edge. These are stray finds, but it is likely that they were used as decorative details around windows or doors. The ruin's only preserved stylistic feature was the remains of the bevelled cellar door. Openings of this type are well known in Romanesque buildings, and undoubtedly the door opening had a round-arched covering. In the fill layer of the cellar one fragment of a glazed pantile was found. This is the only find of a tile in the excavations which probably comes from the roofing of the brick house, which very likely had a pitched roof.[28] Beyond this the building must have had a door into the ground floor and a door into the upper floor. All three floors must have had lights, the building must be supposed to have had heating facilities – presumably brick fireplaces with a chimney in one of the gables.

The two coins from the floor layers show that the building must have been erected some time before 1234, and the first quarter of the 1200s is proposed here. There is nothing to indicate that the building survived the demolition of the other features, and the thorough demolition is unlikely to have taken place much later than 1260. It is notable that during its short functional lifetime at least three considerable rebuildings took place in the cellar room. The limited archaeological investigations of the floor layers could not answer the question of the function of the building, but the find of two coins might suggest some degree of monetary activity in the cellar of the rooms above. There may have been wooden buildings up against the not fully uncovered north side of the brick house.

The actual building type – a quadratic brick house in several floors built in the twelfth to thirteenth century – is now known from a number of archaeological investigations all over the country as well as many foreign parallels. Such brick buildings seem to have been a frequently occurring element on the properties of the aristocracy, whether they were located in the countryside or in town.[29] Similar buildings are now familiar from large parts of the northwestern European area, where they were built until sometime in the thirteenth century.[30]

The brick house at Lustrupholm would have been the prestigious centre of the complex, and its red walls and glazed roof would have been elevated over the landscape and would have been visible to travellers along both of the town's southern exit roads towards Tønder and Haderslev/Schleswig, as a visible sign of the Bishop's wealth and power. The brick house must be described as a thoroughly civilian structure without fortification features. Any attacker would have been able to burn out the stairwell and smoke the occupants out without great problems.

Building J

This is a so-called four-post structure forming a square with side lengths of 3.3 m. In the post-holes, grey-fired sherds from globular pots have been found, as well as two brick fragments. The ascription to Phase 3 is uncertain, but was chosen on the basis of the orientation, which matches that of Buildings C, F and H. The scattering of forge refuse may indicate that Building J was also a small forge.

Phase 4: second half of the thirteenth century

In Phase 4 the building stock at the Bishop's property was greatly expanded. The order of the expansion is uncertain, but here it is considered most likely that Building K was built before Buildings L and M, so for a period the complex had the appearance of a three-winged unit open to the south. The new buildings have been interpreted as barns or animal sheds (Figure 17, Phase 4).

Building K

The Bishop's property was expanded with the extremely long N–S-oriented Building K, after the arrival of which the complex was given an open, three-winged structure. Beneath the northern end of Building K, older features containing pottery and bones from after about 1200 were found, showing that the area around the northern end of the building was used as a refuse dump before the erection of Building K.

Building K measured 54 m in length, and its width can be estimated as 6.2 m, resulting in a ground area of 335 m^2. The building consisted of two parallel rows of posts that did not stand in pairs. There were no traces of openings in the walls, interior divisions or fixtures. At the south gable, a 1-m deep medieval pit was found; its placing does not preclude the possibility that it was dug while the building was standing, but its function could not

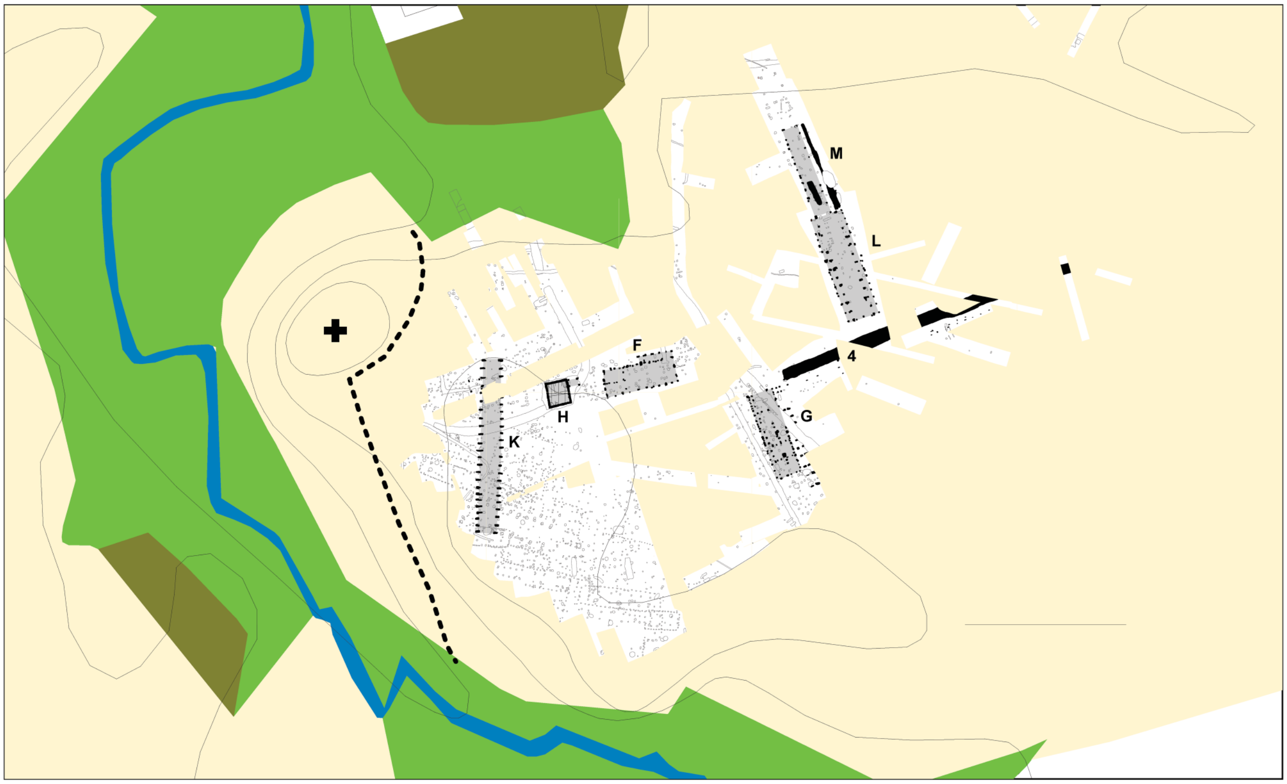

Figure 17. Phase 4. Second quarter of the 1200s. The complex is expanded with animal shed and barn buildings as well as the poker-straight Ditch 4.

be determined. The great bulk of the important find material from the post-hole fill seems to come from refuse dating before the house was built.

The size of the building points towards a use as a barn and/or animal shed. The non-uniform number of posts in the walls suggests that over the posts there had been a wall plate that bore the roof construction. This is likely to have been a mud-walled, single-winged building.

Building L

By virtue of its great width and accurate post positioning Building L was the most impressive house site of the excavations (Figure 18). The N–S-oriented building measured 33.7 × 10.1 m and covered a ground area of 339 m^2 – the same area as Building K occupied. Building L's ground plan was three-winged, and the roof-bearing posts formed sets across the building throughout its length. Towards the north, however, one post was missing in the western and eastern row, respectively; perhaps they had not been dug as deeply as the others. The span between the roof-bearing posts was 6.7 m and the distance between bays was 2.8 m. The building was equipped with a 1.7-m wide projection along both walls throughout its length. The orientation is exactly parallel to that of Building G – a similarity that suggests that the two buildings stood at the same time.

The find material consisted of a few animal bones, a little mud-wall material and bricks as well as 17 potsherds. At the northern end of one projection a small pit was found that contained parts of the skull of a young cow. This was possibly a construction sacrifice with an intended disease-preventing function.[31]

Inside the building a number of double post-holes were found, greatly resembling stalling partitions, but their positioning does not harmonize with either the orientation or the post positions of the building.

In its posts and dimensions, Building L recalls the oldest preserved manorial barns.[32] The preserved examples are head constructions on foundation stones, but may have had predecessors with dug-down posts. The absence of finds in the post-holes as well as the possible stall partitions and the buried cow skull also suggest that the building was used as a barn and/or animal shed.

Building M

In the northern extension of Building L, a structure much discussed during the excavations was found – Building M. It consisted of two 29-m-long post rows parallel to Building L, where the western post row was

Figure 18. The three-winged barn or animal shed, Building L, was laid out with great precision. The roof-bearing posts formed pairs, and by all indications this was a head construction. At the north end of the west side wing of the building, there were stall-like structures and the arrow marks the position of a buried cow skull – perhaps a disease-averting construction sacrifice.

the best defined. The distance between the rows was 5 m. In addition, towards the east, a 50-cm deep ditch was found which seemed to have grown over naturally. The length of the ditch matched that of the post rows. In two cases, bricks were found in the post-holes, but otherwise there were no finds. Along the central axis of the building a large oblong fill layer was registered.

Building M's orientation and placing provide no reason to doubt their connection with the rest of the complex. But the building need not have been very high, and the rafters may have been anchored in the related ditch. The oval fill layer in the middle of the building recalls the wear that arises at the end of animal sheds, and might indicate movements of animals, which in turn points to a use of the building as an animal shed. A large gap at the southern end of the western post-row might have been an opening. Building M is followed by the equally distinctive Building N.

Ditch 4

Between Buildings G and K, a large, very straight ditch was found, Ditch 4, which projected 4 m from the north east corner of Building G and from there ran eastward in a direction exactly at right angles to the buildings. The ditch was of a size that could justify the designation trench, and could be followed over 96 m before it disappeared in under a modern residential house. At the excavation level, the trench was 3.5–4.7 m wide and turned out to have steep sides shored up with stacked turf. In particular, the straight termination towards the east was carefully executed (Figure 19, section of Ditch 4.). Judging from the cross-sections made, the width was between 4 and 6 m at the ground surface and its depth was 1.6 m. At the bottom of the dry trench a growth zone could be demonstrated, and this was probably grass-covered. The overlying fill layers were greyish-brown sand, and the vegetation growth seems to have been natural. No certain traces of any earth wall being thrown back into the trench were seen. The orientation does not suggest that there were fortification motives behind the establishment of the feature.

On the southern side, one or perhaps two rows of oblong, low post-holes were found which may have constituted a fence. Rather paradoxically, the trench does not seem to have demarcated the farm, but rather to have divided it up in accordance with an as yet unknown system.

Figure 19. The sides of Ditch 4 were shored up with turf. Here we see the carefully executed western termination.

Pottery	n	%
Local greyware	3004	94.4
Pingsdorf-type	4	0.1
Paffrath-type	6	0.2
Andenne-type	1	< 0,1
Glazed redware, jugs	31	1
Glazed redware, white slip, jugs	52	1.6
Rouen type, red-yellow	10	0.3
Rouen-type, green	26	0.8
Proto-stoneware	31	1
Other imports	16	0.5
All	**3181**	**99.9**

Figure 20. The total of 3181 medieval potsherds arranged by ware type. The domestic grey-fired pottery from globular pots is clearly predominant, while all the other sherds are probably imported. They come primarily from glazed jugs.

Phase 5: the period up to c. 1260

Building N

Building M was overlaid by a building which, contrary to the normal house typology, had curved long walls. There seems to be no doubt about the stratigraphy, and Building N constituted a relatively well-defined house ruin with a length of over 28.3 m. The width at the gables was just 5 m, while the width at the middle reached just under 7 m. In the post-holes, six grey-fired sherds were found as well as bricks. Building N must be regarded as a light curved-wall construction that can hardly have been built much before 1250, but whether the building was equipped with a roof and whether this was a pitched roof with a curved roof ridge remains an open question. As for Building M, use as an animal shed can be suggested.

The finds

In all, 512 find numbers have been collected from the excavations, covering a total of 6119 objects. The find material from the Middle Ages makes up a considerable part of this, and the medieval pottery with its 3181 sherds is the largest group. The amount of medieval potsherd material is large compared with other excavated rural building complexes and is to a great extent due to the sieving of the excavated features.

In Figure 20, all medieval potsherds are presented and divided into pottery types. The domestic pottery consists of the local grey-fired sherds from globular pots, A1/A2, while the other types were probably all imported from production areas in northwestern Europe ranging from the Rhineland over the Low Countries down to the area around the English Channel.[33] With few exceptions, the imported pottery can be classified as tableware, primarily in the form of jugs. The great majority of the Lustrupholm pottery comes from the Bishop's property, phases 2–5, and has been dated to the period c. 1200–1260; a period when the pottery inventory in the city of Ribe is familiar from many archaeological investigations.[34]

There are striking differences between the pottery inventory at Lustrupholm and in the city of Ribe. The quantity of imported pottery at the Bishop's property is only about 5%, whereas in Ribe itself it is often 20%. The few imported sherds at Lustrupholm almost all come from jugs that do not stand out in size or mountings, and the overall impression of the pottery is that of plainness.

From the fill layer above the ruin of the demolished brick building, Building H, a large quantity of sherds emerged. The layer was probably formed by throwing material into the scrap pit after the demolition, and therefore contains a mixture of sherds whose common feature is that they were dropped or scrapped around the brick building (Figure 21). In the layer above the cellar, the percentage of imported sherds approaches 14%; there also seems to be a clear concentration of tableware around the prestigious centre of the complex.

Beneath the plank road east of Building G, a small pit was found containing two coins minted in the reign of Valdemar II as well as 48 potsherds laid together at the bottom of the hole. The sherds could be assembled into a globular pot which when intact was only a little smaller than the pit itself (Figure 22). The unusual find combination can be interpreted as an already dug-up coin hoard.[35] Duke Abel's capture of Ribe on 28 April 1247 may have been the background for the burial of the hoard, but King Erik Plovpenning's recapture of the city on 3 June may be the reason why most of it came into the possession of the owner again.[36]

In 1996–97, Lustrupholm was scanned with a metal detector. From this there emerged a well-preserved cast casket lock of a well-known thirteenth C type. In addition, a fragment of the yoke from a set of scales was found; its

A682, layer 1	**n**	**%**
Local greyware	387	86.2
Pingsdorf-type	1	0.2
Paffrath-type	0	0
Andenne-type	0	0
Glazed redware, jugs	8	1.8
Glazed redware, white slip, jugs	24	5.3
Rouen type, red-yellow	3	0.7
Rouen-type, green	15	3.3
Proto-stoneware	10	2.2
Other imports	1	0.2
I alt	**449**	**99.9**

Figure 21. The fill layer above the ruin of the brick-built cellar, Building H, is thought to have been deposited during an adjustment of the terrain after the demolition of the building, and thus to contain sherds scrapped/dropped around the brick building. Of the 449 potsherds 14% are imported tableware. One can thus document a clear concentration of imported goods around the prestigious main building of the complex.

surface was covered with circle markings (Figure 22). Similar scales are known from the town of Ribe. The find of the scales is particularly interesting, since it suggests monetary activity which could have been the payment of duties.

From the excavations come a total of six coins ranging in time from the first part of the reign of Valdemar II to that of Christoffer I (Figure 23). They all appear to have been minted by the master of the mint in Ribe, and their datings coincide closely with the mention of Lustrup in the written sources.

In terms of the dating of the find material there is nothing to indicate activity after c. 1300. Later pottery types are entirely absent, and if we are to believe the evidence of the coins, the cessation of activity should be dated closer to c. 1260.

In quality the find material has its closest parallels in the finds from the town of Ribe, where all the find categories from Lustrupholm are frequent. At Lustrupholm, no decidedly high-status finds were made, nor was there anything that pointed towards the written culture such as book mountings, styluses or the like. Taken together with the plain appearance of the pottery, it seems most likely that the Bishop and his household only stayed to a limited extent at Lustrupholm (Figure 24).

Summary and perspectives

The medieval building complex at Lustrupholm seems to have arisen in the first half of the 1100s and consisted in phase 1 of two large farms which may be contemporary or may have been established successively. In the museum archives there is no information on other finds from the Viking Era or the Early Post-Viking Middle Ages, and the farms may be the "thorpe" village unit that accounts for the *-trup* element of the toponym.

The northernmost farm was the largest, but large parts of it were destroyed by later digging, while other areas are not accessible to archaeological investigation. Our knowledge of this probable founder's farm is therefore fragmentary, but the sum of the observations suggests that it consisted of a main building with one smaller building. At one point in the 1100s, the farm was fortified with a possible rampart and a surrounding trench or moat that was quickly filled in again. The fortifications may have been established during the civil wars around the middle of the century. The Chronicle of the Ribe Bishops says of Bishop Helias (1142–62) that he fortified his episcopal farms.[37]

To the south lay another farm whose unfortified main building could be fully excavated. It is unknown whether Lustrup consisted of more farms than these two. Since both farm units were obliterated by the subsequent Bishop's property, we must suppose that the farms from the 1100s were also in the possession of the Bishop, and it would be reasonable to imagine them as farms run by a tenant-manager (bryde) (Figure 6).

The establishment date for the farm that was later to develop into the Bishop's magnate farm is not known, but it is likely that this happened when Bishop Omer (1177–1204) held the office. In consisting at first, in Phase 2, of two equally large buildings where we cannot clearly identify a main building, the Bishop's farm already at this juncture stands out from other archaeologically known rural units (Figure 8). With the appearance in Phase 3 of a prestigious brick house whose roof ridge rose as much as 10 m above the terrain, the magnate aspect became obvious (Figure 9), and after the erection of colossal barn and animal shed buildings, the building stock grew to an extent that as yet has no parallel on Danish soil (Figure 17). Similar units may conceivably have been associated with the magnate farms of the twelfth to thirteenth century, which are known both archaeologically in the form of usually brick-built cellars and from written sources.[38]

It is a conspicuous feature that the building stock at Lustrupholm seems to have been constructed on a variety of principles. In most of the buildings the wall posts were not in pairs, and the posts must be assumed to have borne a wall plate on which the roof construction rested. Some kind of anchor beams must have braced the buildings crosswise. The constructional separation of the wall posts and the roof structure permitted the re-use of the roof structure, whose lifetime must be supposed to have exceeded that of the dug-down posts considerably. This may have happened in two cases at Lustrupholm. Only in the large barn/animal shed Building L were the roof-bearing posts set in pairs, which must be assumed to have been connected by

Figure 22. Finds from the excavations. In the pit A355, the heap of sherds shown here appeared, and could be assembled into a more or less intact, 27 cm tall globular pot. In the fill of the pit the two coins shown were also found; they circulated in the period 1234–55. Could this be a recovered coin hoard buried during the hostilities in 1247? Detector scanning in the early 1990s uncovered a fragment of the yoke of a set of scales with surface-covering ornamentation of circular dots as well as the intact cast casket lock with an octagonal lock housing. On three sides it is decorated with a punched, wavy line.

beams. The varied building types may show in the local perspective that different carpenters were active at the farm. In the wider perspective, the differences can also be seen as an indication that there was rapid development in house-building in the period.

The excavations did not provide many answers to how the buildings looked above ground. The fire site Building G was mud-walled, and the barn/animal shed, Building L, may have had stave-built projection walls. Bricks appeared scattered all over the site, and we cannot preclude the possibility that Building F beside the brick house had masonry elements. In addition to the tiled roof of the brick house, the other buildings probably had thatched or shingled roofs.

ID	Ruler	Type and Mint	Findspot	Method
1301 × 306	Valdemar II (1202-41)	Grenåfundet 35	Floor 2/3 in cellar	sieving
1700 × 74	Valdemar II (1202-41)	Hbg. 42b, Ribe	Recovered coinhoard? A355	excavation
1700 × 75	Valdemar II (1202-41)	Hbg. 42b, Ribe	Recovered coinhoard? A355	sieving field
1700 × 171	Valdemar II (1202-41)	Hbg. 42b, Ribe	Surface find after completion of 2002-campaign	walking
1301 × 299	Abel (1250-52)	MB 50, Ribe	Floor 4 in cellar	sieving
1301 × 42	Christoffer I (1252-59)	MB 97, Ribe	Pit, 1998-campaign	sieving

Figure 23. The six coins from the excavations presented in chronological order.

Other finds, except building materials
4 whetstonees
Quernstone fragments, Hyllestad-type
Quernstone fragments, Mayen-type
2 horseshoes
Iron loop from copper-alloy bowl
Iron bolt from barrel lock
Smithing debris
2 fragments of glass rings
Glass sherds, drinking vessels

Figure 24. List of meaningful refuse and object finds from the excavations at Lustrupholm. Building parts, nails and a few unidentifiable iron objects have been omitted.

The use of the individual buildings may have changed over time, but the buildings D, F, G and the brick house H seem to have been wholly or partially residential.

But what was the background for the initial placing of the Bishop's property at Lustrupholm and its later growth into such an extensive complex? One possibility is to regard it as a traditional manor whose buildings to a certain extent reflect the land around the farm, but in several respects this model does not seem adequate. In that case one would expect to find traces of building stock of similar extent at other magnate farms investigated, but so far that has not been the case. Nor does the placing in the landscape seem – to present-day eyes – to be well suited to a large estate. The meadows around Haulund Bæk are modest, and large infertile heath areas extend densely south of Lustrupholm. Moreover, a placing close to the fertile marshlands would seem more likely for an exclusively farming-based magnate residence.

Lustrupholm's location in the local resource area can thus be characterized as peripheral; but in an overall traffic and communication perspective, the point at Lustrupholm has a much more central position. The buildings lie with easy access to and are visible from the highways towards both Tønder and Haderslev/Hærvejen and at a short distance from the trading centre Ribe, from which connections issued both to the north and to the whole northwestern European region. The placing in the landscape supports an interpretation of the complex as a nodal point in the physical administration of the Bishop's activities. These were many-sided, but one of them was the collection, storage and resale of the goods that came as duties, primarily in kind, to the Bishop. The coins and scales found indicate that hard cash too may have been used for payment of dues in whole or in part. One imagines that the farm in Lustrup was run by the *cellarius* or butler mentioned in the letter from 1258, while the find material does not suggest that the Bishop and his household spent much time at the place.

The Bishop's activities in the early part of the Post-Viking Middle Ages also included a central role in the military organization of the country. As someone responsible for military levies in the individual dioceses, the Bishop participated in the provision of war supplies whether in the form of active military service with his own men or the equipping of forces. During the functional lifetime of the Lustrup farm, the military levy system underwent radical transformations, from a system based on personal military service to a system based on commutation in the form of payment of taxes. The mention in the written sources of Lustrupholm may indicate that the farm also played a role in the Bishop's military obligations. The settlement from 1233 determined in fact that the oat duties were to be delivered to Lustrup – perhaps because there was a large number of horses there intended for the King's cavalry? That the military role of the bishops could be particularly active is evident from the fact that Bishop Tuvo (1214–30) was one of the prominent prisoners-of-war who fell into the custody of the conquering German coalition army after the defeat at Bornhöved in 1227.[39] He was ransomed by the Chapter for 700 marks of silver.

The reason why the lifetime of the farm extends over just under a century we cannot say with certainty, but in the period there were both a number of local physical changes and great historical developments, each of which could have contributed to the closing-down of the farm. The damming of the river Ribe Å in connection with the establishment of the King's mill took place in the period immediately before the appeal case in 1255, and the effect in Lustrup was that the meadow areas were diminished. All other things being equal, this must have reduced the agrarian potential of the farm. But the military development, when the role of the bishops in the war levies was taken over by mercenaries paid from the war taxes, may very well also have been an important factor.

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Notes

1. Manuscript submitted (2008).
2. Søndergaard (1998). Lustrupholm is today in the parish of Skt. Katharine, but in the Middle Ages it belonged to Vester Vedsted parish. Nielsen (1985, p. 60).
3. Feveile and Kieffer-Olsen (2005), Etting and Engberg (2004, p. 136) and Poulsen (2001, p. 418).
4. The excavation campaign of 2003 received support from Queen Margrethe II's Archaeology Fund and the Farumgaard Foundation.
5. The campaigns of 1998–2000 are gathered in the museum case ASR 1301, while the campaigns from 2002 on are gathered in the case ASR 1700. SB. No. 190409-22.
6. The burial site from the Bronze Age has been published in Feveile and Bennike (2002). The finds from the other periods are unpublished.
7. Matthiesen (1930, p. 112). The road from Ribe runs into the ancient military road Hærvejen at Urnehoved. See also Matthiesen (1927).
8. Kinch (1869, p. 603).
9. Diplomatarium Danicum (DD) no. 168.
10. DD no. 156.
11. Paludan (1977, pp. 484ff.).
12. DD no. 257.
13. Søgaard (1973).
14. Jensen (1987, p. 22).
15. Report on the investigation ASR 491 (1987), drawn up in 2001 by Claus Feveile.
16. Sørensen (2003).
17. Madsen (1985), Building 1.
18. Feveile and Jensen (2006, pp. 89ff.).
19. ASR 1301 × 278.
20. For a discussion, see Klemensen (2001, pp. 36ff.).
21. During excavation no attempt was made to locate hammer scales or slag remains.
22. Secondary stoves have been demonstrated archaeologically in Denmark as far back as c. 1100. Kristensen (1999, p. 74).
23. Jantzen et al. (1994, fig. 4).
24. Brick size 25–26 × 10–12 × 7–8 cm. Course sequence: irregular monk bond with an excess of stretchers. Up to seven stretchers in a row were seen in some courses.
25. Grenaa find 35. The obverse matches the coin Hbg. 40, which has been ascribed to Ribe. Galster (1931, p. 224).
26. The coin is of the type MB50.
27. Gläser (2001) and Mührenberg (2001).
28. Roof pantiles, often glazed, appear in large numbers in the Ribe culture layers from the 1200s. They seem to have been the preferred roofing of the time on brick buildings.
29. Callmer (1992), Liebgott (1980, pp. 130f.), Stiesdal (1980) and Andersen and Nielsen (2000).
30. In the German area, the house type is usually called *Steinwerk* or *Kemenate*. For a comparative treatment covering the northern European area, see Mührenberg (2001).
31. ASR1700 × 65. Jensen (1984).
32. Engqvist (1987).
33. Madsen (1999, pp. 73ff.).
34. Madsen (1999) and Søvsø (2006, 2007).
35. First suggested by the excavator, Claus Feveile.
36. Kinch (1869, pp. 58f.).
37. Søgaard (1973).
38. Callmer (1992), Etting and Engberg (2004) and Stiesdal (1980).
39. Søgaard (1973, p. 272).

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Viking Age garden plants from southern Scandinavia – diversity, taphonomy and cultural aspects

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Plant finds recovered from archaeological sites in southern Scandinavia dated to the Viking Age reflect the diversity of useful plants that were cultivated and collected. This review presents the results of 14 investigations of deposits that are dated between AD 775 and 1050. The site types are categorized as agrarian, urban, military and burials. Garden plants are unevenly distributed, as the greatest diversity is recorded in features from urban contexts. We argue that taphonomic processes played an important role in the picture displayed. Archaeobotanical research results from neighbouring regions suggest that Viking Age horticulture has its roots in older traditions, and that the spectrum of garden plants is influenced by central and north-western European horticultural customs, which were to a great extent shaped by Roman occupation.

Keywords: garden plants; archaeobotany; Viking Age; southern Scandinavia; Roman food traditions

Introduction

This article presents the diversity of evidence for garden plants from archaeological contexts in southern Scandinavia dated to the Viking Age (AD 775–1050). Gardens in prehistory have, for centuries, been a rarely discussed topic. In recent years, it has been possible to gain more information by intensifying research in prehistoric settlements (e.g. Heimdahl 2010). In addition, interdisciplinary collaboration between archaeologists and palaeoethnobotanists has become a normal procedure at many excavations, and archaeobotanical investigations have been undertaken increasingly in recent decades. We are now able to date back the evidences for horticultural activities in southern Scandinavia to a time period before Christianization took place. Since information on gardening and garden plants in the written record from the Viking period is very sparse, the plant material, brought to light by archaeological activities, is the main source of knowledge to reconstruct the diversity and significance of gardening. Evidence from research on the layout of prehistoric farms can give hints on the possible locations of gardens, but when it comes to the spectrum of cultivated plants, the finds of remains of plants themselves are the central source of information. Archaeobotanical evidence for garden plants from the Viking Age forms the basis for this article, and the plant macrofossil record from northern Europe as a whole indicates that gardening was a widespread practice during the Viking Age period.

Definition of the term 'garden'

Generally garden cultivation can take a variety of forms. A garden to one particular culture can be a field to another. Furthermore, the use of the term garden or field can vary between specialists. In some tropical areas the term garden is often used synonymous with a field, because horticulture is the dominant land use practice (Van der Veen 2005, pp. 157). Consequently the definition of the cultivated area in discussion is important. The focus of this article – the kitchen garden – is the garden located close to the settlement and characterized by small-scale cultivation of crops. The kitchen garden is a human construction and it is defined by two fundamental characteristics: it is delimited and cultivated. The same can be said for a field and there is thus no unambiguous division between the two terms. This becomes more apparent if we look at cultures or at areas with other societal and climatic platforms than our own. The term horticulture or gardening defines the use of a garden, including the cultivation methods.

Other concepts to define a garden in general are the scale of cultivation, the cultivation methods and the location of the cultivated area, as well as the diversity and type of crop (Gleason 1994; Jones 2005, pp. 165). Generally the cultivation of a kitchen garden is distinguished from agriculture by the devotion to cultivation of several species together, each species represented by a relatively small number of plants in contrast to the large-scale field cultivation of a single crop. Some of the plants grown in gardens require more intensive cultivation than field crops, as some garden plants are more demanding when it comes to manuring, watering and soil management. Plants

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usually considered to be garden crops are vegetables, herbs and spices, as well as medicinal plants. But fruit trees and bushes can also be regarded as a common garden element in the Viking Age. The pleasure garden is often considered to be a medieval or modern arrangement. However, many useful plants have a decorative expression, and a garden layout with an ornamental composition is possible even in a prehistoric context, although our knowledge is currently not adequate. Interestingly Ann-Marie Hansson mentions the possibility of the cultivation of Jacob's ladder (*Polemonium caeruleum* L.) and common daisy (*Bellis perennis* L.) as ornamental plants in Viking Age Birka (Hansson 2001). It is difficult, however, to find evidence in the archaeological material for the cultivation of plants for their aesthetic expression alone.

The physical detection of a garden area in the archaeological context is often indicated by boundary systems. The boundary around a garden can consist of elements such as wooden fences, hedgerows and stone walls as well as terraces, embankments, roads and buildings (e.g. Petterson 2002, p. 502). The fence around a cultivation plot signals ownership and protects the garden from animals and wind.

When attempting to decide whether a plant is a garden or field crop, harvesting methods and rotation cultivation systems are elements to be considered. Many of the plants denoted as garden plants are inconvenient in the general field rotation systems as they are either perennial or biennial plants. Furthermore, some vegetables are harvested successively over a longer period as opposed to, for instance, cereals. Some useful plants were probably harvested from the wild or managed but never cultivated. This could be the case for sweet gale (*Myrica gale* L.), which is a plant that often grows on heathland and on bogs (Hansen 2005, 137pp.). Some of the oldest written sources mention sweet gale gardens and the ownership of these, which indicates that even plant resources located further away from the settlement could be subject to ownership rights (Jensen 1979, p. 72). Sweet gale was in this period probably not a cultivated plant but rather a managed wild-growing resource (Karg and Günther 2002).

It is thus not simple to define a garden plant in the Viking Age or in prehistory in general, because trying to resolve what was grown in gardens, and what was gathered from wild-growing plant resources is, in the case of many plant species, complicated (Karg and Robinson 2002, p. 137). In addition, many oil and fibre plants thrive in field cultivation, but there are examples pointing at plants, such as gold of pleasure (*Camelina sativa* L.) and flax (*Linum usitatissimum* L.), being cultivated by horticultural methods in Scania (southern Sweden) during the early Iron Age (Regnell 2001). Legumes, such as pea (*Pisum sativum* L.) and bean (*Vicia faba* L.), thrive on large-scale cultivation and are often considered to be field crops, but additional evidence points to pea being cultivated in small urban medieval gardens (Hansen 2008, p. 107). Legumes have several soil-improving effects to be utilized in garden, as well as in field cultivation (Körber-Grohne 1987).

In some of the earliest written sources that deal with gardening and garden crops, the term *kålhave* (kale garden) is mentioned (Hoff 1997). In this context kale is probably to be understood as a variety of leaf vegetables. These could consist of species within the Brassicaceae family. It is often difficult, however, to determine the exact species of *Brassica* on the basis of archaeological plant macrofossils. Wild-growing species of *Brassica* are frequent on disturbed soils and can therefore be considered as a part of the local flora in areas with human activity such as settlements. A range of species of *Chenopodium* and *Polygonum* as well as corn spurrey (*Spergula arvensis* L.) have been discussed as possible cultivated plants (Helbæk 1958; Mikkelsen 1994, p. 96; Karg 2012). The plants are edible and are found at many archaeobotanically investigated sites. The seeds of these plants were also detected in the gut of bog bodies dated to the early Iron Age (Harild *et al.* 2007). However, it is necessary to take into account that these plants are common weeds in field crops, and the presence in the stomach contents of bog bodies could be unintended.

Materials and methods

Records of possible garden plants dated to the Viking Age are summarized in Table 1 and mapped on Figure 1. The geographical area discussed includes 14 excavations at 12 localities from present-day Denmark, Scania (southern Sweden) and Schleswig (northern Germany). The plant finds consist of preserved plant parts like seeds, fruits, stems, roots and flowers, but the majority of the finds are seeds and fruits. Information on the find circumstances of the plant record has been retrieved from available archaeobotanical reports as well as published sources, and the references are given in Table 2. As our focus is on plant finds dated to the period AD 775–1050, the broad dating of several archaeobotanically investigated sites and features has reduced the number of localities available. To counterbalance the effect of the dating restrictions on the material, the spectrum of garden plants is compared with the evidence from northern Europe on a wider timescale (Table 3).

The sites included in this article have been categorized as agrarian or urban settlements, or burial and military sites. The urban sites are defined as settlements in cases where agrarian production is of less importance compared with other occupational activities. The establishment of a regulated marketplace seems to have played a fundamental role in the formation of the majority of the early urban settlements discussed here (Nielsen 2010, p. 232).

Table 1. Finds of garden plants from archaeobotanically investigated sites. The plant species (in a few cases only the identification to genus level was possible) are listed alphabetically in groups according to their presumed use. Nomenclature follows Hansen (2005).

Site (century AD) / Plant species	Fyrkat (980)	Elisenhof (775–1000)	Archsum (800–1000)	Hedeby settlement (800–1000)	Hedeby harbour (800–1000)	Stengade II (900–1000)	Vorbasse (949–1000)	Viborg Søndersø (1018–1035)	Kalundborg (775–1050)	Kosel (775–1050)	Århus Søndervold (900–1050)	Tinggård (900–1050)	Lund (1020–1050)	Viborg St. Skt. Pederstræde (1025–1050)
Vegetables and legumes														
Angelica (*Angelica archangelica*)					•									
Bean (*Vicia faba*)		•	•	•	•					•		•		
Bishop's Weed (*Aegopodium podagraria*)	•	•												
Cabbage (*Brassica oleracea*)	•													
Carrot (*Daucus carota*)		•		•	•									
Chicory (*Cichorium intybus*)				•										
Onion (*Allium* spec.)								•						
Pea (*Pisum sativum*)								•		•	•		•	
Herbs, spices, medicinal plants														
Celery (*Apium graveolens*)		•		•	•									
Common Butterbur (*Petasites hybridus*)											•			
Common Soapwort (*Saponaria officinalis*)			•											
Coriander (*Coriandrum sativum*)	•													
Henbane (*Hyoscyamus niger*)	•	•					•			•				•
Hop (*Humulus lupulus*)		•		•	•			•						
Opium Poppy (*Papaver somniferum*)								•						
Sage (*Salvia* spec.)	•													
Fruit and nuts														
Apple (*Malus sylvestris/M. domestica*)				•	•			•	•	•			•	
Cherry (*Prunus avium/P. cerasus*)				•	•									
Damson (*Prunus domestica* ssp. *insititia*)				•	•	•							•	
Grape (*Vitis vinifera*)				•										
Peach (*Prunus persica*)				•										
Walnut (*Juglans regia*)				•									•	

Results

Vegetables

The plants are grouped according to their presumed utilization. Some of the species may have been used as vegetables, as well as herbs or medicinal plants. The list of vegetable species is not indicative of the actual diversity in cultivated vegetables of this period. The edible parts (e.g. leaves, shoots and roots) of many vegetables are harvested before seed production, and as the seeds are usually the most robust part of a plant and therefore have a greater chance of preservation, the presence of vegetables can be difficult to detect in archaeological deposits (Karg and Robinson 2002). Furthermore, the quantity of vegetable seeds harvested and stored for next year's planting is presumably quite small compared with the quantity of those for cereal crops. Table 1 presents the selection of vegetables found in Viking Age deposits. Among the detected species, a single find of onion peel from a household waste deposit has been made. Onion (*Allium* sp.) is believed to have been highly appreciated, due to the strong and spicy taste. Additionally onion has a possible inhibitory effect on bacteria in food (Billing and Sherman 1998, p. 17).

Plant species like angelica (*Angelica archangelica* L.) and chicory (*Cichorium intybus* L.) were probably cultivated for their green parts, but the roots of chicory are also useful, and have in modern times been used as a coffee substitute. It is very likely that these plants were normally harvested before setting seeds. Angelica is traditionally considered to be a Viking Age garden plant (Eggen 1994, p. 45). It is mentioned in the Old Norse Kings' sagas from Iceland (Ramskou 1974, p. 53) and the use of this plant may have its origin in Norway. The

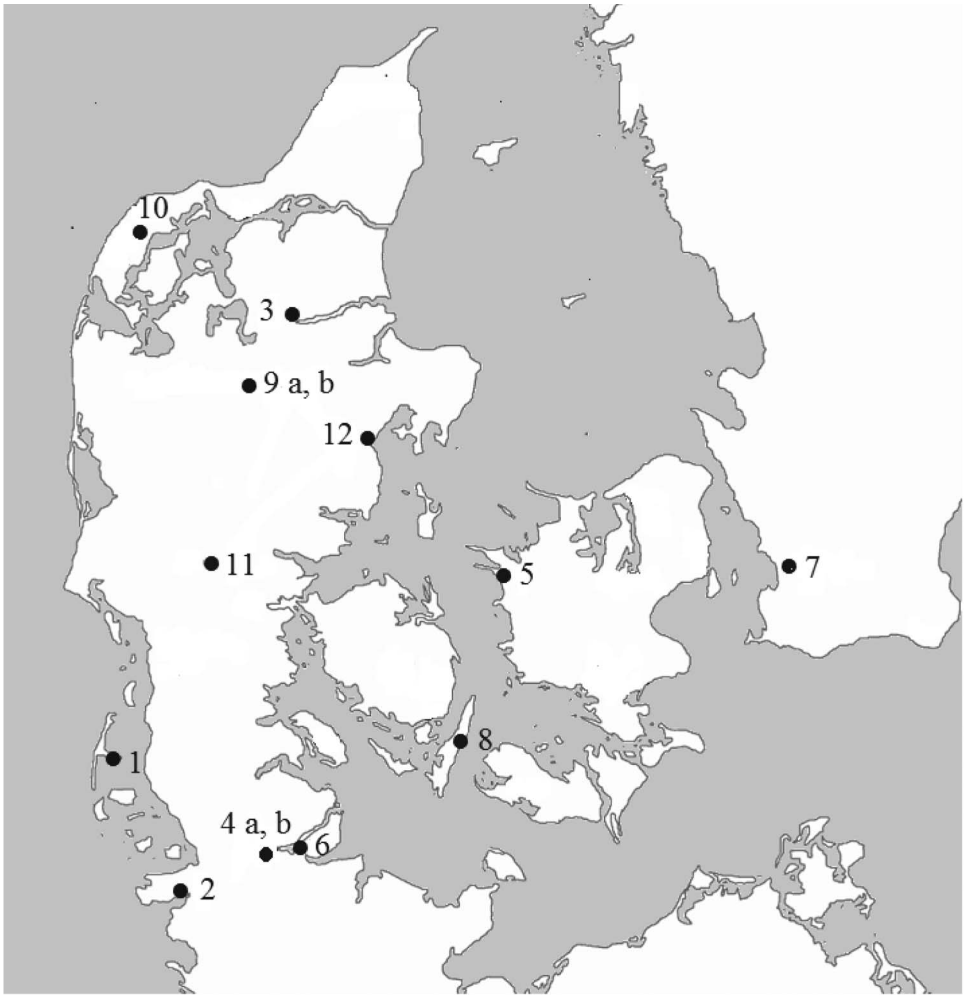

Figure 1. Map showing the locations with plant macro remains of garden plants discussed in this article. 1: Archsum, 2: Elisenhof, 3: Fyrkat, 4a: Hedeby settlement, 4b: Hedeby harbour, 5: Kalundborg, 6: Kosel, 7: Färgaren, Lund, 8: Stengade II, 9a: Viborg, St. Skt. Pederstræde, 9b: Viborg Søndersø, 10: Tinggård, 11: Vorbasse, 12: Århus Søndervold.

single find of angelica from Hedeby (Table 1) may have entered the archaeological context from natural habitats, but there is a real possibility that angelica was cultivated during the Viking Age.

Legumes, such as bean and pea, are present at several of the incorporated sites and have been cultivated throughout the Viking Age. Perhaps the introduction of Christianity with its periods of fasting may have led to an increase in the cultivation of pea, because pulses were important as a substitute for meat in the monastery diet (Hansson 2001, p. 211).

Herbs, spices and medicinal plants

As for the vegetables, the green parts of the plants categorized as herbs may have been used as a dietary supplement. Sage (*Salvia* sp.) was probably cultivated for the aromatic leaves and shoots and was most likely often harvested before setting seeds. This means that there is little chance for sage to be detected in the archaeological record. The seeds of some herbs contain aromatic oils and they were therefore allowed to grow until seed production. Coriander (*Coriandrum sativum* L.) has from this period been observed as a single find from the Viking fortress Fyrkat (Figure 1, no. 3), where its seeds were discovered. Celery (*Apium graveolens* L.) was probably cultivated as a herb in this period and it was the seeds of the plants that were utilized (Greig 1996, pp. 222). The natural habitat for celery is in salt marshes and meadows, but is also found today growing wild in the vicinity of previously cultivated areas (Hansen 2005, p. 372, Behre 1976).

Opium poppy (*Papaver somniferum* L.) seeds have been detected in faecal deposits at the site of Viborg Søndersø (Figure 1, no. 9b), indicating that the seeds were part of the diet. The plant may have been used for its oil-rich seeds, but the medicinal qualities have probably

Table 2. Information about the archaeobotanically investigated sites. The sites are mapped in Figure 1.

	Site name	Dating AD of included features	Site type	Feature type	References
1	Archsum, Sylt	800–1000	Agrarian		Kroll (1987)
2	Elisenhof	775–1000	Agrarian settlement in the marsh	Settlement layers, manure, well	Behre (1976)
3	Fyrkat, Hobro	950–1000 (980 dendro)	Military site, burial ground	House 4 S, grain deposit, floor layer, grave	Helbæk (1977) and Pentz *et al.* (2009)
4	a. Hedeby settlement	800–1000	Urban, marketplace	Pits, wells, fence holes	Behre (1983), Lange (1997)
	b. Hedeby harbour	800–1000	Urban, marketplace	Harbour sediment	Kroll (2007)
5	Kalundborg	775–1050	Agrarian	Wells	Moltsen (2009)
6	Kosel, Svans	775–1050	Agrarian	Longhouse, pit houses, rye deposit	Kroll (1986)
7	Lund, Färgaren	1020–1050	Urban	Culture layer	Hjelmqvist (1963)
8	Stengade II, Langeland	900–1000	Burial ground	Grave	Fredskild (1977, p. 25) and Skaarup (1976, p. 175)
9	a. Viborg St. Skt. Pederstræde	1025–1050	Agrarian	Floor layer in storage building	Jensen (1986)
	b. Viborg Søndersø	1019–1035 (latrine), 1018–1025 (workshop)	Urban, workshop site	Floor layer, wells, manure, faeces (human), latrine	Fruergaard and Moltsen (2005) and Moltsen (2005)
10	Tinggård, Thy	900–1050	Agrarian	Culture layers	Henriksen (2006a)
11	Vorbasse	949–1000	Agrarian	Well	Henriksen and Mortensen (2008)
12	Århus Søndervold	900–1050	Urban, marketplace	Pits by the bank surrounding the settlement, pit houses F & U	Fredskild (1971)

also played an important role. Another species known as a medicinal plant is henbane (*Hyoscyamus niger* L.). A concentration of seeds was found in a woman's grave at Fyrkat (Figure 1, no. 3). Henbane is not native to the Scandinavian flora and must therefore have been imported (Heimdahl 2009, Pentz *et al.* 2009). The species may have been introduced to southern Scandinavia as early as in the Neolithic period (Jensen 1991, p. 312). Seeds are recorded from Pre-Roman and Roman Iron Age contexts at the site of Archsum on the Island of Sylt (Figure 1, no. 1) and Helmut Kroll mentions the possibility that henbane was cultivated at Archsum (Kroll 1987, p. 75, p. 137). It is however necessary to take into account the possibility of the plant having entered the archaeological deposits from natural habitats, as henbane quickly establishes itself as a weed around settlements (Heimdahl 2009, p. 123). Common butterbur (*Petasites hybridus* (L.) Gaertner, B. Meyer & Scherb.) is generally thought to have been introduced in Denmark in the fourteenth century as a remedy against the plague (Lundquist 2007, p. 34), but evidence from Århus (Figure 1, no. 12) indicates an earlier presence. Hop (*Humulus lupulus* L.) has been found at two of the investigated sites. For a long time, it was assumed that only beer flavoured with sweet gale was brewed in southern Scandinavia and that hop-flavoured beer did not make its entry until the thirteenth and fourteenth centuries (Karg and Günther 2002). The finds of hop from Viking Age sites show that hop as a beer additive was probably popular earlier than previously assumed. The finds of hop form a part of a regional pattern already originating in the late Iron Age, which, for instance, is seen in the finds of hop from the royal estate of Järrestad in Scania from the seventh century (Lagerås 2003) and from the early eighth-century marketplace of Ribe (Jensen 1986, p. 18; Robinson *et al.* 2006, pp. 110). Several Swedish provincial laws, which include some regulations that are likely to have their origins in the Viking Age, contain information on the layout of and the directives for the hop garden (humlegården; Hoff 1997, p. 117). Here, it is mentioned that the hop garden can be located within as well as outside of the area of a farm.

Fruit and nuts

Apple (*Malus* sp.) remains were detected in a number of features from the Viking Age. Apple has most likely played a significant role as a diet supplement, as the fruits can be stored fresh and dried and can be used for the production of juice and cider. Apples were found in the Oseberg ship burial in Norway, dated to approximately AD 850 (Holmboe 1927), and played an important role in Norse mythology, where the goddess Idun is associated with apples and youth (Steinsland 2005). In Charlemagne's 'Capitulare de Villis', four varieties of apples are mentioned (Strank and Meurers-Balke 2008,

Table 3. The chronological distribution of a selection of garden plants illustrates the evidence of garden plants occurring in northern and central Europe during a time sequence that covers the Roman occupation, as well as the emerging urban settlements in the subsequent periods (based on Schultze-Motel 1992-94; Kroll 1995-2001; Karg *et al.* 2007; Strank & Meurers-Balke 2008; Alsleben 2009 and Heimdahl 2010). Nomenclature follows Hansen (2005).

	Before Christ				AD 1-400				AD 400-775					AD 775-1050						AD 1050-1300					
Plant species	Denmark	Sweden	Germany	Great Britain	Denmark	Netherlands	Germany	Great Britain	Denmark	Sweden	Netherlands	Germany	Great Britain	Denmark	Poland	Sweden/Norway	Netherlands	Germany	Great Britain	Denmark	Poland	Sweden/Norway	Netherlands	Germany	Great Britain
Apple (*Malus domestica/sylvestris*)	●		●	●			●	●	●		●	●		●	●	●		●	●	●	●	●		●	
Bean (*Vicia faba*)	●	●	●	●	●	●	●	●		●	●	●	●	●			●	●	●	●	●	●		●	●
Beetroot (*Beta vulgaris*)	●		●			●	●	●				●						●						●	
Bishop's Weed (*Aegopodium podagraria*)	●		●				●	●	●					●				●							
Black Mustard (*Brassica nigra*)			●				●	●										●		●	●	●		●	
Cabbage (*Brassica oleracea*)							●	●				●		●						●		●		●	
Caraway (*Carum carvi*)			●			●	●											●				●		●	
Carrot (*Daucus carota*)	●		●		●	●	●	●				●		●			●	●	●	●	●			●	
Celery (*Apium graveolens*)	●	●	●	●	●	●	●	●	●			●		●		●		●	●	●	●			●	
Chicory (*Cichorium intybus*)			●				●							●				●		●	●	●		●	
Common Vervain (*Verbena officinalis*)			●		●		●	●												●				●	
Coriander (*Coriandrum sativum*)			●			●	●	●			●	●	●	●				●	●	●	●			●	
Damson (*Prunus insititia*)			●	●			●	●				●		●	●	●		●		●	●	●		●	
Dill (*Anethum graveolens*)		●	●			●	●	●				●						●	●	●	●	●		●	
Fennel (*Foeniculum vulgare*)			●			●	●	●										●				●		●	
Garden Cress (*Lepidium sativum*)						●	●									●		●						●	
Garden Orache (*Atriplex hortensis*)							●													●					
Greater Celandine (*Chelidonium majus*)							●	●				●								●		●		●	
Good King Henry (*Chenopodium bonus-henricus*)							●	●											●	●		●			
Hemp (*Cannabis sativa*)			●				●	●		●		●	●		●			●		●	●	●	●	●	
Henbane (*Hyoscyamus niger*)	●	●	●	●	●	●	●	●	●					●				●		●	●	●		●	
Hop (*Humulus lupulus*)	●		●			●	●		●	●		●	●	●	●			●	●	●	●	●		●	
Onion (*Allium* spec.)	●		●			●	●	●						●					●					●	●
Opium Poppy (*Papaver somniferum*)	●	●	●	●		●	●	●				●		●				●	●	●	●			●	
Parsley (*Petroselinum crispum*)			●			●	●	●				●						●			●			●	
Parsnip (*Pastinaca sativa*)			●			●	●	●							●				●		●	●		●	
Pea (*Pisum sativum*)	●	●	●	●		●	●	●		●	●	●	●	●		●	●	●	●	●	●			●	
Pear (*Pyrus communis*)						●	●					●			●			●		●	●	●		●	
Plum (*Prunus domestica*)			●			●	●	●			●	●	●		●			●	●	●	●		●	●	
Radish (*Raphanus sativus*)						●														●				●	
Rue (*Ruta graveolens*)						●	●	●																●	
Sage (*Salvia* spec.)					●									●								●		●	
Savory (*Satureja hortensis*)						●	●	●				●	●					●				●		●	
Sour Cherry (*Prunus cerasus*)											●				●			●			●	●		●	
Sweet Cherry (*Prunus avium*)			●	●		●	●	●			●	●						●		●	●		●	●	
Thyme (*Thymus* spec.)							●											●							
Turnip (*Brassica rapa*)	●		●	●		●	●	●				●						●	●	●	●	●		●	
White Mustard (*Sinapis alba*)						●	●	●				●												●	
Wild Mignonette (*Reseda luteola*)			●	●		●	●	●				●	●					●							●
Woad (*Isatis tinctoria*)			●	●	●	●	●												●						●

p. 322). Archaeological finds of "damson" (*Prunus domestica* ssp. *insititia*) indicate that this fruit was introduced during the Viking Age – perhaps the finds reflect the pioneer cultivation of plums in southern Scandinavia. At the burial site Stengade II (Figure 1, no. 8), six "damson" fruit stones were found in a female grave. The stones were placed in a small casted bronze box which had been wrapped in fine linen (Fredskild 1977, p. 25). Karl-Ernst Behre has made a thorough examination of the stones of "damson" found at Hedeby (Figure 1, no. 4a) and Old Schleswig (Behre 1978). As a result, the fruit stones were divided into four probable subspecies of which one – *Formenkreis* A – was by far the most common until the thirteenth century. *Formenkreis* A is almost exclusively the only variety of plum detected at Hedeby. This raises the question of whether the art of grafting was known in Viking Age Hedeby. However, the subspecies has the predisposition to produce root suckers, which can be replanted and grow into new plum trees with identical fruits (clones) (Kroll 2007, p. 320). Sweet cherry (*Prunus avium* L.) has been found at military camp sites and urban settlements as well as in rural areas in the Roman provinces. The cultivar appears to have been much appreciated and was probably introduced to the occupied parts of central and northern Europe during the Roman Iron Age (Strank and Meurers-Balke 2008, p. 379). Sour cherry (*Prunus cerasus* L.) does not seem to be part of the Roman food tradition. The species has been found at several slavic castles and settlements in ninth-century deposits, which indicates that sour cherry came to western and northern Europe from the east (Kroll 2007, p. 323; Strank and Meurers-Balke 2008, p. 382).

Some of the fruits listed in Table 1 are, in all probability, imported goods. Species such as peach (*Prunus persica* (L.) Batsch) and grape (*Vitis vinifera* L.), found at Hedeby, are garden plants, but it is very unlikely that these species were cultivated in southern Scandinavia due to climatic conditions (Behre 1983; Kroll 2007, p. 317). However, little is known about the garden techniques and garden equipment available in the Viking Age period. Cultivation of plants in a specularium (a kind of greenhouse or hotbed) and grafting were techniques known in Roman Italy (Farrar 1998, p. 160). Although it is difficult to confirm the use of horticultural methods such as a form of greenhouse cultivation in the present archaeological evidence, it is definitely a thought that needs consideration in a Viking Age perspective. Perhaps some of the gardening techniques used by the Romans followed the exotic plants on their way into central and north-western Europe.

A great number of nutshells of walnut (*Juglans regia* L.) were found at Hedeby. Today walnut is cultivated in Denmark, but the evidence from Hedeby points towards importation of the nuts, since neither walnut wood nor pollen of the species were detected in any of the samples (Behre 1983, p. 50). New evidence of walnut pollen discovered in Scania from the period of approximately AD 600–800 indicates that the cultivation of walnut trees in southern Scandinavia is a possible scenario already in the Viking Age (Björkman 2007, p. 205).

Horticulture in southern Scandinavia in a western and central European perspective

At the beginning of the period in question, horticulture seems to have involved species that probably had a native origin in southern Scandinavia or had been introduced as cultivars in earlier periods. Plant remains of opium poppy, bishop's weed (*Aegopodium podagraria* L.), henbane, dill (*Anethum graveolens* L.), common vervain (*Verbena officinalis* L.) and hop are found in features from Iron Age settlements in Scandinavia (Behre 1976, p. 26; Jensen 1986, p. 90; Kroll 1987; p. 75, pp. 137; Nielsen 1990, Heimdahl 2010). Species of kale or mustard are present in pollen spectra from the late Iron Age (Kolstrup 2009) and legumes have been cultivated since the Bronze Age (Lange 1997, p. 19). Celery is a native plant growing along the European coastlines and was probably already in use before the birth of Christ at sites located along the shores of the North Sea (Strank and Meurers-Balke 2008, p. 176). In addition, many species such as common elder and hazel, generally considered to be collected plants, may have been incorporated into gardens. It is apparent, however, that the Roman occupation had a marked effect on the cultivation of a wide spectrum of plants in central and north-western Europe. During a relatively short time span, a great variety of cultivated plants spreads over a quite large geographical area, as shown in Table 3. Some species with a Mediterranean origin found in Switzerland and south-west Germany, such as parsley (*Petroselinum crispum* (Mill.) Nym.), dill, celery and rue (*Ruta graveolens* L.) even predate the Roman occupation (Jacomet 1988, Strank and Meurers-Balke 2008, pp. 171, p. 189). Only rarely are remains of onion and its relatives encountered in archaeological features, although both onion (*Allium cepa* L. var. *cepa*) and garlic (*Allium sativum* L.) have been found in Roman Iron Age deposits in Germany (Knörzer and Gerlach 1999). In the southern Scandinavian Iron Age, onion was clearly important in the diet as well as symbolically, however. This is apparent from runic inscriptions of the word *laukaR* on gold bracteates (Hansson 2001, p. 221). Onion is definitely heavily under-represented in prehistoric samples, which is probably also the case in samples from medieval and modern times (Karg *et al.* 2007, p. 183, table 1). Throughout the Viking Age the spectrum of garden plants widens in southern Scandinavia and many of the cultivated species seem to be rooted in a garden culture originating in south and central Europe, where these species had been cultivated at least since the Roman Iron Age. Some vegetables, herbs and fruit species such as parsnip (*Pastinaca sativa* L.), parsley, pear (*Pyrus communis* L.) and sour cherry (*P. cerasus* L.) were not detected in southern Scandinavian Viking Age samples but are present in Viking Age urban deposits along the shores of the Baltic Sea (Kroll 2007; Alsleben 2009; p. 68; Heimdahl 2010, p. 271).

Discussion

The spectrum of garden plant species included in this article contains plants that are generally considered to have been collected from nature. A wide range of species has obviously been used by the Vikings and many of them still today have a natural distribution in southern Scandinavia. For example, hazel (*Corylus avellana* L.) and common elder (*Sambucus nigra* L.) are repeatedly found in archaeological features and could have been deliberately grown in gardens. The nuts and berries from these plants could also have been harvested from wild-growing species around settlements, however. The numerous finds of hazel nuts show that they played a significant role in the diet. In addition, hazel populations may have been affected by anthropogenic influences on the environment around settlements, for instance, in the form of forest clearing, which may have encouraged the propagation of the species (Kirleis *et al.* 2011, p. 32). Some of the wild-growing plants were probably introduced as already cultivated species from elsewhere during earlier periods (Heimdahl 2010, p. 270). In the surroundings of most Viking Age settlements, a wide spectrum of berries was accessible, such as bramble (*Rubus fruticosus* L.), raspberry (*Rubus idaeus* L.), European dewberry (*Rubus caesius* L.) and strawberry (*Fragaria vesca* L.). Rose hips (*Rosa* sp.), rich in vitamin C, may have been an important fruit, and the flowers could have been used for decorative purposes (Henriksen 2006b). Several records from fruit trees reflect the significance of wild-growing species as a dietary supplement, e.g. berries of rowan (*Sorbus aucuparia* L.) and common hawthorn (*Crataegus laevigata* (Poir.) DC.; Behre 1983, pp. 45). Furthermore, a number of species that could have been used as dye plants are native to the southern Scandinavian flora. Evidence for the cultivation of plants used for dyeing, dated to the Roman occupation, is available from the Rhineland (Knörzer and Gerlach 1999). In archaeological samples with Viking Age features found in York, England, a number of possible dye plants were detected (Kenward and Hall 1995, Hall and Kenward 2004).

The range of Viking Age garden plant species is likely to be much more diverse than is reflected by the present state of the art. So far, the spectrum can only tell us to a limited extent about geographical variations in garden traditions in southern Scandinavia, although it is to be expected that there were variations between the regions. The limitations are essentially of taphonomic character (Heimdahl 2005). Figure 2 shows that a greater number of plant species were found in towns (urban sites) than in agrarian sites. One of the main reasons is that the plant finds in towns are mainly preserved in waterlogged conditions. By contrast, the plant finds in agrarian sites are mainly preserved in carbonized (charred) conditions, with the exception of the site at Elisenhof (Figure 1, no. 2).

Figure 3 shows all the factors influencing the presence of a plant species in an archaeological context. Various natural and cultural factors affect the diversity of garden plants in the plant macrofossil record. Biological aspects such as the frequency and quantity of seed production, as well as the robustness of the seeds and other kinds of plant tissue, have to be considered too. Many garden crops are harvested before seed production and the handling of the plants, e.g. cooking and drying, will have an effect on the spectrum of plants that enter the archaeological context. Depositional processes probably constitute one of the main sources of differences in the record between urban and agrarian sites. In the urbanized environment, there is a quicker accumulation of cultural layers and the cultural layers are more rapidly sealed. At agrarian sites the organic waste is presumably utilized as manure, and the accumulation of layers is therefore limited. Organic material is usually preserved either by waterlogging or by carbonization, where the decomposition of the organic compounds is reduced or stopped (Andréasson and Hansson 2010, pp. 328). Carbonized seeds are resistant even in oxidized layers. Uncarbonized plant parts, however, are usually preserved in biologically inactive layers. Waterlogged features and sediments which are deficient in oxygen, such as wells, latrines and bogs, contain ideal conditions for preservation of uncarbonized organic material. As a result, conditions for preservation by waterlogging are generally more frequently present in urban layers, although features with good preservation conditions by waterlogging also exist in agrarian settlements, e.g. in wells and pits. Waterlogging generally preserves a more extensive and complete range of plant species and fragile plant material such as bran, kitchen refuse and faeces (Heimdahl 2005, p. 29; Moffett 2006, p. 42). Finally, processes such as reworking of soil layers and farming activity, as well as vagaries of sampling and analysis procedures, will influence the fossil record from archaeological contexts.

A greater number of plant species have been found at urban sites than at agrarian settlements. Early urban settlements or marketplaces were increasingly dependent on the production of food and textiles from the agrarian settlements, and in return, commodities traded over long distances were distributed from the marketplaces to the surrounding agrarian settlements (Steuer 2007, p. 150). Interaction and trade between urbanized settlements and the surrounding agrarian sites are thus reflected in the general archaeological material, but so far this is very sparingly displayed in the fossil record

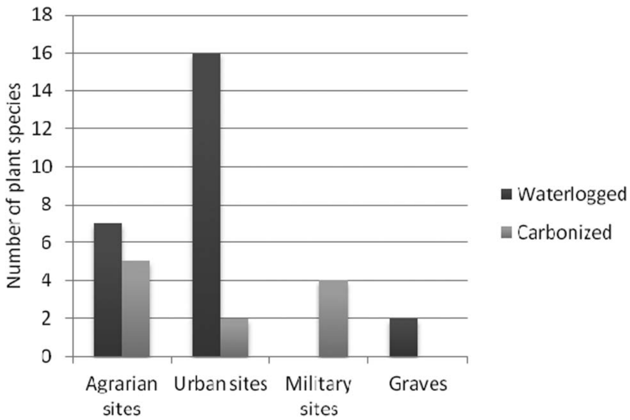

Figure 2. Number of plant species detected at different site types, preserved either by waterlogging or carbonization.

of garden plants. The reason for this could be due to the taphonomic processes outlined above. Future sampling from agrarian settlements – especially from waterlogged layers – will most probably change the picture of garden plant diversity for this type of site. During the centuries that followed the Viking Age the first towns were established in southern Scandinavia and thereby the spectrum of garden plants increased (Karg 2007, 2010). It has been suggested, on the basis of the written record, that the medieval towns functioned as horticultural innovation and distribution centres (Tollin 2005). Again, these distribution channels do not seem to involve the surrounding agrarian settlements to a very high degree. More research into the garden plant spectrum for agrarian sites is essential in order to address this topic, using the archaeological record of garden plants.

It seems likely, however, that the urbanized settlements and marketplaces in the Viking Age functioned as gates, through which new cultivated species were introduced, and it has been suggested that the introduction of some new garden plants was initiated through connections between royal seats and marketplaces in Scandinavia and central European elite culture in the Viking Age (Heimdahl 2010, p. 271). The connection between Scandinavian sites linked to the royal sphere and European elitist customs is further emphasized if the finds from the ring fortress Fyrkat are taken into account, as the ring fortresses are generally considered to be constructed by a royal power. The Fyrkat plant finds include coriander, cabbage (*Brassica oleracea* L.) and sage and

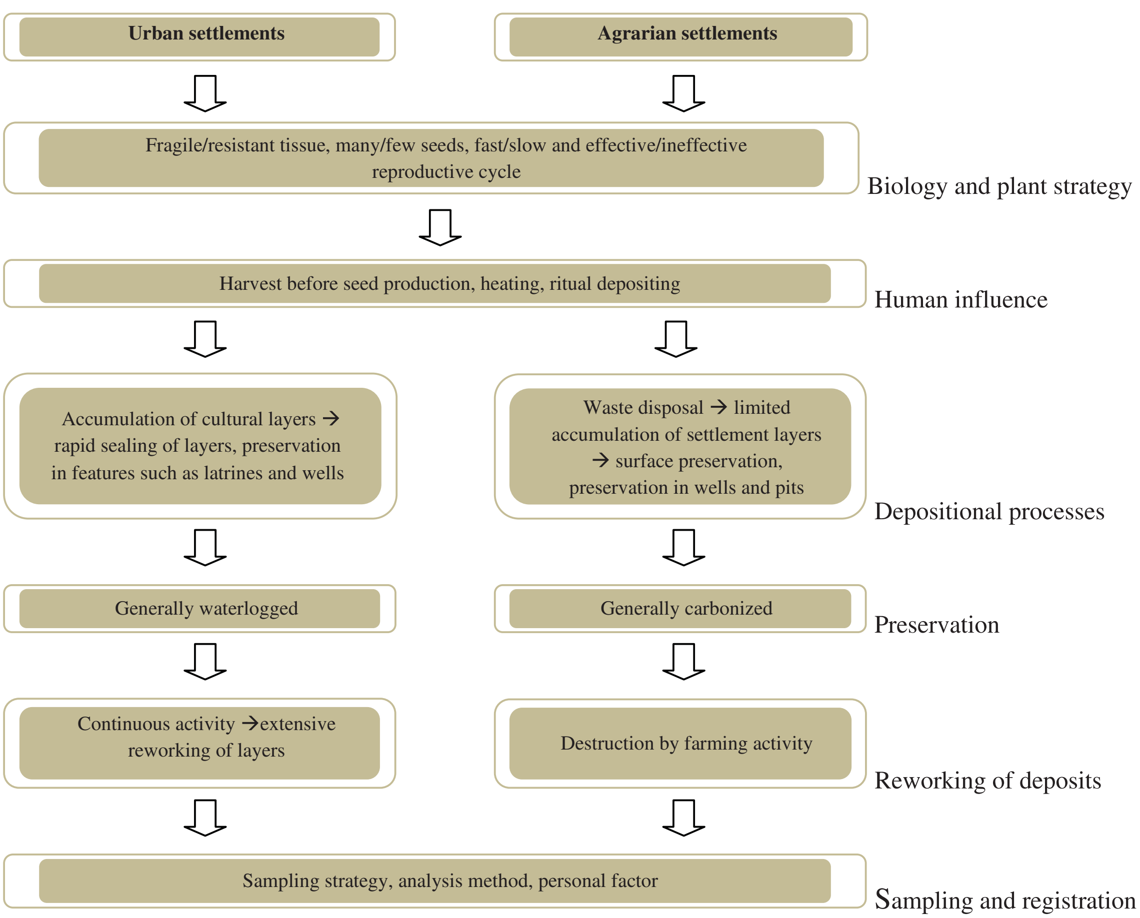

Figure 3. Model of the taphonomic aspects concerning plant macro remains from urban and agrarian settlements.

were originally interpreted as imports with an eastern or central European origin (Helbæk 1977, pp. 38). Recent strontium analyses have, however, indicated local cultivation (Karg *et al* in preparation).

Conclusions

In general prehistoric gardens and horticultural history in Scandinavia have been overshadowed by agricultural research, although the histories of garden and field cultivation methods are intertwined. Horticulture, in a variety of forms, has probably played a very important role for subsistence since the Stone Age. Cultivation of vegetables, herbs, spices and fruits in gardens was a widespread activity in the Viking Age, and inspection of the fossil record from archaeological samples makes it possible to visualize the cultivated garden in this period. Taphonomic restrictions may, however, limit the spectrum of plants detected. Furthermore, preservation conditions may obscure the picture of garden cultivation in agrarian settlements and lead to the idea that garden history is linked to a particular social class or environment. It seems likely that the early urban centres in the Viking Age functioned as gateways for new cultivated plants, which was probably also the case with the emerging towns in medieval Scandinavia. It remains elusive, however, to what extent new plants were distributed in the agrarian hinterland. The apparent under-representation of the range of cultivated garden plants may be compensated for by glancing at the plant remains of horticultural crop plants from neighbouring regions. The Roman occupation of large parts of Europe seems to have functioned as an impetus in the introduction of numerous garden plant species in the subjugated regions. The Romans brought along their food traditions and garden culture and it appears that many of the species incorporated into central and north-western Europe during the Roman Iron Age were gradually introduced into southern Scandinavia during the Viking Age, where the rulers of that time practised an expansive foreign policy. Evidence from northern Europe indicates that a wide range of garden plants was grown, and that more are waiting to be discovered in future excavations.

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The cultural landscape of megalithic tombs in Denmark, reconstructed by soil pollen analysis

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Forty-four pollen spectra from 25 megalithic tombs (5 dolmens and 20 passage graves) in eastern and northern Denmark reveal a highly varied landscape with remains of woodland, coppice woods or secondary woodland and open areas of grass and herb vegetation. Very often there are traces of tree burning. The dominant land-use was cereal growing on burnt sites and pasture. A long-fallow swidden rotation based on the burning of coppice, cereal growing, pasture and coppice regeneration is indicated.

Keywords: soil pollen spectra; megaliths; swidden rotation; land-use; agriculture; Neolithic

Introduction

Excavations and restorations of megalithic tombs in Denmark have revealed a wealth of information about the high cultural and technological level of the mound builders (e.g. Hansen 1993, Dehn *et al*. 1995, Dehn *et al*. 2000). The tombs thus bear evidence of a highly developed society, whose wealth permitted the building of magnificent monuments and the production and sacrifice of highly refined inventory. The tombs, however, give no visible evidence about the setting of the landscape in which they are built and the economic background for these extravagances. Nevertheless, the mounds themselves offer possibilities for revealing such information, if appropriate methods are employed.

Pollen grains in soils buried in megalithic graves

Underneath the mounds, traces of the land original surface often occur. In these soil horizons we can find pollen grains, which were deposited on the land surface and then buried in the soil by the soil fauna. Pollen grains buried in soils are destroyed by microorganisms within a few years in calcareous and aerobic soils but may be preserved for a very long span of years in more acid soils (Andersen 1979, Dimbleby 1985). The erection of a mound around a megalithic grave sealed off the original soil and hindered further breakdown of the pollen grains buried there. The pollen present in these soils is strictly of local origin (Andersen 1992). These pollen spectra are, therefore, narrowly focused in space and time and thus may reveal vegetational composition and possible management methods used by the mound builders at the mound site.

Sections through megalithic burial mounds have revealed that the earth used for building the mounds very often was taken from the land surface around the mounds. Pollen spectra from these layers may differ from the soil under the mound itself and, therefore, indicate variations of the vegetation around the graves (Dimbleby 1962, 1985, Andersen 1992).

The soils buried in megalithic mounds in Denmark are usually of the brown earth type, in which the pollen spectra reflect the most recent vegetation at the site. However, in cases of rapidly changing vegetation stages, differing pollen assemblages may have become mixed during the burial in the soil (Andersen 1992).

The practice of burning felled trees on the ground can be recognized because the pollen grains buried in the topmost soil have been deformed by the heat in a characteristic manner (Andersen 1990, 1992). Tree pollen affected in this way frequently occurs in the soil samples, an indication that tree vegetation has been felled and burned on the site. If a burnt area is invaded by herb vegetation, one may find pollen from the burnt trees mixed with pollen from the herb vegetation in the same soil sample (Andersen 1990).

This manuscript was finished in 1996 for a planned conference proceedings that unfortunately never was published. Before the death of the author in 2009 he gave his consent to the publication of the manuscript in DJA. The manuscript is published here in its original form with minor adjustments to comply with the reviewers' suggestions and journal requirements (Peter Rasmussen, GEUS).
†Deceased.

The landscape of megalithic tombs in Denmark

Soil samples were collected during a megalith restoration campaign and other archaeological investigations in Denmark. Samples from a few of the tombs were devoid of pollen, presumably because of very intensive biological breakdown. Forty-four pollen spectra were obtained from 25 tombs (5 dolmens and 20 passage graves), from the Middle Neolithic Period I A in eastern and northern Denmark (Figures 1 and 2). The tombs were situated on a more or less sandy till substrate, and the pollen spectra did not reflect geographical differences.

Landscape variation, as reflected by the 44 pollen spectra, is shown in Figure 3. This triangular diagram illustrates the representation of original woodland, secondary woodland or coppices and open land within the individual pollen spectra. Common English names for plant species follow Clapham *et al*. (1952), and Latin names follow Tutin *et al.* (1964–1980). Lime (*Tilia cordata*) was common before the introduction of agriculture, whereas early-successional trees such as hazel (*Corylus avellana*), birch (*Betula* sp.) and alder (*Alnus glutinosa*) were common in secondary woodlands created after disturbance of the original lime woodlands. Open areas are characterized by non-tree vegetation, mainly grasses and herbaceous plants. The triangular diagram in Figure 3, therefore, reflects the occurrence of lime-woodland (dots in the lower left-hand corner), secondary woodland or coppice (dots in the lower right-hand corner) and sites invaded by herbaceous vegetation (uppermost corner). The circles around the dots in Figure 3 indicate sites where felled tree vegetation had been burned on the ground.

The wide distribution of dots within the triangle reflects the presence of a very diverse landscape at the time of megalithic tomb construction. A cluster of dots towards the lower left corner is dominated by lime and indicates relic lime woodland. These dots are somewhat separated from the baseline due to the presence of 20–30% herbaceous pollen. These relic lime woodlands from Middle Neolithic time were less dense than the undisturbed lime woodlands from earlier times (Andersen 1984). The lime woodland on three sites had been felled and burned just before the mounds were built. Another cluster of dots occurs in the lower right-hand corner. These dots indicate secondary woodland, which, in nearly all cases, had been burned just before the mound building.

Figure 2. Previous to the restoration of the Tustrup passage grave, eastern Jutland, an excavation revealing the buried topsoil was carried out. During this excavation pollen samples of the different soil horizons under the mound were collected (photo: Torben Dehn).

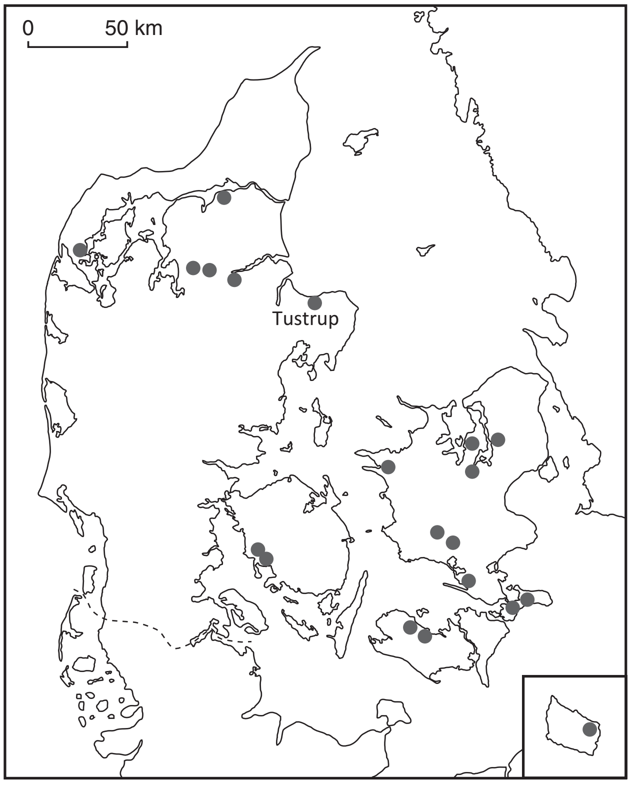

Figure 1. Map of Denmark showing the location of megaliths with pollen spectra from soil samples included in this study.

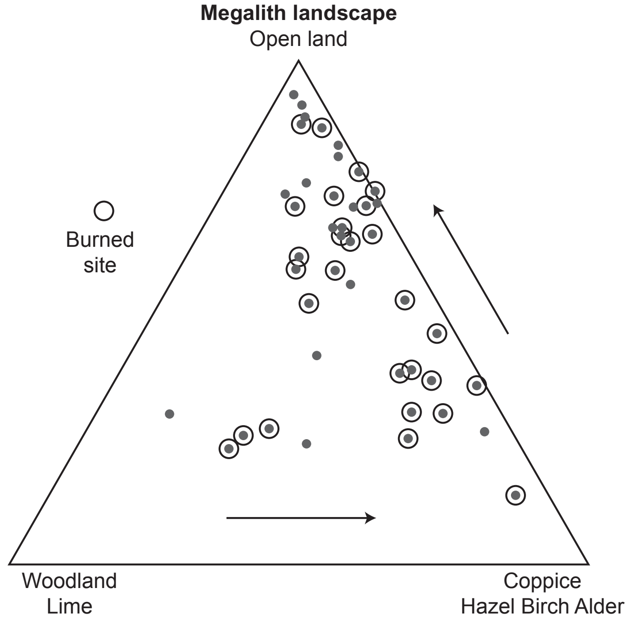

Figure 3. Triangular diagram, indicating landscape variation of the megalithic tombs according to pollen spectra from soil samples. Each dot represents a pollen spectrum from one soil sample. Lower left-hand corner, woodland 100%. Lower right-hand corner, coppices 100%. Uppermost corner, open land (herbs) 100%. Open circles indicate pollen spectra where more than 20% of the tree pollen was deformed due to heating from ground fires.

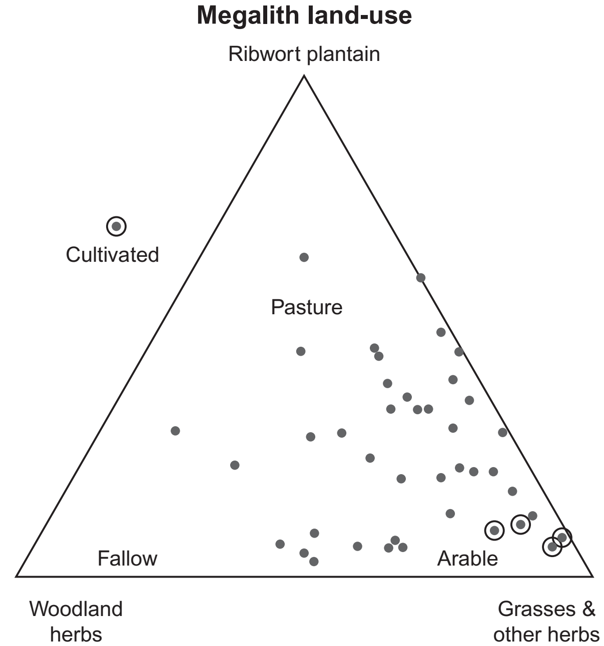

Figure 4. Land-use in megalith time according to the composition of the non-tree pollen in soil samples. Lower left-hand corner, woodland herbs 100%. Lower right-hand corner, grasses and other herbs 100%. Uppermost corner, ribwort plantain 100%. Open circles indicate pollen spectra with traces of cereal cultivation.

Twenty-eight pollen spectra (64%) are concentrated to the upper half of the triangle in Figure 3. These dots indicate sites where trees had been replaced by herbaceous vegetation. At the majority of these sites, trees had been burned prior to the invasion by herbs.

The pollen spectra from the megalithic tombs in Denmark indicate a highly diverse vegetation that was strongly influenced by human activity. Most of the former lime woodlands had been transformed into coppices, and the coppices, in many cases, had been invaded by herbaceous vegetation. Hazel, alder and birch were common in the secondary woodlands due to human interference. The woodlands had been felled and burned at 29 sites (66%) either at the time when the mounds were built or prior to invasion by herbaceous vegetation. The wide use of fire indicates a swidden agriculture system (also known as slash-and-burn or shifting agriculture), where coppices were produced and then burned and used for agricultural purposes.

Land-use in the megalith landscape

The composition of the non-tree pollen reflects agricultural practice. There were three main components present, woodland herbs, grasses (and other herbs) and ribwort plantain (*Plantago lanceolata*, Andersen 1992). Figure 4 shows the occurrence of these plants in the individual pollen spectra.

Woodland herbs, including bracken (*Pteridium aquilinum*) and mugwort (*Artemisia*), were associated with the coppice vegetation. The dots in the lower left-hand part of the triangular diagram in Figure 4 represent this herbaceous vegetation at coppice sites.

The grasses and other herbs indicate herb vegetation, which had invaded the burnt coppice areas. Five of these sites show distinctive traces of cereal cultivation (enclosed by circles in Figure 4). Plants, which prefer bare soil and avoid dense herb vegetation, were particularly frequent at these sites (12–26%) together with cereals (barley and wheat, Table 1). The pollen spectra in the lower right-hand corner, therefore, indicate burnt sites used for cereal cultivation.

Sites with frequent ribwort pollen (20–60%) occupy a major part of the triangle in Figure 4 (26–50%). Grazing by livestock prevents the flowering of grasses and most other herbs, whereas ribwort plantain continues to produce new flowering spikes from leaf rosettes. The enormous quantities of ribwort pollen at the megalithic sites, therefore, indicate widespread grazing of the herb vegetation, which had invaded the burnt coppice sites.

Swidden rotation in megalithic time

The pollen spectra from the Middle Neolithic megalith sites indicate that lime woodlands and secondary woodlands of lime, birch, hazel and alder had been felled and burned for

Table 1. Bare soil plants, Crucifer family, Ribwort Plantain and grasses (in % of non-tree pollen) and deformed tree pollen (in % of tree-pollen).

Bare soil plants	25.9	26.3	11.8	12.7	13.0
Barley, *Hordeum* type	7.0	4.4	3.9	6.3	3.9
Wheat, *Triticum* type	–	0.6	0.8	0.2	1.3
Sheep´s Sorrel, *Rumex acetosella*	15.0	13.4	2.4	3.9	1.3
Cornflower, *Centaurea cyanus*	0.7	1.3	0.8	0.5	–
Knotgrass, *Polygonum aviculare*	1.2	4.4	–	0.5	6.4
Persicaria, *Polygonum persicaria*	–	–	–	0.2	–
Tartarian Buckwheat, *Fagopyrum tataricum*	0.5	–	–	–	–
Corn Spurrey, *Spergula arvensis*	–	–	–	0.2	–
Field Madder, *Sherardia arvensis*	–	–	–	0.2	–
Hemp-nettle, *Galeopsis* type	–	0.6	–	–	–
Goosefoot family, Chenopodiaceae	1.2	–	1.6	–	–
Great Plantain, *Plantago major*	–	–	1.6	–	–
Annual Knawel, *Scleranthus annuus*	0.2	–	–	–	–
Perennial Knawel, *Scleranthus perennis*	–	1.3	–	0.7	–
Stonecrop, *Sedum*	–	–	0.8	–	–
Sheep´s-bit, *Jasione montana*	–	–	–	0.2	–
Crucifer family, Brassicaceae	6.5	18.6	3.4	0.7	6.4
Ribwort Plantain, *Plantago lanceolata*	6.1	10.3	9.4	6.6	1.3
Grasses	42.4	29.4	23.6	64.0	70.1
Deformed tree pollen	21.2	48.7	54.8	15.2	30.2

use in cereal cultivation and livestock grazing. Soils under burnt tree vegetation are well suited for the cultivation of cereals for a short period (Steensberg 1955, 1979, Reynolds 1977, Ehrmann *et al*. 2009). Due to mixing of the pollen, an arable stage is difficult to trace at sites where extended periods of livestock grazing followed. Cereal cultivation can, therefore, only be traced in those cases where the mounds were built in arable fields. However, the presence of ard marks under many megalithic mounds (Kristiansen 1990, Thrane 1991) indicates that cereal cultivation was more common than suggested by the pollen spectra.

Widespread use of a swidden rotation system in megalithic time can, therefore, be suggested (Figure 5). This changed lime woodlands to secondary woodlands which served as fallow land. These were then felled and burned, to be used for cereal cultivation and prolonged livestock grazing. These phases occurred simultaneously in the megalith landscape, and mound building took place during various stages (indicated by broken lines in Figure 5). It can also be surmised that secondary woodlands were re-established by invasion of trees on abandoned pastures.

Swidden rotation at the Tustrup megaliths

The pollen buried in the brown-earth soils reflect vegetation at the sites shortly before and at the time of mound construction. A longer sequence of vegetation phases may be preserved in soils with a low biological activity. The pollen grains are transported downwards from the surface, but mixing of the pollen assemblages is less pronounced than in fertile soils. A vegetational sequence can, therefore, be recognized in soils of this type (Andersen 1979).

At Tustrup on Djursland, East Jutland (Figures 1 and 2), samples were collected beneath a passage grave and a dolmen originally excavated by P. Kjærum (Kjærum 1958). A sequence of vegetation phases could be recognized in a sandy soil beneath the passage grave (Figure 6). In the oldest *phase 1*, tree vegetation (birch dominant) was replaced by herb vegetation with dominant ribwort plantain. High frequencies of birch pollen deformed by heating indicate that the coppice had been burned before it was replaced by grazed herb vegetation. In *phase 2*, the grazing was abandoned and the area was invaded by birch trees. The birch coppice was burned again, and there are traces of renewed grazing (plantain). A birch coppice was re-established in *phase 3* and was felled at the time when the grave mound was built.

The vegetation sequence at the passage grave at Tustrup shows that birch coppices were burned and used for pasture and then re-established in a swidden rotation system. Ard marks indicate cultivation at the site, but a horizon with cereal pollen could not be identified. It can be suggested that cereals were cultivated at the beginning of the first grazing phase.

A shorter sequence was preserved in a soil found beneath the dolmen at Tustrup (Figure 6). Here, a birch coppice was burned and then replaced by pasture vegetation.

Swidden rotation as a basis for the economy of the megalith people

The pollen analyses from soils in the megalithic graves indicate that the landscape around the mounds was used

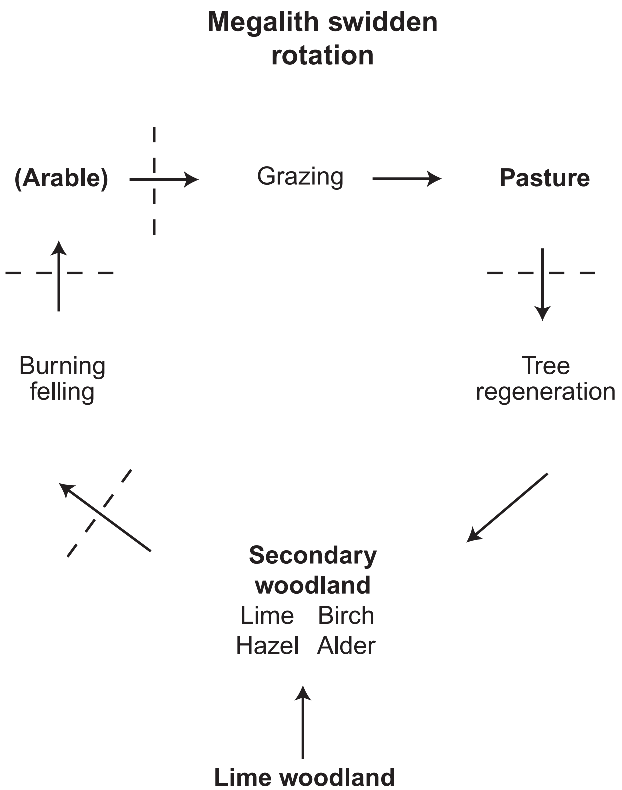

Figure 5. Model for swidden rotation in megalith time based on pollen analyses of soil samples. The broken lines indicate levels represented by pollen spectra.

intensively for swidden rotation, where coppice woods were burned and re-established after cereal cultivation and grazing. Birch coppices are easily developed by self-sowing (Linkola 1916, Grönlund 1995) and trees such as lime, hazel and alder can be rejuvenated by sprouting from the stumps of felled trees (Worsøe 1979).

In historic time in Finland, barley was grown for up to eight seasons on swidden sites after a fallow period of 15–40 years (Voionmaa 1987, Grönlund 1995). Swidden rotation also improves pasture for cattle (pasture burn-clearing, Massa 1987). Similarly, the use of long-fallow coppice rotation in megalith time provided a basis for cultivation of crops and production of cattle fodder without necessity for manuring. The purpose of the swidden rotation thus appears to be twofold: cultivation of cereal crops and production of livestock, the latter of which was probably the more important (compare Madsen 1982, Jensen 1994). Both products were essential for the economy of the megalith people.

Swidden rotation requires extensive areas and is profitable only as long as the rotation cycles remain long enough, however, increased population growth may necessitate a shortening of the rotation cycles, thereby diminishing crops (Grönlund 1995). In eastern Finland, overexploitation led to development of arable cultivation on permanent fields (Grönlund 1995). Scarcity of trees and very high percentages of plantain at many megalith sites in Denmark (Figures 3 and 4) might be an indication of overexploitation. Such overexploitation might have contributed to a greater emphasis on intensive cereal growing on permanent fields in the Middle Neolithic stages A II-V, which followed the period of megalith construction (MNA I, Jensen 1994).

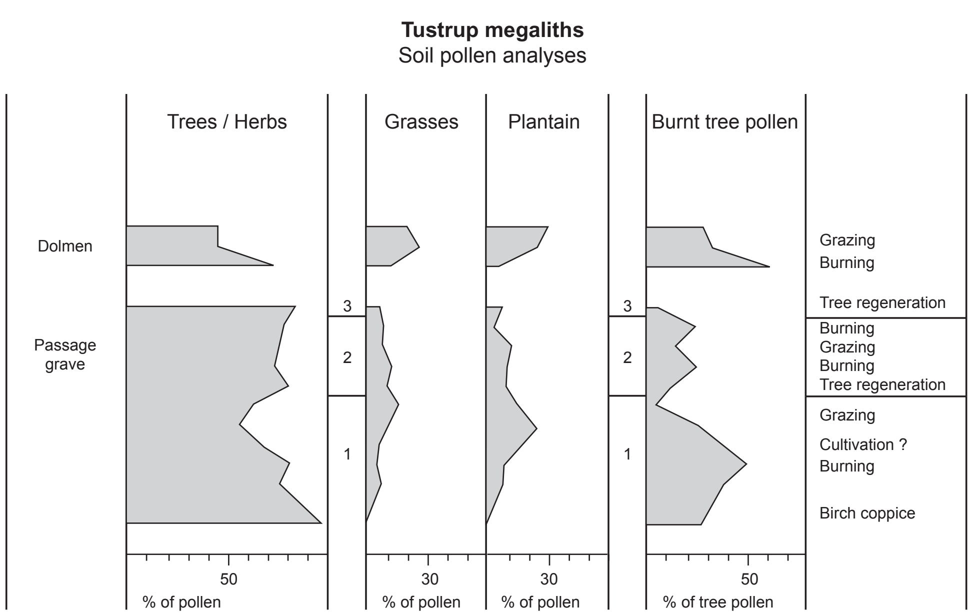

Figure 6. Pollen diagrams from soils under megalithic graves at Tustrup, eastern Jutland. The soils were 3 cm deep (dolmen) and 15 cm deep (passage grave), respectively.

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Original copies: seriality, similarity and the simulacrum in the Early Bronze Age

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This article explores inter-artefactual relations in the Nordic Bronze Age. Notions of copying and imitation have been dominant in the description of a number of bronze and flint artefacts from period I of the Nordic Bronze Age (ca. 1700–1500 BC). It has been argued that local bronze manufacturers copied imported foreign artefacts, and that lithic producers tried to imitate bronze artefacts in flint. This article argues that these archaeological attitudes to resemblance in the material repertoire are a product of typological analyses, but that it is possible to reclaim the cultural reality of similarity by looking at artefactual similarity as the results of prototyping and as a production of simulacra. In this light, the concept of copying turns out to be more than simply a matter of trying to imitate an exotic or prestigious original, and it fundamentally raises the question how different a copy can be from its model and still be a copy.

Keywords: copying; imitation; similarity; difference; types; prototyping; simulacra; flint; bronze; Nordic Bronze Age period I

Introduction

By the beginning of the Bronze Age, metal artefacts began circulating in Southern Scandinavia in quantities that were hitherto unknown. While standardised objects of a limited number of types had been around for centuries, the earliest Bronze Age (ca. 1700–1500 BC, Montelius period I) witnessed an expansion in the quantity, quality and forms of metal artefacts. In the archaeological literature, some of the most famous examples of metal objects from this time are frequently referred to as ‘copies’ or ‘imitations’ of artefacts imported from faraway landscapes; for example, swords of the so-called Hajdúsámson-Apa type, which were imported from present-day Hungary and Romania. However, so-called imitation not only occurred in bronze, but also across material categories. Thus, flint objects were occasionally made to look like bronze artefacts, and archaeologists also regularly refer to these objects as copies or imitations of other artefacts; for example, the flint scimitar from Favrskov on Funen, which is believed to be modelled on the bronze scimitars from Rørby on Zealand. Hence, the logic is that objects with approximately similar forms can be regarded as copies of one another.

But when we look at the production of bronze artefacts in the same period from a more critical perspective, the occurrence of artefactual resemblance turns out to be slightly more complicated. The archaeological literature typically uses other terms than ‘copy’ or ‘imitation’, when describing artefacts of similar forms manufactured in large quantities, namely ‘type’. Hence, a spearhead of the so-called Bagterp type is not referred to as a copy of another spearhead of similar appearance; the two spearheads are instead seen as repetitions of the same form or, in conventional archaeological terminology, two examples of the same type. The problem is, however, that when we look closer at the different examples of the artefacts that are described as belonging to the same type, then they all turn out to be different. Sometimes the differences are minute, at other times they are immediately apparent. We may thus identify a tension between archaeological notions of ‘type’ and ‘copy’, which calls for a critical engagement with how we define the concepts and what attributes we recognise in artefacts. Conceptualisations of ‘copies’ may differ widely and are inherently circumscribed by cultural notions. In a stringent positivist sense, there can never be exact copies as the copy will always be different in time and place from the original (Groom 2001, p. 9, Lefebvre 2004, p. 7). On the other hand, cultural perceptions may deem even rather different things ‘same’, which means that sameness and difference can oscillate between the conspicuous and the subtle (Groom 2001, p. 10, for a variety of perspectives, see Goodman 1981, Goodrich 1988, Preciado 1989, Elkins 1993, Schwartz 1998, Willerslev 2004, Cox 2007, Boon 2010, Jiménez 2010, Kalshoven 2010, Tinari 2010).

In this regard, the nature of bronze work turns out to play an interesting role for our understanding of similarity and difference at the beginning of the Bronze Age. Since the production of bronze artefacts implies a casting procedure, it also offers the potential for replicating existing artefacts by making identical models in clay or wax or by reusing moulds for new casts. This means that the similarities and differences that can be observed in the metal repertoire of period I of the Bronze Age in Southern

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Scandinavia should be seen in the light of the new manufacturing technology that would have the potential for generating novel epistemologies and new notions of objecthood. Even though metal was also circulated and produced in the Late Neolithic, the repertoire and quantity clearly seem to expand in period I. The epistemological underpinnings of the expansion of the new technological potential moreover imply that similarities as well as differences in the metal repertoire can be seen as deliberate and culturally meaningful at this time and cannot exclusively be treated as mere typological differences or variations of types. Following, the question is to what extent archaeologists conflate the similarities and differences that are constructed in typological analyses with culturally meaningful resemblances and differentiations.

This article seeks to address artefacts from an analytical angle that explores artefactual similarities and differences at a cultural level, rather than approaching sameness and diversity through typological analysis. The motivation for exploring an alternative to typological analysis is based on a general problem in the typological approach and emerges from the issues raised above: do analytical types correspond to 'real' types? This is, of course, a classic debate in archaeology (see also discussions in, e.g. Krieger 1944, Spaulding 1953, Ford 1954, Steward 1954, Hill and Evans 1972, Adams and Adams 1991, Sørensen 1997), which I do not wish to recapitulate here, but simply make the point that if we seek to understand an interplay between similarity and difference as a cultural mode of perceiving and constructing artefacts, then we also have to acknowledge that 'resemblance' is a cultural phenomenon and not a schematic category.

A closely related problem transpires from the issue above: do typological classifications of artefacts correspond in any way to past perceptions of the very same artefacts? Can we, in other words, assume a connection between the analytical coordinates of a group of objects and the cultural perception of those objects? Recent anthropological work, for example, contains a challenge to the ease with which archaeology frequently looks at artefacts through an analytical gaze with no or little reference to the cultural perception of the artefacts. It has been suggested from a number of perspectives that objects and concepts can sometimes be understood simultaneously at a variety of ontological strata or as constantly changing, implying that ontologies may be 'multiple' (e.g. Henare *et al.* 2007, Holbraad 2009) or 'chronically unstable' (Vilaça 2005). If this was also the case in the Early Bronze Age, we may suspect that a given artefact would not be broken down to one firm artefactual category, which means that the correlation between the archaeological typology and the cultural perception of the artefact in the past dissolves, because typology does not accommodate multiple and dynamic ontologies.

The aim of this article is by no means to debunk typology as an analytical construct, and I fully acknowledge the tremendous usefulness of typology for analytical purposes, such as dating (for the Nordic Bronze Age, see, e.g. Montelius 1885, Müller 1909, Jacob-Friesen 1967, Lomborg 1969, Vandkilde 1996). Nor does it mean that I refrain from referring to artefacts by using their formal, typological epithets as they offer a starting point for observing how generalised schematic groups of artefacts look similar to or different from each other. Expanding on and redirecting the typological approach, this article then scrutinises notions of copying and imitation from disciplines outside of archaeology (especially postmodern philosophy), where the cultural and conceptual qualities of repetition, resemblances, sameness, difference and alterity have been discussed critically for many years (but see also Biehl and Rassamakin 2008, Frieman 2010, 2012).

Through this critical perspective, we may explore how similarity works at a cultural level, looking closer at concepts such as originals, models, copies, simulacra and prototyping. Methodically, this article begins by observing that a number of artefacts display what seems to be a *deliberate* juxtaposition of repetition and difference, leading to the next conceptual step in the analysis which reconstructs meaningful choices in the production of the objects. Hereby, we may move on to recognising different modes of establishing likeness and disparity within and across artefacts. This mode of analysis allows us to address how the individual object relates to the other individual objects, or, to phrase it axiomatically, the aim is to explore the material, social and philosophical relationship between the one and the many (whereas typology describes the relationship between parts of a perceived whole).

Swords from period Ib (ca. 1600–1500 BC) propel the discussion in the main body of this article, because they are often referred to in the archaeological literature by terms such as 'copies' and 'imitations' from a typological point of view. The intention is to offer a critique of this terminology by exploring an alternative approach to the artefacts. It is worth noting that swords constitute only around 8% of the bronze repertoire in period Ib, while other artefacts are more widespread. In comparison, flanged axes, spearheads and shafthole axes make up 69.5% of the total amount of bronzes in this period (based on Vandkilde 1996, p. 244, but including the swords from Dystrup). Hence, the choice of focusing mainly on swords in this article is based on how they have been analysed in the archaeological literature, and not so much because of any particular quality in swords as a cultural phenomenon.

Seriality in the Early Bronze Age

When bronze working became increasingly common in the beginning of the 2nd millennium BC, and especially in the course of period Ib, a growing number of people would have been confronted with the potential to produce artefactual similarity by using and reusing models and moulds. The reproducibility of bronze did, however, not automatically lead to an increased standardisation of material forms. On the contrary, the idiomatic repertoire expanded in period Ib (Vandkilde 1996, p. 264); while the formal repertoire of period Ia (ca. 1700–1600 BC) was dominated by flanged axes and spearheads, constituting almost 90% of all the metal work (Vandkilde 1996, p. 219), the repertoire widened in period Ib and now also included several types of axes and spearheads, swords, daggers and ornaments in addition to flanged axes and spearheads (Vandkilde 1996, fig. 261). At the same time, the design of certain artefacts may be seen as becoming fixed and standardised from the Late Neolithic through period I (Vandkilde 2000, pp. 19–20), at least in a typological perspective.

Period I as a whole can thus be characterised as a time of experimentation and discovery of the technical and social possibilities of metal work. We should keep in mind that this is a time span of some 200 years, which means that it would be culturally superficial to consider it a transitional period, disregarding the social reality of any given moment within those two centuries. Instead, the material variability – especially in period Ib – should be acknowledged and taken seriously as a cultural norm in its own right, which means that experimentation and discovery would have constituted normative cultural attitudes to bronze working. In this, I contend that we see a pattern of simultaneous repetition and differentiation of material forms, which might have been triggered by the very properties of metal production itself. The particular mode of manufacturing bronze artefacts implies working with transient and transforming material qualities: some stages of the production of an artefact entail working in wet, malleable clay, at other times in solid or fired clay, at some stages with wax models, which are then melted and disappear, finally ending up with fluid and subsequently solidifying bronze. This means that the production of an artefact undergoes several stages of positive and negative material forms and is host to a repetitive interaction with becoming and dissolving materials (soft, wet clay and hard, dry clay, solidifying and melting wax, fluid and coagulating bronze, etc.). In this article, it is argued that these shifting material properties offer a fundamental potential for exploring bronze as form and medium.

The particular mode of production of metal in the earliest Bronze Age was characterised by manual work, centred on craftsmanship and technological experimentation. These activities seem to have been centred on workshop environments, and a variety of modes of production have been suggested in the archaeological literature (Levy 1991, Budd and Taylor 1995, Harding 2000, Kristiansen and Larsson 2005, Goldhahn and Østigård 2008, Kuijpers 2012), yet empirical evidence for places of production is extremely limited, especially for period I (see Jantzen 2008). Identifying actual workshops or specifying individuals producing metal artefacts is, however, not the aim of this article, which instead focuses on the conceptual framework circumscribing the particular qualities of metal production.

One innovative aspect of metal work at this time is that it allows for a serial reproduction of artefact forms to a hitherto unseen degree. Bronze casting offers for a relatively high degree of reproducibility of forms by reusing or copying moulds or models. However, this does not mean that things become reproduced with identical sameness as in industrial mass production (Alder 1998), but that artefacts can be reproduced in series with the relative differences that are the results of the mechanical conditions of this type of work such as deviations resulting from manual work or differences in the degree to which individual artefacts shrink when cooling (Hiorns 1912, p. 301, Eerkens 2000). The point is that it is possible to achieve a very high degree of resemblance between artefacts by exploiting the resilient plasticity of clay moulds and wax models from which a chain of similar objects could be manufactured. On this basis, we may speak of 'seriality' in the production of bronzes in period I, by which is meant a series of independent actions that produce individual artefacts on the basis of existing artefacts that serve as models, prototypes or sources of inspiration.

Imitating imports

Swords of the so-called Hajdúsámson-Apa type are an example of such seriality. The swords are commonly believed to have been imported from present-day Hungary and Romania, which lead to the 'imitation', 'copying' or 'derivatives' of these foreign types in Southern Scandinavia (Müller 1909, p. 13, Lomborg 1959, p. 93, 1969, pp. 97–99, Vandkilde 1996, pp. 225–226, Randsborg 2006, p. 16, Rasmussen and Boas 2006, p. 103). Two particular swords from Stensgård and Torupgårde (Aner and Kersten 1977, nos. 1675 and 1680) in south-eastern Denmark display a number of traits that are described in the archaeological literature as very similar to swords found in Hungary and Romania (Figure 1); their handles and pommels, the curvature of their blades and decorative patterns are frequently argued to resemble the Carpathian swords so much that the two specimens found in present-day Denmark are to be interpreted as imported artefacts (Lomborg 1959, p. 94, 1969, p. 97, Vandkilde 1996, p. 225, Rasmussen and Boas 2006, pp. 102–103).

Other swords with similar features, also found in Denmark, are on the other hand interpreted as local copies of the Carpathian artefacts (Figure 2). One sword, found at Bøgeskov (Aner and Kersten 1977, no. 1682), not far from the two above-mentioned specimens, is characterised by a similar style decoration on the pommel, and the decorative pattern on the blade furthermore supports this

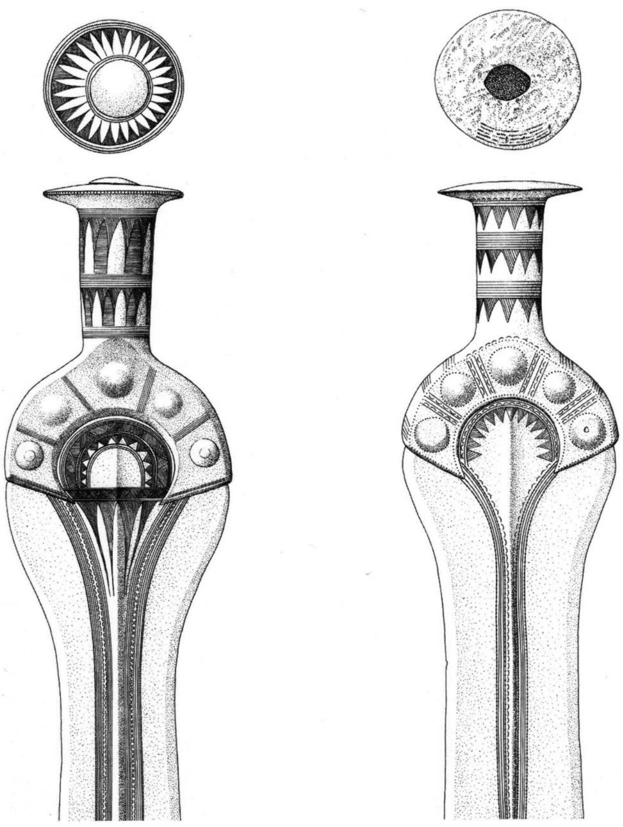

Figure 1. Imported swords of the Hajdúsámson-Apa type found at Torupgårde and Stensgård on Lolland in south-western Denmark. After Aner and Kersten (1977).

resemblance with the imported artefacts. At the same time, this particular sword is clearly distinct from the imported swords in that its handle is decorated with horizontal grooves rather than vertical triangles, and it does not have the same pronounced curvature of the blade.

Of the presumed local copies of the Hajdúsámson-Apa type swords and daggers, a specimen from Guldbjerg on northern Funen (Aner and Kersten 1977, no. 1882) probably bears the least resemblance with the other artefacts commonly described as imitations of imported originals. It has an entire lack of decoration, a straight tubular handle, a short blade with no curvature and an almost perpendicular transition from handle to blade.

The relationship between presumed imported originals and local copies thus calls for a critical discussion of how close resemblance is needed in order for something to be deemed a copy of another artefact. In essence, the archaeological designation as 'copy' in the case of the swords is based on a coexistence of resemblance and alterity: the copy looks like the original, but it is also different. In other words, the copy deviates from the original, which logically means that the copy must contain a new element or an original combination of imitated traits from its alleged model or models. This might imply that the archaeological vocabulary does not do full justice to the complex relationship between originals, models, copies and imitations. By looking at objects such as the period I swords as the results of a serial production based on the principle of prototyping it becomes possible to appreciate them as independent yet inter-referential artefacts, which will be elaborated in the following. At the same time, we also need to pay attention to the specific ways in which similarity and difference materialise in particular artefactual contexts.

For instance, a group of eight swords found in a deposition at Dystrup in eastern Jutland (Rasmussen and Boas 2006) can be seen as 'imitations' or 'copies' of the imported Carpathian specimens (Figure 3); relating to the imported 'originals' by having similar decorative patterns and the same slight curvature of a section of their blades, but since they are cast in one piece they are also different (local imitations of foreign swords are commonly believed to be cast as one piece rather than with separate hilts or handles (Müller 1909, p. 11, Lomborg 1959, pp. 94–96, Rasmussen and Boas 2006, p. 104)). Furthermore, the eight swords from Dystrup are among themselves so similar in shape, proportion and finish that they may even derive from the same workshop, as suggested by the excavators (Rasmussen and Boas 2006, p. 105). So, while they may in one sense be 'copies' of imported artefacts, they also adhere to a common design idiom among themselves, sharing the majority of characteristics, while also being different in certain details.

In particular, two of the eight swords appear to be set apart from the majority of the group in a number of respects; by only having four imitation rivets, instead of five, by having a slightly different decorative pattern on the handle and on the pommel, or no decoration at all, and by having handles with a flat oval profile instead of a rounded profile. Yet at closer scrutiny, details reveal how all the swords differ in one way or the other. Some of the differences seem to be patterned, which might suggest that moulds were reused for the production of new swords. However, the differences are not structured in a way that can support such an interpretation.

The reconstructed lengths, for instance, are given by the excavators as follows: two swords are 43.7 cm (X2 and X7), two are 44.8 cm (X3 and X5), two are 45.4/45.6 cm (X4 and X1), while one (X6) is 45 cm long (and thereby very close to the two swords of 44.8 cm) and one (X8) is 46.6 cm long. These reconstructed lengths are of course tentative (especially regarding X1 and X2, which are the most incomplete swords), but they may nevertheless offer an impression of associations between the swords. So if swords X2 and X7 or X3 and X5 had been made from the same mould, we should also expect

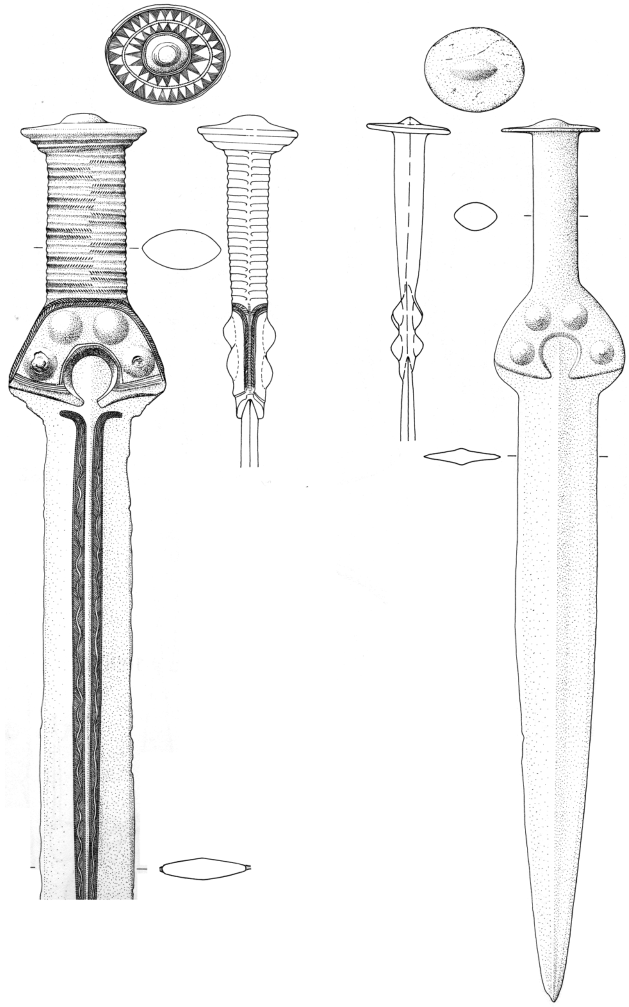

Figure 2. Locally manufactured swords of the Hajdúsámson-Apa type found at Bøgeskov on Lolland and Guldbjerg on Funen. After Aner and Kersten (1977).

other distinguishing features on these swords to be identical, which is not the case: X2 is decorated and X7 is not, and X3 has a straight casting seem on its handle, while the casting seam on X5 is slightly bent towards the pommel.

Differences in the reconstructed lengths should of course not be overemphasised as all of the swords are very similar in lengths, and dissimilarities might be caused by post-production treatment (cold-hammering or polishing). However, a number of other features do seem to suggest patterned connections between some of the swords. Swords X2 and X4 are related in that they share the same raised middle rivet; and swords X4 and X7 are related in that the terminal ends of their hilt forks are slightly more convex than the concave hilt forks that characterise sword X1, X2, X3, X5 and X6. The terminal forks on the hilt on sword X8 are almost straight (for details, see Rasmussen and Boas 2006).

The excavators also argue that there are no signs of punching in the decoration, concluding that it must have been made on the wax model prior to casting (Rasmussen and Boas 2006, p. 93). This is particularly interesting as five of the eight swords (X1–X5) are ornamented in almost identical ways; the uppermost parts of handles have two bands of lines with opposing triangles, forming a space of lozenges in between the bands. They also have two bands of lines towards the hilt, which are bordered by flattened arches. The triangles on sword X6 are smaller than those on the other swords, which means that no lozenge-shaped decoration materialises between the bands of lines. The decoration on the handle of sword X8 only has three bands of lines, where the top of the uppermost band is decorated with triangles facing the pommel. The lower side of the band is decorated with arches. The middle band is bordered by curved arches on the upper side and flattened arches on the lower side. The lower band does not have any arches on its upper side, but broad, flattened arches towards the hilt. Sword X7 is devoid of decoration.

Likewise, the decoration on the blades appears to be very similar for swords X1–X6 with an roughly ogival-shaped border of two lines that run from the terminal ends of the hilts towards the middle part of the blade and are filled in by an arch-like decoration. Sword X8 is different in that it has closely grouped lines with a row of arches on the inside, rather than two parallel lines that are filled in. Again, sword X7 is undecorated (for a schematic ordering of similarities and differences in the Dystrup swords, see Table 1).

It may of course be argued that this copresence of similarity and difference in the swords is simply an unavoidable result of manual reproduction (cf. Eerkens 2000). However, the excavators claim that six of the swords are so similar that they must be based on the same model, referring to the Carpathian originals circulating in Denmark (Rasmussen and Boas 2006, p. 104). This implies that the visual resemblance between the imported and locally produced artefacts is so great that we should expect the local artefacts to be directly inspired by the imported objects, which would have been available as a direct visual source of inspiration in front of the bronze manufacturer. Hence, the individual artefacts served as sources of inspiration in a process of modelling, prototyping and referentiality in the workshop environments. It is this process that can be seen as giving rise to subtle differences in the choice of designing each of them, and the difference between 'local' and 'imported' artefacts is thereby also not so much a result of a lack of understanding of the original, but the outcome of a continuous process of prototyping, where differences and similarities were produced deliberately when working in clay and wax

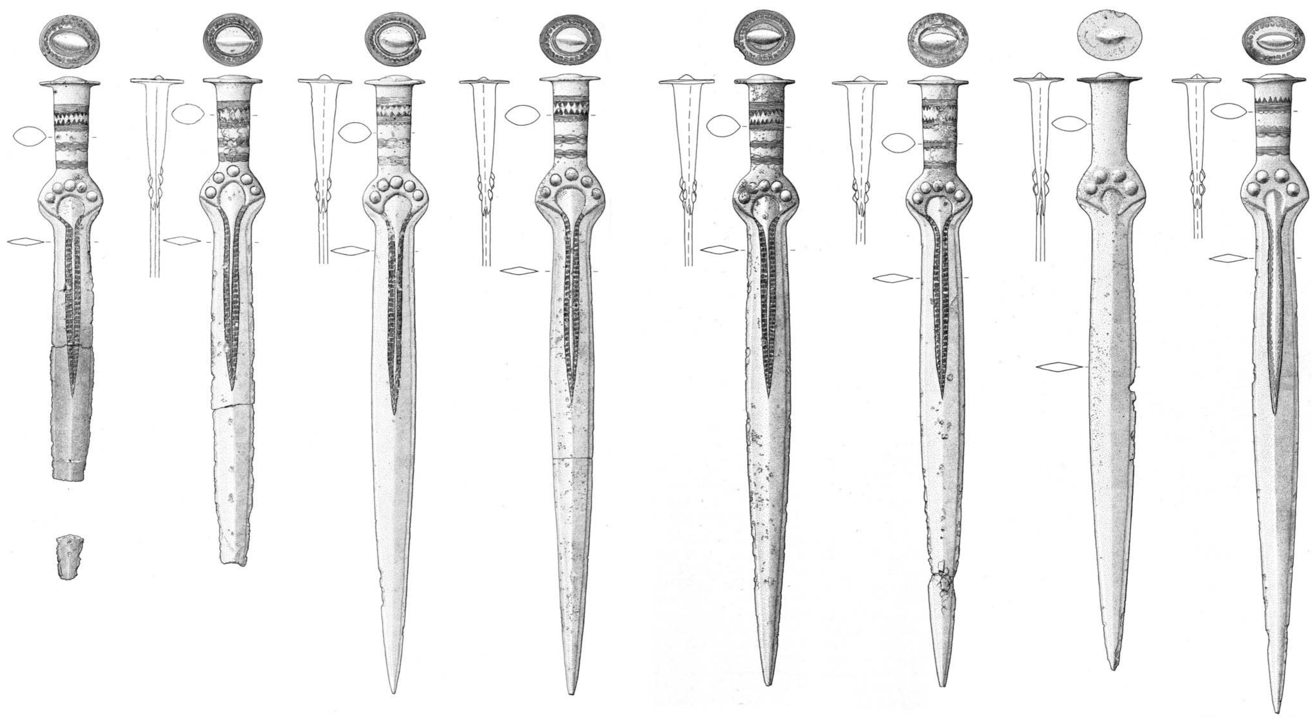

Figure 3. Locally manufactured swords found at Dystrup in eastern Jutland. After Rasmussen and Boas (2006).

(and wood?) before the cast was made. Differences and similarities were thus a part of the conceptualisation of the individual artefact and its relationship with the group of artefacts.

Striking similarity

This line of thinking leads to the question if the distinction between original/model and copy/imitation is merely a matter of scales of difference. Does greater difference imply less originality, and does more similarity in a copy mean that it is closer to its original? The famous Rørby scimitars from Zealand (Figure 4) offer a perspective on modelling and seriality in Early Bronze Age metal work by their high degree of similarity. The scimitars (Aner and Kersten 1976, no. 617) are two curved swords that were discovered roughly 10 m apart, but may originally have been derived from the same deposition context (Mathiassen 1958, pp. 38–39). The scimitars are commonly believed to have been manufactured by the lost wax method and they are so morphologically similar that they have been argued to have been made from the same model, if not from the same mould (Mathiassen 1958, p. 43, Vandkilde 1996, p. 232, Kaul 1998, pp. 73–74, Rønne 2008).

Three other scimitars have been found elsewhere in Southern Scandinavia: two in Scania at Knutstorp (Södra Åby) and Lilla Slågarp and one in Östergötland at Norre (Oldeberg 1974, no. 798, 2258, Jacobsen 1986). They display traits that connect them all closely together, not just a 'type' but also as individual artefacts, which implies that they are not simply related by looking similar in an analytical perspective, but by being intentionally similar. Bo Gräslund (1964, p. 285) and Bengt Jacobsen (1986, p. 283) observe that there are only minor differences between the scimitars from Rørby and Knutstorp produced by the post-cast polishing of the artefacts, indicating that they could have been made in the same workshop. Ebbe Lomborg (1959, p. 118) further suggests that all of the scimitars from Southern Scandinavia could derive from the same workshop due to their high degree of resemblance. Gräslund claims that the scimitars from Rørby and Knutstorp would derive from the same mould (Gräslund 1964, pp. 300–301), and John-Elof Forssander similarly connected the scimitars from Norre and Knutstorp to the same mould (Forssander 1935, p. 186). In addition, Jacobsen (1986, p. 287) argues that the dimensions and proportions of the incomplete Slågarp scimitar match those of Rørby and Knutstorp (Figure 5), and that the minor differences between the scimitars are the products of post-cast treatment and in one case a casting error (there is only one rivet on one side of the Slågarp scimitar, while there are two rivets on the other side). Jacobsen concludes that all four scimitars must derive not only from the same workshop, but also from the same mould.

Table 1. Similarities and differences among the Dystrup swords. Based on Rasmussen and Boas (2006).

	X1	X2	X3	X4	X5	X6	X7	X8
Length (cm)	45.6	43.7	44.8	45.4	44.8	45.0	43.7	46.6
Number of rivets	5	5	5	5	5	5	4	4
Raised middle rivet		+		+				
Fork shape	Concave	Concave	Concave	Convex	Concave	Concave	Convex	Straight
Hilt arc	Open	Elongated	Open	Open	Open	Open	Closed	Closed
Pommel shape	Circular	Circular	Circular	Oval	Circular	Circular	Oval	Oval
Ornament on handle	Same	Same	Same	Same	Same	Slightly different	None	Different
Ornament on blade	Same	Same	Same	Same	Same	Same	None	Different
Casting seam on handle	Straight	Straight	Straight	Straight	Bent	Bent	Straight	Straight
Handle profile	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Flat	Flat

Therkel Mathiassen, on the other hand, believes that the Rørby scimitars – despite their high degree of visual similarity – would require separate moulds, because the individual clay mould would have to be broken after the casting and therefore could not have been used as a 'mimetic machine' (Taussig 1993, p. 24) to cast another, identical scimitar (Mathiassen 1958, p. 43). Recent technical experiments with clay moulds support this observation, suggesting that clay moulds tend to break when releasing the cast (Wang and Ottaway 2004, p. 34). It should be noted, however, that Gräslund (1964, p. 301) argues that the Rørby scimitars are produced in a single bivalve mould, which had been reused to produce the second scimitar. Hence, the decoration would have been made by punching (Gräslund 1964, p. 286) rather than prepared on the model as implied by arguing for a single mould explanation of the scimitars. Preben Rønne (2008, see also Vandkilde 1996, p. 232), however, argues that the decoration was present in the mould stage, which means that the scimitars were differentiated physically and conceptually prior to the casting.

A number of differences do characterise the decoration on the Rørby scimitars (see Table 2), and the presence of what appears to be a ship on the blade of one of them can be emphasised as the defining difference between the two specimens (Vandkilde 1996, p. 232, Kaul 1998, ch. 5). But, at closer examination, there are several additional features that set the two specimens apart: one scimitar has two zigzag bands on the pommel, while the other has one; one scimitar has five bands of triangles on the handle, while the other has six bands of triangles, a band of lozenges and then another band of triangles; one scimitar has two bands of triangles at the beginning of the blade, while the other has a band of lozenges and two bands of triangles; the decoration towards the point of the blade on one scimitar is made up of a band of triangles, an imitation rivet, a band of lozenges, an imitation rivet and a band of triangles, while the other scimitar has a band of triangles, a band of lozenges, an imitation rivet, a band of lozenges, an imitation rivet, a band of lozenges and a band of triangles; the thickness and profile of the blades towards the point of the blade differ for the two scimitars; and lengths of the zigzag bands that run along the upper and lower edges of the blades differ (see also Mathiassen 1958, p. 42, Gräslund 1964, pp. 300–301).

These minute differences in details mean that the scimitars from Rørby cannot have derived from the same mould, but that they were cast in two different moulds that embedded different decorative patterns among other things. Backtracking the manufacture of the scimitars and their production sequence, the decorative patterns must therefore also have been made on two dissimilar models that generated different moulds: two wax models were cast in a single clay mould that produced identical (undecorated) wax models by using it twice. The clay mould would then have been an imprint of a clay

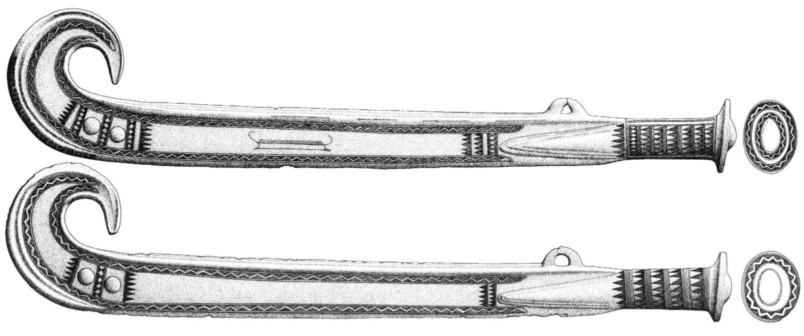

Figure 4. The scimitars from Rørby on eastern Zealand. After Aner and Kersten (1976).

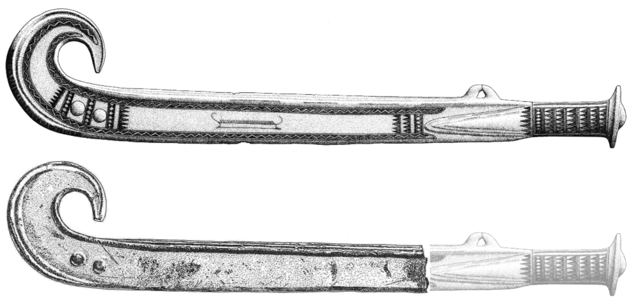

Figure 5. One of the Rørby scimitars and the incomplete scimitar from Slågarp with a tentative reconstruction of the missing part. After Aner and Kersten (1976) and Jacobsen (1986).

prototype of a scimitar, which may have had a wooden precursor. Or, in reverse order: the first step was to make a wooden or clay prototype (a positive) on the basis of the fantasy of a conglomerate artefact compiled of several separate artefact components; the second step was to make a clay mould (a negative) from the wooden prototype; the third step was to cast two identical wax models (two positives) from the clay mould; the fourth step was to discriminate the wax models by decorating them differently (an action that would technically turn the wax models into prototypes); the fifth step was to make two divergent clay moulds (two negatives) from the wax models; and the sixth step was to cast two different bronze scimitars (two positives) from the clay moulds.

This suggests that the disparity between the Rørby scimitars is deliberate and deeply motivated by the manufacturer, offering a number of moments for reflecting on the form and appearance of the artefact in production. While the differences in thickness and profile of the blades could hypothetically be attributed to post-casting treatment (annealing, cold-hammering and/or polishing), the differences in decoration would certainly have been made as a conscious choice and would have been developed in the prototyping stages. As such, the two Rørby scimitars would have been forged with an embedded conceptual difference but with a shared genealogy. While it may be difficult to assess whether all of the scimitars found in Southern Scandinavia were made on the same *physical* prototype, the distinct similarity of the scimitars at least implies that they share a *conceptual* prototype or source of inspiration as their common point of reference, thus binding them together as artefacts with a shared biography.

It has been argued that the inspiration for the scimitars derives from sheathed swords in Hittite Anatolia (Gräslund 1964, p. 296, 1967 see also Engedal 2002, Kristiansen and Larsson 2005, p. 290), and Thomas Larsson goes as far as describing the Rørby scimitars as ‘a deliberate attempt to copy a powerful foreign [i.e. Hittite] symbol’ (Larsson 2000, p. 63, see also Larsson 1997, pp. 72–79). It is worth noting that the rivets on their blades are non-functional, and thus do not serve the purpose of joining separate pieces of the artefact, but seem to be purely ornamental as they are all cast in one piece. Gräslund (1964, p. 293) argues that these rivets are imitations of rivets or other forms of decoration that were part of their supposed model, which could have been a curved scabbard or chape rather than a sword. The Scandinavian scimitars would thus have been imitations of a sheathed sword or, rather, the combination of a handle of a sword and a scabbard, which might suggest that the bronze imitations were not necessarily designed with an actual sword available in front of the bronze worker.

Table 2. Similarities and differences between the Rørby scimitars. Based on Mathiassen (1958), Gräslund (1964) and Aner and Kersten (1976).

	Rørby 1	**Rørby 2**
Length (cm)	60.7	60.7
Weight	1612 g	1526 g
Bands on pommel	1	2
Crest of pommel	Rounded	Pointed
Bands of triangles on handle	5	7
Bands of lozenges on handle	0	1
Bands of triangles at beginning of blade	2	2
Bands of lozenges at beginning of blade	0	1
Bands of triangles at imitation rivets	2	2
Bands of lozenges at imitation rivets	1	3
Ship on blade	No	Yes
Triangles on edge of curvature	0	1
Zigzags on band at upper side of blade	45	51
Zigzags on band at lower side of blade	54	62
Profile at curvature of blade	Straight	Narrow at bend
Profile at point of blade	Rectangular trapezoidal	Square trapezoidal
Signs of wear	Yes	No

Impossible copies

The Scandinavian scimitars as well as the Hajdúsámson-Apa swords can thus be seen as postulates at several levels. Both types of artefacts carry imitation rivets that are entirely non-functional, since the artefacts are cast in one piece (e.g. the swords from Bøgeskov, Guldbjerg and Dystrup, and the various scimitars). Such a non-functional feature is ordinarily termed a 'skeuomorph', which may be defined as an imitation of form and not function, typically in the translation from one medium to another (Sayce 1933, pp. 80–81, Vickers 1989, Knappett 2002, Harrison 2003, Frieman 2010). As illustrated above, such functional loss may also occur when translating artefacts within one medium, in this case bronze. Furthermore, the swords and scimitars are reproductions, replications or representations of artefacts or ideas that derive from remote regions, and in the case of the scimitars it appears that the translation of the 'original' resulted in a entirely new form; a fusion of the handle of a sword and a skeuomorphic scabbard.

But while the swords with imitation rivets are the results of a continuous chain of prototyping that ends up in artefacts with a formal reference to its models (i.e. Carpathian Hajdúsámson-Apa swords), the scimitars are built on a physical model. Or, at least we can say that the conceptual model (the idea behind the scimitar) is a synthesis of several artefacts (i.e. a sword handle and a scabbard), which means that the scimitar is a copy of a non-existing model or, in other words, a postulate. But if the scimitar is the copy of an object that can best be described as virtual, how do we understand an actual, subsequent imitation of the scimitar? How far removed from the original (yet virtual) object is the imitation of the copy? Does it retain any connection with the initial, virtual model at all?

A number of flint artefacts from period I of the Nordic Bronze Age take this question to an extreme by appearing to be explicit replications of bronze artefacts, including a flint scimitar from Favrskov on Funen (Aner and Kersten 1977, no. 1773 I). This imitation of bronze objects in flint does not appear to have constituted a widespread and common practice in the Early Bronze Age of Southern Scandinavia, but this does not mean that we can brush flint imitations aside as oddities that are not representative of a broader cultural expression. Even though certain material forms are unique or rare, they cannot be relegated to a status of expendable cultural anomalies; they may in fact be expressions of a more deep-seated play with material forms in the course of an process of exploration and discovery (for some recent interpretations of the relationship between bronze and flint, see, e.g. Varberg 2007, Fahlander 2008a, 2008b, Frieman 2010, 2012).

The flint scimitar from Favrskov (Figure 6) is thus a unique artefact (yet a questionable specimen of similar shape has been found in Southern Sweden; Oldeberg 1974, no. 1719a). The flint scimitar is commonly believed to be modelled on the Rørby scimitars (Forssander 1935, p. 178, Lomborg 1959, p. 146, 1960, p. 157, 1973, p. 63, Willroth 1985, p. 63, Vandkilde 1996, p. 232), displaying the same remarkable curvature of the blade as the bronze specimens, and it furthermore has a protrusion at the transition from handle to blade that appears to replicate the fastening loops found on the bronze scimitars. Obviously, there are logical differences between the flint sword and the bronze swords; the flint sword has a different surface character, a different colour, shimmer, volume, weight and balance, and it is not decorated. In addition, the bronze swords are 60.7 cm long, while the flint specimen only measures 31.3 cm. Despite these differences, we may conclude that the flint sword clearly refers to the same conceptual form as the bronze swords. It may furthermore be argued that the flint sword is not simply a derivation of the bronze swords, because even though it replicates the curvature of the blade and the fastening loop, it draws at the same time on the flint-working tradition by reproducing the handle of a dagger type VI (Lomborg 1960, p. 157, 1973 p. 63).

Another example of this dialogue between bronze and flint can be found in a composite flint sword from Åtte in south-western Jutland (Aner and Kersten 1986, no. 3924). At least 17 specimens are known from Denmark (Rønne 1988, p. 87) with the Åtte sword being the best known and most complete example (Figure 7). The sword is composed of six flint pieces that make up a handle, a point and four blade pieces, reaching a total length of 46 cm. The sword has been argued to be a 'copy' of or 'modelled' on bronze swords of either the Sögeler type or the Hajdúsámson-Apa type (Müller 1907, p. 82, Forssander 1935, p. 180, Lomborg 1960, p. 154, Rønne 1988, p. 92, Vandkilde 1996, pp. 225–226, Rasmussen and Boas 2006, p. 105).

This kind of idiomatic replication of material forms thus occurs across material categories and across functionalities, as neither the curved flint sword nor the composite flint swords would have accomplished exactly the same practical function as the bronze artefacts (for a discussion of different notions of 'function', see, e.g. Preston 2000, Vandkilde 2000, Risatti 2007, Crilly 2010). Moreover, the flint artefacts would have been made along the lines of existing lithic specialisation and would therefore have referred to a different mode of production than bronze work. The logics behind the artefacts would thus have been different. This suggest that we may move one step further and disentangle the notion of copying from function and mode of production altogether. If functionality is not necessarily inherited in the copied object, then functional categories also become irrelevant in the question of replication. The copy, rather, produces an image of its prototype, regardless of the formal classification of the original or the way it was manufactured. In other words, if there is no link between original and copy in terms of function, production or material properties, then we may instead argue that copying revolved around a more basic, superficial resemblances in form.

To take this line of thinking one step further, it will also be possible to approach the development of material forms without referring to function. To illustrate this, we may consider how it has been suggested that manufacturers of flint daggers in the Late Neolithic attempted to imitate bronze daggers of the Central European Únětice horizon (Varberg 2007, p. 68, see also Vandkilde 1998, p. 254). Much of the connection that has been made between these artefacts is based on their mutual classification as 'daggers'. In period I, however, we could turn the flint daggers on their heads, for example, the flint 'dagger' from a grave at Nordborg on Als in southern Denmark (Aner and Kersten 1978, no. 3159), where it was found in association with a bronze spearhead (Figure 8). We may here disentangle the archaeological classification of the artefacts as belonging to different functions, and instead observe how the contours of the two artefacts are relatively similar. Such a non-functional and purely form-based notion of imitation implies a closer relationship between flint 'daggers' and bronze 'spearheads' than between flint daggers and bronze daggers. The point is not whether one object was handheld and the other hafted, but how they appear as basic visual forms, where the resemblance would have been known to the manufacturer of 'daggers' and 'spearheads', respectively.

The issue here is thus not *exact* sameness in form (in the sense of a facsimile), but – just like we saw with the curved flint sword and the composite flint sword – rather a matter of a material dialogue that creates simultaneous resemblance and difference. This is not to argue that daggers and spearheads were seen as the same artefact category at the beginning of the Early Bronze Age, but simply that the inspiration between forms was not necessarily restricted by functional or formal classifications. Nor is this to say that the dialogue between flint and bronze was entirely abstract or arbitrary. The Favrskov flint scimitar does indeed resemble key traits of the bronze scimitars, and we can also point to the flint dagger from Serup (Lomborg 1960, p. 157, 1973, p. 63), which appears to be the imitation of a contemporary hilted metal dagger. The point is, rather, to argue that the dialogue across materials appears to have opened up for a creative play with the translation of formalised standards (following Benjamin 1973a, pp. 75–77). In other words, even though we may make the observation that several flint artefacts are very likely to be inspired by bronze artefacts, it does not necessarily mean that they have to be understood in the light of the individual source of inspiration or were valued in the same way (but see also Schwenzer 2004, Frieman 2010). Once the flint object was a reality, we may argue that it achieved an autonomous existence with an objecthood of its own.

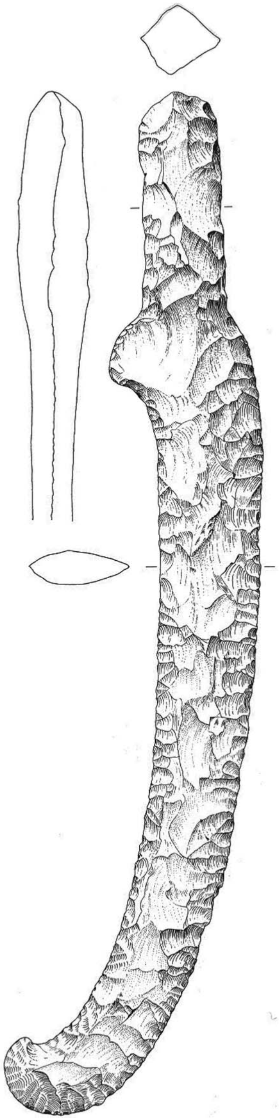

Figure 6. The flint scimitar found near Favrskov on Funen. After Aner and Kersten (1977).

The paradox of similarity

The lack of a functional imitation in the dialogue between flint and bronze allows us to return to the bronze scimitars that appear to imitate a sheathed sword, where the imitated artefact incorporated sword as well as scabbard in one piece. As explained previously, this constitutes a true skeuomorph, i.e. a copy that only refers to its model by superficial, visual resemblance and not by function. Skeuomorphic elements can also be found on the Nordic imitations of Hajdúsámson-Apa swords in the form of non-functional rivets. The Nordic swords are cast in one piece rather than several pieces (blade, rivets, pommel, hilt or two-part hilt), and their 'rivets' thus have no function as they do not serve the purpose of joining the separate parts of the artefact together. Locally produced swords thus

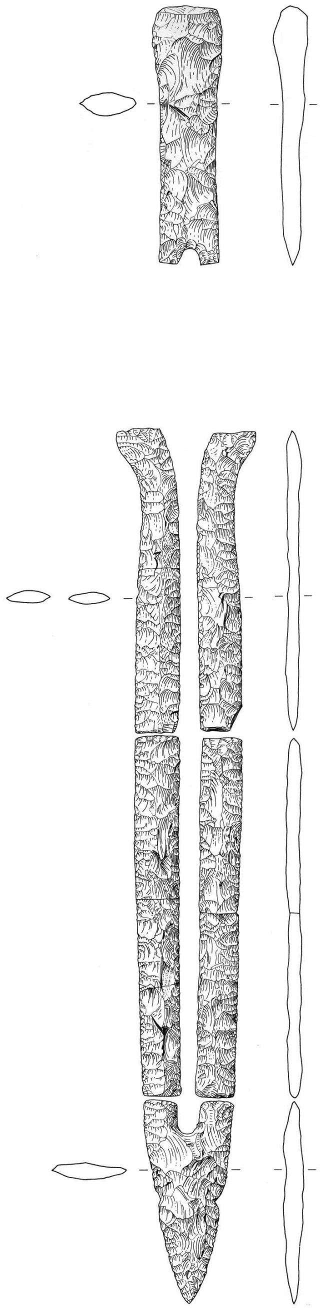

Figure 7. Composite flint sword from Åtte in southern Jutland. After Aner and Kersten (1986).

imitate details in foreign artefacts without replicating their function, just like we saw with the flint reproductions of bronze artefacts. For the sake of definition, we may here recall how Central European Hajdúsámson-Apa swords are also adorned by imitation rivets, but since they are made on the swords that also have functional rivets, I choose to define them technically as ornamental rivets and not as skeuomorphic rivets *per se*.

Once again, the skeuomorphic traits in Nordic swords invite a more critical scrutiny of the relationship between original and imitation, model and copy, prototyping and production. Fundamentally, the conventional notion of a model sees it as an ideal that is reproduced, but with deviation (Deleuze 1983, p. 48, 2004, p. 333), and a prototype is something that other things are based on, but may be rather different (Maniura and Shepherd 2006, Buchli 2010, Guggenheim 2010, Küchler 2010). The reason for these deviations and differences is, in the case of the model, that the copy cannot live up to the ideal, as argued by Plato (Deleuze 1983), and, in the case of the prototype, that the prototype is meant to be an instrument for evaluation, inspiration, testing or learning (e.g. Kirby 1995, Latka *et al.* 2001). So, in other words, copies will always be incomplete reproductions of the ideal model, and prototypes are always meant to lead to the production of difference. The question is, then, how these differences matter as material, social and philosophical facts, and furthermore, at an archaeological level, how similarity and difference can be appreciated in the past.

In archaeology, copies, imitations and similarities are often seen as expressions of competition, inspiration or skeuoumorphism (e.g. Renfrew 1986, Knappett 2002, Kristiansen and Larsson 2005, Vandkilde 2010, Frieman 2010), producing 'derived' or even second-rate artefacts (e.g. Müller 1909, pp. 12–13), utilising inferior materials (e.g. Varberg 2007, p. 87) or being restricted by material properties or technological capabilities (e.g. Willroth 1996, pp. 78–79). However, philosophical and cultural explorations in other fields of research have shown how the relationship between presumed 'originals' and their succeeding 'copies' is far more complex than often assumed in archaeology (e.g. Benjamin 1973b, 1978, 1979, Massumi 1987, Taussig 1993, Baudrillard 1994, Groom 2001, Deleuze 2004, Cox 2007, Boon 2010).

Plato, for example, distinguished ideal forms, or models, from copies (*Sophist* 236a–d; see also Deleuze 2004, p. 333). He argued that copies can be good copies or bad copies, which can be judged qualitatively on their fidelity to the ideal. Then, there are simulacra, which are a lower order of copies, lesser in nature than the ideal models and than poor copies. Copies, for Plato, thus assume a position between the ideal (the model) and the inferior (the simulacrum), and he distinguishes 'essence from appearance, the intelligible from the sensible, the Idea from the image, the original from the copy, the model from the simulacrum' (Deleuze 1983, p. 48).

This distinction forms the starting point for Gilles Deleuze's (1983, 2004) discussion of the simulacrum, exploring further in what way copies are copies. He argues that the copy is meant to represent the image of the model, but at some point the connection between the two can grow so close that their distinction is not a matter of the *degree* of differences between them, but instead of their

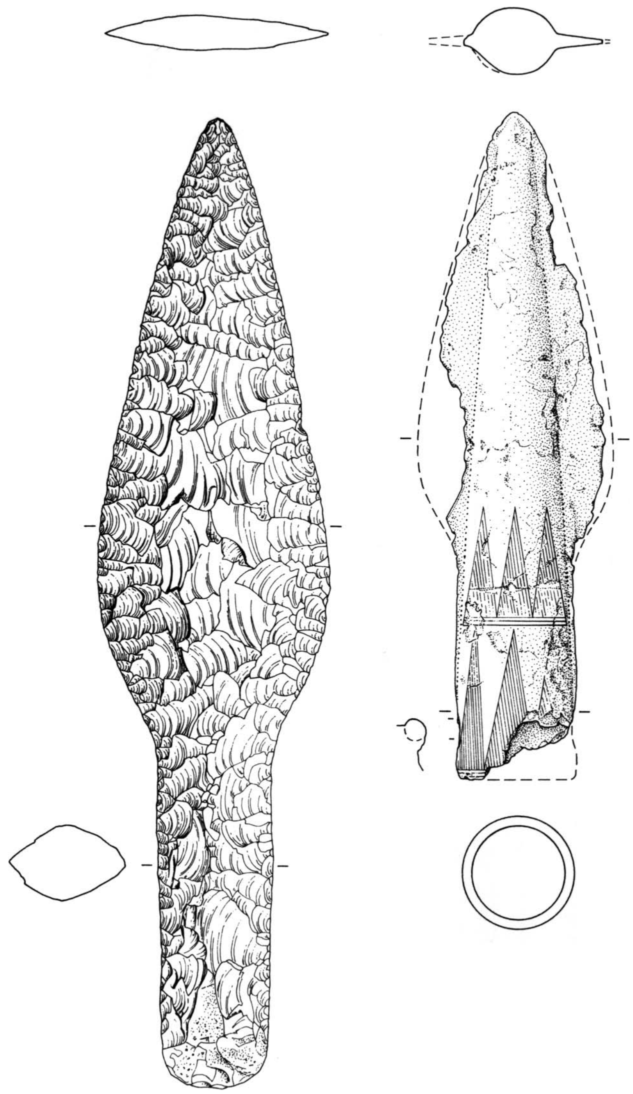

Figure 8. Flint dagger type VI and Bagterp type spearhead from Nordborg, Als, in southern Jutland. After Aner and Kersten (1978).

perceptual qualities or their effects (Deleuze 1983, p. 54). In turn, the simulacrum, according to Deleuze, plays on this resemblance, because it looks superficially similar to the model from the outside (Deleuze 2004, p. 366). However, at closer scrutiny a simulacrum does not *do* the same thing as its model and has different effects on its surroundings. The simulacrum does not imitate its model or try to become the model, but simply uses its resemblance with the model to achieve an autonomous existence (compare with Taussig 1993).

This is what allows Jean Baudrillard (1994) to state, famously, that simulacra are copies without originals, and he further argues that 'simulation is the situation created by any system of signs when it becomes sophisticated enough, autonomous enough, to abolish its own referent and to replace it with itself' (Baudrillard quoted in Smith 2003, p. 70). Baudrillard thus identifies a fault line between the model and the bad copy, which for him is identical with the simulacrum. Thereby, the simulacrum basically generates an order of existence that is without an essence of meaning (Baudrillard 1994, p. 82).

Brian Massumi, however, claims that Baudrillard creates a pessimistic image of simulation that leaves the understanding of resemblance as 'floating images that no longer bear a relation to any reality whatsoever' (Massumi 1987, p. 90), where signs no longer represent or refer to an external 'real' model. Massumi further stipulates that Baudrillard's reading of simulation means that when signs do not refer to something else, then they become interchangeable and their meaning implode; they essentially become indeterminate. Massumi argues that the copy is defined by having internal, essential relations of resemblance to a model. The simulacrum, on the other hand, only bears superficial, external resemblance to a putative model (Massumi 1987, p. 91);

yet unlike Baudrillard, Massumi does not see this as a bad quality, because it contains the promise of and a potential for innovation and new identities (echoing Deleuze 1983, p. 53). This implies that the simulacrum seeks to achieve or stir a different range of effects, and as such it does not merely copy the model, but also creates something new. Thereby, simulacra have the ability to be emancipating phenomena that may offer an alternative to the tyranny of tradition, formality and normativity. Simulacra can thus become new originals and thereby destabilise the ontological relationship between the ideal and the copy, and the real and the virtual.

In this light, we may argue that the swords of the Hajdúsámson-Apa type that were manufactured in Southern Scandinavia have no *origin* and no *originals*. Instead, they only have a *beginning*, and that beginning is characterised by repetition (see also Nielsen 1990, p. 15) by being inserted into a seriality of manufacturing events based on the principle of prototyping (Buchli 2010, Küchler 2010). In the course of this seriality, one artefact continuously leads to the next, but does not pass down a biographical trajectory in the form of a formal genealogy. Instead, the relationship between objects in a serial relation is entirely horizontal. In fact, even the alleged 'originals' from the Carpathian area are characterised by a degree of dissimilarity (Rasmussen and Boas 2006, p. 99, Meller 2010, p. 51) making it difficult to appreciate them as anything but the expressions of a dogma of seriality and materialisations of continuous differentiation (Figure 9). The only distinctly similar artefacts within this complex of swords are in fact the swords in the Dystrup hoard, while all other Hajdúsámson-Apa swords and their local derivations display so many differences in proportions, decorative patterns and construction that they are better characterised by a heterogeneity resulting from a complex process of prototyping in which the ontological positions of originals and copies collapse. Other swords adhering to the Hajdúsámson-Apa idiom and related expressions should of course be embraced in this interpretation, e.g. the swords from Blindheim (Norway), Bragby (Sweden), Nebra (Germany), Rosenfelde (Germany) and Vreta (Sweden) (Ekholm 1916, Kersten 1958, no. 607, Engedal 2005, Meller 2010, Schwab *et al.* 2010). The extreme version of this heterogeneity is obviously the composite flint version from Åtte, which even breaks with the technological uniformity of sword production, yet at the same time clearly refers to the same design idiom.

Furthermore, it is also legitimate to see the bronze scimitars as the result of a process of prototyping in that they are brought about by a complex manufacturing process that is centred on a dialogue between wax models, negatives in several versions of moulds and potentially a wooden prototype. However, they may even better be characterised as true simulacra. If they were produced in Southern Scandinavia, as is commonly believed, then they are not imitations of imported objects or copies of an original artefact, because no such artefact existed. If anything, they are copies of a non-existing object and an imagination of a hypothetical object, or in other words a postulate. At the same time, the scimitars clearly refer to each other, not simply by being reducible to an archaeological 'type', but by being so similar that they must have been manufactured in a shared context. Within this similarity, we may also identify an array of differences, as spelled out previously, where minute details reveal that the scimitars were not simply the results of a mechanical reproduction by the reuse of a mould producing identical artefacts.

So, being an ultimate simulacrum, the scimitar does not carry a referential meaning content, but is an independent and sovereign artefact, producing its own meaning and presence (for an oppositing view, see, e.g. Larsson 1997, 2000, Engedal 2002, Kristiansen and Larsson 2005, Kristiansen 2010). We may see the flint scimitar from Favrskov as the climax of this material fantasy and as an emancipation from the dogma and standardisation imposed by tradition and perceived material constraints. As a cultural statement, the flint scimitar is, rather, a virtual object in that it is entirely removed from any actual, functional or technological predecessor.

Conclusion

The examination of the various objects from the Early Bronze Age of Southern Scandinavia highlights certain problems in the existing approaches to what is perceived as originals and copies and illustrates how the ontological subtleties of similarities and differences are overlooked in the archaeological pursuit of meaning and in the construction of typological systems. In this perspective, it is therefore questionable if Early Bronze Age metal manufacturers based their design solely on the 'imitation' of imported models as a result of aspirations to copy so-called high status or elite material culture or to reproduce exotic styles. Bronze artefacts were not necessarily only carriers of meaningful symbols and a materialisation of interregional contacts (e.g. Kristiansen and Larsson 2005, Vandkilde 2010). Bronze also became emancipated from fixed and dogmatic meanings by being a malleable plastic medium that offered the possibility for deconstructing and reconstructing material idioms in innovative ways, even stirring a critical attitude to the flint-working tradition.

We may therefore consider the possibility that Early Bronze Age craftsmen worked along the lines of a continuous process of prototyping, which implies that there are no originals and no copies, but only 'original copies'. In short, this means that a prototype is understood here as the first working version of a given material form and a beginning for development and change. Prototyping is thus the process of exploring form by looking at an existing artefact by using that artefact as an 'exemplar' (OED)

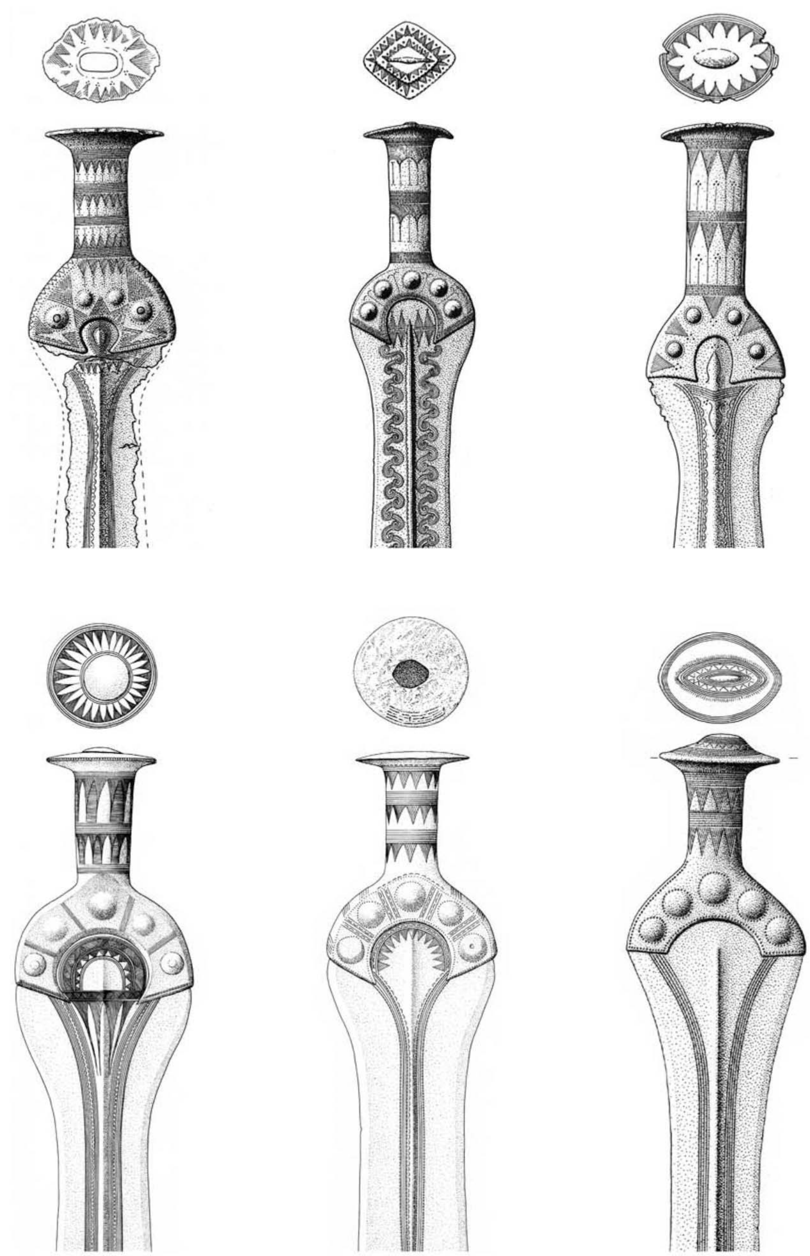

Figure 9. Swords of the Hajdúsámson-Apa type from different places in Europe. After Meller (2010, p. 51, Fig. 20. Used with kind permission from the State Office for Heritage Management and Archaeology Saxony-Anhalt; design by Nora Seeländer).

that is remodelled and reinvented. In prototyping, the individual artefact thus continuously shifts position, significance and status. Accordingly, the model is not superior to the copy, nor is the model a 'pre-copy' of an original (Coaldrake 2007, pp. 199–200), but the copy and the model are different modes of articulating alterity as they will always be different from 'originals' and 'products'.

In this way, the Scandinavian scimitars are not 'misunderstood' Hittite sheathed swords and they do not 'imitate' a foreign ideal, nor are flint replicas inferior to bronze models. These alleged derivatives should instead be appreciated as reformulations of material idioms, just like laminate flooring uses photographic appliqué to achieve the appearance of wood, or like sculpture translates the texture of fabric, skin and hair into marble or gypsum. This does not mean that the notion of models and copies has to be abandoned, and the production of highly resembling artefacts could very well in certain cases be part of a copying strategy; yet I suggest that bronze workers in period I of the Nordic Bronze Age were either well aware of the impossibility of creating 'ideal' copies in a Platonic sense or that the referentiality to embedded cultural meanings and values became disentangled from the artefacts in their local contexts. The important consequence of these observations is not simply that resemblance between artefacts is caused by imitation (as phrased axiomatically by Tarde 1903, p. 14), but rather that the repetition of forms produces variation (paraphrasing Tarde 1903, p. 7).

This repetition *cum* variation of material forms, we may expand, were exposed to and stirred heterogeneous attitudes to the conceptualisation of objecthood, which is also reflected in the flint-working tradition. As such, the production of flint artefacts should not be seen as naive and impossible attempts to create bronze artefacts in stone, but rather as a way of distancing oneself from the dogma of bronze work as well as the form-based traditionalism of flint technologies. This did not so much concern the consumer of artefacts, but more so the very notion of artefacts, their manufacturing processes and mechanical properties.

Conceptualisations of objecthood thus became mobile, not pinned down to one shared ontology or circumscribed by one unified cultural attitude, but were in a constant dialogue with technological exploration and inter-artefactual dynamics. This dynamism resembles the multiple and changing ontologies that have been suggested in recent ethnographies mentioned earlier, but I do not wish to argue that the material I have discussed in this article is evidence of multiple or dynamic ontologies in the beginning of the Bronze Age. Rather, I believe that the material shows clearly that seriality, similarity and simulacra were part of a creative reflexivity that stirred new epistemologies; new ways of knowing, extending beyond the knowledge of properties of materials, artefacts and processes of production by raising more fundamental questions as to what is an object.

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Ungulates exploitation for subsistence and raw material, during the Maglemose culture in Denmark: the example of Mullerup site (Sarauw's Island) in Sjælland

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This article presents results from recent re-analysis of the faunal remains from Mullerup (Zealand), the first excavated site attributed to the Maglemose Culture (9600–6550 cal BC) in Denmark. All faunal remains and fragments related to the bone tool industry (pieces and waste) were studied together, in order to reconstruct the total exploitation of animal resources for dietary as well as 'technical' (non-dietary) purposes by Maglemosian groups. The detailed quantification of species, individuals, skeletal elements, as well as marks on the bone surfaces provides relevant data to reconstruct the relative contributions of the five main hunted species (ungulates) to subsistence and technical activities, such as bone tool production. The ungulates were exploited in different ways, depending on species, transport strategies, and raw material needs. This article particularly focuses on the acquisition of raw material for making bone tools and its influence on the whole carcass treatment. The reconstruction of the total exploitation of animal resources thus addresses important issues in Maglemose socioeconomic organization.

Keywords: Maglemose culture; early Mesolithic; Denmark; archaeozoology; animal exploitation; Carcass processing; bone tool industry

1. Introduction

The Maglemose culture was named after the excavation of Mullerup,[1] located in the 'Magle Mose' peat bog in Zealand (Denmark), in 1900 by G.F.L. Sarauw (Sarauw *et al*. 1903). Mullerup was, at that time, attributed to a period preceding the *køkkenmøddinger* or shell midden period (Sarauw 1906) that was first attributed to the Neolithic and then to the Late Mesolithic Ertebølle culture (Brinch Petersen and Meiklejohn 2007). The Maglemose culture was then more precisely defined, thanks to important excavations in Denmark (Figure 1): Sværdborg I (1918–1919) (Friis Johansen *et al*. 1919), Holmegård I (1923–1924) (Broholm *et al*. 1924), Holmegård IV, V, and VI (Becker 1945), Sværdborg I (1943) and Lundby II (Bille Henriksen *et al*. 1976, 1980), Ulkestrup I and II (Andersen 1951, Andersen *et al.* 1982) and particularly in Åmosen bog (Mathiassen *et al*. 1943); and on the basis of synthetic work concerning the lithic industries (Becker 1945, 1953, Brinch Petersen 1966, 1973).

The Maglemose culture is now considered the first Mesolithic culture in Denmark and southern Scandinavia, lasting from 9600 cal BC[2] to 6500 cal BC (Brinch Petersen 1973, Møller Hansen *et al*. 2004) and preceding the Kongemose and Ertebølle cultures. The Maglemose sites located in Zealand (Figure 1) mainly dated to the Boreal period, yielded very well-preserved faunal remains and an abundant and diversified bone tool industry. This bone tool industry appears to be homogeneous, in terms of typological composition, as well as in terms of raw materials used (species and anatomical parts) and manufacture techniques (David 1999, 2003a, 2003b, 2004). Bone points are predominant (straight and barbed points), alongside heavy tools (hammer-axes, adzes, handles/sheaths, blade axes) from cervid antlers, mainly elk and red deer. Such an industry is now considered one of the main components of the Maglemose culture (David 1999, 2003a, 2003b, 2004). Thus, the acquisition of raw materials for its manufacture was very likely a key issue for Maglemose hunter-gatherers in animal exploitation.

Animal resource exploitation for subsistence and raw materials involves choices in the way animals were selected and how their carcasses were processed. Which species were mainly hunted? For what resources or raw materials were they exploited? Were they all exploited in the same way?

The main faunal assemblages from Maglemose sites have rarely been studied from this specific perspective and in detail. Most are short studies, part of the (sometimes old) monograph publications (e.g., Sarauw *et al*. 1903, pp. 194–199). Maglemose faunal assemblages also provided material for specific studies, such as fauna history reconstruction, notably after the deglaciation of Denmark

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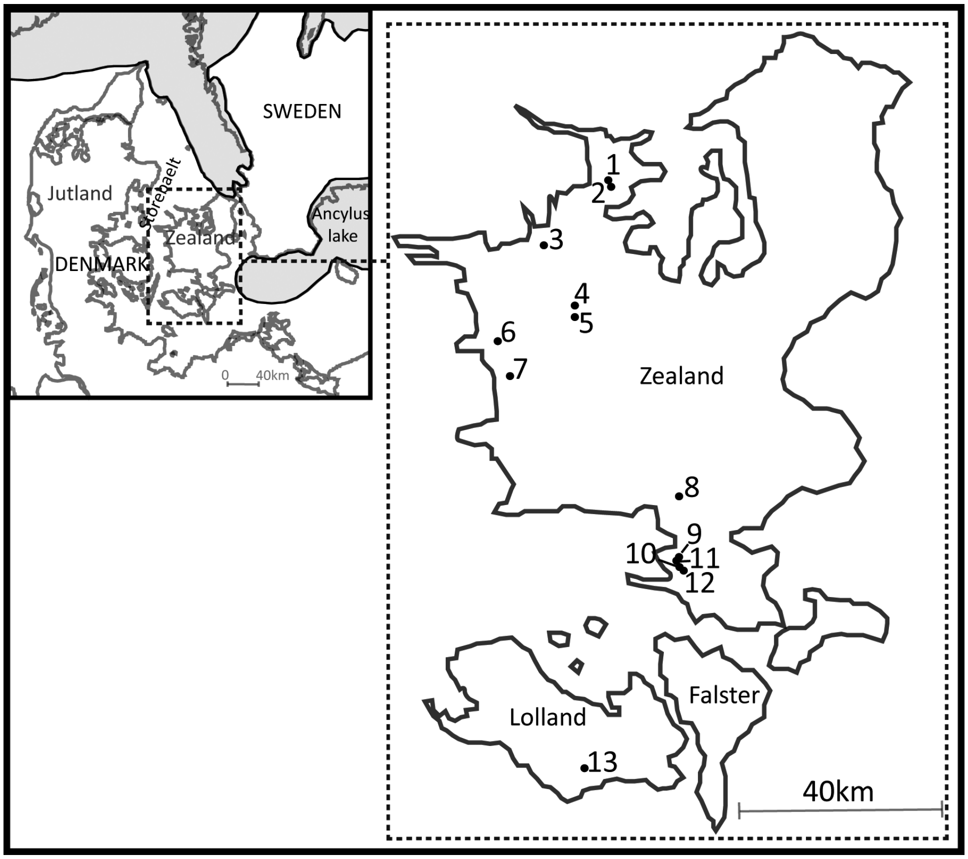

Figure 1. Distribution of the main Maglemosian sites from Zealand (Denmark) with faunal remains: 1, Vig; 2, Prejlerup; 3, Favrbo; 4, Ulkestrup I and II; 5, Verup; 6, Vinde Helsinge; 7, Mullerup; 8, Holmegård I, IV, and V; 9, Lundby I and II; 10, Sværdborg I and II; 11, Lundby Mose; 12, Barmose I; 13, Skottemarke.

(e.g., among many, Degerbøl and Fredskild 1970, Aaris-Sørensen 1992, 1999, 2009) or seasonality of occupations (e.g., Rowley-Conwy 1993, Carter 2001, 2009, Carter and Magnell 2007). We can, however, mention pioneering work on cut-mark analysis and exploitation reconstruction using Mesolithic bone assemblages, including Maglemose sites (Noe-Nygaard 1977, 1987, 1995) and the first synthesis concerning Maglemose subsistence economy (Blankholm 1996) that raised the question of the overlapping between exploitation for dietary purposes and exploitation for raw material.

This article presents the main results from the re-analysis of the faunal assemblage from Mullerup (Sarauw *et al*. 1903), which is the reference site for the Maglemose culture. This analysis was part of a doctoral thesis (Leduc 2010b) that specifically focused on the question of 'total' animal exploitation (see Fontana *et al*. 2009) and the management of animal resources by Maglemosian groups, i.e., the exploitation of all the animal resources and its consequences on the way different species were hunted and processed.

Therefore, one of the purposes of the study was to decipher how carcass exploitation and raw material selection for bone tool manufacturing were articulated at Mullerup. Were they priorities in resource exploitation? Were these priorities the same for each species?

This article will focus only on the exploitation of the five ungulates which dominate the Mullerup faunal assemblage (89% of the number of identified specimens NISP): wild boar (*Sus scrofa*), elk (*Alces alces),* red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), and aurochs (*Bos primigenius*). These examples will emphasize the fact that animal resources were exploited in different ways, notably based on raw material needs.

2. The Mullerup site

Mullerup is located in the north-western part of Zealand (Denmark), a few kilometers from the western coast (Figure 1). At the time of occupation, Mullerup was an inland site located less than 50 km from the outlet of the Ancylus Lake (Sarauw *et al*. 1903).

The site is dated to the Boreal period according to pollen analysis (Jessen 1935) and was later attributed to an early phase (phase 2) of the Maglemose culture based on the lithic industry (Brinch Petersen 1973, 1993).

Several radiocarbon dates (Tauber 1972, 1973) situate the occupations, after calibration, between 8225 and 6828 cal BC (calibration with Calib Rev. 6.0.1© (Stuiver and Reimer 1993, Reimer *et al*. 2009) Leduc 2010b, p. 121). A recent Accelerator Mass Spectrometry radiocarbon date result on a human femur (Fischer *et al*. 2007) provides a similar age: 7510–7187 cal BC (AAR-8554/NM1 A18269: 8310 ± 55 BP).

The archaeological material was all recovered from the same peat layer. Although the duration and number of occupations at Mullerup are not known, the lithic assemblage (Brinch Petersen 1973) and bone tool industry (David 1999, 2004) are homogenous and typical of the early Maglemose period (lithic phase 2). This enabled study of the excavated bone material as a single unit, resulting from occupation(s) by the same group(s) of people. Despite the early date of the excavation (1900), fairly good recovery of faunal remains was done, as many bone splinters are present. However, analysis of the size distribution of bone fragments shows that bone fragments less than 2 cm are under-represented (Leduc 2010b, p. 148), which is likely due to the lack of sieving.

Based on the abundance and diversity of archaeological material, the site was interpreted as a settlement site (Sarauw *et al*. 1903) involving a wide range of activities such as lithic production, bone tool manufacture, and subsistence activities. The spatial distribution of lithic waste (Grøn 1995, Blankholm 1996) led to the hypothesis of a small inhabitation for a small group of people on an islet in the middle of a former lake, with a large refuse area in the lake (Figure 2, Leduc 2010b, p. 127–129), as described at Ulkestrup I and II (Andersen 1951, Andersen *et al*. 1982, Grøn 1995).

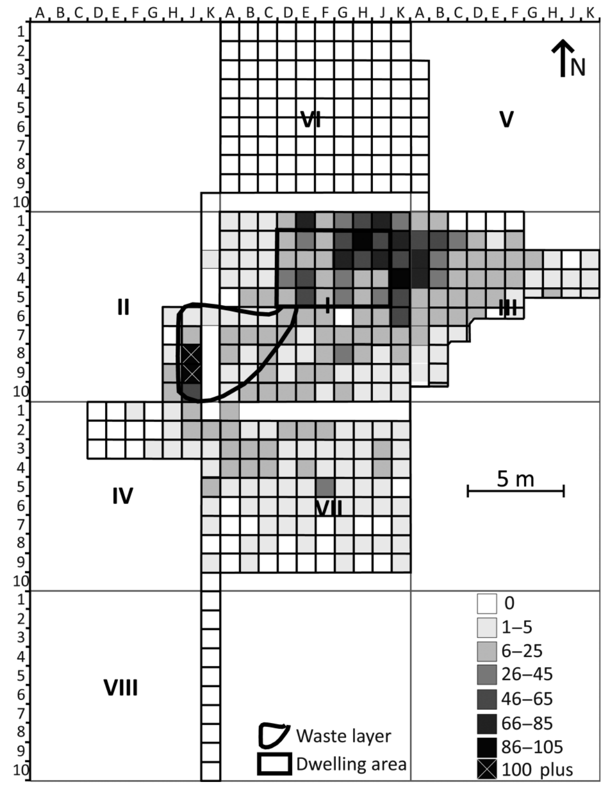

Figure 2. Map of the Sarauw's excavation at Mullerup (Sarauw *et al*. 1903, fig. 2, p. 156 and fig. 8, p. 188), showing the repartition of faunal remains, per density (number of specimen/m^2; Leduc 2010b). One square = 1 m^2. The restitution of the dwelling area and the waste layer position is after Grøn (1995, p. 77) according to the lithic waste distribution.

3. Materials and methods

The former study of faunal remains, undertaken by H. Winge (Zoological Museum, Copenhagen), led to the determination of around 30 species (13 mammal species, 15 bird species, and one fish species). No new species were identified during the re-analysis. Winge's work pointed to a summer occupation, based on the presence of very young individuals, unshed roe deer antlers, and migratory bird species nesting in Denmark during the warm months, such as the common crane (*Grus grus*). Later, Carter (2001) X-rayed the dental remains from young red deer and roe deer from Mullerup in order to very precisely describe the tooth development stages, also concluding a summer, possibly spring, occupation. The re-analysis by the author also led to an occupation period during the warmer months of the year, from April to October (Leduc 2010a, 2010b, pp. 244–245).

The Mullerup site yielded 4515 bone and antler fragments, waste, and pieces from tool manufacture included. Mammals are widely predominant (Table 1). They account for 92.4% of the NISP and 99.8% of the number of unidentified specimens (NUSP). The five ungulates are the main hunted species (Table 1; Figure 3): wild boar, elk, red deer, roe deer and aurochs. They account for more than 89% of the total NISP and 96.9% of the mammal NISP while other mammals (mainly fur-bearing mammals) are represented by a small number of fragments and individuals. There are only a few bird bones (NISP = 128), but they belong to 15 species, mainly aquatic birds. Finally, fish bones are all from one species, pike (*Esox lucius*), mostly large individuals, due to the lack of sieving during the excavation (Leduc 2010b, pp. 249–251).

The data presented here are based on the study of the entire faunal assemblage. This means that not only were remains commonly interpreted as resulting from butchering activities taken into account but also all remains attributed to the bone industry, i.e., manufactured pieces (tools, weapons, ornaments) and waste (fragments showing marks from *debitage* and/or related to the manufacture of pieces).

This new analysis is based on the detailed quantification of bone material, using several criteria: NSP, NISP and NUSP; a derived 'bone industry NISP', i.e., the NISP

Table 1. Taxinomic composition of the Mullerup assemblage.

Taxa	NSP	MNI	NSP (%)	MNI (%)	NSP Bone industry	NSP Bone industry (%)
Sus scrofa scrofa – Wild Boar	938	21	29.9	18.6	17	6.7
Alces alces – Elk (included unshed antlers = 71)	624	7	19.9	6.2	87	34.5
Cervus elaphus – Red Deer (shed antlers exluded)	477	4	15.2	3.5	71	28.2
C. capreolus – Roe Deer (included unshed antlers = 16)	445	13	14.2	11.5	56	22.2
Bos primigenius – Aurochs	326	5	10.4	4.4	13	5.2
Martes martes – Pine Marten	23	6	0.7	5.3	–	–
Castor fiber – Castor	21	2	0.7	1.8	–	–
Meles meles – Badger	12	2	0.4	1.8	–	–
Canis familiaris – Dog	11	2	0.4	1.8	2	0.8
Ursus arctos – Brown Bear	10	3	0.3	2.7	1	0.4
Vulpes vulpes – Red Fox	8	2	0.3	1.8	–	–
Felis silvestris – Wild Cat	4	1	0.1	0.9	–	–
Sciurus vulgaris – Squirrel	1	1	0.03	0.9	–	–
Total identified mammals	2900	69	92.4	61	247	98
Cygnus olor – Mute Swan	46	4	1.5	3.5	3	1.2
Anas platyrhynchos – Mallard	22	7	0.7	6.2	–	–
Anas acuta – Northern Pintail	15	4	0.5	3.5	–	–
Podiceps cristatus – Great Crested Grebe	14	2	0.4	1.8	1	0.4
Phalacrocorax carbo – Great Cormorant	9	1	0.3	0.9	–	–
Haliaeetus albicilla – White-tailed Eagle	7	2	0.2	1.8	1	0.4
Botaurus stellaris – Eurasian Bittern	3	1	0.1	0.9	–	–
Clangula hyemalis – Long-tailed Duck	2	2	0.1	1.8	–	–
Gavia arctica – Black-throated Loon	2	1	0.1	0.9	–	–
Grus grus – Common Crane	2	1	0.1	0.9	–	–
Milvus milvus – Red Kite	2	1	0.1	0.9	–	–
Ardea cinerea – Grey Heron	1	1	0.03	0.9	–	–
Larus ridibundus – Black-headed Gull	1	1	0.03	0.9	–	–
Dryocopus martius – Black Woodpecker	1	1	0.03	0.9	–	–
Garrulus glandarius – Eurasian Jay	1	1	0.03	0.9	–	–
Total identified birds	128	30	4.1	26.5	5	2
Esox lucius – Pike	109	13	3.5	11.5	–	–
Emys orbicularis – European Pond Turtle	1	1	0.03	0.9	–	–
Total identified	3138	113	100	100	252	100
Large Cervids (*Alces*/*Cervus*)	76	–	6	–	36	16.2
Antlers from Large Cervids	21	–	2	–	9	4.1
Large ruminants (*Alces*/*Cervus*/*Bos*)	583	–	45	–	101	45.5
Mammals of Wild Boar/Red Deer's size	143	–	11.1	–	–	–
Large ungulates	327	–	25.4	–	28	12.6
Middle size mammals	54	–	4.2	–	6	2.7
Small mammals	5	–	0.4	–	1	0.5
Mammals	76	–	6	–	40	18
Total unidentified mammals	1285	–	99.8	–	221	99.5
Unidentified birds	3	–	0.2	–	1	0.5
Total unidentified	1288	–	100	–	222	100
Total	4426	113	98	–	474	84.6
Red deer shed antlers	89	–	2	–	86	15.4
Total	4515	113	100	–	560	100

Notes: NSP, number of specimen; MNI, = minimum number of individuals.

related to the bone industry; minimum number of individuals (MNI), according to right and left skeletal part fragments, after Poplin (1976a, 1976b); minimum number of elements (MNE, Lyman 2008). The relationship between the frequency of anatomical parts identified (MNE) and the MNI leads to reconstruction of the distribution of skeletal parts, presented in percentages (%PO) – the ratio of 'found/expected' skeletal elements (Grigson and Mellars 1987, Bridault 1993) – which shows over- or under-representation of body parts relative to taphonomy, or carcass transport and/or processing.

Quantification of the material was thus conducted at different levels: species, individuals, anatomical parts, fragments and even at the level of cut-marks or

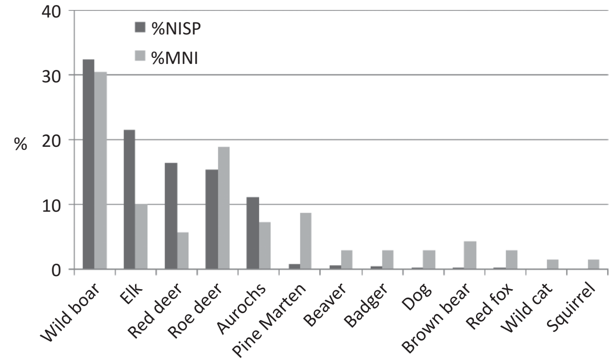

Figure 3. Species composition of the Mullerup mammal bone assemblage, worked pieces included (Total NISP = 2900, shed antlers excluded).

manufacturing marks. The status of each species could thus be analyzed and described: establishing their frequency in the assemblage (number of fragments and number of individuals), evaluating the integrity of carcasses (skeletal part distribution), and reconstructing their exploitation through the reconstruction of the frequency of identified activities (analysis of butchery marks, bone breakage for marrow extraction, use of specific skeletal elements for bone tool manufacture, etc.). The latter issue requires identification of exploitation activities, from the interpretation of cut-marks, breakage marks and manufacture marks observed on bones.

Juvenile skeletal elements, mostly from very young animals, less than 6 months, are quite numerous as they account for 12.7% of the whole assemblage (NISP). These are mostly bone fragments belonging to the ungulate species in various proportions. Bone fragments from young individuals are more fragmented as a result of taphonomic processes because of their higher fragility than those from adults. This has consequences on the potential to identify the species (17.1% of the unidentified mammal bones and 32.1% of the unidentified fragments assigned to large ruminants are from young individuals) and sometimes the anatomical part itself. Moreover, considering each taxa separately, juvenile bones show fewer cut-marks than bones from adults. This can be due to taphonomic biases, resulting from biases observed in body part representation. In addition, most of the proximal and distal ends of juvenile long bones, which often have disarticulation cut-marks, are missing. This may also be due to specific transport strategies or butchering patterns for young individuals, perhaps less disarticulated than adults. Furthermore, young animals were never used as a source of raw material for bone tool manufacture (one exception being a metatarsal bone from a young elk with grooving marks), probably because very young bones, not completely grown, are more fragile and thus unsuitable for *debitage* or use. For these reasons, if both adult and juvenile remains were used to compare the carcass exploitation of each species, they were considered separately for each taxon.

4. Results

4.1. Bone tool industry

4.1.1. Species composition of the bone industry

About 12.4% of the whole faunal assemblage (identified or not) is related to the bone industry (Figure 4). These are complete or broken pieces (*n* = 240), including straight or barbed projectile points, fish hooks, various domestic tools made from bone (awls, points, hammers) or antler (axes, hammer-axes, adzes, punches) and personal ornaments made from teeth (David 1999, 2003a, 2003b, 2004), as well as waste (*n* = 306) and unidentified fragments (pieces or waste: *n* = 14) (Figure 5). This percentage must be considered a minimum as the manufacturing of an object does not necessarily leave traces on all the waste produced from one raw material.

Indeed, the important amount of waste (54.6%) suggests that production of bone tools took place on the site (David 1999, 2004). Mammal bones (antlers excluded) provided the majority of the raw material (69.5%). Since manufacturing processes often deeply modify the morphology of the bone matrix, specifically in projectile point manufacture (David 1999, p. 278, 2004 p. 264), many of the items cannot be attributed to one species or another (Figure 4; Table 2). However, for the most part, these unidentified pieces can be assigned to large mammals such as elk, red deer and aurochs (64.6%).

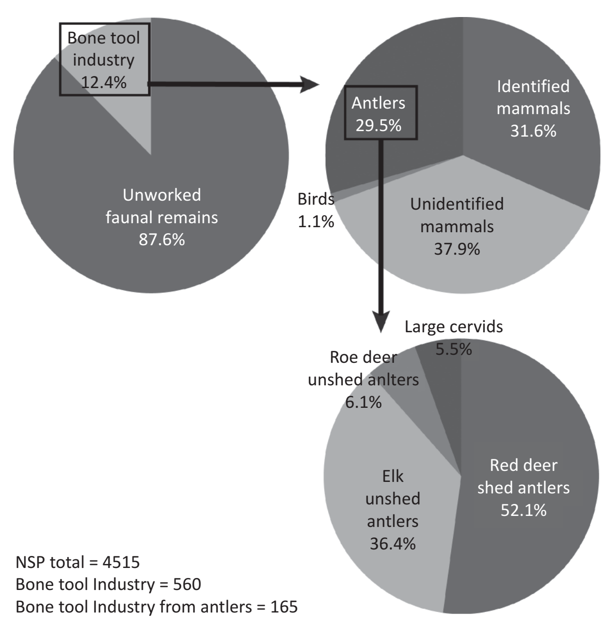

Figure 4. Bone tool industry frequency among the whole faunal assemblage and composition.

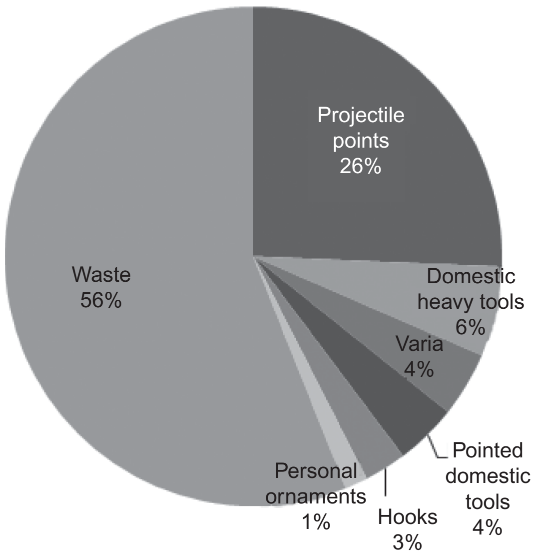

Figure 5. Composition of the bone tool industry, according to large typological categories (see David 1999, 2004, Leduc 2010b): domestic heavy tools refer to adzes, axes, and hammers; pointed domestic tools refer to awls and small points which are not interpreted as projectile points.

4.1.2. Antler exploitation

A third of the raw material used for the manufacture of tools is from cervid antlers (Figure 4; Table 2). Antler exploitation differs from one species to another. Red deer antlers are predominant (52.1%). Seven antler bases are present, all from shed antlers and the 89 fragments of red deer antler identified in the assemblage (96.6% are pieces or waste from the bone industry) could theoretically (Bridault *et al*. 2009) come from these seven antlers, from adult red deer, considering the size and the detailed origin (stump, tine, beam, crown, terminal tine, etc.) of each fragment (Figure 6). As red deer heads and unshed antlers are missing (see below), it can be assessed that only shed antlers were exploited on the spot, for making tools. These antlers were quite intensively exploited: mostly axes, adzes, and punches were made from the different antler parts, and the presence of abundant waste also suggests that manufacturing activities took place at the site.

In contrast, elk and roe deer antler fragments are very likely all from unshed antlers, i.e., removed from animals hunted and at least partially exploited on site. For elk antlers, 71 fragments are present and 84.5% of these are

Table 2. Taxonomic composition of the bone tool industry from Mullerup.

Taxa	Piece	Waste	Unidentified	Total	%
Red deer	9	62	–	71	12.7
Roe deer	16	29	1	46	8.2
Elk	11	16	–	27	4.8
Wild boar	10	6	1	17	3
Aurochs	9	4	–	13	2.3
Dog	2	–	–	2	0.4
Bear	–	1	–	1	0.2
Castor	–	–	–	–	–
Total (identified mammals)	57	118	2	177	31.6
Large cervids	27	9	–	36	6.4
Large ruminants	60	34	7	101	18
Large ungulates	16	10	2	28	5
Mammal (middle size)	6	–	–	6	1.1
Mammal (small size)	1	–	–	1	0.2
Mammal (unidentified)	34	6	–	40	7.1
Total (unidentified mammals)	144	59	9	212	37.9
Red deer antlers (shed)	24	61	1	86	15.4
Elk antlers (unshed)	5	55	–	60	10.7
Roe deer antlers (unshed)	1	9	–	10	1.8
Large cervids antlers	8	1	–	9	1.6
Total (antlers)	38	126	1	165	29.5
Mute swan	–	1	2	3	0.5
White-tailed eagle	–	1	–	1	0.2
Great crested grebe	1	–	–	1	0.2
Birds (unidentified)	1	–	–	1	0.2
Total (birds)	2	2	2	6	1.1
Total	241	305	14	560	100

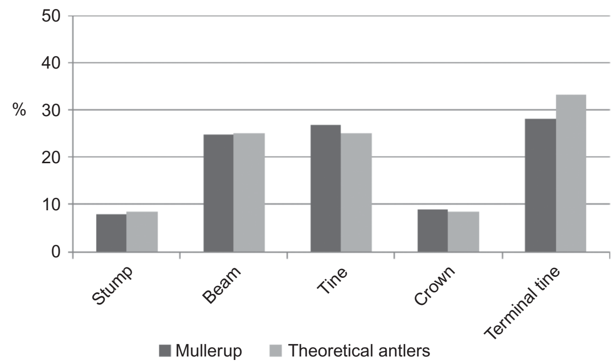

Figure 6. Repartition of the red deer antlers fragments from Mullerup, in comparison to the number of similar fragments from seven theoretical antlers (according to Billamboz, 1979, p. 96, i.e., one antler with two beams, three main tines, one crown with four terminal tines).

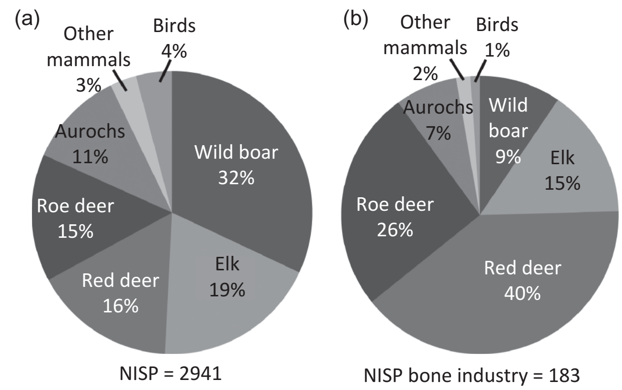

Figure 7. Taxinomic composition of the Mullerup bone assemblage (a, excluding European pond tortoise – *Emys orbicularis*, *n* = 1) and of the Mullerup bone industry (b).

related to the bone industry. Only two bases are present, both from unshed antlers from two different individuals. Elk antlers are highly fragmented, in very small fragments mostly coming from the palm, from upper or lower faces that are often separated. This is due to very high desiccation that occurred after the excavation and which preferentially affected flat elements, among them elk antlers. In consequence, it is more difficult to determine whether all of these antler elements came from these two unshed antlers or whether some pieces were from other antlers for which the bases are missing.

Roe deer antlers (*n* = 16) are more numerous in terms of individuals, as six right antlers and five left antlers are present (after refitting); all are unshed antlers. Nine can be considered as waste from *debitage*, showing a very specific breakage pattern, close to the base: 'flexion-break' or nicking for 'prepared breakage' (David 1999). Thus, the distal ends were the sought parts, but only one finished piece, a hook made from the distal end of a roe deer antler, has been discovered (n° M497, David 1999, pp. 178–179, fig. 51, 2004, pl. 5, n° 15). It is not possible to state with certainty that this piece was made on the site, from one of the unshed antlers discarded at Mullerup, and it appears that, except for this one, the distal ends are missing, perhaps transported to another site (as finished pieces?) or lost during utilization outside the site.

4.1.3. Bone and teeth exploitation

When we examine the industry made on bones and teeth (antlers excluded) and pieces that have been positively identified to species (Figure 7 and Table 2), we see that the cervids are the main species group used for the bone tools (81% of the bone industry NISP), mostly for straight or barbed projectile point manufacture from metapodials and ribs, or for hooks and awls from long bones. For this purpose, red deer, whose bones yielded 40% of the raw material, is the most commonly used species. Roe deer is also very well represented (26% of the bone industry NISP), notably because of the use of their metapodials and tibia for making tools or points, as is also seen for elk (15% of the bone industry NISP), for which the ribs were also used for barbed points and a couple of teeth for personal ornaments. Aurochs was used for a few worked pieces (9% of the bone industry NISP), mostly metapodials for heavy tools such as adzes and hammers (David 2002). Wild boar, while the dominant hunted species (Figures 3 and 7), was used for only a few finished pieces (9%), mostly tools made from male tusks and waste resulting from the *debitage* of a few tibias. The other mammal species are rarely used for making bone tools: two canines from dog (*Canis familiaris*) were perforated for making personal ornaments and one proximal end of an ulna from an adult bear, which is waste from *debitage*.

The use of bird bones also remains marginal (1.1% of the bone industry NISP). Only a few long bones from mute swan (*Cygnus olor*; *n* = 3), white-tailed eagle (*Haliaeetus albicilla*; *n* = 1), and great crested grebe (*Podiceps cristatus*; *n* = 1) and one piece from an unidentified species are present, mostly waste showing scraping or sawing marks. A humerus from mute swan with incisions forming a V-shaped design is also noted (Leduc 2010b, p. 166).

Thus, while mammals, and particularly ungulates, are the main species hunted and also the main species supplying raw material for the bone tool industry, the different species do not have the same value for this purpose. For instance, the mentioned opposition between the involvement of wild boar and red deer in hunting strategies and in the bone tool industry suggests different status of these species and different uses of their resources and may imply different exploitation patterns.

4.2. *Hunting strategies for ungulates*

This section, and before discussing the specific question of differential exploitation of species, focuses on the acquisition of animals, through the reconstruction of mortality profiles of the five ungulates, in order to identify possible differential hunting strategies. Unfortunately, the data allowing identification of age and sex are often scarce at Mullerup and the results are quite limited.

4.2.1. *Wild boar*

At Mullerup, a minimum number of 21 individuals were identified. Isolated teeth and mandible or maxillary fragments (number of teeth = 127) were used for age determination, using accurate references concerning tooth eruption and development (Matschke 1967, Carter and Magnell 2007, Magnell and Carter 2007), and use-wear patterns (Varin 1977, 1980, Iff 1978, Habermehl 1985). As precise age assessment of adults (more than 3 years) is problematic considering the large individual variation, the mortality profile (Figure 8) has been balanced for adults (division of larger age groups). It shows that the wild boar hunted population is divided in two categories of individuals (Leduc 2010a, 2010b, p. 204). First, very young individuals were hunted (44.4% of individuals are less than 6 months old; 31.5% of the number of teeth). Second, adults more than 3–10 years old are present (50% of the individuals; 63% of the number of teeth), mainly young adults from 3 and 5 years (five individuals).

The young individuals are mostly 2–5 months years old (M1 not yet erupting but present as complete crown in the cavity). Individuals from 6 to 12 months are absent, as well as from 14 to 24 months old (one individual was killed when 13 months old). Indeed, individuals aged from 6 to 12 months would normally be easily identified, showing erupted M1 with no wear or in a very early stage, but a not yet erupted M2, and also those from 18 to 24 months, showing erupted M2 and permanent premolars, and a not yet erupted or erupting M3. If we consider that there is no differential preservation between these individuals and the younger ones, we can thus argue for a real absence of individuals in these age classes. The lack of these age classes most likely reflects seasonal hunting, during the warmer half of the year.

The wild boar sex-ratio for adults, estimated from a combination of osteometric data from the scapula, compared to data from modern and Mesolithic wild boar (Magnell 2005, 2006), and canine[3] morphology, is six females to three males. At Mullerup, we can thus conclude that Maglemose people hunted mainly sounders, i.e., females with their offspring, and a few solitary adult males.

4.2.2. *Red deer and elk*

The red deer yielded very few teeth remains. Three individuals have been identified: one juvenile between 3 and 6 months old (one mandible fragment with deciduous P3 and P4 without wear, cf. Riglet 1977, Habermehl 1985) and two adults between 6 and 7 years old (three complete mandibles) according to the wear stages (Habermehl 1985, p. 29, Brown and Chapman 1991). As teeth are rare,

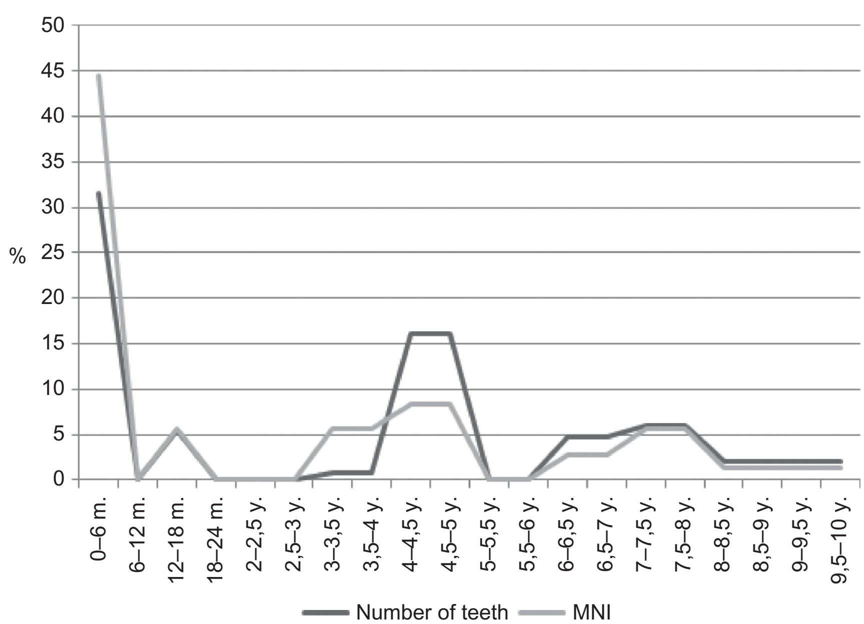

Figure 8. Wild boar mortality profile at Mullerup (number of teeth = 127; number of individuals = 18).

examination of epiphyseal fusion and bone development stages has been used to assess the age of red deer (Habermehl 1985). This led to the identification of four young individuals under 3 months old and five individuals over 36 months (Leduc 2010b, pp. 215–217).

Since antler fragments all come from shed antlers and skull fragments are rare, only few osteometric data could be used to attend to assess sex-ratio from red deer bones. The results show very high values, higher to actual males values (Boessneck *et al*. 1963) evidencing possibly three stags (Leduc 2010b, pp. 218–222). These data are also high in comparison with data from other Mesolithic sites, such as Star Carr, in England (Legge and Rowley-Conwy 1988, p. 54) or earlier Mesolithic sites from Kongemose or Ertebølle contexts (Noe-Nygaard 1995) and Neolithic contexts (cf. Seeberg Burgäschisee-Süd in Switzerland, Boessneck *et al*. 1963). But data from other Danish Early Maglemose sites also show high values (Bille Henriksen *et al.* 1980; Noe-Nygaard 1995) and could be related to higher sizes in red deer populations from this period in Scandinavia.

Regarding elk, only 21 dental elements allowed the identification of five individuals of different ages. Two individuals are 2.5 months old and one is approximately 1 year old (Habermehl 1985). Two individuals are adults, approximately 2–3 years old and approximately 4 years old (Quimby and Gaab 1957, pp. 441–443, Jensen 2001). But, like the red deer, examination of epiphyseal fusion and bone development stages (Habermehl 1985) increased the number of individuals: one more young individual and three more adults, over 36 months old, were identified (Leduc 2010b, p. 211). As stated above, the presence of two antlers of different morphology and size suggests the presence of two males. Rare osteometric data (atlas) confirm the presence of one male, in comparison with actual and archaeological data (Chaix and Desse 1981).

Concerning red deer, excluding the autumnal rut period during which stags are following hind groups, mature individuals form single-sex groups, hinds living with their offspring while stags are often solitary or forming small groups when they are young (Macdonald and Barrett 1995, Geist 1998). On the other hand, elk are more solitary, females staying with their offspring. But during and after the rut, elk form small family groups and occasionally gather in larger groups during winter (Macdonald and Barrett 1995, Geist 1998). Although, here, data are too weak to infer a real predominance of stags for the two species. Moreover, the presence of four young red deer and three young elks confirms that family groups were hunted. We can thus suggest that red deer and elk acquisition likely combined two different hunting strategies, in early summer before the rut period, when some of them were hunted: first, the hunting of herds of hinds with juveniles and, second, the hunting of solitary stags or herds of stags.

4.2.3. Roe deer

Nine individuals have been identified and aged from roe deer dental remains (*n* = 22 elements; 53 teeth). According to erupting and wear stages (Tomé 1999, Carter 2001, 2006, Tomé and Vigne 2003), one individual is 3–4 months old, five individuals are between 12 and 20 months old (among them two individuals approximately 15 months old), two are about 2 years old and one is over 3 years old. Young individuals are better represented by post-cranial elements, as four individuals are less than 9 months old according to analysis of epiphyseal fusion and bone development stages.

As presented above, six males are identified from complete or almost complete skulls wearing unshed antlers. The examination of the pelvis morphology (Boessneck *et al*. 1963, p. 112) allowed the identification of three males and two females.

Thus, for roe deer, considering the sex ratio from skull elements that are most numerous, and bearing in mind the small number of individuals, hunting strategies could have been mostly directed toward subadult and adult males, but did not exclude females and young individuals. As roe deer did not reach their maximal weight before reaching 2–3 years in age (Tomé 1999, p. 53), we can probably exclude the search of maximal meat weight as motivation for hunting of males. However, subadults and young males often form small herds during the rut period (Legge and Rowley-Conwy 1988, Tomé 1999), probably making them more vulnerable. On the other hand, the search for antlers could have been another motive, as they are all removed from skulls, despite the scarcity of clearly manufactured pieces from roe deer antlers on the site.

4.2.4. Aurochs

Excluding the two perforated teeth that could have been transported to the site as finished pieces, dental remains from aurochs are rare (*n* = 3). One complete maxillary bone with all the permanent teeth, without very deep wear is from an adult, and two isolated teeth (lower M2 and upper P4) are probably from another individual, an old adult showing advanced wear. The epiphyseal fusion stages from post-cranial elements (Habermehl 1975) allowed the identification of three young individuals (two less than 3 months old and one 3–10 months old), one individual less than 30 months old, and two adults more than 36 months old. Concerning the sex identification, according to the pelvis morphology and osteometric data (pelvis, horn core, scapula, femur, tibia), one female and four males have been identified.

Thus, although small herds of females with their offspring were hunted, adult males may have been a preferential target for hunters at Mullerup. Hunting large males can be considered more dangerous for hunters, but more profitable in terms of meat quantity and perhaps also of greater value from a symbolic point of view. If we consider that these hunting episodes occurred during the warmer months, they could have occurred during the rut period, when males joined the females (Van Vuure 2005, p. 271), making them easier to find and hunt.

Since the duration and the number of occupations at Mullerup are not known, it is difficult to interpret hunting strategies at the scale of occupation. At the site scale, hunting strategies for the five ungulates seem to be quite similar, i.e., without real selection aimed toward specific individuals. However, complementary strategies depending on species could have occurred, showing a kind of gradient concerning the presence of adult males as target. Boars were occasionally hunted, males are present among the large cervids, and finally, males are the main target for roe deer and aurochs. Bearing in mind the small number of individuals for each taxa and the relative weakness of age and sex data, preventing clear conclusions, this gradient, if reflecting real hunting strategies, could be due to specific needs: meat and specific raw materials such as boar tusks, big and strong long bones, antlers. Though, at Mullerup, evidence supports rather several successive hunting episodes that were more or less selective depending on species and immediate needs.

4.3. Exploitation patterns

4.3.1. Wild boar

At Mullerup, under-representation of wild boar axial skeletons (Figure 9) can partly be explained by taphonomic reasons: vertebrae and ribs are often less preserved and less identifiable to species level in archaeological contexts than are long bones (Lyman 1985, 1994). This could also be due to selective collecting and the lack of sieving, which would also account the under-representation of lower extremities such as phalanges and sesamoid bones. However, such bones could also be absent due to specific treatment of hides, for instance. They could have been still attached to the skin when removed. Despite these losses, which could be explained by taphonomic reasons or excavation methods, and perhaps by selective behaviour linked to hide treatment, wild boar skeletal parts are well represented, particularly by heads and limb bones. All parts of wild boar carcasses must have been transported to the site, as a whole or as large portions of carcasses, after disarticulation of some elements (limbs, head).

More than a third of wild boar anatomical elements (36.3% of MNE) have cut-marks from different activities. Hide and sinew removal is suggested by specific cut-marks on skulls and lower extremities. Disarticulation is widely represented, at each articulation (to a lesser extent at the knee), and all the fleshy parts show cut-marks from meat removal. Finally, all long bones, but also mandibles, and first and second phalanges were broken for marrow extraction. Only 2% of the bones from wild boars were used in the bone tool industry. These are mainly complete male tusks (*n* = 8), which often show some scraping marks on the occlusal surface. Two other pieces are interpreted as used as 'Knives' and one more, which is shaped on a longitudinal enamel

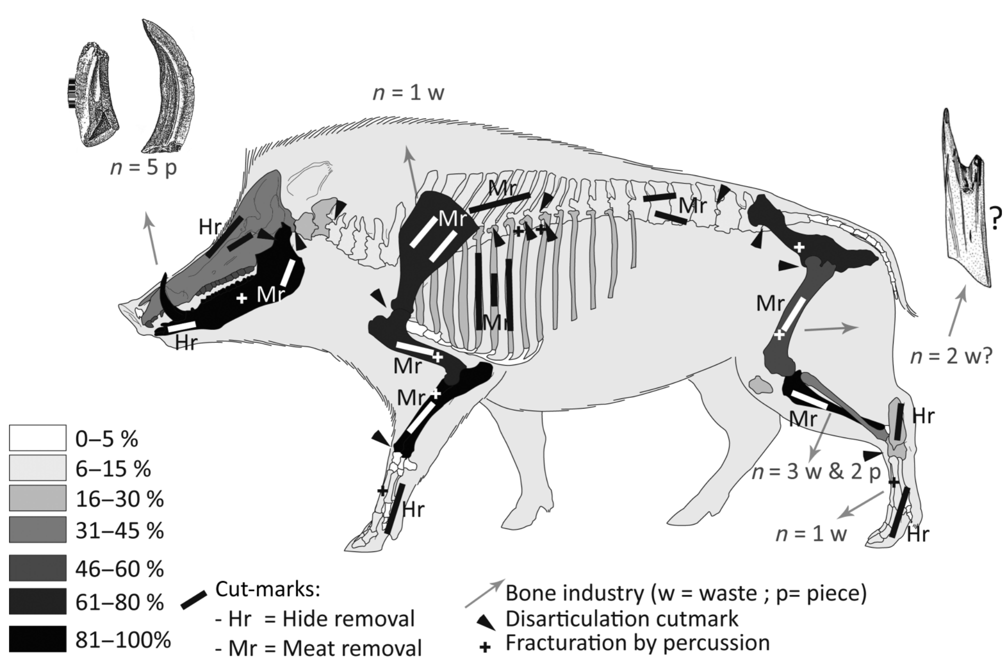

Figure 9. Skeletal part, cutmark and bone tool industry distribution for adult wild boar at Mullerup (NISP = 837; MNE = 465; MNI = 16). Drawing of the wild boar: M. Coutureau, after Pales & Garcia (1981); bone tool industry drawings from E. David (1999; 2004) and G. F. L. Sarauw (Sarauw *et al.* 1903).

fragment, as an 'adze blade' (Sarauw *et al*. 1903). Some of these tusks could have been transported from another site as finished pieces, given that males are not very well represented in the assemblage. A few bone fragments are tool-making waste ($n = 6$) from tibia, femur, scapula and metapodial. The use of wild boar bones as raw material for the bone tool industry seems, however, to be occasional.

4.3.2. Red deer and elk

The red deer and elk skeletal part distribution shows that the axial skeleton is under-represented, likely for taphonomic reasons (Figures 10 and 11). Yet the attested use of ribs in the bone tool industry, for making the numerous barbed points, could also partly explain such under-representation. At Mullerup, waste and tools from large ruminant ribs are numerous, but difficult to attribute to one particular species given that they are fragmented and deeply worked (e.g., scraped).

Red deer heads are nearly absent and the reason of such absence is not very clear. If we consider a predominance of stags but the absence of unshed antlers, one can suppose that red deer heads could have been left at the kill-site or discarded elsewhere. Elk heads are better-represented, possibly for the use of unshed antlers, and thus selected to be transported to the site. Like wild boar, cervid lower extremities may be missing due to collecting techniques during excavation or a specific hide treatment. In contrast, fleshy parts and metapodials in particular are well represented. All elk skeletal parts are generally less well represented than red deer: all bones are present but often under-represented relative to the scapula and pelvis bones. It can be inferred that elk may have been sometimes transported to the site as large carcass portions, favouring specific pieces such as the fleshy upper legs. This could also be the case, to a lesser extent, for red deer carcasses of which the heads were removed and probably left at the kill-site.

Considering the red deer skeletal part distribution, the over-representation of metapodials is striking and must be clarified (Figure 12). Quantification of metapodial fragments indicates the presence of 10 individuals (10 left

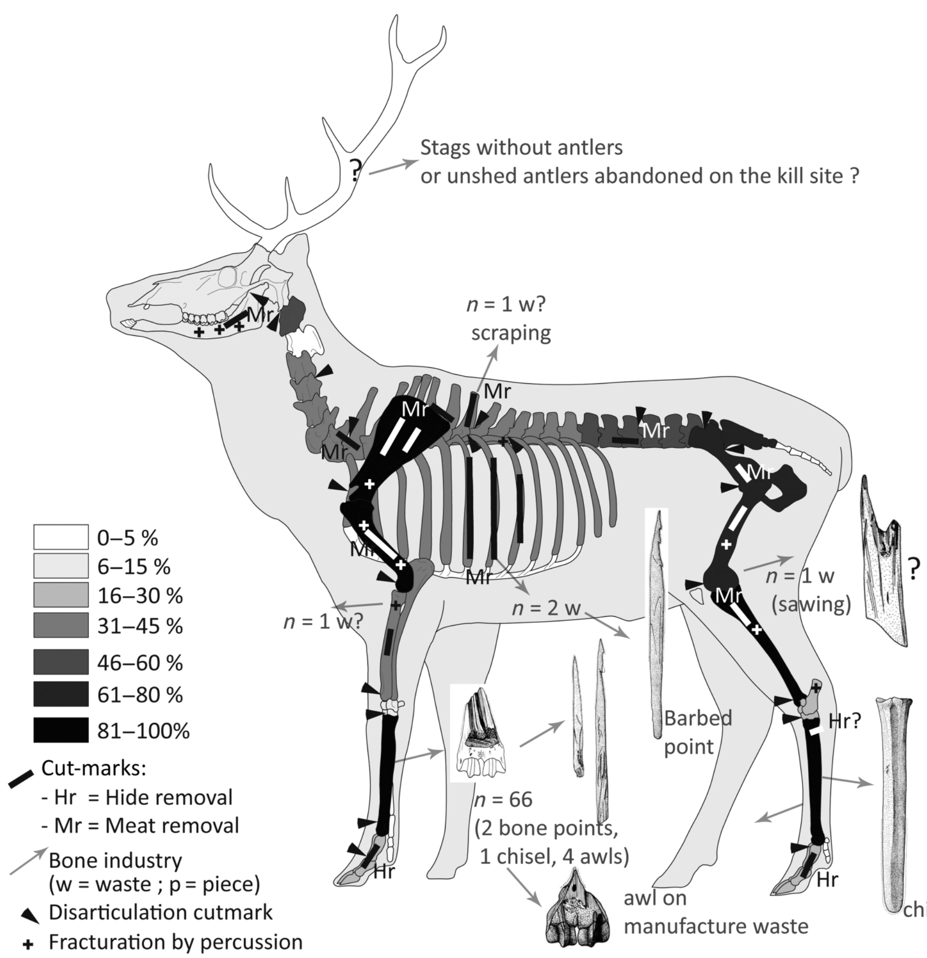

Figure 10. Skeletal part, cutmark and bone tool industry distribution for adult red deer at Mullerup (NISP= 405; MNE= 203; MNI= 4 [metapodials are excluded for the calculation of MNI, see in the text]). Drawing of the red deer: J.G. Ferrié (2004), modified after "Reindeer" (C. Beauval). Bone tool industry drawings from E. David (1999; 2004).

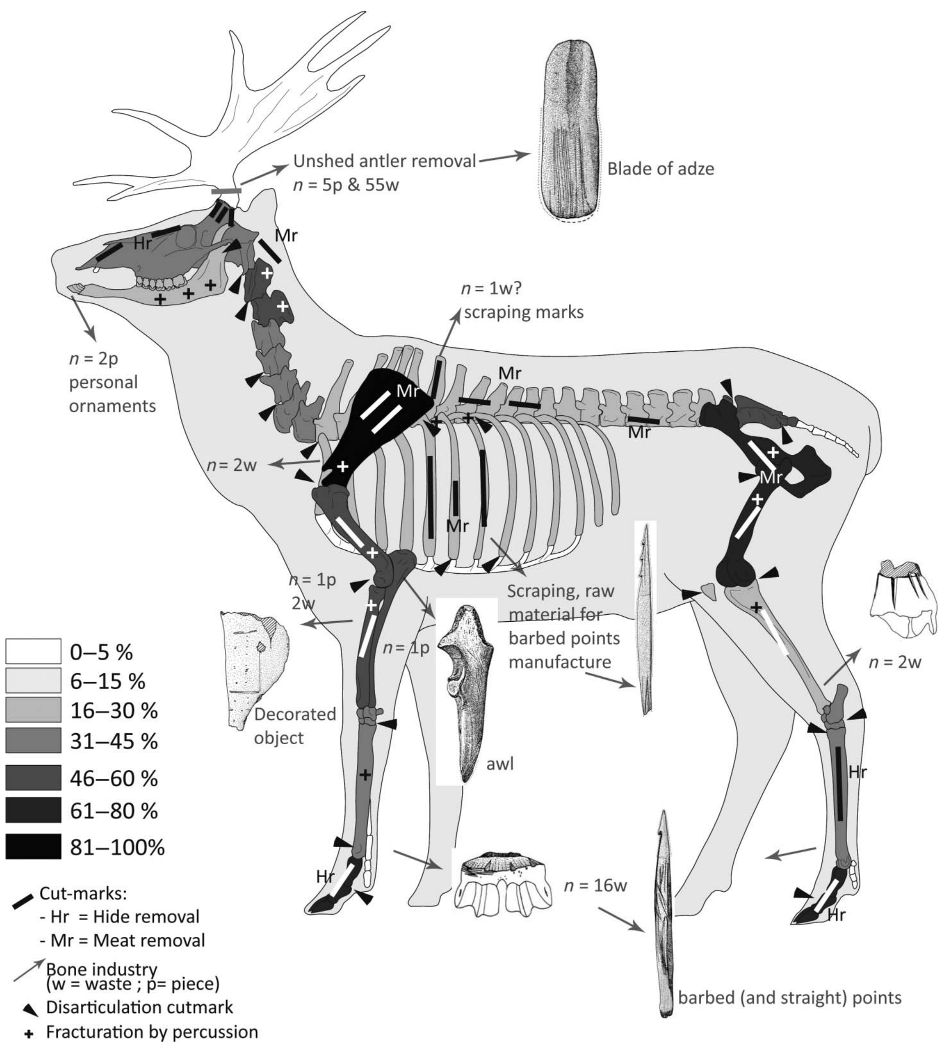

Figure 11. Skeletal part, cutmark and bone tool industry distribution for adult elk at Mullerup (NISP= 559; MNE= 260; MNI= 5). Drawing of the elk: "red deer" J.G. Ferrié (2004), modified after "Reindeer" (C. Beauval); antlers: C. Leduc. Bone tool industry drawings from E. David (1999; 2004).

metatarsal bones) whereas all of the other anatomical parts point to only four individuals. This can be considered as a real over-representation since it is as for all long bones based on the number of epiphyses.

Furthermore, all the metapodial fragments are waste or fragments of finished pieces from bone weapon production (NISP = 66), nearly exclusively for bone points, using a very standardized method of manufacture, the 'method D' as defined by David (1999, 2003a, 2003b, 2004). This method includes specific calibration techniques of the bone (e.g. removal of axial flakes from the upper articular surface, using wedge-splinter technique and dotted perforation of the upper articular surface; and drilling technique for taking off distal ends) before grooving for getting long products.

Therefore, such over-representation of metapodials may reflect systematic selection of these parts for the bone industry. This issue led to the hypothesis that some of these metapodials could have been imported from another site as raw material in order to make some of the very abundant bone points. Thus, some of these metapodials would have been not extracted from the red deer carcasses exploited at Mullerup, but from other red deer carcasses exploited elsewhere. Following this hypothesis of additional imported metapodials, and taking into account the discrepancy between the MNI relying on the metapodials (10) and the one considering other long bones (4), the skeletal part distribution was thus calculated considering the smallest MNI data, probably more close to the relative importance of the species, in terms of individuals exploited onsite at Mullerup (Leduc 2010a, 2010b, p. 271).

Elk metapodials were also quite often used in the bone tool industry, as 71.4% of the metapodial fragments are finished pieces or waste, again mostly for bone points. This use is thus very important, but not as systematic as

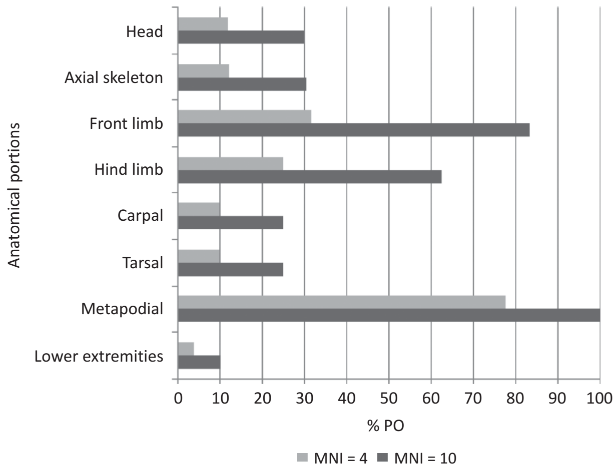

Figure 12. Red deer anatomical portions distribution, according to MNI = 10 (number of metapodials) and MNI = 4 (number of other bones), given in %PO = the ratio of 'found/expected' skeletal elements (Bridault 1993, after Grigson and Mellars 1987).

for red deer. Moreover, unlike red deer, these bones do not appear to be over-represented and we cannot infer the importation of some of these bones as isolated raw materials.

Around 40% of the red deer and 38% of the elk anatomical elements show cut-marks. Hide and probably sinew removal can be inferred from a few cut-marks on phalanges. Disarticulation cut-marks are visible on red deer first vertebrae and mandibles. This supports the hypothesis of a specific treatment of red deer heads that were removed and left at the kill-site. Elk heads were also removed, but for some of these, likely at Mullerup where they were then discarded. Disarticulation can also be seen at each joint for both species and suggests that the majority of carcass treatment took place at Mullerup. Evidence of meat removal is broadly present on every fleshy bone. Like wild boar, all of the long bones, mandibles, and first and second phalanges were broken for marrow extraction.

More than 17% of red deer bone fragments are waste or finished pieces from the bone industry. These are rib fragments (n = 2), probably for barbed points (David 1999, pp. 210–212, figs. 67 and 68, 2003a, p. 81, fig. 7), long bones represented by radius (n = 2), femur (n = 1), and metapodials (n = 66), almost exclusively for the manufacture of bone points (David 1999, 2003a, 2003b, 2004, Leduc 2010b). Elk bones (excluding antlers) were less often used for the bone industry (only 5.3%). These include two perforated incisors, a few long bones (one decorated piece and two waste pieces from a radius, two waste pieces from a tibia and one awl from an ulna), a few pieces from ribs and thoracic vertebrae (n = 3) and bone points and waste from metapodial *debitage*.

4.3.3. Roe deer

Taphonomic processes and the lack of sieving would have more significantly affected roe deer bone than the other ungulates since this is the smallest species among them. This could explain the under-representation of some fragile bones (Figure 13) such as ribs and vertebrae, and small bones such as phalanges, sesamoids, carpals, and tarsals. We can thus infer that roe deer must have been transported as whole carcasses since the heads and long bones are well represented. Along with the scapula, heads are the best-represented skeletal parts and the need for antlers could explain this. Skulls are often complete or almost complete and antlers are fractured at their basis or under the fork, and thus easy to identify within the whole bone assemblage, while long bones were highly fragmented for marrow extraction.

Only 29.3% of roe deer anatomical elements have cut-marks, primarily for disarticulation and meat removal. This lower percentage could be related to the size of the animal. It is possible that roe deer were more easily disarticulated than other ungulates, using 'flexion' techniques, i.e., without cutting as far as reaching the bone. The well-represented heads and the atlas rarely show decapitation cut-marks. We also suggest that roe deer were not treated in the same way because of their smaller size, i.e., not completely disarticulated or boned before consumption.

A large part of the roe deer bones were used as raw material (11%, antlers excluded). Some finished pieces were made from anatomically unidentified long bones, including barbed and straight points, awls and one personal ornament; waste from long bones is also present. Like red deer and elk, the bones most commonly used as raw material are the metapodials, 60.4% of which are related to the manufacture of points.

4.3.4. Aurochs

Unlike the roe deer, aurochs bones undergo less taphonomic degradation and are easier to collect and identify as they are bigger and thicker than those of the other ungulates. Thus, the skeletal part distribution likely reflects a real picture of which aurochs parts were discarded at Mullerup (Figure 14). All skeletal parts are present, but are often under-represented, relative to the MNI of five, calculated from the number of scapula and pelvis which are the best represented bones. This may be due to selection of the fleshiest parts of most of the carcasses, such as the upper legs, to be transported and consumed at the site. But the absence of some long bones such as humerus or femur may suggest intense disarticulation offsite, in order to take only the pelvic or pectoral girdles. We note that two scapula fragments are waste from point manufacture and could thus partly explain why these bones were

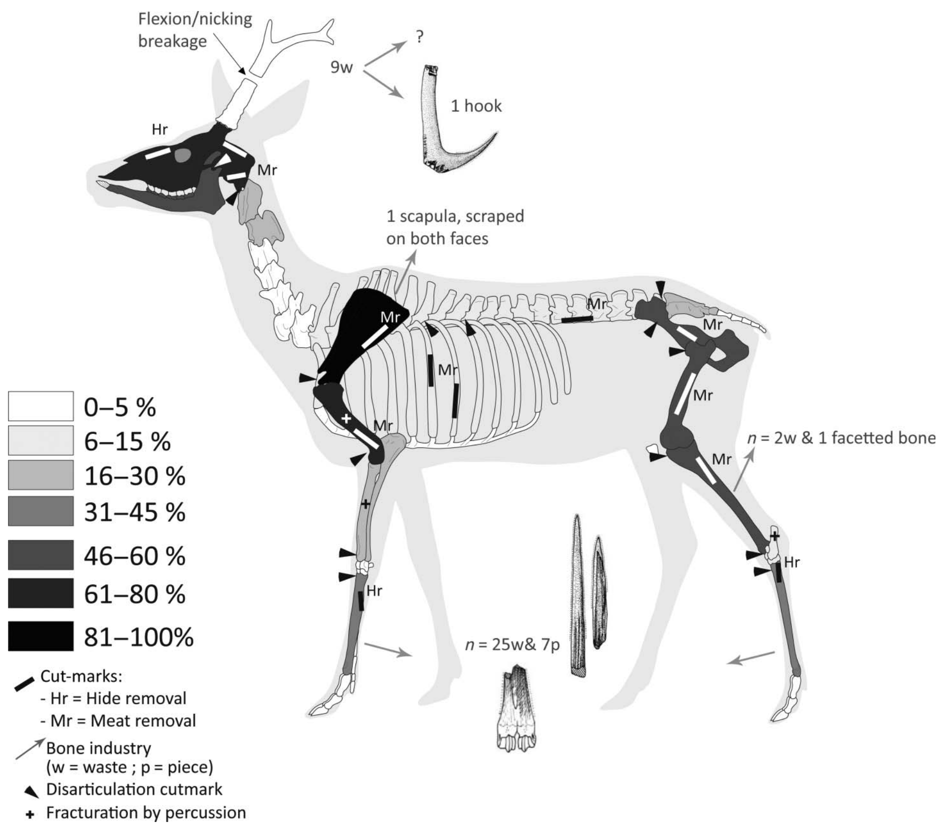

Figure 13. Skeletal part, cutmark and bone tool industry distribution for adult roe deer at Mullerup (NISP= 433; MNE= 239; MNI= 13). Drawing of the roe deer: J.G. Ferrié (2005), modified after "Red deer". Bone tool industry drawings from E. David (1999; 2004).

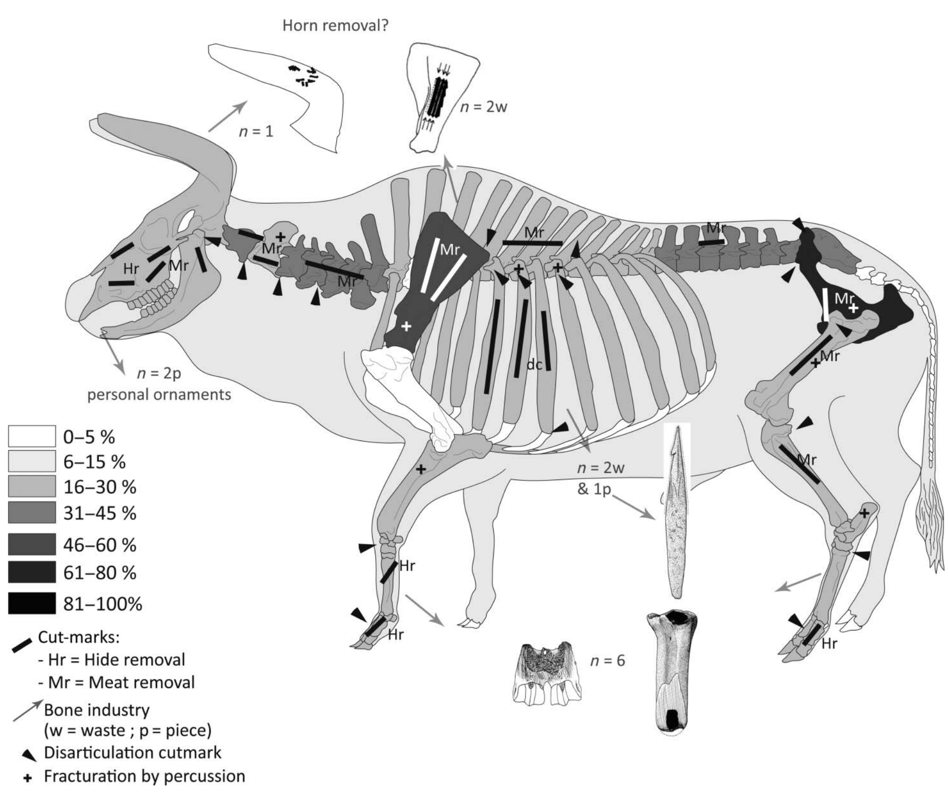

Figure 14. Skeletal part, cutmark and bone tool industry distribution for adult aurochs at Mullerup (NISP= 292; MNE= 178; MNI= 5). Drawing of the aurochs: M. Coutureau, after skeleton from the Angoulême Museum (2009). Bone tool industry drawings from E. David (1999; 2004).

selected to be transported to the settlement site. Under-representation of aurochs bones may also be due to the transport of boned meat to the settlement site or to the discarding of butchering waste elsewhere, specifically concerning this species. The metapodials are also under-represented but are all (*n* = 6) waste or pieces associated with heavy bone tools. It is not possible to determine with certainty whether these objects (adzes, hammers) were made from the aurochs carcasses processed at Mullerup. Indeed, such pieces could have had a 'long' use life, longer than weapons, and could thus have been transported to the site as finished pieces and discarded after being broken. Like the large cervids, the under-representation of ribs may be due partly to their use in the manufacture of barbed points, since waste and finished pieces (*n* = 3) resulting from such use is present. Finally, the lack of lower extremities and coccygeal vertebrae may be interpreted as resulting from hide removal or discard at a primary butchering site. The importation of selected carcass portions for aurochs can be easily understood in terms of transportation constraints, as the species is the largest ungulate known during the Mesolithic (approximately 800 to 1000 kg for a male; Guintard 1999, p. 10).

Around 40% of the aurochs anatomical elements have cut-marks. Like the other ungulates, the most represented cut-marks result from disarticulation (legs, trunk, head) and meat removal (head and upper legs), but many cut-marks indicating hide removal are visible on one skull and some phalanges. Only 4.5% of the aurochs bone fragments were used in the bone industry, mostly metapodials and the flat bones scapula and ribs.

5. Discussion

The five ungulates – wild boar, red deer, elk, roe deer, and aurochs – together form the basis of subsistence and furnished raw materials for a very large part of material culture production at Mullerup. The hunting of these animals does not appear to have been very selective but rather occurred in successive hunting episodes, during the warm season, in addition to the acquisition of small mammals, birds, and fish.

Regarding the five ungulate species, the exploitation for dietary products, such as meat and marrow, has been very intensive. This is shown by the high number of cut-marks related to disarticulation and meat removal, involving every skeletal part of each species, in quite uniform proportions. Only roe deer showed fewer cut-marks but as suggested, this could be due to specific butchering patterns. The removal of hides is suggested for each species, but often by very little evidence, such as specific cut-marks on skulls, metapodials, and phalanges. However, the general under-representation of the lower extremities and the absence of coccygeal vertebrae may indicate the removal of hides, processed onsite or elsewhere. One common feature is the systematic breakage of all marrow-yielding bones, including mandibles, and bones that yield very little marrow, including the first and second phalanges and some tarsal bones (calcaneus). Such intensive marrow extraction is well known in Maglemose contexts and has been described at several Maglemose sites (Friis Johansen *et al*. 1919, Broholm *et al*. 1924, Bille Henriksen *et al*. 1976, Bille Henriksen *et al*. 1980, Andersen *et al*. 1982). The bone breakage patterns for marrow extraction observed at Mullerup are very similar to those known from Maglemose sites and to those described in detail by Noe-Nygaard (1977, 1987, 1995), for early Danish Mesolithic sites. The very specific breakage of the mandibles, along the tooth row, possibly to extract the fat which surrounds the nerves into the *canalis mandibulae*, has been described by Møhl (1978) at Skottemarke and Favrbo, and is also known at Lundby Mose (Møller Hansen 2003, Møller Hansen *et al*. 2004, 2006, Leduc 2010b), and could thus be a particular characteristic of the Maglemose bone breakage pattern, since the earliest phases of this culture.

While there are clearly common patterns in the exploitation of ungulates, when examined in more detail, carcass exploitation patterns vary for each species (Figure 15), depending mainly on transport practices, but also on raw material needs.

Wild boar and roe deer would have been transported as whole carcasses to the site (Figure 15). Carcass processing took place at Mullerup. For wild boar, such exploitation mainly focused on dietary resources. However, some skeletal parts were used for the bone industry, mainly male tusks, among which some were possibly imported. Roe deer supplied additional raw materials, including antlers and long bones, mostly metapodials, which were quite often selected to make tools and weapons.

After removal of the head, red deer may have been transported as whole or sometimes large carcass pieces, selected for both meat and raw material. A similar pattern, but more significant, can be seen for elk, for which transportation as pieces of carcasses seems to have been more frequent, probably due to its bigger size. Metapodials must have been a priority in red deer exploitation and to a lesser extent also for elk as they are over-represented and systematically used as raw materials for weapons. Some transport or storage strategies must have been developed for this purpose. This may be due to very important needs for projectile bone points, as these skeletal parts were quite exclusively used to manufacture such pieces, amounting to 54.7% of the pieces made of osseous material. The question of a preference for weapons using bone points during the Maglemose culture has been debated (David 1999, p. 269, 2004, p. 256) and remains open. The use of bone points as hunting weapons for large mammals and not only as fishing weapons is probable (Vang Petersen 2009, Leduc in press). But the presence

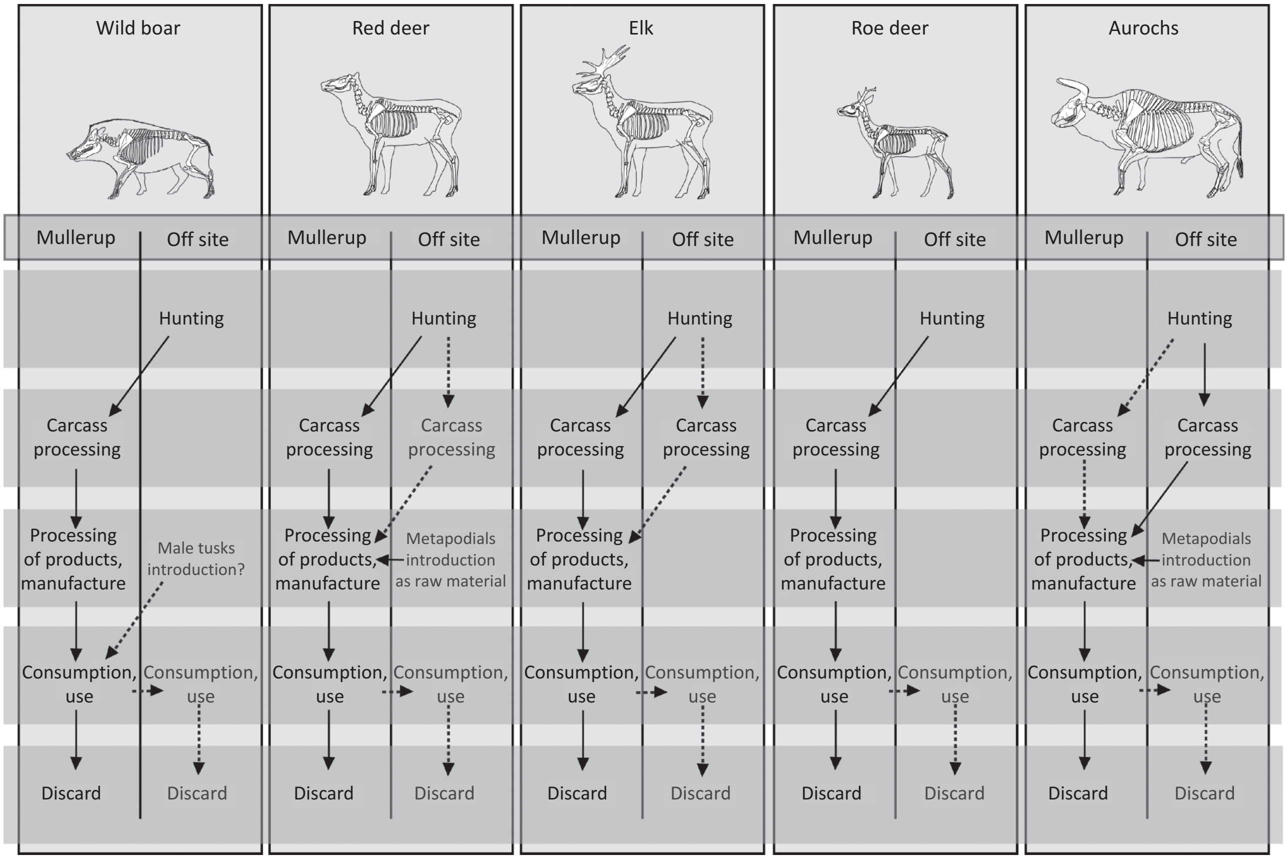

Figure 15. Schematic animal exploitation patterns at Mullerup, for each ungulate.

at Mullerup of embedded lithic fragments in some bones (an aurochs rib, thoracic vertebrae from a young deer and wild boar), demonstrates the use of lithic arrowheads for hunting (Leduc in press). Other examples such as the discovery of Maglemose lithic arrowheads associated (and sometimes embedded), with aurochs complete carcasses at Vig and Prejlerup, in Zealand (Noe-Nygaard 1973, Aaris-Sørensen and Brinch Petersen 1986a; 1986b) also confirm this assertion.

Finally, the selective transportation of carcasses is more significant regarding aurochs for which the very large size required selection of the meat-yielding parts. Here again, the use of metapodials as raw material is systematic, but these bones are not very well represented and used only for heavy tools, thus exploiting the specific properties of these bones: big size, strength, and weight.

The importance of cervid metapodials for the Maglemose bone industry has already been discussed. Their abundance was noted early in Maglemose settlement bone assemblages (Friis Johanssen *et al*. 1919, p. 262, Bille Henriksen *et al*. 1976, p. 137). The detailed quantification of fragments and skeletal elements emphasize not only the abundance, but the over-representation of these bones at Mullerup. This might also be the case at other classical Maglemose settlements whereas metapodials are missing from kill-sites or butchering sites, such as Skottemarke and Favrbo (Møhl 1978) and Lundby Mose (Møller Hansen 2003, Møller Hansen *et al*. 2004, 2006, Leduc 2010b). These latter sites, assigned to the very Early Maglemose culture, are older than the Maglemose settlement sites, for which such contemporaneous specialized sites, yielding preserved faunal remains, are unknown. It is thus not possible to establish clear contemporaneous links between sites where metapodials are missing and sites where they are over-represented. But, looking at the Maglemose culture as a whole, in Denmark, it can be concluded that cervid metapodials must have received particular treatment by means of selection, transport (import and export), storage, '*débitage*', and manufacturing (mainly bone points). This may also be the case, but to a lesser extent, for aurochs metapodials and wild boar tusks, which could also have been transported as finished pieces.

The circulation of such resources, between sites with different functions implies fragmented '*chaînes opératoires*' of exploitation, in different places, at kill-site/butchering sites and settlement sites, i.e., a disconnection in time and space of processing sequences, integrated in Maglemosian mobility, at local and regional scales. Unfortunately, data concerning the mobility of these early Mesolithic hunting societies are rare, and only small summer settlement sites, with faunal remains, are known in Zealand. The chronological gap between the earliest kill/butchering sites during the Late Preboreal/ Early Boreal period and the classical settlement sites during Boreal and Early Atlantic period and the absence of winter sites prevent detailed reconstruction of the annual cycle of occupation and the Maglemose mobility pattern. But considering these few elements, probable mobility of small (family) groups (Grøn 1995), in a relative restricted area or with repeated seasonal occupations of the same areas, can be proposed. This was, for instance, discussed after the discovery and analysis of healed hunting injuries on some mammal bones (Noe Nygaard 1974, 1975, Leduc in press), suggesting a certain territoriality of animals and humans, probably at a seasonal level, during this period, and leading occasionally to the hunting of the same ungulate populations. While a kind of residential mobility or 'foraging system' (Binford, 1980) can be proposed from these few elements, the study of the Mullerup faunal assemblage suggests a more complex system, including some 'logistical mobility' for the acquisition of animal resources, as evidenced by the broken '*chaînes opératoires*' of animal exploitation and the circulation of raw materials. Expeditions for ungulate acquisition do not necessarily imply long distances since the immediate surroundings of the site offered particularly optimal conditions (lake, forest, marsh) for hunting not only ungulates but also waterfowl and for fishing.

6. Conclusion

The detailed analysis of the complete bone assemblage from Mullerup, the bone industry and faunal remains combined, provides relevant data to reconstruct the respective contributions of subsistence and 'technical' activities relative to animal exploitation, undertaken on the site. Such analysis, relying on rigorous methodology (quantification criteria, cut-mark analysis, etc.) and exhaustive study of all of the faunal remains enables a global view of animal resource management by the human groups occupying the site. The subsistence economy relies mainly on the exploitation of the five main ungulates, which supplied the most important parts of the diet. The exploitation of specific raw materials such as antlers, tusks, metapodials, ribs, or long bones to produce an abundant and standardized bone tool industry led to variations in exploitation patterns. Some specific results, in the first line those concerning the circulation of certain resources (e.g., metapodials) and their extrapolation to other Maglemose sites from published data, emphasize the role of animal resources in Maglemose socioeconomic organization and suggest that animal exploitation should be highly linked to the mobility of Maglemose hunter-gatherers. In addition, animal exploitation seems to be very standardized at the scale of Maglemose culture, in Denmark, since the pattern described here seems to exist at other Maglemose settlements, with a very high predominance of ungulate exploitation, following standardized patterns for subsistence and the production of material culture.

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Notes

1. Here, 'Mullerup' only refers to the site excavated by G.F.L. Sarauw in 1900 (Sarauw *et al.* 1903), also known as 'Mullerup Syd' (=Mullerup South) or 'Mullerup Sarauw's Island'.
2. According to the recent excavation of the Lundby Mose site, dated from 9650 to 9270 cal BC, averaged from three dates published by K. Møller Hansen *et al*. (2004).
3. Male tusks (lower canines) have been excluded for the calculation of wild boar sex-ratio (which relies mostly on female upper and lower canines, male upper canines and tooth alveolus morphology from maxilla or mandible) since these pieces are often manufactured or used as tools and thus, could have been transported to the site as finished pieces unrelated to the wild boar hunted at Mullerup.

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A critical approach towards jade axes in southern Scandinavia

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Southern Scandinavian jade axes have been interpreted as items of prestigious exchange illustrating contact with the agrarian societies of Central Europe and reflecting agrarian ideas and ideology. They are therefore important in the discussion concerning the process of neolithisation in Northern Europe, but the difficulties in differentiating between Neolithic axes of alpine jade from axes imported from other continents has attracted some criticism. Furthermore, some of the jade axes found in Southern Scandinavian collections originate from private collectors, many of whom had contacts all over Europe. The axes lack therefore secure archaeological contexts, and may suggest that they have not been found in Scandinavian soil. The aim of this paper is to maintain a critical approach towards the question of the origin of the jade axes from Southern Scandinavia. However, the many imitations of jade axes produced in local raw materials clearly indicate the importance of this artefact group within the Mesolithic and Neolithic transition in Southern Scandinavia.

Keywords: jade axes; Southern Scandinavia; Caribbean islands; exchange systems; neolithisation; flint mines; pointed butted axes

Introduction

Until Klassen's (2004) paper, jade axes played an anonymous role in the discussion of the neolithisation process, but they are now seen as having a key role as items of prestigious exchange between agrarian societies in Central Europe. They can also be seen as reflecting the advent of agrarian ideas and ideology within hunter–gatherer and early farming societies in Southern Scandinavia during the Mesolithic and Neolithic transition. For many years, it was believed that Danish jade axes came from former European colonies and is one of the main reasons why some jade axes were found in ethnographic collections. At least one jade axe (ODIg 53, Klassen 2004, p. 88) was 'rediscovered' in the ethnographic collection of the Danish National Museum. It was believed to have originated from one of the Caribbean islands. Another axe from Lolland or Falster (Figure 1, LFS3527, Klassen 2004, p. 88) was believed to have originated in Asia.

The unknown quarries

The 'ethnographic' interpretation of these axes was due to jade quarries being unknown in Europe until Pierre and Anne-Marie Pétrequin found jadeite quarries in the Italian Alps and the northern Apennines (Pétrequin et al. 2012a). Based on petrographic studies it was concluded that the two above mentioned jade axes from Denmark (ODIg 53 and LFS3527) were made of jadeite procured at Mount Beigua. Another two axes from Denmark (OBM A258, Klassen 2004, p. 84 and private collection, Klassen 2004, p. 85) were made of jade from Mount Viso (Amico 2012, p. 439). The European jade project also suggested a typological classification of the jade axes, based on axes found in dated contexts. The dominant jade axe in Southern Scandinavia belongs to the Durrington type, which is almond shaped, with a pointed oval cross section.

A questionable context

According to Klassen's *Jade und Kupfer* book from 2004, a total of 13 jade axes are accepted as imported to Southern Scandinavia during the Stone Age. It was possible to determine a parish or region for 10 of the jade axes (Klassen 2004, p. 427: finds list 9. No. 1, 2, 5, 6, 7, 8, 10, 11, 12 and 13). The remaining three of the 13 jade axes are from private collections and are without any kind of information about their origin. They can be regarded as stray finds with an unsecure context. These three axes (Klassen 2004, p. 427: find list 9. No. 3, 4, 9) could have been exchanged and traded by antique dealers, who had contacts all over Europe, during the nineteenth and twentieth centuries. The context within Southern Scandinavia of these axes remains an open question.

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Figure 1. Original and the copy. Jade axe (LFS3527) with rusty plough marks found on either Lolland or Falster, together with a pointed butted axe of flint from the same region also with rusty plough marks. Photo: Lasse Sørensen and Jens Lauridsen.

The ethnographic problem

The main problem with all the jade axes is that visually it is difficult to distinguish between Neolithic axes of alpine jadeite and imported ethnographic axes from for instance, the Caribbean islands. Jade axes from the Caribbean islands display some of the same types, shapes and sizes as the Neolithic Alpine axes. The jade axes from the various Caribbean islands probably originate from Central American jadeite mines, thus indicating an organised long distance trade network similar to the one suggested for the Early Neolithic cultures in Europe (Harlow 1993, pp. 9ff, Harlow et al. 2006, pp. 306ff, Knippenberg 2006, Pétrequin et al. 2012a). It is therefore important to carry out petrographic studies on the jadeite from Central America in order to exclude a Caribbean origin of jade axes found in Europe. In the past, people brought antiquities to Europe from various colonies in the Caribbean including jade axes (Randsborg 2001). Denmark was no exception, the Virgin Islands being a Danish colony from 1672 until 1917.

Petrographic studies of Caribbean jade axes could be initiated within the ethnographic collection of The National Museum in Copenhagen (Toftgaard 2013). The museum has one of the most important collections of jade axes from the Virgin Islands, acquired from plantation owner Gustav Nordby, who lived on Saint Croix from 1903 to 1924 (Yde 1947, pp. 29ff). Archaeologist Gudmund Hatt also brought some jade axes to The National Museum from Santo Domingo in connection with his expedition in 1923 (Hatt 1932).

Figure 2. Detailed photo of the rusty plough marks on the jade axe from Lolland or Falster. Photo: Lasse Sørensen and Jens Lauridsen.

A distinctive feature of the Caribbean axes is their great width, a characteristic rarely seen among the Alpine jade types. More importantly, none of the jade axes from the Caribbean islands investigated in this study show any rusty plough marks. The significance of this observation is due to these features being found in a few of the jade axes from Southern Scandinavia (Figure 2, Klassen 2004: finds list 9. Nr. 2, 10) and indicates that they have been lying in European soil during modern agricultural tilling. The fact that no jade axes have, as yet, been found in Southern Scandinavia in any archaeological context is problematic but also rather curious, as other exotic axes, such as the shoe-last-axes, have been found in connection with several archaeological excavations.

Imitations of jade axes during the early Neolithic

That jade axes reached Southern Scandinavia during the Early Neolithic (4000–3500 cal BC) is supported by the imitation of these axes (Durrington, Saint Michel, Tumiac and Chenoise types) in local raw materials such as flint or diabase (Figure 1). Several pointed butted flint and greenstone axes in Southern Scandinavia from Early Neolithic contexts were unused and some are more than 25-cm long. Seemingly, locally produced axes had a non-utilitarian purpose similar to the Alpine jade axes. Smaller imitations like the pointed butted axe of flint found in Lisbjerg Skole in pit A2247, together with Oxie ceramics, could also be interpreted as a copy of a jade axe of the Durington type (Skousen 2008, p. 131). Furthermore, there are a few examples of pointed butted axes of diabase with an oval cross section and a perforation through the butt, which also points towards a clear jade axe imitation. Some rare examples of copper flat axes like the ones from Pilegård and Vester Bedegadegård can also be interpreted as copies of jade axes (Klassen 2000). However, the imitation of jade axes into local materials does not necessarily represent a direct contact with any agrarian societies. It could simply represent a new hafting method, where the shape was linked to the shape of jade axes. It is therefore questionable whether jade axes, together with the local imitations, really represent the coming of an agrarian society. But, recent investigations into the radiocarbon dates of new evidence of agriculture in Southern Scandinavia document the introduction of pointed butted flint axes, domesticated animals and cereal cultivation during the period of 4000–3700 cal BC, thus arguing for the synchronous introduction of both jade axes and agrarian societies.

Flint mines – incoming farmers

The distribution pattern of the jade axes in Northern Europe could easily be interpreted as a classical down the line exchange pattern, where limited interaction between farmers and hunter–gatherers would have occurred. However, it is more likely that the distribution of the jade axes reflects an exchange pattern between the higher ranking societies in Europe, where the ideas and knowledge of agriculture could spread alongside these axes. This argument gains weight by investigating distribution of the few jade axes together with the local imitations in flint and other local materials, as they present a much denser distribution at inland habitation sites on easily worked arable soils. Generally, there seems to occur a change in the settlement pattern around 4000–3800 cal BC, where previously uninhabited inland areas in regions like the Fallbygden area, the inner part of Scania, Bornholm and the northern parts of Funen and Jutland are suddenly settled (Sørensen 2012). This settlement change could reflect pioneering farmers settling on easily worked, arable soils.

Maybe it was not only the ideas which spread alongside the jade axes, but also actual people who had produced, seen and owned jade axes? The few ^{14}C dates of charcoal found in the flint mines at Hov in Northern Jutland and Södra Sallerup in Scania suggest systematic flint mining activities from 4000 cal BC onwards. These Southern Scandinavian mines produced pointed butted flint axes and were partly contemporaneous with other flint mines in Central Europe and Britain (Sørensen and Karg 2012). Deep flint mines were a characteristic feature of the Central European Michelsberg Culture (4400–3500 cal BC) and it is possible that this technical knowhow was introduced in Southern Scandinavia by migrating farmers from Central Europe. These pioneering farmers could have brought with them a whole package of the agrarian technocomplex – including Alpine jade axes.

Concluding remarks

The many imitations of different types of jade axes produced in local raw materials clearly support the interpretation that the axes constitute an important artefact group within the Mesolithic and Neolithic transition in Southern Scandinavia. It is also clear that jade axes can be interpreted as a kind of mediator of agrarian ideology, which followed the expansion of agrarian societies from Central to Northern Europe. However, a petrographic study on the jadeite from Central America is necessary in order to exclude a Caribbean origin of some of the jade axes found in Europe.

The potential of finding jade axes within the museum collections in Southern Scandinavia is still possible. During a research stay at the Historical Museum in Stockholm, the author found a potential jade axe from Scania, but unfourtunately without any context and from an unregistred antique collection. A greater surprise, also from the Historical Museum, was a thin adze of a non-local, green stone material

Figure 3. Adze of a non-local green stone material from Växjö in Småland. Stockholms Historiska Museum (SHM 12628). Photo: Lasse Sørensen and Jens Lauridsen.

from Växjö in Småland (Figure 3) and of very similar material and shape to an adze of nephrite from Hallwillersee in Switzerland (Pétrequin *et al.* 2012b, p. 193). Petrographic studies are necessary to clarify the exact origin of the material used for the Växjö adze. Generally, the number of Alpine jade axes in Southern Scandinavia are still very few and their context is still questionable. Hopefully, we will find 'the smoking jade axe' within a secure archaeological context in the future.

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Axes of Alpine jade from southern Scandinavia and northernmost Germany

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This short contribution summarises the present state of knowledge regarding axes of Alpine jade in southern Scandinavia. Origin, age, exchange and importance to Neolithic societies in the North are discussed and it is argued that several of the axes were genuinely deposited in southern Scandinavia during the Neolithic. These axes therefore represent Neolithic trans-European exchange. It is furthermore argued that the place of origin and circumstances of extraction of the jade itself, could have given rise to specific ritual behavior related to the life and deposition of the axes.

Keywords: Alpine jade axes; southern Scandinavia; exchange

With one exception, axes of Alpine jade were not recognised in southern Scandinavia before the late 1990's (Klassen 1999). Since then the number of registered (certain or possible) artefacts found in northern Germany, Denmark and southern Sweden has risen to approximately 30 pieces. The exact number is difficult to establish due to uncertainties regarding the find location as well the lack of scientific investigations of the raw material for a number of them.

The term 'Alpine jade' is used here to denote a number of different types of rock (jadeitite, eclogite, omphacitite and also some types of amphibolite) which were used for axe production in the western Alps between the end of the sixth and the first half of the third millennium BC. The sources of the raw materials and their Neolithic quarries have been located at Mont Viso (Piemonte, northern Italy) and to a lesser degree at Mont Beigua (Liguria, northern Italy).

All the axes have a more or less pronounced pointed butt and an oval cross-section, except a few pieces with a rectangular cross-section (Figure 1; rectangular cross-section: type Puy). The colours range from very dark green (almost black) to very light, pale green. Around half of the finds are comparatively small with lengths of between 5.7 and 13.5 cm, while the other half measure between 13.5 and 36 cm.

Six of the finds are from Schleswig-Holstein in northern Germany, twenty-two are certainly or probably from Denmark and two are possibly from Scania (Figure 2). All the northern German finds have precise and reliable find location information, while this is only the case for around half of the Danish and Swedish finds. Many of these are in private collections. The overall distribution appears to be centred in the eastern parts of southern Scandinavia between eastern Jutland and Scania.

Approximately two-thirds of all the known finds (with and without reliable find location information) belong to a single type, the Durrington drop-shaped type (Figure 1.3-5, 7). On a European scale, the distribution map of the Durrington type shows that the exchange runs from the Alps, through the valleys of Rhône and Rhine to the present day Netherlands and from there, across north-western Germany towards Schleswig-Holstein and eastern Denmark (Figure 3).

A number of local imitations of flint, copper and greenstone also testify to the presence of these artefacts in prehistoric Scandinavia (Klassen 2010). Due to these imitations, it is possible to substantiate that the Alpine axes in southern Scandinavia must be dated to the Early Neolithic and not to the Late Mesolithic as initially thought. Some of them might have been introduced by immigrating groups of farmers at the time of neolithisation, as is discussed in relation to the English and Scottish Alpine axes. At this point in time, these axes would already have been very old. In one case, it is possible to demonstrate that an axe type that went out of production in the Alps around 4500 BC, was imitated in Denmark as late as in the late Early Neolithic (EN II), when the Alpine axes had been in circulation for at least 1000 years (Klassen 2010).

None of the known finds have any recorded find context. This is almost certainly not just resulting from the lack of reliable find location information, but also reflecting the fact that the axes were generally not deposited in graves (with a few notable exceptions) or 'lost' in settlements. On the contrary, the European evidence suggests that we are dealing with sacred objects that belonged to supernatural powers and therefore could not be owned by men. They were probably exchanged between elites across Europe and deposited at specific sites of ritual significance

Figure 1. Axes of Alpine jade from Denmark and Scania. 1, 2 Zealand, unknown find location; 3 Højsgård, Tulstrup parish, eastern Jutland; 4 Denmark, find location unknown; 5 Lolland-Falster, find location unknown; 6 possibly South Funen, find location unknown; 7 possibly south-western Scania, find location unknown. 1,2,6,7 are jadeitite; 3 and 6 are eclogite (?); 4 is amphibolite (?); 1 Chelles repolie type; 2 and 6 Puy type; 3–5 and 7 Durrington type. Scale in cm. Photos: Aarhus University, Department of Culture and Society, Department of Photo and Media, Moesgård. Plate assembled by Louise Hilmar, Moesgård Museum.

Figure 2. Distribution of axes of Alpine material in Denmark, southern Sweden and northern Germany. Areas south of the Elbe River have not been not mapped. Filled squares indicate precise find location information is available, open squares indicate no precise find location information available, approximate location indicated. Map: Lutz Klassen.

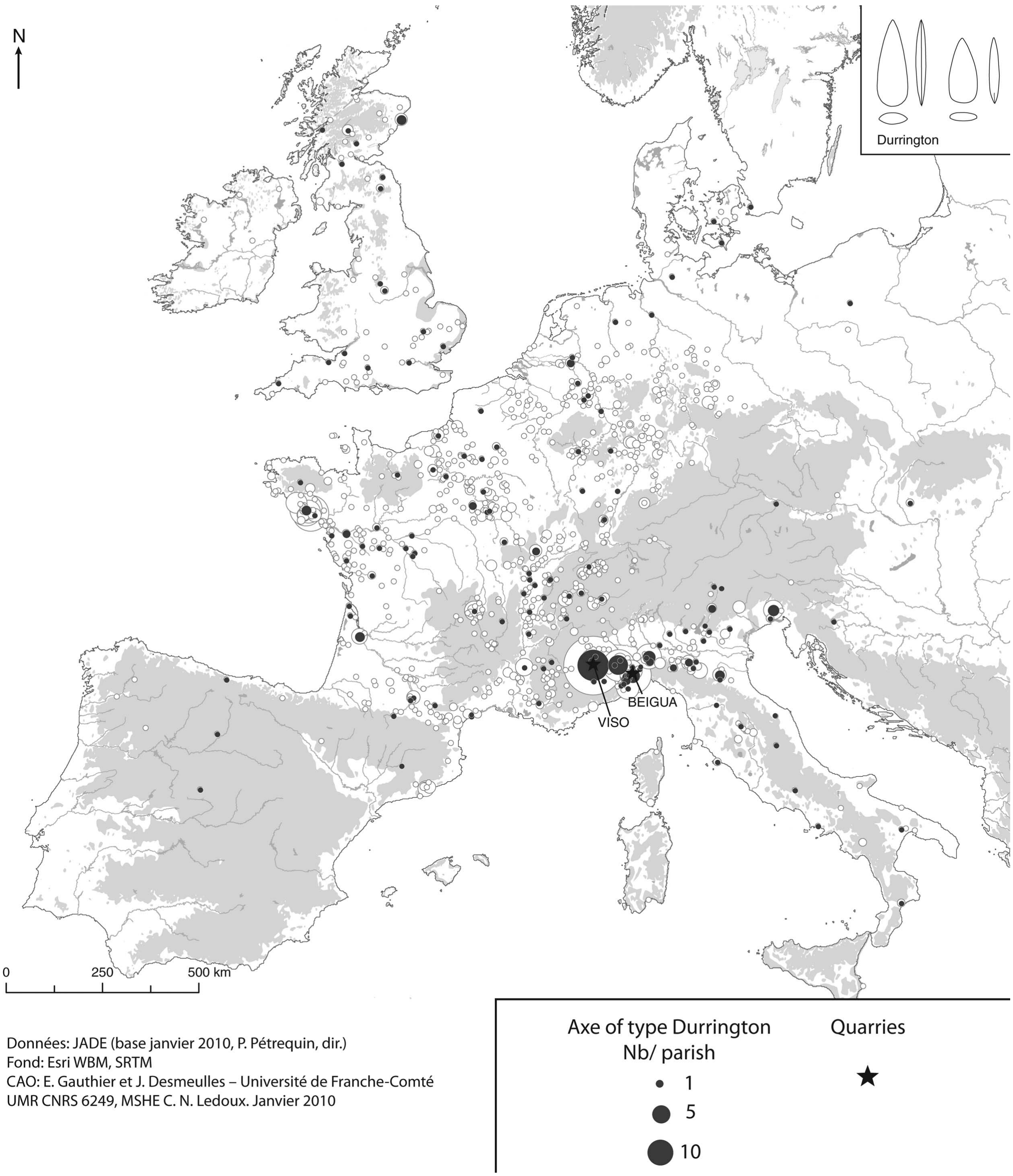

Figure 3. The distribution of Alpine axes of type Durrington in Europe. Only axes larger than 13.5 cm have been mapped. Large axes of Alpine material of other types are indicated by open symbols. The origin of the axes at Mont Viso and Mont Beigua in northern Italy is indicated. Map: Project JADE, Pierre Pétrequin (dir.), E. Gauthier, J. Desmeulles.

in the landscape on special occasions. The fact that at least two locally made imitations of Alpine axes from Denmark are of copper, which itself had to be imported from the north Alpine region, testifies to the enormous importance these objects must have had for the Early Neolithic societies in southern Scandinavia.

Being true objects of power, specific ritual beliefs were intimately tied to the axes of Alpine jade and circulated along with the axes throughout Europe. Several of these beliefs certainly derive from the source of the raw material itself. This is indicated by a large number of ethnographical observations, including in the quarries of New Guinea, which indicate that Mont Viso is likely to have been considered a holy mountain by the Neolithic groups exploiting its jade resources. Other beliefs were probably attached to the axes during the life history of the objects. Specific rites of ritual deposition well known from southern Scandinavian flint axes (deposition in wet places, in cracks in large rocks, in vertical position edge facing upwards, both singly or in groups and sometimes forming circles) can be observed in jade axe depositions throughout Europe in the fifth millennium BC and must be assumed to have spread to Scandinavia with the jade axes. As demonstrated by depositions of flint axes in the Single Grave Culture that followed the same rules, the beliefs maintained their importance for up to 2000 years. Finds such as that from Bjurselet in northern Sweden (a large number of axes pushed vertically into the ground and arranged in a circle) demonstrate that the specific ideas that entered southern Scandinavia with the axes of Alpine jade spread much further north in the course of time.

In the mid-fifth millennium BC, large numbers of axes of Alpine jade were re-shaped into new types in the Morbihan-area on the south coast of Brittany. They were an essential part of a new religious universe created by a few extraordinary persons, who were buried in proto-megalithic graves together with large numbers of burnt jade axes. Few of the re-shaped axes, which must have been truly extraordinary objects, left the region again. While none of these have yet been found in southern Scandinavia, local imitations still attest to their presence in this region. The rite of burning (flint) axes, as well as possibly the idea of the burial in stone chambers, probably reached southern Scandinavia with Carnac-type axes in the first half of the fourth millennium BC (Klassen *et al.* 2011).

Due to a grant by the French National Research Agency (ANR) to the JADE 2 project, it will be possible to continue research into the Scandinavian axes of Alpine jade in the coming years

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Axes of alpine jade in Denmark: the point of view of an alpine prehistorian

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This article presents the typological and chronological relationship between information derived from the central find locations for alpine jade axes around the area of Mount Viso, and the examples found elsewhere in Europe. Furthermore, by making comparisons between the composition of the hoards of alpine axes found in northwestern Europe to those located in southern Scandinavian, it is argued that the Scandinavian examples presumably reached the area via secondary centres of distribution.

Keywords: Alpine jade axes; centres of distribution; circulation; hoards

Denmark, and especially the island of Zealand, represents the northern border of the distribution of large axes of alpine jade. The two most famous finds (Fischer 1880; see contribution L. Klassen, this volume, Figure 1.1–2) have been subjected to analysis with reflectance spectroscopy (Pétrequin *et al*. 2012, pp. 440–532). The results leave no doubt about their origin in the quarries at Mont Viso in the Italian Alps, at a distance of 1200 km as the crow flies. Based on macroscopic comparison with an extensive reference collection, the same origin can be assumed for the remaining eight large axes from Denmark (Pétrequin *et al*. 2012, pp. 292–419). However, many of these axes lack information on their find location, which has lead some researchers to doubt whether these objects really represent trans-European exchange in the Neolithic. Instead, they are proposed to be recently acquired collector's items.

The Danish axes belong to well-defined types and this question can, therefore, be addressed by placing them in their European chronological, typological and spatial context. In the hoard from the island of Zealand (Hessisches Landesmuseum Kassel), an axe of the Puy type (23.7 cm) is associated with an axe of the Chelles type (36 cm, with traces of cutting). Also considered are one further axe of the Puy type (no find location information, private collection, 18.4 cm (fragment)), see Klassen (this volume) Figure 1.6) and a further two Danish axes belonging to the Bégude type (1. Haraldsted: National Museum Copenhagen, 20.5 cm, and 2. probably Magleby, Zealand: Moesgård Museum, 18.7 cm). The most frequent is the Durrington type with five examples (1. southern Jutland: private collection, 12.7 cm, 2. Hyllested, Zealand: National Museum Copenhagen, 12.8 cm, 3. Lolland-Falster (?), Lolland-Falsters Stiftsmuseum Maribo, 17.2 cm (see Klassen (this volume), Figure 1.5), 4. no find location information: Horsens Museum, 15.1 cm (see Klassen (this volume) Figure 1.4) and 5. no find location information, Besançon, 17.3 cm). The following picture emerges when we return to Mont Viso in the Alps and look at the chronology and distribution of these axe types (Pétrequin *et al*. 2012, pp. 574–727, 623, Figure 49):

The production of large jade axes begins at the end of the 6th millennium BC. At the beginning of the 5th millennium BC, the most common type in northern Italy was the Bégude type (torpedo-shaped with round cutting edge). It reached southern France and the Morbihan, where it was associated with the oldest of the giant tumuli in the Carnac region, shortly before the mid-5th millennium BC.

From 4500 BC onwards, new types dominated the exchange towards the north-west: the Altenstadt type (large, flat, symmetrical and triangular in shape) and the Durrington type (somewhat thicker water drop-shaped axes, see Klassen (this volume), Figure 1.3–5 and 7). At this point in time, a 'Europe of jade', as opposed to a 'Europe of copper and gold', emerges and England, Scotland and Germany are included in the distribution area of jade axes.

In northern Italy, the Puy type (compact axes with rectangular cross section and sub-rectangular cutting edge, see Klassen (this volume) Figures 1.2 and 6) displaces the earlier types after 4300 BC. Oversized axes of this type seem to appear in southern France and Germany at the turn of the 5th to the 4th millennium BC and replace the Altenstadt axes.

Until now, we have been concerned by exchanges from the production centre, the Mont Viso and to a lesser degree,

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the Mont Beigua, towards the periphery of Western Europe. But there were also secondary centres of redistribution where the alpine types were modified by repolishing in order to obtain thinner axes of new, original shapes. The secondary preparation of the axes appears in the Paris Basin, but primarily in the Gulf of Morbihan, which attracted the largest axes of jadeitite. Here the axes were repolished in order to obtain the so-called Carnac-type axes. Some of the Carnac-type axes have subsequently been re-injected into circulation, as were other older, repolished axes (f.ex. re-polished axes of the Bégude type). These axes reached the Atlantic coast of Portugal, as well as the centre of the European continent in Switzerland and, additionally, many parts of Germany, where their circulation is connected to the appearance of the first *menhirs* and *stelae* in the second half of the 5th millennium BC (Pétrequin *et al*. 2012, pp. 1015–1045).

In this context, the Danish jade axes raise some serious problems as the Bégude type, the oldest type, is represented by two pieces. It is difficult to imagine that these have arrived in Scandinavia in the mid-5th millennium BC without intermediary points of diffusion. Furthermore, the Durrington type is normally associated with the Altenstadt type but in Denmark this is not the case. Therefore, from an alpine point of view, the association of the types observed in Denmark neither equates to that of northern Italy nor, more regionally, to that of north-western Europe. This observation could lend support to the theory that Alpine jade axes never circulated as far as southern Scandinavia.

However, the matter is more complicated. The composition of the hoard of two large axes of jadeite from Zealand does, in fact, conform completely with other hoards from western Europe at the transition from the 5th to the 4th millennium BC. Furthermore, in a second peripheral region of Europe, the Netherlands, an association of 'old' axes of the Durrington type with that of 'young' axes of the Puy type also can be observed. Here the Altenstadt type, which is very frequent in Germany, is very rare. Another factor is the European distribution of the Durrington type (Klassen (this volume) Figure 3) which allows us to identify an exchange between the northern Paris Basin and the southern part of Denmark on a path west and north of the distribution of the Altenstadt axes in Germany.

The impression is therefore, that most of the axes of alpine jade known from Denmark reached the region from secondary centres of distribution, like the Paris Basin, without any direct connection to the areas of large concentrations of jade axes at the end of the 5th millennium BC (as f.ex. Germany or Great Britain). The influence of the Morbihan and the axes of Carnac type are without any doubt present in Denmark as attested by imitations made of local types of rock and flint (Klassen *et al.* 2011).

In other words, if the axes known from Denmark were no more than recent acquisitions from the antiquities market, the represented types certainly would have been dominated by those that are most frequent in Europe (Altenstadt, Puy). This obviously is not the case.

It is not possible, within this short contribution, to comment on the context of circulation of alpine jade axes and the values attributed to these exceptional objects, which are dominated by religious concepts and social functions. The reader is referred to the recent monograph covering this topic (Pétrequin *et al.* 2012).

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Isotopic investigation of human provenience at the eleventh century cemetery of Ndr. Grødbygård, Bornholm, Denmark

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Bornholm is a Danish island almost in the center of the southern Baltic Sea. The strategic location of the island, its rich archeology, and its complex geology make it an intriguing location for the isotopic study of past human mobility. The focus of this study is on the large cemetery of Ndr. Grødbygård in the southern part of the island, which dates to the eleventh century AD and contains 553 individuals in 516 graves. The majority of the burials were in a supine position oriented west–east, with the heads to the west, following the tradition of that time. In contrast to the Christian traditions, however, the graves at Grødbygård were richly equipped by Scandinavian standards and some of the burial practices more closely resembled those from the Western Slavic region of the south (present day northeastern Germany and Poland). We have used isotopic analyses to examine the external relations and potential places of origin of the inhabitants of the cemetery. Strontium and oxygen isotope ratios in human tooth enamel provide a signature of place of origin and can be compared to the ratios of the place of burial to determine local or non-local origins. In the case of Bornholm, the local geology is quite complex, with a variety of rocks of different age and composition, resulting in a wide range of strontium isotope sources on the island, complicating the issue of identifying migrants. At the same time, Grødbygård provides an important example of the application of such methods in less than ideal conditions.

Keywords: strontium isotopes; oxygen isotopes; carbon isotopes; migration; archeology; Baltic Sea; bioavailable; bioarcheology; human remains

Late Viking Age/Medieval Bornholm

Bornholm is a small island in the Baltic Sea (Figure 1). It is the easternmost island of Denmark, located to the south of Sweden and north of Poland. The island is roughly trapezoidal in shape with dimensions of approximately 25 km east–west, 30 km north–south. Bornholm is 587 km^2 in area and has a coastline of roughly 140 km in length. The population today is slightly more than 42,000 people. The closest landfall is the southern tip of Sweden, 38 km to the northwest. The capital of Denmark, Copenhagen, lies 150 km to the west. The coasts of Kaliningrad, Lithuania, and Latvia lie further to the east. The topography of the island consists of dramatic rock formations in the north, sloping down towards pine and deciduous forests and farmland in the center, and sandy beaches to the south. Most of the northern three-quarters of the island is a plateau, composed of Precambrian magmatic and metamorphic rocks, with elevations above 100 m. The castle ruins of Hammershus on the northwestern tip of the island are those of one of the largest medieval fortresses in northern Europe, testimony to the importance of the island's strategic location.

In the Viking Age and in the Middle Ages, Bornholm's position on the sea lanes connecting Scandinavia with the southern and eastern coasts of the Baltic made the island a well-known place to the merchants, sailors, and travelers. The eleventh-century German chronicler, Adam of Bremen, noted that the island was 'the most celebrated port of Denmark and a safe anchorage for the ships that are usually dispatched to the barbarians and to Greece' (Adam of Bremen, Book 4, p. 16).

In the light of archeological sources, Bornholm appears as not only a convenient stop on Baltic Sea routes, but also a place involved in the contemporary political and economic activities of the region. The overseas contacts of the Bornholmers, related to trade, warfare, or migration, seem to be extensive. The evidence from a large number of English coins issued at specific mints found in the silver hoards on the island points toward Bornholmers' participation in the Viking raids on England (Von Heijne 2004,

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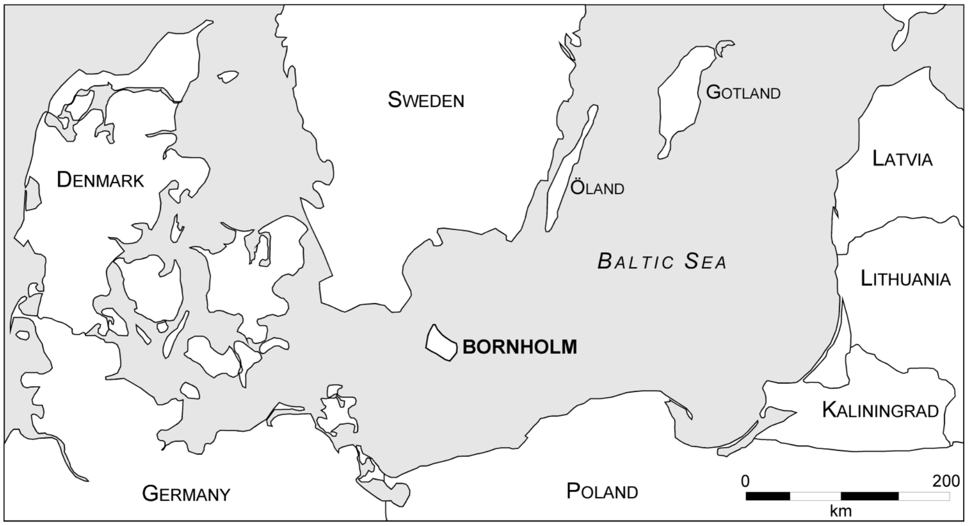

Figure 1. Bornholm and its neighbors in the southern Baltic Sea.

pp. 134–135, Ingvardson 2012). Numismatic sources (numerous hoards and single coins found in the context of settlement sites) also indicate close trade connections with the Saxons and Slavs along the southwestern coasts of the Baltic (Watt 1988, Von Hejine 2004, p.24).

The runic scribes working on the island in the eleventh century used styles characteristic of central–Swedish runic art, perhaps indicating direct personal contacts with provinces of Västmanland and Uppland. Other archeological sources from the island point to the eleventh century immigration of people from the Slavic-speaking areas south of the Baltic Sea (Naum 2008). To add to this picture of complex interactions to the north, west, and south, one also has to consider the eastern orientation of Bornholmers' travels and interests, although these are more difficult to document from the archeological and historical record.

Despite extensive travel to and from the island and its strategic position, contemporary writers had very little to say about Bornholm. One of the earliest pieces of information comes from Wulfstan, a traveler who was sent by king Alfred the Great around the year 880 to explore the Baltic Sea. Wulfstan describing his journey from Hedeby to Truso notes that Bornholm, or Burgenda-land, as he calls the island, had a king of its own. Wulfstan's remark about the island's self-rule, as well as the longevity of Bornholm's independence, continues to ignite debates among archaeologists and historians (e.g., Randsborg 1980, p.163, Nielsen 1998, Lihammer 2007, pp. 261–262).

Another interesting historical reference regarding Bornholm's position and political status comes from the pages of *Gesta Hammaburgensis Ecclesiae Pontificum,* written by Adam of Bremen. In his description of the island, he describes the official conversion of the island to Christianity, which, according to the author, happened in the 1060s. In Adam's words, Egino, the Archbishop of Lund, won the islanders to Christ, moving them to tears with his preaching and he made them destroy their idols and recognize their errors, which they did immediately and without hesitation (Adam of Bremen, Book 4, p. 8). Although this description might be rhetorical exaggeration, Adam's words nonetheless are an important indication that at least from the second half of the eleventh century the process of strengthening ties with the Danish kingdom and the institutionalization of the Church had begun on the island. Adam, who spent some time in Denmark as a guest of the king Sven Estridsen (ruling between 1047 and 1074) had first-hand knowledge of these events.

The cemetery of Ndr. Grødbygård

More helpful information for understanding Viking and medieval Bornholm comes from archeology. Some of the most exciting excavations in the years have involved three cemeteries dated to the end of the Viking Age and the early Middle Ages (AD 900–1100), in the southern part of Bornholm (Watt 1985, Wagnkilde and Pind 1996, Wagnkilde 1999, 2000, 2001, Naum 2008, pp.179–253, 2009). The discoveries made at Runegård, a small burial ground most likely used by a single extended family, and the excavations at the much bigger, communal cemeteries of Ndr. Grødbygård and Munkegård provide clues about the process of Christianization on the island, and the potential tensions that was created (Naum 2007). Moreover, the evidence reveals the particular character of eleventh century burial customs on the island, and invites interpretations about possible immigration to the island.

The cemetery at Ndr. Grødbygård warrants particular attention. It is the largest totally excavated early medieval

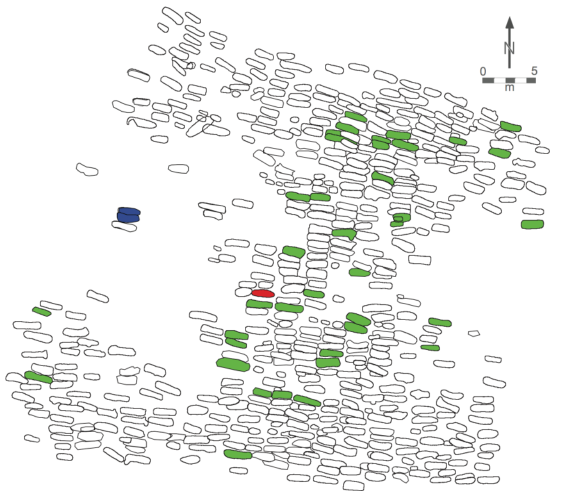

Figure 2. The cemetery at Ndr. Grødbygård The two large shaded areas represent structures at the site predating the cemetery. The graves with dark fill were sampled for strontium isotope analysis. The dark isolated grave in the left center of the plan has the highest strontium isotope ratio of the sampled individuals.

burial site on Bornholm. The cemetery is located in Aaker parish in the southern half of the island not far from the coast. Approximately, 553 individuals were buried there in 516 graves covering an area of 2275 m^2 (Figure 2). The cemetery was excavated between 1986 and 1993 (Wagnkilde and Pind 1996, Wagnkilde 1999, 2000, 2001) and has been dated to the eleventh century (ca. AD 991–1074?) AD by coins and other objects in the graves. A total of 123 coins were found in 61 graves with dates from AD 985–1074.

Although no archeological traces of a church were found, it is likely that such a structure was originally present at the site. Other features of the cemetery also point to a Christian tradition of burial. Similar to other medieval cemeteries in Scandinavia, Ndr. Grødbygård was a row-grave burial ground, divided into two zones – a northern female zone and a southern male one. Children's graves were found in both zones and a few were grouped in the central part of the cemetery in the liminal space between the female and the male graves.

In spite of the large number of burials in the cemetery, the preservation of human skeletal remains was very poor and relatively little anthropological information is available. In most cases only the teeth, some parts of the skulls and very few other bone fragments remained. Tooth enamel is largely composed of the mineral apatite, an inorganic material, and is the most durable tissue in the skeleton. Most information regarding the individuals in the cemetery is the result of the odontological study by Torben Pind (Wagnkilde and Pind 1996, Wagnkilde 2000).

Sex and age determinations for the population from Ndr. Grødbygård are based largely on the protuberant aspects of the badly damaged skulls such as occipital, frontal, temporal, and mastoid parts. In the material, sex could be determined for only 254 of the 553 skeletons, with 56% males and 44% females. It is rather usual to find more male than female skeletons in a medieval cemetery, and again poorer preservation at Ndr. Grødbygård of the more fragile female remains may be a factor.

It was possible to estimate the age of only 82% of the individuals recorded in the cemetery. Of those, 167 individuals (15%) were non-adults and 386 were adults. Some of the burials were without any physical remains, but the length of the grave could be used to suggest an adult or a non-adult context. As commonly seen in medieval cemeteries, only very few individuals belonged to the oldest group, senilis, more than 45 years of age. The small percentage of non-adults is certainly not representative of the actual number of children and young people in the population at Ndr. Grødbygård, and may be a function of the very poor conditions of preservation. In some other medieval burial populations, up to or more than 50% of the non-adults have been reported, a number which is actually recorded in some of the first church registries in the Aaker Parish at Bornholm during the seventeenth century (Vensild 1996). At other known medieval cemeteries, the average age of women was somewhat lower than the average age of men. The calculation of average age is usually rather inaccurate, but of those who reached adulthood, 18–20 years, most had less than 20 years left to live.

Based on the number of burials, the age distribution in the cemetery, and the length of cemetery use, this churchyard might have served a once-living population of some 300 individuals or 20–25 farms (Wagnkilde 1999). Most of them seem to be local, but some of the interred may also have come from other parts of Bornholm, or indeed abroad. The majority of the burials were oriented west–east, with the heads to the west and most were placed in a supine position, reflecting the Christian ideas of preparation for resurrection and a readiness to see Christ appearing in the east. The custom of placing the deceased in coffins was fairly common and appeared in more than half of the burials. In some cases arrangement of the bones could suggest that the dead person was wrapped in a shroud. The uniformity of the graves and the presence of iron pins and buckles in a number of the graves, likely used to hold the shroud together, suggest that wrapping of the body was a common feature of burial at Ndr. Grødbygård.

Ndr. Grødbygård is distinct from Danish or Scanian eleventh century cemeteries (although consistent with other contemporary burial grounds on Bornholm) in the custom of burying the deceased equipped with jewelry and common tools. More than half of the graves (about 63%) contained elements of dress such as jewelry, metal parts of garments, simple tools, and everyday objects (knives,

Figure 3. Grave 210 at Ndr. Grødbygård.

whetstones, sewing needles, and less often spindle whorls and tweezers, pottery) and other grave gifts (Figure 3).

Other traces of rituals, like food preparation and consumption, associated with funerals and commemoration of the dead, were also observed. These took the form of burnt animal bones in the fill of the graves, in cooking, and other pits recognized in the cemetery area, that were filled with burnt organic material and with potsherds. While some of these are of earlier date, others were contemporary with the burials, as indicated by the finds of potsherds of Baltic ware produced on the island between the eleventh and the thirteenth century AD.

Another interesting feature at Ndr. Grødbygård is the stratigraphic superpositioning of the burials, and the occurrence of clusters of graves with the interred provided with similar sets of objects (Naum 2008, pp. 235–242). While the overlapping of graves is not unusual in the context of medieval cemeteries and is frequently observed at crowded town churchyards, it is less common at rural graveyards. In case of Ndr. Grødbygård, the fact that some of the individuals buried close to one other were given similar objects and buried in a similar manner may indicate that at least some of these clusters represent family groupings.

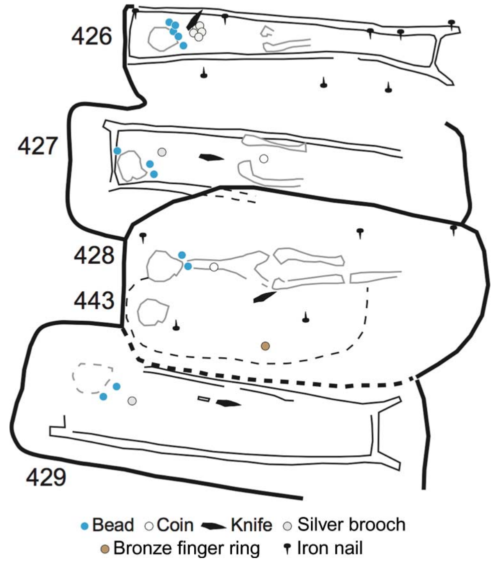

Figure 4. Grave Cluster 426–429, 443, at Ndr. Grødbygård.

One such cluster was made up of five female graves located in the central part of the northern zone of the cemetery (graves 426–429, 443). In the three overlapping graves, the women were given almost the exact same grave goods, consisting of beaded necklaces including the same type of silver beads in two graves, knives (one in a mounted sheath), and coins (Figure 4). In another group of graves 613, 617, 618, 619, and 621, the adult women (613, 617, 618, and 619) were wearing beaded necklaces (beads were found underneath their chins). Three of them were buried with brooches for fastening clothing and three of them were given knives. Two of these women, buried last in this group, were also given iron needles, which in the case of the woman interred in grave 613 was placed inside her mouth.

Yet, another distinct cluster of four burials was observed in the western part of the cemetery, cutting through the remains of an older house, and spatially isolated from other interments. Burials in this grouping (77, 78a, 78b, 219) lay very close to one other. Two of them involved the stratigraphically older burial of an adult (78b) beneath the largely destroyed burial of a 11–12 year-old child (78a); the child had been put in a coffin and buried on top of the adult. The graves of these two individuals were lined up and covered with stone slabs, suggesting perhaps that the buried individuals might have been members of the founding family of the church (?) or cemetery or considered as different by the community using the cemetery due to some other factors. The only object found in these burials was an iron knife placed under the left arm of the person in grave 78b. Some contemporary potsherds were found in the soil covering graves 219 and 78a (Figure 5).

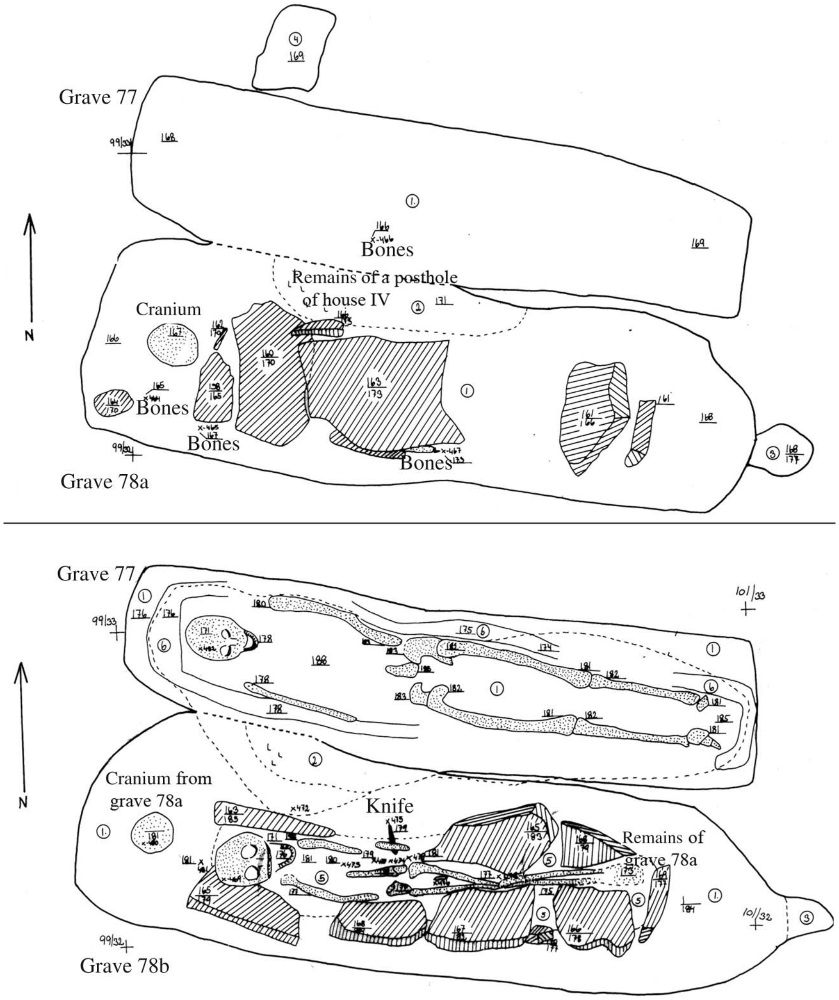

Figure 5. Upper and lower excavation levels of the graves 77, 78a, and 78b.

Ndr. Grødbygård and external connections

Towards the beginning of the twelfth century AD, most of the churchyards in southern Scandinavia, particularly those associated with urban centers, show a uniform pattern of burial in which the dead were swaddled and placed in wooden coffins without clothing, goods, or gifts (Kieffer-Olsen 1997). Against this background, Bornholm's early medieval cemeteries (ca 1000–1100 AD), including Ndr. Grødbygård, appear unusual. The material evidence of rituals and norms of practice required to complete a proper funeral might be a reflection of a lingering continuation of pre-Christian ideas about dying, death, and afterlife. Such a blend of Christian practices (the use of coffins, the orientation of the graves, the existence of separate female and male zones) with pre-Christian traditions (the deposition of tools, vessels with food, and perhaps commemorative feasts) may be due to the relatively recent arrival of Christianity on the island or a relatively weak impact of missionary efforts in this place (Naum 2007).

Material remains of ritualized practices at the Ndr. Grødbygård cemetery raise attention for yet another reason. Not only are the graves richly equipped by contemporary Scandinavian standards, but the sets of objects and the way they were treated and placed in some of the graves resemble the funerary customs in the eleventh century Western Slavic region in modern northeast Germany and Poland (Naum 2004, 2008, 2009). The most visible elements of foreign culture are the amulets and female jewelry. A number of burials located in the female zone had head ornaments of beads (made of silver and other materials). Their use as head ornaments is supported by the fact that they were found by the ears and temples of the interred or collected during the excavation of the crania. Similar beads in the form of a necklace were also found under the mandible in other graves.

The custom of wearing head decoration in the form of a headband or a scarf with attached rings or sewn-on beads is regarded as Slavic, and does not seem to have been practiced in the Viking Age/Medieval Scandinavia. Most of the silver beads found at Ndr. Grødbygård (interpreted as parts of the head ornaments or located in different parts of the body/grave) came from earrings or beaded necklaces produced by Slavic silversmiths.

Other pieces of jewelry that are connected with the Slavic practice of body decoration include temple rings (i.e., thin rings attached to a headband or scarf, found in two separate graves) and a tabular amulet, the so-called *kaptorga*. Besides female jewelry, knives in bronze-mounted sheaths and a particular way of depositing pottery, namely the custom of breaking a pot into sherds and placing a single sherd or a selection of pieces next to the body, seem closer to Slavic practices than Scandinavian ones (Naum 2008, pp. 190–196, 227–232). These objects and practices were observed in about 16% of Ndr. Grødbygård burials (Figure 6).

The possibility of Slavs buried at the Ndr. Grødbygård cemetery gains credence when considered in the context of other archeological sources from the island. In the eleventh century AD, there was a dramatic change in the technology and style of pottery production in Bornholm. The local hand-made, undecorated, and rather uniform pottery was replaced by ceramics made on a turning table, decorated with incised designs, and produced in a variety of new forms (Watt 1988, Nielsen 1998, Naum 2008, pp. 85–146, 2012). The new style of pottery, the so-called Baltic ware, was inspired by the late medieval Slavic ceramic production. Its swift adoption and similarities with Slavic pottery, as well as lack of evidence for experimentation with the new technology and style prior to its widespread production, suggests that it was made by the Slavic potters.

Migration is also possible in the light of contemporary political events around the Baltic Sea. From the early tenth century AD until the end of the twelfth century AD, the Slavic groups occupying the coastal zone of the Baltic Sea (the Obodriti, Veleti/Liutizi and Pomeranian tribes) were drawn into a struggle for independence and survival against their ambitious and expansive neighbors in the German and Polish kingdoms. Harsh economic and political conditions forced many of them into exile. Considering the trading activities that connected Bornholm with the southern coast of the Baltic it is possible that these previously established contact networks and routes were utilized by the refugees in their flight.

Figure 6. Some of the finds associated with Slavic workshops and funerary practices found in Ndr. Grødbygård graves: (A) remains of a tabular amulet (kaptorga) and a silver bead from grave 28; (B) Baltic ware pot and bronze knife sheath mounting from grave 496; (C) potsherd and fragment of a bead from grave 542; (D) knife sheath mounting from grave 243; (E) clover-shaped silver bead from grave 426; and (F) silver bead pendant and bead from the so-called basket shaped earring from grave 627.

Even though Slavic settlement on the island can be traced through the archeological finds usually associated with Slavic culture, the straightforward interpretation of these artifacts as tokens of Slavic migration to the island can be problematic. Taking into consideration the mobility and trading activities of the Bornholmers, their orientation towards the sea, and their exposure to foreign customs and material culture, one has to consider that some of these objects functioned simultaneously in cultural worlds of both the Slavs and the islanders.

Strontium isotope analysis

Correlation of material culture with the identity of its makers and tracing human movements unrecorded in historical sources are difficult problems in archeology. In the recent years, the application of bone chemistry analyses, especially isotopic studies, has provided a means for directly assessing the place of origin of human skeletal remains, and can be used to answer certain questions concerning migration in the past (e.g., Montgomery *et al.* 2003, Price and Gestsdottir 2006, Price *et al.* 2011, Montgomery 2010) The application of strontium isotope analysis to the human skeletal material from the cemetery at Ndr. Grødbygård offers a means to evaluate such questions.

Strontium isotope analysis provides a robust method for examining human mobility in the past, and in tracing the first generations of immigrants. The principle is straightforward. The strontium isotope ratio of $^{87}Sr/^{86}Sr$ varies among different kinds of rocks. Because ^{87}Sr forms through a radiogenic process from rubidium-87 over time, in general, older rocks with more rubidium have a higher $^{87}Sr/^{86}Sr$ ratio, while younger rocks with less rubidium are at the opposite end of the range with low ratios. Sediments reflect the ratio of their parent material.

Strontium moves into humans from rocks and sediment through the food chain (Sillen and Kavanagh 1982, Price 1989). Strontium substitutes for calcium in the formation of the human skeleton and is deposited in bone and tooth enamel. Tooth enamel forms during early childhood and remains unchanged through life and commonly after death. A number of studies have demonstrated the general robustness of enamel in a variety of burial contexts and in the survival of biogenic ratios over time (Budd *et al.* 2000, Lee-Thorp and Sponheimer 2003, Schoeninger *et al.* 2003). Values in human tooth enamel that differ from the place of burial usually indicate that the individual moved from one geological terrain to another during their lifetime. Analytical methods are described in detail in several publications (e.g., Sjögren *et al.* 2009, Frei and Frei 2011).

An essential question regarding strontium isotope analysis concerns the local strontium isotope signal for the larger region in which the cemetery is located. This baseline information on isotope values across an area needs to be obtained in order to make useful and reliable statements about the origin of the human remains under study (Price *et al.* 2002, Frei and Price 2012). There are two major sources of isotopes for human consumption: marine and terrestrial. Marine foods everywhere share the same isotopic value of 0.7092, which is also the value of seawater (e.g., Vezier 1989).

Terrestrial sources vary according to bedrock and surface sediments. Strontium moves from rocks and sediments into plants, animals, and human tissue through the food chain. Although local levels of elemental strontium in plant and animal tissue vary due to many factors (e.g., Burton and Wright 1995, Burton *et al.* 1999), the $^{87}Sr/^{86}Sr$ value is not changed (fractionated) by biological processes because of the very small relative mass differences of the strontium isotopes (Blum *et al.* 2000, Faure and Mensing 2004). The strontium isotope compositions of plant tissues and the bones and teeth of animals and humans thus match to those of the nutritional intake of the individuals, which in turn is *assumed* to reflect the strontium isotope composition of the local geology.

In actual fact, levels of strontium isotopes in human tissue may vary in local geology for various reasons (Price *et al.* 2002). It is necessary to measure *bioavailable* levels of $^{87}Sr/^{86}Sr$ to determine local strontium isotope ratios. In the following pages we first present a very brief summary of the geology and strontium isotope sources of the countries surrounding the western Baltic. We then turn to the geology of Bornholm as an introduction to sources of strontium isotopes on the island, followed by a report of baseline bioavailable ratios. We then report the isotopic results from Ndr. Grødbygård and their implications for assessing immigration in the early medieval period on the island.

Bioavailable strontium isotopic ratios

As part of this study, we have measured various materials from Bornholm and around the Baltic in order to establish the range of strontium isotope ratios on the island and in the possible homeland areas for migrants to Bornholm. Materials we have analyzed include surface water, modern owl pellets, modern snails, archeological fauna, and prehistoric human remains. This research is summarized briefly here and the results to date are presented to place Bornholm in the larger context of Baltic strontium isotope sources.

The baseline strontium mapping of the larger Baltic area is a long-term project that is still underway. Denmark is largely completed (Frei and Frei 2011, Frei and Price 2012); there is a good bit of unpublished data from northern Germany, there is a growing body of data from central and southern Sweden, and we have some samples measured from Poland and a few from Kaliningrad. The available information from these countries and the baseline data from Bornholm are discussed below.

There is also some published information on the brackish waters of the Baltic Sea. The waters of the Baltic come from two major drainage regions to the north and to the south (Åberg and Wickman 1987). To the north, most of the waters that flow into the Baltic come off the Precambrian rocks of the Fenno-Scandinavian Shield, and have generally high strontium isotope ratios (>0.720). To the south, a large sedimentary basin from northern Germany to the Neva River near St. Petersburg provides approximately 55% of the waters to the Baltic, and a much lower $^{87}Sr/^{86}Sr$ signature. Values reported from the Vistula and Oder average 0.710 (Åberg and Wickman 1987). Andersson et al. (1992) measured Sr and Nd isotope ratios in the Baltic to study mixing of waters from river input and the sea. Strontium isotopic ratios are generally correlated with salinity in the Baltic waters. Modern $^{87}Sr/^{86}Sr$ values for the southern Baltic Sea waters are slightly variable and are somewhat higher depending on salinity, but usually fall within the range of 0.7092 and 0.7097.

Denmark

Denmark is characterized by a relatively young (geologically) and rather homogenous 'basement' geology. About 50% of the country is constructed of Late Cretaceous–Early Tertiary carbonate platforms, the other 50% by marine clastic sediments, all covered by more or less thick sequences of diverse glaciogenic sediments deposited during the two last Ice Ages. The Quaternary glaciogenic sediments are composed, among other things, of various weathered Precambrian granitoids (gneiss and granite). Almost everywhere in Denmark, the glacial deposits are the source of strontium isotopes for plants, animals, and people. There is very little bedrock exposure anywhere in the country. Frei and Price (2012) present strontium isotope ratios from samples of modern mice, snails, and archeological fauna. The $^{87}Sr/^{86}Sr$ values for faunal samples range from 0.70717 to 0.71185, with an average of 0.70919 (S.D. = 0.0011). These values increase slightly from west to east, but in general terms the geology and the strontium isotope ratios in this heavily glaciated region are largely homogeneous.

Sweden

Sweden's geology is rather complex, but generally can be divided into three main components: Precambrian crystalline rocks (which are a part of the Baltic or Fennoscandian Shield and include the oldest rocks found on the European continent), the remains of a younger sedimentary rock cover, and the formation of the Caledonides during an ancient mountain building episode in the Mesozoic era, ca. 400 mya.

The oldest rocks in Sweden are Archean (> 2,500 million years old), but these only occur in the northernmost part of the country. Most of the northern and central parts of Sweden are composed of Precambrian rocks belonging to the Fennoscandian Shield, an ancient craton of mantle rock, with generally high strontium isotope ratios. The Swedish Geological Service has measured $^{87}Sr/^{86}Sr$ across the country and reports very high rock values for most of this region, generally greater than 0.722. This rock is covered in places by glacial moraine, but is exposed intermittently to frequently on the surface. Further to the south, Phanerozoic sedimentary rocks rest upon the Precambrian shield. They are less than 545 million years old, and cover large parts of Skåne, the islands of Öland and Gotland, the Östgöta and Närke plains, the Västgöta mountains, the area around Lake Siljan in Dalarna ,and the areas along the Caledonian front in northern Sweden.

The youngest rocks in Sweden are from the Tertiary, formed about 55 million years ago. They occur in the most southerly and southwestern parts of Skåne. Quaternary deposits formed during and after the latest glaciation (when Sweden was completely covered by an ice sheet) partially cover this bedrock. Southernmost Sweden is a glaciated landscape much like the neighboring areas of Denmark ,and strontium isotope ratios should be similar as well.

The west coast of Sweden was an area of known medieval settlement. Isotopic studies there provide some information on the levels of $^{87}Sr/^{86}Sr$ in this region (Figure 7). As part of a study of inland Neolithic sites in this area, Sjögren *et al.* (2009) measured a few samples of human enamel from the sites in the coastal region. These samples exhibit substantial variation, although the sample numbers per site are too small to provide much information. Specifically, values generally range from 0.711 to 0.714 and probably reflect the local range in Bohuslän.

We also have some additional data from the southern and eastern parts of Sweden. From the east coast and Gotland we have ca. 140 samples, of which 8 are faunal. We have 10 or more samples from several sites in eastern Sweden, and the pattern of $^{87}Sr/^{86}Sr$ is similar at each site. There is a high proportion of what appear to be local values showing a continuous range and then a few significantly higher values that very likely represent individuals from inland areas or much older terrains. The site of Birka near modern Stockholm was an important Viking center and the gateway to the east. We have sampled 10 individuals from the cemetery at Birka. These values range from 0.7103 to 0.7335, with a mean of 0.7174 ± 0.0078. These ratios clearly represent a range of origins but may provide at least a rough estimate of values in this area. It is clear that the older rocks of the $^{87}Sr/^{86}Sr$ Fennoscandian Shield dominate most of Sweden and play a large role in higher values. Lower values

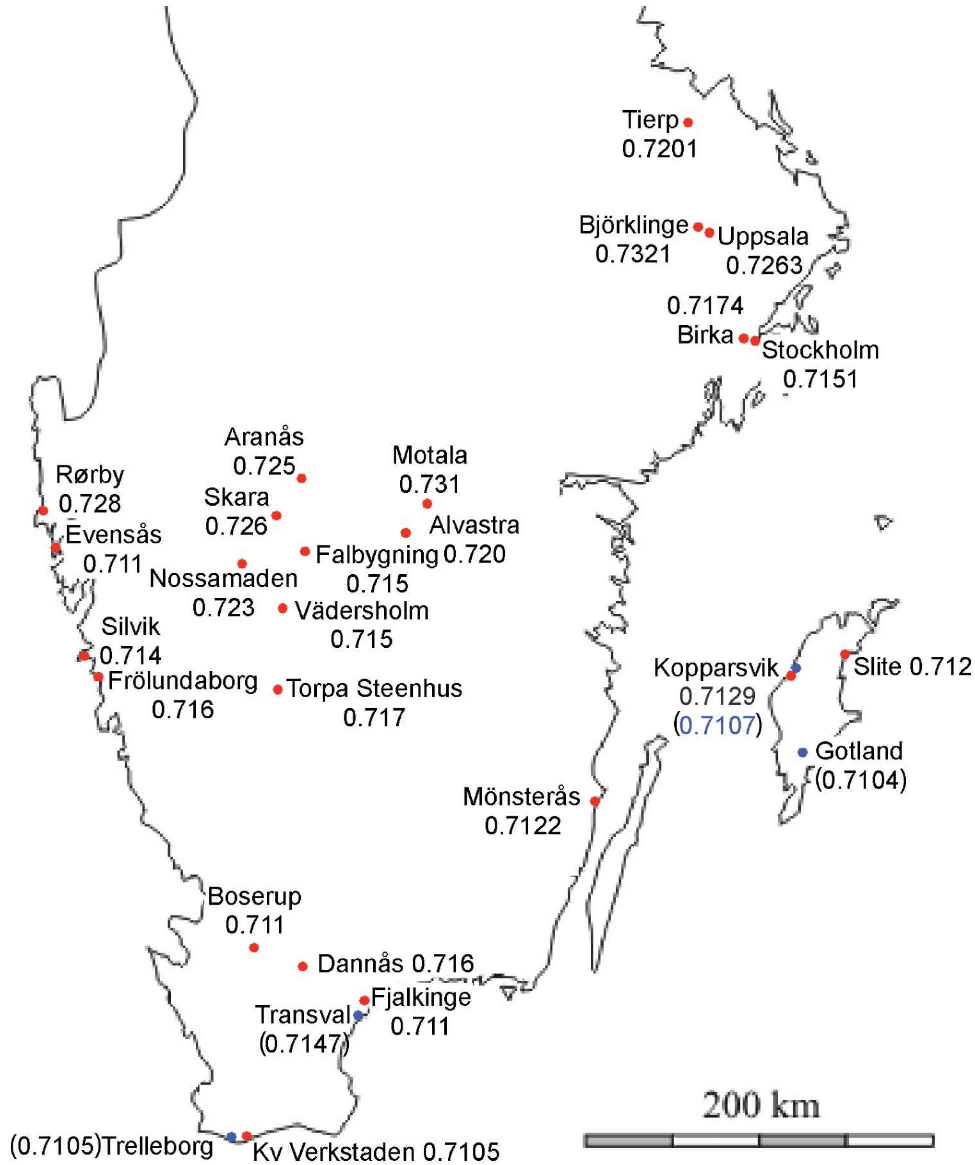

Figure 7. Averaged strontium isotope ratios from human and archeological faunal (in parentheses) samples from southern and central Sweden. Values are averaged.

around 0.710–0.711 are found largely in the southernmost part of the country in the province of Scania and on the island of Gotland in the Baltic. These data are summarized in Figure 7.

Northern Germany

There have been a significant number of strontium isotopic studies done in Germany to date, albeit the majority in the south of the country. There are some data, however, from the north. There are two major surface deposits in Northern Europe. The ground moraine and glacial deposits of the last glaciation covers the northernmost parts of Germany and almost all of southern Scandinavia. The coversand deposits of the North German Plain run east-west from the Netherlands across northern Germany and into Poland. The morainic landscape of southern Scandinavia is a mixture of rocks and sediments carried south by glacial advance and ground is into the surface of the region. The coversand region, stretching from the Netherlands across northern Germany to Poland, is dominated by aeolian sands consisting largely of reworked fluvial and glaciofluvial sediments. These coversands rest on the glaciogenic materials deposited in this region during the Late Glacial.

Gillmaier *et al.* (2009) report a series of strontium isotope samples from the North German Plain, primarily in the state of Schleswig-Holstein. The six samples are largely from archeological bone and antler and the $^{87}Sr/^{86}Sr$ values range between 0.7090 and 07096, similar to the values reported from the southern part of nearby Denmark. Strontium isotope studies of the Iron Age war sacrifices from the northern German bog of Thorsberg in the same region (Carnap-Bornheim *et al.* 2007) report similar values around 0.7090 for peat samples from the bog and the local archeological materials. De Jong *et al.* (2010) in a study of five human teeth from the Neolithic site of Eulau in the southern part of Saxony-Anhalt reported two sets of values, three teeth averaged around 0.7015 and two teeth averaged ca. 0.7133. These two distinct sets of values are likely to reflect the local landscape which is composed of glacial moraine lowlands and Paleozoic uplands in the south of northeastern Germany.

Our own studies have added more data to the strontium isotope information from Northern Europe. A number of reindeers from the site of Stellmoor near Hamburg had values ranging from 0.7092 to 0.7105. The site is located in a classic tunnel valley in the glacial landscape of northern Germany. We have also measured a number of samples of archeological fauna from the coastal site of Neustadt in Schleswig-Holstein, with results from 0.7090 to 0.7100. Data also come from the Bronze Age war sacrifices locale at Weltzin in the easternmost part of northern Germany, not far from the Polish border. At Weltzin, we see a wide range of values from 0.7080 to 0.7150 in archeological fauna and human teeth. Many of the individuals found here may well be non-locals given the context of the finds, but the three samples of local fauna (a roe deer, a black rat, and a snail) show a wide range of values, 0.7075, 0.7013, and 0.7110, respectively. The higher values seen in the rat and snail suggest that the glacial and coversand landscape in this region may have a significantly higher strontium isotope ratio than the North German Plain to the west.

In sum, much of the North German Plain, in the areas of coversand and glacial moraine has $^{87}Sr/^{86}Sr$ ratios very similar to Denmark, with values around 0.7090–0.7100. At the same time, as one moves south and east, the emerging uplands generally contain older rocks and higher strontium isotope ratios. It may also be the case that the glacial moraine and coversand in parts of the North German Plain across Poland are composed of source materials from older rocks exposed on the floor of the Baltic and transported by a glacial lobe to this region of Northern Europe.

Poland

The focus here is on northern Poland and those areas closest to Bornholm. The geology of Poland was shaped primarily by tectonic forces from the continental collision of Europe and Africa during the Cenozoic era, and by the Pleistocene glacial activity in northern Europe. Continental ice sheets moved across the northern half of the Polish landscape, leveling the terrain and leaving deep glacial deposits. The moraine landscape of northern Poland contains sediments largely of sand or loam, while the river valleys toward the south also contain loess.

There is some information available regarding strontium isotope ratios in Poland from other studies. Voerkelius *et al.* (2010) report $^{87}Sr/^{86}Sr$ for natural mineral waters, surface water, soil extracts, and wheat from various countries in Europe. Original data values and sample locations are not provided, but approximate ranges of strontium isotope ratios can be estimated from Figure 2. Soil extracts range from 0.7069 to 0.7123 with a mean value of 0.709. Surface water ratios exhibit a narrower range from 0.7078 to 0.7096, with a mean ca. 0.7085. Wheat ratios range from 0.7090 to 0.7106, with a mean of approximately 0.7100. Rossmann *et al.* (2000) report a ratio in Polish butter of 0.7088. Löfvendahl *et al.* (1990) report a value of 0.7095 for the waters of the Vistula and estimate a mean of 0.710 for the sedimentary basin of the southern Baltic Basin which includes much of the area of Poland.

To date, we have recorded only a small number of locations, shown on the map in Figure 8. Two values for a site in Figure 8 indicate the range of values in the samples from there. There is a substantial variation in $^{87}Sr/^{86}Sr$ in these samples, and we are uncertain whether the higher values in Northern Poland reflect non-local origin of our samples, taken primarily from rural medieval settlement sites (fauna) and cemeteries, or if these higher values, above 0.711, come from local sources in the terrain. In general, it appears that lower isotope ratios are more common in the north of Poland, increasing in value to the center and south of the country, where older rocks dominate a higher terrain.

Bornholm

In contrast to most of the sand or moraine regions around the coasts of the southern Baltic Sea, the island of Bornholm is made up of a number of rock formations ranging from Precambrian bedrock to Mesozoic sediments (Figure 9). Technically, the island is known as the Bornholm Block, a composite fault block. Bornholm is located within the Fennoscandian Border Zone, and the bedrock on the island is composed of a Precambrian crystalline basement of gneisses and granites outcropping to the north. A complex mosaic of fault blocks outlined by Lower Paleozoic platform sediments are found to the south, while Mesozoic sediments, largely of marine origin, occur mainly to the southwest. Upper Cretaceous deposits here consist of greensand and limestone formations made up of marine glauconitic sands, marls, clays and limestones, and conglomerates with numerous fossils.

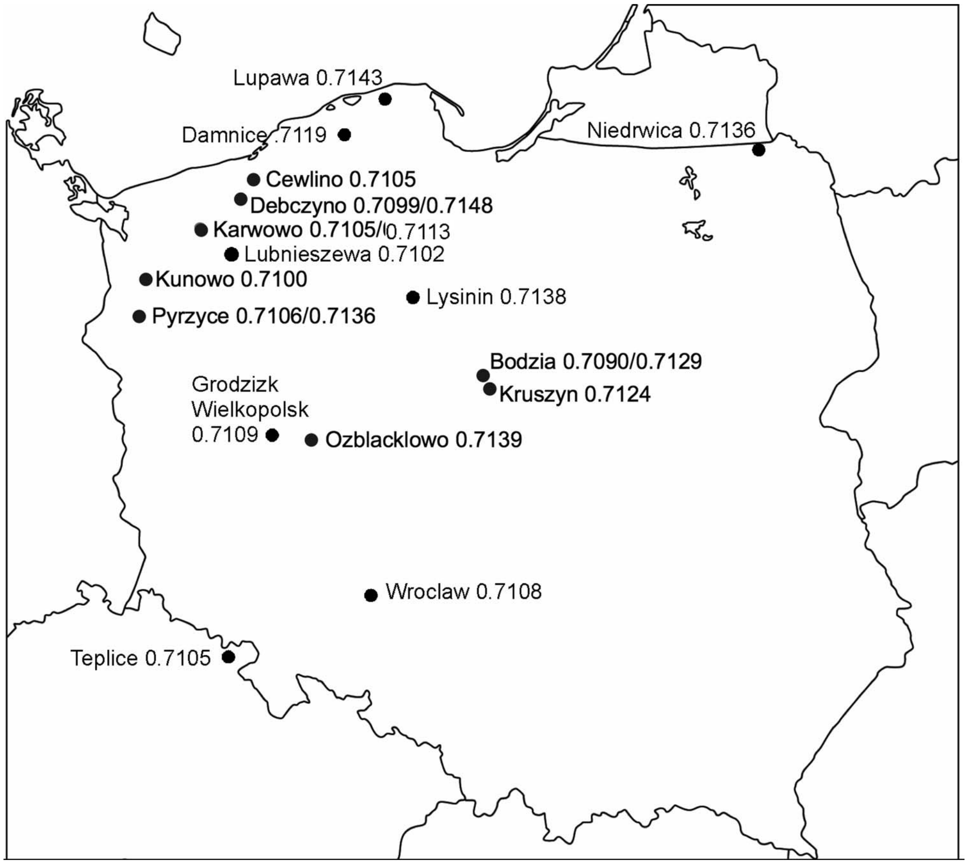

Figure 8. Baseline strontium isotope ratios from selected sites in northern and central Poland.

The bedrock geology of Bornholm is covered in many places with Quaternary deposits of till and meltwater sediments (Figure 10). The glaciers that covered Bornholm came from the northeast, and deposited till from the Baltic Sea floor on the western coast of the island (Lindstrom 1991). The till also forms moraine plains in the south as well as in some parts of the crystalline bedrock area in the north. Further inland and east of the island, the till is composed of older island sediments and bedrock (Møberg 1994). Late Glacial deposits on Bornholm include sands and gravels deposited by the Baltic Ice Lake. Littoral and eolian sediments, e.g., the dune sands in the southeast, are largely postglacial deposits (Fuchtbauer and Elrod 1971).

We have measured a number of samples of archeological fauna, modern snails, and surface water to record the bioavailable $^{87}Sr/^{86}Sr$ on Bornholm. The water data are taken from Frei and Frei (2011). We attempted to sample fauna from each of the major geological units on the island. The results appear in Table 1 and are shown graphically on the map of the island in Figure 8. The bedrock geology of the sample location, where known, is also included in the table. These values show a wide range, 0.7092–0.7231, reflecting the diverse geology of the island. Porcelænsgård is located in an area of kaolin which may explain the unusually high strontium isotope ratio for the Mesozoic deposits in that area of the island.

We have also measured a series of 15 snails from the site of Ndr. Grødbygård itself, and these values are shown in Figure 11. The mean value for these snails is 0.7133 ± 0.0020, with a range from 0.7093 to 0.7155. Ground moraine covers bedrock in the area immediately north of the site, but the transition to ^{87}Sr-rich Paleozoic bedrock lies only a few kilometers away. The bimodal distribution of $^{87}Sr/^{86}Sr$ for the snails appears to confirm this situation, with values ranging from 0.7095 to 0.7160, depending on the sources of the food that were consumed. Based on the bioavailable data from the snails at Ndr. Grødbygård, and with consideration of the baseline values from the rest of the island, we would suggest a range of 0.7095–0.7155 be used for the baseline values at the site. The upper value is a particularly cautious estimate for humans, as seafood consumption would increase the intake of the lower marine $^{87}Sr/^{86}Sr$ at 0.7092 and reduce the terrestrial strontium isotope ratios.

The diversity of strontium isotope ratios on Bornholm makes the definition of local and non-local individuals a difficult talk, and brings into question the meaning of

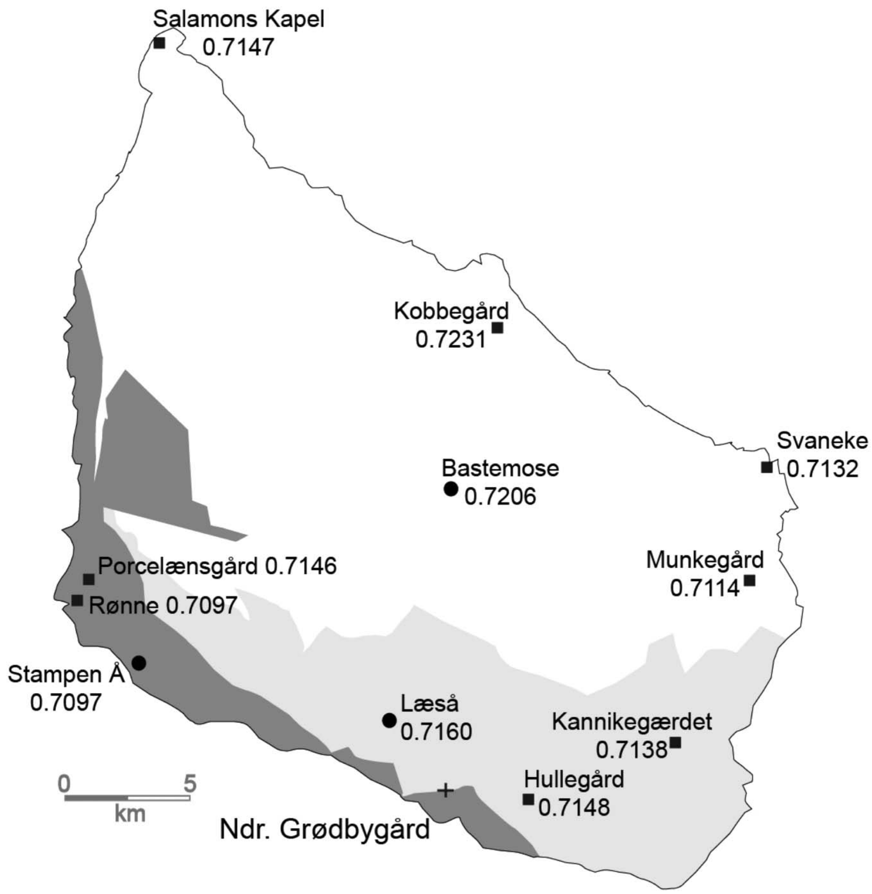

Figure 9. A simplified geological map of Bornholm, the location of Ndr. Grødbygård, and the sampling sites for bioavailable strontium isotope ratios. The white geological zone to the north is underlain by rocks of largely Precambrian age, the lighter grey area to the south consists of Paleozoic rock, heavily faulted, and the darker gray area along the west and south coast is composed of Mesozoic Age deposits, often of marine origin. Circles are water samples, squares are fauna.

local. In the case of the analysis of Ndr. Grødbygård local really has two meanings: 1. individuals from the area around the cemetery. This area could be defined by previous analysis of the cemetery (Nielsen 1998, pp. 12–17) that suggested that the cemetery may have been used by the inhabitants of 20–25 farms that could have been found within a ca. 5 km radius and individuals who are from the island of Bornholm. Non-locals could be from elsewhere on the island or from off the island. Because of the isotopic variation present in the samples from the cemetery itself, these distinctions are not immediately obvious and our discussion of the results must be taken as speculative rather than demonstrated.

Results

The skeletal remains in the Ndr. Grødbygård cemetery were for the most part very poorly preserved, in contrast to the teeth. Tooth enamel was, however, often preserved and was available for isotopic analysis. This in fact also allowed for an age evaluation of most of the individuals (by analyses of the dental development (subadults) and age-related abrasion (adults).

Some 41 samples were originally selected for this study based in part on the prior archeological analysis of burial practices at the cemetery, and constrained by the preservation of the dental material. Our sample included a substantial number of individuals that were buried with objects associated with the Slavic tradition, such as beads and fragments of earrings found in the cranial area, knives in mounted sheaths, and potsherds of Baltic ware (graves 272, 107, 428, 427, 518, 6, 294, 536, 459, 628, 281, 558, 382, 243, 496, 613, and 452).

Four additional samples for this study were selected based on possible unusual physical features observed during excavation. Burial 256 was reported to exhibit the only distinctively Slav morphology in the teeth. Burial 292 was an adult individual without tooth wear, in marked contrast to others in the cemetery. Burial 418 seemed to have rather massive muscle insertions at the base of the cranium, and

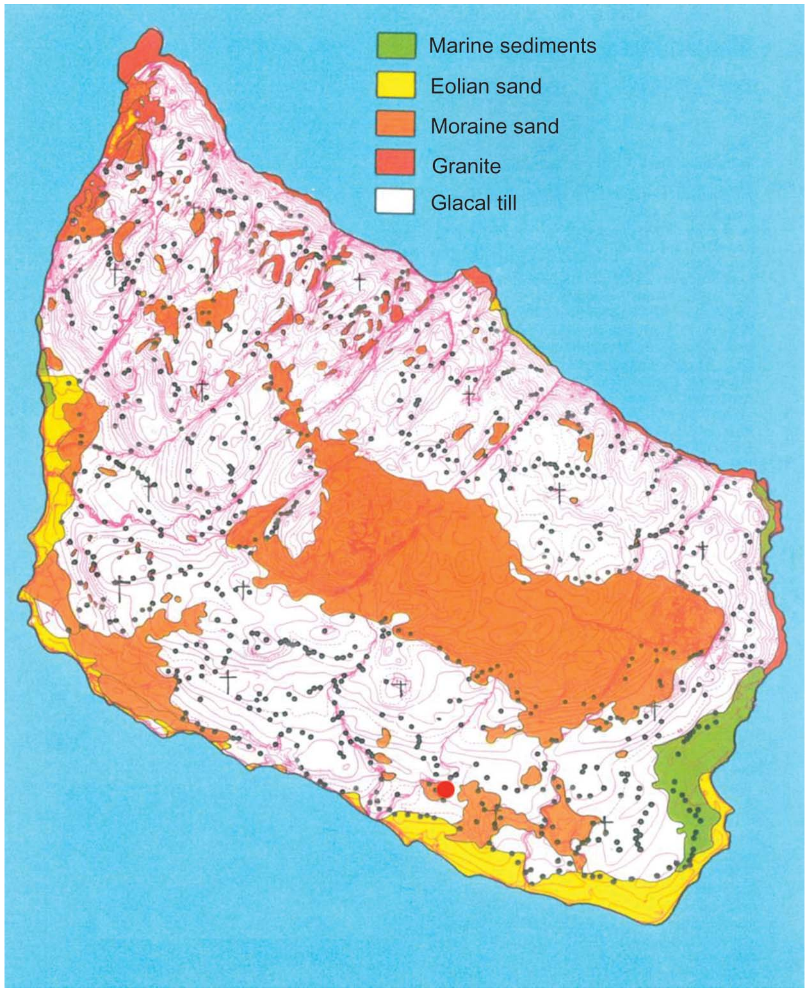

Figure 10. Soil map of Bornholm showing the distribution of more recent sediments on the island. The black dots mark the location of some of the 962 farms on Bornholm and the crosses indicate 15 rural churches (Messenburg 1972). The location of Ndr. Grødbygård is marked by a red dot.

Table 1. Samples of fauna and water for bioavailable strontium isotope ratios on the island of Bornholm.

Location	Material	Geology	$^{87}Sr/^{86}Sr$
Kobbegård	Arch. fauna	Granite/Gneiss	0.7231
Munkegård	Arch. fauna	Svaneke granite	0.7114
Kannikegærdet	Arch. fauna	Glauconitic sandstone	0.7139
Hullegård	Arch. fauna	Rastrirtes/Cryptograptus shale	0.7148
Porcelænsgård	Arch. fauna		0.7146
Svaneke	Modern snails	Svaneke granite	0.7131
Svaneke	Modern snails	Svaneke granite	0.7134
Rønne	Modern snails		0.7092
Rønne	Modern snails		0.7104
Stampen Å	Surface water		0.7097
Bastemose	Surface water		0.7206
Læså	Surface water		0.7160

such massive muscle attachments were also seen on Burial 438, along with apparently very broad cheekbones. Later physical anthropological examination of these individuals did not indicate that these features were significantly different. However, due to poor conservation, thus rendering more precise dental and physical anthropological analyses

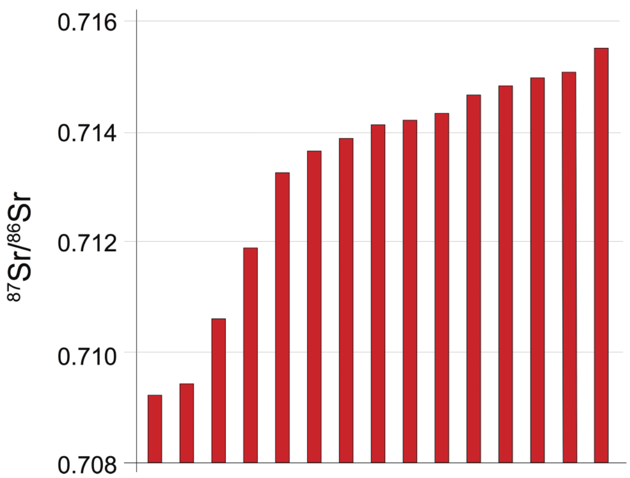

Figure 11. Histogram of $^{87}Sr/^{86}Sr$ values for 15 snail shells measured at Ndr. Grødbygård.

difficult, it was decided to sample these individuals anyway.

Furthermore, burial 250 was selected for sampling at a later point, because this individual displayed a probable sharp trauma to the occipital region, the only evidence of violence found in the cemetery. The blow could very well have been lethal, probably from a sword, but does not look like an attempt at decapitation.

The results of the analysis of 45 samples of enamel from the graves are provided in Table 2. The location of the graves that were sampled is shown in Fig. 2, and the graves with the highest and the lowest strontium isotope ratios are indicated on the plan. The $^{87}Sr/^{86}Sr$ values for both baseline and human enamel samples are shown in the graphic form in Figure 12. In this bar graph, values within the two groups of samples are rank ordered from lowest to highest. The baseline values include both fauna and surface water. The

Table 2. Burial and isotopic data from the Ndr. Grødbygård cemetery, Bornholm, Denmark.

Lab#	Burial#	BMR#	Sex	Age	$^{87}Sr/^{86}Sr$	$\delta^{13}C_{ap}$	$\delta^{18}O$
F5714	8	x264		A	0.71317	−13.71	−4.95
F6907	77			S	0.71024		
F5727	78A		M	sub	0.71077	−12.58	−6.31
F5713	107	x589	M	S	0.71268	−12.66	−4.66
F5717	196	x937		M	0.71716	−10.86	−5.16
F5720	199 o	x949		M	0.71510	−15.23	−5.39
F5721	199 y				0.71171	−11.81	−4.90
F5709	210	x951		A	0.71465	−14.31	−4.86
F5700	243	x1121	M	M	0.71780	−15.30	−5.58
F5710	249	x1138	M	M	0.71530	−12.81	−4.61
F5706	250		M	A	0.71421	−13.97	−4.36
F5705	251	x1147	M	M	0.71490	−14.41	−4.50
F5704	272	x1181	M	A	0.71260	−13.04	−3.64
F5730	280		M	A	0.71531	−13.19	−5.24
F5715	281	x1324	M	A	0.71524	−14.07	−4.80
F5731	294		M	A	0.71334	−9.38	−4.84
F5734	306		M	M	0.71644	−13.74	−5.30
F5728	307		M	A	0.71375	−14.00	−4.89
F5708	382	x1508	M	A	0.71599	−14.31	−4.63
F5733	427	X1687	F	A	0.71300	−13.44	−4.87
F5732	428	x1724	F	A	0.71298	−13.04	−4.96
F5725	429	x1749	F	A	0.71296	−14.64	−4.76
F5718	452	x1739		M	0.71484	−13.01	−4.60
F5707	459	x1780	F	A	0.71441	−14.42	−4.29
F5722	465	x1766	F	M	0.71166	−12.88	−6.41
F5723	496	x1898	F	A	0.71223	−14.79	−4.46
F5703	518	x1984		A	0.71315	−14.02	−5.29
F5711	527	x1983	F	M	0.71319	−14.65	−5.01
F5702	536	x2076	F	A	0.71383	−14.51	−5.53
F5738	554			sub	0.71680		
F5712	558	x2087	F	M	0.71547	−14.24	−5.04
F5735	559	x2088	F	A	0.71680	−13.86	−4.40
F5719	613	x2310	F	A	0.71483	−14.53	−4.07
F5724	617	x2334	F	A	0.71446	−12.57	−4.58
F5729	618	x2366	F	A	0.71394	−13.74	−4.38
F5726	619	x2346	F	A	0.71135	−13.54	−5.36
F5716	626	x2389	F	M	0.71146	−13.16	−5.62
F5701	628	x2407	F	M	0.71442	−14.22	−4.48

Note: M = male, F = female, A = adults, S = senilis, M = maturus. O = old, y = young.

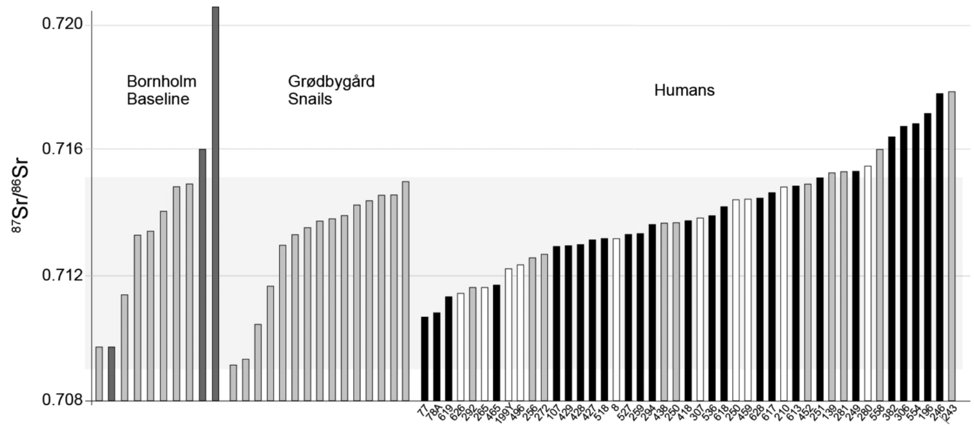

Figure 12. $^{87}Sr/^{86}Sr$ values for Bornholm baseline, fauna are light grey, water samples are dark grey. snails at Ndr. Grødbygård and Ndr. Grødbygård humans in rank order. White = female, grey = male, black = unknown. The large grey rectangle is an estimate of the local strontium isotope ratio available in the area around Ndr. Grødbygård.

range of values is very wide, 0.7092–0.7231, as noted above. The wide range of $^{87}Sr/^{86}Sr$ values on the island makes the identification of immigrants a difficult undertaking. The estimated local range for Ndr. Grødbygård suggested above, 0.7095–0.7155, is shown in the horizontal band on the graph.

There are several things to be noted from the graph. First, most of the human enamel values fall within the range of baseline bioavailable values from Ndr. Grødbygård. This means that many of the individuals in the cemetery may be local to the area of the cemetery, or from other parts of the island with similar isotopic values. Second, there is an interesting break in the curve of the human enamel values in the bar graph. The seven highest human values in the bar graph (Burials 382, 306, 554, 559, 196, 246, 243) show a slightly different angle of increase from the remainder. In addition, these individuals lie outside the baseline values for the site and outside all but the two highest water values from the island, suggesting that they are non-local and possibly not from Bornholm. These seven graves are found scattered through the cemetery, without obvious spatial relationships. If these individuals are non-local to Bornholm, the more likely homeland for these individuals would be to the north and west, where the ancient rocks of eastern Sweden have comparably high values. There is little evidence of values above 0.716 in northern Poland or northern Germany.

There are also five individuals very close to the upper boundary of the local $^{87}Sr/^{86}Sr$ range (Burials 199, 281, 249, 280, and 558) that may or may not belong to the local population. These are at the limits of 'locality' but lie on the same curve as the majority of the burials in our sample. For these burials, we hesitate to distinguish them and for the present will include them in the local group of burials.

It is also the case that there are no human values below 0.7108 in the cemetery, suggesting that few or none of the inhabitants are coming from the glacial and coversand areas of northern Germany, Denmark, or southwestern Sweden. The moraine/coversand area of northern Poland, on the other hand, does have some values in the range between 0.7095 and 0.7150, so that some of the individuals who appear to be local to Bornholm could also have originated in those parts of Poland.

It should be noted that two individuals (77 and 78a), an 11–12 year-old boy buried directly above an adult male, found in the isolated group with the stone-built grave to the west in the cemetery (Figures 2 and 5), had the two lowest $^{87}Sr/^{86}Sr$ values recorded in human enamel at Ndr. Grødbygård, although still within the local baseline. The isolated location of the burials, the construction of the graves, and the exceptionally low strontium isotope values suggest that these individuals were personages of some note. These stone-built chambers are unusual, as most of the other burials are in simple earthen flat graves. There is a possibility that these graves were associated with an original church at Ndr. Grødbygård, of which no trace remains today. Because these are the two lowest values we have recorded, there is also a possibility that these individuals may not originate from Bornholm.

There is one other intriguing pattern in the $^{87}Sr/^{86}Sr$ data from the cemetery. Three individuals buried very close to one another in a cluster of five graves (Burials 427, 428, 429—an adolescent ca. 14 years of age, and two women aged ca. 30–35 years, respectively) were sampled in our study and have remarkably similar isotope values (0.71300, 0.71298, and 0.71296 respectively). This similarity suggests a similar provenience and diet for these individuals, perhaps as members of the same household. Furthermore, the material culture recovered from these graves, suggests rather uniform ritual customs surrounding burial of these individuals. They were buried in coffins and given knives, strings of beads of silver, glass and sandstone, or amber. Two of them were clothed in a garment requiring a brooch and two of them were given a fragment of a coin. The spatial proximity of these internments, as well as the similarities in burial ritual and strontium values suggests close connections and the same origin for these individuals, perhaps as members of the same household.

None of the four individuals selected because of perceived unusual morphologic dental and skeletal traits (at excavation) showed non-local strontium levels, in line with later dental and physical anthropological analysis, which did not indicate anything unusual about these individuals. Burial 250, the one example with probable trauma to the head, showed a likewise local strontium level.

Oxygen isotopes in enamel apatite

The addition of oxygen isotopes in the provenience analysis of the inhabitants of the Grødbygård cemetery provides some further insight, but the absence of a narrow strontium isotope baseline on the island limits the resolution of our analysis.

Oxygen has three isotopes, ^{16}O (99.762%), ^{17}O (0.038%), and ^{18}O (0.2%), all of which are stable and non-radiogenic. Oxygen isotopes are much lighter and highly sensitive to environmental and biological processes. Oxygen isotopes, which are commonly reported as the per mil difference (‰ or parts per thousand) in ^{18}O/^{16}O between a sample and a standard, can be measured in either the carbonate $(CO3)^{-2}$ or phosphate $(PO4)^{-3}$ ions of bioapatite. This value is designated as δ^{18}O. In this study, we have measured carbonate as a component of tooth enamel.

Oxygen isotope ratios in the skeleton reflect those of body water (Luz *et al.* 1984, Luz and Kolodny 1985), which in turn predominantly reflects those in local rainfall. Isotopes in rainfall are greatly affected by enrichment or depletion of the heavy ^{18}O isotope relative to ^{16}O in water due to evaporation and precipitation. Major factors affecting rainfall isotope ratios are latitude, elevation, and distance from the evaporation source (e.g., an ocean) – i.e., geographic factors. Like strontium, oxygen is incorporated into dental enamel – both into carbonate and phosphate ions – during the early life of an individual where it remains unchanged throughout adulthood. Oxygen isotopes are also present in the bone apatite, and are exchanged throughout the life of the individual by bone turnover, thus reflecting place of residence in the later years of life. Thus, oxygen isotopes, although non-radiogenic, have the potential to be used like strontium to investigate human mobility and provenience. At the same time, there is significant variation in oxygen isotopes that makes their application less straightforward.

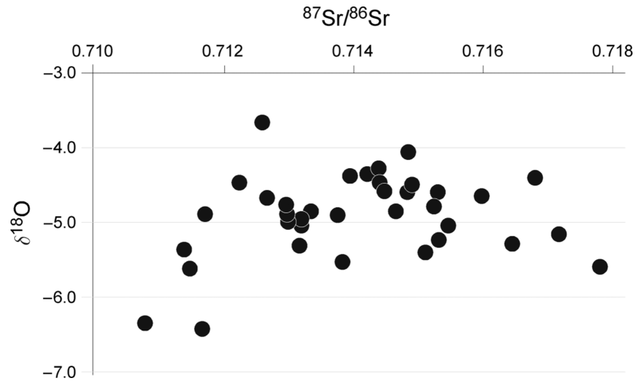

Figure 13. Strontium and oxygen isotope ratios in human tooth enamel from the cemetery at Ndr. Grødbygård.

Oxygen isotopes were measured in 36 samples of tooth enamel carbonate, and gave a mean of –4.9‰ and an SD of +0.56, and range from –3.6‰ to –6.4‰. These values are listed in Table 2 for the individual samples. These δ^{18}O values are plotted against ^{87}Sr/^{86}Sr in Figure 13. The spread of δ^{18}O values, with the exception of three individuals, varies between –4.0‰ and –6.0v in the data. δ^{18}O values in a population generally vary between ±1.0, so this range seems to be reasonable as a 'local' value for Bornholm.

The three exceptions are 1. The individual with the lowest ^{87}Sr/^{86}Sr value has a δ^{18}O of –6.3‰. The combination of the two end-range values likely points to this individual (burial 78a) as unusual and non-local to Bornholm. This is the same individual reported earlier in the strontium isotope analysis. 2. There is another individual (465, an approximately 50-year-old female), with a very negative δ^{18}O (–6.4) and ^{87}Sr/^{86}Sr value (0.7117) that stands out in the graph. 3. Finally, there is an individual (272; a young male) with the most positive δ^{18}O value (–3.6‰) and a ^{87}Sr/^{86}Sr value of 0.7126 who appears different from the majority of the sample. Again, it should be noted that oxygen provides a rather weak measure of geographic variation and these results must be viewed with caution.

From an archeological point of view, these last two graves (465 and 272) are not distinctive. Both were simple burials in coffins without any diagnostic grave goods. The only artifact associated with burial 465 was a potsherd of contemporary Baltic ware deposited in the fill of the grave. In grave 272, probably of an adult male, a single potsherd of Baltic ware was found under his knee. Between his knees a few animal teeth were found in a dark, fatty clump.

Carbon isotopes in bone collagen

Carbon isotope ratios were measured for five bone collagen samples from the cemetery at Grødbygaard. The results are presented in Table 3. These data provide an estimate of the contribution of marine foods to the diet, averaging 20% for the five samples with relatively little

Table 3. $\delta^{13}C$ values from five burials at Ndr. Grødbygård.

Lab#	Burial	Age	Sex	$\delta^{13}C$	% Marine food
K-6865	11	40	F?	−18.5	25
K-6866	379	40	M	−19.0	20
K-6867	438	40	F?	−19.0	20
K-6868	476	28	M	−19.3	17
K-6869	538	40	F?	−19.2	18

variation. The intake of seafood will affect the strontium isotopic composition of the individual, depending on the amount consumed. The marine foods will shift the strontium isotopic values in human enamel towards the $^{87}Sr/^{86}Sr$ value of seawater 0.7092. In the case of Bornholm, this will mean that the terrestrial bioavailable values in enamel are reduced toward the value of seawater, in proportion to the marine foods in the diet.

Carbon isotopes in enamel apatite

The measurement of carbon isotope ratios in bone collagen is well-known in the study of marine resources or C_4 plants in human diets. Carbon is also is present in the mineral or apatite portion of bone and tooth enamel and also contains information on diet (Ambrose and Norr 1993, Ambrose *et al.* 1997). $\delta^{13}C$ values in dental enamel reflect the diet of early childhood and may inform on movement if diets changed between place of origin and place of burial.

Carbon isotopes were measured in 36 samples of tooth enamel (Table 2) and yielded a mean value of –13.57‰ with an SD. of 1.18. All but three of the values range from –13.0‰ to 15.3‰. The three values of –11.8‰ (Burial 199, ca. 50 year-old), –10.9‰ (196, ca. 45 year-old individual), and –9.4‰ (294, ca. 40 year-old male) distinguish individuals with a significantly higher marine component in their diets. Burials 199 and 196 are adjacent and overlapping in the southern part of the cemetery, again suggesting potential kin relations among the inhabitants. The $^{87}Sr/^{86}Sr$ values are not distinct. None of these three individuals were measured for $\delta^{13}C$ in bone collagen.

Conclusions

Bornholm is an unusual place in the Baltic, significantly different from the countries that surround it in terms of its geology. Bornholm is a mosaic of rock types of different ages and composition. In terms of strontium isotope ratios, there is a wide range of values (ca. 0.7095–0.7160) present on this small island that contrasts greatly with the generally homogenous areas that surround the southern Baltic Sea. Most of the southwestern Sweden, Denmark, northern Germany, and parts of northern Poland are composed of relatively recent sediments from the last glacial and early Holocene. These moraine and coversand materials generally have $^{87}Sr/^{86}Sr$ values between 0.709 and 0.7105, values lower than most of those found on Bornholm. Higher $^{87}Sr/^{86}Sr$ values are found in many parts of Sweden in association with the Fennoscandian shield of very old rock. There, with exceptions, values generally range above 0.712. The easternmost part of northern Germany and northern Poland exhibit a range of values from ca. 0.709 to ca. 0.715 that may represent two distinct sources of strontium isotopes in the region, perhaps a result of deposits from different lobes of glacial ice.

Given this broad-ranging strontium isotope ratio context, the analysis of human burials from the eleventh century cemetery of Ndr. Grødbygård for information on place of origin becomes a difficult assignment. The majority of $^{87}Sr/^{86}Sr$ values from 45 samples of human dental enamel fall within the range of baseline bioavailable samples we have measured from the different geological provinces on the island.

The wide spectrum of isotope ratios recorded of those buried at Ndr. Grødbygård may be reflective of internal mobility among the islanders. The eleventh and twelfth centuries seem to be a transformative period involving the reorganization of existing settlement, the establishment of new farms (so-called Østersø-settlements), and the foundation of royal farms (Nielsen 1994, Naum 2008, pp. 55–56). These changes were likely responsible for some resettlement on the island. Other factors at play in the wide range of isotope values may also be the movement at marriage, and perhaps even the sharing or exchanging of food across the island.

At the same time, we can identify a number of individuals who do not appear to fit within the population at Ndr. Grødbygård. The seven highest $^{87}Sr/^{86}Sr$ values (Burials 382, 306, 554, 559, 196, 246, 243) may indicate a small group of burials that are different from the others in the cemetery. As noted, there is a reasonable probability that these individuals are not from Bornholm and, given the high isotope ratios exhibited, may be from the north and west of the island. Individuals from the Slavic region of eastern Germany and Poland could not be distinguished isotopically from persons born on Bornholm because of the overlap in isotope values between Bornholm and these two regions. There may well be individuals buried at Ndr.

Grødbygård from these areas that we simply cannot recognize.

The presence of Slavic objects in the burials of individuals whose isotope ratios indicate that they were born on the island merits attention. The inclusion of knives in characteristic knife sheaths (Burials 281, 243, 382, 452, and 613), potsherds (Burials 452 and 558), and beads from earrings found in the necks and head area of the deceased (Burials 459, 558, 559, and 628) might be a testimony of a persistence of cultural practices and ideas about proper burial among the second and following generations of Slavic immigrants. Being born on the island and consuming foods from the same sources as the rest of Bornholm's population would make their isotopic values indistinguishable from other individuals raised in the vicinity of Grødbygård or elsewhere on Bornholm. Such conservatism and preservation of traditions is a frequently noted aspect of pre-modern and modern diaspora (e.g., Cohen 1997, Safran 2005, Androshchuk 2008, Naum 2012).

However, one cannot exclude another scenario. Perhaps objects, such as mounted knife sheath, silver string, and earring beads lost their cultural associations becoming elements of material culture on Bornholm. Considering close contacts between southern Scandinavia and Slavic areas reflected in archeological material and historical sources, the possibility of including these artifacts into new fashions has to be taken into account.

Three individuals with very similar $^{87}Sr/^{86}Sr$ values (Burials 427, 428, 429) were buried in a rather special context of five isolated graves in the western part of the cemetery that may also reflect their distinctiveness. The oxygen isotopes were not particularly helpful in our study but do suggest three individuals that may also be of interest, one of whom is Burial 78a, a 11–12-year-old child, also identified in the strontium isotope analysis. This person may be of non-local origin and is buried with an adult male with a similarly low $^{87}Sr/^{86}Sr$ value. The fact that this individual is a child suggests movement with other family members, perhaps the other individuals buried in this isolated plot at the cemetery.

In sum, isotopic studies of human provenience depend on patterned variation in the sources of the isotopes in order to effectively discriminate between local and non-local individuals. On the Danish island of Bornholm, a mosaic of geological formations provides a range of isotopic values that can be matched in many of the neighboring areas of the island. We can identify a few probable migrants to the island, and we are able to suggest related individuals or family members on the basis of very similar isotope values. In order to proceed further, it will be necessary to use other methods such as ancient DNA and perhaps lead isotopes to better determine the place of origin of these early medieval inhabitants of the island.

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Exploring the potential of the strontium isotope tracing system in Denmark

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Migration and trade are issues important to the understanding of ancient cultures. There are many ways in which these topics can be investigated. This article provides an overview of a method based on an archaeological scientific methodology developed to address human and animal mobility in prehistory, the so-called strontium isotope tracing system. Recently, new research has enabled this methodology to be further developed so as to be able to apply it to archaeological textile remains and thus to address issues of textile trade.

In the following section, a brief introduction to strontium isotopes in archaeology is presented followed by a state-of-the-art summary of the construction of a baseline to characterize Denmark's bioavailable strontium isotope range. The creation of such baselines is a prerequisite to the application of the strontium isotope system for provenance studies, as they define the local range and thus provide the necessary background to potentially identify individuals originating from elsewhere. Moreover, a brief introduction to this novel methodology for ancient textiles will follow along with a few case studies exemplifying how this methodology can provide evidence of trade.

The strontium isotopic system

Strontium is a member of the alkaline earth metal of Group IIA in the periodic table. Strontium is a trace element whose ionic radius is 1.13 Å, very similar to that of calcium 0.99 Å (Faure 1986). Due to their similar ionic radii, strontium can replace calcium in mineral lattices and thereby is incorporated into the skeletal tissues and body through diet. Strontium is concentrated in Calcium-bearing minerals such as hydroxyapatite, the mineral with which tooth enamel is composed. This is one of the characteristics that make strontium useful to archaeologists.

Moreover, strontium has four naturally occurring isotopes ^{88}Sr (82.53%), ^{87}Sr (7.04%), ^{86}Sr (9.87%), and ^{84}Sr (0.56%) (Faure 1986). Three of the four naturally occurring isotopes of strontium are 'stable', whereas ^{87}Sr is radiogenic and is therefore variable, as it is partially formed by the radioactive decay of naturally occurring ^{87}Rb (half-life of 48.8 billion years) (Faure 1986). The strontium isotopic tracer system relies on the use of two of the four 'naturally occurring' isotopes, ^{87}Sr and ^{86}Sr. The ratio of these isotopes, ^{87}Sr/^{86}Sr, is somewhat related to their natural abundance and is often ~0.7 (~7% ^{87}Sr/~10% ^{86}Sr).

In general, what needs to be kept in mind is that age and the type/nature of rocks are parameters which control the strontium isotopic composition of a geological basement and its sedimentary derivates. These strontium isotopic properties are maintained in recent processes (i.e., the strontium isotopic signatures are not changed in – from a geological perspective – very small time spans, due to the very slow decay of 87-Rubidium) and can be followed through processes of weathering, and on into the food chain, through the diet as previously mentioned (Figure 1). Even though differences in the strontium concentrations may occur along such uptake chains (due to different partitioning of strontium into various media such as water, plants, bones, and so on), strontium isotopes are not significantly fractionated, and strontium isotopic compositions are not affected and thus remain 'stable', making these signatures highly useful for tracing. In conclusion, the rate of production of ^{87}Sr is so slow that the ^{87}Sr/^{86}Sr ratio of a substance can be considered invariant over archaeological timescales. Thus, in terms of strontium delivery to a plant, the groundwater inherits ^{87}Sr/^{86}Sr ratios characteristic of the soluble 'biologically available' fractions/components in a soil which, in turn, are transferred isotopically unchanged and unfractionated on to the plant (Benson *et al*. 2006) and throughout the food chain. Therefore, the skeletal tissues of, for example, a sheep, will reflect the bioavailable strontium isotope characteristics of its feeding ground.

The bioavailable strontium

The strontium isotopic ratio which is incorporated in living organisms and thus characteristic of a particular catchment area can be affected by other exogenous factors which can contribute to the strontium budget of a soil

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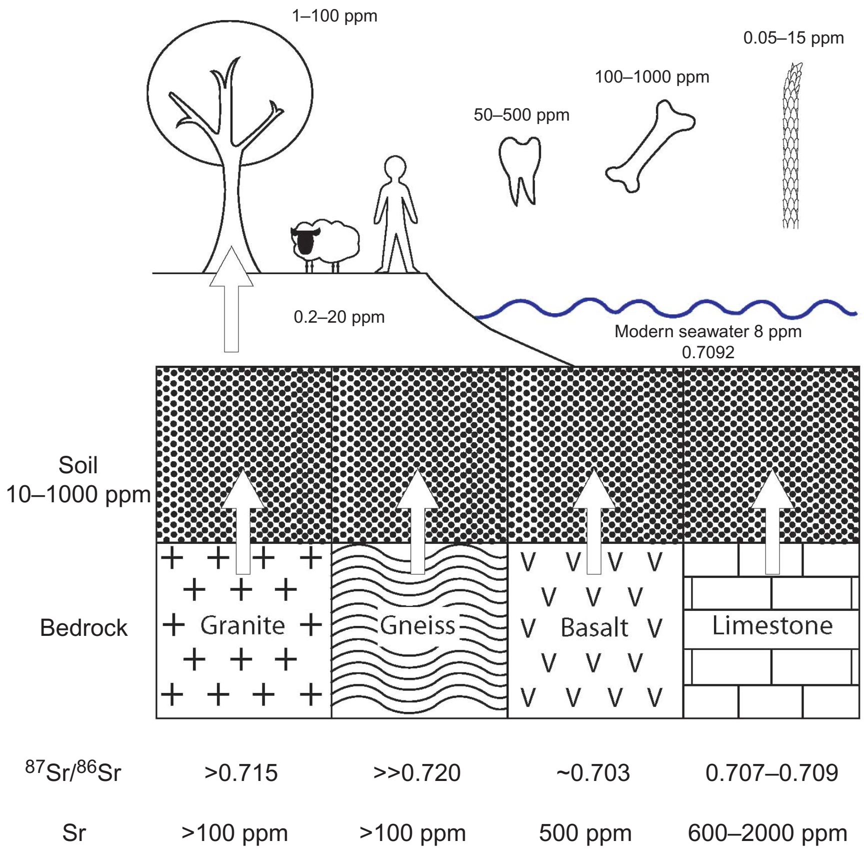

Figure 1. Diagram illustrating the strontium path from the geological strata to the human/animal hair (Frei 2010).

(Price *et al*. 2002). The exogenous factors can be several: some of the most important are seawater spray, atmospheric dust, diet, and modern fertilizer (Frei and Frei 2011).

(1) Seawater contains strontium with a strontium isotopic ratio of $^{87}Sr/^{86}Sr$ ratio of ~ 0.7092 (Figure 1), which has remained unchanged through the archaeological/historical/present timescale. Places like the Faroe Islands or Iceland which are surrounded by seawater have shown to be highly affected by this factor (Price and Gestsdottir 2006, Frei *et al*. 2009a, Frei 2010). This means that the sea-spray contributes to the total strontium budget of a soil when near the coast. Therefore, this is an important issue that needs to be considered in Denmark.

(2) Fertilizers have also often been suspected as being potential contaminants of soils. Recent studies aiming to show the actual effect that modern fertilizers have on soils have demonstrated that concentrations of strontium in fertilizers utilized in Denmark are often so small that their effect is minimal and often not even measurable (Frei and Frei 2011).

(3) Atmospheric particles, for example, ash from volcanic eruptions or sand particles from the Sahara can contribute variably depending on the topography, wind direction, forest canopy, distance to the shore, as well as the nature of the particles. Regrettably, there is little information available on this topic, thus a more detailed evaluation is needed to better estimate their potential effect. However, it is suspected that the influence will be minimal, unless there is a large and continuous deposition of atmospheric particles on the soil.

(4) Diet is also an important factor to consider when interpreting the results of the strontium isotopic analysis, as it can be misleading when high amounts of seafood have been consumed throughout an individual's childhood. Since seawater has a $^{87}Sr/^{86}Sr$ value of ~0.7092, this will affect the strontium isotopic composition of a person living off seafood. Thus, in prehistoric periods when seafood was known to constitute an essential part of the diet, it is highly recommended to perform $\delta^{13}C$ measurements of the same individuals (same tooth if possible) to estimate the percentage of possible strontium deriving from seafood in relation to terrestrial food.

In conclusion, there is no doubt that some of these exogenous factors may contribute in various degrees to the bioavailable strontium isotopic composition of the soil or diet. Therefore, it is important to create bioavailable strontium baselines and not only consider the local basement geology.

Baselines

There are several ways in which baselines of the bioavailable strontium isotopic range of a place can be constructed. For example, Evans *et al*. (2010) constructed a strontium isotope distribution 'map' across Britain based essentially on data from modern plant material. Other studies considered the composition of surface and mineral waters (Montgomery *et al*. 2006, Voerkelius *et al*. 2010, Frei and Frei 2011), others performed combinations of modern and archaeological fauna to achieve the same purpose (Frei and Price 2012). There is as yet no ideal way to perform baselines; therefore, it is plausible that a combination of several methods can provide the most accurate range. To produce such baselines is, however, time-consuming and costly, nevertheless they are crucial for providing reliable information on mobility issues. Once local sites and potential target areas are sufficiently characterized with respect to their bioavailable strontium isotope ranges, we might be able to eventually succeed in linking the composition of an archaeological material to its potential area of origin. However, regardless of the amount of already available data on archaeological finds/materials, it is highly recommended to nevertheless characterize the local bioavailable strontium isotopic range to identify if there is any unexpected local variation. Moreover, it should be noted that there are areas that have similar strontium isotope ranges; thus these areas cannot be differentiated by this tracing methodology, and other isotopes could eventually be applied (for example, Pb, lead).

Danish baseline

Denmark has an excellent potential to conduct tracing studies applying the strontium isotope system due to its relative homogeneous geology (Bornholm excluded), as shown in Figure 2, in comparison to the rest of the Scandinavian countries which present a variety of bedrocks of mostly Precambrian era. However, strontium isotopic studies within archaeology in Scandinavia are at an early stage. A few examples are the Neolithic megalithic tombs from southern Sweden (Sjögren *et al*. 2009), Medieval sites in Norway (Åberg *et al*. 1998) and Iceland (Price and Gestsdottir 2006), the Viking Age fortress sites of Trelleborg in Denmark (Price *et al*. 2011) and Sebbersund: an eleventh- to twelfth-century AD Danish churchyard in northern Jutland (Price *et al*. 2012).

Nevertheless, in Denmark, two recent projects have provided a very rich data set of proxy strontium isotope values and a baseline range for future successful tracing investigations. The first study is based on strontium isotope values of surface waters, including a few samples from Bornholm and northern Germany (Frei and Frei 2011). The second is based on strontium isotope analyses of archaeological and modern fauna from Denmark (Bornholm excluded) (Frei and Price 2012). The results of these two studies are quite similar and can be used together to define the Danish local bioavailable strontium isotope range (Figure 3). The overall bioavailable strontium isotope range in Denmark, Bornholm excluded, is ~0.708–0.711. The lowest values come from the Limfjord area near Mors and Fur, most probably due to the geological outcrops of the Paleogene volcanic ash layers (Frei and Frei 2011). The highest values derive from the island of Zealand, which can be interpreted as a result of glaciogenic silica-rich till topsoils. In general, it seems that the lowest $^{87}Sr/^{86}Sr$ ratios are between 0.7078 and 0.7098 which stem primarily from the western part of Denmark, whereas the higher values $^{87}Sr/^{86}Sr$ ratios are between 0.7089 and 0.7108 and stem from the eastern part of Denmark, east of the Lillebælt (Little Belt) (Frei and Price 2012). Thus, the presently available baseline data combined with the rather homogeneous geology of Denmark provide a good point of departure for future strontium isotope tracing studies of various kinds, for example, to evaluate which individuals seem to be non-locals or to investigate the raw material to produce textiles. However, the available data values from Bornholm (Frei and Frei 2011) are insufficient to define the highly complex geology of the island. Therefore, we are presently conducting a detailed investigation based on soil and water samples from the different lithologies present in Bornholm (Frei and Frei, in prep).

Strontium isotopes in archaeological textiles

The phenomenon of travel, transmission, and trade in the field of textiles and fiber material has often been investigated through comparative studies (e.g. Barber 1991).

However, until recently, there were no absolute terms for determining the origin of textile raw material. New developments have aimed at filling this gap by the means of strontium isotope analysis. Thus today, strontium isotope analyses are also applied to other organic materials such as wool, plant fibers from ancient textiles (Figures 4 and 5), and plant fibers from basketry and carbonized seeds. These investigations have been possible due to further development of new geochemical protocols (Benson *et al*. 2006, Frei *et al*. 2009a, Heier *et al*. 2009, Frei 2010, Frei *et al*. 2010).

Denmark possesses a unique collection of well-preserved prehistoric garments from the Bronze and Iron Ages, and thus, this collection constituted the perfect point of departure to address the question of whether

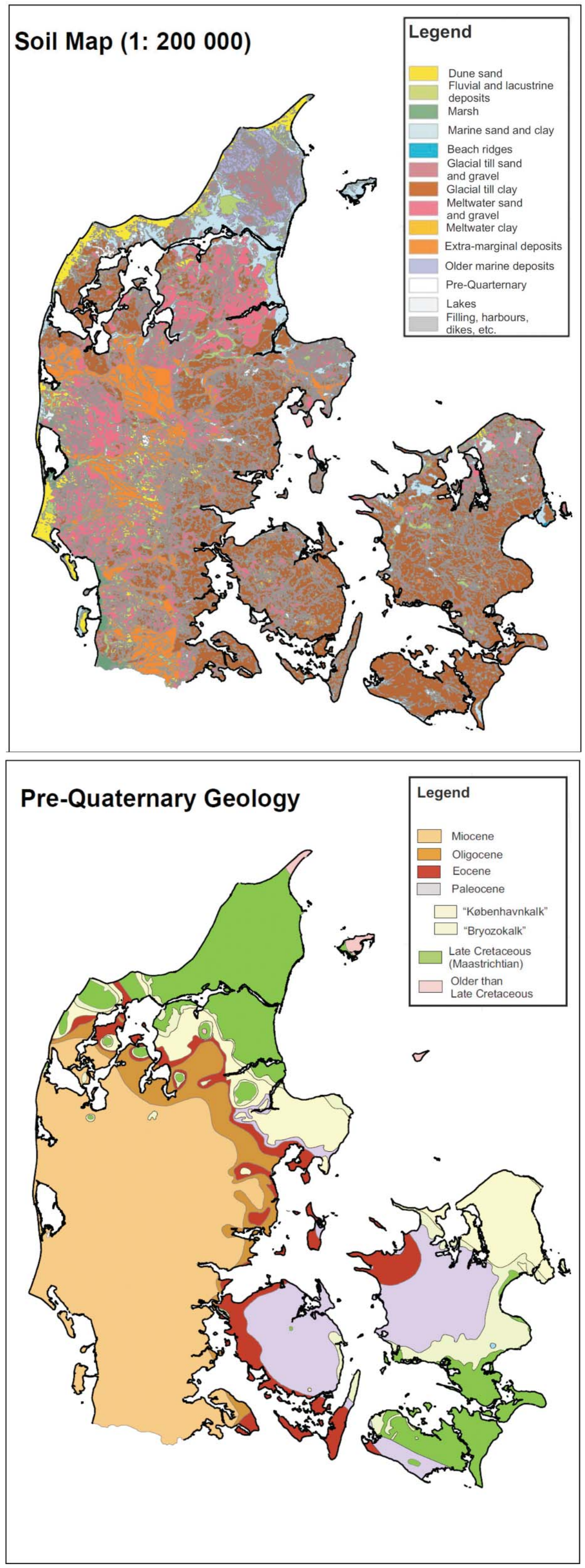

Figure 2. Map (upper) of Denmark delineating the different soil types within a1-meter depth, from GEUS Denmark and the Greenland Geological Survey. The lower map depicts geological pre-quaternary rocks, from GEUS Denmark and the Greenland Geological Survey (GEUS 2004). The sedimentary strata get generally younger from the north-east towards the south-west, because the Danish north-eastern area has experienced an uplift with a consequently higher degree of erosion.

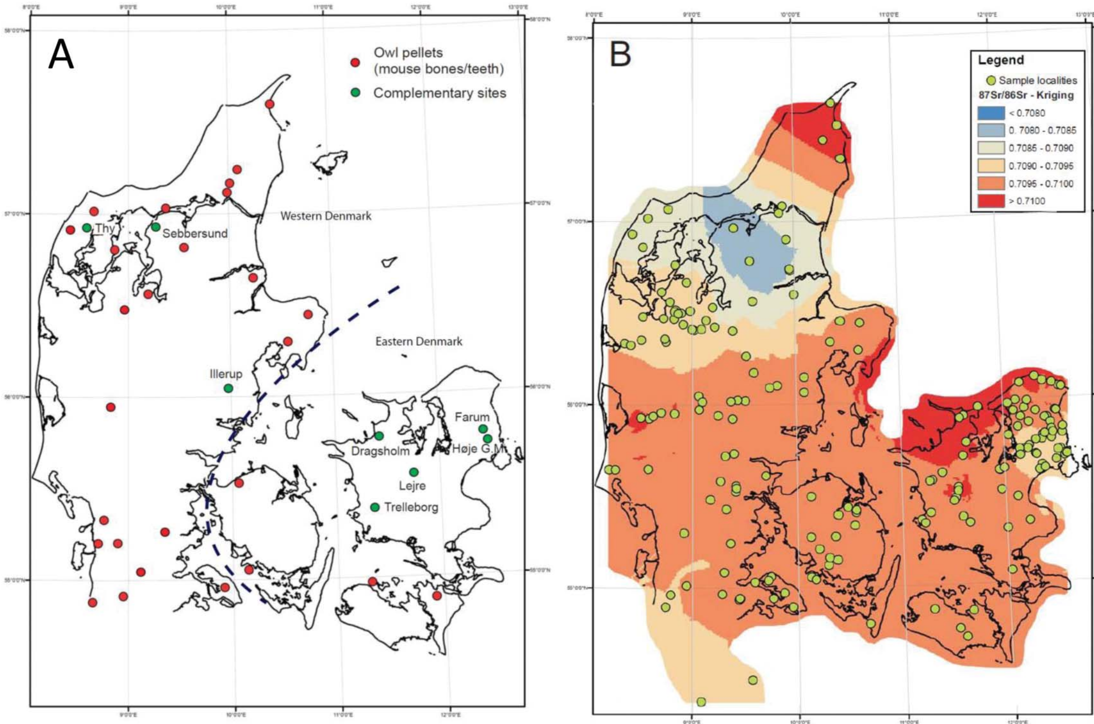

Figure 3. A. Localities where fauna samples were taken for baseline measurements, the stipple lines depict the boundary between eastern and western Denmark, after Frei and Price (2012); B. Depicts the countered distribution of the strontium isotope ratios of surface water samples, after Frei and Frei (2011).

textile raw materials had been traded in Danish prehistory. There are several ways in which archaeological textiles are investigated, for example, by textile tools, fiber counting/recognition techniques, ^{14}C-dating techniques, context analyses, dye analyses (HPLC-analyses), visual quality analyses, weaving techniques, and function analysis (Andersson Strand *et al*. 2010). However, the important research question of the provenance of textile raw material was usually investigated by means of comparative analyses. Thus, the recent developments provide a novel method to acquire information on the provenance of archaeological textile raw material (Frei 2010). In the following section, a brief description of the new methodology for textiles (Frei 2010), as well as a short explanation of the differences between skeletal tissues as compared to that of wool is provided.

Concentrations of strontium in bone tissue are often between ~50 and 1000 ppm (Bentley 2006) whereas in hair ranges between 0.05 and 15 ppm (Frei *et al*. 2009a) (Figure 1). Thus, wool fibers have much lower strontium concentrations than, for example, tooth enamel (Morita *et al*. 1986, Attar *et al*. 1990, Kohn *et al*. 1999, Rosborg *et al*. 2003, Frei 2010). Consequently, the precleaning protocol, the strontium separation (chromatography), and the final analytical measurements (mass spectrometry) are considerably more difficult in wool/hair than in teeth, as they present a greater methodological and analytical challenge than those found in tooth enamel.

Furthermore, the issue of contamination by soil and percolating water is more pertinent when dealing with textiles than with teeth due to the differences in resistance to contamination of these two very different materials (the tooth enamel being the hardest tissue in the body). Moreover, dyestuffs, from , for example, plants, can also be a source of contamination if these dyestuffs have a different origin than that of the textile's raw material. Thus, the main focus of the development of this new methodology has been on decontamination procedures to ensure the recovery of the primary ^{87}Sr/^{86}Sr ratios, which could otherwise be masked by the above-mentioned processes. The methodology is a multistep leaching procedure that includes a 20% cold hydrofluoric acid (HF) wash, a hydrochloric acid (HCl) wash, and an organic dye-removal step consisting of a strong oxidative procedure using ammonium peroxodisulfate ($(NH_4)_2 \cdot S_2O_8$) (Frei *et al*. 2009a, 2010). In between all these steps, several rinses with deionized water (Milli-Rho-Milli-Q; Millipore) should be included. Afterwards, the textile residue is dissolved and ion chromatographic procedures are followed. Finally, the ^{87}Sr/^{86}Sr ratio is measured on a thermal ionization mass spectrometer (TIMS).

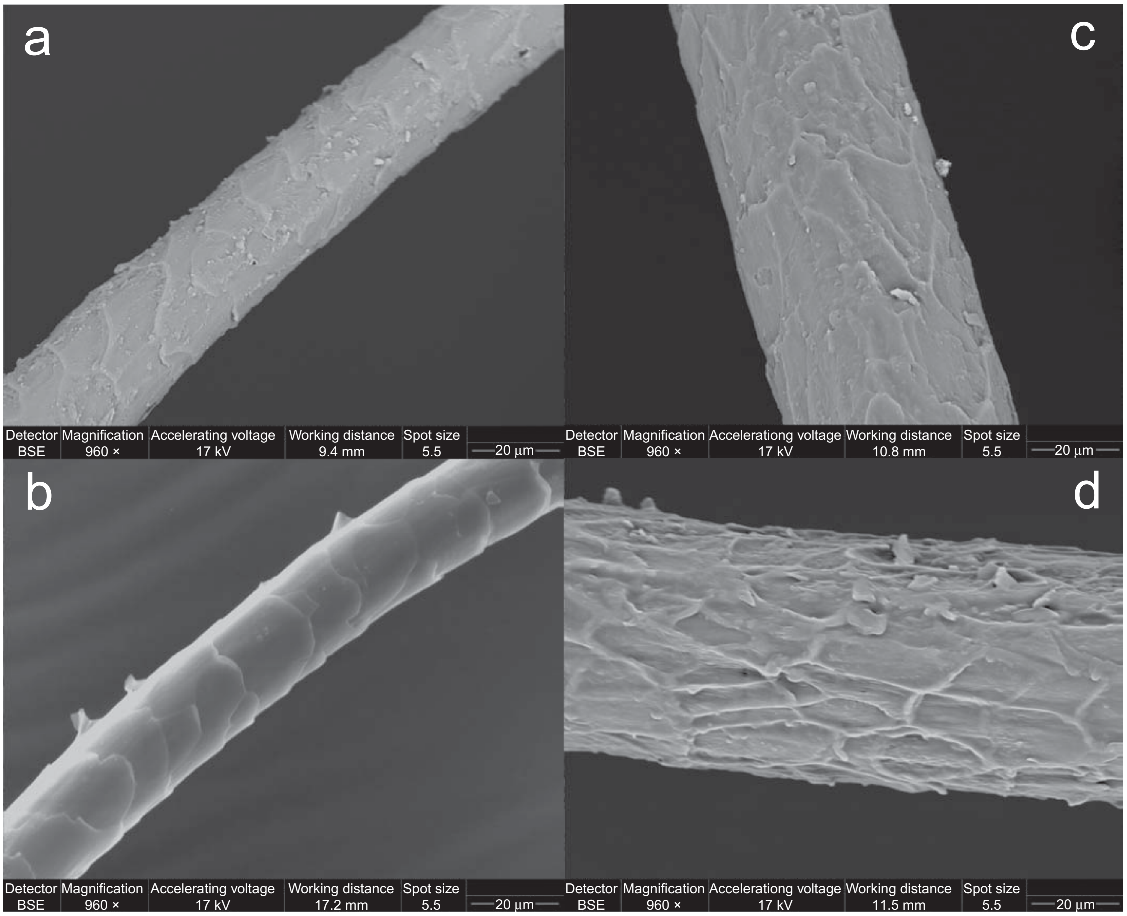

Figure 4. SEM images of individual single wool fibers. The fibers in ‘a’ and ‘c’ were dyed with organic dyestuff (red and blue respectively), the dyed wool fibers indicate that the organic dyestuff coats the hair scales (typical of animal hair) with a thin layer. Small individual particles, identified as mordant salt crystals, occur at the surface. The fibers in ‘b’ and ‘d’ changed to red and blue (respectively) wool fibers after exposure to APDS (ammonium peroxidisulfate)-HF(hydrofluoric acid) treatment. The deterioration is only minor (although stronger in the case of the blue sample ‘d’) as the fiber cuticle remains largely preserved (Frei *et al*. 2010).

In spite of the difficulties that textile raw material presents (Frei 2010), the chemical protocols developed by Frei have shown that it is possible to analyze minute pieces of thread from ancient textiles often in the order of only 10–20 mg per sample equalling a few cm long thread (Frei *et al*. 2009a).

Case studies of Danish archaeological textiles

The development of this new methodology in strontium isotope analysis of archaeological textiles has already provided new crucial information from Southern Scandinavia (Frei 2009, Frei *et al*. 2009b) as well as new insights into the network and trade of textiles during the Danish Bronze and Iron Ages (Bergfjord *et al*. 2012, Frei 2010).

The case studies presented herein were unearthed from peat-bog contexts and all belong to the Danish Iron Age. In general, the Danish textile bog finds have been divided into two main groups by Hald (1950), named after two textile finds: the first is the ‘Huldremose group’ and the second the ‘Corselitze group’. Later, Bender Jørgensen (1986) further developed Hald’s categories into the Huldremose type, the Haraldskær type, the Virring type, and the Spin-pattern type. In this investigation, textiles belonging to the two groups proposed by Hald were chosen.

(1) *Textiles from the Huldremose group*

Some of the first textiles to be investigated by this new methodology were some of the best preserved and complete garments from the Danish pre-Roman Iron Age (500 BC– AD 1). Archaeological textiles have been retrieved twice from the peat-bog site of Huldremose in Northeastern Jutland (Huldremose I and Huldremose II). Typologically, both belonged to Hald’s “Huldremose

Figure 5. Preparing samples at the laboratories of the Danish Center of Isotope Geology (DCIG) at the University of Copenhagen. Photo by Karin M. Frei.

group" of textiles (Hald 1950). This group is defined by textiles usually woven/spun as 2/2 twills and S/S spun and by the twisting of every other warp pair and a low thread count of 7–8 threads per centimeter (Hald 1950).

The textiles from the Huldremose I find were made in connection with the discovery of a peat-bog body of a woman (Figure 6). She was wearing several pieces of clothing: a chequered skirt, a chequered scarf, and two skin capes; today, she is on display at the permanent exhibition of prehistory in the National Museum of Denmark. Wool fibers from the yarn belonging to the chequered scarf were analyzed for strontium isotopes (Figure 7). In addition, three pieces of plant fibers adhering to the bog body were discovered during the process of this study (Figure 8) and analyzed (Frei *et al*. 2009b). The existence of this plant fiber textile was not known prior to this discovery. It is thought that this additional textile could have been a kind of undergarment (Frei 2010, Mannering *et al*. 2011).

Moreover, peat samples still adhering to the bog body were also studied to check for potential contamination. The results of the Huldremose I (Figure 9) demonstrate that the plant textile samples had radiogenic strontium isotope ratios (elevated) which can be expected from, for example,. old geological terrains as those present in Norway and Sweden and hence were nonlocal. On the other hand, the wool yarn from the chequered scarf (C 3474) showed a local strontium isotopic value. Thus, the Huldremose woman was wearing garments made from materials that stemmed from abroad as well as from Denmark (Bornholm excluded). It is therefore possible to assume that she had either herself been travelling outside Denmark and traded or was presented with her plant fiber garment while she was abroad, or she acquired the textile of imported plant fibers material in Denmark itself, either through trade or as a gift.

The Huldremose II find (Figure 10) is a single deposition find, composed of a large single tubular textile. From this textile, a total of 11 samples were analyzed (Frei *et al*. 2009b).

The results from the Huldremose II find (Figure 11) demonstrate that the 11 wool samples taken randomly from all over the garment have a highly interesting pattern. The 11 samples cluster somewhat into three groups. The first six seem to be of local provenance. However, the two other groups have too radiogenic strontium isotopic values to be of Danish provenance, (the island of Bornholm excluded). Hence they are non-local.

However, the Huldremose II textile has previously been considered typologically as being of local provenance as was the type of spinning which is also in itself impressively homogeneous (Irene Skals, National Museum of Denmark, personal communication). Therefore, these facts suggest that the wool was gathered from different places (one within Denmark and probably two from outside Denmark) prior to

Figure 6. Author sampling small peat-bog remains directly from the body of the Huldremose woman bog mummy at the conservation department of the National Museum of Denmark at Brede. Photo by Karin M. Frei.

Figure 7. Wool scarf (sample C 3474) from the Huldremose woman, Huldremose I find; the red circle shows where the sample was taken at the conservation department of the National Museum of Denmark at Brede. Photo by Karin M. Frei.

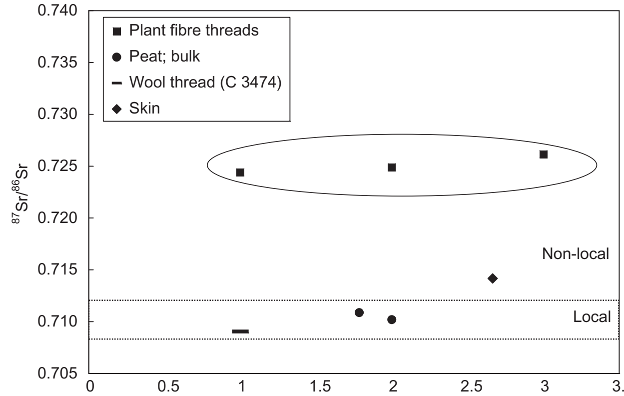

Figure 9. $^{87}Sr/^{86}Sr$ ratios of bulk peat, and residues of skin, plant, and wool fibers from the Huldremose I find. Plant fibers define a group (encircled by an ellipse) that is characterized by non-local $^{87}Sr/^{86}Sr$ ratios. The skin sample also lies in the non-local $^{87}Sr/^{86}Sr$ range. Peat and wool yarn fibers from the scarf of the Huldremose I find (sample C 3474) lie within the range of $^{87}Sr/^{86}Sr$ ratios that are considered local (after Frei *et al.* 2009b).

Figure 8. Magnified picture (binocular microscope) of one of the plant fiber thread samples found still adhering to the body of the Huldremose woman find. Photo by Karin M. Frei.

Figure 10. Sampling the large wool tubular textile find Huldremose II, at the conservation department of the National Museum of Denmark at Brede, Irene Skals and author. Photo by Karin M. Frei.

spinning the yarn, although, the spinning could still have occurred locally. Thus, this new information shows the complexity that can be concealed within one single large garment. Moreover, it sheds new light into the societies of the Danish pre-Roman Iron Age, as the Huldremose II garment was undoubtedly crafted by a highly knowledgeable and skilled person (or people) (Mannering *et al.* 2011) and as very similar wool qualities had been chosen, but from sheep that were very far apart, that is, from raw materials derived from different sources.

(2) *Textiles from the Corselitze group*

Two different textiles belonging to Hald's Corselitze group were analyzed: Corselitze (7325 a, Figure 12) and Haraldskær (3707 C1, Figure 13) (Frei *et al.* 2009a). The Corselitze find is the only one from the Iron Age period, besides the find from Horreby Lyng, which was retrieved outside the Jutland Peninsula. Both textile finds were instead recovered on the island of Falster. The cloth was wrapped around a woman's body fastened by a wool cord and a woven band (Hald 1980). A bronze fibula by the woman's neck dates the find to around AD 300. The results of the sample taken from the Corselitze textile (7325 a) has a strontium isotope ratio that falls within the Danish bio-available strontium isotopic range; thus, this textile most probably was made of wool from sheep

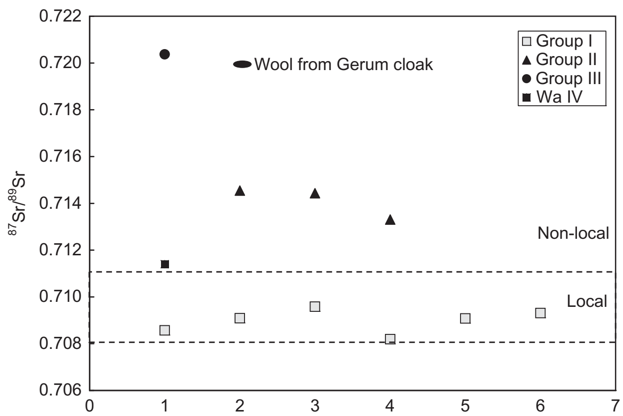

Figure 11. $^{87}Sr/^{86}Sr$ ratios of wool residue samples from a single large archaeological garment (Huldremose II find). Three provenance groups can be discerned: Group I wool threads indicate a local source of strontium. Groups II and III comprise wool threads with elevated $^{87}Sr/^{86}Sr$ ratios implying a non-local provenance. Group III sample shows a $^{87}Sr/^{86}Sr$ ratio similar to wool from a textile find in Sweden (Gerum cloak; (Frei *et al.* 2009a)). Sample Wa IV plots between group I and II.

grazing on Danish soil (Bornholm excluded) (Frei *et al.* 2009a).

The final textile is from a well-known find, the Haraldskær woman who was recovered in a bog near Vejle. Her remains are exhibited at Vejle Cathedral. She was discovered with the remains of three wool textiles, a skin cape and a finely braided wool hairnet. Of the three wool textiles, the one chosen to be analyzed by the strontium isotopic method was the textile with fringed edges and fine stripes in both directions (3707 C1). The results of the strontium isotope analysis on this sample demonstrate that this textile also falls in the Danish bio-available strontium isotope range; thus, this textile most probably was made of wool from sheep grazing on Danish soil (Bornholm excluded) (Frei *et al.* 2009a).

Conclusions

The strontium isotope tracing system has been proved to be an important tool within archaeology in the fields of migration and trade. Yet, very few such investigations have been conducted within Denmark. However, the very recent construction of two different types of baselines (Bornholm excluded) now provides the necessary prerequisite to enable strontium isotopic tracing studies to be conducted in Denmark.

Moreover, recent developments within the field of textile research have made it possible to investigate the provenance of archaeological textiles by following a multi-step pre-cleaning method.

Thus, these two achievements provide new possibilities to investigate human and animal migration and

Figure 12. Sampling the wool textile fragment belonging to the Corselitze find (7325 a) at the conservation department of the National Museum of Denmark at Brede, Irene Skals and author. Photo by Karin M. Frei.

Figure 13. Sampling the wool textile fragment belonging to the Haraldskær find (3707 C1) at the conservation department of the National Museum of Denmark at Brede, Irene Skals and author. Photo by Karin M. Frei.

textile trade throughout Danish prehistory by applying the strontium isotopic tracing system. It is, nevertheless, important to mention that all methods have their limitations, and this one is unfortunately no exception. The success of the strontium isotope analyses depends on the archaeological context, the preservation, diagenetic processes (contamination), as well as on how well defined the bio-available strontium isotope range of the retrieval site and the potential place of origin are. However, the numerous worldwide publications prove that there is a great potential in tracing studies applying the strontium isotope system. In Denmark, it is even more pertinent due to the fact that we now have a well-defined baseline of the bio-available strontium isotopic range, (and soon we will also have one from Bornholm) which will provide researchers the necessary tools to identify potential migrations and trade.

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The Fensmark settlement and the almost invisible Late Palaeolithic in Danish field archaeology

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Traces of Late Palaeolithic activity in the North European landscape are practically invisible to modern field archaeology. The result is an almost complete loss of information about the presumably numerous activity sites from this period which each year are either damaged or destroyed by agriculture and development. This article addresses the root causes of this situation and outlines the possibilities for its mitigation. The difficulties involved in demonstrating the existence of Lateglacial settlements are illustrated via the investigation history of the Fensmark site on the margin of the bog, Holmegård Mose. This is a typical settlement of the Bromme culture, dated to 10,810 ± 120 radiocarbon years BP. The site's considerable unexploited research potential has been secured for the future by a landscape scheduling which protects a wide range of archaeological remains hidden beneath the soil.

Keywords: archaeology; method; assessment; trial excavation; *in situ* preservation; wetland; Lateglacial; Palaeolithic; Bromme culture; Denmark

A blind spot in field archaeology

The Late Palaeolithic era in Denmark extended over about three millennia, from c. 12,500 to 9700 calendar years BC (cf. Grimm and Weber 2008, Pedersen 2009, Figure 2; Weber and Grimm 2009). Even so, Danish archaeologists have for many years consistently recorded and investigated much fewer localities from this period than from any subsequent sections of prehistory, despite the fact that most of the latter are of significantly shorter duration. Furthermore, the majority of recorded Lateglacial activity sites were located incidentally as a by-product of investigations targeting ancient monuments of later date (cf. Petersen 2000, Skaarup 2001, 2002).

Until 2001, annual accounts detailing the number of investigated archaeological localities by period were published in the journal *Arkæologiske Udgravninger i Danmark*. Table 1 summarises the data given in the final five volumes (Rigsantikvarens Arkæologiske Sekretariat 1998, 1999, 2000, 2001, Kulturarvsstyrelsen 2002). The author's own experiences from the national administration of archaeological fieldwork between 2006 and 2011 suggest that the situation since then has remained unchanged: the Late Palaeolithic and (Early) Mesolithic periods are, year on year, represented by a lower number of investigations than subsequent periods.

The limited representation of Late Palaeolithic sites and excavations is not necessarily a consequence of there being fewer sites from the Lateglacial than from subsequent periods. The population density in agrarian prehistory was certainly markedly greater than during the Lateglacial. Conversely, settlement was much more stable; whereas the houses in an Iron Age village probably had to be replaced every 20 years or so, during the Lateglacial use of a typical activity site lasted perhaps as little as a couple of weeks.

It has been suggested that a significant cause of this scant representation could be that Late Palaeolithic activity sites were generally located differently (lower) in the landscape than the settlement of later periods and, as a consequence, they are less exposed to the effects of building and development works. This suggestion is, however, inconsistent with the observation that a considerable proportion of the localities so far recorded from the Hamburg, Federmesser, Bromme and Ahrensburg cultures lie relatively high up in the landscape (Rasmussen 1972, Fischer 1991, Holm and Rieck 1992, Petersen and Johansen 1993, Holm 1996, Petersen 2006, Riede *et al.* 2011). Neither does it tally with the fact that many new records are products of investigations directed at features and structures dating from agrarian prehistory (e.g. Andersen 1998, Fischer 1990a, Dehn *et al.* 1995, 2009, Nielsen 2000, Høier and Schilling 2001, Andersen in press, cf. Eriksen 2006). A more compelling reason for the under-representation is clearly the fact that Late Palaeolithic activity sites have very limited archaeological visibility. At least seven factors can be listed which have a limiting effect on archaeology's ability to identify localities from this period:

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Table 1. Archaeological fieldwork in Denmark between 1997 and 2001, number of reported investigations by period.

	Late Palaeolithic	Mesolithic	Unspecified stone age	Neolithic	Bronze age	Iron age
1997	1	26	11	111	97	103
1998	3	34	13	125	138	363
1999	1	28	5	157	142	369
2000	1	32	38	142	164	471
2001	2	29	20	134	193	409
Total, 1997–2001	8	149	95	669	734	1840
Period begins	12,500	9700	12,500	3950	1700	500
Period ends	9700	3950	3950	1700	500	1067
No. of years	2800	5750	10,800	2250	1200	1567
No. of localities per century	0.3	2.6	0.9	29.7	61.2	117.4

- The socially simple and geographically mobile existence of the period which resulted in people only leaving behind relatively small and artefact-poor activity sites with no immediately recognisable cultural deposits, features, stone constructions, etc. As a consequence, there is a risk of 'throwing the baby out with the bathwater' if the research potential of a locality subjected to trial excavation and assessment is judged solely on the basis of whether it contains features and structures or dark-coloured cultural deposits.
- The extensive disturbance resulting from the processes of graviturbation and cryoturbation during the Lateglacial has contributed to obscuring settlement traces from the period.
- Tree roots, burrowing animals, etc. have had a relatively long time, in which to disturb and obscure activity traces from this early cultural period.
- The extensive cultivation of winter crops, together with the widespread practice of sowing fields immediately after ploughing, makes it more difficult to carry out efficient field reconnaissance today than was the case, for example, in the 1960s and 1970s when Danish archaeology experienced an almost explosive increase in the number of Late Palaeolithic sites (Fischer 1985).
- The cultural traces from the Lateglacial normally occur at low concentration and with broad vertical distribution in light-coloured sandy layers which are easily confused with the 'natural subsoil' (Andersen 1973, Fischer 1990a, Holm 1993).
- The methods presently employed in archaeological evaluations and excavations, characterised by machine removal of the soil, are generally unsuited to the observation of activity traces from the Lateglacial.
- Difficulties associated with the correct dating of small Lateglacial flint assemblages which only rarely contain characteristic projectile points or *zinken* in such an intact state as directly to facilitate a typological–morphological date.

The latter problem of dating small Lateglacial flint assemblages is probably not of equal significance throughout all parts of the period. The large tanged points of the Bromme culture presumably have a greater chance of being found during a trial excavation. Field archaeologists can also fairly readily and reliably date them as this type is relatively characteristic and frequently mentioned in the literature. The chronologically significant projectile points of the other Lateglacial cultural groups are generally smaller in size and have also enjoyed less academic attention to date. These circumstances are probably reflected to some extent in the current records of Late Palaeolithic activity traces in the Danish Agency for Culture's national database 'Sites and Monuments'. A search for all activity traces from the Hamburg, Federmesser, Bromme and Ahrensburgian cultures (17 May 2012) resulted in 12, 5, 123 and 17 localities, respectively. A more general search for Late Palaeolithic and Palaeolithic records yielded 173 and 358 localities, respectively.

The differences between the totals for the four cultural epochs are possibly also, to some extent, a reflection of a slow rate of the first human immigration as well as differences in climate and variation in the duration of the respective cultures. The suggestion that difficulties associated with typological dating also play a significant role will be substantiated below via two examples relating to, respectively, the Federmesser and Ahrensburgian cultures. The former was probably of more or less the same duration as the Bromme culture. In chronological terms, the Federmesser culture apparently belonged to the climatically mild first half of the Allerød period (GI-1c according to Björck *et al.* 1998, cf. Blockley *et al.* 2012), whereas the Bromme culture was, by all accounts, associated with the second half of the same climatic period (GI-1a and probably the initial part of GS-1, Fischer 1991, Pedersen 2009, Fischer *et al.* 2013).

The extent of the dating-related difficulties is apparent from the outcome of the first excavation season at the Slotseng site. This research project was led by one of Denmark's leading experts in the Late Palaeolithic. On the basis of several years of intensive field reconnaissance at the site, yielding a number of artefacts from the Hamburg culture and a few tanged points of Bromme character, the excavation director was expecting to excavate a partly ploughed-up flint concentration dating from the Hamburg culture. To his surprise, however, the site turned out to be an artefact-rich, heavily ploughed-up flint accumulation from the Federmesser culture (Holm 1993). A similar experience awaited archaeologists from the museum in Vordingborg when, in 2002, they began a research excavation at a well-known locality from the Bromme culture, Eskebjerg (Rasmussen 1972) and subsequently discovered the most artefact-rich flint accumulation from the Ahrensburgian culture yet encountered in Denmark (Pedersen 2009, cf. Petersen and Johansen 1993, p. 30).

Danish field archaeology's difficulties with respect to dating small flint assemblages resulting from archaeological reconnaissance and evaluations can in part be due to archaeologists not keeping up to date with research developments. It is actually often possible to arrive at an approximate date solely on the basis of the flint debitage recovered from Lateglacial localities. In some instances, this date can be further supported by characteristic bluish-white surface transformation of the flint ('skimmed milk patina'). These observations are not particularly new, but have regrettably only been published in a preliminary fashion and/or in not particularly accessible publications (e.g. Andersen 1973, Fischer *et al.* 1979, Fischer 1990a, Madsen 1992, 1996, Johansson 2003, Petersen 2006). The focus on flint debitage evident in the artefact illustrations below should be seen as a contribution to the dissemination of professional knowledge on the subject.

The problem of identifying Late Palaeolithic activity sites in the course of normal field-archaeological procedures is very closely associated with current practices for the execution of archaeological evaluations. These are predominantly carried out by the cutting of 2–4 m wide trial trenches, whereby the topsoil is rapidly removed in order to search for cultural deposits, pits and postholes in the subsoil (Kulturstyrelsen 2012). Danish archaeologists have long been aware of the fact that this approach leads to a marked under-representation of Late Palaeolithic and Early Mesolithic localities (e.g. Petersen 2000, Eriksen 2006). Only the Late Mesolithic Ertebølle culture, with its often extensive and easily discernible cultural deposits extending along the contemporary coastline, apparently has an archaeological visibility which prompts an intensity of investigation approaching that seen for the later parts of prehistory. The Neolithic also appears to have a marked blind spot: excavations of sites from the East Danish Single Grave culture are somewhat of a rarity, despite the fact that the abundance of this culture's hollow-ground thick-butted flint axes demonstrates that the Zealand archipelago must have been intensively occupied during this period (Glob 1945, Figure 90).

The fact that the Late Palaeolithic also constitutes a blind spot in the developer-funded field archaeology of other NW European countries was established at a conference in 2002 (Rensink and Peeters 2006). In order to compensate for the low archaeological visibility which characterises early parts of the Stone Age, archaeologists in the Netherlands and Belgium recommend the implementation of systematic auger survey of undisturbed sand layers with the potential to contain settlement layers from these epochs. In order to function optimally, this approach should be combined with wet sieving of soil samples. It has been applied for many years in these countries and has led to the identification of numerous significant, in research terms, Stone Age localities (e.g. Kooijmans 2001a, 2001b, Kooijmans and Jongste 2006, Van Gils and De Bie 2006, Ryssaert *et al.* 2007).

Should a Danish archaeologist, when carrying out a traditional evaluation or an actual excavation, quite exceptionally happen to direct the bucket of the excavator down into undisturbed layers containing traces of Late Palaeolithic activity, they would very probably be guilty of causing the destruction of a large part of the site. The most find-rich parts of the most artefact-rich and intact settlement deposits from the Bromme culture occupy an area of only about 6–10 m in diameter (Andersen 1973, Fischer and Nielsen 1987, Johansson 2003, Pedersen 2009). There is therefore a good chance that a mechanical excavator will cut right into the centre of such a site before the latter is even discovered. Other settlements from this period have proved to have find-rich areas, which are significantly smaller. This is true, for example, of Trollesgave: over most of its area of c. 300 m^2, the number of artefacts was so modest that the site would in practice be invisible given a standard evaluation using a mechanical excavator – unless one of the flint workshops, measuring 1–2 m in diameter, happened to be struck directly (cf. Fischer *et al.* 1979, Fischer 1993a).

Despite the fundamental loss of information that would result from the hard-handed trial trenching approach outlined above, a discovery of this type must nevertheless be welcomed. Experience shows that where there is one concentration of Late Palaeolithic finds there are often others of the same type in the immediate vicinity (cf. the example given below from the Fensmark site and other areas on the margins of Holmegård Mose). The discovery can, therefore, with appropriate recording in the national archaeological database, result in a heightened archaeological awareness with respect to future development works in the local area.

So little flint knapping took place at some activity sites from the Bromme culture that, in practice, it has proved to be almost impossible to demonstrate their existence even by manual excavation of closely spaced 1 m^2 test pits at locations where field surface collection has demonstrated the presence of extensive Late Palaeolithic activity (Nilsson 1989). The situation in Denmark and neighbouring countries appears to be no better with respect to the other Late Palaeolithic epochs, where the quantity of worked flint usually does not exceed what is normally seen at Bromme localities (Madsen 1983, Holm 1993, Petersen and Johansen 1993, Pedersen 2009).

The Fensmark site (Figures 1 and 2) exemplifies these aspects of archaeological invisibility. At the same time, it is also a typical example of the most commonly recorded sites from the Bromme culture: small flint concentrations located on a sandy plateau in direct association with a contemporary lake where the artefact assemblages are characterised by 'domestic activities' (cf. Fischer 1991, 1993a).

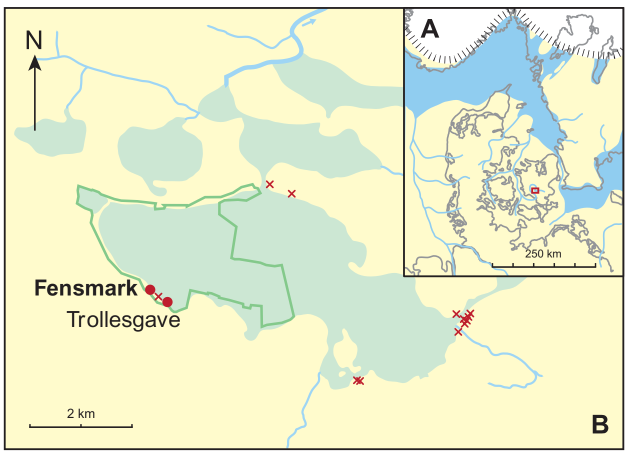

Figure 1. Location of the study area and the relations between land, water and the inland ice in mid-Allerød times, c. 13,500–13,000 calendar years BP (A), together with well-defined Lateglacial settlement sites associated with the Holmegård basin (B). The distance between the Fensmark and Trollesgave settlements is c. 250 m. The irregular polygon marks the extent of the landscape scheduling, which protects archaeological remains hidden beneath the soil. Figure modified from M. Houmark-Nielsen (2012, Figure 14–13), Fischer *et al.* (1978), Fischer (1985), and Johansson (2003).

The investigations at Fensmark

Late Palaeolithic activity sites are usually found and identified by people with a particular interest in the period and, thereby, an acquired knowledge of its material culture and of the localisation of such sites. Many of the sites discovered to date have turned up as the result of targeted and persistent reconnaissance work by amateur archaeologists and archaeology students. This was also the case with the Fensmark site. The first finds were picked up at the site in 1965 by trainee accountant, subsequently archaeologist and museum curator, Per Noe Jacobsen (Johansson 2003, p. 95). The fact that, in addition to postglacial artefacts, there were also activity traces from the Bromme culture at the site was securely established in 1970, when amateur archaeologist Axel D. Johansson found the first tanged point of Bromme type. In subsequent investigations by the author of this article in the period up until 1981, a considerable assemblage of Late Palaeolithic finds was recovered from the site. The fieldwork included both surface collection and trial excavation.

Collection from the field surface took place up to several times in the course of a winter, after the area had been ploughed. This work was, as far as possible, carried out at times when a long period of rainfall or strong spring winds had ensured that the artefacts lay clean and easily visible on the surface. The finds distribution was in the first instance compared visually with the terrain and soil characteristics. It became apparent that scrapers, burins and blades of Bromme character were associated with a sandy plateau, bordered on one side by a heavy clay slope and on the other by wetland deposits. The indications of Late Palaeolithic activities occurred in particular on a small weakly defined promontory – the location which on the basis of the subsequent excavations is referred to as find concentration A.

During the later years of the investigations, all finds – cores, blades (L ≥ 2B) and retouched tools from the field surface – were plotted in to the nearest metre, using a

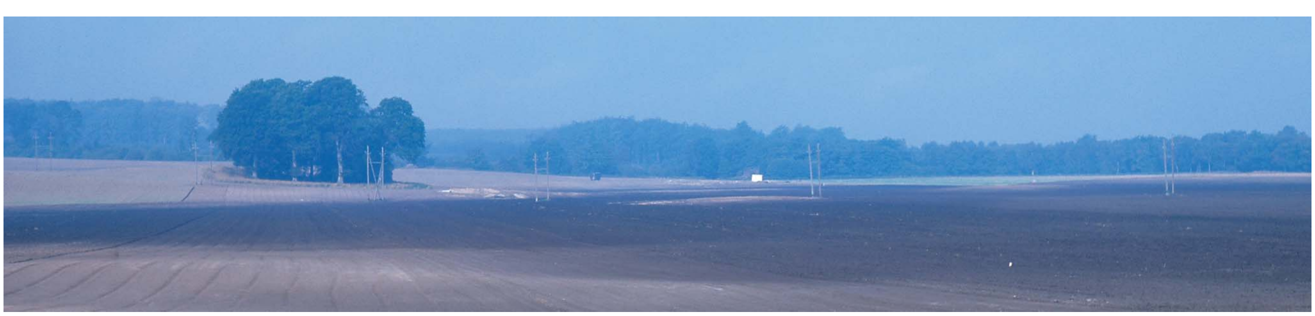

Figure 2. The SW end of Holmegård Mose where intensive field reconnaissance along the edge of the bog has revealed several Late Palaeolithic activity areas. To the right, a white excavation tent can be seen at the Fensmark site and the spoil heaps generated by the excavation of the Trollesgave settlement are evident to the right of the small group of trees. A further site from the Bromme culture has been discovered between the two localities.

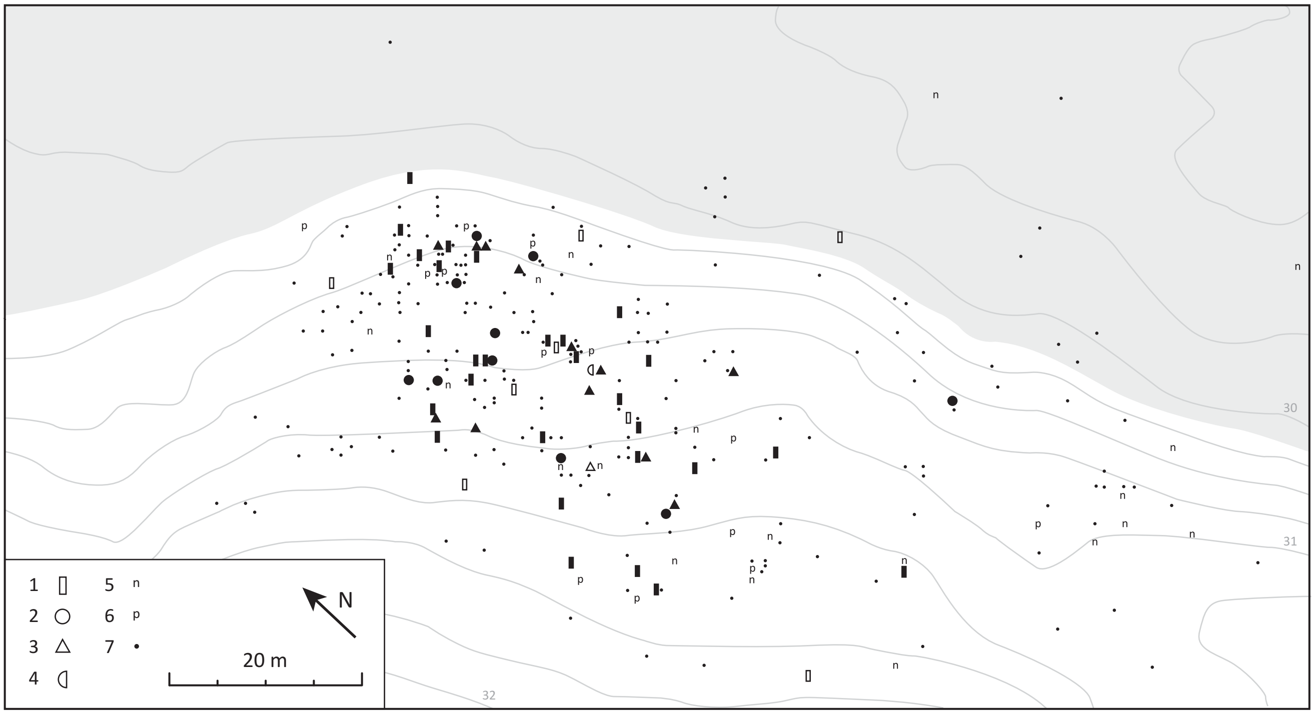

Figure 3. Fensmark: finds from the field surface plotted in relative to the height contours for the terrain (equidistance 0.25 m). Artefacts of Late Palaeolithic character are shown with a solid symbol when they result from a representative random sample, taken when the entire site area was searched in a uniform manner. 1: blade, Late Palaeolithic; 2: scraper, Late Palaeolithic; 3: burin, Late Palaeolithic; 4: Federmesser; 5: Neolithic artefact; 6: postglacial artefact (unresolved whether Mesolithic or Neolithic); and 7: artefact, unspecified Stone Age.

measuring tape and optical square. The results are given in Figure 3, which shows that flint artefacts of Late Palaeolithic character were concentrated within an area of c. 65 × 25 m. In this area, and continuing further towards the SE, there were also a few Mesolithic artefacts and numerous Neolithic finds. Artefacts of Late Palaeolithic character appeared to be mostly concentrated on the above-mentioned weakly defined 'promontory' in the NW part of the investigated area.

Trial excavations (Figures 4 and 5) took place in 1974 and 1975. Their primary aim was to find intact settlement layers and scientifically datable wetland deposits with cultural traces – corresponding to what had already been demonstrated at the neighbouring site of Trollesgave (Fischer and Mortensen 1977, Fischer 1990b).

Apart from some of the wetland deposits, all the soil was sieved using a mesh size of 4 × 4 mm. The finds were divided up according to geological layers in horizontal units of 1 × 1 m. In the examination of the layers beneath the plough soil the investigation units were often reduced to 0.25 m^2. Larger and chronologically more significant artefacts were mostly plotted in to the nearest centimetre, in three dimensions (Figure 5).

In the first instance only the plough soil was investigated. The entire area where field reconnaissance had yielded artefacts of Late Palaeolithic character was covered by a regular network of 1 m^2 test pits, situated 9 m apart (Figure 4). The astonishing result of this considerable investment of effort was that traces of Late Palaeolithic settlement were practically none existent: a total of 13 flint implements with retouch were encountered, of which only two appeared to be of Late Palaeolithic date (Figure 6).

Subsequently, in the central part of the investigation area, a series of supplementary test pits was laid out midway between those, which had already been dug. These additional efforts invested in sieving plough soil did not lead to further finds of retouched implements of Late Palaeolithic character. Consequently, the Lateglacial settlement remained virtually invisible to this systematic and intensive investigation of the plough soil. This permits the following conclusion to be drawn with respect to future investigations of totally or partially ploughed-over Late Palaeolithic activity sites: plotting in of artefacts found on the field surface, at a total cost of about 10 man-days, gave a significantly more precise picture of the presence of

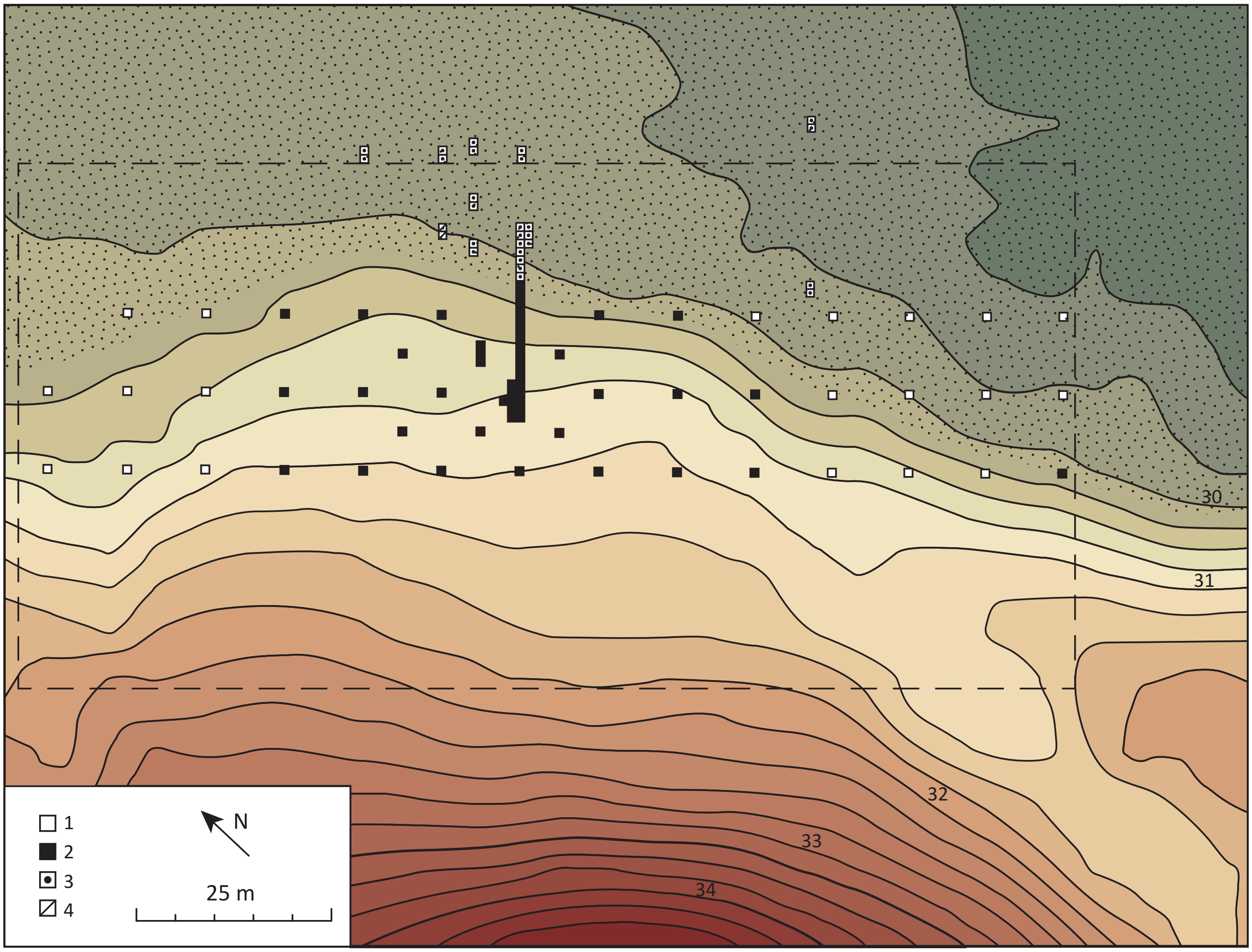

Figure 4. Excavation trenches and geomorphology. The extent of gyttja and peat deposits is marked by dot shading. The broken line denotes the extent of the area shown in Figure 3. 1: plough soil sieved, not excavated deeper; 2: both plough soil and sand layers sieved; 3: the layers beneath the plough soil excavated with shovel and trowel; 4: plough soil sieved and layers beneath the plough soil excavated with shovel and trowel.

Lateglacial habitation at the locality than the c. 25 man-days invested in sieving of random samples from the plough soil.

It was first when the excavation of test pits was continued down into the pale-coloured sandy layers beneath the plough layer (Figures 5 and 18) that secure contact was made with Lateglacial settlement traces. These sediments showed no similarity to the dark-coloured cultural layers, which often characterise settlements from later prehistory. On the contrary, they have much more in common with the kinds of deposits, which in excavations in plan of, for example, Iron Age settlements are often termed 'the subsoil' or 'the natural' – expressions which in themselves can contribute to diverting attention away from possible traces of Late Palaeolithic activity.

It turned out that beneath the centre of the concentration of finds in the plough soil to the NW there were significant quantities of flint artefacts of Bromme culture character (cf. Figures 6 and 7). Even greater quantities of Late Palaeolithic flint artefacts were encountered beneath the southern extension of the same flint accumulation in the plough soil. In the following, these two flint concentrations are referred to as, respectively, Fensmark A and B. Due to the relatively limited number of test pits, the possibility cannot be excluded that there are further Late Palaeolithic artefact accumulations in the sand beneath the plough soil at the site. Finds concentrations A and B are located in the centre of a plateau, which slopes slightly down towards the area of the Lateglacial lake. The soils of the activity areas are characterised by well-drained sandy sediments.

Figure 5. Investigation of the central part of Lateglacial Fensmark B, incorporated within a solidly cemented pale-coloured sand layer. At this point it contained flint artefacts and a hammerstone, but was otherwise hardly distinguishable from the 'natural subsoil'.

Finds from the plough soil

A significant proportion of the finds from the plough layer can, with certainty or great probability, be assigned to the Neolithic, more precisely the Early Funnel Beaker culture. Intensive field reconnaissance around the entire Holmegård basin (cf. Fischer *et al.* 1978) has demonstrated that this period is represented by settlement traces on a number of sandy plateaux at the edge of the bog – in several instances directly on top of activity sites from the Bromme culture. Settlement during the Early Funnel Beaker culture has thereby played a systematic part in reducing the possibility of identifying sites of Late Palaeolithic activity around the former lake basin. The same problem is true of the settlement from the Maglemose culture, which was located on 'dry land' around the Holmegård basin (Fischer 1993b, Schilling 2003, Kulturarvsstyrelsen 2004, p. 9). There are presumably similar barely recognisable Lateglacial elements at numerous other artefact-rich Mesolithic and Early Neolithic settlements located on the edges of bogs in Northwestern Europe (cf. Fischer and Nielsen 1987).

The intensive surface collection of flint artefacts over a period of 16 years at Fensmark resulted in the recovery of a total of four Late Palaeolithic tanged points (Figure 8a–d) and a significant number of cores, flakes, scrapers and burins which, on the basis of their production technique, size and morphology, can with great probability be assigned to the Bromme culture. The same date is possibly also appropriate for a flint point, which was found on the field surface immediately above the west end of Fensmark B (Figure 8e). Its dimensions and form, including its steep in parts bilateral side retouch as well as its lack of micro-burin facet, speak more in favour of a Late Palaeolithic 'Federmesser' or 'Rückenspitze' than a Mesolithic lancet microlith (cf. Johansson 2003, p. 95).

Finds beneath the plough soil on the plateau

On the basis of the artefacts recovered from the undisturbed sand deposits at Fensmark A, it is only possible to establish that this was an activity site, with some flint knapping, dating from the Bromme culture. The frequent finds of Late Palaeolithic artefacts resulting from field collection on this part of the site suggest that flint concentration A has been damaged by ploughing, to a considerable extent. Fensmark B is significantly better preserved. In the latter, the artefacts mostly lay some way down into the sand – generally more than 10 cm below the base of the plough soil – within a diffuse horizon of up to about 20 cm in thickness. A small number of postglacial types were encountered in the upper centimetres of the sand, and in a pit, which cut down through the Late Palaeolithic horizon. In order to exclude such later elements from consideration, mention will only be made below of the artefacts recovered from the sand deposits in the southernmost 9 m^2 of the excavation trench (see Figure 16); these yielded a total of 2385 pieces of worked flint (>4 × 4 mm).

Cores and flakes

The 19 cores (Figure 9 and 10) recovered from the undisturbed sand deposits at Fensmark B were produced by working nodules of moraine-worn flint. The raw material was a relatively brittle and homogenous flint of Danien type (Thomsen 2000), which would have been well-suited to the controlled detachment of regular flakes. The material would originally have been dark grey to greyish-black in colour. The majority of the flint artefacts from the site have undergone a bleaching process resulting in a light grey colour. This phenomenon is seen most markedly in flint originating from the interior of the nodules (Figure 19 and 20) and is a characteristic feature of many Late Palaeolithic assemblages from Denmark. Occasional pieces also show a bluish-white surface transformation ('skimmed milk patina'; Figure 15a), which characterises many Late Palaeolithic flint assemblages (Petersen 2006). More frequently the Fensmark B flints display a faint yellowish patina (e.g. Figures 9 and 11).

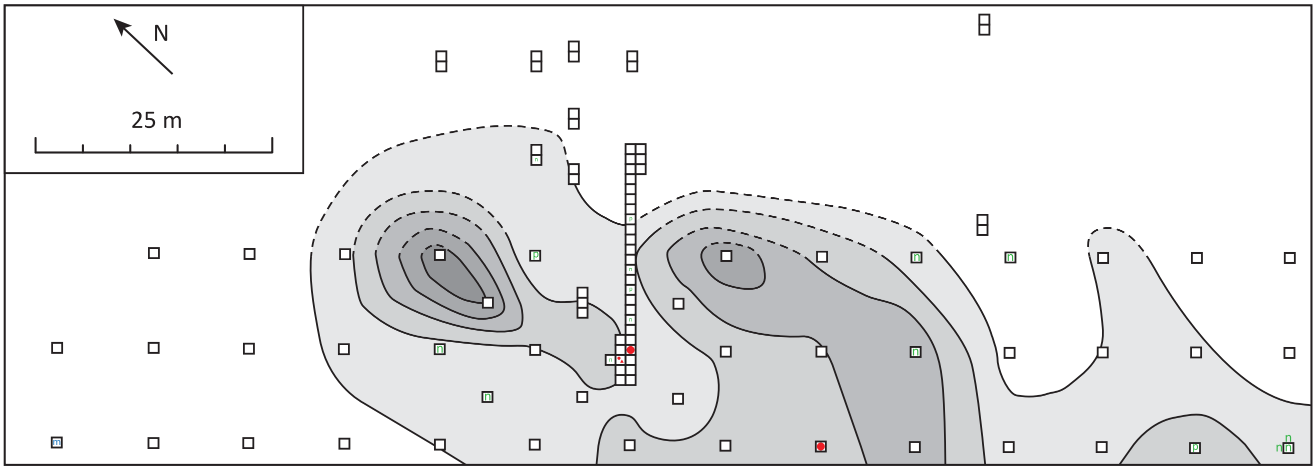

Figure 6. Distribution of finds in the excavated parts of the plough soil. The contours denote 20, 40, 60, 80 and 100 pieces of worked flint per m^2, respectively. The key is the same as on Figure 3. Large symbols mark finds from test pits arranged in a regular array, small symbols mark artefacts resulting from later extensions of the test pitting. Solid symbols mark artefacts with retouch (two scrapers) of Late Palaeolithic character. It is clear that a significant proportion of the finds were of Neolithic date and that the labour-intensive sieving of the plough soil did not provide a basis for pointing out the location of Late Palaeolithic activity areas.

The flint knapping at Fensmark B was clearly directed towards the production of large longish flakes with regular sharp edges. Some characteristic successful examples are shown in Figure 11a–d. Judging from the form and size of the bulbs of percussion and, not least, the crushing and the percussion scars on the platform remnants, knapping was carried out exclusively with hammerstones. The finds recovered from the 9 m^2 dealt with here also included a heavy hammerstone (weighing 140 g) of granite (Figures 5 and 12).

The cores and blades from Fensmark B are characteristic of the flintworking of the Bromme culture. They reflect a relatively simple craft tradition, involving heavy consumption of raw material, which stands in stark contrast to the situation in both the preceding Hamburg culture and the subsequent Ahrensburgian culture (Fischer 1990a, Madsen 1992, Weber 2012). In terms of flint technology – and probably also in its broadest sense – the Bromme culture can be perceived as the first complete adaptation to the environment in the flint-rich moraine areas of Southern Scandinavia (Fischer 1993a).

Flakes with use-wear traces

Most of the more than 2000 flakes can be considered to be debitage. However, use-wear traces visible to the naked eye demonstrate that some of the largest flakes were actually used in various ways. The commonest of these

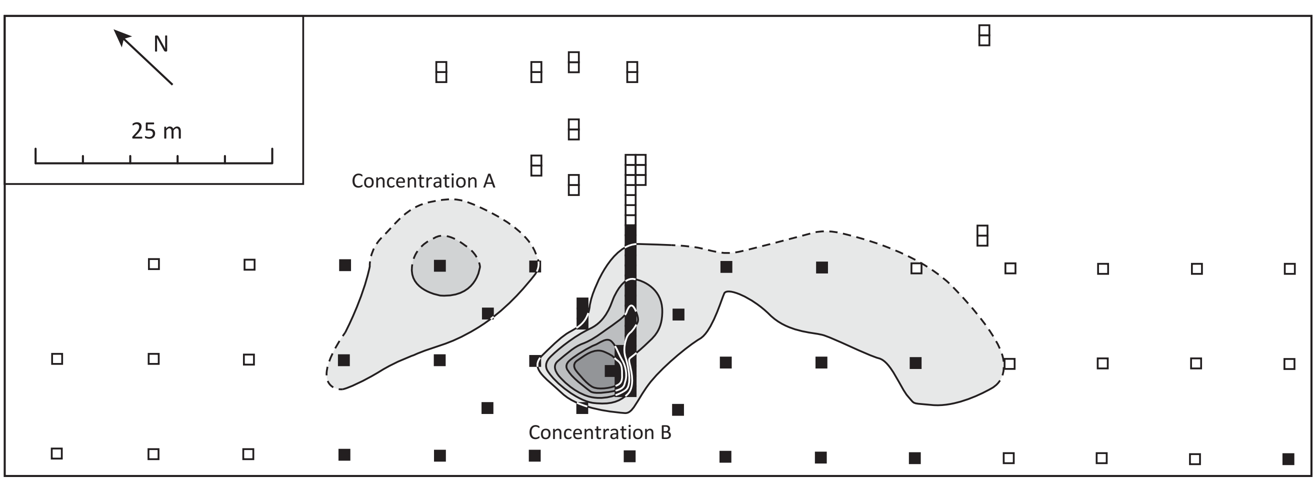

Figure 7. Number of pieces of worked flint per m^2 from all the artefact-containing layers. The contours represent the values 100, 200, 300, 400 and 500. The parts of the excavation where all excavated layers were sieved are highlighted in black.

Figure 8. Flint points from surface collection (a–e) and evaluation trenches in find concentration B (f–i). Tanged points (a–d and f–i), possible 'Federmesser' (e). The following symbols are employed: ● platform remnant preserved; ○ percussion bulb end, platform remnant lacking. Scale in centimetres.

traces comprises use-wear retouch on longish, sharp-edged pieces, which were probably used as knives.

One unusually large flake (Figure 13) shows heavy crushing with step-like terminations and 'soft' percussion bulb negatives. These use-wear traces suggest that this artefact was used to chop a relatively hard material (such as reindeer or elk antler) – i.e. as a kind of axe. Blades and large flakes with related use-wear traces are known from a number of NW European flint assemblages from the Lateglacial and from Early Pre-Boreal times (Rust 1943, Tafel 47, Taute 1968, Tafel 81, Andersen 1973, Figure 76, Fagnart 1988, Barton 1991, Johansson 2003, fig. 29).

Tools with retouch

The most important typological-chronological guide type in the flint assemblage, the tanged point, is represented by four examples. They are of fairly unattractive appearance (Figure 8) as they show heavy use damage (Figure 8g and probably h and i) and evidence

Figure 9. Characteristic unipolar core from Fensmark B. Like the typical blade cores from other sites of the Bromme culture, it is of roughly conical form with less than half of the perimeter consisting of the original surface of the flint nodule. Scale in centimetres.

Figure 10. Irregular bi-polar core with one dominant platform. Scale in centimetres.

of exposure to fire (Figure 8i). In each case, the tang has been formed at the proximal end of the flake with the retouch extending from the percussion bulb side. Part of the platform remnant is preserved on the fire-damaged example. A small and somewhat clumsily retouched example (Figure 8h) was made from a blade, which lost its platform remnant at the moment of detachment.

All the 15 scrapers from Fensmark B were made from flakes with relatively straight and roughly parallel longitudinal edges (Figure 14). One has a scraper edge at one end and a burin edge at the other (Figure 14d).

The assemblage includes 45 burins (Figure 15), including the above-mentioned combined scraper plus burin. In their manufacture, use was most often made of regular oblong flakes. Many of them have deliberately produced edge retouch. The burin edges are generally robust and distinctly shaped.

On the burin edges use-wear retouch is frequently visible. Similarly, several of the scrapers show wear polish along the convex scraper edge and use retouch along their longitudinal edges. This shows that the assemblage does not only represent a flint-knapping workshop based on the local abundantly occurring flint. Other manufacturing processes also took place, such as the production of tools of bone or antler and the scraping of skins/hides, to an extent which suggests an occupation of longer duration (cf. Donahue and Fischer in prep.).

Settlement organisation

Although only a limited part of Fensmark B has been excavated, it is still possible to identify specific patterns in the artefact distribution: most of the debitage from the flint knapping is concentrated within the northernmost part (Figure 16), whereas the tools are concentrated a little further to the south (Figure 17). The distance from the most find-rich 0.25 m^2 square out to the edge of the heavy flint concentration is about 3 m.

No archaeological traces, in the form of soil features or stone structures of Late Palaeolithic date, were observed at the site. Sporadic occurrences of both fire-crazed and white-burnt flakes suggest that somewhere (beyond the limits of the excavation trench) there was a hearth (cf. Fischer *et al.* 1979, Fischer and Nielsen 1987).

Finds from the lake deposits and scientific dates

Four cores and 15 large flakes were encountered in a peat-covered solifluction layer (Figure 18) located c. 20 m from the centre of Fensmark B. In their size, mode of production and overall character these show great similarity to those found in Fensmark B. All of them were detached using a hammerstone and the cores are distinctive in being unipolar and by having platforms consisting of a single man-made detachment surface. Several of them can be refitted (e.g. Figure 19), suggesting that they originate from one and the same relatively small part of the activity area above the lakeshore at that time.

In the solifluction deposits to the north of Fensmark B a piece of unworked amber was found along with three pieces of red ochre (report from 1982 by mag.scient.

Figure 11. Examples of flakes characteristic of the Bromme culture. Entire successful blades (a–d), unsuccessful attempt at blade detachment (detachment surface turned outwards before it reached the tip of the core) (e). These are characterised by, among other things, carefully trimmed platform edges and large flat platform remnants showing crushing and curved percussion scars. Scale in centimetres.

Figure 12. Hammerstone with crushed corners and scars from detached chips. Scale in centimetres.

Søren Floris, Geological Museum, Copenhagen). Similar finds of intentionally produced ochre pigment are known from the neighbouring and approximately coeval locality of Trollesgave. This suggests that the site's Lateglacial inhabitants were not occupied exclusively in practical craft activities but were also engaged in more esoteric pursuits, such as painting their bodies or clothes.

The flint artefacts, the pieces of ochre and the amber originated from sediments, which also contained a quantity of small charcoal fragments and charcoal dust. Cand.

Figure 13. Flake with heavy use-wear traces suggesting an axe-like function. Scale in centimetres.

Figure 14. A selection of scrapers illustrating the significant variation in form, size and method of production of this type. Scale in centimetres.

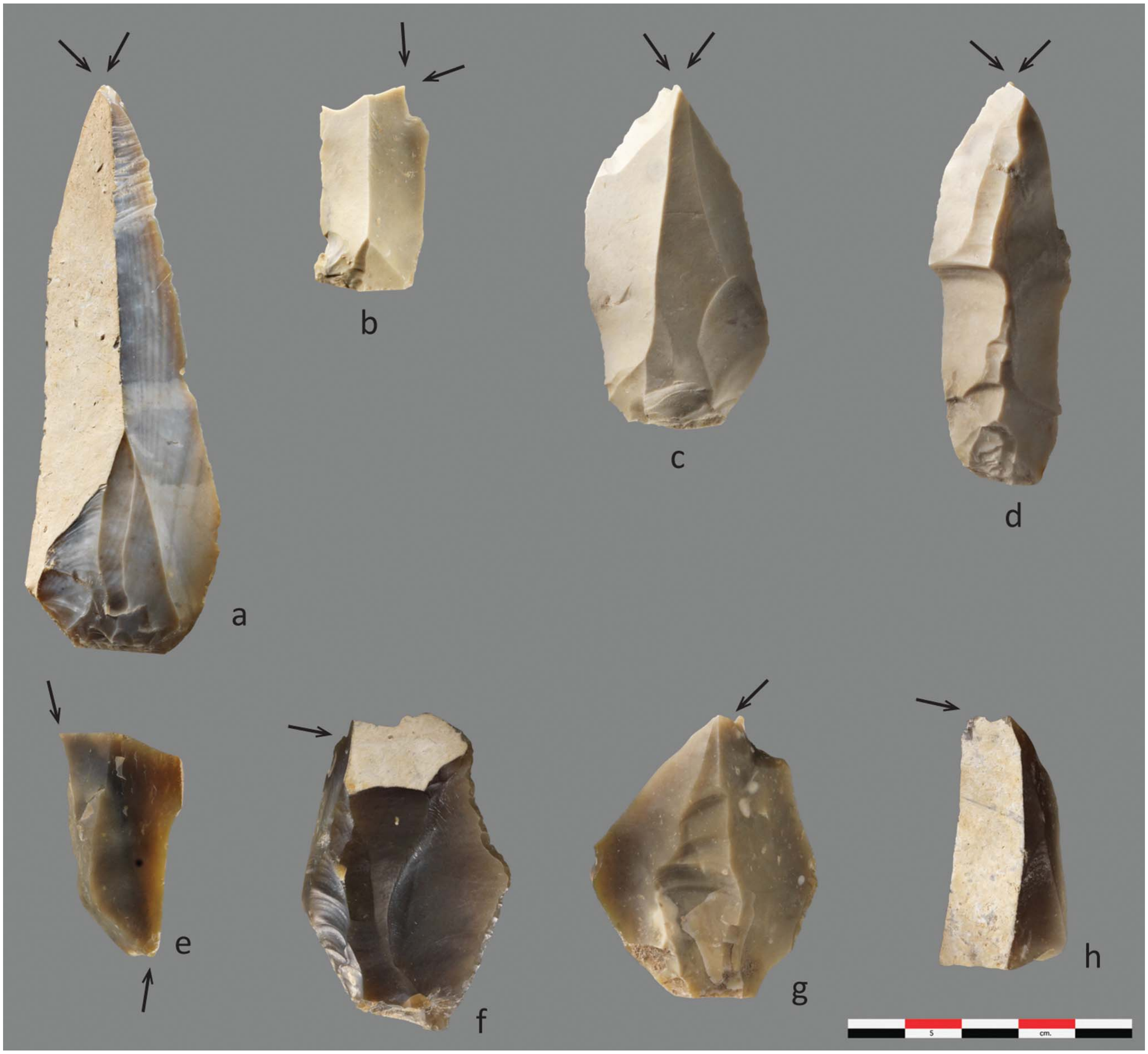

Figure 15. Burins. The burin blows of specimens e and f initiate from pre-existing flaking surfaces, while those of g and h initiate from edge retouches. Scale in centimetres.

scient. Charlie Christensen of the National Museum of Denmark has, on the basis of a pollen sample, arrived at a date of Lateglacial or Early Pre-Boreal for these deposits (report from 1976).

In the course of the trial excavations, a few pieces of charcoal were also found in the solifluction layer containing the flint artefacts. One of these has been subjected to microscopic analysis and even though it proved to be pressure-deformed it was possible to establish that it came from a diffuse porous hardwood (e.g. willow/*Salix sp.*, birch/*Betula sp.*, aspen/*Populus tremuls L.* or whitebeam/*Sorbus sp.*; report from 1992 by cand. mag. Kjeld Christensen of the National Museum of Denmark). A radiocarbon analysis of the charcoal fragment gave a date of 10,810 ± 120 BP (OxA-3614; 13,065–12,543 cal BP (95.4%); OxCal 4.1), corresponding to the initial part of Grenland ice core climate period GS-1 (Fischer *et al.* 2013). This date is at present the best estimate for the age of the finds in concentration B.

The AMS date means that the Fensmark site is a member of a distinguished group. To date, it has only proved possible to obtain radiocarbon dates for three settlements from the Bromme culture. There is a single date from a peripheral part of the actual Bromme site itself of 10,720 ± 90 BP (AAR-4539; cand. mag. Ingrid Sørensen, personal communication 2012). The Trollesgave site has a larger number of

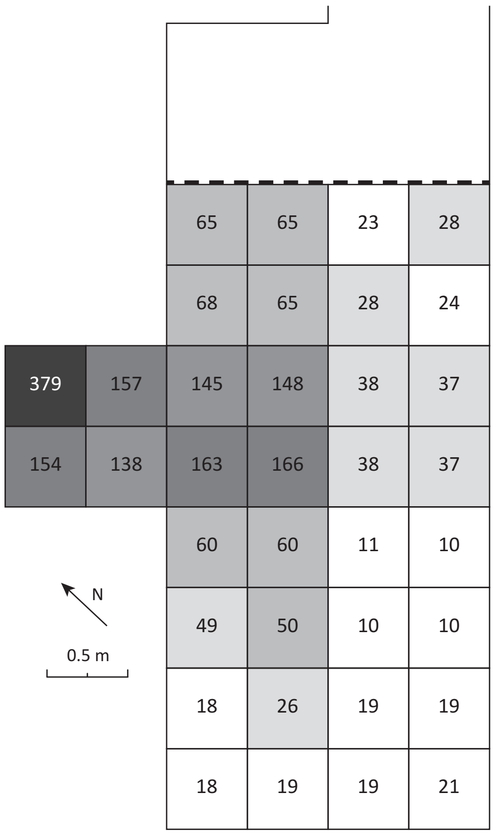

Figure 16. The intensity of worked flint per 0.25 m^2 in the layers beneath the plough soil. The area to the NE of the broken line was partially disturbed.

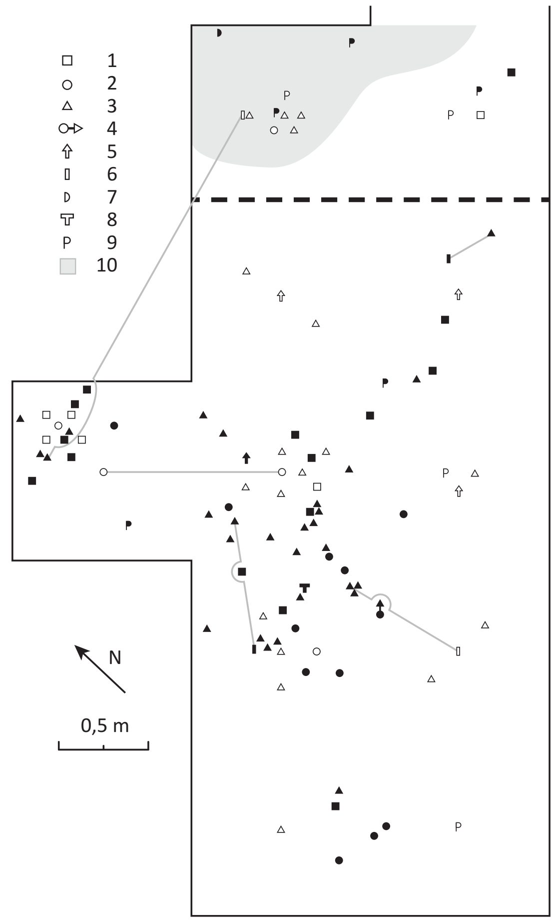

Figure 17. Distribution of cores and tools. The positions of the precisely mapped artefacts are shown with solid symbols and finds from sieving with open symbols. Flint pieces which could be refitted are joined with lines. Only finds from the area SW of the broken line are mentioned in the text. Core (1), scraper (2), burin (3), combined scraper and burin (4), tanged point (5), refitted burin spall (6), Federmesser? (7), hammerstone (8), post-glacial artefact (9), more recent disturbances (10).

radiocarbon dates as well as dates based on thermoluminescence and pollen analysis, including samples from sediments older and younger than the Late Palaeolithic habitation. These unanimously indicate a date in the Late Allerød period. An AMS analysis of a piece of charcoal from the refuse layer in the lake deposits adjacent to the settlement area resulted in a date of 10,826 ± 42 BP (AAR-16019).

It therefore appears that the two geographically, topographically and typologically closely related finds concentrations, Fensmark B and Trollesgave, are also closely related chronologically. The dating of the Fensmark site should, however, be taken with some reservation, partly because it relies solely on a single AMS date and partly because the dated material originated from a solifluction deposit. As a consequence, it is not completely certain that the charcoal and the flint artefacts originated from one and the same short-term activity. Considering the proportion of the locality that remains untouched, there is a good possibility that future excavations will permit greater certainty to be attained with respect to the absolute age of this settlement from the Bromme culture.

Ways to mitigate the blind spot

The archaeology of the North European plain is presently characterised by a high level of field activity. Even so, investigations of Lateglacial and Early Holocene sites are still very much a rarity. This is, no doubt, largely due to the fact that localities from this period are very difficult to detect using the methods, which presently dominate archaeological fieldwork in this region. Despite the limited number of new records in recent years it can, therefore, safely be assumed that sites from the Late Palaeolithic and the Early Mesolithic are being damaged and destroyed by cultivation and development to approximately the same extent as localities from later parts of prehistory.

Figure 18. Wetland sediments adjacent to Fensmark B. The pale-coloured layers are from the Lateglacial and possibly the Early Pre-Boreal. The relatively granular solifluction deposit beneath and adjacent to the large stone contained worked flint of Bromme character. The bars on the rod are 20 cm in length.

Figure 19. Refit of two cores from the lake deposits. Scale in centimetres.

Investigations of the Bromme culture site at Fensmark provide an example of the approaches, which can be adopted in order to locate significant – in research terms –

Figure 20. Core recovered from the lake deposits adjacent to Fensmark B. Scale in centimetres.

activity sites from the Lateglacial and Early Holocene (i.e. reasonably undisturbed, with preserved organic remains, etc.). The results from the site testify to the advantages of employing field reconnaissance coupled with systematic plotting in of the relevant artefact finds as the first stage in an archaeological evaluation. Modern GPS equipment has made it much easier to carry out such evaluations efficiently and precisely. Conversely, present-day agricultural practices in Denmark (and almost certainly in other EU countries with a corresponding agricultural policy) mean that the search for artefacts on field surfaces must most often take place under relatively poor conditions for observation. It is now only possible under exceptional circumstances to carry out archaeological reconnaissance on ploughed fields where the soil has been allowed to lie exposed for months so as to render any potentially exposed flint artefacts readily identifiable following prolonged periods of precipitation. However, these favourable conditions for surface recording on areas of ploughed soil could be established through archaeological evaluations extending over the several months the process requires. It is therefore recommended that a combination of superficial ploughing, long-term exposure and field reconnaissance be added to developer-funded archaeology's standard repertoire of methods for use in evaluations.

Since the 1970s, ploughing has without doubt caused severe damage to numerous Late Palaeolithic sites in the North European lowlands (cf. Pedersen 2009, p. 11). Nevertheless, the excavations at Fensmark demonstrate that particularly well-preserved activity sites from the Lateglacial can lie at such a depth that they are not disturbed by agriculture, and are, in practice, impossible to locate via field reconnaissance. Corresponding observations have been made, for example, at Bromme *locus classicus* (Fischer and Nielsen 1987). It is therefore recommended that, in future archaeological evaluations, a systematic array of closely spaced test pits is dug (as at Fensmark), or an auger survey involving a dense network of sampling points is carried out in places where the topography or previous finds in the local area suggest the possible existence of Late Palaeolithic activity traces. Regardless of whether the method adopted involves excavation or auger survey, the holes must be large enough and close enough together to ensure a real chance of detecting cultural traces in the small concentrations, which usually characterise Late Palaeolithic localities.

Should it not prove possible to invest such efforts in archaeological evaluations, finds of Lateglacial activity sites will continue to be absolute rarities in the future. As a consequence, cultivation and development will destroy significantly greater numbers of sites from this period than will be the case for agrarian prehistory. It is possible to compensate to some extent for such a loss of information through the launching of targeted searches for Late Palaeolithic activity traces. Field reconnaissance around Holmegård Mose has shown that this approach can produce valuable results. A correspondingly positive output for Stone Age archaeology has been achieved by targeted field reconnaissance in other areas of the NW European lowlands, often involving local amateur archaeologists (e.g. Nilsson 1989, Andersen 1993, Nielsen 2001, Gerken 2003).

Regardless of which methods are employed in the future to compensate for the present under-representation of Lateglacial sites in North European field archaeology, it is recommended that great care be taken of those localities with significant research potential that are already known or which turn up in the future either by chance or as the result of a targeted search. The most secure solution in this respect would be protection through scheduling, bringing to a halt any form of intervention in the soil at these particularly valuable sites. The Fensmark locality has now been secured in this way. The area was taken out of cultivation in connection with the landscape scheduling of a total of c. 6 km^2 of Holmegård Mose and its adjacent slopes (Figure 1). This scheduling has made it possible, at one and the same time, to give permanent protection to the archaeological assets in the soil and to create better conditions for the area's special flora and fauna. The prehistoric sites within the area (Kulturarvsstyrelsen 2004) can be considered as scientific reserve capital which has been lodged in an account in a state-guaranteed bank and which can be gradually withdrawn in appropriately small instalments as dictated by research requirements.

If even a moderately representative selection of scientifically significant localities from the Lateglacial are to be preserved, it will be necessary in the (near) future to establish several of these larger or smaller archaeological reservations in various landscape types and in various parts of Denmark where the presence of well-preserved activity sites from the period has been established. The Holmegård scheduling in 2009 and a campaign presently in progress under the auspices of the Danish Agency for Culture directed at obtaining permanent protection for kitchen middens dating from, in particular, Late Mesolithic times demonstrate that solutions of this type are possible. Furthermore, measures such as these, resulting in the permanent protection of Late Palaeolithic and Mesolithic settlement deposits, will often prove to be considerably less expensive than archaeological 'rescue' excavations of the implicated areas.

It can therefore be concluded that the Late Palaeolithic need not necessarily remain a virtually invisible part of Danish prehistory. It is actually possible to make developer-funded archaeology better at locating activity sites from this long and relatively poorly researched period. Furthermore, it is also possible to preserve *in situ* some of the most significant, in research terms, localities from the period such that researchers in the future will be able to draw on primary sources of high quality.

Acknowledgements

The Fensmark site is record no. 8 in Fensmark parish, Tybjerg district, Præstø county (see the Danish Agency for Culture's database Sites and Monuments, http://www.kulturarv.dk./fundogfortidsminder/). It is included in the area scheduling for Holmegård Mose (the Nature Protection Board of Appeal ruling of 29 April 2009, ref. no. 111-00019), prepared by the Danish Society for Nature Conservation with financial support from Aage V. Jensen's Foundations and with archaeological assistance initially from the Danish Forest and Nature Agency's Cultural History Department, subsequently the Cultural Heritage Agency of Denmark (2004).

The excavations at the site were carried out under the auspices of the National Museum of Denmark. The site archive is stored under ref. nos. NM 1 1042/75 and NM 8 5903, where the site name Fensmark Skydebane is employed. The finds recovered have accession no. A51811.

Fieldwork at the Fensmark site and postexcavation analysis of the finds and data from the site took place in immediate continuation of investigations of the Trollesgave settlement (Fischer and Mortensen 1977, 1978, Fischer 1990b). The direct transfer of recording systems, equipment, personnel and practical expertise, possible as a consequence, markedly improved the efficiency of the present investigation.

Running costs during the fieldwork at the Fensmark site were funded by the Danish State Research Council for the Humanities. Fensmark Municipality supported the investigations by making young unemployed people available for the excavation work. The preparation of this article was carried out under the auspices of the National Museum of Denmark as part of the research initiative Northern Worlds by way of a grant awarded by the Danish Council for Independent Research | Humanities (FKK ref. no. 273-08-0424). The owners of the field at the time of the investigations, the Nordsted-Jørgensen family, are warmly thanked for accommodation and permission to work at the site. Thanks also to everyone who participated in the fieldwork and in the subsequent post-excavation analysis including, not least, local archaeology enthusiasts who, on a voluntary basis, carried out a significant part of the excavation work. Sincere thanks are also due to several colleagues from museums, universities and heritage administration for inspiring discussions during the writing of the paper and, not least, to mag.art. Lisbeth Pedersen, Kalundborg, for critical reading and constructive suggestions with respect to earlier versions of this article. Finally, David Earle Robinson is thanked for swift and precise translation of the article into English. Moesgaard Museum's Drawing Studio assisted with the graphic. Rógvi Nolsøe Johansen (Moesgård Museum) assisted with Figures 8–15, and 19 and 20.

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Vestervang at Kirke Hyllinge, Zealand: a late Iron Age settlement with rich stray finds

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In 2007 Roskilde Museum investigated a settlement dated to the late Germanic Iron Age/Viking Age. The excavated area of c. 18,000 m^2 unveiled 18 longhouses and 21 pit houses but is probably best understood as a single farm in c. six phases. The settlement consists of rather modest structures, not exceeding 20 m in length, which contrasts with the broad range of rich contemporary metal stray finds from the site. This paper presents the excavation results and briefly proposes a possible connection between this site and the nearby elite complex of Lejre.

Keywords: Iron Age; Viking Age; agrarian settlement; pit houses; longhouses; metal stray finds; metal detector; Roskilde Fjord; Lejre; Karleby

The cultural landscape of Denmark has experienced significant changes in the last few years, as countless hectares of arable land have been redeveloped as residential areas. This large scale transformation has not been seen since the 1960s when vast residential developments last enveloped and faded the traditional rural village. But the extent of the present restructure of the cultural landscape, has been much greater than that of the 1960s, due to for example, changes in legislation and increased mechanization, and has involved countless trial trenches and vast areas of archaeological excavation. The data collected exceeds any previous amounts in such a short time period and extensive scientific analysis and dissemination of this data will be required.

As a consequence there has been a high frequency of excavations in the district of Roskilde Museum on Zealand until recently. One of the more extensive and advantageous archaeological campaigns took place in April–December 2007 near the farm of Vestervang, Kirke Hyllinge parish, where 15 hectares of arable land was to be residentially developed (Figure 1) (Kastholm 2009).[1] The excavation uncovered traces of settlement from two prehistoric periods: Late Bronze Age and Late Iron Age. This paper aims to present the latter.

Topography

The rural village of Kirke Hyllinge is situated on a ridge in the heart of the peninsula of Hornsherred, which stretches northwards from the centre of Zealand and is flanked by the waters of Isefjord and Roskilde Fjord. The church of Kirke Hyllinge is placed on the highest point at c. 43 m above sea level. To the west, the landscape consists of hilly terrain towards the cliffs of the Isefjord coastline. To the east the terrain slopes down towards Lejre Vig in the inner waters of Roskilde Fjord and is characterised by a flat valley traversed by the small stream of Ørbæk.

The area of investigation is situated on arable land, about halfway between the old village of Kirke Hyllinge and the village of Store Karleby, on a ridge about 23 m above sea level. To the west the area is limited by a modern settlement. To the north and east the ground slopes, while it rises to c. 30 m to the south. Although the terrain appears to be smooth sloping, the trial trenches unveiled a landscape of numerous depressions, mostly consisting of small ponds levelled by ages of ploughing.

The subsoil was variable and mostly consisting of yellow-brown to yellow-white sandy clays. The subsoil clay on the higher areas was criss-crossed by natural grooves of a more sandy and humic composition. The top soil is 40–80 cm thick with the thicker soils downslope.

The excavation

A total of c. 27,000 m² was excavated: c. 8700 m² in the trial trenches and c. 18,300 m² in the subsequent excavation. The excavation formed a field of slightly rectangular shape on the highest part of the area, covering all concentrations of relevant features discovered during the trial excavation (Figures 2 and 3). Thus the prehistoric traces ought to be more or less fully investigated on three sides: north, east and south. Trial excavations to the west of the excavation field, which was residentially developed in 2005, revealed nothing of interest.[2] The area immediately

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Figure 1. Historical map from the first half of the twentieth century. The trial excavation area is shown in grey. The star indicates the settlement. The Viking Age cemetery at Kirke Hyllinge Church and the settlement of Stensgård, both mentioned in the text, are also shown with a cross and a square respectively (map © National Survey and Cadastre).

adjacent to the excavation field of Vestervang was however not investigated and archaeological features may have been lost here.

A total of 1608 features were registered: 1298 post holes, 86 pits (of which 21 appeared to be pit houses), 2 cooking pits, 4 trenches, 1 wall ditch, 1 stone heap and 1 natural hollow. Another 215 features appeared to be of no significance. Furthermore, a large number of stake holes in the walls of the pit houses were not seen as independent features, but were registered directly in the context of the pit house concerned.

Of the total of 1298 postholes only 311 could be connected to a structure as either roof bearing posts, wall posts, entrance posts, supporting posts or posts in a fence. In all 43 structures were recognized. Two well preserved post-built structures, as well as a number of pits, were part of an earlier settlement dated to late Bronze Age/early Iron Age (cf. Kastholm 2009, 25f., for a preliminary presentation).

The settlement

The late Iron Age settlement stretches in a broad belt over the excavation field, from NW to SE, consisting of 41 structures: 19 post-built structures, 21 pit houses and one structure consisting only of a wall ditch (Figure 4).

The post-built structures

These buildings appear to be of variable size and character (cf. Figure 5; Table 1) though of note, the longhouses are generally rather small. The maximum length of the largest longhouses does not exceed c. 20 m (respectively 19 m, 15.25 m and 18.25 m) with the majority being c. 10 m long with just three sets of roof bearing postholes. The floor plans are commonly rectangular (10 cases) along with curved (7 cases) and trapezoid (2 cases). As no walls survive in this Iron Age/Viking Age settlement, the floor plan must be estimated solely on the basis of the width span between the roof bearing postholes. An exception is house I, in which leaning supporting posts in curved rows on both sides are present. A further difference between the longhouses is the width span between the roof bearing postholes, which varies from between 1.9 to 3.5 m. There is general similarity in the length span of the longhouses, as long as specific narrowed roof bearing sets are excluded. The prevalent length span is between 4.5 to 5.5 m.

Figure 2. An overview of the excavation field and the trial trenches. Equidistance 2.5 m.

Stratigraphic correlation between the post built structures was mostly inconclusive as most of the houses are solitary. Two exceptions are that longhouse I can be seen to be older than pit house XIX and longhouse II, can be seen to be older than pit house V. Additionally, the longhouses XXVII and XXXV could not have been contemporary and neither could longhouses XI and XII. The longhouses XV, XVI, XXIII are situated so close to each other that they probably cannot have stood at the same time. The same goes for the longhouses XIII, XIV as well as XXXVII, XXXVIII.

The pit houses

There is a variety of shapes and sizes in the 21 pit houses (cf. Figure 6; Table 2). The pit house floor plan shapes are identified through wall poles or stakes, which were driven into the

Figure 3. An overview of the excavation field with all features (digital redrawing by Cille Krause).

ground and found in 12 of the houses. The most common floor plan seen is oval (6 houses), followed by a rectangular shape with rounded corners (3 houses), circular (2 houses) and in a single case, square shaped with rounded corners. The largest pit house is no. VI, which measures a length of 4.5 m and a width of almost 4 m. An estimated internal area of this building is 10 m² although most of the houses have an estimated internal area of between 4–7 m². The depth of the pit houses varies from almost nothing except the roof bearing postholes to more than 0.5 m of preserved material. It was not possible to separate floor layers in any of the pit houses and all material is thus to be regarded as fill.

The walls of some of the pit houses are, as mentioned, marked with poles driven into the ground. Other wall types, such as wall ditches, are not seen. The pole holes show that the poles were usually pointed spars, but cleaved and pointed poles with square or triangular cross sections were also used. Their common diameters were 4–5 cm, which is confirmed by pole marked fragments of burned mud wall from the burned pit house XLI. Presumably these slender poles were

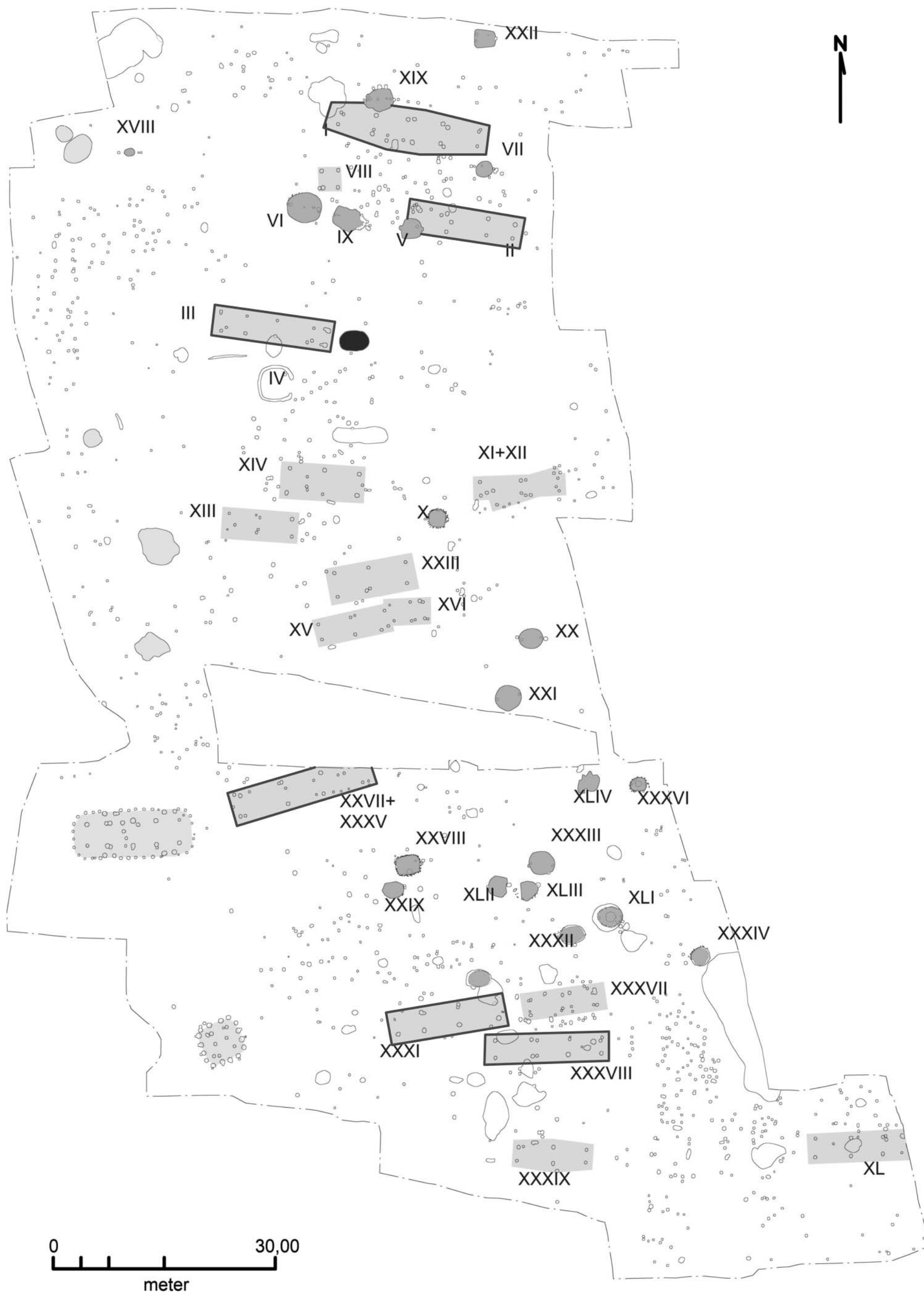

Figure 4. The excavation plan with structures highlighted. Longhouses are shown in light grey (solid outlines indicate possible main houses), pit houses are in medium grey and the stone heap is the black structure east of House III. Unnumbered highlighted house-structures and pits indicates the Late Bronze Age/Early Iron Age settlement not dealt with in this paper.

the base for mud walls. Fragments of mud walls were located in 10 pit houses.

Of interest are the small, solitary pits at the base of at least four of the pit houses (XXVIII, IXXX, XXXVI, XLI). They are mostly flat bottomed, 0.5 m in diameter and a maximum of 0.2 m in depth. One exception is in the larger pit in house XXVIII, which is 0.5 m deep. These pits occur in the centres as well as the corners of the houses. They should be probably be understood as depressions in which a person could stand upright, or as foot pits for a person sitting, a similar feature to that at Østergård in Southern Jutland (Sørensen 2011, 56 ff.). Another possibility might be that they were a kind of drain or barrel pit, though no traces of standing water or other finds were present.

Material from each pit house was sieved on site where possible. Alternatively 10 litres of material from each

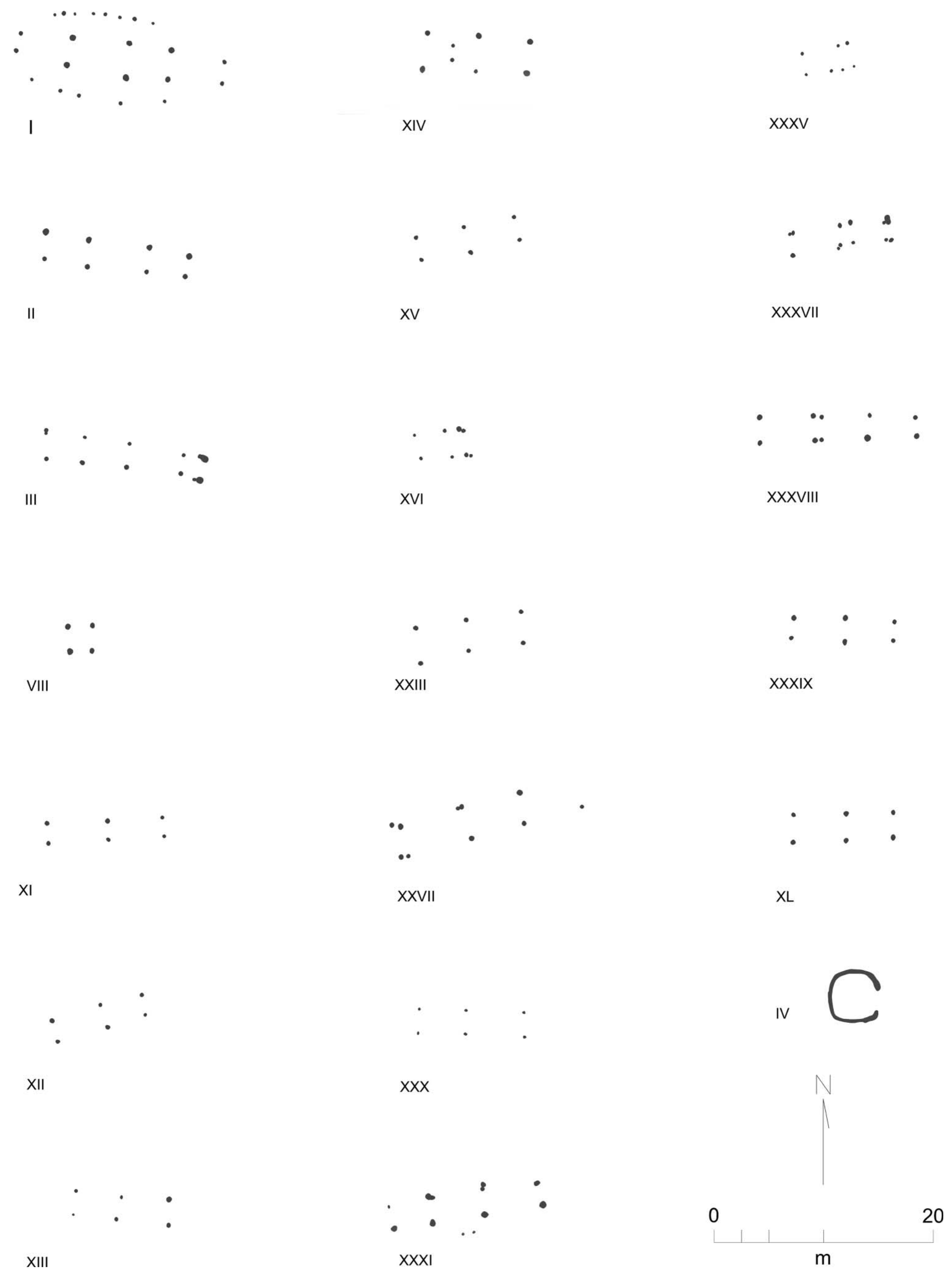

Figure 5. The floor plans of the longhouses and structure IV.

house was investigated using the flotation method at Roskilde Museum producing small fragments of charcoal, faunal material and ceramics.

Stratigraphic correlation between the pit houses was mostly inconclusive as most of the houses are solitary. Only this could be concluded: pit house V is younger than longhouse II and the pit house XIX is younger than longhouse I. Furthermore it seems that the pit houses XLII and XLIII are lying too close to have existed at the same time.

^{14}C dating the pit houses

Faunal material from 6 pits houses was submitted for radiocarbon dating.[3] This material is broadly dated from the late seventh century to the earliest eleventh century AD. The dates show a tendency towards two main phases, the earliest from c. 660–780 AD (house XIX, XXVI, XLI) and the latest from c. 880–1020 (house VI, XXVIII). House X has a somewhat wider age range of c. 680–890 AD (Figure 7; Table 3).

It should be stressed that dating the fill material does not necessarily date the construction itself. But it seems

Table 1. Three-aisled longhouse inventory (* supporting post are included).

House no.	Set of roof bearing post	Ground plan	Length m	Width m	Span width m	Span length m
I	5	Curved	19	8*	2–2.5	4.5–5.5
II	4	Curved	13	2.75	2.4–2.75	3.75–5.5
III	5	Rectangular	15.25	2.25	2–2.25	2–5
XI	3	Rectangular	10.9	1.9	1.9	5–5.5
XII	3	Curved	8.9	2.15	2–2.15	4–4.75
XIII	3	Rectangular	9	2.5	2.25–2.5	4.25–4.75
XIV	3	Rectangular	10	3.5	3–3.5	4.9
XV	3	Curved	8	2.4	2.2.–2.4	4.5–4.75
XVI	3	Curved	4.5	2.5	2.25–2.5	1.5–3.75
XXIII	3	Trapezoid	10.2	3.25	3–3.25	4.75–5
XXIV	5	Rectangular	16.5	6.75*	3.25	3.25
XXVII	4	Rectangular	18.25	3	3	5–6
XXX	3	Rectangular	9.5	2.1	2.1	4.3–5
XXXI	4	Curved	14.25	2.75	2.25–2.75	3.75–5
XXXV	4	Rectangular	4.5	2.25	2–2.25	1–2.25
XXXVII	4	Rectangular	9	2	2	1.25–4.5
XXXVIII	4	Trapezoid	14.75	2.5	2–2.5	4.5–5
XXXIX	3	Curved	8.75	2.25	2–2.25	4.5–4.75
XL	3	Rectangular	8	2.5	2.5	4.5–4.75

Note: *indicates that supporting post are included.

plausible that abandoned pits lying in an area of activity would be filled quite rapidly with the settlement's day-to-day waste (cf. e.g. Sørensen 2011, 49f.). The date of the oldest fill strata in a pit house ought consequently to be regarded as corresponding to the period immediately after the abandonment of the building. It must be noted though, that there is always a risk of contamination in the samples from previous activity phases and this risk can only be reduced by undertaking numerous analyses.

Other structures

Two undated constructions (IV and VIII) are found in the Iron Age/Viking Age settlement, that are neither longhouses nor pit houses (Figure 5).

House IV is a square shaped wall ditch with clearly rounded corners and an entrance facing east. In metaphorical terms the shape might be described as horseshoe-shaped. The construction measures 4.75 × 4.75 m. No traces of an inner, roof bearing construction were recognized and thus, it is not certain whether this 'house' was roofed at all. The wall ditch did not contain traces of poles or stakes. The profile was rounded with a depth of no more than 0.15 m. No archaeological finds were made. A number of similar horseshoe-shaped constructions are known from, for example, the ring fortress of Trelleborg, Slagelse. These constructions of unknown function, were excavated inside the fortress' walls and although they are not dated, they do not appear to be contemporary with the main settlement (Nørlund 1948, 39ff.; Nielsen 1990, 106ff.). Poul Nørlund interpreted these features as fences associated with the so-called sacrificial wells at the site (Nørlund 1948, 39ff.; see also Jørgensen 2009, 329f.).

House VIII is a square construction measuring 2.75 × 2.75 m, and defined by the holes of four roof bearing posts. Thus it belongs to the large group of constructions traditionally referred to as small barns.

Fences

On such a fairly extensive excavation, with numerous non-contextual post holes, it is appropriate to attempt to identify any possible fences. In all, 987 non-contextual post holes were excavated. None of these form clear, uninterrupted rows. Only short rows of 3–5 m can be unmistakably recognized besides unstructured concentrations of post holes, and therefore the identification of fences is difficult without further evidence. One of these short fences is found leading from the 'entrance' of the horseshoe-shaped structure (IV) towards the stone heap A245 (see below).

Although there is no clear evidence for fences, belts of post holes do occur in what seems to be 'fence *areas*'. This is most evident alongside the western field boundary. Such belts of post holes might reflect fences in multiple phases, but another possibility is that they represent the presence of more or less temporary outhouses leaning against a fence.

Other features

Two other recognized features are worth mentioning. The stone heap A245, just east of longhouse III, consists of burnt stones and faunal material. Such stone heaps are known from for instance, Fredshøj at Gl. Lejre and at Tissø, although on a much larger scale (Christensen and Tornbjerg 2009, Jørgensen 2009, Nielsen and Baastrup 2011, 112f.). These features probably reflect feasting waste.

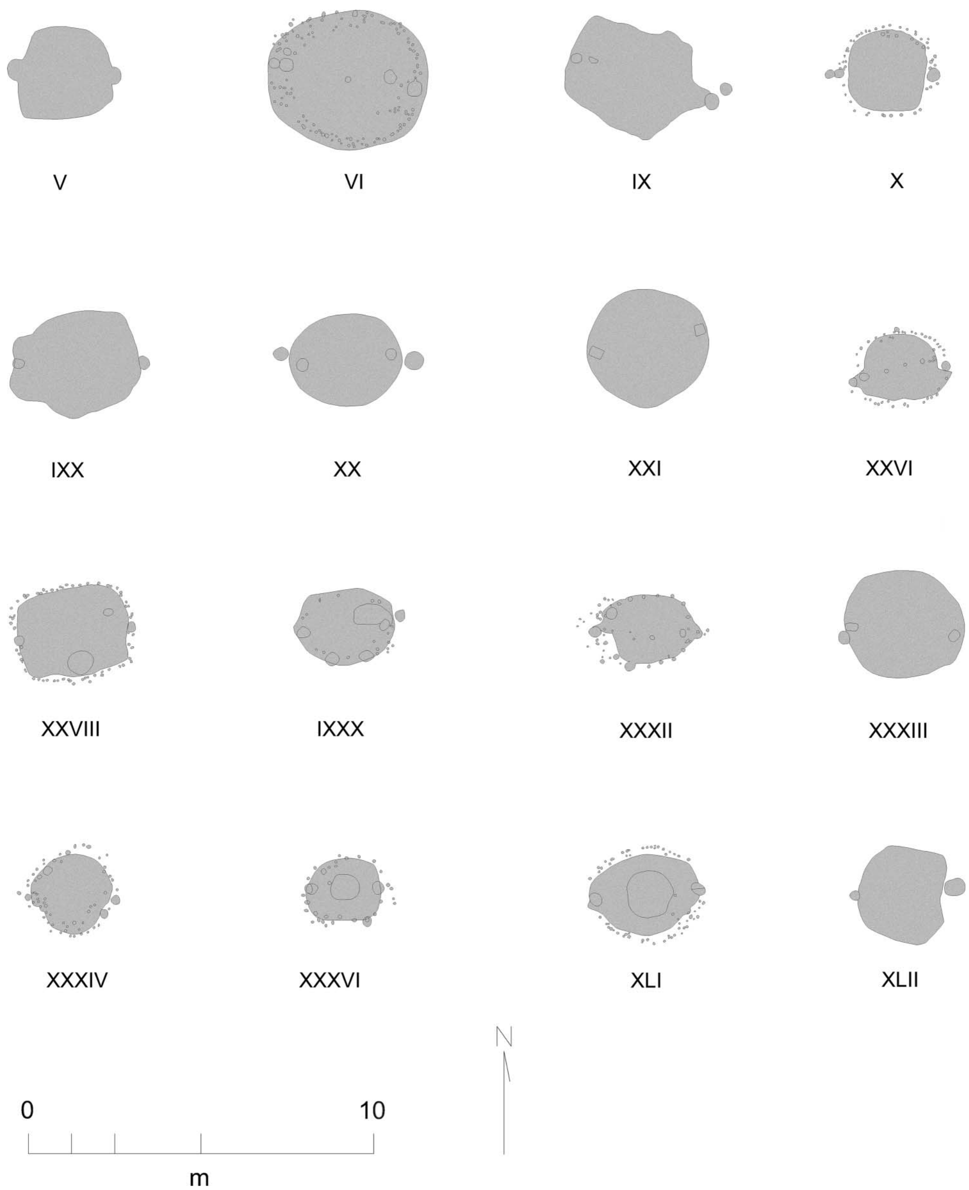

Figure 6. Selected pit house floor plans.

Additionally, a cultural layer of burnt stones covered parts of the excavation, primarily in the SE area where the concentration of post holes was largest. The material was similar to that of the pit houses and of most of the post-holes. The layer was monitored as well as regularly surveyed with a metal detector during the mechanical excavation, but had to be removed before the underlying features could be identified.

State of preservation at the site

It is well known that many centuries of ploughing slowly remove prehistoric settlement features from the subsoil and this is especially the case on the heavily cultivated island of Zealand. The exact state of preservation at Vestervang is nevertheless difficult to pin down. At first glance the preservation seems rather poor with most structures being only visible through their roof bearing posts. But this only applies to the Iron Age settlement as the Bronze Age house, over 1000 years older, is quite well preserved with relatively deep outer and inner wall posts. This prompts the question of why the Iron Age wall posts are absent. One explanation may be a variation in topsoil thickness thus giving a differential spatial preservation. However, the variability in soil thickness does not correspond with the areas of greatest/least preservation. A more probable explanation may be that they never existed and that the structures of this era had a different type of wall construction, for

Table 2. Vestervang pit house inventory.

House no.	Feature no.	Ground plan	Size (est.) m²	Length m	Width m	No. of phases	^{14}C date AD
V	A106	–	6	3.3	2.65	1	
VI	A57	Circular	10	4.4	3.95	2	880–1000
VII	A158	–	4	3.9	2.15	?	
IX	A58	–	9	–	2.9	?	
X	A459	Rectangular	4.5	3.45	2.7	1	680–900
XVIII	A18	–	–	3.35	–	?	
XIX	A60	Rectangular	8	3.5	2.3	2+	670–780
XX	A517	–	6.5	4.4	2.75	2	
XXI	A518	Circular/oval	9	3.4	–	1	
XXII	A619	–	6	3.1	2.3	1	
XXVI	A969	Oval	5	3.0	2.2	1	680–780
XXVIII	A927	Square	7	3.5	2.9	1	900–1020
XXIX	A925	Oval	4.5	3.1	1.9	1	
XXXII	A1016	Oval	5.5	2.85	2.1	1	
XXXIII	A1005	–	8	3.3	2.6	?	
XXXIV	A1045	Rectangular/oval	4	2.3	2.3	?	
XXXVI	A863	Oval	3.5	2.3	1.9	?	
XLI	A1017	Oval	7	3.35	2.9	1	680–770
XLII	A999	–	5.5	2.8	–	1	
XLIII	A1002	Oval	4.5	3.4	–	1	
XLIV	A864	–	5	2.4	–	1	

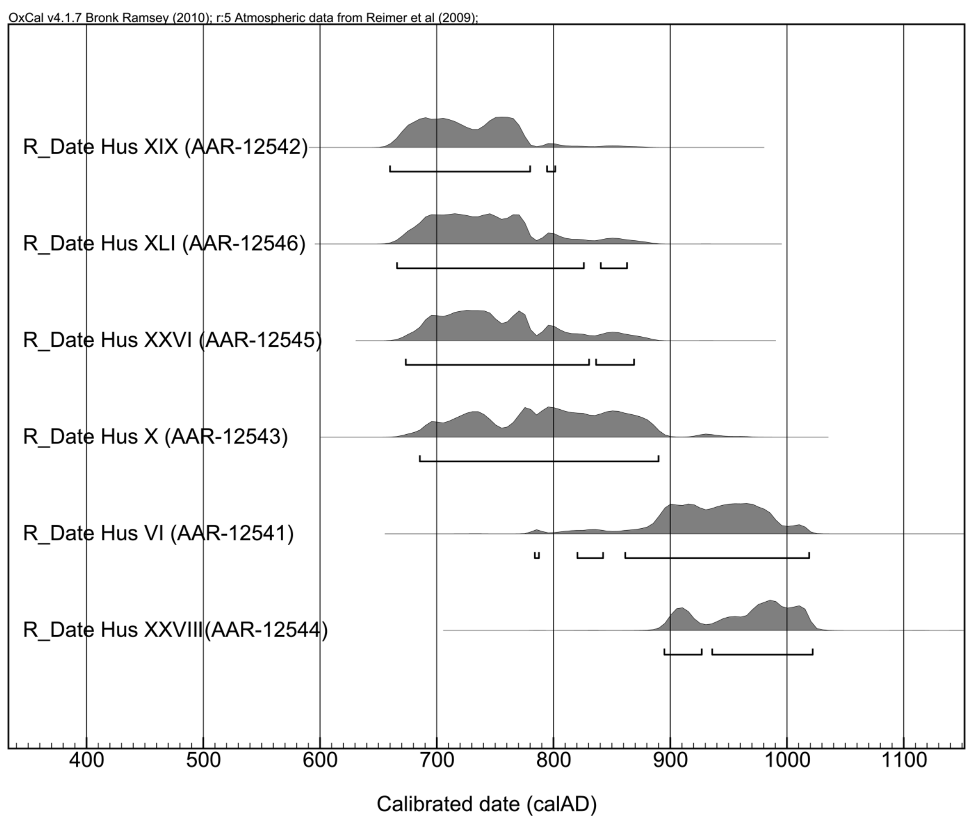

Figure 7. Calibrated ^{14}C results from the pit houses. The calibration uses OxCal 4.1 © (Bronk Ramsey 2009, Reimer et al. 2009).

example with some kind of foot beam placed on the topsoil or with stakes/poles driven into the ground similar to the pit house walls. Such traces could easily be ploughed away or overlooked during the excavation.

Table 3. The uncalibrated ^{14}C results.

House no.	^{14}C years	Lab. code
VI	BP 1109±39	(AAR-12541)
X	BP 1224±39	(AAR-12543)
XIX	BP 1284±32	(AAR-12542)
XXVI	BP 1253±30	(AAR-12545)
XXVII	BP 1069±34	(AAR-12544)
XLI	BP 1265±33	(AAR-12546)

The cultural layer mentioned above, which covered parts of the excavation field, as well as the stone heap, demonstrate that the site is fairly well preserved as does the rather good condition of the stray finds, which show no or limited traces of plough wear.

Discussion of the settlement

The concentration and number of features at the site is obviously the result of repeated occupation. A precise understanding of the phases, the generations of Vestervang, is nevertheless not simple. Specific elements such as fences, the precise dating of each house, significant stratigraphy or certain characteristics grouped among the structures are required to segregate the phases. Such elements are limited at Vestervang but nonetheless some hypothetical considerations on the nature of the settlement's character can be put forward.

The post built structures can be grouped by size despite the lack of significant characteristics concerning each building and its function. Six of the longhouses have 4–5 regular sets of roof bearing posts (I, II, III, XXVII, XXXI and XXXVIII) and may be regarded as 'main houses', each representing a phase in the settlement. Among these main houses, house I is typologically the youngest and probably dates from the tenth century. This corresponds well with the stratigraphically older pit house XIX, from which the fill is ^{14}C dated to the eighth to ninth century. If the time of use for each of the main houses is estimated as 30–40 years, the total 180–240 years usage agrees well with the apparent activity period of the settlement (see below). This model applies if it is accepted that the six largest longhouses are the main houses and that the smaller buildings, with 2–3 sets of roof bearing posts, are regarded as economic buildings. Although their exact function is unknown, they may be barns, stables, working places, storage rooms, living quarters or a combination hereof.

The pit houses are all of the same general type according to the definitions offered by Anne Birgitte Sørensen (2011). They belong to the most simple pit houses, types IA or IB, which are round, oval or rectangular pits with a roof bearing post at both ends and either without traces of walls (IA) or with pole holes marking the position of walls (IB) (cf. Sørensen 2011, p. 48). Although generally of the same type, the Vestervang pit houses nevertheless show a great variety in shape, size and pit depth. As previously mentioned, the site is not particularly badly preserved, and the variation in pit depth ought therefore to be seen as a sign of diversity instead of a mere matter of preservation. Some pit houses were deep, others were not. Some had walls, others did not. A few pit houses have such a provisional character that they may be more like shelters for short-term use rather than permanent buildings.[4] As no preserved floor layers or other significant interior features were found, the pit houses' primary function(s) cannot be established. While pit houses have traditionally been regarded mainly as workshops, not least connected to textile production, attention has recently been drawn to the need to perceive them as structures with multiple purposes depending on their actual context (Gotfredsen and Gebauer Thomsen 2011, Nørgård Jørgensen et al. 2011). Regarding the non-agrarian sites, like assembly sites and landing sites, the idea has been proposed that the pit houses were temporary accommodation for families or working groups performing the activities reflected in the finds from the site in question (Nørgård Jørgensen et al. 2011, 103ff.). But why restrict this idea to the specialized sites? Agrarian sites probably also had the need to accommodate for example, seasonal labourers, travelling craftsmen as well as local gatherings and feasts. This need might be reflected in the pit houses at Vestervang and could explain their provisional character and lack of significant floor layers.

To sum up, the structures of Vestervang seem to reflect an agrarian settlement, a farmstead, in six phases. Each phase is characterized by a main longhouse and a diversity of smaller structures, primarily minor longhouses and pit houses. The youngest phase is typologically dated to the tenth century and ^{14}C dates of fill from the pit houses show a period of activity from Late Germanic Iron Age to Late Viking Age.

Finds related to the Iron Age settlement

The archaeological finds can be divided in two groups of excavated finds and stray finds, of which the latter were mostly found using a metal detector.[5] The metal detector finds cover a range of significant artefacts. The majority of the finds however, originate from the fill material of the pit houses (Table 4) with only a few from post holes and pits. The two most marked find groups are ceramics and faunal material, but a number of artefacts of bone, metal, glass, amber, burnt clay and stone were also found. It must be noted however, that all the objects from the pit houses should be regarded as secondary deposits. Nevertheless it seems plausible that these pits, situated in an active settlement area, were filled quite rapidly and therefore date the period immediately after the house was demolished.

Ceramic vessels (c. 390 pcs.)

The majority of the potsherds were found in the fill material of the pit houses. The ceramics are characterized primarily by flat based vessels with an even out-leaning

Table 4. Finds in the pit houses' fill material.

House no.	Ceramics	Soapstone	Spindle whorls	Loom weights	Bone combs	Iron knives	Scissors	Chisels	Whet stones	Fired clay
V	X								X	X
VI	X	X	X			X		X	X	X
VII										X
IX	X				X					
X	X		X	X		X				X
XVIII	X							X	X	X
XIX	X						X			
XX	X			X	X					
XXI	X									
XXII										
XXVI	X	X		X	X	X		X		X
XXVIII	X							X	X	X
XXIX	X			X						
XXXII	X									X
XXXIII	X									X
XXXIV	X					X				
XXXVI	X									
XLI	X				X					X
XLII						X				
XLIII	X									X
XLIV										

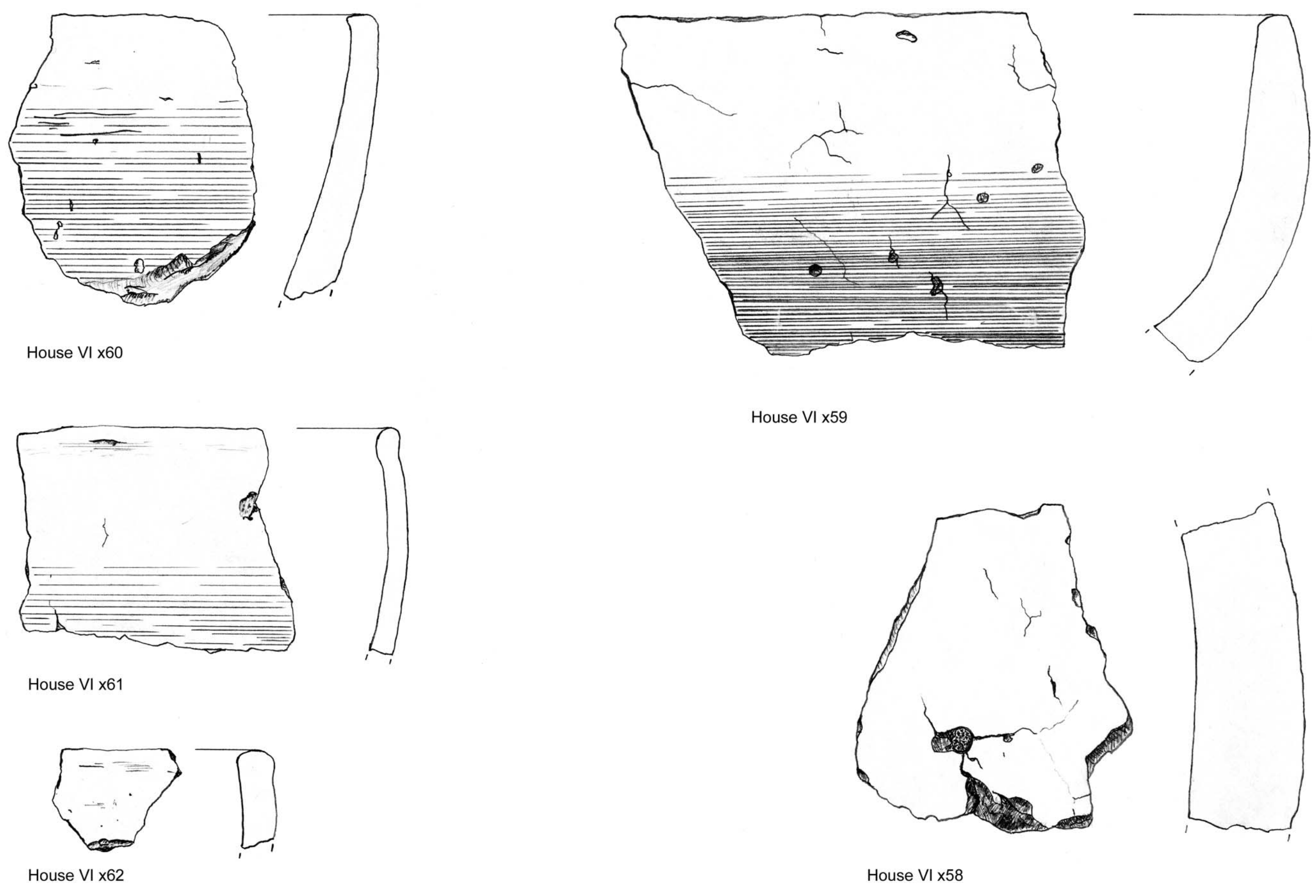

Figure 8. Fragments of pottery (left) and soapstone vessels from pit house VI, ^{14}C dated to c. 880–1000 AD. Scale 1:2.

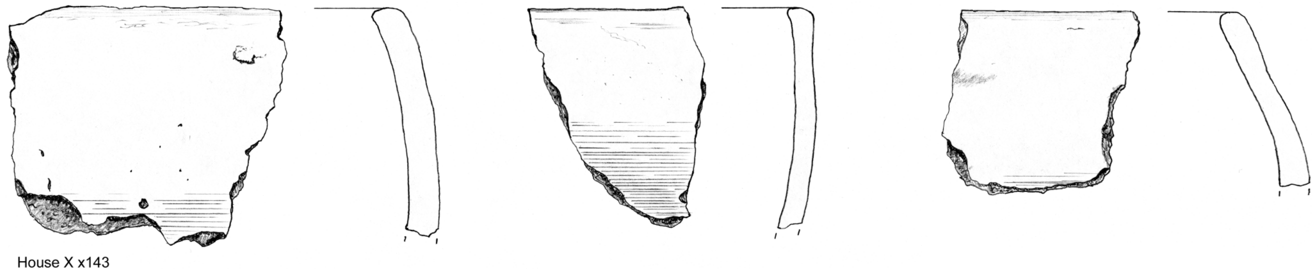

Figure 9. Fragments of pottery from pit house X, ^{14}C dated to c. 700–900 AD. Scale 1:2.

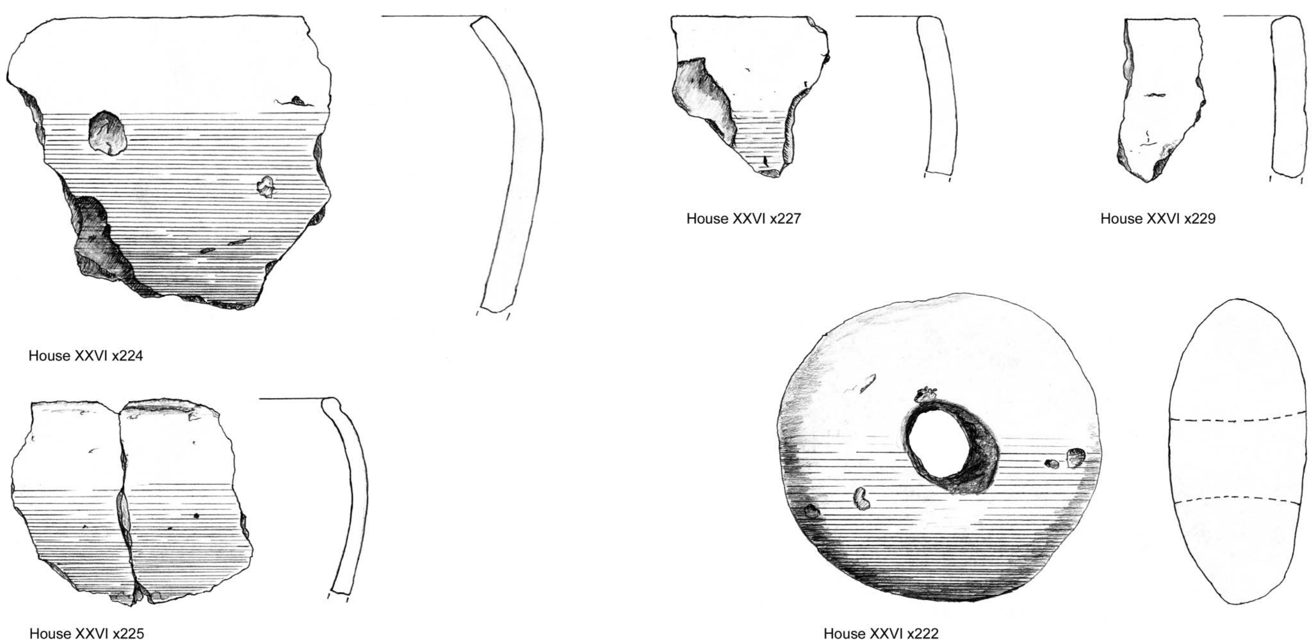

Figure 10. Fragments of pottery and a loom weight from pit house XXVI, ^{14}C dated to 680–770 AD. Scale 1:2.

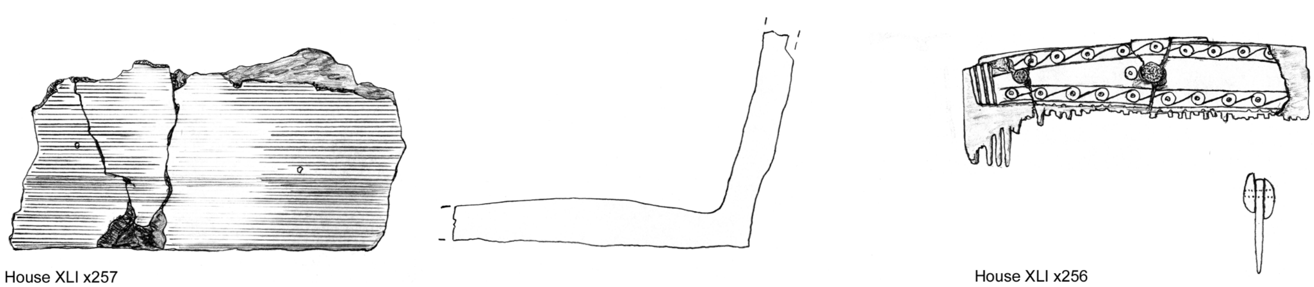

Figure 11. A pottery fragment and a fragmented comb from pit house XLI, ^{14}C dated to c. 680–770 AD. Scale 1:2.

body and inwardly turned neck, with a rounded or straight cut lip. Other vessel designs were however also seen (Figures 8–12). The earthenware is generally relatively hard burned and has a rough, everyday character. One fragment was decorated with concentric circles (Figure 12), a decoration similar to that known from for example, the settlement at Fyrkat (Roesdahl 1977, Figure 11). Otherwise no decorations were seen. The lack of Baltic ware is striking, only one single fragment was found and at some distance east of the central settlement.

Soapstone vessels (3 pcs.)

Fragments of soapstone vessels were found in the fill material of two pit houses (VI and XXVI). One large rim shard has a thin, slightly inwardly bent rim which was rounded on the inner side. It originates from a bowl

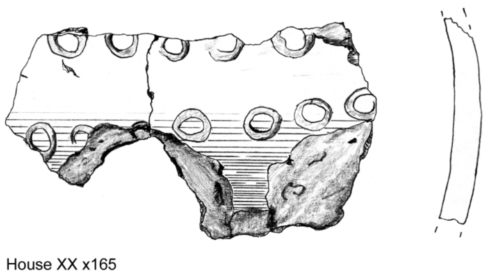

Figure 12. Decorated pottery from pit house XX. Scale 1:2.

with a c. 22 cm opening. Another shard is riveted with an iron nail, a feature often seen and used in order to prolong the vessels life time (Figure 8).

Spindle whorls (5 pcs.)

Spindle whorls were found in two pit houses and in a solitary posthole. A further two were collected as stray finds (Figure 13). As shown in Table 5, several types and materials are represented within this group.

Loom weights (5 pcs.)

Fragments of loom weights were found in four pit houses (X, XX, XXIX and XXVI). A further fragment was found in the solitary post hole A1397 that also contained a spindle whorl. Just one weight is fully preserved (x222), it weighs 309 g, is 40 mm thick and 90 mm in diameter (Figure 10). All the weights are lens shaped and made of fired clay.

Combs (5 pcs.)

Combs made of bone occurred in four pit houses (IX, XX, XXVI, XLI). One fully preserved comb was found in house XX and an almost fully preserved one was found in house XLI. The latter is decorated with rows of connected concentric circles (Figure 11). Both specimens are composite single combs with a convex ridge. The remaining three fragments seem to originate from combs of the same type and with the same decoration.

Iron tools (10 pcs.)

Determinable tools of iron occurred in seven pit houses (VI, X, XIX, XXVI, XXVIII and XLII) and the pit A1018. There were four standard knives, three small chisels, a well preserved pair of scissors, an awl and a sickle-shaped knife possibly for cutting leaves (Figure 14).

Animal bones (c. 12 kg)

The many animal bones found in the pit houses, are almost entirely from ordinary domestic animals such as dogs (Canis familiaris), pigs (Sus domesticus), cattle (Bos Taurus), sheep (Ovis aries), goat (Capra hircus) and horse

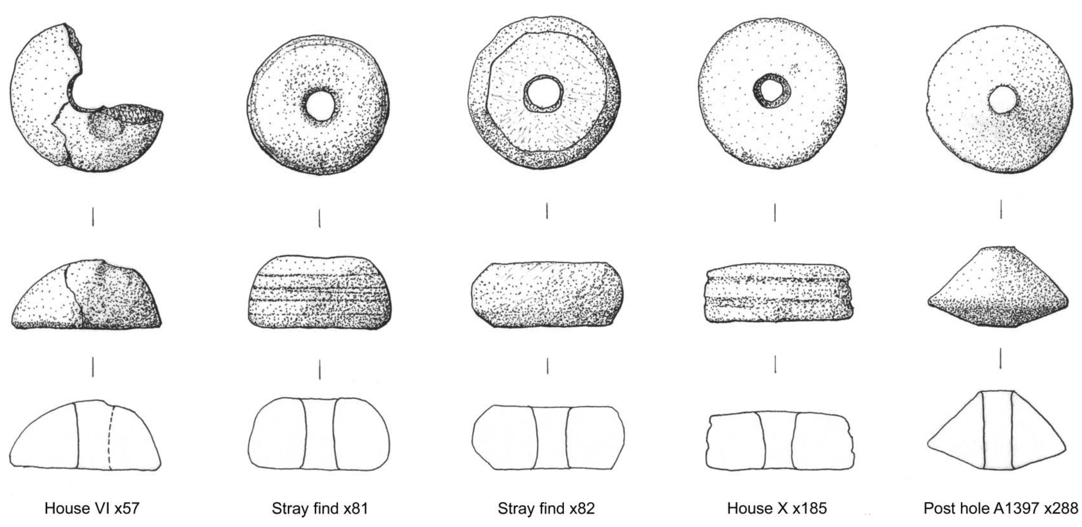

Figure 13. Spindle whorls. Scale 1:2.

Table 5. Spindle whorl inventory.

Shape	Material	Weight	Structure	No.
Spherical	Bone	7 g (fragm.)	Pit house (VI)	x57
Spherical with three grooves	Sandstone	23 g	Stray find	x81
Tablet shaped with convex sides	Soapstone	21 g	Stray find	x82
Tablet shaped with two grooves	Sandstone	32 g	Pit house (X)	x155
Conical with convex bottom	Fired clay	19 g	Post hole (A1397)	x288

Figure 14. Iron tools.

(Equus caballus). A few bones have cut marks and many show dog tooth marks – even one of the dog bones. As far as it is possible to calculate, the size of the ox and horses match well with our knowledge of Viking Age livestock. Only a few non-domestic bones were found and the only fish bones are two finds of cod (Gadus morhua). In addition, there are a few bones of duck (Somateriinae), goose (Anserinae), goshawk (Accipiter gentilis), crane (Grus grus) and deer (Capreolus capreolus), the latter with cut marks.[6] Thus an element of hunting and fishing is present at the site. Even though hunting activities seem to be connected with the aristocracy, the amount of wildlife bones at Vestervang is not higher than for common settlements (cf. Villumsen 2011, 207 f., Figure 2).

Miscellanea

Most notable are a glass fragment from a drinking glass and two amber beads, one of which is however fragmentary, from houses IX and pit A405 respectively. A large bone needle from the pit A1563 also deserves a mention. In addition were found: bronze fragments, whetstones, crush stones, a glazing stone, nails and rivets of iron, indeterminate iron fragments, slag, fossilized sea urchins and fragments of fired clay.

Discussion of the excavated finds

The clear impression gained from the excavated finds is that they mainly represent the everyday household of common people living in an agrarian Iron Age settlement. Personal equipment is represented by combs, hand knives, whet stones and probably the fossilized sea urchins. Artefacts related to the handicrafts of an everyday household are spindle whorls, loom weights, crush stones, scissors, the leaf knife and of course the fragments of pottery and soapstone. There are no concentrations in the find material which point towards certain specialized crafts besides those of a farmstead. The everyday character of the site is underlined by the species represented among the animal bones, although a limited occurrence of wildlife bones reflects hunting activity.

Stray finds

While the excavated finds were mainly of an everyday character, a number of exciting stray finds were made by metal detector in collaboration with volunteer amateur archaeologists (Table 6).[7] The most significant finds derive from the excavation area or immediately adjacent areas and from top soil or soil piles. The metal detector was, however, used throughout the whole trial excavation area without further significant results.

Decorated artefacts

The detector survey unveiled a variety of jewellery material from Germanic Iron Age and Viking Age, primarily brooches or fragments of such, but also a strap end and an arm ring were found. Two of the brooches were quite remarkable.

A circular 'baroque' brooch

The most spectacular find is a large, circular brooch of Scandinavian origin with a diameter of 73 mm and a weight of 132 grams (Figure 15). The brooch is designed as a cast disc of copper alloy with a marked and decorated rim, from which three ribs to the centre divides the disc into three equal fields. These ribs are shaped as identical face masks. In one of the fields an animal image is fastened with rivets. In the two other fields only the rivet holes remain, but it seems evident that similar animal images also decorated the surface in these fields (Figure 16). The masks show pronounced eyebrows running into the nose, under which the mouth is represented by a large, drooping moustache. A circular mark is seen between the eyebrows and above this, two ears or horns emerge, giving the human-like mask an animal character. From underneath the eyes, shown by two concentric circles, a series of short lines radiate outwards and can probably be interpreted as eyelashes. From the lower edge of the moustache as well as from the mask's neck, a bead-like line or chain seems to connect all three masks.

The surviving animal image is more complex. The head is shown facing the brooch's centre and designed as a heart shape with rounded ears and circular eyes. The neck is covered by a bead-like chain. Above the creatures fore legs there are marked elbow joints and three-fingered paws or feet which awkwardly grasp backwards to what might be hind legs or wings. The heads of the two non-preserved animal images also face the centre.

Stylistically, this brooch contains several disparate parts. The animal image is clearly under the influence of the symmetrical animal style, Borre style. The heart shaped head, as seen en face and the feet with three toes

Table 6. Inventory of dated stray finds in chronological order.

Artefact	Dating	Type	Type Provenience	No.
Circular brooch	c. 500–750	Merovingian	Frankish	x40
Oval brooch	Eighth century	N1b-N2	Scand.	x9
Arm ring	c. 750–775	Q3b	Scand.	x5
Trefoil brooch	c. 775–825	SK 1	South Scand.	x19
Coin	822–840	Louis the Pious	Frankish	x18
Oval brooch	c. 850–950	JP 51	Scand.	x14
Equal-armed brooch	c. 875–925	SK 4	South and East Scand.	x7
Trefoil brooch	c. 850–950	SK 4	South Scand.	x314
Circular brooch	c. 900–950	'Baroque'	Scand.	x331
Circular brooch	Tenth century	–	Scand.?	x17
Weight	Tenth century	Spherical	Scand.	x1
Scale	Tenth century	–	Scand.	x2
Urnes brooch	c. 950–1100	–	South Scand.	x6
Bird-shaped brooch	Eleventh century	–	South Scand.	x41

Figure 15. The 'baroque' brooch x331, c. 850–950 AD.

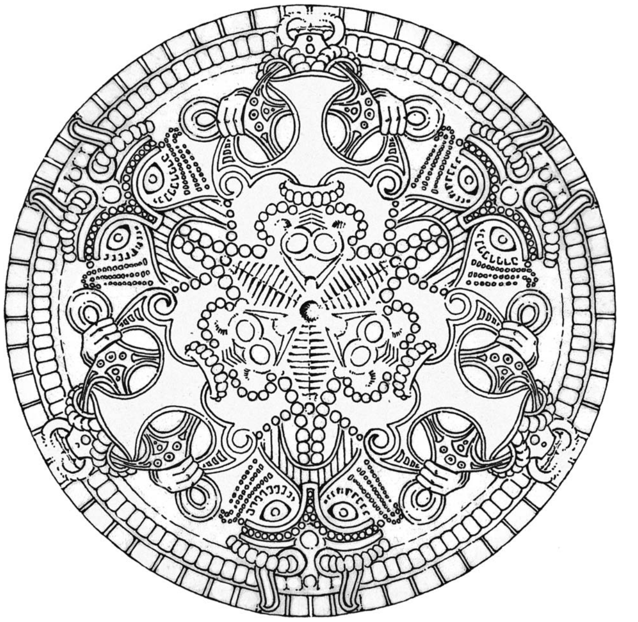

Figure 16. An artist's reconstruction of the 'baroque' brooch. The rim is folded out to show the full motif (drawing Rune Knude, Zoomorgraphic).

are also elements of this very broadly defined style which dates from ca. 830 to the mid- 900s. The mask seems to represent a less organic style, which resembles the later Mammen style, traditionally dated to ca. 940–1000. The decoration of the brooch therefore most probably dates to the 'late' Borre style, i.e. the first half of the 900s. It must be stressed however, that the stylistic ambiguity is not a real aspect of the decoration but merely an example of our inadequacy in the understanding of prehistoric art.

Such an artefact is of course rare, although not unique. A handful of these circular brooches are known and have been given the term 'baroque' by Michael Neiß. Neiß furthermore suggests that their three dimensional layout refers to aspects of Norse mythology (e.g. Neiß 2009). Neiß has recently (2011, 2012) examined the Vestervang brooch and has suggested that it contains a puzzle picture with at least eight different motifs and with parallels in contemporary art. He furthermore points out that such puzzle pictures ought not to be seen as products of coincidence, but as distinct communicative media (Neiß 2011, p. 69). Michaela Helmbrecht has suggested that these 'baroque' brooches do not form a distinct type, but represent individual works of art probably to be seen in connection with the aristocracy of the sites of elite complexes (Helmbrecht 2011, p. 299, 402 ff.).

A geographically close parallel is known from the elite complex of Toftegård near the city of Køge. Again a threefold division of the brooch's surface is seen, with plant ornamentation instead of masks, and with three zoomorphic images evidently in Borre style (Tornbjerg 1998, fig. 12).

A circular Merovingian brooch

Another artefact of particular interest is a circular brooch most likely of continental origin and cast in copper alloy (Figure 17). The decoration consists of a central wheel cross in relief, with inlaid gold pressed into a waffle form. The waffle gold is in some areas covered with transparent red glass or semiprecious stones and forming an equal-armed cross. The passage of time has however taken one arm of the cross and perhaps even more. The central wheel cross is surrounded by nine smaller circles, also in relief, and with a waffle gold inlay. These were probably also originally covered with coloured glass or semiprecious stones. It can be observed that the waffle gold here is fixed into an underlying material probably consisting of very fine clay. The reverse shows visible traces of both pin anchor and holder although the pin itself is only partially preserved.

Artefacts made with this same technology are known from for example, Tissø, where it is debated whether they are of continental origin or made in Scandinavia under continental influence (Nielsen and Baastrup 2011, p. 120, Baastrup 2012). Nevertheless parallels of this brooch appear to be found in the Frankish Empire under the Merovingian's reign o. 500–750, where related jewellery is often found in pairs in female graves for example, in Cologne (Martin 1994, s. 573 f.). This type seems to precede the small circular brooches of Carolingian and Ottonian types which have been found in considerable numbers in Denmark in the last decades (cf. Ulriksen 2000, Baastrup 2009).

Other brooches

Apart from the two artefacts mentioned above, the stray finds cover a broad range of brooches although most of them are fragmentary. Eight brooches are represented and cover various types.

Two specimens of oval brooches were found. The first was just a diminutive fragment from a small brooch, decorated with South Scandinavian animal style in gilded relief. This probably corresponds to Mogens Ørsnes' types N1-N2, which are dated to c. 680/700–775/800 by Karen Høilund-Nielsen (Ørsnes 1966, 149 ff.; Høilund-Nielsen 1987, 66 ff.;) (Figure 21e). The second was a well preserved upper part of a double-shelled brooch of Jan Petersen's classical type (JP) 51 (Figure 18). It is partly gilded and can be dated to c. 850–950 (Petersen 1928, Skibsted Klæsøe 1999, p. 114).

Two specimens of trefoil brooches were found. The first is a well preserved piece decorated in geometrical style and certainly dating to the early Viking Age, probably from the late 700s to the early 800s (Figure 19) (SK type 1: Skibsted Klæsøe 1999, p. 106; cf. Maixner 2005, Typ E 1.2, Taf. 38). The second fragment shows acanthus ornamentation and was probably designed in Scandinavia under Carolingian influence (Figure 21b). It can be dated

Figure 17. The Merovingian brooch x40, c. 500–750 AD.

to c. 850–950 (SK type 4: Skibsted Klæsøe 1999, 106f.; cf. Maixner 2005, Typ P 2.2, Taf. 25).

One specimen of circular brooches was found in addition to the two dealt with above. This piece is cast in gilded copper alloy and decorated with three sets of double-horned, heart shaped spirals in low relief (Figure 20). It has a parallel in Mainz dated to the 8/900s (Wamers 1994, p. 586, Abb. 180). They are furthermore known from three graves in Birka and in grave no. 1090, they are together with oval brooches of JP type 55, and probably date to c. 900–950 (Arbman 1940, Taf. 69–70; Skibsted Klæsøe 1999, p. 114).

Furthermore a fragment of an equal-armed brooch was found (Figure 21a). Only the central part was preserved, but it seems to be the type with riveted animal figures facing a likewise riveted central crown which was used c. 875–925 (SK type 4: Skibsted Klæsøe 1999, p. 103 & fig. 29).[8]

The late Viking Age/early Medieval is solely represented by two brooches (Figure 21c–d). The first is a

Figure 18. The double shelled oval brooch x14, c. 850–950 AD.

fragment of an Urnes brooch with some gilding and dated to c. 950–1100 (Gjedssø Bertelsen 1994, 358f.). The second is a tail fragment from a bird-shaped brooch which has the pin anchor surviving on the reverse and dated to the eleventh century (Pedersen 2001, 26f.).

Arm ring

One copper-alloy arm ring was found. It is massive with an oval cross section, slightly expanded terminals and decorated with crescent-shaped punches. Two almost identical parallels are found at Nørre Sandegård Vest (grave 77) and dated to c. 750–775 (Jørgensen and Nørgård Jørgensen 1997, 52 & 190, fig. 26, pl. 26). The arm ring corresponds to Mogens Ørsnes' type Q3 which is dated to c. 680/700-775/800 by Karen Høilund-Nielsen (Ørsnes 1966, 166 f.; Høilund-Nielsen 1987, 62, 66 ff.).

Coins

Only one of the seven coins found could be dated to the Viking Age. It is a well preserved, though fragmentary coin minted in Louis the Pious reign between 822 and 840 (Figure 22). The coin is of the so-called temple type and is secondarily provided with a crude suspension hole. The number of such Carolingian coins found in Denmark is c. 40 at present.[9] The six other coins found at Vestervang originate from the Medieval and Renaissance time periods and will not be further discussed here.

Weights and scales

Two weights were found. The first is a spherical iron core covered by a copper alloy and weighing 108 g. It has a flat top and bottom and the top is decorated. The second is a tablet shaped lead weight of 23 g. Furthermore fragments

Figure 19. The trefoil brooch x19, c. 775–825 AD.

of a small balance scale were found. These items are traditionally seen as a part of the monetary system, derived from the Caliphate in the late 800s, and the decoration on the spherical weights is suggested to be an imitation of Arabic coins (Steuer 1987, Sperber 1996, 96ff.; Sindbæk 2005, 45ff.).

Miscellanea

Of other stray finds worth mentioning is one half of a small mould of copper alloy for casting metal beads. The beads cast in this mould would be very similar to those cast by a soapstone mould from Sigtuna (e.g. Floderus 1928, Fig. 55). Another interesting stray find is an animal head shaped item, most likely a dog or a wolf, and is probably a strap end fitting or a strap disperser of some kind (Figure 23).

Figure 20. The circular brooch x17, c. 900 AD.

Discussion of the stray finds

The metal stray finds may be divided roughly into two groups, the jewellery and the artefacts for use. The brooches and the arm ring belong to the first group. Most of the jewellery are standard Scandinavian items although still indicative of a certain prosperity. The two circular brooches however might be interpreted as representing contacts to an elite milieu. The scales and weights, the bead mould and the Carolingian coin belong to the second group, although the latter might also be regarded as jewellery. This small group reflects an element of trade and production.

The metal stray finds do not seem to correspond with the everyday character of the excavated site, but instead reflect a quite wealthy site with an interregional outlook.

Figure 21. Fragments of brooches: (a) equal-armed brooch x7, c. 875–925 AD, (b) trefoil brooch x314, c. 850–950 AD, (c) Urnes brooch x6, c. 950–1100 AD, (d) bird-shaped brooch x41, c. eleventh century and (e) oval brooch x9, c. eighth century.

Figure 22. Louis the Pious coin x18, 822–840 AD.

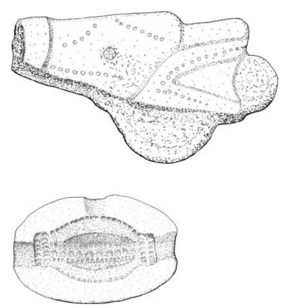

Figure 23. The mould x8 and the animal head shaped fitting x4. Scale 1:1.

Despite the modest structures it appears reasonable to conclude that the people inhabiting this agrarian settlement had an extraordinary network.

Perspective remarks

Vestervang in the settlement landscape

The lower part of the peninsula Hornsherred, the area where Vestervang is centrally situated, is characterized by several Late Iron Age sites (Figure 24). A short overview has recently been provided by Tom Christensen and Svend Åge Tornbjerg (2009, 63ff.), while the local sites with maritime connections are more thoroughly dealt with in Jens Ulriksen's survey of the Iron Age landing sites of Roskilde Fjord (Ulriksen 1998).

Two sites of particular interest are found in the vicinity of Vestervang (Figure 1). At Stensgård, excavated in 1998, are found 14 pit houses as well as three post built structures consisting of two three-aisled longhouses and one two-aisled building. The structures are primarily dated to the Viking Age but the many metal stray finds that also characterize the site cover a wider time span of c. AD 500–1100. The site is only partly excavated and its exact function is still not fully understood. Nevertheless it seems certain that this place was not an agrarian settlement in the 'normal' sense, and that it had a specialized function, e.g. as a handicraft site. A vast number of metal stray finds are still being found at Stensgård (Ulriksen 1999, 2000, Christensen and Tornbjerg 2009, 63f., Ulriksen, pers. comm.). Kirke Hyllinge church lies on a hill south of the village in a solitary position and situated almost halfway between the Vestervang and Stensgård. Just north of the church a late Germanic Iron Age/Viking Age burial site was excavated in 2000. Here 28 burials, primarily inhumation graves, were excavated and dated to the period from the seventh to the tenth century AD (Ulriksen 2011, 164 ff.).

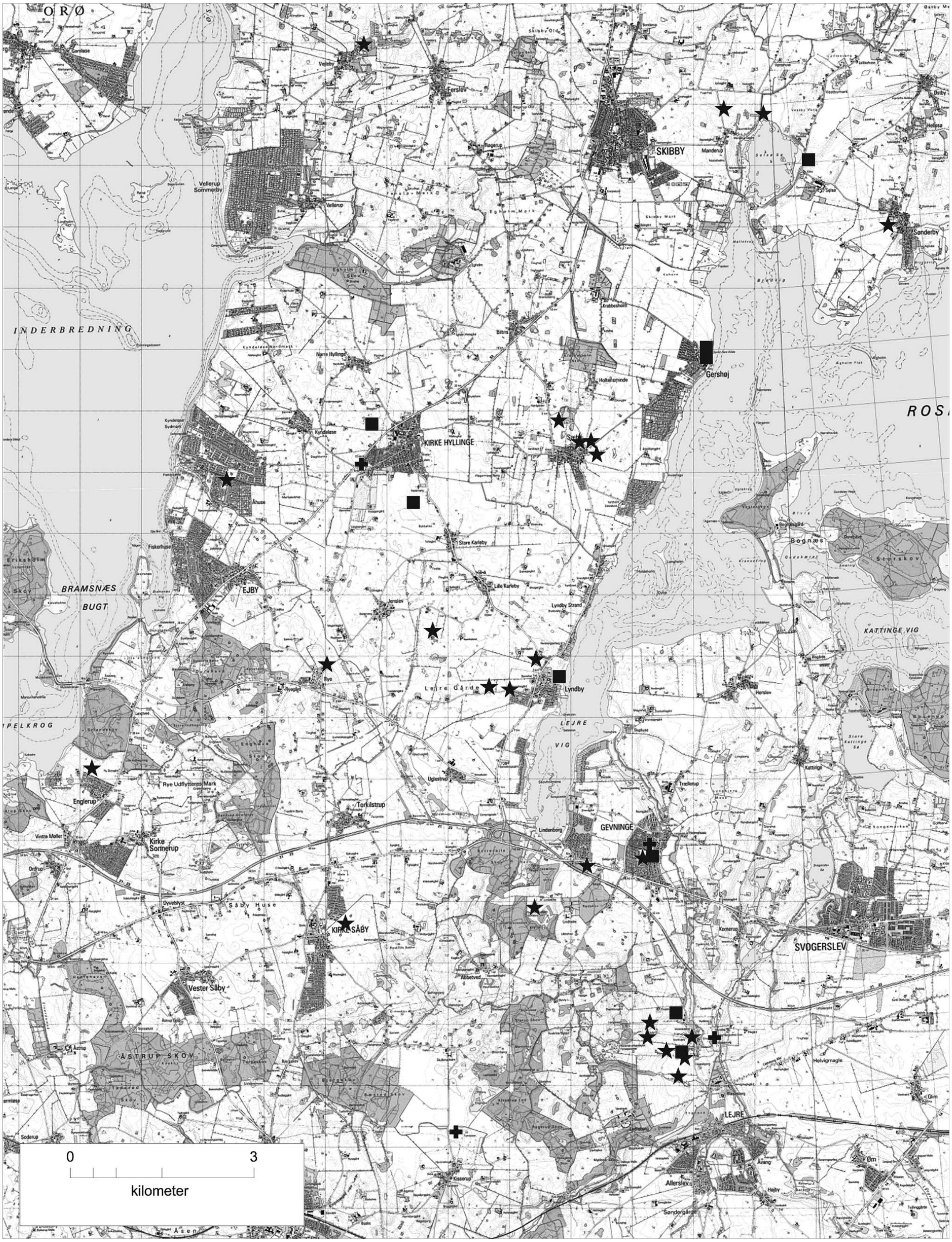

Figure 24. Finds from the Germanic Iron Age/Viking Age around Vestervang, stars = stray finds, squares = settlements, cross = burials. Based on the Danish Cultural Heritage database 'Fund og Fortidsminder' September 2012 (map © National Survey and Cadastre).

At the nearby shore of Roskilde Fjord three sites are found. Selsø-Vestby is a landing site situated eight km to the northeast and furthest away from Vestervang in a well-protected natural harbour. The site, excavated in 1994, primarily consists of 37 pit houses and thought to be specialized in the production and repair of ships and sails (Ulriksen 1998, 42 ff.). Gershøj, a rural village with a small fishing port, is situated on the straight coastline about 5 km east of Vestervang. In 1995 and 2008 settlement traces from the Viking and Medieval Ages were excavated near its medieval church but it is uncertain whether this reflects an actual landing site or merely an agrarian settlement situated near the coast (Ulriksen 1998, 78ff., 2008a). A few kilometres further south at the village of Lyndby and facing the mouth of Lejre stream, traces of long term Late Iron Age activity have been discovered through metal stray finds. Additionally, traces of a cultural layer were found during trial excavations in 1988 and 1994, although clear traces of buildings have not yet been detected (Ulriksen 1998, 104 ff.).

The last site to be mentioned here is at the village of Gevninge situated 2 km upstream from the mouth of Lejre stream. In 1999–2000 a Viking Age settlement was discovered here. The settlement remains themselves were modest but among the metal finds were a gold arm ring, a portion of a gilt bronze helmet, a bronze bucket and a winged spearhead. This discrepancy, along with a topographical analysis of the area around the Lejre, has indicated that Gevninge was probably the gateway to the elite complex of Lejre, a distance further upstream (Ulriksen 2008b).

Kirke Hyllinge – Karleby

Although the site of Vestervang has now become part of modern Kirke Hyllinge, this was not the case just a few decades ago. Maps predating the vast residential development of the 1960s show the site situated halfway between the two villages of Kirke Hyllinge and Store Karleby. The name 'Vestervang' also refers to the 'western fields' of Store Karleby district. This may indicate that Vestervang was a predecessor of Store Karleby. Store ('great') Karleby is paired with Lille ('little') Karleby a few kilometres further south. These two villages probably reflect one place which at some time was split in two.

Karleby – Lejre?

The elite complex of Lejre lies 10 km SSE of Vestervang. Old Norse legends of Lejre cite it as populated by the aristocracy and this was archaeologically confirmed in the 1980s. Excavations have since revealed numerous massive buildings west of the Lejre stream and facing a burial ground of mounds and monumental ship settings on the opposite bank. The elite complex was active between c. 500 and 1000 AD (cf. Christensen 2010).

The easiest and most practical route from Vestervang to Lejre is first c. 3½ km over land along the Ørbæk valley to the landing site at Lyndby, then a crossing of Roskilde Fjord by boat and landing at Gevninge on the Lejre stream, which is a distance of c. 3 km, i.e. c. ½–1 h of rowing/sailing. Finally, c. 3½ km over land along the Lejre valley from Gevninge to Lejre. This avoids the wetland area at the bottom of the fjord. Travel time using this route would take no more than 3 hours.

Although there is no absolute proof of a connection between the two sites, this does suggest the possibility that Vestervang was a kind of satellite site to Lejre. A study of middle Sweden by Stefan Brink suggests that place names show a repeated system where an elite complex, e.g. *Husaby* or *Tuna,* gives rise to a range of satellite settlements with names such as *Rinkaby*, *Karlaby*, *Tegnaby* (e.g. Brink 1999, 424 ff.; 2008, 117 f.). With reference to Anglo-Saxon written sources Brink suggests that these place names reflect the king's retainers and the land that they were given control over. Thus the landscape of today offers knowledge of the Late Iron Age's social order. Although the same fossilized pattern in the distribution of place names apparently cannot be found in Denmark, probably due to the reason that many of the names have been lost (cf. Brink 1999, p. 425), it may give some food for thought. The old Scandinavian term *karl*, corresponding with the old English *ceorl*, refers to a member of the king's professional warrior escort, the *hirð*. Brink points out that the king's retainers of course had their profession, for example as warrior, but primarily they were farmers and they were accordingly given farms and hamlets for their daily livelihood (Brink 1999, p. 433).

Whether the existence of a 'Karleby' near the excavated site of Vestervang is coincidental is uncertain. Furthermore one might question if the physical distance between Lejre and Vestervang is too large. Regarding the latter, it must be emphasized that the elite complex of Lejre bears a tradition of numerous centuries and it would have had a major impact not only on local areas, but also on the larger region. Bearing this in mind, it seems probable that the settlement of Vestervang was a farm controlled by a Lejre superior and given to generations of retainers, i.e. to a *karl* of the *hirð*. This would explain the extraordinary character of the stray finds contrasting with the somewhat ordinary traces of settlement.

Notes

1. The excavation took place in two stages: from 21 May to 13 July and again from 24 October to 14 December 2007. Daily director and responsible for reporting was the present author assisted by the following students of Prehistoric Archaeology at University of Copenhagen: Sofie Laurine Albris, David Brink, Nikolaj Wiuff Kristensen, Katrine Ipsen Kjær and Julie Nielsen and furthermore archaeologist, M.A. Patrick Lawrence Marsden, museum assistant Niels

Karl Wedel Nielsen and museum technician Cille Krause. Responsible for the excavation was curator, mag. art. Tom Christensen, Roskilde Museum. Original documentation is kept at Roskilde Museum, case record: ROM 2384 Vestervang, Kr. Hyllinge.
2. Cf. case record ROM 2299 Ammershøjvej, Kr. Hyllinge, Roskilde Museum's archive.
3. The ^{14}C analyses were carried out by The Aarhus AMS ^{14}C Dating Centre. The results are calibrated with 2 σ precision with OxCal 4.1 (C. Bronk-Ramsey 2009) with background data from Reimer et al. (2009).
4. The same interim kind of 'pit houses' is for example seen on a recently excavated Viking Age farmstead, Lindenborgvej Syd I-II, southwest of Roskilde (Kastholm 2011, 73 ff.).
5. The excavation was assisted by a number of volunteers with metal detectors: Eva Brix, Kaare Bøgh-Jensen, Michael Jensen, Ib Nielsen, Lars Nissen, Ole Sommer og Mauritz Tchikai.
6. The analysis of the faunal material was undertaken by conservator Kristian M. Gregersen, Natural History Museum of Denmark (case record: ZMK 17/2008).
7. The site of Vestervang is still today (December 2012) producing interesting artefacts corresponding with the hitherto known stray finds.
8. This artefact is wrongly categorized in Kastholm (2009).
9. Personal message from curator Jens Chr. Moesgaard, The National Museum in Copenhagen, 7 May 2008.

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