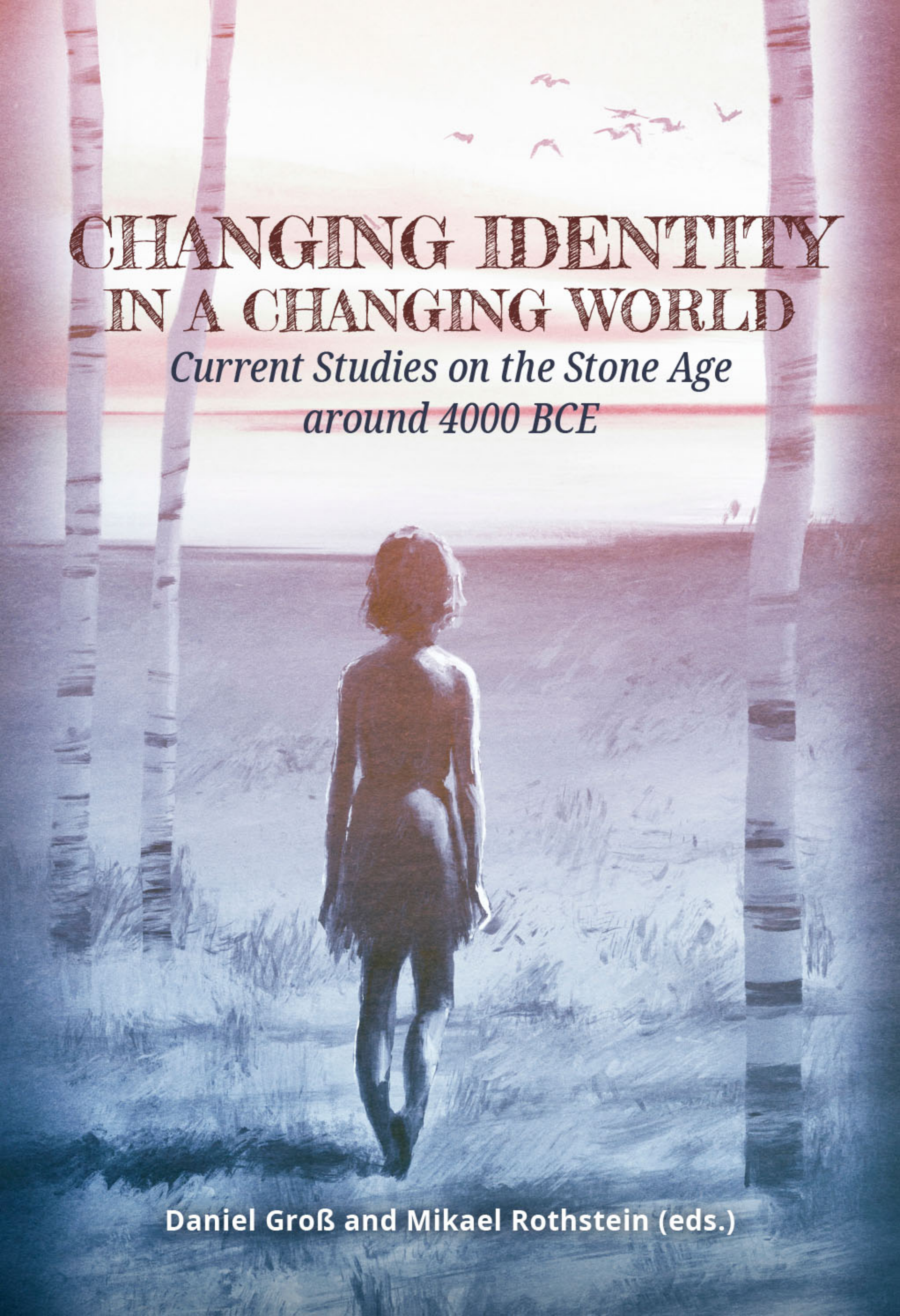

CHANGING IDENTITY IN A CHANGING WORLD

Current Studies on the Stone Age around 4000 BCE

Daniel Groß and Mikael Rothstein (eds.)

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IN A CHANGING WORLD

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Contents

Foreword

The Femern project is Museum Lolland-Falster's name for the huge archaeological investigation project prior to the fixed link under the Femern Belt, which has been underway for more than 14 years.

The investigation project covers an area of approximately 3.5 million square metres east of Rødbyhavn. The majority of the area lies on ancient seabed behind the dike built to protect the south coast of Lolland after the Great Flood of 1872.

Planning for the Femern project began in December 2008, at the same time that the Museum Lolland-Falster was established as a cultural history museum for the two islands. The development of the project and the museum have followed and influenced each other since then.

In 2011, the first feasibility studies started and, in autumn 2012, the first of a series of excavations on the ancient seabed began. At that time, the fieldwork was scheduled to be completed by the end of 2015.

This was not to be. In November 2022, the last excavation was shut down, 10 years after the first one started.

The excavations on – or rather under – the old seabed constitute the largest Stone Age excavation in Danish history. They have uncovered a prehistoric fjord system where optimal preservation conditions have made it possible to reveal unique artefacts and data.

Combined with the fact that most of the excavations date to the late Mesolithic/early Neolithic, this allows for detailed and multifaceted studies of the processes and changes that occurred during one of the most crucial periods in northern European prehistory – the Neolithisation.

Also, it places – at least potentially – the Femern project in the international archaeological super league. The potential is underlined by the research that has been carried out so far in parallel with the fieldwork. This has resulted in exciting and in some cases sensational discoveries, which have made it possible to communicate new aspects of life in the Stone Age.

A good example of the interaction between the project's archaeological fieldwork, research and dissemination is the discovery of Lola: A fictional Stone Age girl created on the basis of analyses of human DNA found in an approximately 6000 year old piece of birch pitch "chewing gum".

When the find was published by scientists from the Globe Institute (University of Copenhagen) in late 2019, it resonated not only in the research world but very much in the international media. From America to southeast Asia and Australia, stories were written and reported about Lola. She is, without comparison, the world's most famous Lollandian inhabitant.

Locally, the story of Lola and her world is told in the popular exhibition of the same name at the Stiftsmuseet in Maribo, through lectures and educational programmes.

With the completion of the field work, it is time to unleash the research and dissemination potential of the Femern project. This is not a task that can be undertaken by individuals and single institutions alone. It requires collaboration and inspiration from a wide range of research disciplines and methodologies.

With this in mind, it is a great pleasure to present the anthology "Changing Identity in a Changing World. Current Studies on the Stone Age around 4000 BCE" with research papers based on presentations given by the authors at the research conference "LOST 2022 – Changing Identity in a Changing World" on 16–17 June 2022 in Maribo on Lolland.

The book is the first comprehensive research publication related to excavations from the Femern project, and its articles address perspectives on the Neolithisation process around 4000 cal BC within three main topics:

"Changing worlds" presents research perspectives on how Stone Age people and societies responded and adapted to changes in ecosystems and landscapes. "Losing Boundaries "reflects on the temporal course of the Neolithisation process. Finally, the articles under the theme "Identities of Change" deal with the archaeological record and its inherent information about change and continuity in prehistoric societies and their adaptations to changing socio-cultural settings.

We hope that the book will be well received by students, teachers and researchers, as well as all those interested in archaeology and the Stone Age, and that it will help to establish the inter-institutional cooperation necessary to harvest all the knowledge hidden in the artefacts and data from the Femern project.

Finally, we would like to thank all past and present colleagues who have contributed to the implementation of this major research project, and Femern A/S (the constructor of the fixed link) for their exemplary cooperation. Thanks to all authors for their articles, and to colleagues who planned and edited the book. Last but not least, a big thank you to the Augustinus Foundation, which not only provided the necessary funds for the book's production, but also for the LOST 2022 conference and for the realisation of the LOLA exhibition.

Enjoy reading!

Ulla Schaltz, Director
Kasper Høhling Søsted, Head of Cultural Heritage

Introduction: Changing Identity in a Changing World

Daniel Groß and Mikael Rothstein

With the end of the last excavation of the Femern project on the 3rd of November 2022 the field work of the biggest excavation project in Denmark so far has come to an end. Ten years of year-round excavations have, along with yielding a plethora of archaeological material, investigated one of the best-preserved Stone Age fjord- and laguna landscapes in northern Europe.

This book is a result of the conference "LOST 2022 – Changing Identity in a Changing World" hosted by Museum Lolland-Falster in Maribo in the summer of 2022 which was held on the occasion of the project's practical conclusion. The museum, and the editors, kindly thank Augustinusfonden and Femern A/S for supporting the conference and the LOLA exhibition at Stiftmuseum Maribo. In addition, thanks are due to Augustinusfonden for the financial contribution to this book and the anonymous peer reviewers of the contributions for their suggestions.

In 21 articles, this volume presents the current state of research on the Femern project and several case studies on the material. It is the first overview of the whole Femern project, and in that capacity it provides a baseline for all future endeavours on the topic.

In order to broaden our understanding of the many finds, the studies that specifically deal with the Femern excavations are embedded in a wider international framework that underlines the relevance of the material and sheds more light on the significant changes in Europe around 4000 BCE. We believe these chapters to be important steps towards an even deeper acknowledgement of what transpired in our part of the world during times that would change cultures and landscapes forever. We are delighted that so many researchers have taken part in the work, and we thank each and every one of them for their contributions. We trust that future collaborations will take us even further.

The Femern project and beyond

The Femern project revealed deep and significant insights into prehistoric Lolland and in this book the time around 4000 BCE is highlighted as it represents one major change

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Current Studies on the Stone Age around 4000 BCE. Leiden: Sidestone Press, 11–18.

in the archaeological chronology: the Mesolithic/Neolithic transition. This period is highly significant as much understanding of prehistoric socio-cultural development is implicitly embedded in the division of the Mesolithic and the Neolithic. Moreover, this creates a certain framing that provokes specific implications for the prehistoric societies under question. It is a consequence of "established" models of cultural development, or as Arnold *et al.* (2016, 91, their emphasis) phrase it: "technological determinism situating farming as foundational to everything complex constitutes not just an incomplete telling of the story of human cultural evolution of the last 10,000 years but an *incorrect* telling of that narrative."

In order to provide some nuance and offer more critical, and in many aspects more imaginative, approaches the authors of our book present different studies from the Femern project and beyond, which show a diverse picture of the Mesolithic/Neolithic transition and underline how human decisions and aspects of intentionality become more important when dealing with socio-cultural change in that timeframe. Gronenborn (2007, 90) highlights that "The spread of farming is a complicated and differentiated process with considerable local and regional variations" and "certainly not a process occurring along a supposedly well defined 'frontier' but one which lasted for several millennia, and which happened in stages." And the same can be said about the adoption of other Neolithic trademarks, such as sedentism or animal husbandry, as how they were integrated into the societies is "largely unknown, even though there are countless theories about it" (Jacomet and Vandorpe 2022, 12). The contributions of this book, then, intend to shed more light on the archaeology of this interesting period and cover a range of topics.

The first section "Changing Worlds" provides and introduction to the Femern project (Måge *et al.*) and addresses environmental changes and human reactions to these (Bennike and Jessen; Koivisto); anthropogenic landscape changes and their perception are dealt with in this section (Mennenga *et al.*; Wunderlich) as well as conceptual and explanatory baselines for our understanding of the past (Johannsen). The following section "Losing Boundaries" addresses to a large extent material from the Femern project and shows how depositional practises and contacts (Jensen and Sørensen; Sørensen) or dietary habits and hunting implements (Chaudesaigues-Clausen; Philippsen; Rowley-Conwy) blur the lines between the Mesolithic and Neolithic. This section furthermore discusses "Neolithic elements" in hunter-gatherer societies, such as pottery or farming (Meyer; Nielsen and Stokke). Finally, "Identities of Change", addresses changing values of species and diets in societies (Maring; Schmölcke) as well as changes in the material culture (Hinders; Stafseth and Groß). This section furthermore highlights new insights into the Neolithisation process in other areas and shows clear differences and similarities (Raemaekers *et al.*; Terberger *et al.*). The book ends with a brief discussion of how concepts of time, place and distance in the Stone Age may be approached by means of ethnographic analogy and comparative research (Rothstein).

A note on terminology

To some extent, confusion has been caused by the lack of a unified terminology in previous Femern project-related studies. In order to avoid future misunderstandings, a unified terminology is presented in a brief section below: *The Femern project: Terminology and principles for reference*, including a short index of the most common terms in use. A correlation table of previous studies and the respective sites used, has been included to clarify former mislabelling and imprecisions.

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The Femern project: Terminology and principles for reference

The organic nature of project planning as well as the involvement of many different archaeologists and professionals from other disciplines has led to the introduction of several terms for similar or comparable aspects of the project. In the following we propose a harmonized terminology for the most common terms used in connection with the Femern project and related studies.

Dates

Date ranges in this book are given in the format "before the common era" (BCE), while radiocarbon dates follow the conventional way of being reported as calibrated date-range (cal BC) and uncalibrated age (BP) (cf. Millard 2014).

Site names

As the excavations are separated into several sites with different trenches or subunits, these should be regarded when referencing. This means that the site name should be referred to, at least when mentioned first, including its full name and site ID, for instance "Syltholm II (MLF00906)". If a certain subunit is meant, this is added to the site ID with Roman numerals, *e.g.* "MLF00906-II". All sites must be reproduced with their full ID, that is, including preceding 0s.

Femern project

"Femern project" describes the total of all archaeological investigations and related activities that were conducted in connection with the building of the Femern-Belt-tunnel and its facilities on the Danish island of Lolland. This tunnel will provide a land-fast connection between Lolland and the German island of Fehmarn. The terms "Femernbelt-project", "Femerntunnel-project" and "Femern link project" (Tab. 1) have been used synonymously but should be avoided in future studies.

Syltholm Fjord

The ancient water body, which was dammed in historic times and produced most of the wetland sites in the project, was called the Syltholm Fjord. Due to its varying history, it has been referred to as both a fjord (Groß *et al.* 2018; Jensen et al. 2016; Måge 2019; Mortensen *et al.* 2015; Out *et al.* 2020; Philippsen 2018; Sørensen 2015; 2018; 2019; 2020; Taylor 2020; Terkelsen 2017) and a lagoon (Philippsen *et al.* 2019). As the term "fjord"

In original article	Reference	Standardized nomenclature
Fehrmanbelt project [sic!]	Bailey *et al.* 2020, 36	Femern project
Rødbyhavn (MLF906–1)	Cubas *et al.* 2020, supplementary information 1	Syltholm II (MLF00906-I)
Syltholm	Cubas *et al.* 2020, supplementary information 2 and 4	Syltholm II (MLF00906-I)
Rødbyhavn sites	Courel *et al.* 2020, 8	Syltholm II, subunit I (MLF00906-I); Syltholm XIII, subunit I (MLF00939-I)
Syltholm (Rødbyhavn; MLF906-I/906-II/939-I),	Courel *et al.* 2020, 4	Syltholm II, subunits I and II (MLF00906-I and -II); Syltholm XIII, subunit I (MLF00939-I)
Rødbyhavn (MLF906–1)	Courel *et al.* 2020, supplementary information	Syltholm II (MLF00906-I)
Rødbyhavn (MLF939–1)	Courel *et al.* 2020, supplementary information	Syltholm XIII (MLF00939-I)
Syltholm MLF932	Glykou *et al.* 2021, supplementary information	Syltholm VI (MLF00932)
Syltholm MLF 939-I	Glykou *et al.* 2021, supplementary information	Syltholm XIII (MLF00939-I)
The Fehmarn Link archaeological project	Groß *et al.* 2018, 32	Femern project
Excavation at Syltholm	Grøn 2020, 283	Syltholm II (MLF00906-II)
Site of Syltholm	Jensen *et al.* 2019	Syltholm II (MLF00906-II)
Syltholm site (906-II)	Jensen *et al.* 2020	Syltholm II (MLF00906-II)
Femern Bælt projektet (="The Femern Belt project")	Mortensen *et al.* 2015	Femern project
Femern	Out *et al.* 2020	Femern project
Syltholm	Papakosta *et al.* 2019	Syltholm II, subunits I and II (MLF00906-I and -II) and Syltholm XIII, subunit I (MLF00939-I)
Syltholm (Rødbyhavn) complex of sites	Robson *et al.* 2021, 2	Site complex 5
Syltholm (MLF906–1 and MLF939–1)	Robson *et al.* 2021, 13	Syltholm II, subunit I (MLF00906-I) Syltholm XIII, subunit I (MLF00939-I)
Femern-udgravningerne (="The Femern excavations")	Sørensen 2015, 22; Sørensen 2018	Femern project
Syltholm I	Sørensen 2020	Syltholm II, subunit I (MLF00906-I)
Syltholm 1	Taylor 2020, 14	Syltholm II, subunit I (MLF00906-I)

Table 1. Overview of the different site names and terms used in previous publications and the standardized reference.

has been used in most publications for referring to the area, we promote this for reasons of consistency, even if the history of the waterbody had other characteristics at times (Bennike and Jessen this volume).

Syltholm (excavations)

Used as in "Several excavations at Syltholm near Rødbyhavn" (Jensen *et al.* 2020, 2) or "excavation at Syltholm on the island of Lolland" (Grøn 2020, 283) usually means "in the area of the former Syltholm Fjord" or "in the area around the Syltholm sites", *i.e.* the sites of Syltholm I – XIV or site complex 5 (see Måge *et al.* this volume).

As this term was also partly used to refer to excavations that predominantly focused on the site of Syltholm II (MLF00906), as well as to the whole Fehmarn-project (Jensen *et al.* 2016), it should no longer be used due to imprecisions.

"Kæbefeltet"/"Jaw field"/"Structure A"

These terms describe a feature of potential ritual activity with several deposited animal jaws (Sørensen 2015; 2016; 2019; 2020; this volume). The feature should be referred to as "Structure A" (Sørensen 2019, 154).

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CHANGING WORLDS

The Femern project

A large-scale excavation of a Stone Age landscape

Bjørnar Tved Måge, Daniel Groß and Marie Kanstrup

Abstract

The Femern project encompasses the archaeological excavations connected with the building of the Femern Belt tunnel: a fast connection from the Danish island of Lolland to the European mainland. In this context, it was possible to uncover a prehistoric coastal landscape and the physical remains of human activity in the area.

Large numbers of Stone Age fishing equipment, both mobile and stationary, faunal remains, and hunting and domestic tools provide a great insight into prehistoric life at the coast. The excavations produced a high number of settlements and artefacts and prove that fishing was still a large part of the subsistence strategy when animal husbandry was established on southern Lolland *c.* 4000 BCE. Additional information on the intangible world of early farmer-fishers was unearthed in the form of extensive ritual deposits in the shallow fjord.

In this contribution, we provide an overview of the current state of research and summarise the data from the project. Our aim is to provide a starting point for the other contributions in this book and to highlight the immense potential of the material. As a baseline for future investigations, we will present the chronological and spatial distribution of the sites and provide a brief overview of the different investigated areas.

Femern project; wetland archaeology; settlement archaeology; organic preservation; chronology

Introduction

The Femern project is the biggest archaeological excavation of a Stone Age landscape in Denmark to date. Due to the extensive terraforming activities in the context of the construction of the Femern Belt tunnel, a huge part of a former fjord system was investigated. The area affected by the construction covers *c.* 368 ha, with more than half

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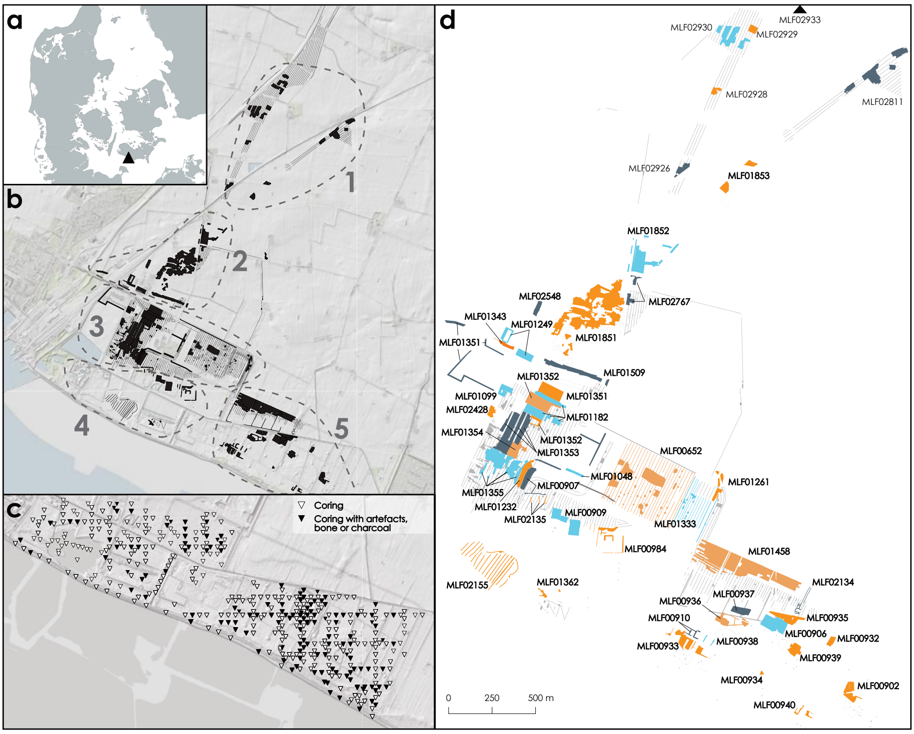

Figure 1. a) Location of the prehistoric Syltholm Fjord on Lolland; b) All excavated trenches (~ 57 ha) during the Femern project and the delimitation of the site complexes. What appear to be parallel lines are survey excavations; the main investigations opened larger areas (black polygons); c) Overview of cores drilled during the survey campaigns. Cores with archaeologically relevant finds are highlighted as filled black triangles. d) Overview of the excavation trenches from the main excavations with the respective site IDs (MLF02933 is located just north of the area, see map b). Different colours are only used for visual purposes to visually separate closely located excavations.

within the former wetland area of the so-called Syltholm Fjord (Sørensen, 2016a, 3). Due to the extent of the area, it was not possible to excavate it in its entirety, so smaller areas of interest were identified after preliminary geological and archaeological analyses had been conducted. The preliminary investigation involved both the use of core drilling, auger drilling and a total of 63 4 × 4 m fixed iron boxes for survey-digs. A total of 25 sites in the wetland area were identified and investigated (Groß *et al.* 2018, 32; Sørensen 2020, 398).

Here, we will briefly present the different sites to provide a complete overview of the project and the excavations, without discussing finds and features in detail. Previous studies have already dealt with various aspects of the material by, for instance, the analysis of organic residue from ceramics (Courel *et al.* 2020; Cubas *et al.* 2020; Papakosta *et al.* 2019; Philippsen *et al.* 2019; Robson *et al.* 2021; 2022), stable isotope analysis and radiocarbon dating (Philippsen 2018; Philippsen *et al.* 2019), landscape reconstruction, including a sea-level curve, looking at the ecological histories of species, and by the analysis of wood (Bennike *et al.* 2022; Glykou *et al.* 2021; Jessen *et al.* 2018; Out *et al.* 2020). Or they have focussed on selected materials and find groups (Forsberg 2016; Glykou *et al.* 2021; Jensen *et al.* 2019; 2020; Måge 2019; Sørensen 2016b; 2018; Terkelsen 2017; Wadskjær 2018; Wadskjær and Høgsbro Nederby 2020) as well as on selected features (Sørensen 2016a; 2016c; 2019; 2020; 2021).

Overview of the sites

The investigated area (fig. 1) was divided into 51 different projects, meaning that several sites were subdivided due to organisational or logistical constraints during fieldwork, and they were hence given different activity numbers or site identifications (site IDs). To give a better overview and a more concise interpretation, we merged the excavations into archaeological site complexes as shown in fig. 1b (see also tab. 1). Additionally, several of the excavations had to be split into different trenches and sub-units for logistical reasons, which consequently created further subdivisions. For this reason, several sites are shown with additional Roman numerals, for instance, MLF00906-I to III. In this contribution, we summarise these sites under their main site identifier – a separation is only kept for the sites of Strandholm VI (MLF01232-I) and Strandholm X (MLF01232-II) due to their diverging site names.

Site complex 1

The sites are all from younger periods with one site from the Bronze Age to the pre-Roman Iron Age (MLF02811), three Iron Age sites (MLF02928, MLF02929, MLF02930), one site dating to the Late Iron Age and Middle Ages (MLF02933), and two Late Viking Age and Early mediaeval settlements (MLF01853, MLF02926). Five of the sites show clear settlement features, including houses, wells, and a range of pits. At MLF02929, two burials were found: one urn grave and one cremation pit (cf. Harvig *et al.* 2014). The sites in complex 1 have not yet been analysed.

Site complex 2

This site complex is mainly characterised by the large Iron Age settlement of Riksø I / Agersø (MLF01851, MLF02767, MLF02548) and a belt of "Ceasar's lilies", *i.e.* a defensive structure with small holes and presumably sharpened stakes at its centre, south of it (MLF01078, MLF01249, MLF01343, MLF01509). Furthermore, a Middle Neolithic Funnel Beaker site (MLF01852) was uncovered in this area.

Site complex 3

This site complex contains the largest number of archaeological sites on dry land. The finds and features cover different periods, ranging from the Neolithic to the Bronze Age. Among others, two destroyed Neolithic dolmens (MLF00652, MLF01099) as well as Neolithic and Bronze Age settlement structures have been found. The only younger activities in this area are a long ditch measuring at least 1400 m, which dates to the Late Iron Age and Early Middle Ages (MLF00652, MLF01261, MLF01353, MLF01354, MLF02428), as well as a World War II airfield (MLF01261).

Site complex 4

The excavations from this site complex targeted the western basin of the prehistoric Syltholm Fjord and produced a long chronology of human activity. The majority of sites in

Site complex	Site name	Site ID	Dating
1	Elholmgård II	MLF01853	Viking Age – Early Middle Ages
	Darketvej	MLF02811	Bronze Age – pre-Roman Iron Age
	Ottelundvej	MLF02892	Iron Age – Middle Ages
	Nøjsomhed	MLF02926	Late Iron Age, Middle Ages
	Brogård	MLF02928	Iron Age
	Ottelunde	MLF02929	Iron Age
	Ottelundsgård	MLF02930	Iron Age
	Næsbæk Syd	MLF02933	Iron Age – Middle Ages
2	Finlandsvej I	MLF01249	Older Iron Age
	Finlandsvej II	MLF01343	Older Iron Age
	Sulkavavej	MLF01509	Older Iron Age
	Riksø I	MLF01851	Neolithic – Iron Age
	Elholmgård I	MLF01852	Neolithic
	Finlandsvej II	MLF02548	Neolithic – Iron Age
	Agersø	MLF02767	Iron Age
	Egelund	MLF02893	Bronze Age – Iron age
3	RGS90	MLF00652	Neolithic – Late Bronze Age
	Rødbyhavn Øst	MLF00001-XII	Neolithic, Bronze Age
	Strandholm VIII	MLF00907	Bronze Age
	Strandholm IV	MLF01099	Neolithic – Bronze Age
	Strandholm V	MLF01182	Early Neolithic – Bronze Age (period 4–6)
	Strandholm VI	MLF01232-I	Bronze Age (period 4)
	Strandholm X	MLF01232-II	Neolithic – Bronze Age
	Strandholm VII	MLF01261	Iron Age – Middle Ages
	Annasminde I	MLF01351	Neolithic
	Annas Minde II	MLF01352	Middle Neolithic – Bronze Age
	Annas Minde III	MLF01353	Neolithic – Bronze Age
	Annasminde IV	MLF01354	Neolithic – Bronze Age
	Annasminde V	MLF01355	Bronze Age
	Strandholm XI	MLF02135	Indet.
	Annasminde VI	MLF02428	Neolithic – Bronze Age
4	Strandholm I	MLF00909	Late Mesolithic – Iron Age
	Strandholm II	MLF00984	Late Mesolithic – Bronze Age
	Gokartbane	MLF01333	Middle Neolithic
	Femern Belt I	MLF01362	Middle Neolithic
	Strandholm Sø	MLF02155	Late Mesolithic – Early Neolithic

Table 1. Site complex number, site identifier and site name. The dating of the sites is provided using broad archaeological categories (see chapter chronology for more details).
* = Note: MLF01507 was merged with MLF01458, so all their finds and documentation are combined under site ID MLF01507.

Site complex	Site name	Site ID	Dating
5	Syltholm I	MLF00902	Late Palaeolithic – Bronze Age
	Syltholm II	MLF00906	Late Mesolithic – Neolithic
	Syltholm V	MLF00910	Late Mesolithic – Neolithic
	Syltholm VI	MLF00932	Late Mesolithic – Neolithic
	Syltholm VII	MLF00933	Late Palaeolithic – Middle Neolithic
	Syltholm VIII	MLF00934	Middle Neolithic
	Syltholm IX	MLF00935	Early Neolithic – Early Bronze Age
	Syltholm X	MLF00936	Late Mesolithic – Early Neolithic
	Syltholm XI	MLF00937	Early Neolithic – Middle Neolithic
	Syltholm XII	MLF00938	Late Mesolithic – Early Neolithic
	Syltholm XIII	MLF00939	Late Mesolithic – Early Neolithic
	Syltholm XIV	MLF00940	Early Mesolithic, Late Mesolithic
	Hyldtofte Fæland I	MLF01458	Neolithic
	Hyldtofte Fæland II	MLF01507*	Neolithic
	Hyldtofte Fæland IV	MLF02134	Late Mesolithic – Neolithic

Table 1. Continued.

this area date from the Late Mesolithic to the end of the Bronze Age. Among other things, fish weirs have been found, as well as other fishing equipment such as a complete leister point (MLF00909-II; see Stafseth and Groß this volume). All the sites are situated in the former fjord basin and thus represent the littoral zone to 'site complex 3'.

Site complex 5

The sites in this complex are located in the eastern basin of the prehistoric Syltholm Fjord and on its northern shoreline. They have provided some of the most profound evidence for extensive fishing in the prehistoric fjord and predominantly represent the former littoral zone – only MLF01458/MLF01507 is completely located on dryland. The sites show various artefact depositing activities in the former shore zone, several of which are considered ritual (*e.g.* Sørensen 2016a; 2020; this volume; Jensen and Sørensen this volume). Additionally, sites have been uncovered that were occupied before the fjord was formed in *c.* 5000 BCE (Bennike and Jessen this volume), including one Late Palaeolithic Ahrensburgian site (MLF00902) and one Early Mesolithic Maglemose site (MLF00940; Måge 2019).

Chronology

Several of the sites from the Femern project are located in and around the prehistoric Syltholm Fjord (*e.g.* Mortensen *et al.* 2015) and have to be classified as palimpsests where artefacts and features from different periods were recovered. Hence, the sites need to be analysed in detail to disentangle the mixed nature of the material.

More than 800 radiocarbon samples highlight the intense deposition of finds between *c.* 5000 and 3000 BCE (fig. 2; supplementary material). As many stakes and

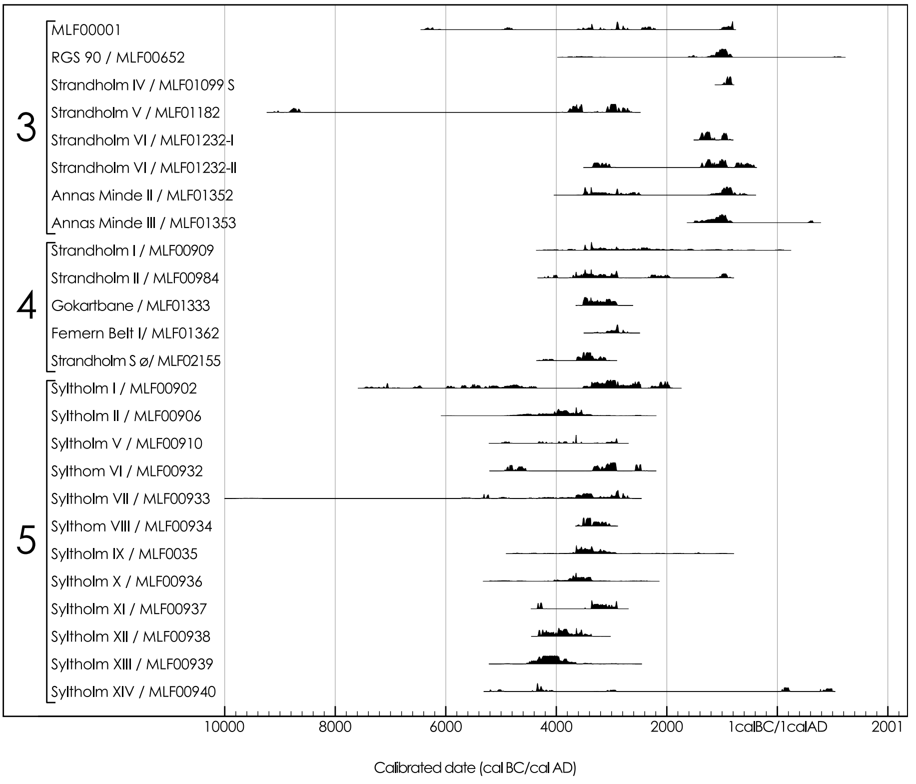

Figure 2. Sum-calibrations of different sites from the Femern project, separated by site complexes (numbers on the left). Site complexes 1 and 2 have not yet produced radiocarbon dates (calibrated with OxCal v4.4.4 (Bronk Ramsey 2021, see Bronk Ramsey 2009), atmospheric data from Reimer *et al.* 2020).

piles from the former littoral zone are directly dated, a very clear picture of the shore bound activities can be drawn. However, the number of dated samples might obscure the actual activity intensity due to sample selection. Furthermore, most of the sites show a rather long chronology and/or occupations during several periods, so that radiocarbon samples alone might not reflect human activity very well. Additionally, not all sites are yet sufficiently radiocarbon dated, so we conducted an aoristic analysis (Mischka 2004) for the timeframe between *c.* 5500 and 2000 BCE to better reflect the occupation patterns. This was based on their typochronological association and radiocarbon ages. As this analysis incorporates more dating evidence, it provides a better picture of the number of sites in the area during the Stone Age (fig. 3). It becomes clear that the number of sites in and around the Syltholm Fjord was increasing in the Early Neolithic with a peak during the Middle Neolithic *c.* 3300–3100 BCE. This higher number of sites likely reflects an increase in activity in the fjord basin, as the size of the archaeological inventories grows similarly.

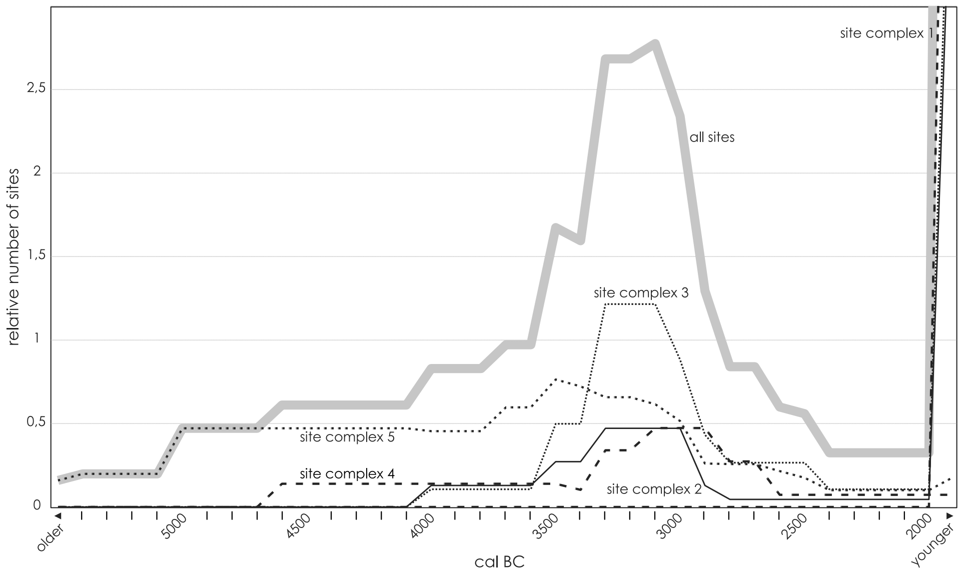

Figure 3. Aoristic analysis of the sites from the Femern project. The local maximum during the Stone Age is reached *c.* 3300–3100 BCE, mainly represented by sites from site complexes 2 and 3. Sites from site complex 5 have generally been dated to an older period and all excavations from site complex 1 produced Iron Age or younger finds. Note that sites younger than *c.* 2000 BCE were summarised and hence produce high deflections of the curves.

The Syltholm Fjord in a wider perspective

As a result of the large areas that were investigated during the Femern project, it is possible to see patterns in landscape use and interaction as well as in settlement strategies. These would have been difficult to uncover in such clarity by excavating smaller areas, as the relationships were not only chronological but also spatial.

The intense use of the Syltholm Fjord in the Stone Age highlights the area's involvement in human subsistence and settlement systems. The use of the waterscape for fishing and hunting marine mammals is evident from several finds, while herding and terrestrial hunting also took place on the shore zone (*e.g.* Jensen *et al.* 2016).

Even though the Bronze Age people still lived close to the fjord, it seems that the activity areas moved further away. This is represented by a significantly lower number of organic artefacts in the littoral zone. For instance, only 18 out of 460 individually dated wooden artefacts (incl. worked wood, tools, and constructional elements such as stakes) date within the margins of this period. It cannot fully be excluded that this is due to a sample selection bias, yet this seems unlikely as the number of post-Neolithic archaeological finds from the fjord basin also decreases.

Another significant change in the settlement pattern becomes visible in the pre-Roman Iron Age: after having lived at the coast during the Neolithic and Bronze Ages, the settlements were moved inland to another, ridge *c.* 750 m further north (site complex 1). Contemporaneously, the construction of a belt of “Caesar’s lilies” (in Danish: “hulbælte”) was established between the settlement area and the Syltholm Fjord in the area where one would travel from the coast towards the hinterland. The “hulbælte” is at least 700 m long and 10 to 15 m wide. Based on ceramic finds, the construction is dated to *c*. 300–400 BCE.

The motive for the relocation further away from the coast is not fully clear. But the construction of defensive structures indicates a need for protection from people arriving from the sea. This is corroborated by the fact that the settlements have indeed moved further inland but not to higher ground, so hydrological developments cannot have been the reason.

It is noteworthy that there are almost no signs of human activity in the Syltholm Fjord after the Bronze Age: Only one pointed stick (MLF0909-I X359) is dated to the pre-Roman Iron Age (749–398 cal BC; AAR-25665: 2413 ± 36 BP). It can be surmised that the activities linked to the water, such as fishing and transport, were moved to the more protected Rødby Fjord, *c*. 1.3 km west of the Iron Age settlements.

This contribution aimed at providing a condensed overview of the archaeological material and activities in and around the former Syltholm Fjord to serve as a point of reference for past and upcoming projects. Due to the extent of the project and the size of the individual assemblages, past, present and future studies will make it possible to write a conclusive history of human activity in the area.

Supplementary material

The table with all the radiocarbon dates, including an indication of which articles they are used in, is available at DOI: 10.5281/zenodo.7303645.

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CRediT statement

BTM and DG are responsible for the conceptualisation and writing (original draft, review, and editing). MK is responsible for resources (radiocarbon dating).

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Environmental changes after the last deglaciation, southern Lolland, Denmark

Ole Bennike and Catherine Jessen

Abstract

The Lolland region has seen a dynamic development since the last deglaciation, from a tundra-like landscape to woodland, back to tundra, and then to woodland, followed by closed forest, then more open forests due to deforestation and finally to cultural steppe. The dominant large mammal fauna shifted from reindeer to elk and aurochs at *c.* 9500 BCE and then to red deer, roe deer and wild boar after *c.* 8000 BCE. Seals populated the waters after the sea inundated the region at *c.* 6000 BCE. The marine transgression of the Syltholm area of southern Lolland began *c.* 5000 BCE, creating small fjords with a zone of reed beds along the shore. As the sea level continued to rise, the fjord environment developed into a shallow water lagoon within protective sand spits and the reed beds moved progressively inland. Rich vegetation, consisting of water plants developed, along with a rich fauna of invertebrates that provided food for fish. This dynamic environmental history forms the background for the wide-ranging cultural activities of the Syltholm area.

Femern project; shore-level changes; vegetation history; fauna history; landscape change

Introduction

The low-lying areas of southern Lolland were gradually transgressed by the sea during the Holocene, and a number of small, shallow-water fjords and lagoons were formed along the south coast of Lolland (Colding 1881). In 2013, a large archaeological project began in the Syltholm area, east of Rødby on southern Lolland and adjacent to the Femern Belt prior to the construction of three large factories (fig. 1). The factories are positioned on reclaimed land and will produce elements for the coming 18 km long tunnel between the islands of Lolland in south-eastern Denmark and Femern in northern Germany. The surveyed area therefore included 187 ha of reclaimed seabed, which not only documented

in: Groß, D., Rothstein, M. (eds.). Changing Identity in a Changing World.
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Figure 1. Map of Denmark showing the location of Lolland (Lol), Femern Belt (FB) and Mecklenburg Bay (MB). The rectangle on Lolland (marked by an arrow) shows the Syltholm area (after Bennike *et al.* 2022, fig. 1).

the post-glacial sea level rise but also allowed for excellent preservation conditions for organic material. All Danish prehistoric periods are represented in the archaeological material, but the richest material in the wetland sites derives from the late Mesolithic and the early Neolithic. The archaeological material comprises a great variety of finds, such as fish weirs, artefacts including bows, a paddle, flint tools, pottery and ritual depositions of mammal mandibles (Mortensen *et al.* 2015; Sørensen 2017; 2020).

Here, we give a short review of the development of the nature of Lolland since the last deglaciation as background to the archaeological investigations. The review is based on published studies from the Lolland region. It includes short descriptions of the local environment of the Syltholm area itself based on our studies of the stratigraphy and the analyses of macrofossils and pollen carried out in association with the excavations (Jessen *et al.* 2018). The excavations revealed a general stratigraphy of clayey till with soil formation features on the surface formed prior to the sea-level rise (terrestrial phase), peat or peat-like sediment (swamp phase), gyttja and sandy gyttja (fjord and lagoon phase) and thick sand deposits (littoral phase) over a time period of around 7500 years.

The Lateglacial

According to cosmogenic exposure ages of erratic boulders, Lolland was deglaciated between 18000 and 17000 years ago (Houmark *et al.* 2012). The oldest dated plant remains from the region date to *c.* 13100 BCE (Jensen *et al.* 1997) and the absence of older plant remains may be due to the presence of bodies of stagnant ice, unstable soils and low temperatures. Prior to the Allerød warm period (before *c.* 11900 BCE, fig. 2), the vegetation was dominated by dwarf-shrub heaths with, for example, polar willow (*Salix polaris*), dwarf willow (*Salix herbacea*), dwarf birch (*Betula nana*) and mountain aven (*Dryas octopetala*). The large mammal fauna was characterised by reindeer (*Rangifer tarandus*) (Aaris-Sørensen 2009). The northern part of the Baltic Basin was covered by the Scandinavian ice sheet, whereas the Baltic Ice Lake covered the southern part, including the deeper parts of the present-day Femern Belt (Jensen *et al.* 2002).

During the Allerød period (*c.* 11900 to 10900 BCE), south-eastern Denmark became covered by open woodlands dominated by downy tree birch (*Betula pubescens*) with some aspen (*Populus tremula*) (Mortensen *et al.* 2014). Reindeer was still part of the fauna, but it also included, for example, elk (*Alces alces*), beaver (*Castor fiber*) and Russian desman (*Desmana moschata*). At the very end of the Allerød period, the water level of the Baltic Ice Lake dropped by ~20 m, but a large lake was still found in the deeper parts of the Femern Belt.

During the Younger Dryas cold period (*c.* 10900 to 9700 BCE), an open tundra-like landscape with dwarf-shrub heaths returned to Lolland. Both tree birch and aspen survived throughout this cold period, although probably as bushes, and reindeer once again dominated the large mammal fauna. The level of the Baltic Ice Lake increased, and the lake again extended into the Femern Belt.

The Early Holocene (*c.* 9700–6200 BCE)

Temperatures increased rapidly at the transition from the Younger Dryas to the Holocene and continued to rise during the Early Holocene, although interrupted by several cold events (Hoek and Bos 2007). Downy birch and aspen expanded, and pine (*Pinus sylvestris*) immigrated soon after the Younger Dryas/Holocene transition, with the oldest dated pine remains giving an age of *c.* 9300 BCE. The open woodland was gradually transformed into open forests and light-demanding dwarf shrubs disappeared. Hazel (*Corylus avellana*) arrived and dominated the vegetation in dry and moist areas from *c.* 8000 to *c.* 6500 BCE. Elm (*Ulmus*), oak (*Quercus*), alder (*Alnus*) and lime (*Tilia*) also immigrated during the Early Holocene (Iversen 1973).

A large number of terrestrial mammals immigrated to the region during this period, including aurochs (*Bos primigenius*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). Elk, which was not present during the Younger Dryas, re-immigrated into the region (Aaris-Sørensen 2009).

The water level of the Baltic Ice Lake dropped abruptly by ~25 m at the Younger Dryas/Holocene boundary. This rapid drainage marks the beginning of the Yoldia Sea stage of the Baltic Basin, with its connection to the Kattegat via narrow straits across south-central Sweden (Björck 1995). A freshwater stage once again followed: the Ancylus Lake (*c.* 8700–6000 BCE). During the early part of this stage, mires and small local lakes were found in the Femern Belt (fig. 3), but the shore level soon began to rise, and large lakes formed in both the Femern Belt and Mecklenburg Bay. Towards the end of the Early Holocene, about 6200 BCE, the sea began to inundate the Femern Belt (Bennike *et al.* 2021) but had not yet reached the Syltholm excavation area.

The Mid-Holocene (6200–2200 BCE)

Dense, closed temperate forests dominated by broad-leaved deciduous trees, such as lime, oak, elm and hazel characterised the region during the Mid-Holocene. The arrival of farmers at *c.* 4000 cal BC led to some changes in forest composition, but the forests were still fairly dense and closed. Elm declined markedly at about the same time as farmers arrived, probably mainly due to Dutch elm disease (Rasmussen 2005).

The Mid-Holocene flora included warmth-demanding plants such as mistletoe (*Viscum album*), ivy (*Hedera helix*) and water chestnut (*Trapa natans*), and the fauna included pond tortoise (*Emys orbicularis*) and Dalmatian pelican (*Pelicanus crispus*) and other warmth-demanding species. The mean July temperature was around 2°C higher than pre-industrial values and winters were also mild. Elk and aurochs disappeared from the region, probably mainly because the forests became denser. The marine fauna included grey seal (*Halichoerus grypus*) and harp seal (*Pagophilus groenlandicus*). The

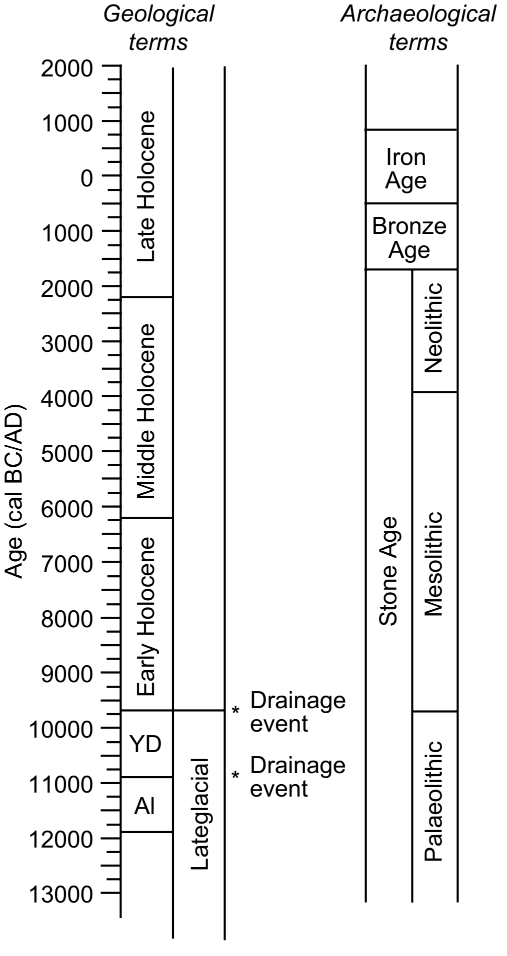

Figure 2. Chronological terms used in this chapter. YD: Younger Dryas cold period, Al: Allerød warm period. The term 'Lateglacial' is used in this chapter for the time period from the last deglaciation to the transition to the Holocene. The division of the Holocene is according to Walker *et al.* (2019) and the chronology of the archaeological time periods is according to Skousen (2008).

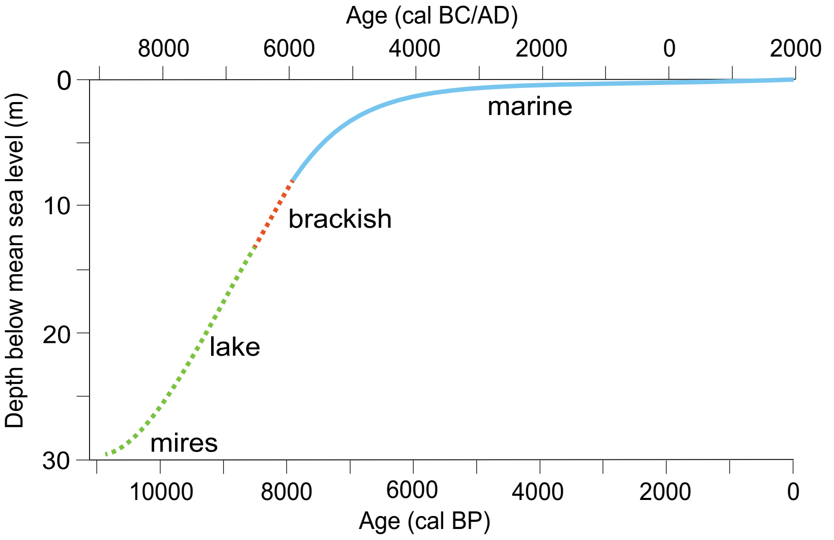

Figure 3. Model of Holocene shore-level changes in the Femern Belt and Lolland region. Details are provided by Bennike *et al.* (2022).

latter is an arctic species that now breeds on sea ice, but it had a breeding population in the Baltic Sea during the Mid-Holocene. The relative sea level in southern Lolland rose from ~10 m below present-day mean sea level at 6200 BCE to ~1 m b.s.l. at 2200 BCE (figs 3, 4).

At Syltholm, the rising shore level can now be seen in the stratigraphy as a time-transgressive soil – peat – gyttja – sand sequence beginning in the deepest coastal part *c.* 7300 BCE and continuing inland until reaching the pre-1800s coastline. Firstly, a zone of reed beds dominated by common reed (*Phragmites australis*) developed along the shores (fig. 5). The 'B' horizon of soil that had developed in the clayey till are preserved beneath the peat layers, and large concentrations of sclerotia of the soil fungus *Cenococcum geophilum* were found at several places at the transition from till to peat. Such concentrations indicate soil erosion and testify to the erosion of the soil 'A' horizon. A number of *in situ* tree stumps from drowned forests had survived the transgression and the dating of seven stumps gave ages from *c.* 5200 to 3700 BCE, depending on the elevation of the samples. Most of the tree stumps were identified as oak.

As the transgression continued, the reed beds moved inland and deeper areas were transformed into shallow fjord waters with the accumulation of gyttja. Gyttja can only form in calm waters and the presence of gyttja shows that the areas were protected by coastal spits, which migrated inland with the rising sea level. These shallow waters had a rich vegetation of submerged water plants, dominated by ditch grass (*Ruppia*), horned pondweed (*Zanichellia palustris*) and charophytes (*Chara* and *Tolypella*). The mollusc fauna during the fjord stage was dominated by mud snail (*Hydrobia*), cockle (*Cerastoderma*), periwinkles (*Littorina*) and common blue mussel (*Mytilus edulis*). A few juvenile specimens of oyster (*Ostrea edulis*) were found, as well as a few, small adult specimens. The fossil

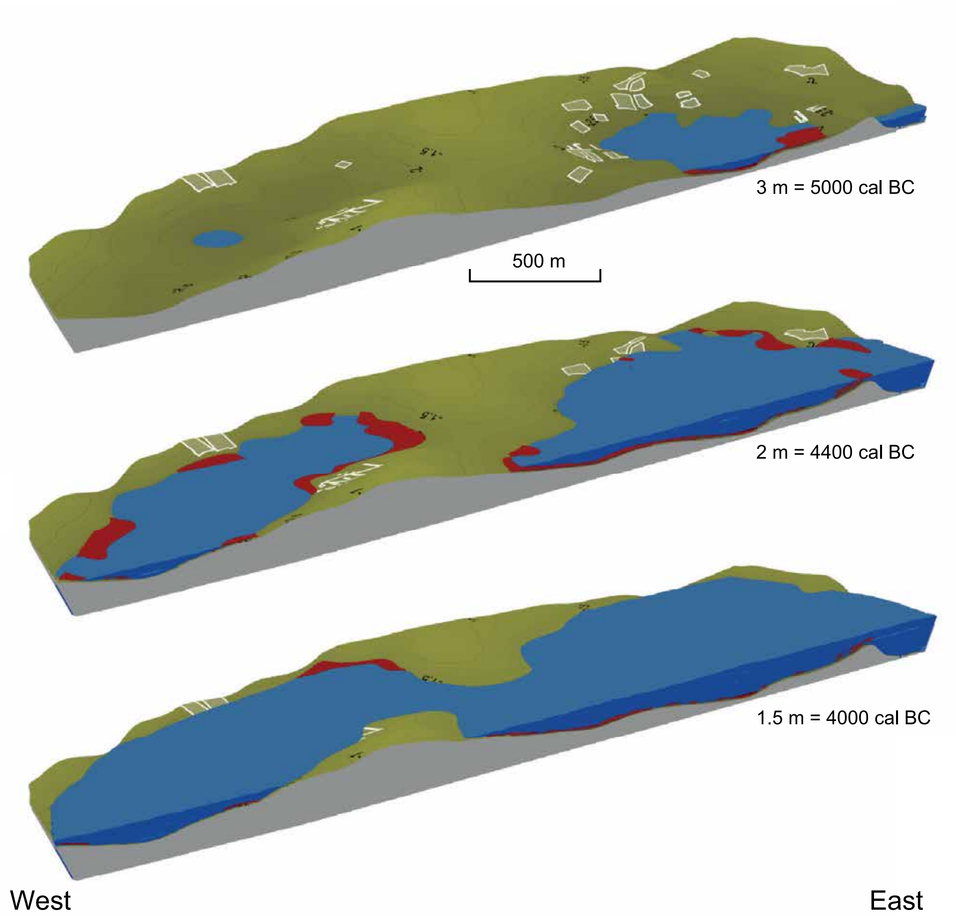

Figure 4. Model of the Syltholm area, showing drowning of the landscape from *c.* 5000 to 4000 BCE, corresponding to a relative sea-level rise of 1.5 m, from 3 to 1.5 m below the present-day mean sea level. Small fjords and lagoons with shallow water formed during the sea-level rise. The red areas represent the reed beds and the blue areas the open, shallow waters. The polygons show the major excavations.

assemblages and the rare occurrence of oyster reflect the low salinities of the water. Bones and spines of three-spined stickleback (*Gasterosteus aculeatus*) are fairly common. Three-spined stickleback is a small fish that plays an important role as food for larger fish and birds – and it was also eaten by stone age people (Enghoff 1994).

The sequence is punctuated by layers of sand, which represent storms during which the coastal spits were either breached or overflowed. These storm layers became more frequent as the transgression progressed.

Interpretation of pollen data from Syltholm is somewhat hampered by the large changes in sediment types (Jessen *et al.* 2018). The pollen grains in the peat would predominantly be from the local wetland plants, whereas a larger proportion of the pollen in the gyttja would be from plants from regional sources.

The pollen assemblages from the peat are dominated by, for example, alder, grasses and ferns where the grass pollen was probably dominated by the common reed. The

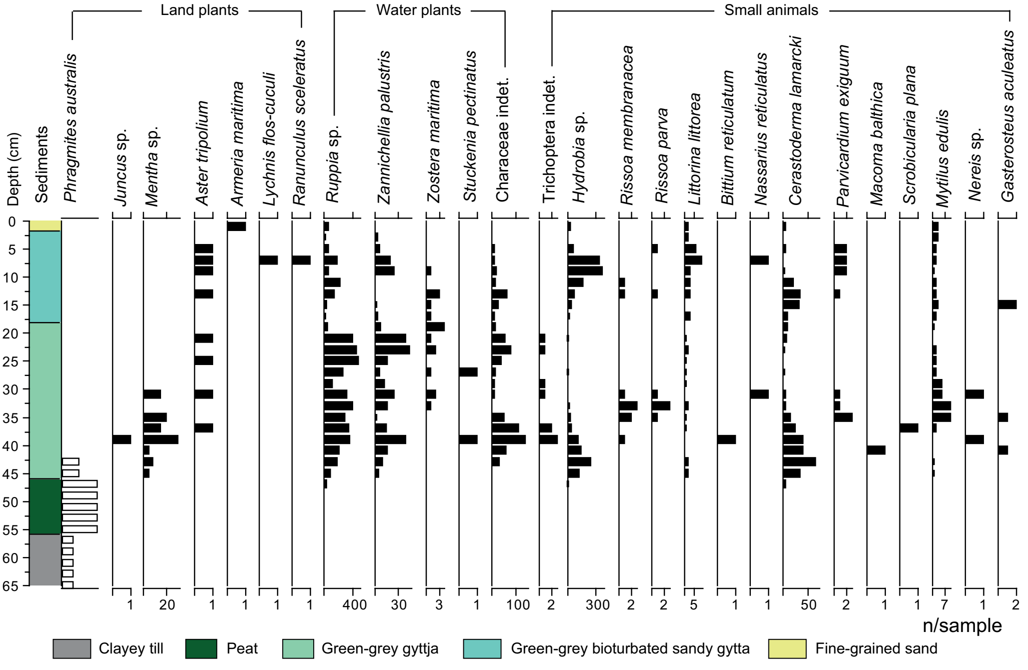

Figure 5. Macrofossil concentration diagram for MLF01515-P7 (=MLF00906-I, P197), from the so-called Structure A (see Sørensen this volume). The diagram covers an interval from 175 to 235 cm below mean sea level, corresponding to an age of 300 to 5300 BCE. The species diversity of molluscs is higher than at other sites, the fauna includes several species that indicate a fairly high salinity.

assemblages from the gyttja were dominated by pollen from deciduous trees such as alder, oak, hazel and lime. A distinct elm decline is seen in several pollen diagrams from Syltholm and the appearance of pollen grains of ribwort plantain (*Plantago lanceolata*) at *c.* 4000 BCE indicates the presence of grazing animals and therefore animal husbandry. Finds of a few pollen grains of cereal plants also reflect early Neolithic agriculture.

The gyttja deposits are overlain by sandy deposits, which indicates increasing energy as the sea level rose. The sandy deposits are up to ~2 m thick; they did not contain archaeological finds and were not studied in any detail. However, erosional boundaries between beds show evidence of storm or flooding events, indicating that there were periodic openings in the coastal spits or barrier island. The sand began to cover the gyttja in the deepest areas by *c.* 3000 BCE and reached the areas closer to the 1800s coastline by *c.* 300 CE.

The Late Holocene (2200 BCE to present)

During the Late Holocene, beech (*Fagus sylvatica*) spread and became an important tree in the forests, whereas elm and lime declined. At the same time, the landscape changed due to forest clearance. Temperatures declined and reached a minimum during the Little Ice Age some few hundred years ago. Warmth-demanding species characteristic of the Holocene thermal maximum became locally extinct or rare (Iversen 1973).

The relative sea level continued to rise slowly and reached the modern-day level. The Holocene relative sea-level rise was caused by a global eustatic sea-level rise that surpassed the local glacio-isostatic rebound, which is estimated to 4–5 m during the last 8000 years (Bennike *et al.* 2022).

At Syltholm, the rising sea levels promoted more frequent breaches or overflows of the protective coastal spit but otherwise the local environment was fairly stable with shallow, brackish lagoonal waters with a dense aquatic vegetation. The terrestrial vegetation in general mirrors that of the region with, for example, the increase in beech but, in the local vegetation, it can be seen as a period of more intensive livestock grazing between 1000 and 500 BCE.

Final remarks

The stratigraphic, sea-level and palaeoecological studies carried out in conjunction with the archaeological excavations at Syltholm have given us a detailed picture of a small area within the known development of Lolland. This detailed picture can be directly related to the cultural activities of the coastal communities of southern Denmark. From the palaeoecological studies, we can see that a variety of food sources were available in the local landscape, which can be directly detected in the ancient DNA found in the birch pitch chewed by a local girl or woman (Jensen *et al.* 2019). We can relate the rising sea level to the stratigraphy and link these to the landscape of areas of ritual significance, and we can see the increasing consequences of storms on fishing communities and their fish weirs. And maybe even the footprints preserved in the sediment show how they tried to protect their livelihoods from a coming storm (Mortensen *et al.* 2015). These examples show how valuable these types of integrated and cross-disciplinary studies are and how a better understanding of the natural environment can be achieved.

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Niche construction

Hard-working settlers and a neglected principle in understanding the early Neolithic of southern Scandinavia

Niels N. Johannsen

Abstract

This paper proposes to view cultural developments during the early Neolithic of southern Scandinavia as a set of niche construction processes. The purpose is to focus further research efforts – empirical, methodological and theoretical – on understanding the processes by which the earliest farmers in the region partly transformed their environment to a new economic and cultural niche – one that was better suited to a Neolithic way of life than that which the first farmers faced. At present, the early part of this sequence is difficult to study empirically, in part due to the limited resolution of both palaeoenvironmental and archaeological information (on a small population) at our disposal. However, by looking at the empirically more evident economic, cultural and probably demographic developments of the mid-fourth millennium BCE, *i.e.* the later part of the sequence, and then applying a 'reverse engineering' logic to discuss prerequisites for this *landnam* phase, we gain some impression of the analytical task before us. This, in turn, may be useful for focusing research efforts within a framework that takes niche construction processes as a central analytical starting point.

Niche construction theory; agriculture; landnam; long-term change

Introduction

The Neolithic of southern Scandinavia is, archaeologically, one of the most extensively researched Neolithic sequences in the world – and yet, there are many gaps in our understanding of how domestic modes of life became established in the region during the decades and centuries following 4000 BCE. While our knowledge constantly develops through the addition of new finds and through the ever-growing possibilities

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and power of new methods, improving our understanding equally depends on developments in our perspective on the analytical challenges we are facing. And one of the most central challenges is this:

Domestic crops and animals, material culture such as polished flint axes and Funnel Beaker (TRB) pottery and longhouses located in places suitable for agriculture all become widely distributed across southern Scandinavia in a period of decades during the century 4000–3900 BCE. In other words, we appear to see the contours of a fully ‘Neolithic’ culture from the very onset of the fourth millennium BCE. Isotope studies have long shown that this new way of life was associated with a very different diet than that of the late Mesolithic foragers, *i.e.* a shift from a highly marine to a predominantly terrestrial diet (Tauber 1981, and many subsequent studies), and recent genomic studies have confirmed that migrants from Neolithic cultures south of the region played a main role in introducing domestic economy and culture (Allentoft *et al.* 2022). On the other hand, there were also continuities in parts of the material culture (Fischer 2002; Wadskjær 2018; although see Högberg and Berggren 2023), and the coastal kitchen middens – the core sites of the late Ertebølle forager groups – were still used extensively during the Early Neolithic I, *i.e.* until *c.* 3500 BCE (Andersen 2008). Moreover, there is little overall impact of agricultural activities on the general vegetation cover of the early fourth millennium landscape, at least according to what can be detected in the pollen record (Feeser *et al.* 2012; Rasmussen 2005). The situation just described does not change until the middle part of the fourth millennium BCE. Starting gradually after 3700 BCE, but increasing dramatically from around 3500 BCE, human impact on the landscape changed significantly and across a wide spectrum of activities. The pollen records show the clearing of forest for agricultural land and forest management, partly for grazing (Feeser *et al.* 2012; Rasmussen 2005), and settlements increase in number and in some cases size (Artursson *et al.* 2003; Madsen 1990). The construction of monuments on a remarkable scale sets in, starting with non-megalithic long barrows, followed by thousands of megalithic tombs (Andersson *et al.* 2022; Ebbesen 2011; Eriksen and Andersen 2017), and ritual depositions and activities in wetlands, at causewayed enclosures and by the tombs (Andersen 1997; Koch 1998; Madsen 2019; Schülke 2019) escalate to such a level that rituals and ritualization appear to have been as central to the everyday activities as the basic needs for food, shelter and reproduction. Furthermore, despite the difficulties associated with population density estimates for prehistory (cf. Crema 2022), plausible models indicate that the overall population of southern Scandinavia rose significantly during this period (Müller and Diachenko 2019). At the same time, supra-regional connections seem to flourish, as reflected for instance in the import of copper items, the adoption of basic metallurgy and the ritual consumption of copper items (Gebauer *et al.* 2021; Klassen 2001). Finally, the once so central coastal kitchen middens are abandoned, seemingly having lost their economic and cultural relevance.

The challenge referred to above is understanding *why* the early Neolithic sequence plays out as sketched above? Why do we not, archaeologically, see the true impact of the transition from forager to farmer lifeways more clearly until several centuries into the Neolithic? Some scholars have suggested that the Early Neolithic I was a long phase of gradual, cultural adjustment (of indigenous groups) to the idea and practice of domestic production (Andersen 2008), while others have emphasised changes in socioeconomic competition and preferences around the mid-fourth millennium transition to the Early Neolithic II and the megalithic phase of the TRB (Madsen 1982; 1990). Building in part on the latter perspectives, several contributions have suggested that the introduction of the ard and a new agricultural regime, possibly coinciding with minor climate changes, could have been a main driver of economic and cultural transformation in the *landnam* phase (Beck 2013; Johannsen 2006; Kirleis and Fischer 2014; Mischka 2014). While these and many other contributions all point to factors that may have been important, they arguably have in common that they neglect or underestimate the general causal centrality of a fundamental dynamic that, to a large extent, set the boundaries for each and all of these more specific factors. The discussion presented here draws attention to that dynamic and thus argues for a change of perspective – or, to be more precise, for the addition of an analytical principle to existing perspectives, such as those just mentioned. The fundamental purpose and proposition of this short paper is thus to focus research efforts on the earliest Neolithic of southern Scandinavia within a framework that takes niche construction processes as a central analytical starting point.

Early Neolithic activities as niche construction

As indicated above, the earliest groups that practiced farming in southern Scandinavia were (mainly) newly arrived immigrants – newcomers in a landscape that was anything but agricultural. Although the late Mesolithic foragers who already inhabited this region surely manipulated their natural surroundings in a variety of ways (cf. Groß *et al.* 2019), they did so for the purpose of forager activities and preferences – not with an eye to domestic production or other 'Neolithic' ways of inhabiting the landscape. The early Neolithic settlers had to establish the agricultural niche by carving it into the landscape themselves. In biology, such directed altering of the environment by a biological species has become known as 'niche construction'.

Niche construction, as foregrounded in the body of analytical theory of the same name, was developed as part of an effort to understand processes by which organisms, through their activities and choices, modify their own ecological niches as well as those of other individuals and species, thereby changing the living conditions and selective pressures experienced in those niches (Odling-Smee *et al.* 2003). A particularly popular example of niche construction among non-human animals is the construction of dams by beavers, which have a range of different ecological consequences for the beavers themselves as well as other species in the same environment – but in addition to such relatively obvious examples, like the building of burrows, mounds, nests *etc.*, a vast number of biological species (down to bacterial level) carry out one or more forms of activity aimed at promoting certain physical conditions in their environment, not all of which are equally obvious at a human scale of perception. The key principle is the recursive feedback relation between the activities of organisms and the environments they are born into and, so to speak, operate in. Niche construction is in general a cumulative process for niche-constructing species, each subsequent individual experiencing a more or less different starting point than its predecessors (Odling-Smee *et al.* 2003). While the main interest in evolutionary biology is in natural selection pressures, the principle of niche construction, arguably, applies equally well to historical processes in human societies. In terms of the diversity of their niche-altering activities and their combined range and implications, humans are the niche constructors *par excellence* among all biological species. Though perceiving niche construction as central to many cultural processes is not yet commonplace in archaeology, this way of thinking has already seen some interesting applications, for instance in attempts to understand how the initial development of domestic economies and culture in southwest Asia took place (Sterelny and Watkins 2015).

Turning back to our discussion of the early Neolithic in southern Scandinavia, such a perspective may have significant implications for our understanding. Could it be that, underlying many more specific factors, the most central causal factor of all in shaping the cultural development after the arrival of farmers was the pace by which, and the specific way in which, their niche construction efforts progressed? Whatever other factors we can appeal to – be it normative adaptation, technological and broader economic innovation, social preferences, *etc.* – none of them would have been able to negate the constraints presented by an environment that was, until it had been significantly altered, not very ideal for Neolithic ways of life at all. While interaction and collaboration with members of the pre-existing forager population is likely to have been key in providing newcomers with an understanding of local conditions and resources, newly settled farmers could not simply adapt to the new landscape; they (also) had to do what they could, given group and total population sizes as well as the technological means at their disposal, to alter these constraints.

Unfortunately, even if we can assume that establishing a Neolithic way of life in southern Scandinavia required no small amount of hard work, an extensive accumulation of local, area-specific experience and a demanding adaptation of cultural practices to a new reality, studying this initial niche construction process empirically is at present difficult. The first farmers were probably not many, and though we can identify a new type of settlement site in terms of dwelling structures and their location in the landscape (Gron and Sørensen 2018; Madsen 1982), as well as the remains of farming products, *i.e.* grains and domestic animals (Fischer 2002), we are ill-equipped to identify the character and extent of the earliest Neolithic niche construction processes. In addition to the general factor of significant taphonomic loss affecting prehistoric material culture and economic waste products (which affects the archaeological visibility of smaller populations in particular), we face the key problem that the resolution of our traditional, localised landscape proxies, such as pollen spectra, is limited. When occurring on a small scale, modifications of the landscape, such as forest clearance, at best show up as small glimpses in our palaeoenvironmental and archaeological records – glimpses that are difficult to interpret. This, in turn, hinders the integration of such information with other lines of evidence of how these groups inhabited and used the landscape, thus preventing us from arriving at a somewhat realistic understanding of the cultural situation in the earliest Neolithic communities of the region. While it is likely that future methodological developments may provide finer-grained data and improve this situation, detecting and understanding the smaller-scale alterations in the landscape remains difficult at present.

Despite – or perhaps because of – this analytical situation, it is useful to lay out the analytical task before us, and for that our best option at the moment is, arguably, to apply what we might call a reverse engineering logic. By looking at the phase during which the deeper impact of Neolithic economy and culture becomes evident archaeologically, we may in turn consider what the prerequisites for that phase would have been. In a nutshell, we may recapitulate the mid-fourth millennium economic and cultural boom phase, which started gradually around 3700 and escalated drastically around 3500 BCE, as follows[1]:

- Larger parts of the primary forest that had covered most of the landscape was cleared and replaced by more or less permanent clearings or, more widely, secondary, sometimes managed forest.
- The ard or scratch plough was introduced which, together with a change in the crop spectrum, signalled a new agricultural regime.
- Settlements increased significantly in number and, in some cases, size.
- The population of the region probably grew significantly during this phase. Of course, overall population size/density is key to the quantity and thus the archaeological visibility of past activities in general, including all of the above. This correlation may immediately seem to pose an analytical circularity – but it is not necessarily one that is problematic for the argument presented here, since population growth itself is predicated on the necessary niche conditions, which were to a large extent an outcome of the activities and developments listed.
- Supra-regional connections flourished, as reflected for instance in the import of copper and copper metallurgy and in stylistic similarities and imitations across large distances.
- A very labour-intensive construction of monuments, such as long barrows, megalithic tombs and causewayed enclosures was undertaken by the thousands, further clearing and transforming local areas in the process.
- Ritual depositions and activities in wetlands and at the monuments took place on a scale that is probably unmatched *per capita* in any other (pre)historical period in the region.

The list just presented refers to a set of environmental and cultural realities that are a long way from the situation encountered by the first Neolithic settlers who arrived in southern Scandinavia. While this may superficially seem a banal observation, the causal centrality of the 'starting conditions' and the practical constraints they imposed on the earliest Neolithic communities have rarely been acknowledged and formulated clearly in present-day research (see Gron 2020 for a notable exception), just as the recursive, cumulative character of the niche construction dynamic that followed has not been recognised sufficiently in previous research (including the author's own) that attempted to grasp the overall development in this region during the fourth millennium BCE. Though more detailed arguments can be made for each of the parameters listed above, extensive, prior niche construction was a prerequisite for them all. With or without new technologies such as the ard, new forms of social organisation, new ideological preferences, or even minor climate changes, it remains a fact that the remarkable mid-fourth millennium *landnam* transformation could not have happened without a huge human investment in the landscape during the preceding centuries; it required an environment and resources that simply were not available to the first Neolithic

1 Please find references for each of these points above.

Figure 1. Farmer with a team of draught oxen returning to his farmstead after working his field with an ard (scratch plough), which he carries across his shoulder. Titicaca region, Peru, 2002 (photo: N. N. Johannsen). As in ethnographically known contexts like this one, efficient use of this technology during the Neolithic was predicated on foregoing niche construction efforts by the farmer and, not least, preceding members of the settlement/community. In turn, it contributed to accelerating the extent and impact of human niche construction in the landscape by rendering more area-intensive agriculture possible and advantageous.

generations. While the accumulated outcome of niche construction efforts through generations did not determine the particular course of the mid-fourth millennium economic and cultural boom, it made it possible and, apparently, advantageous in the perception of the Neolithic individuals and communities that drove it.

At this point, it is important to emphasise that Neolithic niche construction not only pertained to the needs and strategies associated with subsistence production and improving material living conditions more broadly. Energetically very substantial and culturally important activities, such as the massive investment in the construction of monuments and in ritual depositions, were mainly directed at facilitating and supporting certain ways of thinking and relating to one another, and to ancestors and other transcendental beings, in these communities (Andersen 1997; Andersson *et al.* 2022; Koch 1998; Schülke 2019; Wunderlich 2019). In other words, main parts of the niche construction activities pursued by TRB agricultural communities during the fourth millennium BCE served decidedly cognitive purposes – they were aimed at shaping the cognitive qualities of the cultural niche so that they promoted certain beliefs, norms, social constellations and agendas that prevailed among their members (cf. Johannsen 2010).

The limitations and transformation of Neolithic niche construction

The lifeways of communities practising farming during the first centuries of the fourth millennium BCE in southern Scandinavia were not just a matter of cultural preference and choice. These lifeways were significantly shaped by what the environment allowed or rendered attractive, and that equation – what the environment allowed and rendered attractive – was gradually changed by the choices and hard work of these communities themselves. This 'niche constructivist' perspective is very different from former trends in archaeology to see the environment as simply determining culture, since the agency of Neolithic people themselves contributed crucially to shaping the environments they inhabited. It also differs from progressivist narratives of (European) settlers, who fought hostile environments heroically until they succeeded in establishing the trajectory towards modern societies (based, ultimately, on agriculture), in that while there was a great deal of cultural path-dependency in the process that followed 4000 BCE, there was probably little or no strategic deliberation that aimed beyond what could be imagined for one's grandchildren, or their children[2]. Moreover, the ability of Neolithic niche construction to meet the economic needs and cultural desires of the TRB agricultural communities in a sustainable way was not without limitations. By the end of the fourth millennium BCE, despite all of the efforts to consolidate and continuously improve the niche conditions for TRB culture specifically, this way of life at some point became unsustainable – economically, environmentally or culturally – and Neolithic culture in southern Scandinavia fragmented into several, distinct ways of life, each restricted to certain parts of the region (Johannsen in press). While discussion of the reasons for this collapse lies beyond the limitations of this short paper, what can be said for certain is that, from this point onwards, the character of niche construction took very different directions in different areas of southern Scandinavia, with long-term repercussions for the economic, environmental and cultural histories that ensued in those areas (Johannsen 2017).

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2 My aim here is not to make a very specific point about the cognition of Neolithic individuals and groups in this context. My aim is to contrast the situation in Neolithic southern Scandinavia – and the niche construction perspective – with any teleological notion of grand projects of 'founding civilization', 'nation building' etc., which are sometimes projected retrospectively onto prehistoric societies. While this is not the place for an exhaustive argument on that point, I believe the realities to be that the agendas and strategies of Neolithic people – like those of most people in the present world – were predominantly local and relatively proximal in terms of timescale.

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Estuary and lacustrine fishing with stationary wooden structures in Neolithic Finland

Evidence from waterlogged sites

Satu Koivisto

Abstract

Fish have constituted an essential part of subsistence and diet among prehistoric foragers and the even later farming populations of Fennoscandia. Northern hunter-fisher-gatherers have often adapted their site location strategies to maximise fishing at favourable fishery locations, such as river estuaries, coastal areas and inland lakes. Changes in the settlement patterns of the fourth millennium BCE estuary populations of coastal northern Ostrobothnia, northwest Finland, have been seen as reflecting increased social communality. This also allowed joint initiatives in resource procurement, for instance, mass fishing with stationary wooden structures, which have been found in abundance in waterlogged conditions in the area. Riverbank housepit villages, especially the ones located by the rapids and islands, may be assumed to have been associated with the mass-harvesting and/or processing locations of seasonally and spatially aggregated fish resources. During the early Neolithic, the settlement pattern of the lake populations of southern Finland may be suggested to have been mobile and periodic, and the economy related to seasonally abundant lake resources, freshwater fish (*e.g.* pike and cyprinids) and nutrient-rich plants (water chestnut and hazel) in particular. Wooden stationary structures were frequently used in lake fishing practises and, through time, more permanent habitation at profitable fishing grounds increased. More active and long-term use of lake settlements in the northeast Baltic, starting in the mid-fifth millennium BCE, may be linked to the economic shift towards a more intensive utilisation of freshwater resources, as has been observed at waterlogged lake sites with good preservation of organic materials.

Fennoscandia; hunter-fisher-gatherers; fishing techniques; waterlogged sites

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Introduction

The identification of direct evidence for prehistoric fish consumption in Finland is usually problematic because fish remains at archaeological sites are poorly preserved. The degradation of organic materials within acidic podzol soils, the fragmentation and brittleness of burnt bones, and the excavation and recovery methods used all hinder the taphonomic and taxonomic study of fish remains (*e.g.* Nurminen 2020). In addition, fishing-related artefacts are relatively rare in the archaeological collections (*e.g.* Minkkinen 2000), thus suggesting that they were mainly manufactured from organic materials, such as bone, antler, wood, and various plant and animal fibres and have decomposed over time (Koivisto 2017).

The shore-bound settlement pattern of the Mesolithic and Neolithic populations of boreal Fennoscandia (*c.* 9000–2000 BCE) resulted in the extensive utilisation of various coastal, riverine, and lacustrine landscapes (*e.g.* Bergsvik *et al.* 2021; Ekholm 2016; Mjærum and Mansrud 2020), which also served as suitable fishing grounds. Human occupation was not restricted solely to drylands, and nearby waterways, waterfronts and wetlands constituted an essential part of the living space and were used for various everyday activities, such as transportation, resource procurement, water supply, washing, and discarding of waste, as well as for ritual practices.

Stationary wooden structures associated with fisheries represent the most numerous wetland archaeological site type in Finland (Koivisto 2017). Approximately 100 such sites are currently known from peatlands, shallow waterways and alluvial landscapes, and they are most typically found through drainage operations. Until recently, fishing structures have not aroused much archaeological interest in Finland, and the find spot locations have not been inspected or included in the registers of protected archaeological sites. However, the gradually increasing research has enabled us to enhance our understanding of these previously inadequately explored wetland archaeological resources, which contain a huge potential for various scientific and multidisciplinary investigations (*e.g.* Koivisto 2017; Koivisto *et al.* 2018).

Fishing with stationary structures in the northeast Baltic

A stationary wooden fishing structure refers to a wooden structure associated with passive fishing, which takes advantage of the regular movements of fish in both running and still water (Koivisto 2017). They include fish traps and weirs manufactured of wood that have been set and anchored firmly in favourable fishing locations, such as rivers, estuaries, inlets, coves, fjords, lagoons, and lakes. The term ‘lath screen fishing structure’ refers to a long fence-like construction manufactured from narrowly split pinewood laths, bound together with ties made of birch bark, roots, twigs or tree bast (fig. 1). The lath screen modules were supported by piles and stakes of varying dimensions and installed firmly on the sea floor or lakebed. Typically, the lath screen modules were arranged to form one or several circular or heart-shaped trap nests, on average a few metres across, and guiding fences several tens of metres long, which channelled the fish towards the trapping arrangements. Separate traps, such as basketry traps and nets, were also attached to the openings on the weir walls.

Both archaeological and ethnographic records demonstrate that nearly similar designs were in use for several millennia, as fishing gear was designed to target certain species

Figure 1. Early modern (above) and Neolithic (*c.* 3400 BCE) (below) lath screen fishing structures bear many similarities in design and construction (photos: Eino Nikkilä 1935, Finnish Heritage Agency (KK1739:705) and Satu Koivisto 2012).

in a specific habitat (Koivisto and Nurminen 2015). The majority of the securely dated examples from Finland have yielded prehistoric dates, ranging from the Neolithic to the early Iron Age, between *c.* 4000–100 BCE (Koivisto 2017). A few medieval and early modern datings are also known, falling approximately between the 14th and 19th centuries CE. Based on ethnographic accounts, spawn fishing in lakes with stationary wooden structures that targeted northern pike (*Esox lucius*), European perch (*Perca fluviatilis*), burbot (*Lota lota*), and common roach (*Rutilus rutilus*), provided a profitable and reliable livelihood, alongside other economies, in the historic period. The Neolithic examples further suggest that very similar structure types were utilised in both estuary and lacustrine fishing.

In addition to Finland, pine lath fishing structures represent a relatively common type of wetland archaeological resource in the northeast Baltic (and northwest Russia). Laths of pinewood and bindings made of tree bast, wicker and birch bark were the most typical stationary fishing structure materials in this region (*e.g.* Bērziņš *et al.* 2016; Piezonka *et al.* 2020; Piličiauskas *et al.* 2020; Vankina 1970). The ages of the securely dated structures range from the Mesolithic to the Bronze Age, *c.* 6000–1000 BCE. For example, at the lakeside settlement of Sārnate, western Latvia, several rolled-up lath screen modules have been dated to the settlement phases between *c.* 4000–3000 BCE (Bērziņš 2008; Vankina 1970). The Neolithic fish weirs and trap panels in the Lake Lubāna valley, eastern Latvia, were manufactured from narrow pine laths bound with willow twigs and tree bast (Loze 1988). The fishing gear at the Neolithic and Early Bronze Age coastal sites of Šventoji, western Lithuania, also includes several weirs and panels made from pine laths (*e.g.* Piličiauskas *et al.* 2020). To sum up, pine lath fishing structures in northeast Europe in the Mesolithic, Neolithic and Early Bronze Age are usually found associated with occupation and fishery sites, or they are deposited in nearby waterways.

Partially comparable designs made of other wood species are known worldwide, signifying the huge importance of passive fishing with stationary structures, for instance, the Mesolithic and Neolithic hazel rod, wattle-work and wicker screens of northern Europe (*e.g.* Hansson *et al.* 2018), such as those at Syltholm (Sørensen 2016), and the fish weirs of the Ob-Ugrian Khanty and the Mansi of western Siberia (Sirelius 1906). Many similarities can also be found in the wooden tidal weirs by the Tlingit, Haida and Chinook groups on the Northwest Coast of North America (*e.g.* Moss and Erlandson 1998; Stewart 1977).

Case studies

Estuary fishing on the Bothnian coast in the Neolithic

Major rivers, especially those that drain into the Gulf of Bothnia in the northern Baltic, have been used as routes of communication and exchange between coastal and inland areas for millennia (*e.g.* Mökkönen 2011). The emergence of nutrient-rich wetlands due to a strong isostatic rebound in this area has affected the concentration of resources that were widely utilised by prehistoric and later historic populations. The dynamic landscape was susceptible to flooding, and archaeological organic materials were occasionally preserved at waterlogged sites under thick layers of alluvial sediments and peat (Koivisto 2012). The local topography and environmental circumstances provided advantageous conditions for developing a Neolithic procurement strategy that utilised stationary wooden structures, *c.* 4000–2500 BCE (Butler *et al.* 2019; Koivisto and Nurminen 2015).

The Neolithic settlement complex of Kierikki by the estuary of the Iijoki river (*c.* 4000–2800 BCE) is unique in Fennoscandia in many respects. The estuary of the Iijoki river is one of the largest Stone Age housepit concentrations in northern Europe, and

Figure 2. Wooden materials from the Neolithic fishery of Purkajasuo (photos: Satu Koivisto and Finnish Heritage Agency).

hundreds of housepits in village-like clusters have provided the basis for multiple studies concerning, *e.g.* the settlement pattern, social dynamics, environmental conditions and other characteristics of this area (*e.g.* Butler *et al.* 2019; Koivisto and Nurminen 2015; Mökkönen 2011; Núñez and Okkonen 2005). It has also been suggested that the long multi-room houses at Kierikki indicate increased communality and demonstrate the possibility that the idea of a longhouse was borrowed from the contemporaneous Neolithic cultures in the south (Mökkönen 2011).

The wetland site of Purkajasuo by the Kierikki settlement site complex is topical for the prehistoric fishery studies in this region (fig. 2). The site's well-preserved organic materials suggest the utilisation of both active and passive fishing techniques in a sheltered lagoonal landscape *c.* 3900–2700 BCE: (1) weir fishing with lath screen structures, (2) net fishing, and (3) leister fishing (Koivisto 2012). Based on the palynological and dendrochronological evidence, the wood for manufacturing the weirs was collected from nearby forests during winter for 19 years (Koivisto 2012 and references therein). The shallow lagoon served as a productive fishing ground all year round; filled with brackish water and rich in aquatic vegetation, it was an ideal spawning arena for several local and migratory fish species. Furthermore, in a low-lying estuary habitat, the spring and early summer flooding seasons may already have been utilised in the Neolithic estuarine fishing techniques.

Changes in fishing techniques may reflect shifts in the abundance of certain fish species, and people may have created a well-designed strategy to extend the use of seasonally abundant resources, including adequate harvesting and storage adaptations

(Koivisto 2017). The prime resource for the coastal population equipped with the necessary mass harvesting technologies was presumably migratory fish, such as Atlantic salmon (*Salmo salar*) and whitefish (*Coregonus lavaretus*) (Butler *et al.* 2019; Koivisto 2017). The productive fishing grounds were probably the prime motive for the initiation of settlement in the estuary habitat, *c.* 5000 BCE, and later (by *c.* 3500 BCE) the settlement approached semi- or full sedentism. Collaborative labour and organisation were needed to collect all the wood and to construct and maintain the fishing facilities, and to conduct fishing with all its procedures. However, the economic importance of other estuary resources, *e.g.* seals, land mammals and waterfowl, cannot be excluded. Climatic conditions were especially advantageous for the application of highly advanced fishing strategies during this period (*e.g.* Koivisto 2017).

Neolithic lake fishing in the hinterlands

Small, shallow lakes near the coastal zone constituted important environments and provided a broad spectrum of resources all year round. Archaeological data suggests that spawn fishing in shallow lakes was a productive and significant form of subsistence among the Neolithic hunter-fisher-gatherers in southern and southwest Finland (*e.g.* Koivisto 2021; Siiriäinen 2004). The microclimatic conditions were attractive to human habitation and allowed the procurement of various freshwater fish (*e.g.* pike, cyprinids) and nutrient-rich plants, for example, hazel (*Corylus avellana*) and water chestnuts (*Trapa natans*) (*e.g.* Vanhanen and Pesonen 2016). The environmental and climatic factors also produced a vegetation composition that attracted land mammals and waterfowl, among many other species. It has been suggested that lake sites were used as long-term periodic procurement camps for the seasonal utilisation of nearby resources (*e.g.* Koivisto 2021). Annual lake level fluctuations, transgressions and regressions have resulted in formation processes that have occasionally affected the sedimentation and preservation of organic materials. Many smaller lakes have turned eutrophic and been paludified.

The lake settlement of Järvensuo 1 in Humppila, southwest Finland, is an excellent example of such a site (fig. 3). It was a chance discovery via drainage operations in the 1950s when a well-preserved wooden paddle was revealed in one of the drainage ditches. The artefact yielded a Late Neolithic dating, and more artefacts, including a wooden scoop with a bear-head handle, fishing implements, and pottery, were later found in the same ditch (Koivisto 2021). The site is located at the foot of a moraine hill that rises in the middle of a large peatland plateau, where archaeological horizons resulting from human occupation and resource procurement (*c.* 6000–2000 BCE) lie within peat and gyttja. The water-level fluctuation and sedimentation have resulted in formation processes that have aided the extraordinary preservation of organic archaeological remains.

Recent excavations at the site in 2020 and 2021 yielded rich evidence of sedimentation, environmental conditions and anthropogenic activities from the Late Mesolithic and Neolithic. The high number of fishing-related artefacts suggest economic activities, yet with a possible ritual element related to the use of the lakeshore (Koivisto and Lahelma 2021). The majority of the archaeological assemblage comprises organic materials including, for instance, wooden tools, utensils and figurines (*e.g.* the life-sized wooden snake figurine), piles, net floats and sinker stones, and fragments of lath screen fishing structures, along with pottery, lithics and bone. Most of the bark artefacts represent pine and birch bark fishnet

Figure 3. Organic artefacts from the Neolithic lake settlement of Järvensuo 1 (photos: Satu Koivisto).

floats, and small sinker stones with birch bark sheeting and plant cordage, along with tiny fragments of fishnets, have also been preserved (Koivisto *et al.* in prep.). The remaining (fragmentary) wood materials include pieces of pine laths representing fragmentary parts of lath screen fishing structures, which were set on the waterfront during periods of lower lake levels, especially during the Late and Final Neolithic settlement phases of the site (*c.* 2500–2000 BCE). No binding materials from the lath screens have been preserved, but a number of vertical and oblique piles in their vicinity may have supported the lath screen modules. Interestingly, fishnets may have been attached to the lath screen structures.

In addition to the material culture record, there are certain similarities in the settings and long-term use of the northeast Baltic lake sites, which were located by the shores of shallow, smaller lakes with fluctuating water levels, which could be associated with particular economic and cultural traditions. Their utilisation has been identified as beginning in the Late Mesolithic, flourishing especially in the Mid and Late Neolithic and continuing into the Early Metal Age and Bronze Age (*e.g.* Koivisto 2021 and references therein). Many eastern Baltic sites have also yielded evidence of pile dwellings, and their construction was more active during periods of lower lake levels. The more active and long-term use of similar lake habitats may be linked to the economic shift towards a more intensive utilisation of freshwater resources, which began to increase in the mid-5th millennium BCE, as is also supported by the organic residue studies of Neolithic pottery in the region (*e.g.* Mökkönen and Nordqvist 2019).

Conclusions

Today, studies focusing on stationary wooden fishing structures published in the Baltic Sea region are increasing (*e.g.* Bērziņš *et al.* 2016; Piezonka *et al.* 2022; see also Jørgensen *et al.* 2022). Ethnographic materials have been found useful when exploring the functions, designs, and characteristics of the fishing structures, and have allowed us to project the technologies back into prehistory and evaluate their significance. A balanced subsistence strategy based on fishing was dependent on several ecological, physical, and biological factors. These were governed by climatic and environmental circumstances, such as the abundance of certain species in a given habitat, procurement seasonality, preservation technology, and storage adaptations. Environmental changes may have affected the subsistence subsystems, which may be mirrored in the archaeological record – for example in fishing techniques. Here, the well-preserved organic materials preserved in the boreal wetlands provide us with rare opportunities to explore the development and changes in subsistence strategies. In addition, fishing techniques are topical from an ecological viewpoint, as changes in fishing patterns may be assumed to be closely related to changes in fish abundance and affected the livelihoods of the shore-bound Stone Age populations of the Baltic Sea region.

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How to build a Neolithic?

Perspectives on megalith building practices and landscape perception during the Funnel Beaker period in northern Germany

Maria Wunderlich

Abstract

With the transition to the Neolithic period around 4100 BCE, a new form of cooperative action – the construction of monumental megalithic tombs – appears in northern central Europe, as well as southern Scandinavia. This practice had a great influence on the social organization and the expression of identities of communities of that time, as well as on the perception and use of landscape.

A deeper look into the intensity and form of the construction of megalithic burial sites within a small region in modern-day northern Germany leaves us with an impression of the diversity that was connected to the overarching idea of megalith building. The paper will examine perspectives on the intra and inter-community significance of the socio-economic act of constructing landscapes. Focus will be on the megalithic construction activities themselves and the chronological developments of megalithic burial grounds with reference to the Funnel Beaker period in northern Germany, focusing on the time between 4100 and 3200 BCE. This includes a consideration of the embeddedness of megaliths in specific systems of landscape division and use, as well as the diverse economic abilities and choices of existing communities.

Neolithisation; megalithic monuments; cooperation

Introduction

Compared to large parts of central Europe, the Neolithisation in the areas that are now attributed to the Funnel Beaker Complex (hereafter: TRB) took place in an area where these processes of change were late in starting (*e.g.* Terberger *et al.* 2018). Many of the components that make up the Early Neolithic, but especially the Middle Neolithic, are

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known chronologically earlier within the same area, or in adjacent areas of western and central Europe. These include pottery already known in Ertebølle contexts, the (disputed) hints at domesticated pigs (Krause-Kyora *et al.* 2013; Rowley-Conwy and Zeder 2014) or different forms of monumentality (such as Mesolithic shell middens, or else megalithic monuments in other Neolithic contexts; cf. Schulz Paulsson 2017; Sørensen 2014; Wunderlich *et al.* 2019). Early copper finds in northern central Europe attest to pre-existing exchange relations being already present in the early phases of the Neolithic in these areas (cf. Klassen 2000).

There is no question that Neolithisation was a protracted and multifaceted, but also very profound, process that changed the way of life of the affected communities, sometimes fundamentally. Thus, in order to gain a better understanding of the internal dynamics of this process, it seems worthwhile to use bottom-up approaches to look at specifics within the communities that participated in this process. In the case of Early to Middle Neolithic Funnel Beaker societies, for example, these are megalithic building traditions, which not only occupy a special place within the history of research (cf. Midgley 2008), but have also constituted an important part of social life. Consequently, in the following, social implications of megalithic building traditions, as well as their significance within the Neolithisation process, will be considered in more detail.

Megaliths in Funnel Beaker contexts

Within the study area, which comprises parts of eastern Holsatia, Stormarn and northwestern Mecklenburg in present-day northern Germany (cf. fig. 3), the Neolithic begins with the onset of the Early Neolithic (EN) around 4100 BCE. TRB phases can thereby be summarized with the Early Neolithic from 4100–3200 BCE, as well as with the Middle Neolithic (MN) from 3200–2800 BCE (Müller 2019, 38). Within the study area, the first monumental burials appear around 3900 BCE with the (non-)megalithic long barrows, which are then quite rapidly replaced by megalithic burials (dolmens and passage graves) from *c.* 3600 BCE (cf. Hage 2016). The presumably earliest grave types, the (non-)megalithic long barrows, do not have a megalithic grave chamber, yet a stone frame built of boulders might well be present (cf. fig. 1A). The construction of the megalithic tombs ends around *c.* 3200 BCE, but the monuments continued to be used for later burials until the Bronze Age, which makes the study of the burial chambers much more difficult due to the processes of disturbance and clearance (cf. Blank *et al.* 2020, 89; Schuldt 1972).

The internal chronology of the megalithic monuments is not easy to determine, due to dating difficulties, but a rough sequence as outlined above can be supplemented by the earlier construction of the different dolmen types, which are then complemented by the construction of passage graves at the beginning of MN I (cf. Furholt and Mischka 2019; Mischka 2014; Persson and Sjögren 1995). The dolmen types can be distinguished within the study area into small dolmens and extended dolmens or polygonal dolmens (fig. 1; cf. Hoika 1990). However, although regional specifics and differences have to be taken into account, they do not change the very rough chronological sequence of the types of megalithic tombs.

A weighty distinction, however, is that of burial rite or type of use. The inaccessible burial chambers of (non-)megalithic long barrows and also small dolmens indicate a use for single burials. Larger dolmen types partially start to show permanent access or

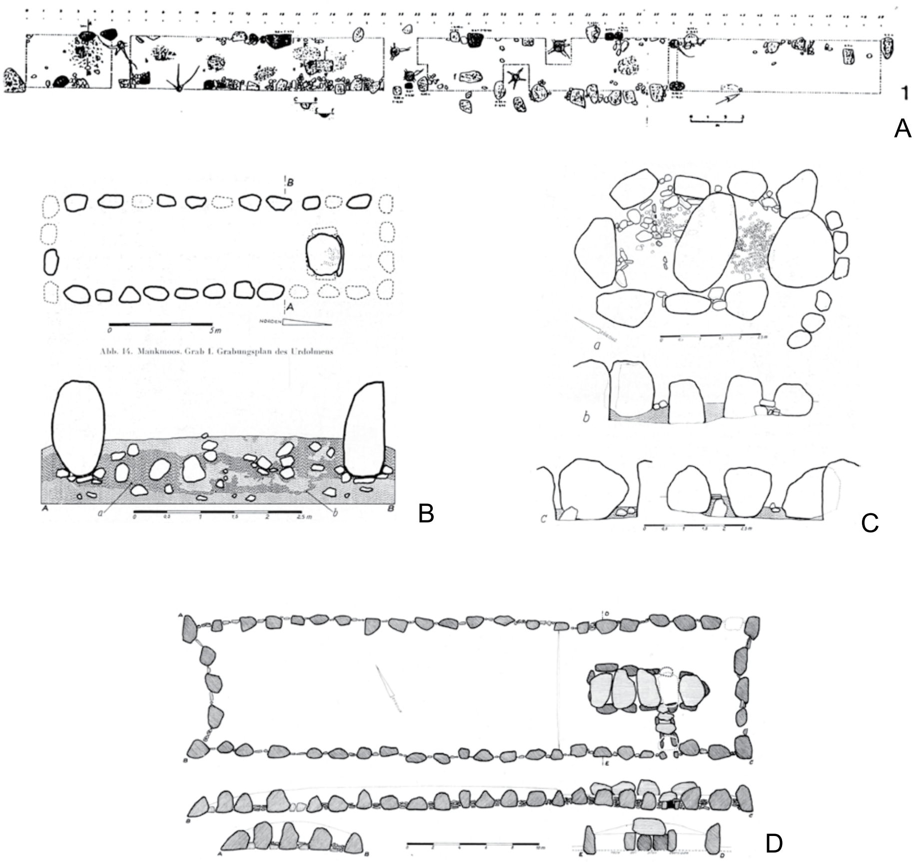

Figure 1. A selection of the most important dolmen types within the study area: A) Non-megalithic long-barrow (Schirren 1997, 121); B) Small dolmen ("Urdolmen") (Schuldt 1969, 24); C) Extended dolmen (Schuldt 1969, 27); and D) Passage grave (Schuldt 1970c, 62).

pseudo passages and were probably also used for multiple burials (*e.g.* Schuldt 1970a). In the case of passage graves, there was always permanent access and their use for collective burials is undisputed (*e.g.* Ahlström 2009). These burial complexes also frequently exhibit extensive activity and depositional practices outside the burial chamber, suggesting repeated visitation and also a use for ritual purposes beyond the burials themselves (*e.g.* Kjærum 1969; Larsson 2019; Madsen 2019; Wunderlich 2014).

Despite the often very poor state of preservation of the gravesites due to intensive agricultural activities but also to the use of erratic blocks as building material in historical periods (cf. Hinz 2014, 192; Schirren 1997, 147–149), there are some sites that allow statements about the location of the graves. For example, two exceptionally well-preserved grave clusters are preserved in the Eberswalder forest in Mecklenburg-Vorpommern (Schuldt 1969; 1970b; 1970c; but for more examples of such clusters, see Gebauer 2014). Based on the represented grave types, a temporal depth can be reconstructed for both clusters, consisting of ten and five grave complexes, respectively, probably encompassing the EN II and MN I stages. Both grave clusters were repeatedly

Phase	Working step	Assumption	Formula
Preparation	1. Clearing	Cutting down trees 10–20 cm: 0,8 h; 1 tree/m²	*A x 0,8 = person-hours*
Preparation	2. Digging pits for orthostats	V pit = V stone: 4	*V: 0,5 = person-hours*
Preparation	3. Earth transport	45 kg (0,35 m³)/h; 100 m distance	*V: 0,35 = person-hours*
Raw material sourcing	4. Quarrying stones	Max. 180–330 kg/h	*Weight:330 = person-hours*
Transport stones	5. Smaller stones	0.028 m³/h; 1 km distance	*V: 0,028 = person-hours*
Transport stones	6. Megaliths	1t =132 p-h; 1 km distance	*Weight x 132 = person-hours*
Erection stones	7. Megaliths	1t = 65 person-hours	*Weight x 65 = person-hours*
Dry-stone walling	8. Dry-stone walling	0,38 m³/h	*V: 0,38 = person-hours*
Construction barrow	9. Construction barrow	Earth transport: 222,04 kg/h	*V = ⅔ x π x r² (- V chamber)*

Table 1. The working steps considered in megalithic construction; values taken from: Renfrew 1979 (step 8); Erasmus 1977 (step 2–5); Heyerdahl 1957 (step 7); Atkinson 1956 (step 6).

visited and thus represent central burial sites that were repeatedly referenced, probably for centuries. In this context, the size of the burial sites and the grave complexes suggests that several settlement communities came together here and collectively constructed and used the graves (cf. Wunderlich 2019, 308–310).

Work-expenditure calculations for the building of megalithic monuments

The case study described above opens up a question that is central to the specific use and implication of megalithic monuments: how much effort did the construction of megalithic tombs involve, and how can we think of it in concrete terms? One way to approach this question is through labor calculations. Here, it can and should be critically observed that work-expenditure calculations show purely artificial results, since the actual work processes and many of the relevant parameters cannot be reconstructed archaeologically. Thus, work-expenditure calculations represent simplifications and reduce the, in all likelihood, socially highly complex process of erecting megalithic monuments in a very static and reduced way (cf. Nikulka 2016, 144; Rosenstock *et al.* 2019; Xie *et al.* 2015). For example, ethnographic examples clearly show that the effort expended to erect the monuments was by no means characterized by efficiency, but that this process was sometimes intentionally prolonged and more elaborate than strictly necessary (cf. Wunderlich 2019, 167). This is primarily related to the social significance of collective ventures and collective actions, which often serve to bring social groups together and negotiate social prestige and influence (cf. DeMarrais and Earle 2017). Despite these pitfalls, work-expenditure calculations are an important aid in assessing the extent to which collective efforts on the part of different village communities were necessary or helpful. Moreover, the calculations are comparable and applicable to different data sets, even if the results are only artificial approximations. Lastly, work-expenditure calculations appear helpful when considering how much work was put into creating or altering landscapes in the wake of the EN and MN. Taking into account the available pollen analyses, a dense forest cover must be assumed during both the EN and MN, although clearing and intensified landscape use is recorded around megalithic sites

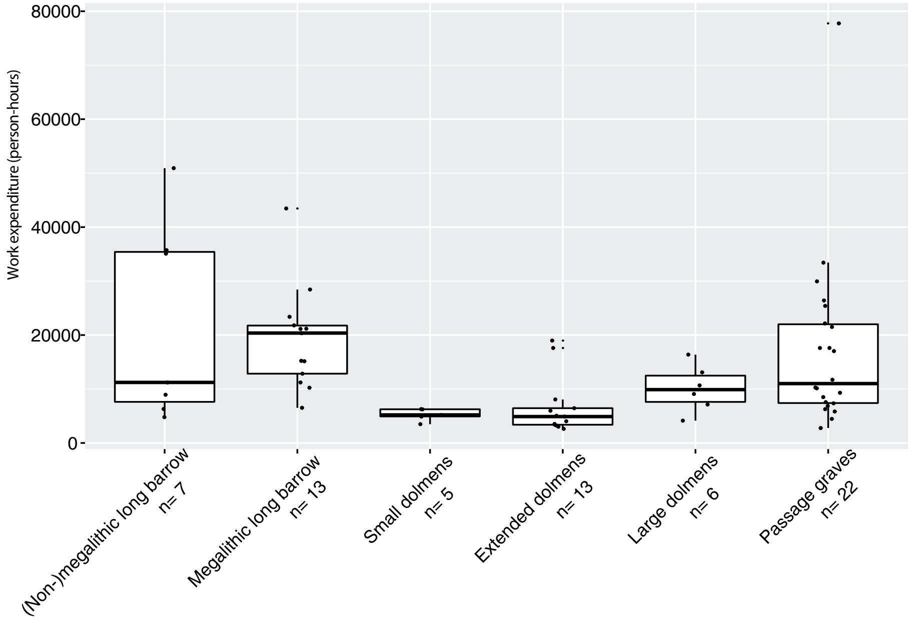

Figure 2. Result of the work-expenditure calculations for megalithic graves in the study area presented as a boxplot diagram.

(Diers and Fritsch 2019, 719). The moving of the boulders was certainly influenced by this vegetation and will have potentially increased the workload.

The work steps, parameters, and calculation bases summarized below provide a brief background for the following results of the calculations. Restrictively, however, it must be emphasized here that ultimately only a small portion of the grave sites are ever suitable for the calculations, and thus only a section of the obtained data set can be visualized.

A creation of social landscapes and memories

Despite the limitations, the results of the work-expenditure calculations are of great interest to the question of whether and to what extent the perception of landscapes and the need to shape and transform the same changed as the Neolithic progressed. Within the data set, a very profound change in the landscape can be evidenced with the earliest construction phase of the monuments (fig. 2).

Thus, the (non-)megalithic long barrows already show up to 50,000 person-hours. Considering the very small settlements, which still comprised no more than a few houses in the MN (cf. Brozio 2016), collective efforts can be assumed here. During the following phases, however, the intensity of construction activities decreases and reaches its low point with the construction of the relatively small dolmen types and extended dolmens. Another clear upswing, on the other hand, can be grasped with the onset of the MN and the construction of the passage graves, which in turn equal or exceed the effort in the construction of the early (non-)megalithic long barrows. Within the study area, clear spatial foci can also be recorded (fig. 3), which correspond to the overall distribution of burials within the study area.

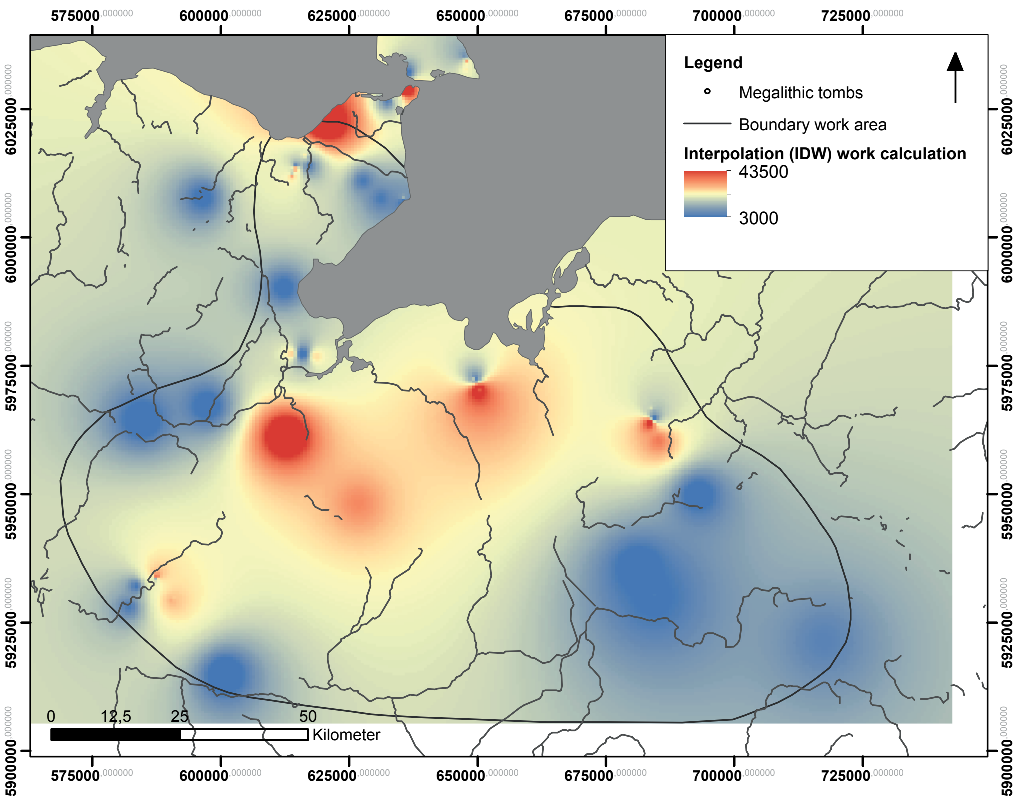

Figure 3. Result of the work-expenditure calculations for megalithic graves in the study area in the form of an IDW interpolation.

Especially near the coast and in the vicinity of densely populated areas (*e.g.* near the Oldenburger Graben), particularly intensive construction activities can be observed. Here, it can be assumed that many village communities worked together intensively to build burial grounds and frequented and extended them over a long period of time. In addition to regional variations, different regional or even local strategies can be identified as to how the local collectives designed the creation of monumental landscapes. This is, for example, the case in the above-mentioned Everstorfer forest. While one grave cluster consists of many, but rather small grave monuments, the second cluster encompasses only a few, but very large grave monuments. It can be assumed that the two groups building and using these burial grounds, which neighbored each other at a distance of *c.* two km, chose different strategies to design and maintain their respective burial grounds. Megalithic construction can thus be described as a shared concept, which individually, however, found a very different translation and expressed itself in different construction strategies.

Considering the small settlement sizes mentioned above and the sometimes very great effort of grave construction, it can be assumed that communal networks and imagination were of high importance and were expressed in shared megalithic building traditions (fig. 4).

In summary, construction activities during the time of the TRB appear to indicate extensive changes and structuring of the existing landscapes that can be linked to the

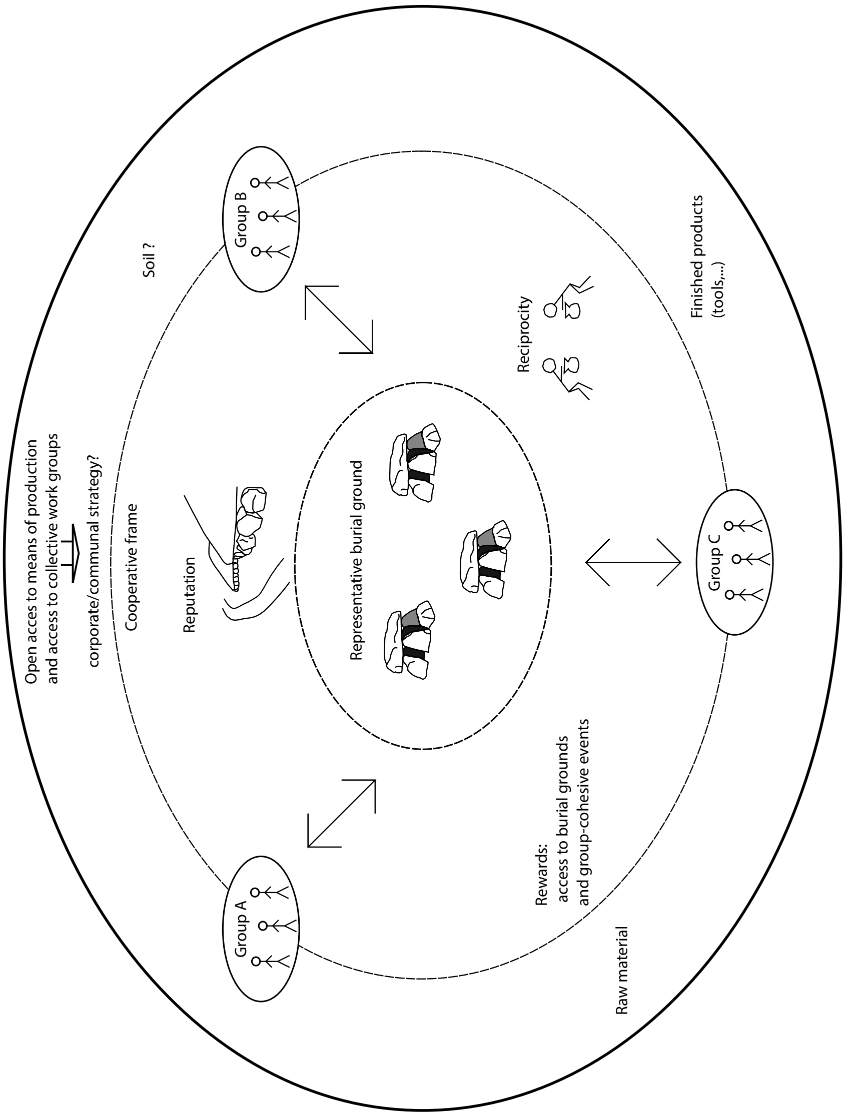

Figure 4. Model of the social implications of megalith construction activities in Funnel Beaker contexts.

importance of communal identity. Here, it is necessary to mention the importance of differentiation towards others, which is highly significant in the creation and maintenance of collective identity. In the context of the need for social networks and social security that accompanied sedentarization and, increasingly, intensive agriculture, the extensive shaping of the landscape through the building of megalithic monuments certainly played an important role. These can be seen as places of gathering, as well as being an important element of collective memory, which certainly played an important role in the course of the Neolithic and required permanent places within the changed landscape.

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Tombs and Settlements, Bog and Sea

The influence of landscape change on Neolithic life in the Ahlen-Falkenberger Moor, Germany

Moritz Mennenga, Anja Behrens, Martina Karle and Steffen Wolters

Abstract

Since 2019, a drowned prehistoric landscape has been investigated in the Ahlen-Falkenberger Moor in the Elbe-Weser-Triangle in northwest Germany. In recent decades, megalithic tombs have repeatedly emerged from the bog due to peat extraction, shifting the focus of archaeological research from the Pleistocene sandy soils to the bog. Drilling allowed a reconstruction of the Neolithic palaeorelief as palaeobotanical, geoarchaeological and geophysical measurement investigations have traced the bog expansion and shoreline changes. With archaeological prospections, potential settlement remains of the Mesolithic, Neolithic and Iron Age could be located, and the investigation of bog-covered tombs revealed the favourable preservation conditions under the bog. The detailed investigations not only yielded new archaeological and landscape findings, but also provided information on the human-land relation. The first results will be presented using the examples of the sites of Wanna 1603 and 1592.

Megaliths; wetland archaeology; settlement archaeology; microregion

Introduction

Bogs are a special source in archaeological research. In the history of research, impressive prehistoric finds have repeatedly been made, due to the excellent preservation conditions in the waterlogged environment, including, above all, bog bodies, depositions and trackways. For several decades, not only archaeology but also the reconstruction of the palaeolandscape has been the focus of investigation – including human influence

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and its impact on the changing environment: the human-land relation (see Geary and Chapman 2004, 199; van Beek 2015).

Peatlands are widespread in northern Europe (Tannenberger *et al.* 2017) and are being (landscape) archaeologically investigated, with a spatial focus in the Netherlands (*e.g.* van Beek 2015; van Beek *et al.* 2015), Great Britain (*e.g.* Chapman and Gearey 2013; van de Noort 2004) and Ireland (see Cooney 2000). An interdisciplinary approach that combines archaeological and natural scientific data is necessary to reconstruct the spread of the bog and the societal response and still remains a desideratum, as mostly the focus of the research is very much on either the landscape or the archaeology (Plunkett and McDermott 2007; van Beek 2015).

The challenges of these investigations are: (1) In many regions, the peatlands have been destroyed by exploitation and cultivation since the Middle Ages. In the Netherlands, peat areas have been reduced by 90% (van Beek 2015, 2) and in Great Britain by 64% (Gearey and Chapman 2004, 199). Consequently, this also means that finds and features located in the bog have been destroyed. The sites under the bog are not more likely to be better preserved because in such cases they now have the same preservation conditions as classical mineral soil sites (see also Groenendijk 2003). (2) The sites are still covered by bog or alluvial sediments and cannot be identified (Chapman and Gearey 2013, 151; van de Noort 2004, 61). In many cases, this can also be assumed for sites that were not initially constructed in the bog, but were overgrown later on (*e.g.* Fokkens 1998). Even though the bogs are now protected in many cases, the archaeological heritage is still at risk due to ongoing environmental change. Degeneration of the peat body due to falling groundwater levels in wetlands are destroying their anaerobic conservation conditions (*e.g.* Heumüller *et al.* 2017). Nevertheless, the archaeological potential of these sites under the bog is still very high, as seen in the rare systematic prospections *e.g.* at Rönneholms Mosse, Sweden or Céide Fields, Ireland (Cooney 2000, 26; Larsson and Sjöström 2011). In addition, the great potential of interdisciplinary research on bogs is beyond question.

Previous studies on the human-land relation often face the difficulty that either peatland growth can only be roughly modelled or that only few archaeological sources are available (*e.g.* Chapman and Gearey 2013; Fokkens 1998; Groenendijk 2003; van Beek *et al.* 2015; van Beek 2015). In the working area, extensive previous work can be used, especially with regard to bog stratigraphy and vegetation history (Behre 2005; Behre and Kučan 1994; Kramer and Bittmann 2015; Petzelberger *et al.* 1999), but new investigations have also been carried out within the framework of the project to complement the data.

The Ahlen Falkenberger Moor – regional setting and research history

The Ahlen-Falkenberger Moor (AFM) offers an excellent basis for studying the human-land relation, since the conservation conditions are still very good – especially since peat cutting began very late here and the degree of destruction was relatively low (see also Ahrendt 2012; Schneekloth 1983). Some of the sites were only exposed for a few hundred years before they were covered by bog. In the past decades, capstones from megalithic tombs of the Funnel Beaker Culture (TRB) repeatedly emerged from the bog (Behre 2005). Since 2019, the Lower Saxony Institute for Historical Coastal Research in Wilhelmshaven (NIhK) has conducted intensive research on the Neolithic settlement history in the area of today's AFM as part of the project "Preserved in the bog – relics of prehistoric settlement landscapes in the Elbe-Weser triangle". The aim of this "Pro*Niedersachsen" / "Niedersachsen Vorab" project, funded by the Ministry of Science and Culture of Lower Saxony, is to investigate cultural remains as well as the entire natural and cultural landscape under the bog using archaeological, geological and botanical methods. New sites are classified functionally, culturally and chronologically, and the relationship between landscape change and land use strategies are described. Environmental conditions changed due to extensive bog growth and the Holocene sea level rise, which temporarily led to the expansion of marine environments into deeper lying valleys. This inevitably leads to the question of how significantly and fast the landscape changed while people were settling or burying their dead here – and to what degree the natural changes had an influence on societies in this former coastal area.

Peat formation in the Elbe-Weser triangle commenced in the Mesolithic with the formation of fens along river floodplains and at the edges of lakes. With the increasing oceanic influence about 8000 years ago, the extensive growth of raised bogs began (Behre 2002; Gerdes *et al.* 2003; Streif 2004). From an archaeological point of view, the large area of the AFM, including the Pleistocene sandy (Geest) islands of Wanna in the north and Flögeln in the south, is particularly interesting (fig. 1). Systematic prospection has taken place in the Wanna area, and thus a large number of sites are known (Nösler *et al.* 2011). The region around Flögeln has been in the focus of archaeological as well as natural scientific research for decades. The site of Flögeln 46 is well known for its large-scale excavated Iron Age settlement (Dübner 2016). During this research in the 1970s and 1980s, it was possible to document Funnel Beaker period buildings and flat graves, too (Mennenga 2017; 2019; Zimmermann 1979; 2000). Further, a large number of palaeoecological studies were also carried out, which provided insights into landscape development, especially from a botanical perspective (Behre and Kučan 1994; Kramer *et al.* 2012). However, all investigations were carried out from the perspective of the settlements on the Geest, excluding the raised bog area on the northern side of Lake Dahlem and Lake Flögeln.

The first archaeological investigations in the AFM were conducted in the 1970s on bog-covered megaliths (Behrens *et al.* 2022). Since then, isolated tombs have repeatedly become visible in the bog (fig. 2) (Behre 2005, 215). When further megalithic tombs emerged in the 2010s due to peat shrinkage, more focus was laid on this area. It became apparent that the potential for good conservation preservation was great and that it was also possible to study the very dynamic landscape changes associated with sea level rise (in general: Behre 2003; Vink 2007) and peatland expansion (for the AFM: Behre 1976; Gerdes *et al.* 2003; Kramer *et al.* 2012; Nösler *et al.* 2011; Petzelberger *et al.* 1999; Schneekloth 1970). Despite the large number of previous investigations, the available data, in particular the radiocarbon data on raised bog initiation, were not sufficient to enable a refined chronological evaluation. The same applies to the effects of the late Holocene sea-level rise in this area: the general trend is known as well as the fact that the AFM had been temporarily affected by an incursion of the sea before bog growth resumed. However, the radiocarbon dates provided by Schneekloth (1970) are not in agreement with today's knowledge about sea-level rises (Behre 2003; Vink *et al.* 2007) and required a new examination.

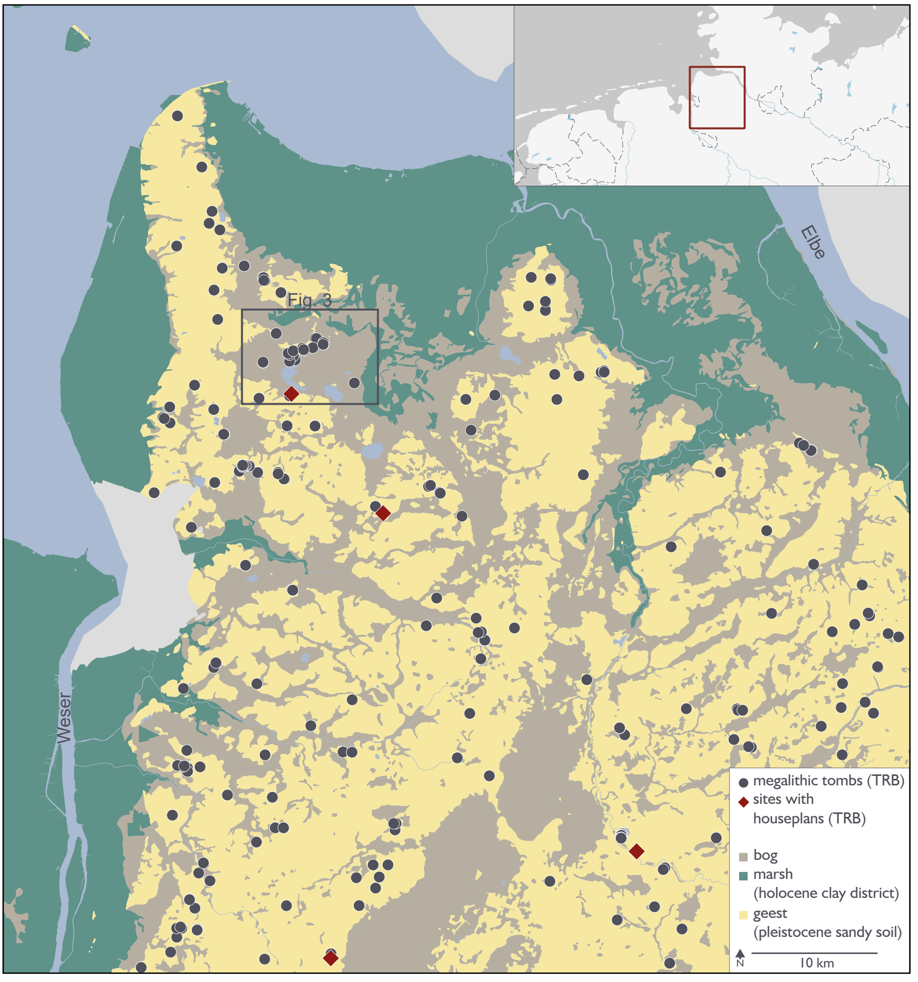

Figure 1. The working area around the AFM in the Elbe-Weser triangle. (map basis: State Office for Mining, Energy and Geology Lower Saxony, Hannover; soil landscapes scale 1: 50,000; mapping of megalithic tombs after data from the Lower Saxony Monument Database ADABweb and Fritsch *et al.* 2010; mapping of settlements after Mennenga 2017, 57).

Methods and first results

In order to address the questions raised, a wide variety of methods were used. About 800 ha were prospected with geomagnetic surveys. In this process, two new sites were discovered. The first, Wanna 1592, is a megalithic tomb that was still almost completely covered. Another site is Wanna 1594, which after investigation is presumed to have been a cult site of the Single Grave Culture (fig. 3). Furthermore, the measurements provided information about landscape elements, such as a former saltmarsh belt with tidal channels.

In order to model the Neolithic land surface underneath the bog, geological archive data was used. In addition, 915 cores were drilled with a 25 mm gauge auger in an area of about 1500 ha. In the course of the prospection, a potential settlement site of the TRB was found and investigated (Wanna 1603). Peat stratigraphy studies were carried out on some

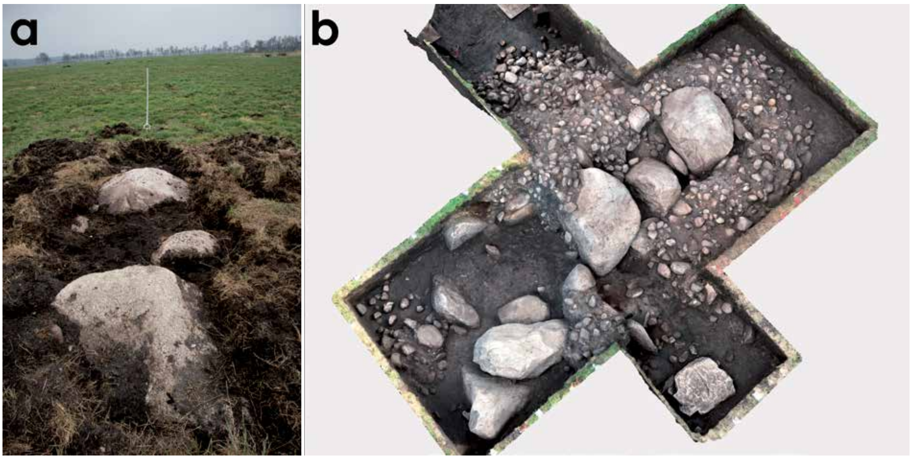

Figure 2. Preservation condition of the megalithic tomb, Wanna 1592, a) during the first documentation and b) model of the tomb during the excavation.

of the profiles and on material from additional boreholes in order to date the start and the pace of the bog expansion. By using radiocarbon dating, the coastal development in relation to sea-level change could locally be more precisely delimited and correlated with the archaeological phases of use.

The detailed presentation of methods and data, the modelling of the palaeolandscape as well as the archaeological data is currently in preparation. In the following, only a short summary of two excavated sites (Wanna 1592 (megalith) and 1603 (potential settlement)) is provided.

Wanna 1592 is a passage grave built around 3300 BCE on a small spit of land surrounded by bog and wetland, which was already enclosed on three sides between 4000 and 3500 BCE. At the time of building, the waterlogged wetlands were about 50–150 m away and at around 2900 BCE they reached the foot of the tomb. Subsequently, the accumulating peat started to overgrow the site. The last datable archaeological evidence of the TRB can be dated to Brindley horizon 5 (Brindley 1986) and thus the period between *c.* 3200 and 3000 BCE (see Mennenga 2017, 94). From comparisons with other megalithic tombs, it can be supposed that use continued until the end of the TRB, around 2750 BCE (Furholt and Mischka 2019). A last verifiable phase of activity is attested by the impact of the Single Grave Culture around 2500 BCE. By 2000 BCE at the latest, the tomb was being increasingly enclosed by the bog until it was completely covered in the following millennium.

Wanna 1603 was also discovered and prospected in the course of the project. The documented cultural layer and the recovered finds show that this was an activity zone, which is today covered by almost two meters of peat. It was possible to determine the extent of the cultural layer by coring (cf. fig. 4). The find material of the first excavations included charred grain residues, pottery, flint tools and the remains of production activities, the semi-finished product of an amber bead but only a few stone artefacts, such as a grinding stone. Based on the composition of the find material, it can be assumed that this was an activity

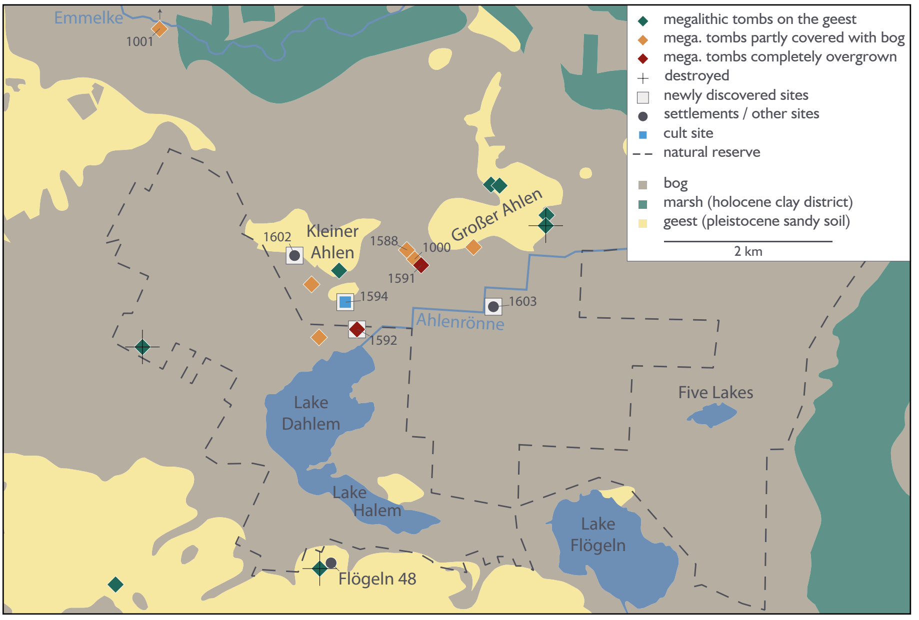

Figure 3. The working area with its known Neolithic sites with preserved features or cultural layers. Other sites containing activity zones with features without clear interpretation (map basis: State Office for Mining, Energy and Geology Lower Saxony, Hannover; soil landscapes scale 1:50,000; mapping of megalithic tombs based on data from the Lower Saxony Monument Database ADABweb and Fritsch *et al.* 2010).

zone related to settlement activities. The site can be dated to the TRB based on deeply engraved pottery (*Tiefstichkeramik*). One sherd can be assigned to the Brindley horizon 3–4 (Brindley 1986) and the radiocarbon dating supports this classification (AWI-8967: 4582 ± 75; 3526–3028 cal BC; AWI-8968: 4518 ± 26; 3357–3102 cal BC). Thus, a settlement cannot be assumed before 3300–3000 BCE (see Mennenga 2017, 94). It is interesting to note that the cultural layer can be traced through boreholes to about the former boundary with the wetlands. At this location, the potential for wetland preservation is particularly high. For an estimation of the preservation, function and occupation period, further investigations are needed.

In this period, the landscape changed considerably in the area surrounding Wanna 1603. In the period from 3400–2800 BCE, the wetland continued to expand until it almost reached the settlement area. The Geest island or peninsula on which the settlement was located was very likely fragmented by bog growth into several smaller islands and thus the area of land use was reduced. The most severe change took place in the small valley of the Ahlenrönne (fig. 3), only a few hundred meters away. Here, between 3400 and 3100 BCE, a marine ingression occurred, as evidenced by clay deposits (fig. 4: 3000bc), and covered the basal carr peat with minerogenic sediments of up to 40 cm. Subsequently, this small-scale tidal flat area silted up and reed beds formed that exceeded the rise in sea-level. The resulting decrease in flooding frequency led to a shift of the coastline by about 1.5 km. During the time of the marine incursion, the Ahlenrönne valley provided a very protected access to the North Sea

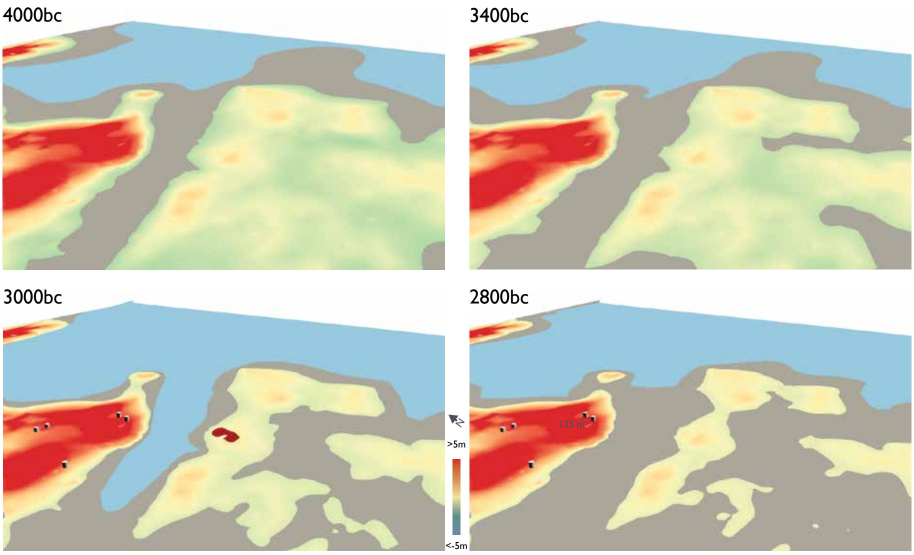

Figure 4. The landscape during the Neolithic around the settlement in different time slices. The model is a DEM and is based on the corings of the State Office for Mining, Energy and Geology Lower Saxony, Hannover (LBEG) and the project "Relics in the bog"; the extent of marine sediments is based on Schneekloth (1970), core data from the LBEG, project cores and geophysical data; the temporal depth of the data results from ^{14}C dating in the vicinity of the settlement and a general preliminary age-depth model of bog growth (Blue areas = tidal area; brown areas = bog or wetland vegetation; red area = drilled extension of the cultural layer; cylinder = megalithic tombs; elevation in m NHN).

existed via the Elbe estuary. It can be assumed that the founding of the settlement can be related to the formation of this small tidal area: however, an exact chronological classification cannot be made at this point. Most areas of the settlement have not yet been excavated.

The formation of islands in the bog has also been observed in other regions (Chapman and Gearey 2013, 136; Fokkens 1998, 53) and, in contrast to Wanna, this was regarded as something that excluded possible occupation (Fokkens 1998, 53). Whether there was a permanent occupation in the AFM or whether it was only used temporarily remains uncertain.

For both sites, but especially for the settlement area, it is obvious that the changes in the landscape had an influence on the living conditions of the people during the period of use. Certainly, the greatest effect was the narrowing of the usable space due to the rising groundwater level, the growth of the bog and the associated waterlogging of the farmland. Building on this, the question arises of how these changes affected society.

Perception of landscape change

How humans perceived the bog is certainly one of the most difficult questions to answer. Paulissen *et al.* (2022) have approached the topic from a reverse chronological perspective, starting with the perception of people living in the immediate periphery of the bog today, and going back through the Middle Ages to the time before written sources.

Eight basic terms were used to distinguish between the different perceptions: Mystery, Risk, Functionality, Biodiversity, Beauty, Attachment, Admiration, Historicity. The first three were associated with prehistoric times and the rest were added later. However, the example of the 1603 settlement in Wanna also shows that the influence of Risk and Mystery, at least for use on an island surrounded by bog, takes a back seat when it comes to an advantage in functionality.

It is very likely that the people noticed the landscape changes. It can be assumed that landscape-altering processes, which extended over several generations, spatially delimited and re-shaped the activity zones and areas of use. In the vicinity of the potential settlement area, it can be assumed that potential pasture and arable land, but also forested areas, became waterlogged over time. But the environmental changes also offered new opportunities, such as a protected access to the sea. When considering the perception of landscape change, the type and pace of change certainly plays a role. Environmental changes can happen very quickly in coastal areas and can have a strong, direct impact on people. This certainly includes events where cause and effect are clearly recognizable, such as storm surges (*e.g.* Second Marcellus Flood). But there are also natural events whose cause is presumably unknown, but whose effect is rapid and strong (*e.g.* Late Antique Little Ice Age). The changes that can be traced by the project, on the other hand, are rather slow. Sea level rise, weather and climate changes or even wetland expansion are processes that proceed slowly but are visible over generations. However, at certain stages they can lead to sudden events that are socially relevant. For example, paths and areas may no longer be usable, ritual, sacred places may disappear, or the habitat may become too small.

The longer these events lie in the past, the more difficult it is to classify them historically and the greater the risk of reinterpretation. The first two examples, however, show events that were written down relatively close to the time. For prehistoric times this is not possible. Nevertheless, it is such changes in the landscape that can be assigned to the third example that can be traced in oral societies. In studies by Nunn *et al.* (2021), landscape changes caused by sea level rise, which occur in stories of Australian aboriginal peoples but also in northwest Europe, can be linked.

The question is, of course, whether these slow processes are noticeable and extraordinary enough for societies to communicate about them at all and whether it then passes from communicative to collective or cultural memory and remains there, thus also supporting the identity of the group (Assmann 2018, 36 and 53). An influence on communicative memory (Assmann 2018, 56) is probable and the examples mentioned above show that the transition into cultural memory is also possible.

However, the landscape change or the resulting events should be socially relevant. Strong individual events are not to be assumed in the AFM. Since the landscape changed relatively consistently from the beginning of land use, there was probably no evidence of great vulnerability of the society in this respect, as it permanently adapted to the processes. A direct relevance for the people settling the areas around the bog is also questioned for the Frisian-Drenthe Plateau. For this region, a bog expansion of 3–9 ha per generation and region can be assumed, the average total area per region being 92 km^2 (Fokkens 1998, 135–136). Based on preliminary data, there was probably already an island in the area of the potential settlement in the AFM around 3400 BCE, with a size of about 840 ha; this was subdivided in the period up to 3000 BCE. In the period leading up to 2800 BCE, it decreases again. At around 2200 BCE, it can be assumed that the whole island is completely under wetland conditions except for a few hilltops. The described tomb is located on a peninsula surrounded by wetlands. The width of this peninsula was approximately halved between 3400 and 2800 BCE. Again, it can be assumed that this grave and another one about 500 m to the west were already enclosed by the wetlands by the end of the 3rd millenium BCE. However, the capstones and the stone packing would still have peeked out.

Fokkens (1998, 136) assumes for the Frisian-Drenthe Plateau that these relatively slow changes have not led to any problems. As a strong argument, he states that the constant shifting of farms – presumably after a few generations – has led to the landscape change being unconsciously compensated for. But it is possible that, at a certain point, the sea and wetland expansion determined such a large impact on the landscape that an abandonment of individual elements became necessary, even if not due to profound threats to existence. Cultural memory is always mediated and shaped by specific carriers and is closely related to feasts or ritual acts (Assmann 2018, 53–54). This can also be traced in the TRB in the form of bog or spring sacrifices (*e.g.* Koch 1998). The Hatfield trackway is also directly linked to landscape change by Chapman and Geary (2013, 136–138). They postulate that it was created for ritual purposes in response to bog expansion and was an important site for the whole region. This approach is also supported by Paulissen *et al.* (2022, 9), who sees the bog paths – which often end in the bog – as a desire to enter the bog. In this way, cultural reactions to landscape changes could be archaeologically verifiable in the AFM, too.

Conclusion and Outlook

A prehistoric landscape has been preserved under the Ahlen Falkenberger Moor, in which palaeobotanical, geoarchaeological and archaeological archives are in very good condition due to the protection of the bog. Through the investigations carried out so far, it has been possible to trace the chronological change of the Neolithic landscape. This shows that the relatively flat landscape has been increasingly restructured by the spread of the wetlands and that islands of elevated sandy areas have formed in the bog. Especially in the area of a possible settlement site, it is obvious that these areas were an attractive place in the Middle Neolithic. There may have been varying, not mutually exclusive, reasons for this attractiveness. First of all, the island or peninsula in the bog offers a certain protection against other groups of people due to its poor accessibility. More likely, the use of the site had to do with the formation of the estuary, whose marine resources were certainly of great interest. If this use is assumed, the site also offers some protection against nature. A site directly on the coast would be more unprotected against weather or even storm surges. Thus it can be seen that the location on the bog was positive. At the same time, with the slow expansion of the wetlands, it cannot be assumed that this had a significant impact on society. It can be assumed rather that the silting up of the estuary led to the abandonment of the area.

This shows that the AFM is an appropriate region for the investigation and reconstruction of such processes, on the one hand due to the potential for favourable preservation conditions under the bog, but also due to the excellent archive for the further temporal-spatial delimitation of the sea-level rise and the bog expansion. For the TRB, the impact on the cultural landscape is obvious. In the area of the ritually used sites, this cannot yet be proven with certainty but, when looking at the settlement or use area, the changes in the landscape seem to have created the conditions for both the use and the abandonment of space. In particular, the documentation of a so-far unique potential cult site of the Single Grave Culture confirms that finds and possibly features have been preserved under the bog, which have long since been destroyed in other places on the Pleistocene sandy soil and are worthy of further study.

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LOSING BOUNDARIES

Duality in the Early Neolithic on Lolland-Falster and in south Scandinavia

Theis Zetner Trolle Jensen and Lasse Vilien Sørensen

Abstract

Decades of research have shown that the transition from the Mesolithic to a full-scale agrarian society happened around 4000 BCE in south Scandinavia. This transition was marked by a relatively rapid introduction of domesticated plants and animals, as well as material culture. Yet we know relatively little about how this transition took place and the scale of the demic and cultural diffusion processes between the migrating farmers and indigenous hunter-gatherers within the different regions. Here, we present the current status of the evidence for population duality and the degree of interaction between the two groups by integrating theories of communities of practice. Our study focuses on different levels of continuity and change, from regional land use based on stray finds (Lolland-Falster) to site-level investigations (the Femern project) to individual-based studies of Lola and the Dragsholm man. The empirical data documents the necessity of working at different degrees of scale when trying to identify the Neolithisation processes in south Scandinavia. The data that has been obtained challenges the view that this transition was a monistic event, as incoming farmers originating from western or central Europe lived alongside the last hunter-gatherers for a few centuries in many regions, including Lolland-Falster.

Femern project; Neolithisation; duality; hunter-gatherers; farmers; practices; negotiations

Introduction

Research into the transition from the Mesolithic to the Neolithic is one of the oldest archaeological research topics (Fischer and Kristiansen 2002). The transition in Denmark is marked by a sudden change in ways of life and the introduction of new technologies, but most importantly the sudden appearance of domesticated animals and the use of

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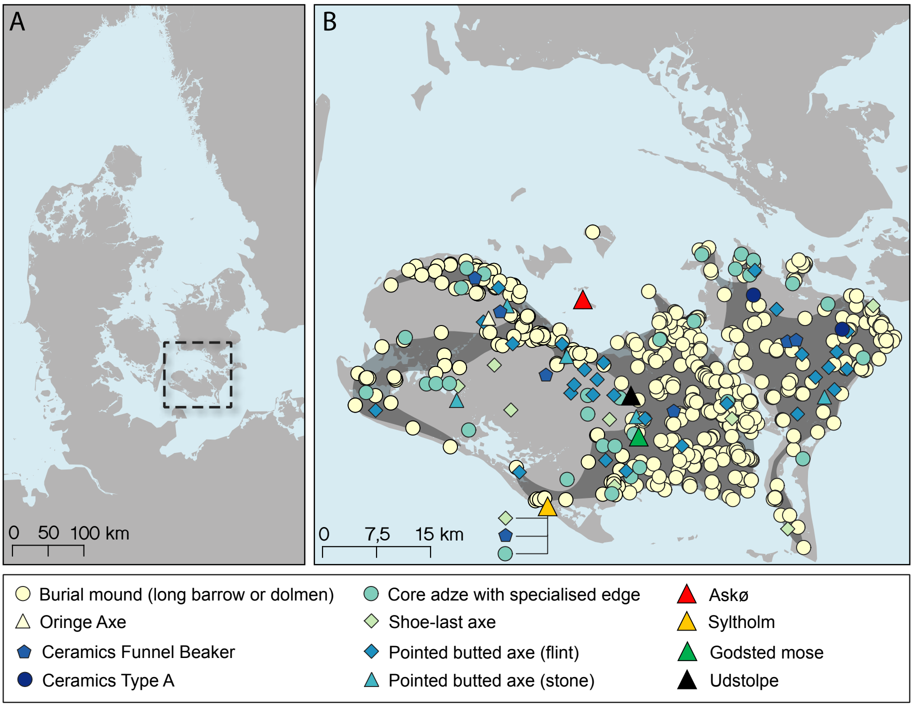

Figure 1. A) Map of Denmark showing the approximate shoreline in 4000 BCE after Astrup (2018). B) Map of Lolland and Falster, showing the distribution of stray finds during the late Ertebølle and the clustering of megaliths (obtained from Fund and Fortidsminder) during the early Funnel Beaker Culture, as well as sites mentioned in the text. Dark grey polygons show the extent of the Neolithic burial mounds.

domesticated crops. Most of these technologies and ideas originated in western Asia, and they gradually spread along different routes into western and central Europe (Zeder 2008). The groups diffused into different regional Neolithic cultures along the way, and a cessation of the agrarian expansion is observed in northern Germany around 5000 BCE, which lasted nearly a millennium (Hartz *et al.* 2007). By the late fifth to early fourth millennium BCE, different contact networks started to become established between Ertebølle hunter-gatherers in south Scandinavia and Neolithic groups in northern Germany (Sørensen 2020a). It is generally accepted that the transition occurred quite abruptly around 4000 BCE in Denmark. But how did this happen and was it only part of the "package"? Different hypotheses have been put forward, such as the demic and cultural diffusion of ideas (Sørensen 2014). Recently, several studies have argued that there was a swift and rapid transition in some regions, combined with a possible cultural dualism that consisted of indigenous hunter-gatherers and incoming farmers originating from central Europe during the first centuries of the Early Neolithic (Gron and Sørensen 2018; Sørensen and Karg 2012). Now, with the large-scale excavations in the prehistoric Syltholm Fjord on southern Lolland and the availability of hundreds of radiocarbon dates, as well as genetic evidence, there are indications of cultural duality in the early part of the Neolithic (Allentoft *et al.* 2022; Sørensen 2020b). In this paper, we will investigate the land use of the Lolland-Falster region (fig. 1) during the Ertebølle and early Funnel Beaker transition, together with the levels of change and continuity observed at the site-level perspective of Syltholm II, and from the individual viewpoint of the genetic evidence of Lola and the burial of the Dragsholm man. Our theoretical approach involves using the concept of communities of practice to conceptualise the dynamics behind the negotiations and interactions between indigenous hunter-gatherers and incoming farmers.

Theoretical approach

Within communities of practice, knowledge is negotiated through a process of participation and reification, and they are therefore important places of learning, meaning, identity and power (Lave and Wenger 1991). Some characteristic features have been identified in connection with communities of practice: Firstly, members interact, thus establishing norms and relationships through mutual engagement. Secondly, members are bound to one another by an understanding of a common goal. In addition, members accumulate a shared knowledge of history and routines over time, which leads to increased competencies in learning practices. If farmers and hunter-gatherers had direct social relations, as neighbours, then such communities of practice could have emerged, resulting in different levels of interaction. This would have been dependent, however, on the farmers' and the hunter-gatherers' desire to teach and learn different practices from each other. There are, however, some challenges associated with communication strategies when different groups, in this case indigenous hunter-gatherers and incoming farmers, speak different languages. Language acquisition and learning specific practices using a foreign language make knowledge exchange an even harder task and is time-consuming for the individuals involved (Roberts 2006). The learning of husbandry and cultivation practices could potentially last for several years for the hunter-gatherer participants, as the activities require years of planning novel agrarian habitations (Sørensen 2014). From a hunter-gatherer perspective, the degree of interaction with agrarian communities, as legitimate peripheral participants, could result in the use of new material culture (polished axes or Funnel Beaker pottery) and variations in the implementation of agrarian subsistence. In this process of knowledge exchange and the learning of agrarian practices, the hunter-gatherers would either gradually change their traditional practices and identity towards becoming farmers or, if they were isolated, end up with refugia habitations that continued the foraging subsistence practices. Integrating local hunter-gatherers could very well have been highly necessary and a deliberate strategy for the first pioneering farmers in southern Scandinavia because they needed a labour force to clear a dense and thick forest to create arable land. However, the opposite scenario could also apply, in which the incoming farmers did not interact to any significant extent with the neighbouring hunter-gatherers. In this case, the presence of agrarian material culture at hunter-gatherer sites could represent exchanged or stolen objects, whereas animal husbandry may involve either wild feral animals or animals that had escaped from farming settlements. The empirical data from the regional, site and individual levels can be used to discuss different aspects of the melting-pot situation.

In the following, we will focus on the use of the landscape and how new ideas and practices were adopted, whilst the old traditions were still adhered to between the Ertebølle and early Funnel Beaker cultures.

Studies on a regional level

We have combined data from stray finds, hoards, sites and megalithic structures in order to document the use of the landscape in the Lolland-Falster region from the late Ertebølle to the Middle Neolithic (fig. 1A; Sørensen 2014, 274). Mapping the distributions of the empirical data from these periods on Lolland-Falster is the first step, to which further information can be added in the future. Despite the varying quality of the distributions, they can still contribute to a nuanced understanding of the different phases of contact/scouting, introduction, negotiation and homogenisation within the Neolithisation process in this region (Gron and Sørensen 2018).

The contact phase began around 4400 BCE and reflects a widespread use of the landscape, clustering near the coastal and lake zones, together with activities further inland during the late Ertebølle Culture. The first direct contact with central European agrarian communities is associated with the two axe hoards from Udstolpe, which contain one pointed-butted axe and two shoe-last axes, whilst the Askø hoard contained two shoe-last axes, which suggests visits from either farmers to the north (Lomborg 1962), or hunter-gatherers to the south. The raw material of amphibole-rich metabasite was used to produce the majority of these shoe-last axes and the quarries were recently identified near Jistebsko in northern Bohemia in the Czech Republic (Bernardini *et al.* 2012; Přichystal 2014, 192). The shoe-last axes were produced by central European craft specialists from 5300 to 4600 BCE and were distributed within and beyond the agrarian networks to hunter-gatherer societies in the Swifterbant and Ertebølle cultures (Klassen 2004; Müller and Schirren 2022; Raemaekers *et al.* 2011; Verhart 2012) (fig. 2). Axe deposits of shoe-last axes are usually found in central European agrarian societies, and could have been symbolic offerings made by scouts searching for new territories and specific resources in the north. Perhaps the demands of these agrarian neighbours could have stimulated a new and different niche production of specific goods within the late Ertebølle hunter-gatherer societies in certain key areas. Examples of a niche production of specific goods have been documented by the increased hunting of animals with fur, consisting of pine marten (*Martes martes*), polecat (*Mustela putorius*), wolf (*Canis lupus*), fox (*Vulpes vulpes*), domestic dog (*Canis familiaris*), lynx (*Lynx lynx*), wild cat (*Felis silvestris*), otter (*Lutra lutra*), newborn roe (*Capreolus capreolus*) and red deer (*Cervus elaphus*). The exploitation of the high-quality skins of these animals has been observed at late Ertebølle sites, such as Ringkloster, Agernæs, Tybrind Vig, Hjerk Nor and Bodal K (Sørensen 2020a). Such specialised hunting camps could stimulate a growing demand for fur and skins within the agrarian societies, perhaps resulting in increasing exchanges between hunter-gatherer and agrarian communities, and therefore the significant numbers of shoe-last axes that appear within the late Ertebølle Culture (Klassen 2004, 24). The greatest concentration of shoe-last axes in south Scandinavia is located on Lolland-Falster. Other exotic stray finds have also been documented in the same region, such as an amphibolite disc mace head found on Vejrø, a pointed-butted axe of Alpine jadeite on Lolland and a copper flat axe from Vantore, also on Lolland, which indicates that this was one of the regions that were in continuous contact with central Europe (Klassen 2004).

New impulses in the centuries before 4000 BCE may have been derived from a combination of agrarian scouting expeditions and hunter-gatherers from across the Fehmarn Belt, who had already integrated elements of the Neolithic material culture.

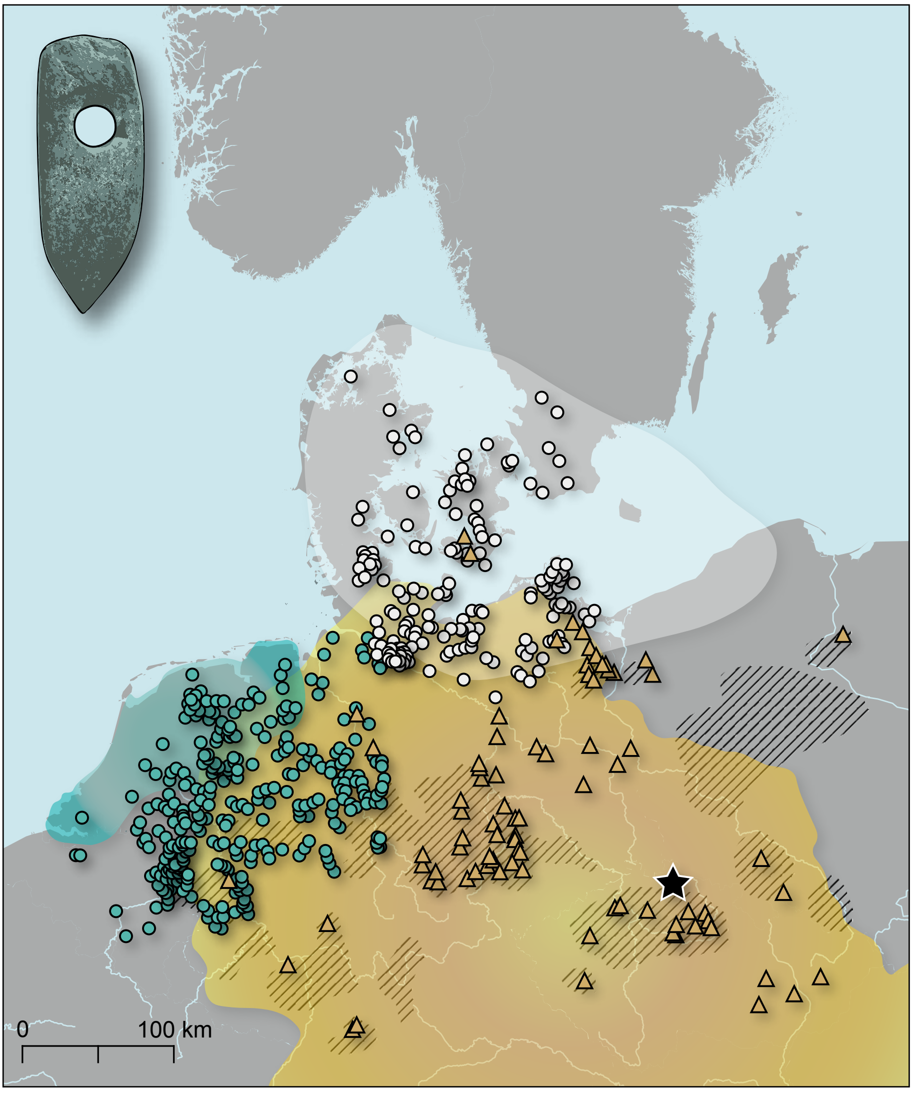

Figure 2. Distribution of shoe-last axes in agrarian and hunter-gatherer societies in Europe. Ochre triangles: Middle Neolithic hoards; white dots: Ertebølle Culture sites; green dots: Swifterbant Culture sites; black star: the primary source of amphibole-rich metabasite near Jistebsko (star) in northern Bohemia, Czech Republic; loess-rich soils are marked with hatched polygons (after Bernardini *et al.* 2012; Klassen 2004; Raemaekers *et al.* 2011).

These contacts resulted in the emergence of new practices in south Scandinavia, such as polishing core adzes with specialised edges or making local imitations of polished pointed-butted flint/stone axes in the shape of Oringe axes. Other local imitations are bone rings made from shoulder blades, which imitate the rings made of marble associated with the Rössen Culture (Klassen 2004). Despite the exchange of new ideas and exotic objects, it is not until the centuries after 4000 BCE that the scale of agrarian activities began to dramatically increase, which is related to several pioneering migrations of incoming agrarian societies from central Europe who had Anatolian ancestry (Allentoft *et al.* 2022). The duality of the population is a characteristic feature of the successive introduction and negotiation phases, which involved the arrival of material culture associated with the Funnel Beaker Culture and is synchronic with the appearance of domesticated animals and plants, along with a continuation of foraging strategies. It is within this dynamic context, in the first half of the fourth millennium, that we see different degrees of either social interaction between, or isolation of, the indigenous hunter-gatherers and incoming farmers in south Scandinavia.

Obvious regional variations can be observed within the Neolithisation process, which is either associated with a quick or slow transition, depending on the amount of contact between, and population sizes of, the hunter-gatherers and incoming farmers (Gron and Sørensen 2018; Sørensen 2014, 274). Bornholm and the western parts of Scania are regions with long, exposed coasts, and they are characterised by the rapid replacement of foraging with farming subsistence strategies, corresponding to a shift from coastal to inland-orientated settlement (Gron and Sørensen 2018; Nielsen and Nielsen 2020). In contrast, both northern Jutland and Lolland-Falster, with their many islands, inlets and estuaries, contained both coastal and inland settlements in the Early Neolithic. Here, there was a period of population duality, which is confirmed by the continuous, widespread exploitation of the coastal, lake and inland areas from the late Ertebølle to the Early Neolithic. In other areas that have been more intensively surveyed, such as the Risø area on Zealand, the distribution clearly illustrates that the late Ertebølle kitchen middens are located near the coast, whilst the early Funnel Beaker sites are situated further inland, on the sandy and more easily workable soils of arable areas (Sørensen 2016a). These inland-orientated sites have been interpreted as the settlements of the pioneering agrarian societies, based on their finds of short-necked funnel beakers, pointed-butted axes, charred cereals and domesticated animals (Sørensen 2014; 2015). A few core adzes with specialised edges, which are characteristic archetypes of the late Ertebølle Culture, have been observed at or near the agrarian inland sites on Lolland-Falster (fig. 1). These finds may be the result of contacts and negotiations between incoming farmers and indigenous hunter-gatherers. The phase of population duality lasted until the dual presence of foraging and farming activities shifted decisively in favour of the latter. Afterwards, from 3700 to 3300 BCE, a homogenisation phase began, involving increased exploitation of the landscape, as well as flint sources, and the construction of large-scale monuments, which are characterised by some obvious concentrations as well as gaps (fig. 1B). Could these gaps in the centre of Lolland represent long-lasting refugia of coastal hunter-gatherers, who implemented their material culture together with some farming practices from their agrarian neighbours? Here, the results from the excavations at Syltholm II provide some new insights into this question, as well as the degree of negotiations between hunter-gatherers and agrarian communities.

The site-level investigations in the prehistoric Syltholm Fjord

The area of Syltholm Fjord is located just southeast of present-day Rødbyhavn. It is a low-lying area that used to be open water but was reclaimed after 1875 following a catastrophic flood. The site in focus is Syltholm II (MLF00906-I, II and III) (referred to hereafter as Syltholm II), which covers a total area of around 35,000 m^2. When the first layer of laminated sand was removed, a layer of drift gyttja of varying depths was exposed,

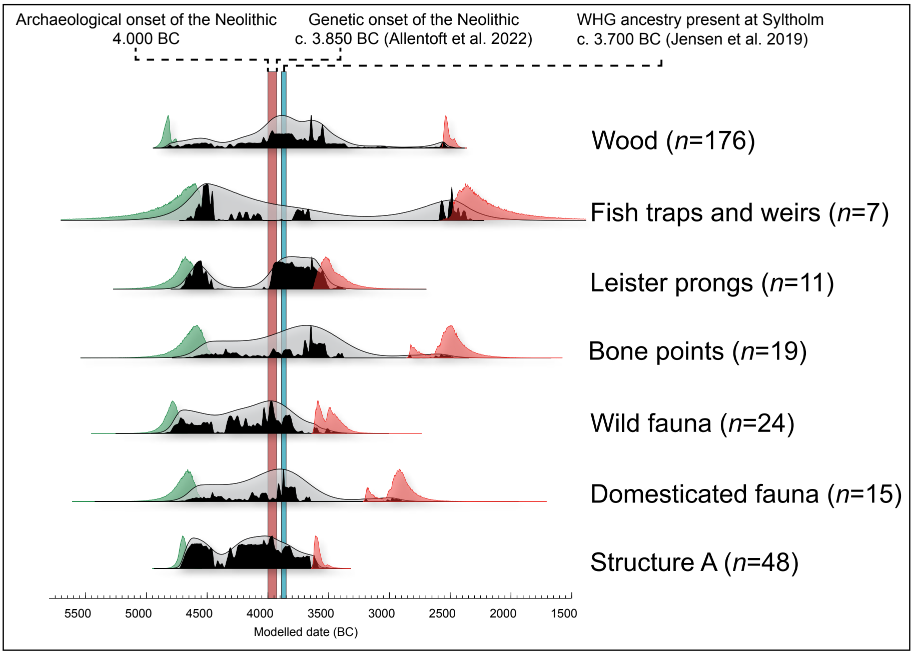

Figure 3. AMS dates from Syltholm II (MLF00906) grouped into categories. Each cluster was modelled using KDE plots and summarised distributions. The red bar signifies the archaeological and genetic onset of the Neolithic, while the blue shows the presence of late Western Hunter-Gatherer (WHG) ancestry at Syltholm Fjord.

which also contained finds. However, due to the low rate of sedimentation in prehistory, finds were uncovered with the same vertical distribution, making the chronology of the activities at the site difficult to determine. A few categories could, however, be indirectly dated based on typologies, such as Ertebølle and Funnel Beaker ceramics, core adzes with specialised edges and bones derived from domesticated animals, such as sheep, goats and cattle. This suggests that there was human activity at the site for a quite long time during the Ertebølle and Neolithic periods. What sets this location apart is the extraordinarily well-preserved organic material, such as wood, bone and antler. It is not just the finds that are interesting, however, it is the dates of many of the finds that place them in context.

An enormous number of finds were recovered, and a total of 238 direct AMS dates were obtained from the three sites, the majority of which are from wood (see supplementary material). Here, we grouped the dates based on their material, species and excavation feature. Dates from taxa that could potentially be influenced by reservoir effects, such as otter, harbour porpoise (*Phocoena phocoena*), seal (*Phoca* sp.) and dog were discarded (*n*=9). Furthermore, the indigenous wild boar (*Sus scrofa*) can be only differentiated from potential foreign domesticated species based on in-depth geometric morphometrics or genomic approaches (Krause-Kyora *et al.* 2013). All *Sus* sp. were therefore not included in further analyses as neither analysis was carried out on this assemblage. Although the wooden samples could be influenced by the *old-wood effect,* they were still included. However, caution is advised.

We then grouped the dates as follows: archaeological wood (excluding tree stumps), fish traps and weirs, leister prongs, bone points, wild fauna, domesticated fauna and all dates from Structure A (mandible pit). Each group of dates was then analysed individually using OxCal v. 4.4 (Bronk Ramsey 2009) and the IntCal20 calibration curve (Reimer *et al.* 2020) and modelled using the Kernel Density Estimation command KDE plot, together with summed probabilities and boundaries around each phase (fig. 3; Bronk Ramsey 2017). Modelled dates are reported in the following section.

Wood

Samples taken from archaeological wood comprise 176 samples. The majority are from stakes that had been rammed down through gyttja and into the late glacial till. Others are spears made from ash wood (*Fraxinus*), paddles or axe shafts. None of the stakes seem to be arranged in lines, indicating the presence of stationary fishing structures. The dates of all wood, including leister prongs and fish weirs and fences, are within the range 4857–2518 BCE.

Fishing

Whilst evidence of fishing structures was not abundant in Syltholm II (MLF00906), seven dates were obtained from three features (cf. Stafseth and Groß this volume). One from a wicker mat made of hazel wood (*Corylus avellana*) dated to 2572–2308 cal BC and the other from two fragmented pieces of funnel-shaped fish traps dated to 4617–3648 cal BC. The fish weir is much later than most of the dates from the site and may have been dislodged from its primary position and drifted to where it was found. However, a stake (4601–4451 cal BC) was found lodged vertically close to one of the traps, which is thought to have fastened the trap, and is thus indicative that the trap is *in situ.*

Leister prongs and bone points

Other more definite indications of fishing at the site consist of several hundred bone points as well as wooden leister prongs, which were found *in situ*. These would have been mounted on a pole, with two leister prongs attached to one end and a bone point in the middle. Such composite instruments are traditionally thought to have mainly been used for eel fishing. The bone points (n=19) were dated to 4666–2470 BCE, whilst the wooden leister prongs (n=11) were dated to 4701–3496 BCE (one excluded due to Kongemose date).

Wild fauna

The faunal remains of various species were mostly found in mixed concentrations, such as Structure A. These mainly consist of disarticulated bones, antlers or skulls. The species are red deer, roe deer, wild cat and fox. In general, it appears that most of the osseous material was deposited deliberately. The wild faunal remains (n=24) were predominantly derived from Structure A (n=14; see Sørensen this volume) and were dated to 4840–3709 BCE (one date excluded due to poor agreement).

Domesticated fauna

As in the case of the wild fauna, the bones from domesticated taxa were also found in various concentrations. These are represented by sheep (*Ovis aries*) or goats (*Capra hircus*), cattle (*Bos taurus*) and dogs. The domesticated fauna (n=15) are dated to 4664–2470 BCE. These rather early dates need to be approached with some caution, however. Neither sheep nor goats were endemic to Denmark and are therefore foreign. Postcranial skeletal bones identified as sheep or goat can also in some cases be mistaken for those from roe deer. Samples analysed in 2019 using peptide mass fingerprinting indicated that two potential early domesticates were roe deer (data not presented here).

Structure A

This feature measured around 4x5m and took the form of a shallow depression, which 6000 years ago would have been filled with shallow water and surrounded by reeds. Hundreds of artefacts and faunal remains were deposited here for almost a thousand years, spanning the late Ertebølle and Middle Neolithic. The finds consist of uncommon artefacts, such as a t-antler axe, a decorated red deer antler, 18 tinder fungi (*Fomes fomentarius*) and, most strikingly, 50 mandibles from various animals (Sørensen 2016b; 2020b; this volume). Forty-eight radiocarbon dates indicate that depositions took place within the timespan 4720–3642 BCE (one date excluded due to poor agreement).

The fog of transition

The finds from the site and the radiocarbon dates reflect high activity over almost a thousand years, spanning the transition to agriculture. The wooden stakes rammed down into the seabed are probably not from stationary fishing structures and must have served a different purpose. Yet ramming down stakes into this seascape served some kind of purpose. Whether the stakes had something attached to them or whether they functioned as markers is difficult to determine. Other functional objects, such as paddles, bows or axe shafts, may have been rammed down, to be retrieved at a later date, but this never happened.

Fishing also took place nearly uninterruptedly, and there seems to have been a change in methodology. The earliest median date of leister prongs is 4621 cal BC, but the dates suddenly stop at 4544 cal BC, appear again at 3916 cal BC and end at 3526 cal BC (see fig. 3). Although only 11 have been dated, the leister prongs presumably provide a relatively good overview of the use period. This could indicate a different use of the area over time in terms of fishing. Interestingly, depositional practices continued throughout the entire period, with no apparent gaps.

There is an increase in domesticates dating to the Early Neolithic. A few dates obtained from presumed domesticated taxa are, however, much earlier than expected and would require further scrutiny to validate, using molecular methods. If verified as domesticated taxa, these would further demonstrate contact between foragers and farmers.

The above-mentioned archaeological examples point towards an uninterrupted continuation of practices and thus cultural duality at Syltholm II. This seems to indicate that indigenous hunter-gatherers were partly responsible for activities at the site a few hundred years into the Neolithic period. Neolithic farmers may have already settled down in the hinterlands, with the two groups maintaining some form of contact with one another. In terms of land use, there is a large gap on the island, where no megalithic structures have been constructed (fig. 1B). Syltholm II is located in the borderlands, with a few megaliths separating the site from this empty land. The question is whether this is evidence of a refugium of the indigenous population or a

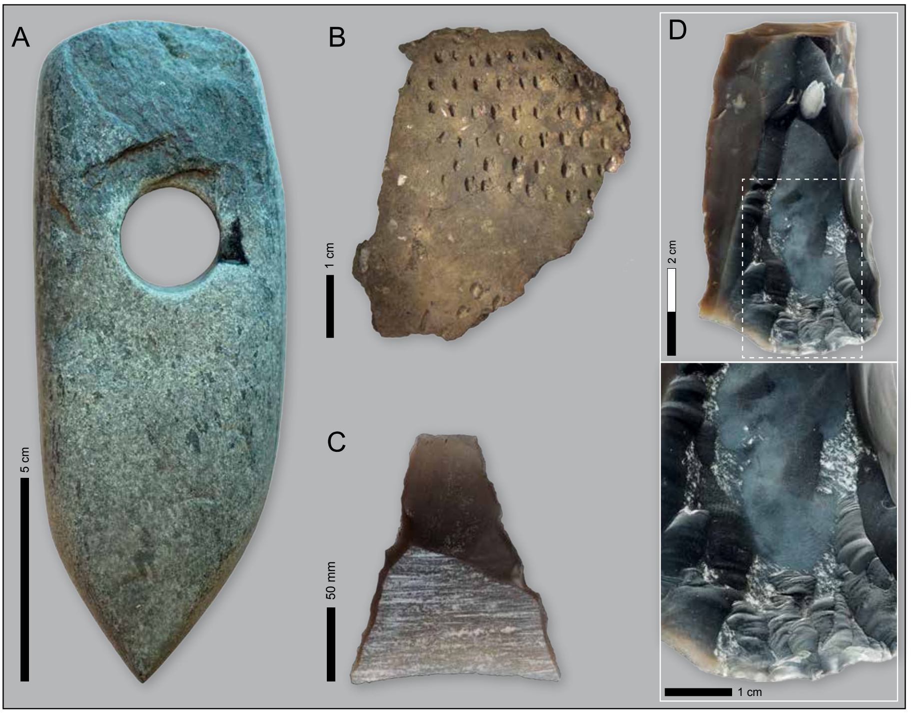

Figure 4. A) Shoe-last axe found close to Syltholm II, B) a piece of Stichbandkeramik; C) transverse arrowhead with striations showing that it was made from a polished Neolithic axe; D) core adze with specialized edge showing partial striations that show it was made from a polished Neolithic axe (photos: A: Museum Lolland-Falster; B – D: Theis Zetner Trolle Jensen).

negotiated no-man's land. It could also represent a gradual and forced encirclement by Neolithic farmers, perhaps to maintain control over foragers, which would eventually lead to cultural homogenisation.

Several strands of evidence point towards the existence of extensive contact networks both before and after the transition to the Neolithic. Various exotic finds were found in the Syltholm Fjord area, such as a shoe-last axe of amphibolite, pottery (Stichbandkeramik) (fig. 4A – B), and a finger ring made of antler or bone (Jensen *et al.* 2020). Other evidence of contact consists of quern stones for grinding flour that ended up in a wetland, which is a somewhat strange place for this activity, but they ended up there for unknown reasons. Two other artefacts of significance are a transverse arrowhead and a core adze with a specialised edge, both of which have been made from polished axes (fig. 4C – D). These two artefacts are of Mesolithic type but were made from Neolithic artefacts. These findings underscore the fact that the manufacture of artefact types of Mesolithic origin continued into the Early Neolithic period in both Denmark and northern Germany (Hartz *et al.* 2007; Wadskjær 2018). In general, it seems that the hunter-gatherers exercised a kind of hybrid technological flexibility, in which new innovations or traded, perhaps stolen, items of Neolithic origin could easily be remade into old types. However, it could also be the case that the artefacts were manufactured by individuals carrying Neolithic ancestry.

After 4000 BCE, there is a sudden increase in domesticated fauna, with domesticated ungulates presumably kept on the salt meadows, which is indicated by hoof imprints in the mud (data not presented). Some would have been butchered on site, whilst selected parts of the skeletons were still deposited within the established Mesolithic “offering” grounds. Structure A was used for nearly 1000 years, which means that dozens of generations knew of this place and used it in the same way over the course of time. Knowledge of the importance of the location would have been passed down through the generations, but they did not alter their routines even when times were changing, and the Neolithic way of life was fast approaching.

Scales of duality

Regional scale

In northern Europe, there are signs that groups of hunter-gatherers persisted into the Neolithic. At the Lithuanian site of Sventoji, a fully-fledged Mesolithic lifestyle continued for centuries into the Neolithic (Rimantiené 1992). A similar situation has been observed at Ostorf in northern Germany, where Neolithic hunter-gatherers lived side-by-side with Neolithic farmers (Lübke *et al.* 2009). This complex relationship between immigrating farmers and indigenous hunter-gatherers has been observed at several sites in northern Germany (Hartz *et al.* 2007).

Genetic evidence from the Baltic countries also shows a remarkable continuity well into the Neolithic period, with very little evidence of Neolithic ancestry (Jones *et al.* 2017; Mittnik *et al.* 2018). However, the opposite seems to have applied in the British Isles. Here, the arrival of farmers with Aegean Neolithic ancestry occurred around 4000 BCE, which is also when the Neolithic began in southern Scandinavia. In Britain, the degree of admixture between local foragers and incoming farmers seems to be very limited, reflecting a large-scale replacement of the population. This could either be due to the low population densities of local foragers (Brace *et al.* 2019), or perhaps deliberate avoidance of mixing between the two groups.

Until recently, little was known about the genetic makeup of Stone Age individuals in Denmark. However, a recent preprint, analysing ancient DNA from a selection of Danish Mesolithic, Neolithic and Bronze Age skeletons (*n*=100), shows a complete population turnover during the Early Neolithic in Denmark (Allentoft *et al.* 2022). Interestingly, the first individual of these pioneers carrying Neolithic ancestry is dated to *c.* 3850 BCE. From then on, the gene pool was dominated by Anatolian ancestry until the arrival of Steppe Ancestry *c.* 1000 years later (Egfjord *et al.* 2021). This apparent delay in full-scale genetic turnover is remarkable because it would mean that the Early Neolithic expansion into Denmark was probably a coordinated effort between indigenous Ertebølle hunter-gatherers and immigrating Neolithic farmers from central Europe. Yet this comes with the caveat that few Early Neolithic skeletons have so far been discovered. These genetic results also correspond well with ideas put forward by Gron and Sørensen (2018); namely, that the first phase of the Neolithic was partly carried out by indigenous Ertebølle hunter-gatherers, perhaps under the supervision of Neolithic farmers.

The origin of these incoming pioneering farmers points towards a direct or indirect connection with the Michelsberg Culture. This is based on similarities that can be observed in the early Funnel Beaker Culture, involving short-necked funnel beakers, the establishment of flint mines and the production of pointed-butted axes, combined with the appearance in the archaeobotanical record of tetraploid, free-threshing wheat (Kirleis and Fischer 2014; Sørensen 2014). During the time of the Michelsberg Culture, a different use of the landscape is observed. In some areas, the Michelsberg communities began to cultivate the marginal areas and clear areas located outside loess soils (Sørensen 2014). These agrarian societies became more independent of the loess soil, which is rich in nitrogen. This resulted in a cultivation strategy that depended on animal manuring and long fallow periods, which would prevent the soils from becoming exhausted. Supposedly these agrarian societies managed to come up with advances in cultivation such as a nitrogen revolution. In that case, it could have paved the way for migrations towards the British Isles and northern Europe. Yet the reasons behind these migrations are still discussed. Interestingly, demographic bust and boom cycles in northern Germany (Feeser *et al.* 2016) seem to correlate with an increase in Neolithic artefacts and ideology in Denmark. When there is an increase, a boom, in northern Germany, the same is seen in Denmark, which could be indicative of population pressure south of the Syltholm Fjord area.

The paleogenetic evidence also supports a connection between the Michelsberg Culture and the early Funnel Beaker Culture, as their ancestries exhibit the same low degree of admixture with WHG (Allentoft *et al.* 2022; Beau *et al.* 2017; Rivollat *et al.* 2020). This indicates that if there was genetic admixture between WHG and farmers of Anatolian ancestry then, firstly, the mutations were diluted quite quickly and, secondly, these interactions occurred several hundred years before 4000 BC or, thirdly, there was very limited admixture. If there was increased genetic interaction between the late Ertebølle Culture and incoming groups of farmers in south Scandinavia, we would expect a greater amount of WHG-related ancestry in the individuals from the early Funnel Beaker Culture. This is not the case, however, which therefore indicates a rather limited admixture between these two groups in south Scandinavia. Such an admixture could have occurred though, but if the population of hunter-gatherers in south Scandinavia was very small then this genetic impact may be difficult to trace. We suggest that future genetic analysis of individuals from the passage graves could document what happened to the last hunter-gatherer communities.

Individual scale

The Neolithisation process in south Scandinavia only lasted a few centuries, which may sound insignificant on an archaeological scale. But these centuries might have been some of the most dramatic in terms of change and would have involved many generations. It has been estimated that a single generation on average lasted *c.* 26.9 years (Wang *et al.* 2023). This indicates that *c.* 11 generations of hunter-gatherers were directly involved in establishing the Neolithic way of life in south Scandinavia, where we would expect different degrees of duality.

In the previous section, we have shown that the site Syltholm II was frequented for more than 800 years, covering the transition to farming. The site contains several finds that point towards early contact networks with central European Neolithic farmers in the Mesolithic and a continuation of said practices in the Early Neolithic period. However, we have limited knowledge of the people who inhabited the place. Few human remains were uncovered and sequencing of ancient DNA from these has not been attempted. However, DNA was successfully extracted and sequenced from a piece of chewed tar found at the site. The results showed that the person who chewed the tar was a female who lived *c.* 5700 years ago, and she was given the name Lola. Curiously, she did not share ancestry with Anatolian farmers, but instead with the indigenous population, which was genetically composed of WHG ancestry (Jensen *et al.* 2019). This was an interesting observation, but hardly conclusive at the time, although it fits the archaeological findings regarding the presence of hunter-gatherers in the Early Neolithic period.

We can also observe this particular duality on an individual scale, based on one of the earliest Neolithic burials, that of the Dragsholm man. He was buried in a kitchen midden on Zealand and was dated to 4000–3800 BCE. Whilst his bone collagen showed terrestrial ^{13}C values, the burial assemblage contained a mixture of artefacts from both periods. Some of the significant finds include a short-necked funnel beaker (Oxie style/type 1), a type F III polygonal battle axe, teardrop- and disc-shaped amber beads, flint blades and transverse arrowheads, and a wrist guard. These finds connect the material culture and triality of being a hunter-gatherer, a farmer and a warrior (Petersen 2008; Price *et al.* 2007).

The Dragsholm man and Lola, with her associated genetic evidence, are therefore two important individuals for the discussion of duality and the adoption of a new material culture and ideology. The implementation of a new agrarian identity and ideology was probably a divisive step for the hunter-gatherers who had adopted the Neolithic material culture. But what if these refugia of hunter-gatherers decided to continue their symbolic practices, as observed at Syltholm, and not engage themselves in the construction of larger megalithic monuments? Could the lack of megalithic monuments in the centre of Lolland represent a deliberate ideological choice made by these hunter-gatherers? Such a choice is also observed in eastern Sweden, where there are very few megaliths or enclosures, thus arguing that these monumental constructions and territorial markers were not included in the Neolithic expression (Fritsch *et al.* 2010; Hallgren 2008). The lack of monuments could indicate that some of these communities had their own identity, which was under a larger influence of a hunter-gatherer identity and resulted in the early emergence of the early Pitted Ware Culture in eastern Sweden (Coutinho *et al.* 2020; Larsson 2009). In the discussion of duality during the Early Neolithic on Lolland-Falster, we are lacking detailed investigations of the first pioneering inland-orientated settlements to compare with the activities observed at Syltholm II. One of these sites is Godsted, located in Vester Ulslev parish, which remains unpublished and contains a large assemblage of lithics and organic materials (Møller Hansen 2001).

In general, Lolland-Falster has considerable potential for unravelling the unknown aspects of the Neolithisation process, especially concerning population duality, as this region can be regarded as constituting the bridgehead to central Europe 6000 years ago.

Conclusions, perspectives and new questions

The Neolithisation in southern Scandinavia was not one single event, but a continuous social process lasting for several generations, involving several migrations of incoming central European farmers and various degrees of interaction with the indigenous hunter-gatherers. The trends of continuity and change can be documented archaeologically at different scales of regional use of the landscape down to site and individual level, revealing how fast or slow the process occurred. To conceptualise the dynamic behaviour when humans meet each other requires a more developed theoretical approach. We have decided to use the theories behind the communities of practice, which allow us to pose more operational questions relating to the degree of participation and the material effects within these arenas of learning, as well as negotiations between hunter-gatherers and the incoming farmers.

The finds from the regional perspective of Lolland-Falster or northern Jutland document continuous use of the landscape during the late Ertebølle and Early Neolithic, whilst in other areas, such as Risø and Bornholm, there is a more abrupt change that is associated with inland settlements (Nielsen and Nielsen 2020; Sørensen 2016a). Agrarian impulses in the form of hoards of shoe-last axes could be interpreted as the results of visits by scouts from neighbouring farming communities during the late fifth millennium (fig. 2). It is suggested that the shoe-last axes that appeared in south Scandinavia represent objects that may have been exchanged for skins and furs, as animals with fur in particular have been identified amongst the faunal remains from several late Ertebølle specialised hunting stations. These exchanges may have taken place directly with agrarian groups, or indirectly with neighbouring hunter-gatherers in northern Germany, who were in direct contact with the farmers.

At a site level, the results from the Femern project indicate that a potential relict population of Mesolithic hunter-gatherers resided on Lolland-Falster for several hundred years into the Neolithic. The people inhabiting the area undertook activities that reflected the ideas of both the Mesolithic and the Neolithic. While we cannot be sure that these observations are potentially biased, due to the thousands of square metres that were excavated and the extraordinary preservation of the archaeological remains, the question remains whether Syltholm was a unique place, or whether the same situation was more widespread. We suggest that Syltholm was habited by a hunter-gatherer population who had engaged on the periphery of communities of practice with the neighbouring agrarian groups (fig. 1B), which also reflects the continuity of subsistence and depositional practices, together with the implementation of Neolithic material culture. If these hunter-gatherers had fully committed themselves to the agrarian communities of practice, they would have changed their identity and ideology, but this does not seem to have been the case. We would otherwise have observed a greater density of megalithic structures when the agrarian societies began to increase the use of the landscape. There is instead a notable lack of megalithic structures in this part of Lolland (fig. 1B), thus suggesting that this could represent refugia habitation of hunter-gatherers, who had adopted some elements of the agrarian way of life, but not the full ideology. Studies at an individual level support this interpretation as, based on his burial gifts, the Dragsholm man was a hunter, farmer and warrior.

Much of the previous research has focused on the first farmers, but what happened to the last hunter-gatherers? Did they disappear because of their limited population or due to more dramatic events, such as zoonotic diseases transmitted by domesticated animals or conflicts with their agrarian neighbours? And we could expand the question to all the Early and Middle Neolithic coastal habitations and ask whether these were the remains of such hunter-gatherer refugia or the result of agrarian communities commuting between the coastal and lake shore and inland zones? The recent paleogenetic investigations of humans are a third scientific revolution, as it is now possible to pose new questions about duality down to the level of single sites or even individuals, thus helping to make sense of the complexities of the Neolithisation process. With a more evolved theoretical apparatus, we can also now begin to pose questions that could not have been posed, discussed and answered before.

Supplementary material

The table with all the radiocarbon dates used in this article, including a seperation in categories, is available at DOI: 10.5281/zenodo.7541114.

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Long-term perspectives on Neolithisation

Pottery use in the Ertebølle Culture and its connection to the development of settlement patterns and hunter-gatherer complexity

Ann-Katrin Meyer

Abstract

The Ertebølle Culture (*c.* 5400–4000 BCE) is understood as a primarily coastal phenomenon with aquatic subsistence preferences, a (seasonal) settlement permanence and other complex hunter-gatherer traits, such as hierarchies, food storage and pottery use.

Pottery appears around 4600 BCE and is well researched in regards to typology, technology and vessel contents, yet very little research has ever been carried out as to the reasons behind the adoption of the technology or its impact on Mesolithic life and the Neolithisation process.

The research presented here focusses on these aspects. Through the analysis of previously neglected inland find assemblages and an extensive comparison to the coastal materials as well as the employment of methods from behavioural archaeology and entanglement theory, the project showed that ceramics played a central role in the Final Mesolithic and significantly influenced various activities of daily life. The use of ceramic vessels thus led to an intensification of existing subsistence and resource preferences, which stabilised formerly established settlement and subsistence patterns and helped anchor the typical material signature and (coastal) settlement focus of the Ertebølle Culture. In this sense, ceramics are involved in forming complex social structures rather than resulting from them, and they facilitate the gradual establishment of Neolithic modes of subsistence by replacing more “traditional” Late Mesolithic structures.

Ertebølle Culture; Mesolithic pottery; Neolithisation; ceramic technology

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Introduction

The Ertebølle Culture (EBC) defines the terminal Mesolithic of northern Germany and southern Scandinavia between 5400 and 4000 BCE (Hartz and Lübke 2005) and is generally viewed as a complex forager society with a largely coastal lifestyle and typical "complex" attributes, such as territoriality, hierarchies, (semi-)sedentariness and migrating settlement patterns between coast and inland (Andersen 2010; Hartz and Schmölcke 2013; Johansen 2006; Klassen 2004; Klooß 2015). Additionally, close contacts with neighbouring regions and the vicinity to Neolithic groups further south (Hartz *et al.* 2007; Klassen 2004) are the main reason why the Final Mesolithic is usually discussed with a focus on the Mesolithic-Neolithic transition (Fischer and Kristiansen 2002). Neolithisation models are based on economic and ecological necessity (Andersen 1989; Rowley-Conwy 1984; Rowley-Conwy 1985), social and prestige mechanisms (Fischer 2002; Svizerro 2015), ideological concepts (Hodder 1990; Müller 2013; Tilley 1996) or diffusion/acculturation processes due to contacts with Neolithic groups (Hartz *et al.* 2007; Hoika 1993; Zvelebil and Rowley-Conwy 1984). Lately, the dichotomy between long lasting "Mesolithic" continuities and "abruptly" appearing "Neolithic" changes, together with recent isotope and aDNA analyses, have re-established theories about migrating farmers replacing local hunter-gatherer groups in regionally varying interaction processes (Gron and Sørensen 2018).

Similarly, the presence of pointed-bottom pottery from *c.* 4600 BCE onwards (Hartz 2011) was at first attributed to the close proximity to Neolithic farmers further south (Andersen 2010; Gebauer 1995; Stilborg and Holm 2009), but was also taken as one of the typical attributes of a complex forager society. Hunter-gatherer pottery is thought to appear in contexts with aquatic resources and to be associated with delayed-return economies, storage, prestige mechanisms, hierarchies, sedentariness, territoriality and resource ownership (Hommel 2014; Jordan and Zvelebil 2009). Based on the fact that there is pottery in the EBC, together with a preference for coastal localities and resources (Rowley-Conwy 1983), all traits mentioned were assumed to be present as well. In general, EBC pottery is well researched regarding technology, typology (Andersen 2008; 2010; Tranekjer 2013) and vessel contents (*e.g.* Courel *et al.* 2020). Given the typical S-shaped form with a pointed bottom and its similarity to Eastern Baltic ceramic traditions, together with recent chronological studies, it has been established that EBC ceramics were probably inspired by Eastern Baltic hunter-gatherers (Piezonka 2015; Povlsen 2013).

Yet, neither the reasons behind the adoption of ceramic technology nor its impact on Mesolithic life have played an important role in research until recently, and neither has the connection of Mesolithic ceramics to the Neolithisation process. This paper addresses these issues by focusing on the questions of why pottery was introduced in the EBC, how its use and production changed mobility patterns, settlement strategies and resource preferences and how these changes might relate to the Neolithisation process long before the actual transition phase around 4000 BCE.

Materials and methods

The research presented here is the result of the author's PhD project "Frühe Keramik im Ostseeraum. Die Rolle binnenländischer Ertebølle-Plätze bei der Einführung von Keramik und der Neolithisierung in Norddeutschland und Südskandinavien" (Early pottery in the Baltic – The role of Ertebølle inland sites in the introduction of pottery and the Neolithisation

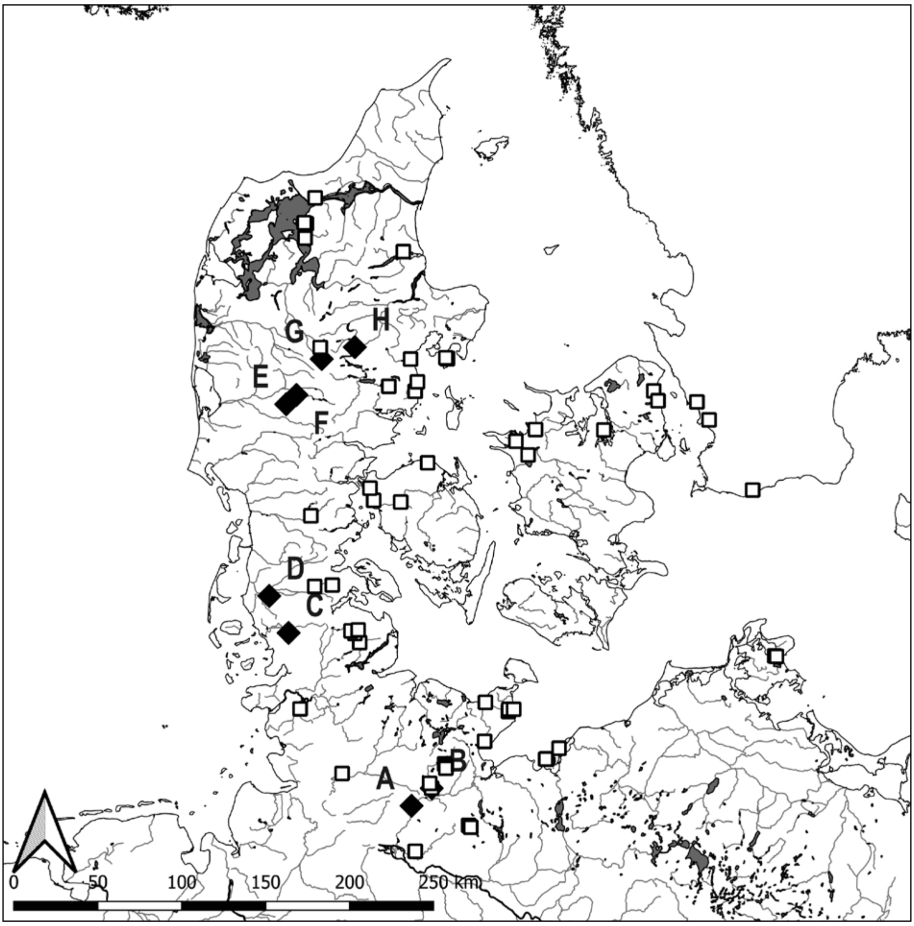

Figure 1. Map of processed assemblages (A Kayhude LA 08; B Schlamersdorf LA 15; C Bargum LA 07; D Aventoft LA 06; E Blåkær; F Enggaard II; G Dværgebakke P-plads; H Sminge Sø III) and comparison sites.

in northern Germany and southern Scandinavia) (University of Hamburg 2020), which addressed the topic of EBC settlement systems with special emphasis on formerly neglected inland sites and the introduction of pottery technology and its consequences in regards to settlement patterns, subsistence, and social and cultural aspects.

To this end, eight inland and west coast flint and ceramic assemblages of Schleswig-Holstein and Jutland were typologically and technologically analysed and then compared to a large body of coastal and inland material available through literature (fig. 1). The analyses followed the approach of Hartz (1999) and Lübke (2000) and included all flint artefact categories. Similar specifications (Glykou 2016) were applied to the processing of ceramics. The analyses aimed at a comprehensive picture of individual site activities and settlement intensity, which is why both ceramics and flint have to be taken into account for each site in question, since different uses and functions of pottery assemblages can only be determined in connection to other site activities mirrored within flint inventories.

The published assemblages used for comparison included coastal and inland sites of all types in northern Germany and Jutland (fig. 1). All sites were examined for features, location, and topographical aspects. Where possible, ^{14}C- and AMS-dating were taken into consideration, as well as analyses of the faunal assemblages.

Differences in excavation methods and the total areas uncovered (*e.g.* settlement sites proper vs. waste deposits) needed to be taken into account to avoid bias in the interpretation. Additionally, different approaches to flint and ceramic finds used by various authors complicated a coherent analysis for individual sites. For the further interpretive analyses of the role of pottery, a complex contextual analysis of ceramic finds was employed, focusing on archaeological context, vessel contents (if available through publications and previous analyses), technological choices and performance characteristics as well as the chronological development of the EBC.

To expand the interpretation beyond tangible vessel properties, methods from behavioural archaeology (Schiffer 2011) and entanglement theory (Hodder 2016) were combined and applied to investigate the life history and the behavioural chain behind vessel production and use.

Behavioural archaeology is concerned with the function of objects, which can encompass mere technological properties but also social, ideological, or emotive functions. In this respect, technological choices (Lemonnier 1993; Schiffer 2011) visible on the archaeological material were used to determine the performance characteristics and various functions of the pottery, which also helped to identify possible reasons for the adoption of the technology (Schiffer 2011, 141). Additionally, the finds were examined for properties associated with social/prestige functions (*e.g.* visible qualities, special treatments, decorations, or formal attributes) (Schiffer 2011, 104). To further determine the role of EBC pottery within daily Mesolithic life, a so-called behavioural chain encompassing all relevant activities during the manufacture, use and discard of a vessel was generated, as well as a life history diagram displaying the five general processes of sourcing, manufacturing, use, repair/maintenance and discard (Schiffer 1995, 26–28, fig. 2.1; Schiffer 2011, 30–31).

Generally, the adoption and use of a technology can lead to manifold (and partly unintended) consequences, which are strongly connected to the concept of object agency, meaning the potential influence of an object on its environment (Bernbeck and Burmeister 2017, 8; Lemonnier 1993, 7; Schiffer 2011, 141). Similarly, entanglement theory as defined by Hodder (2011; 2016) explores the relationships between humans and things and the (positive) dependences and (negative) dependencies authored by the manifold connections between them. A growing entanglement in the sense of a growing network of mutual relationships between people and objects (or resources, practices etc.) can create so-called entrapment mechanisms, meaning increasing dependencies on certain objects or activities because people invest time or resources in them, and they become increasingly dependent when the object or activity in question demands constant reproduction or maintenance in order to protect said investments. This also means that small changes within the entanglement network can result in far-reaching consequences (Hodder 2011; 163; 2016, 14).

To visualise the connections of and around EBC vessels, an entanglement analysis in the form of a network analysis was used, based on the concept by Hodder (2011; 2016). The elements in the network were identified in the analyses described above

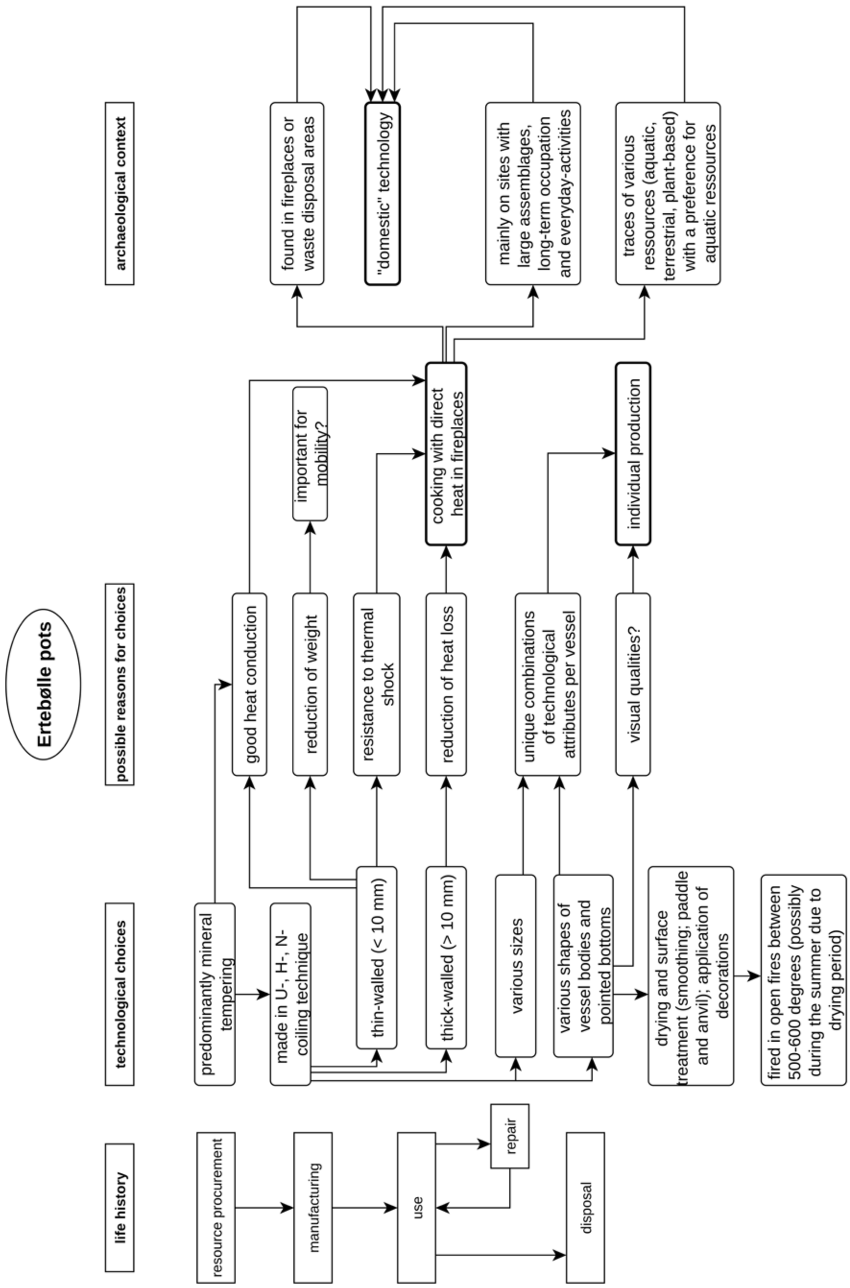

Figure 2. Properties and life history diagram of EBC pottery.

and represent either practices, objects/materials, activities, or locations connected to vessel use and production. However, the nodes in the network do not represent any sort of hierarchy between different actors in the network, nor do the connections between them mirror temporal sequences (as would be the case in a behavioural chain). The connections between the nodes can either be mutual or unilateral, which makes it possible to determine degree centrality (the number of connections a single node has) and betweenness centrality (the number of times a node lies on the shortest path

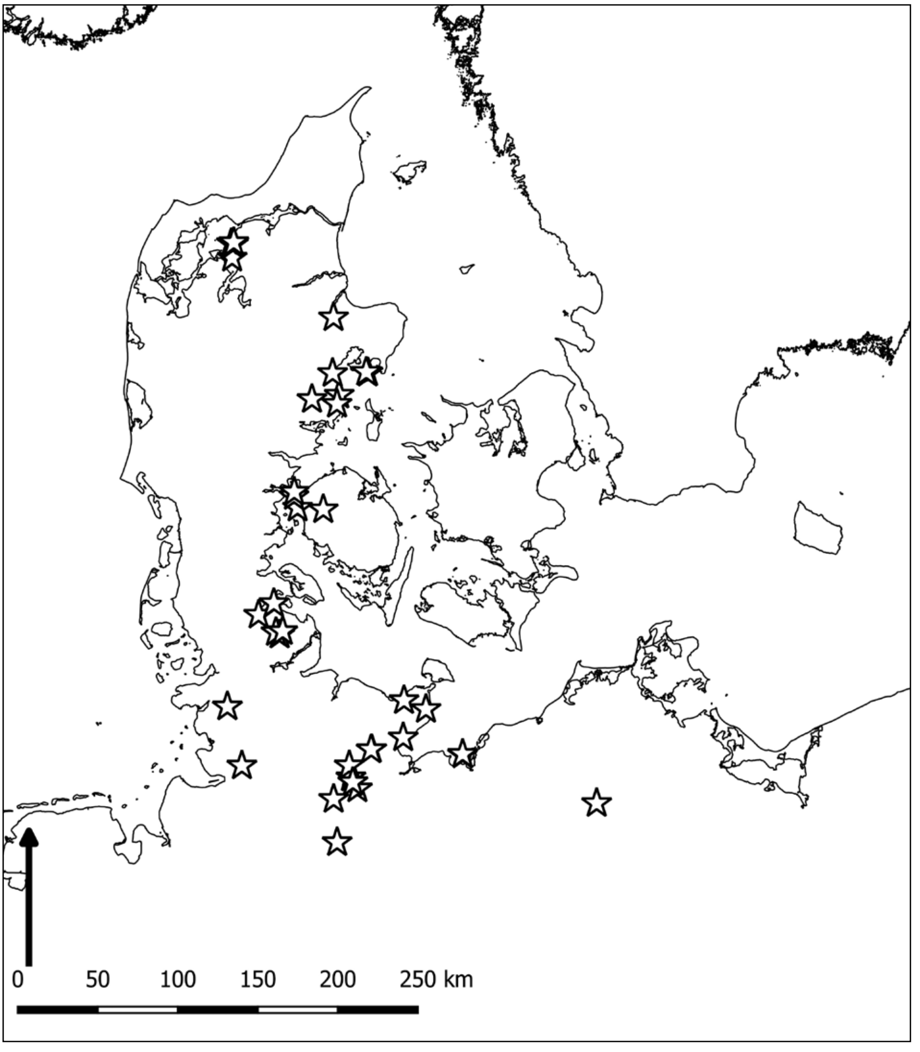

Figure 3. Map of sites with pottery in Schleswig-Holstein and Jutland (excerpt from fig. 1).

between two others). Contrary to a classical (social) network analysis, an entanglement network is not looking to create an abstract image of a complex system but is concerned with the nature of relationships between the nodes, while presupposing those relationships are present. There is no chronological depth or hierarchy between nodes included. It is thus aiming to visualise qualitative findings rather than also providing a quantitative interpretation, which makes the betweenness centrality values of greater importance than those measured for degree centrality, since betweenness centrality will reflect nodes with a high grade of entanglement. It also has to be kept in mind that the choices to include the nodes in question are based on the author's interpretation of the archaeological record and thus do not claim to represent "absolute" findings, but rather represent a visualisation of the findings of the EBC context analysis.

	Possible advantages of ceramic technology	Pro +/contra – in the EBC context
Practical advantages	„multi-tasking“ while cooking is possible simplified processing of „small“ resources (fish, shellfish)	- similar resources were used already before + possible intensification through simplified processing
	quicker/simpler production in contrast to textile vessels (better cost-benefit-ratio)	+ equals „technological investment model“ (Sturm *et al.* 2016), fits ecological background of the Mesolithic
	less time and material investments in contrast to using cooking stones (per the behavioural chain analysis)	- older cooking technologies are not well researched
	one vessel can be used for processing various resources	- not enough data to compare with older cooking technologies
	cooking temperatures can be controlled better (*e.g.* for oil processing)	- pots are not directly associated with oil production, since it cannot be determined if blubber/oils were processed in the pots or used for cooking
	storage is possible	- no evidence of a connection between pots and storage
Prestige and social status	preparation and presentation of large amounts of food is possible (*e.g.* feasting, potlatch) surplus production	- no evidence + various vessel sizes and types hint at different functions
	Preparation of „special“ foods or drinks (alcohol, oil, blubber)	- no evidence of an exclusive connection between vessels and potentially special resources

Table 1. Summary of the possible advantages of using ceramic vessels correlated to the archaeological record of the EBC.

Properties of EBC pottery and possible reasons for the adoption of pottery technology

Fig. 2 sums up the properties and life history of EBC pottery as they became apparent in the analysis. The archaeological record mirrors mainly the domestic character of the technology, with vessels appearing at long-term settlements with medium-sized or large assemblages (determined by settlement size and duration, stratigraphy and overall (flint) find numbers reaching amounts >10.000), often highly fragmented in waste disposal areas or the fireplaces and other places of use (fig. 3).

There are exceptions to this, but very little pottery is known from so-called activity or functional sites (*e.g.* in Dyngby III (Andersen 2004) or Rønbjerg Strandvolde (Skousen 1998)). Only one site is known where a pot was recovered in close vicinity to a burial (Asing 2000), and the connection between these two features is doubtful. Additionally, two pots from Maglelyng, Zealand, might be connected to a ritual deposition, but the context remains unclear (Koch 1998, 157–158). There are no definite indications that pots were used for long-term storage (no clear caches, no lids *etc.*), and also very few to no direct indications that pottery was used within the context of prestige or status (very little decoration, no clear association with “prestige” goods or depositions *etc.*). It can thus be concluded that most ceramics functioned as very effective cooking pots, which could be used for various (small sized) resources (see below).

Similarly, the practical advantages of using ceramic vessels exceed those concerned with prestige as possible reasons for the adoption of the technology (tab. 1).

In general, there is little evidence of changes in resource preferences after the adoption of pottery (Andersen 2011, 209). Similarly, the use of cooking and hearth pits (*e.g.* Andersen and Johansen 1986; Andersen 1991) still continues, contrary to what is known from the

Swifterbant Culture (Raemaekers 2014, 809–810). Even though older Late Mesolithic cooking technologies are not well researched, pottery might have yielded a larger return rate because it could have been manufactured easily within the climatic and environmental conditions of the EBC (Sturm *et al.* 2016), while at the same time representing a more efficient way of processing a broad spectrum of (already known) seasonally available or "small-sized" resources, such as mussels, fish, nuts, berries, and plants. Additionally, ceramic containers might have simplified the rendering of oils and fat due to easy temperature and heating control, even though pottery is not essential for this process (Gjesfeld 2019, 95; Spray 2002, 28–29) and there is no direct evidence for this kind of use in the EBC. Definite evidence for storage in pots is also missing, and it is clear that preservation techniques without the use of vessels were present from beginning of the Mesolithic (Boethius 2016; Holst 2014).

Regarding prestige, pottery is often associated with potlatch ceremonies or feasting (Hayden 2009). For this, the usually small number of vessels per site and the different vessel sizes might be important, since it is possible that small pots might have served as drinking/serving bowls. Yet, a definite connection to "special" resources (Courel *et al.* 2020) or definite proof for seasonal gatherings is absent, even though pots could in theory have been used to generate surplus and in the context of potlatch and feasting.

So far, EBC pottery can thus mainly be connected to its domestic function, but it is possible that the very first pots were made for social reasons and only later became a widely available product. To prove this, more data from the oldest pottery horizon is needed, which is not currently represented in the archaeological record. The quick spread of pottery within northern Germany and southern Scandinavia is proof of the usefulness and compatibility of the technology with the existing cultural and material network of the Final Mesolithic.

The impact and consequences of the adoption of pottery technology on Mesolithic life

The following considerations are consistent with the archaeological data as it became apparent in context analysis, and they aim at creating an alternative model of pottery function in the EBC. The impact and consequences of the technology are well illustrated by correlating major developments with the chronological timeline (fig. 4).

From 4500 BCE onwards, the archaeological record shows an intensified use of coastal areas and resources in the form of more and larger settlements (Andersen 1995; 2000) and the appearance of sites with exceptionally large assemblages (Hartz 1999), which follows the earliest appearance of pottery. Similarly, the typical flint tool types of the EBC, such as blade scrapers, flake axes and concave end retouched blades, appear at coastal sites in the ceramic phase (Hartz and Lübke 2005) and become more differentiated and focussed on aquatic exploitation during the following periods. The same applies to fishing tools (Andersen 1995), which all become standardised following the onset of the ceramic EBC.

Generally, pottery manufacture might clash with highly mobile settlement strategies, since freshly made vessels require a longer drying period before firing, during which they cannot be transported. This is also the reason why it is generally assumed that pottery was made during the summer (*e.g.* Povlsen 2013), as the warmer, yet moist climate of the Final Mesolithic would have prolonged drying times during the winter. It stands to reason that EBC ceramics either did not upset mobility patterns or that these were adjusted,

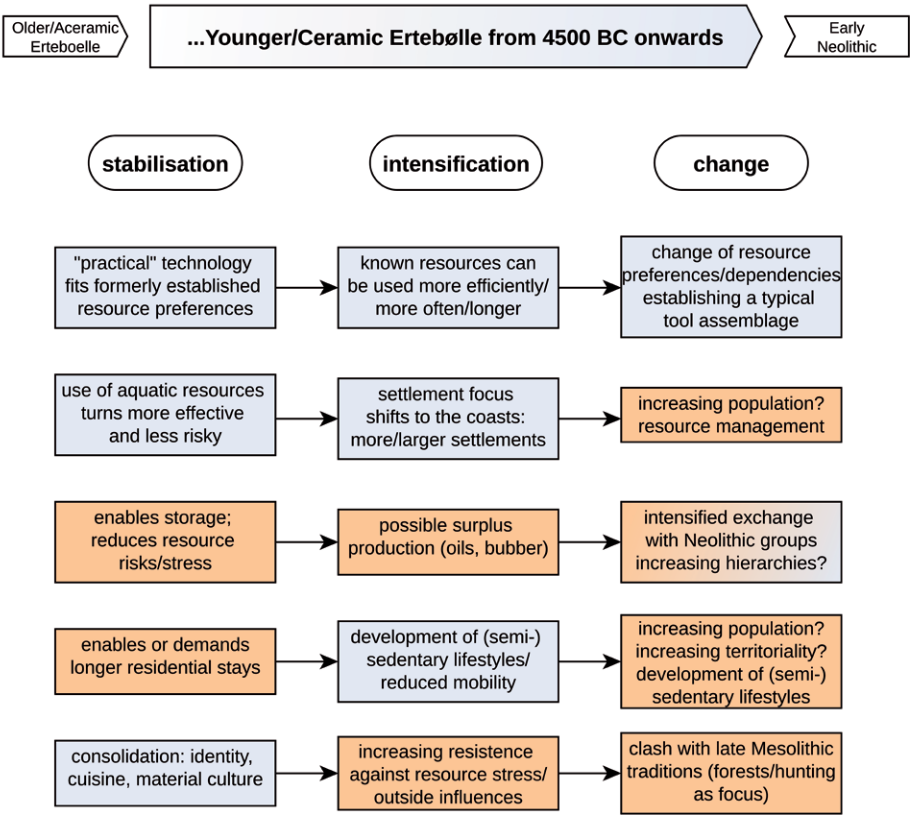

Figure 4. Summary of developments and changes during the EBC (blue: correlates with the archaeological record; orange: no direct archaeological evidence).

since the pots yielded a large return rate, making this investment less costly. If the latter is connected to specific resources or areas, it will likely result in a shift towards those, together with increased settlement permanence.

If pottery enabled this semi-permanent settlement strategy, it would have created dependence on the resources in question and on the technologies necessary to exploit them. In consequence, this might have led to territoriality or resource management, characteristics that are assumed to be typical for the Late EBC. There are indeed hints at regionally varying fishing preferences (Ritchie 2010), which might mirror group-related claims on specific resources, and traces of maintenance-intensive "permanent" structures such as fish weirs that were considered group or individual property (Maring and Riede 2019, 23). Similarly, the demand for wood seems to have resulted in specific plant management strategies (Klooß 2015). Resource management and territoriality are traits of complex hunter-gatherers and are associated with social hierarchies. However, evidence for increased social inequalities within the EBC in the form of "special" burials or housing structures is mostly absent (Price and Gebauer 2005, 146–148), and it is the same for pottery (see above), even though the potential surplus production and the "special" products associated with it could have been the means to gain prestige, *e.g.* via trade. The

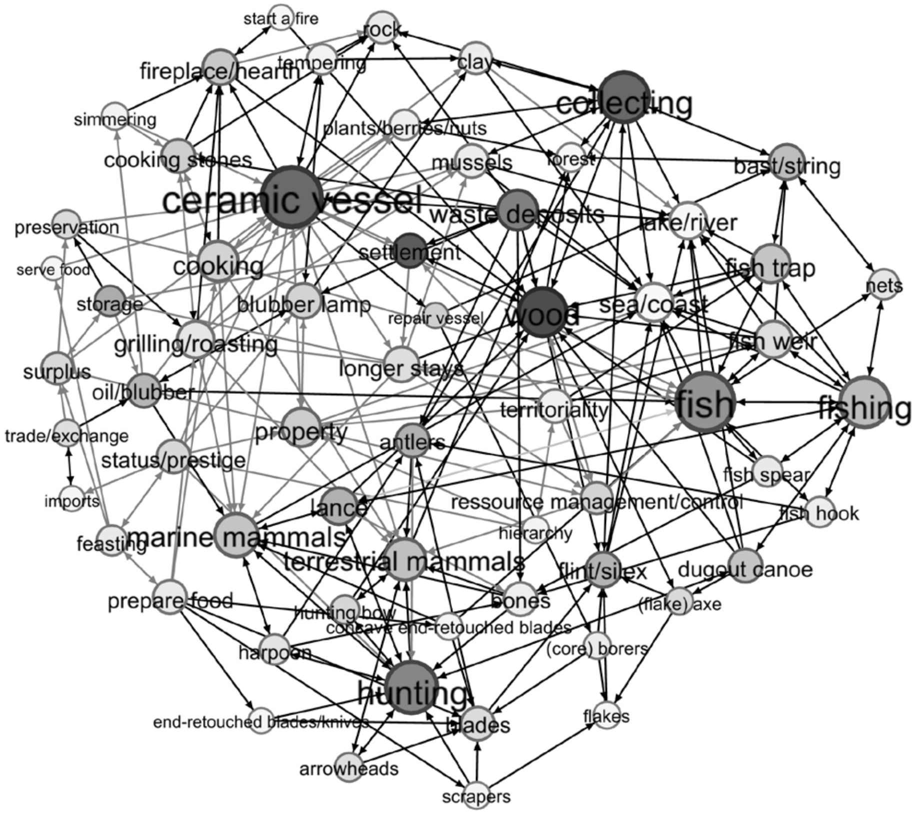

Figure 5. Network analysis of EBC ceramics. Arrows read as "is dependent on" (dark arrows: connection is archaeologically established; light arrows: connection has no direct proof). The size of the nodes depicts degree-centrality (count of single connections; big node: high degree), the colours depict betweenness-centrality (the number of times a node lies on the shortest path between two others; dark colours: high betweenness-centrality).

influx of Neolithic objects from the south during the Late EBC might indirectly be connected to this (Klassen 2004), since foreign objects are generally interpreted as prestigious items because of their exclusiveness and exotic qualities (*e.g.* Fischer 2002).

In addition to these "catalyst" effects, pottery could also have been disruptive to Late Mesolithic systems of tradition and values. These are characterised by predominantly "terrestrial" symbols and objects, which is obvious at burial sites (*e.g.* Albrethsen and Brinch Petersen 1977; Brinch Petersen 1990; Brinch Petersen *et al.* 1993; Price *et al.* 2007) and hints at the symbolic importance of (terrestrial) hunting, a worldwide phenomenon known from Mesolithic and Neolithic communities (Hamilakis 2003; Hodder 2016). With the shift towards the coasts, it is likely that marine hunting or fishing may have gained greater importance in everyday subsistence than these (Ritchie 2010, 201–202), thus causing the break-up of old status patterns within the EBC and leading to conflict and the building of new hierarchies and compensation activities, such as the acquisition of new and potentially exotic technologies/objects, as are mirrored in the Neolithic imported objects (Klassen 2004). With these might have come new and object-centered mechanisms to gain prestige. Similarly, new technologies often change structures of identity (Frink 2009, 283), which might have impacted the EBC's concepts of group identity, personal property (see also Anderson 2019, 139) and cuisine (Isaakson *et al.* 2019).

To visualise the findings outlined above, all connections between EBC vessels and relevant objects, practices, environments, and resources apparent in the archaeological record were included in an entanglement network (fig. 5).

The result shows that pottery affected many aspects of EBC life and belongs to one of the most central nodes as depicted by the centrality scores, controlling many direct and indirect connections to other nodes. Similar values are represented by "wood", "collecting", "hunting" and "fish"/"fishing", all aspects that have already previously been established as very important to the EBC. The analysis thus visualises the entanglement created around a single technology and hints at the increasing dependence on the technology itself and on the resources and practices (indirectly) connected to it. What is more, an increased entanglement means increased entrapment and the impossibility of removing the node in question without destroying the overall network, thus causing even more reliance on, and investment into, it (Hodder 2016, 91 and 103–105).

Conclusion: Pottery as consolidation and as an "agent of change"

The picture emerging from this analysis is that of ceramic technology as one of the most important aspects for the development of the younger EBC. The technology is linked to many aspects of daily Mesolithic life, even if only indirectly. Following the argument of Hodder (2016), that increasing investments into a technology cause increasing dependence or entrapment, a massive change or even its removal from the material network of the EBC would have been disastrous, since the disruption would also affect subsistence patterns as well as hunting and settlement strategies. The same is true, of course, for any disruption or change in the other direction. Instead, entanglement networks develop a tendency to expand, especially when new objects or practices are added to the network, either as additions or replacements, which is a mechanism Hodder (2011; 2016) uses to explain the initial Neolithisation process in the Near East.

In the case of the EBC, pottery seems to have created a "positive feedback loop" (Jordan and Gibbs 2019, 4), which helped to fuel the emerging cultural trends of the Late Mesolithic while at the same time preparing the way for the transformation towards the typical "classic" late EBC and, eventually, the Early Neolithic. This feedback becomes visible in the form of a stabilisation and long-term intensification of previously established settlement and subsistence preferences, which created a stable foraging society with a pronounced and recognisable identity. Furthermore, the developments visible after the introduction of pottery can all be connected to the typical elements of "complex" foragers (Ames 2014), who are seen as either "predestined" to become "Neolithic" or very resistant against Neolithisation processes (Finlayson and Warren 2010; Kienlin 2006).

This is especially important because the beginning of the Neolithic is characterised by both long-lasting continuities and rather abrupt changes. Continuities include flint and pottery manufacturing technologies and the use of coastal and freshwater sites and resources, whereas change is represented by new settlement localities, new vessel shapes and flint tool types as well as the introduction of domesticated resources (see Gron and Sørensen 2018 for an overview). These differences are nowadays explained by theories of migrating farmers replacing local forager groups in regionally varying interaction processes (Gron and Sørensen 2018), while aDNA studies point towards "Mesolithic" people continuing to exist during the Early Neolithic (Jensen *et al.* 2019; Kashuba *et al.* 2019).

In regard to the entanglement network, the changes in question would present themselves as additions to the network before finally replacing some "older" nodes. Based on the observations described above, it could well be that the social, cultural, and economic changes brought about after the introduction of ceramic technology paved the way for the eventual assimilation of new subsistence strategies and Neolithic migration. Especially the intensified contacts with Neolithic groups would have been important for this, since the marine lifestyle of the EBC potentially produced many desirable trading goods on which this intensified contact was surely based. Similarly, "complex" foragers have much more in common with early Neolithic societies in regard to semi-sedentariness, resource management or social organisation, and thus it stands to reason that the eventual assimilation of Neolithic practices and modes of subsistence represented a smaller obstacle to these than they would to highly mobile groups with a different social and cultural background. Since the development towards a more complex society can also be linked to the use of pottery, the "positive feedback loop" quality of the technology (see above) becomes even more apparent.

Still, it has to be kept in mind that this is in no way an inevitable development, but rather the result of choices and changes going on for decades before the actual transition phase. In the context in question, EBC pottery worked as an "agent of change" within the entangled interplay of benefits of, and an increasing dependency on, the technology and thus helped enable the developments during the younger EBC and towards the early Neolithic as they are perceived archaeologically. However, pottery is not solely responsible for this, but only functioned in this way in the given ecological, climatic, and cultural context of the EBC. Yet a new understanding of this innovation as a trailblazer for other, even more consequential innovations also changes the view of the beginning of the Neolithisation process in general, because it shifts the focus to the agency of hunter-gatherer groups and the consequences (intended or not) of their decisions, long before actual "Neolithic" elements actually appear in the archaeological record.

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Changing diet in a changing world

Bente Philippsen

Abstract

One of the most fundamental interactions between people and landscape is through food. How food is obtained, which kinds of food are eaten, and the way food is prepared are important parts of human identity. The transition from foraging to farming (from the Mesolithic to the Neolithic in the case of Danish prehistory) can thus be regarded as one of the most profound changes in human history.

The problem of change or continuity of diet during the Mesolithic-Neolithic transition has been debated vigorously over the past decades, with a focus on the question of whether aquatic resources continued to be exploited in the Neolithic. Different methods from archaeology and the natural sciences have come to different conclusions, based on different data and sample materials, which reflect different aspects and time scales of the prehistoric economy.

In this study, I will show how analyses of bones and pottery can add to our understanding of the complex dietary situation during the Neolithisation, when hunting, fishing and gathering was practised at the same time as dairy husbandry and cereal agriculture. I will place the results of the Femern project into their south Scandinavian context and discuss how cultural identity may be reflected in the foods produced and eaten by different groups at the time around 4000 BCE.

Femern project; diet; food; Neolithisation; pottery

Introduction

One of the most fundamental interactions between people and landscape is through food. People depend on the resources that are provided by their environment. At the same time, people influence the environment by their actions, through hunting, fishing, gathering and of course more fundamentally through agriculture. How food is obtained, what kinds of food are eaten, and the way food is prepared are important parts of human identity. The transition from foraging to farming can thus be regarded as one of

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the most profound changes in human history. This is the case for all societies where such transitions occur, regardless of when or where in the world this happens. In the case of Danish prehistory, the introduction of agriculture is the most important aspect of the shift from the Mesolithic to the Neolithic.

The problem of change or continuity of diet at the Mesolithic-Neolithic transition in northwest Europe, especially Britain and Denmark, has been debated vigorously during the past decades, with a focus on the question of whether aquatic resources continued to be exploited in the Neolithic (Barberena and Borrero 2004; Blankholm 2008; Fischer 2007; Fischer *et al.* 2007; Hedges 2004; Lubell *et al.* 1994; Milner *et al.* 2004; 2006; 2007; Richards and Schulting 2006; Richards and Hedges 1999; Richards *et al.* 2003; Schulting and Richards 2002; Tauber 1981b; 1981a; 1983; Villotte *et al.* 2014). Different archaeological and bioarchaeological methods have exposed the various aspects of the economy, diet and cuisine. Each specialized discipline can only analyse certain datasets and can come to different conclusions than other methodologies that focus on different sample materials, datasets, geographical areas or timescales. Therefore, the apparently contradictory conclusions of different studies actually show the overall variability of diet during the Neolithisation.

In this study, I will show how analyses of bones and pottery can add to our understanding of the complex dietary situation during the Neolithisation and explore the relationship between hunting, fishing and gathering with dairy husbandry and cereal agriculture. I will put the results of the Femern project into their south Scandinavian context and discuss how cultural identity may be reflected in the foods produced and eaten by different groups in the time around 4000 BCE.

This study focuses on two groups of finds. Firstly, I will present stable isotope measurements on animal bones and on wood, as they can be regarded as proxies for the stable isotope values of the food that was prepared and consumed at these sites. Secondly, I will summarize isotopic and biomolecular analyses of ceramic sherds. This includes analyses of food crusts on the sherds, which most probably are dominated by the last cooking event, as well as analyses of the ceramic matrix, which contains biomolecules absorbed during earlier cooking events.

Lipid analysis can pick out individual compounds that are indicative of individual ingredients, which might be overlooked by bulk stable isotope analysis. On the other hand, bulk stable isotope analysis identifies the ingredients that contributed most to the food crust. An additional advantage is that bulk stable isotope analysis uses the same sample material as radiocarbon dating, so this method is ideal for predicting reservoir effects in food crusts.

Stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$)

Ideally, we would measure isotope ratios of all the ingredients that were available in prehistory in order to reconstruct the meals prepared in the analysed pottery. This is impossible for several reasons: In the case of plant foods, the only materials available for analysis are wood and hazelnut shells – and not the edible parts of the plants. In the case of animal food, only the bones are preserved. Therefore, we have to use the available material, informed by analyses on modern reference samples, as proxies for the Stone Age food resources.

Modern reference samples are only useful to a limited extent because of anthropogenic effects that distort the $\delta^{13}C$ and $\delta^{15}N$ values, such as the Suess effect (decreasing $\delta^{13}C$ values due to combustion of fossil fuels) or modern agriculture with intense manuring, either with animal manure (increasing $\delta^{15}N$ values) or with chemical fertilizers (decreasing $\delta^{15}N$ values), as well as heated greenhouses (decreasing $\delta^{13}C$ values). Modern land-use practices can also have altered the environment to such a degree that plants growing "wild" and unmanaged today will have different isotope values than their Stone Age counterparts. This can also be the case for wild animals, *e.g.* a wild boar that, although shot in a forest, had fed mainly on maize, a C4 plant (Philippsen 2012, 123).

$\delta^{13}C$ values of plants and wood samples

The $\delta^{13}C$ values of wood (trunk, branches and roots) are consistently more enriched than those of the leaves (Li and Zhu 2011), which would have been used *e.g.* as leaf fodder for cattle. Therefore, we cannot use wood $\delta^{13}C$ values directly to reconstruct the $\delta^{13}C$ values of the plant food. In addition, there are no preserved remains of the plant food that was actually consumed by people, such as leafy vegetables, fruits, berries, nuts, roots and tubers. Mushrooms, although more closely related to animals than to plants, can be included here as well: we only have some samples of tinder fungus, but no finds of edible mushrooms.

The wood $\delta^{13}C$ values, however, can be used to explore the variability one has to expect at the base of the food chain (Philippsen *et al.* 2019). While the absolute values might not be directly comparable, the broad ranges found in the wood samples can also be expected in other parts of the plants.

$\delta^{13}C$ values in dense forests are generally lower than in more open landscapes. The CO_2 from decaying organic material has $\delta^{13}C$ ratios comparable to that of the organic material. As about 99% of the organic matter produced in a forest is returned to the atmosphere as CO_2, the air in a dense forest is enriched by CO_2 from decaying plants, which has $\delta^{13}C$ values close to those of the plants (around -25‰), and thus lower than the atmosphere's -7‰. This so-called canopy effect is most pronounced in leaves growing closer to the ground. It can shift $\delta^{13}C$ ratios by *c.* 3‰ to 5‰ (Medina and Minchin 1980; Vogel 1978), which means that about 15% of the carbon in leaves growing close to the ground is derived from decaying organic matter (Vogel 1978). Other physiological causes have been suggested, such as altered fractionation due to photosynthesis in low light or nutrient deficiency.

This can also lead to lower $\delta^{13}C$ values along the food chain to forest and even aquatic fauna (Francey and Farquhar 1982; van der Merwe and Medina 1991), for example in the bones of herbivores that mainly browsed in forests. Thus, the canopy effect has been suggested as an explanation for the fact that aurochs in Denmark tend to have lower $\delta^{13}C$ values than contemporaneous domesticated cattle (Noe-Nygård and Hede 2006). However, the forests have to be very dense in order to result in a measurable canopy effect (Drucker *et al.* 2008). In the case of ^{14}C concentrations, the canopy effect is less important for prehistoric samples, as most of the carbon is recycled shortly after the formation of the primary plant matter. However, it can be an issue in modern reference samples, as *e.g.* leaves growing next to a motorway were found to have ^{14}C-concentrations up to 9% lower than the atmosphere (Münnich 1961).

$\delta^{13}C$ and $\delta^{15}N$ values of animal bones

In addition to the above-mentioned canopy effect, other aspects can influence the $\delta^{13}C$ values of animal bones. The main factor in Danish Stone Age research is the proportion of marine versus terrestrial resources. The difference between C3 and C4 photosynthetic pathways is irrelevant, as C4 plants do not occur naturally in relevant numbers and domesticates such as millet are only introduced later. Only few edible C4 plants are native to northern Europe, such as purslane (*Portulaca oleracea*). The C3 cycle is particularly suited to wet and mesophytic environments (Browman 1981) and C3 plants are preferred by herbivores because they are easier to digest.

There is a $\delta^{13}C$ fractionation of about 5‰ from plant food to animal bone collagen and generally less than 1‰ per subsequent trophic level (Katzenberg *et al.* 2000; Lanting and van der Plicht 1998; Schoeninger and DeNiro 1984). The $\delta^{13}C$ values in bone collagen reflect the $\delta^{13}C$ values of the protein component of the diet, especially in the case of protein-rich diets, but depend also on the amount of protein in the diet and on the difference in the $\delta^{13}C$ values of protein and non-protein fractions (van Strydonck *et al.* 2009).

$\delta^{15}N$ values mainly reflect the animal's trophic level (Ambrose 2001; Schoeninger and DeNiro 1984; Schoeninger *et al.* 1983) but can also be influenced by physiological and environmental factors (Knowles and Blackburn 1993). For example, it has been observed that horses from Neolithic contexts had lower $\delta^{15}N$ values than other contemporary herbivores (Klassen *et al.* 2023; Stevens *et al.* 2010). This could be caused by differences in habitat/diet (*e.g.* horses browsing on trees), or physiology (non-ruminant vs. ruminant). A similar effect, horses having lower $\delta^{15}N$ values than other animals, has already been observed for a Middle Pleistocene context (Kuitems *et al.* 2015, Table 3), so it could be a general characteristic of the physiology or diet of Equidae.

Some factors, such as those caused by aridity, are not relevant for Denmark and will not be discussed further here. Fertilizing grassland or crops with animal manure can result in $\delta^{15}N$ increases by about one trophic level, or *c.* 3.5‰ (Bogaard *et al.* 2013; Fraser *et al.* 2011). This increase will be transferred to increased $\delta^{15}N$ values in herbivore bone collagen. When under the control of humans, increased $\delta^{15}N$ values can be caused by a different mechanism. The animals can have more "omnivorous" feeding patterns, including *e.g.* pondweed or human food refuse (Bonsall *et al.* 1997; Schwarcz 1991).

$\delta^{13}C$ and $\delta^{15}N$ values of food crusts on pottery

There are large differences between the $\delta^{13}C$ values of bone collagen and of the other edible parts of the animal, with differences of 1.5 to 4‰ between fish flesh and bone collagen (Katzenberg *et al.* 1995; Lanting and van der Plicht 1998), or of more than 7‰ between bone collagen and body fat in an ungulate (Browman 1981). Fat is generally depleted in $\delta^{13}C$ when compared to lean meat (Bonsall *et al.* 1997; DeNiro and Epstein 1976; Parker 1964). Therefore, isotope values between bone collagen and food crusts are not directly comparable.

Fully terrestrial samples have isotope ratios of $\delta^{13}C$=-29 to -26‰ and $\delta^{15}N$=2.5 to 6‰.

Fully marine samples have $\delta^{13}C$=-18 to -15‰ and $\delta^{15}N$ around 10‰ or higher (Philippsen 2012, and references therein). Most food crust samples would be expected to lie on a mixing line between fully terrestrial and fully marine. Values outside of the mixing line are most probably caused by mixtures of ingredients with different carbon and nitrogen concentrations. For example, a mixture of protein-rich terrestrial food with lipid-rich marine food would result in a value below the mixing line.

The effect of heating (such as boiling or roasting) or fermentation on the isotope values is small and no systematic fractionation effects have been observed (Abonyi 1993; Bonsall *et al.* 1997; Boudin *et al.* 2009; DeNiro and Hastorf 1985; Hastorf and DeNiro 1985; Katzenberg *et al.* 2000; Marino and DeNiro 1987; Privat *et al.* 2005).

Lipid analysis

Lipids absorbed in the ceramic matrix are protected from degradation and contamination and are thus regarded as an ideal sample material (Heron *et al.* 1991). There is a long tradition for fatty acid analysis of prehistoric samples (Chapman and Plenderleith 1926; Charters *et al.* 1993; Condamin *et al.* 1976; Evershed 2008; Evershed *et al.* 2001; Formenti and Condamin 1978; Isaksson 1997; Olsson 2003; Olsson and Isaksson 2008; Mathiassen 1935; Mottram *et al.* 1999; Plant 1879; Rottländer 1985; 1990; Rottländer and Blume 1980; Rottländer and Schlichtherle 1980; 1983; Van Diest 1981). Certain fatty acids are indicative of heated fish oil (Hansel *et al.* 2004) and are thus direct evidence for the preparation of marine food.

In the early 2000's, preparative capillary gas chromatography (PCGC) was used to isolate individual fatty acids from absorbed lipid residues (Copley *et al.* 2003; Stott *et al.* 2001; 2003). The $C_{16:0}$ and $C_{18:0}$ fatty acids are targeted here, as they are the most abundant fatty acids (Berstan *et al.* 2008). In addition to radiocarbon dating, these fatty acids can also be used for $\delta^{13}C$ analysis. The $\delta^{13}C$ values of the $C_{16:0}$ and $C_{18:0}$ fatty acids, and especially the difference between the two, termed $\Delta^{13}C$, indicate the presence of dairy fat and groups the lipid residues into marine, non-ruminant adipose, ruminant adipose and ruminant dairy (Copley *et al.* 2003; Dudd and Evershed 1998; Mukherjee *et al.* 2005). The above-mentioned canopy effect would also lead to lower $\delta^{13}C$ values of the fatty acids, but the $\Delta^{13}C$ values would be unaffected (Mukherjee *et al.* 2005).

Integrated pottery analysis

The most comprehensive cuisine reconstructions are obtained when the different methods are combined. Lipid analysis can pick out individual compounds that are indicative of individual ingredients, which might be overlooked by bulk stable isotope analysis. On the other hand, bulk stable isotope analysis identifies the ingredients that contributed most to the food crust. An additional advantage is that bulk stable isotope analysis uses the same sample material as radiocarbon dating, so this method is ideal for predicting reservoir effects in food crusts (because the carbon used for radiocarbon dating is the same, and thus from the same source(s), as the carbon used for bulk stable isotope analysis).

Food crusts are biased towards the final cooking events, while lipids absorbed in the clay matrix are only slowly replaced and show no strong signal of the final cooking (Miller *et al.* 2020).

Study site

An overview of the Femern project and descriptions of the individual sites is provided by Måge *et al.* (this volume). Here, I will summarize the main aspects of the sites considered in this study.

Surveys and rescue excavations prior to the construction of the Femern Belt Tunnel resulted in the discovery of numerous archaeological sites from the past 10000 years. This study focuses on sites discovered in an area of former sea floor, which had been diked after a storm surge in 1872. Culturally, these sites can be assigned to the Danish Mesolithic Ertebølle Culture (EBC) and the Neolithic Funnel Beaker Culture (TRB). They date to around 4000 BCE, a period that has traditionally been termed the Neolithisation of Denmark. The Stone Age coastal landscape changed continually, with ephemeral barrier islands forming temporary lagoons and shallow fjords. The sediments in the study area reflect the postglacial sea-level rise: glacial till with soil formation horizons is overlain by freshwater peat, then marine gyttja and finally marine-deposited sand (Bennike *et al.* 2022; Groß *et al.* 2018). The sites covered in this study comprise depositions and refuse areas in the shallow water, but no dry-land settlement remains or burial sites. While the preservation of organic remains is excellent, the dynamic coastal environment has caused those sites to be palimpsests of mixed and redeposited artefacts and ecofacts. There is no stratigraphical relation between the finds. Due to the continuous sea level rise, the same type of layer (*e.g.* freshwater peat or marine gyttja) formed at different times, depending on the site's elevation and distance from the shore. Only a few finds were still *in situ*, including fish weirs, stakes and artefacts stuck into the sea floor, while the sediments around them may have been eroded and re-deposited. It is therefore impossible to assign individual artefacts to a specific time period just by measuring their geographical position and elevation. A minor proportion of the ceramic sherds can be assigned to the EBC or one of the phases of the TRB. Apart from these, only directly dated samples can be considered when investigating changes of economy and diet over time. Radiocarbon dates of the different artefact groups are provided by Måge *et al.* (this volume). For example, the radiocarbon dates show that domesticated animals had already appeared before 4000 BCE, while fish weirs only gained in importance during the Middle Neolithic.

Here, I will present an overview of the isotopic and biomolecular data from the Femern project. A full analysis, including comparisons to data from other sites, will be published later (Philippsen *et al.* in prep.).

Materials

I include 130 radiocarbon dates of bones from the entire Femern project. These samples were selected because of their archaeological interest, not for palaeodietary reconstructions. All bones and bone artefacts had been deposited in the former sea floor. Some were food refuse thrown into the shallow water, others were placed deliberately at certain locations, such as a concentration of mandibles found within a circular structure of wooden stakes (*e.g.* Sørensen this volume).

As no burials were found, only four stray finds of human bones are available for the entire project. None of these dates to the Mesolithic. Therefore, we use stable isotope and lipid analyses of food crusts on pottery and ceramic sherds to reconstruct the cuisine rather than the long-term diet that would be reflected in the human bones.

Stable isotope values were obtained from 52 food crusts on pottery sherds from the sites of Syltholm II (MLF00906-I, MLF00906-II) and Syltholm XIII (MLF00939-I; cf. Måge *et al.* this volume). Food crusts adhering to two stone slabs thought to have a food preparation function (finds: X5486 and X9077) were analysed by GC-MS, as well as the food crusts on potsherds and sediment samples from putative cooking pits. Based on the results of the GC-MS analysis, six samples were selected for GC-C-IRMS analysis. These include one Ertebølle and five Funnel Beaker vessels. These data were published in Courel *et al.* (2020) and Cubas *et al.* (2020), respectively. In addition, Vasiliki Papakosta (Stockholm University) conducted lipid residue analysis on food crusts on nine Ertebølle potsherds (Papakosta *et al.* 2019).

Methods

Radiocarbon dating and stable isotope analysis of animal bones and food crusts

Collagen was extracted from bone samples according to the protocol by Longin (1971), with modifications by Brown *et al.* (1988) and Jørkov *et al.* (2007). All age determinations were performed by AMS by measuring the ratio of ^{14}C to ^{13}C atoms at the Aarhus AMS Centre, Department of Physics and Astronomy, Aarhus University. The ages are stated in conventional radiocarbon years BP and corrected for isotope fractionation by normalising to $\delta^{13}C$=-25‰ VPDB (Stuiver and Polach 1977). The radiocarbon ages are calibrated to calendar years before present (cal BP) using the IntCal20 calibration curve (Reimer *et al.* 2020). Marine samples are subject to a reservoir age, which can be estimated to be around 250 ^{14}C years for the study area and period (Philippsen 2018). This value is similar to the reservoir age of 273 ± 18 ^{14}C years reported for southern Kattegat in the Neolithisation period (Fischer and Olsen 2021). However, the reservoir age may have varied somewhat over the Holocene, and the ages of marine material are therefore more uncertain than the ages of terrestrial material (Olsen *et al.* 2009).

The $\delta^{13}C$ and $\delta^{15}N$ values of the bones were measured by isotope radio mass spectrometry (IRMS) at the Aarhus AMS Centre. The reported measurement uncertainties are 0.05 to 0.71‰ for $\delta^{13}C$ and 0.1 to 0.36‰ for $\delta^{15}N$. $\delta^{13}C$ and $\delta^{15}N$ values of food crusts were measured at the University of Bradford and the University of York.

Lipid analysis (GC-MS and GC-C-IRMS)

Food crusts and dried sediment samples were ground and extracted with a dichloromethane/methanol mixture (2:1 v/v). A measured amount of an internal standard was added to each sample before analysis to allow quantification and the samples were derivatised before analysis. Gas chromatography (GC) was used to check the lipid preservation and presence of contaminants. Based on the GC results, samples were selected for gas chromatography – mass spectrometry (GC-MS) analysis. GC-MS analysis was carried out on an Agilent 7890A series GC attached to an Agilent 5975C Inert XL mass selective detector. Based on the GC-MS results, samples were selected for isotopic analysis (GC-C-IRMS) of the $C_{16:0}$ and $C_{18:0}$ fatty acids (gas chromatography – combustion – isotope ratio mass spectrometry).

Results and discussion

Radiocarbon dating and stable isotope analysis of animal bones and bone artefacts

In total, 130 radiocarbon dated bone samples were analysed in this study. Not all dated samples were large enough to allow for stable isotope (especially $\delta^{15}N$) measurements. For 129 of these samples, $\delta^{13}C$ values are available. 115 samples yielded $\delta^{15}N$ values. Error bars are excluded from the graphs for clarity and because in many cases the size of the symbol exceeds the size of the error bars. Due to space limitations, all radiocarbon dates and stable isotope measurements are available as supplementary material.

The stable isotope results ($\delta^{13}C$, $\delta^{15}N$) of human and animal bones from the Femern project are shown in fig. 1. This figure includes data from all archaeological periods examined in this project. Most samples belong to herbivores and have corresponding isotope ratios; $\delta^{13}C$ between -24 and -21‰, $\delta^{15}N$ between 3 and 9‰. Most of the herbivores lie in a narrow $\delta^{15}N$ range, though: Apart from one wild horse with $\delta^{15}N$=3.2‰, a red deer with $\delta^{15}N$=4.1‰ and two sheep/goats with $\delta^{15}N$>8‰, the range is 4.7 to 7.8‰. Measurements on terrestrial herbivores are shown in a separate diagram together with the $\delta^{13}C$ values of wood samples as a proxy for vegetation $\delta^{13}C$ values (fig. 2).

The two sheep/goats with $\delta^{15}N$>8‰ are in the same area of the diagram as three humans, three wild cats and a dog; their diet can be regarded as terrestrial on a higher trophic level and/or a terrestrial diet with the admixture of some marine resources. The bone with $\delta^{15}N$=9.9‰ is a humerus from a sheep with a lot of cut marks; the osteological report does not mention that it is from a young individual. The bone with $\delta^{15}N$=8.4‰ is the left shoulder blade of a sheep, also with cut marks and also not classified as a young individual. A nursing effect can thus be excluded and the high $\delta^{15}N$ values must be a result of the diet. In the case of sheep, marine plants or macroalgae could have supplemented the fodder, whether provided by humans or sought out by the animals themselves. Goats, dogs and cats could have fed on food remains left by humans.

As described in the introduction, a very dense forest can cause a depletion in the $\delta^{13}C$ values of the vegetation, and in the $\delta^{13}C$ values measured throughout the food web based on this vegetation. There are only a few specimens where a canopy effect is probable: The only terrestrial herbivores that have $\delta^{13}C$ values below -23‰ are sheep/goat, roe deer and red deer (fig. 2). The sheep/goat (the species could not be determined) with $\delta^{13}C$=-24.2‰ is the oldest domesticated animal from the site (fig. 3; 5313 ± 32 BP, 4310–4304 (0.7%) and 4249–4046 (94.8%) cal BC, calibrated with IntCal20). It could have been browsing in the forest or have been fed leaf fodder. The red deer and roe deer bones span the whole range of *c.* 24 to 21‰, while the cattle/aurochs only have $\delta^{13}C$ values between *c.* 22.5‰ and 21‰.

The two sheep bones with the highest $\delta^{15}N$ values have been discussed above. Apart from these, there is also a group of five cattle bones with $\delta^{15}N$>7‰, while all other herbivores have $\delta^{15}N$ values below 7‰. Further studies will show whether there really are two isotopically distinct groups of cattle. Interestingly, some of the cattle and sheep/goat have higher $\delta^{15}N$ values than all of the pig samples, although pigs are omnivores and sheep/goat and cattle are herbivores. The pigs were thus most probably not fed with food refuse, as this would have caused a higher trophic level and more marine $\delta^{13}C$ values.

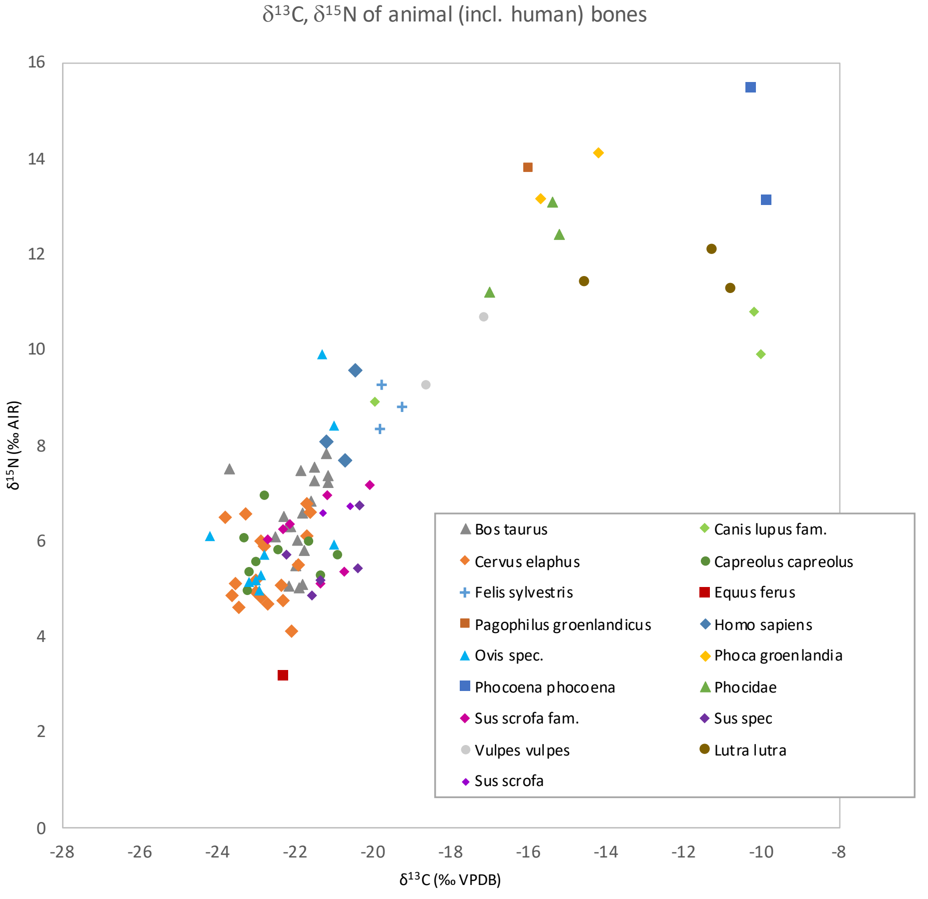

Figure 1. Stable isotope values of bones from the Femern project.

Such an effect has been observed with wild boar from an Ertebølle kitchen midden site in Jutland (Maring and Riede 2019).

The horse bone has the lowest δ15N value (3.2‰) of the dataset, which agrees with previous studies of prehistoric horse bones (Klassen *et al.* 2023; Kuitems *et al.* 2015; Stevens *et al.* 2010). This specimen of *Equus ferus* is dated to 2812 ± 29 BP (1051–897 (94.7%) and 867–857 (0.8%) cal BC, calibrated with IntCal20) and is thus too young to be relevant for a discussion of the Neolithisation process.

There are some apparent trends in fig. 2. For example, there seems to be a linear relation between the δ15N and δ13C values of *Bos taurus* with a correlation coefficient of R^2=0.61. However, generally the sample numbers are too small to allow for meaningful statistical analyses.

Figure 3 displays the δ13C values of the aforementioned taxa over time. It is difficult to discern any trends, as many animal species are only found from within short time periods. For example, the group of animals with the highest δ13C values includes two harbour porpoises (*Phocoena phocoena*), two Eurasian otters (*Lutra lutra*) and two dogs (*Canis lupus* fam.) from a very narrow timespan. While the δ13C values of around -10‰

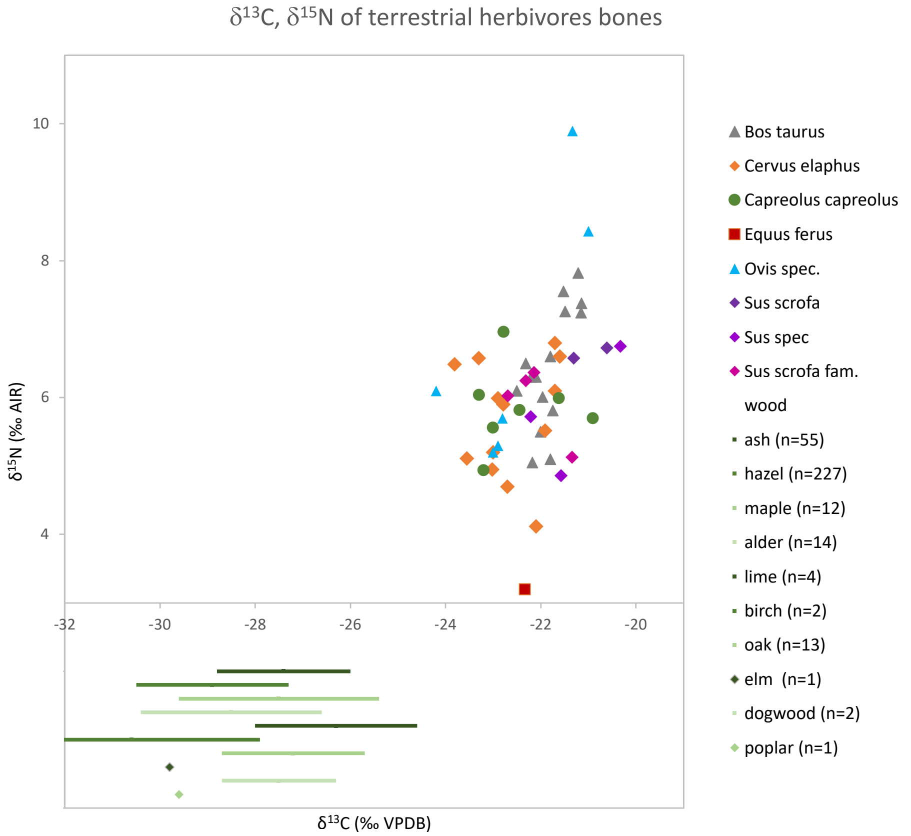

Figure 2. Upper part of the diagram: $\delta^{13}C$ and $\delta^{15}N$ values of terrestrial herbivores. Lower part: $\delta^{13}C$ values of wood from the Femern project (Philippsen *et al.* 2019), average ± 1σ, as proxy for plant $\delta^{13}C$ values. The values in the diagram are in the same order as the species names in the legend.

are not unusual for porpoises, they are an interesting case for the dogs – these clearly had a largely marine diet, unlike the slightly later humans from this site. The marine diet of the otters indicates that they had lived at the coast and consumed marine fish, which is not unusual for the Eurasian otter (Kruuk 2006), and that they had not been caught in an inland lake or stream. However, the otter needs regular access to freshwater to clean its fur (Ozkazanc *et al.* 2019). Therefore, its presence indicates that there must have been access to a lake or stream nearby. The extended use of the sites by humans would, of course, not have been possible without access to freshwater either. However, for human use, a small freshwater spring would have sufficed.

Some trends can be observed in the $\delta^{13}C$ values over time. The *Ovis* $\delta^{13}C$ values increase with time (R^2=0.72), while there is also a slight increase in *Cervus elaphus* $\delta^{13}C$ values (R^2=0.35). This might indicate that the forest was being cleared and the sheep/goats were grazing in a more open landscape. Furthermore, they could consume larger amounts of seaweed and/or human refuse. This is supported by the increase in $\delta^{15}N$ values by 4500 cal BP (supplementary material). The $\delta^{13}C$ increase in red deer is

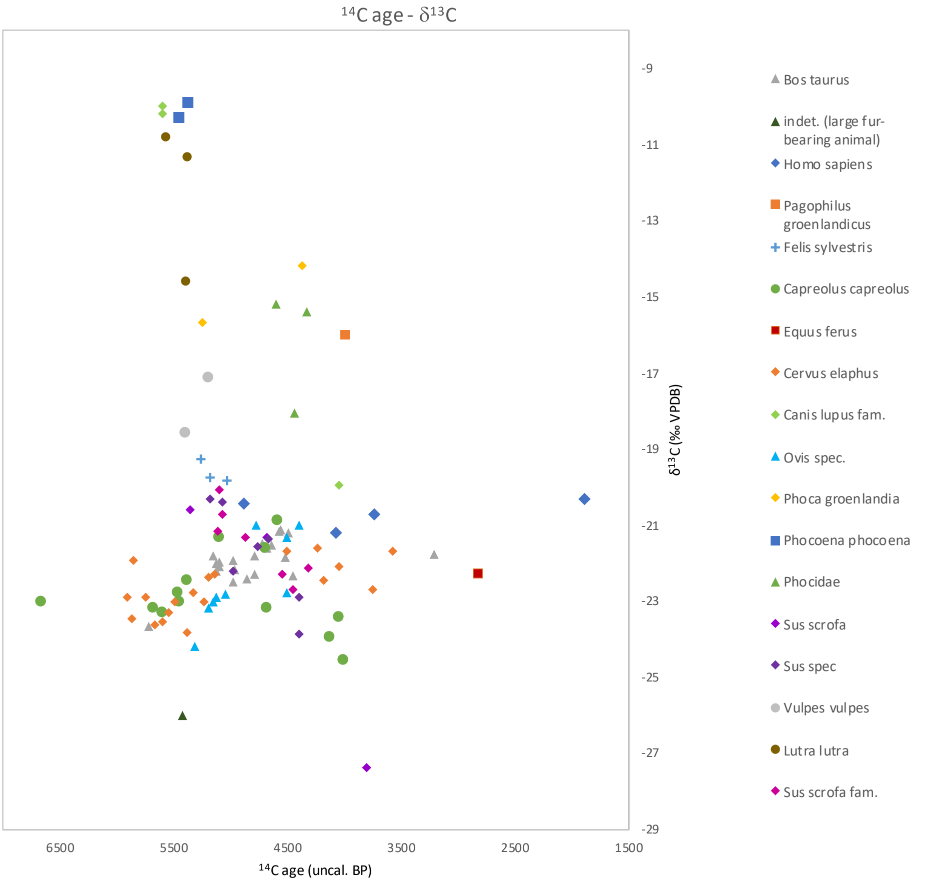

Figure 3. $\delta^{13}C$ values compared to the radiocarbon age of bones from the Femern project. This plot includes more data points than fig. 1, as not all samples were large enough to allow for a $\delta^{15}N$ measurement.

not accompanied by an increase in $\delta^{15}N$. Therefore, their increasing $\delta^{13}C$ values can best be explained by a change in landscape, which became more open. In contrast, there is a decrease in *Sus* $\delta^{13}C$ values (R^2=0.76). This would indicate that the pigs had a slightly more marine diet during the Ertebølle period and a more terrestrial diet later. However, there is no trend in the $\delta^{15}N$ values that could support this interpretation (supplementary material).

The four human bones, which unfortunately were all stray finds, show no trend over time. $\delta^{15}N$ values are only available for three of the human bones. They decrease from 9.6‰ in 4875 cal BP to 7.7 ‰ in 3738 cal BP – a decrease of less than one trophic level.

Food crust stable isotopes ($\delta^{13}C$, $\delta^{15}N$)

The stable isotope values of food crusts from the Femern project have been and will be published elsewhere (see introduction for details and references). A synthesis paper of all results including data tables is under preparation. Therefore, this section will only summarize the main results in figures (all data is available in the supplementary material).

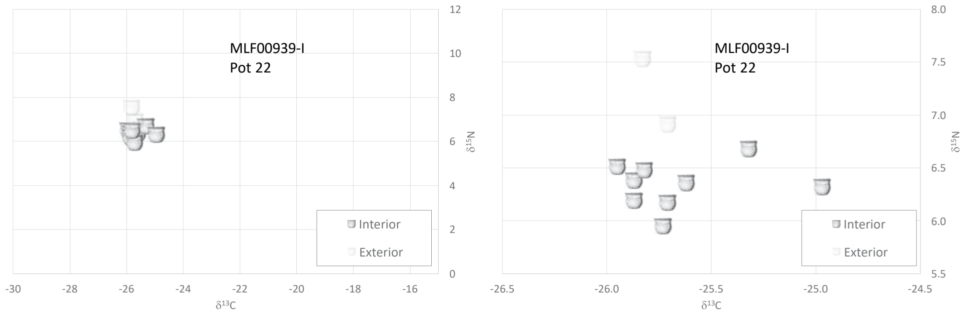

Figure 4. Stable isotope results ($\delta^{13}C$, $\delta^{15}N$) of food crusts on sherds from one vessel, pot 22 from MLF00903-I. Left: full range diagram for comparability with the other isotope diagrams in this paper; right: detail.

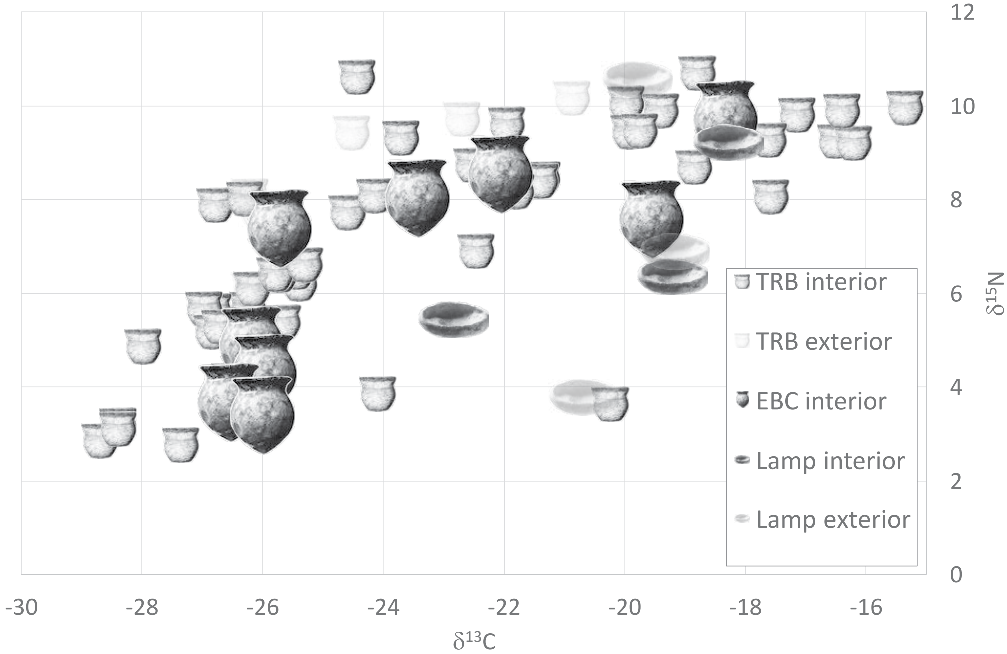

Figure 5. Stable isotope values of food crusts on Funnel Beaker and Ertebølle sherds as well as lamp fragments. $\delta^{13}C$ in ‰ VPDB; $\delta^{15}N$ in ‰ AIR. The pottery type is indicated by the shape of the symbol: funnel beakers for Funnel Beaker pottery, pointed-based vessels for Ertebølle pottery, and shallow bowls for lamps. Crusts on the outer surface of the vessels are indicated by a lighter symbol.

The variability of the stable isotope values has been tested by analysing nine interior and two exterior samples from sherds of the same vessel, "Pot 22", from MLF00939-I. Although the results span a range of about 1‰ for $\delta^{13}C$ and 1 to 1.5‰ for $\delta^{15}N$, depending on whether the exterior crusts are included, all values would indicate the same interpretation of terrestrial, low to middle trophic level food. I thus suggest regarding

EBC interior (n=9)	δ13C (‰ VPDB)	δ15N (‰ AIR)
Min	-26.69	2.99
Max	-18.32	9.70
Lamp interior (n=4)	**δ13C (‰ VPDB)**	**δ15N (‰ AIR)**
Min	-26.19	5.45
Max	-18.27	9.23
Lamp exterior (n=2)	**δ13C (‰ VPDB)**	**δ15N (‰ AIR)**
Min	-20.67	3.78
Max	-19.16	6.89
TRB interior (n=31)	**δ13C (‰ VPDB)**	**δ15N (‰ AIR)**
Min	-28.70	2.76
Max	-15.36	10.04
TRB exterior (n=6)	**δ13C (‰ VPDB)**	**δ15N (‰ AIR)**
Min	-26.21	6.08
Max	-20.88	10.17

Table 1. Minimum and maximum values of all analysed food crusts.

measurements on individual sherds as representative of the entire vessel, even though experimental studies have shown that some variation has to be expected when cooking mixed foods (Philippsen 2012).

The $\delta^{13}C$ values of all analysed food crusts are in the interval between -29 and -15‰. $\delta^{15}N$ values range from *c.* 2.5 to 10.5‰. Most values follow a mixing line between fully terrestrial ($\delta^{13}C$=-29 to -26‰, $\delta^{15}N$=2.5 to 6‰) and fully marine ($\delta^{13}C$=-18 to -15‰, $\delta^{15}N$ around 10‰, fig. 5).

As shown in fig. 5, Ertebølle and Funnel Beaker pottery have the same range of isotope values and both pottery types were used for both terrestrial and marine resources. The funnel beaker $\delta^{13}C$ values span a larger range than those of the Ertebølle vessels. This could be caused by a diversification of food resources during the Funnel Beaker period, or could just be an effect of the larger sample size. The minimum and maximum values of all analysed food crusts are given in Table 1.

Lipid analysis (GC-MS and GC-C-IRMS)

Based on the GC-MS results, seven samples were selected as being suitable for isotopic analysis (GC-C-IRMS) of the $C_{16:0}$ and $C_{18:0}$ fatty acids: P145 X57, P251 X3363, P252 X3495, P253 X8352, P254 X9243, P256 X10588 and P257 X11841 (P=sample number, X=find ID).

Lipids were extracted both from food crusts and from the ceramic matrix of sherds. Fig. 6 displays the $\delta^{13}C$ values of the $C_{16:0}$ and $C_{18:0}$ fatty acids. The measurements on the Funnel Beaker sherds were made on five food crust samples, while the Ertebølle pottery includes one food crust sample and nine samples of the ceramic matrix. The funnel beaker samples display either purely marine or purely terrestrial (dairy) fats, while the values of the Ertebølle sherds vary between ruminant adipose fat, where an admixture of dairy cannot be excluded, and marine fat.

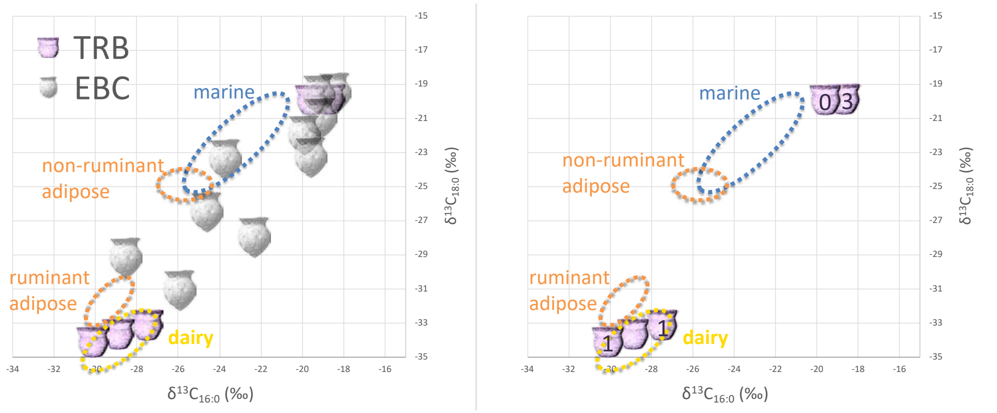

Figure 6. δ^{13}C values of the $C_{16:0}$ and $C_{18:0}$ fatty acids, measured in ‰ VPDB (Courel *et al.* 2020; Cubas *et al.* 2020; Papakosta *et al.* 2019). The pottery type is indicated by the shape of the symbol: funnel beakers for Funnel Beaker pottery (additionally coloured pink), pointed-based vessels for Ertebølle pottery. Ellipses indicate the typical isotopic ranges of modern reference fats. Left: all Funnel Beaker and Ertebølle sherds. Right: only Funnel Beaker sherds. Numbers indicate the Funnel Beaker type in those cases where it could be assessed (typological analysis of the pottery by A. Glykou, unpublished report).

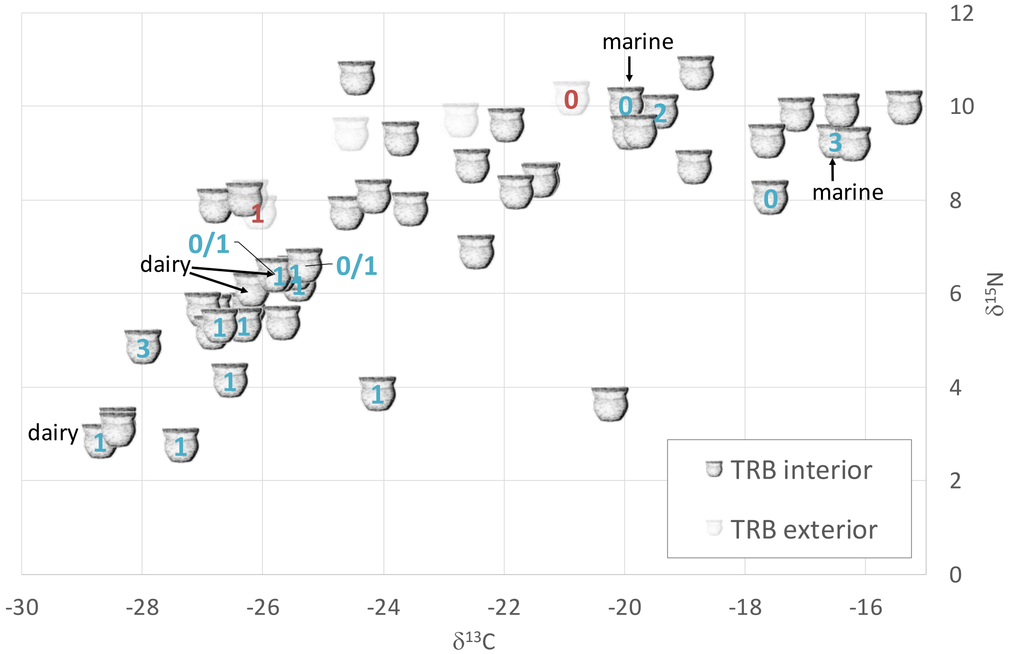

Figure 7. Stable isotope values of food crusts on Funnel Beaker sherds. δ^{13}C in ‰ VPDB; δ^{15}N in ‰ AIR. Coloured numbers indicate the Funnel Beaker type, blue numbers for samples of the vessel's interior surface, red numbers for exterior samples. Text indicates the assignment based on lipid analysis (GC-MS, GC-C-IRMS) of the same food crusts (Cubas *et al.* 2020).

Comparison stable isotopes – lipids

In six cases, bulk stable isotope and lipid analyses were performed on the same food crusts. Five of these were funnel beakers and are shown in fig. 7, one was an Ertebølle sherd and is displayed in fig. 8.

Additionally, lipids were extracted from the ceramic matrix of nine Ertebølle sherds. Food crusts on five of these sherds were also sampled for stable isotope measurements. Three of the isotope values are excluded from the plots because of too low nitrogen or carbon contents. However, fig. 8 shows a plot of the stable isotope values of food crusts on Ertebølle sherds, which are included for better comparability with the lipid results. Marine biomarkers and/or marine lipid $\delta^{13}C$ values were found in all five cases, irrespective of the bulk stable isotope results. This indicates that both techniques are necessary to understand the full range of foodstuffs prepared or stored in the vessels. Food crusts are biased towards the final cooking events, while lipids absorbed in the clay matrix are only slowly replaced and show no strong signal of the final cooking (Miller *et al.* 2020). For example, we analysed one Ertebølle sherd with terrestrial food crust isotope values ($\delta^{13}C$=26.69, $\delta^{15}N$=2.99) and lipids that indicate marine/ruminant ingredients (fig. 8). In this case, the pot was probably used once or several times for the preparation of marine food, while the last cooking event only contained terrestrial ingredients.

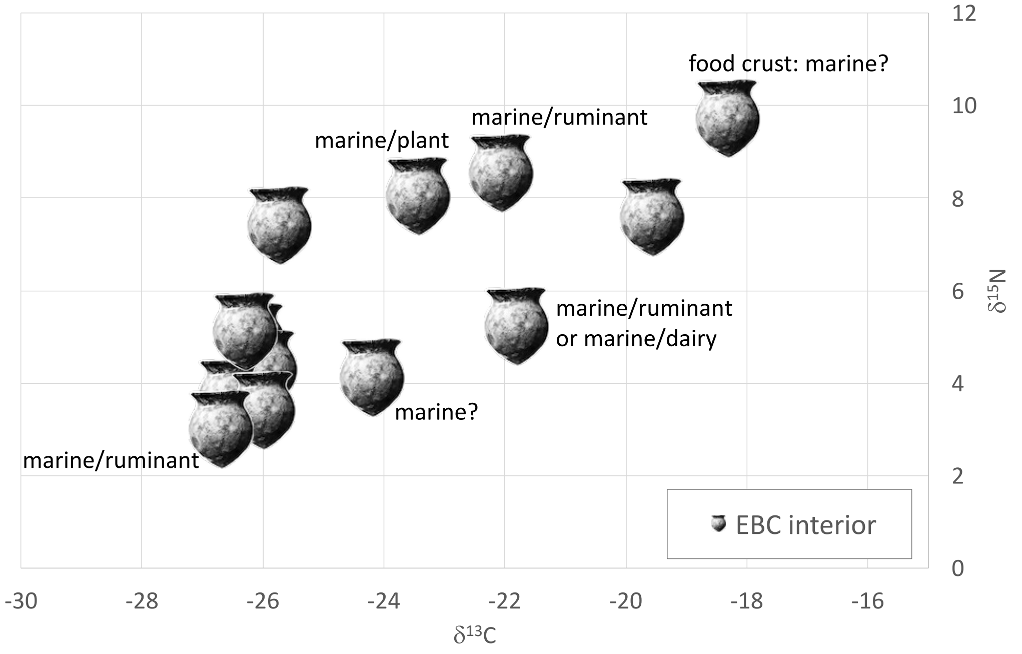

Figure 8. Stable isotope measurements of food crusts on Ertebølle pottery. $\delta^{13}C$ in ‰ VPDB; $\delta^{15}N$ in ‰ AIR. Text indicates the assignment based on lipid analysis (GC-MS and GC-C-IRMS) of the ceramic matrix by Papakosta *et al.* (2019).

Conclusion

Stable isotope analyses of the animal bones and food crusts and lipid analysis of the pottery show that the inhabitants of the Syltholm Fjord area used a broad variety of resources. This did not change during the Neolithisation process, although new pottery forms were introduced. New agricultural products, such as dairy, were integrated into the cuisine, while marine resources continued to be important. Although the stable isotope values of human bones indicate a predominantly terrestrial diet throughout the Neolithic, pottery food crusts and lipids, as well as finds of fishing fences, underline the importance of marine resources. This indicates that the Neolithisation process in this part of Denmark was not a simple replacement of a hunter-gatherer lifestyle by agriculture, or a persistence of a Mesolithic culture surrounded by Neolithic groups, but a complex interplay of traditions and innovations.

Supplementary material

Basic data for the figures is available under 10.5281/zenodo.7598004 and 10.5281/zenodo.7597900. More detailed information on the isotope measurements and radiocarbon data are available from the author on request.

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Mesolithic persistence and Neolithic emergence at Syltholm II (MLF00906-III)

Osseous artefacts before and after 4000 BCE on the coast of Lolland, Denmark

Solveig Chaudesaigues-Clausen

Abstract

This paper presents some results of the study of osseous artefacts from Syltholm II (MLF00906-III) on the southern coast of Lolland, Denmark, which is dated to between the latest part of the Late Mesolithic Ertebølle Culture (*c.* 4500–4000 BCE) and the end of the Early Neolithic Funnel Beaker Culture (4000–3300 BCE). Two finds from the adjacent sites of Syltholm IX (MLF00935-I) and Syltholm VII (MLF00933-III) are also added. The aim of the study is to present a short typology and technology of Mesolithic and Neolithic osseous artefacts that are related to the Syltholm sites in order to characterise these traditions. Thereafter, the results from 18 radiocarbon dates that were performed on a selection of artefacts are presented. All these elements allow us to discuss the role of osseous industries at Syltholm during the Neolithisation period. This encompasses the continuity of some Mesolithic osseous traditions and practices after 4000 BCE and the emergence of Neolithic industries at the site, as well as a possible cultural negotiation between hunter-gatherers and farmers. This study suggests that Syltholm II may have been an enclave for continued hunter-gatherer practices, possibly up to 500 years after the start of the Neolithic.

Femern project; Ertebølle Culture; Early Funnel Beaker Culture; osseous artefacts; Neolithic transition

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Introduction

Numerous hypotheses have been suggested to understand the changes in material culture that took place during the Neolithic transition in southern Scandinavia *c.* 4000 BCE. Narratives of migrations, creolisation and resistance suggest a complex picture (Jennbert 2011; Sørensen 2014; Stafford 1999, 134; Wadskjær 2018), in which cultural negotiation between foragers and farmers seemed to occur around 4000–3700 BCE (Gron and Sørensen 2018, 967). A certain continuity between the Late Mesolithic and Early Neolithic is seen in several aspects of material culture, settlement occupation, and diet (Craig *et al.* 2011; Gron and Sørensen 2018; Stafford 1999).

While many elements of this period have been studied (Gron and Sørensen 2018, 968), artefacts from osseous materials have rarely been considered. The role these objects may have played during the Neolithisation is little known, especially concerning how they may have contributed to change, maintain, or transform identities during this crucial period. In such a changing world for both foragers and farmers, a complex picture of persisting traditions and adaptations to new social and natural environments may arise. In order to tackle these issues, this paper will focus on osseous artefacts from the site of Syltholm II (MLF00906-III), as well as two finds from Syltholm VII (MLF00933-III) and IX (MLF00935-I) (Lolland, Denmark).

The specific questions that were asked, based on the osseous artefacts studied from these selected Syltholm sites were:

- What are the characteristics of the Ertebølle and Funnel Beaker osseous industries? To what extent are they distinguishable from each other?
- Do certain osseous objects or techniques of Mesolithic tradition continue within the Early Neolithic? And if they do, for how long?
- When do artefacts of Neolithic tradition or influence appear?
- Can some degree of cultural negotiation between the different groups be suggested?

This paper investigates the raw material, typology and technology of osseous artefacts at Syltholm. Thereafter, the results from radiocarbon dating undertaken on selected objects will be presented. These dates were performed to further test the hypotheses and questions formed during the primary analysis of the material. Due to this possibility of directly radiocarbon dating osseous artefacts, a more precise timeframe of the finds can be suggested.

Materials and methods

The main site of this study, Syltholm II (MLF00906), is situated on the southern coast of Lolland, Denmark (Måge *et al.* this volume, fig. 1). This paper concentrates on the third excavation season in 2019, MLF00906-III. The main period of activity at this site ranges from the Late Ertebølle to the Late Early Funnel Beaker Culture (EN II), *c.* 4500–3300 BCE (Sørensen and Olesen 2020). The excavated area covers 4115 m² and encompasses both the beach and underwater area that formed part of a protected lagoon during the Late Mesolithic-Early Neolithic (fig. 1) (Jensen *et al.* 2020; Sørensen and Olesen 2020). The finds represent mundane and ritual activities that took place on the beach and in shallow waters. On the beach, they are mainly concentrated in a grey, sandy gravel layer, whereas in the underwater area they

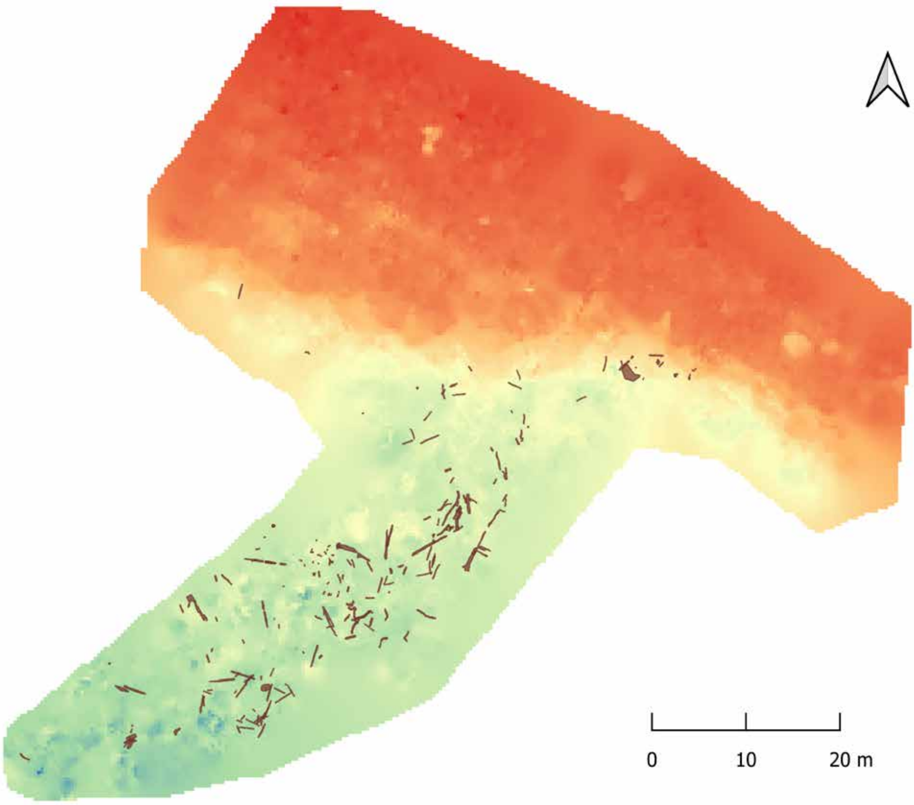

Figure 1. Interpolation map of depth points at Syltholm II (MLF00906-III). Red-orange: beach. Yellow-orange: transition area. Green-blue: underwater area. Brown polygons: large wood pieces/antlers (map: M. Nørtoft and S. Chaudesaigues-Clausen; background map: Natural Earth. For the location of the site see Måge *et al.* this volume, fig. 1).

extend in a thin *cardium* (cockle) shell layer, with thick gyttja underneath. The site being a palimpsest, these geological layers do not contain stratigraphically ordered cultural layers and finds from different periods can co-occur in the same layer. However, the excellent conditions of preservation have permitted the uncovering of *c.* 22,500 finds – flint, bone, pottery, wooden objects -, including 715 osseous artefacts so far identified. Pointed bone artefacts constitute 669 finds, antler is represented by 37 objects, and teeth by one find. Many bone points seem to have been lost during fishing/hunting activities in the underwater area. However, it cannot be excluded that some were also intentionally deposited in the water, as seen at Syltholm I (Sørensen 2019; 2020).

The finds from two adjacent sites are also included in this paper because of their research potential regarding the questions asked in this study. The first site is Syltholm IX (first excavation season, MLF00935-I), just north of Syltholm II, which comprises 46 bone tools, with finds ranging from the Mesolithic to the Bronze age, and a concentration of radiocarbon dates between *c*. 3600–3000 BCE (Måge *et al.* this volume, figs. 1–2). The artefact included is a perforated cattle (*Bos taurus*) astragalus (find number: X1145). The second site is the fish weir site of Syltholm VII (MLF00933-III), which is situated further out in the fjord (Måge *et al.* this volume, fig. 1). There seems to have been very little osseous industry at this site, as there are only five objects in total. It is dated to between the Late Palaeolithic and the Middle Neolithic, with a varied concentration of radiocarbon dates ranging between *c*. 5600–2600 BCE (Måge *et al.* this volume, figs. 1–2). The artefact included is a worked cattle metapodial (X502).

Due to the nature of the Syltholm sites, it can be difficult to establish which period or culture the archaeological finds may belong to, as they are not stratigraphically ordered. In order to cope with this problem, this study revolves around a first level of identification of the finds, which is typology – artefact shapes, raw material choices and remaining anatomical parts, and technology – techniques and their application (this aspect will only briefly be mentioned here). The raw material identification of manufacturing products and of bone artefacts that presented diagnostic epiphyses was performed at the Zoological Museum of Copenhagen by Pernille Bangsgaard and Betina I. Magnussen. Both typology and technology are based on the author's observations of finds from Ertebølle and Funnel Beaker sites (*e.g.*, Ertebølle, Lollikhuse, Fannerup D, Tudse Hage, Lindø, Troldebjerg, Ørum Å, Gadegaard Skævinge, *etc.*), which are then compared with Syltholm, for which only relevant types will be presented. These typo-technological aspects are crucial as they can help to characterise Ertebølle and Funnel Beaker osseous industries, as well as establish the similarities and/or differences between them.

However, typological identification can be difficult for nondiagnostic artefacts or manufacturing products, and it can even be misleading in certain cases. For instance, the burr axe from Syltholm II, which would typologically be attributed to the Early Ertebølle, was in fact radiocarbon dated to the Early Neolithic, 3953–3771 cal BC (X10092; wooden shaft: AAR-21930: 5045 ± 27 BP) (Sørensen 2019, 160; 2020, 404). Moreover, the lack of fine-grained temporal sequences obtained from typological and technological observations may impede a more detailed understanding of the Neolithisation process at the Syltholm fjord for certain artefacts. Therefore, after the initial typo-technological analysis, radiocarbon dating was carried out on a selection of 15 osseous artefacts from Syltholm II (MLF00906-III), together with X502 from Syltholm VII (MLF00933-III), to understand a more precise temporality of these artefacts. The selection strategy was clearly defined: a more precise radiocarbon date for the objects could help investigate whether some artefacts of hunter-gatherer tradition continued after 4000 BCE, and how early artefacts of Funnel Beaker tradition appeared at the site. From Syltholm II (MLF00906-III), and from different areas on the site (beach and underwater area), a diverse range of object types and raw materials, together with a few manufacturing products, were thereby selected. The aim was to get a good intra-site geographical and temporal representation of both Mesolithic and Neolithic artefacts, together with less culturally secure finds.

Additionally, two unpublished radiocarbon dates established by Museum Lolland-Falster prior to this study will also be presented and added to this analysis because of their relevance to this study. They concern a leister head with central bone point from Syltholm II (MLF00906-III) of which the wood (X17499) was dated. The second find is X1145 from Syltholm IX (MLF00935-I) (tab. 2).

The 16 samples selected for this study were sent to the Aarhus AMS Center, Aarhus University. For all samples, the quality of the collagen was acceptable, based on collagen yield and isotopic data. The criteria for good collagen preservation are considered to be a collagen yield at minimum 1–2% (after ultra-filtering), carbon concentration (C%) at 35–45%, nitrogen concentration (N%) at 13–16%, and a C:N ratio close to 3.2 (Kanstrup 2022a; 2022b). All samples were therefore successfully dated.

Results

Typology

At Syltholm II, most artefacts are known Ertebølle types, such as barbed points from roe deer antler, punches, and red deer antler shafts (Andersen 2013). Moreover, the presence of numerous bird bone points and one T-shaped red deer antler axe suggests connections with northern Germany and the western Ertebølle area (Petersen 1984). There are two categories of bone points at Syltholm II that are present in large numbers (>560 objects).

The first and most abundant category comprises the slender points from mammal bone diaphysis. They are mostly made from long bones, more rarely from flat bones (probably rib, n=12). On long bones, this type can either consist of the bone's diaphysis (compact tissue only) (fig. 2a) or comprise a very small part of the reworked epiphysis. It has a length that ranges between 39 and 180 mm, and its cross-section is generally round, oval, square, or rectangular. The proximal end is either straight (aligned with the shaft width), rounded, or pointed. This type is very common at Ertebølle settlements (*e.g.*, Lollikhuse, Fannerup D, Tudse Hage), but usually in smaller numbers than at Syltholm II. Those that are made from large mammal flat bone are mostly made from a half section of flat bone (fig. 2b). Many are fragmented at the proximal end but it seems that, for the ones that are whole, the shape of the proximal end is straight, rounded or pointed. This type is rare at Ertebølle sites, but one example is known, for instance, from Ringkloster (Andersen 1994/95, 37).

The second common category comprises bone points from a longitudinal segment of medium-sized ruminant metapodial, with a portion of proximal epiphysis. This epiphysis is left unworked and retains a part of the subchondral bone, which gives a thicker and wider proximal end to the object in comparison to the previous category. Most of this type at Syltholm are made from a quarter segment of metapodial (fig. 2c) rarely from a half lateral segment (fig. 2d). The cross-section is shaped in a half-circle, following the natural shape of the bone. The length ranges between 57 and 127 mm, and the width of the proximal end is usually between 5 and 10 mm. This type is very common at settlements, especially at Ertebølle (Madsen *et al.* 1900).

There are also osseous artefacts that can typologically be attributed to the Neolithic: nine artefacts at Syltholm II (MLF00906-III), and one at Syltholm IX (MLF00935-I). Other objects from Syltholm II (MLF00906-III) are less secure because they are manufacturing products or they lack comparison with Funnel Beaker sites. Concerning the identified objects, they are first and foremost represented by five bone points that are made from a half lateral segment of medium-sized ruminant metapodial, on which the distal epiphysis is retained (fig. 2e). This type is usually produced from adult or juvenile sheep (*Ovis aries*) and goat (*Capra hircus*) and constitutes one of the most common artefacts at Funnel Beaker sites (Winther 1926; 1928; 1935). Another regular type is a large, worked tine (sometimes thin beam) from red deer antler, which displays a diffuse rounded distal end and worked distal side. It is 110 mm long and 34 mm in

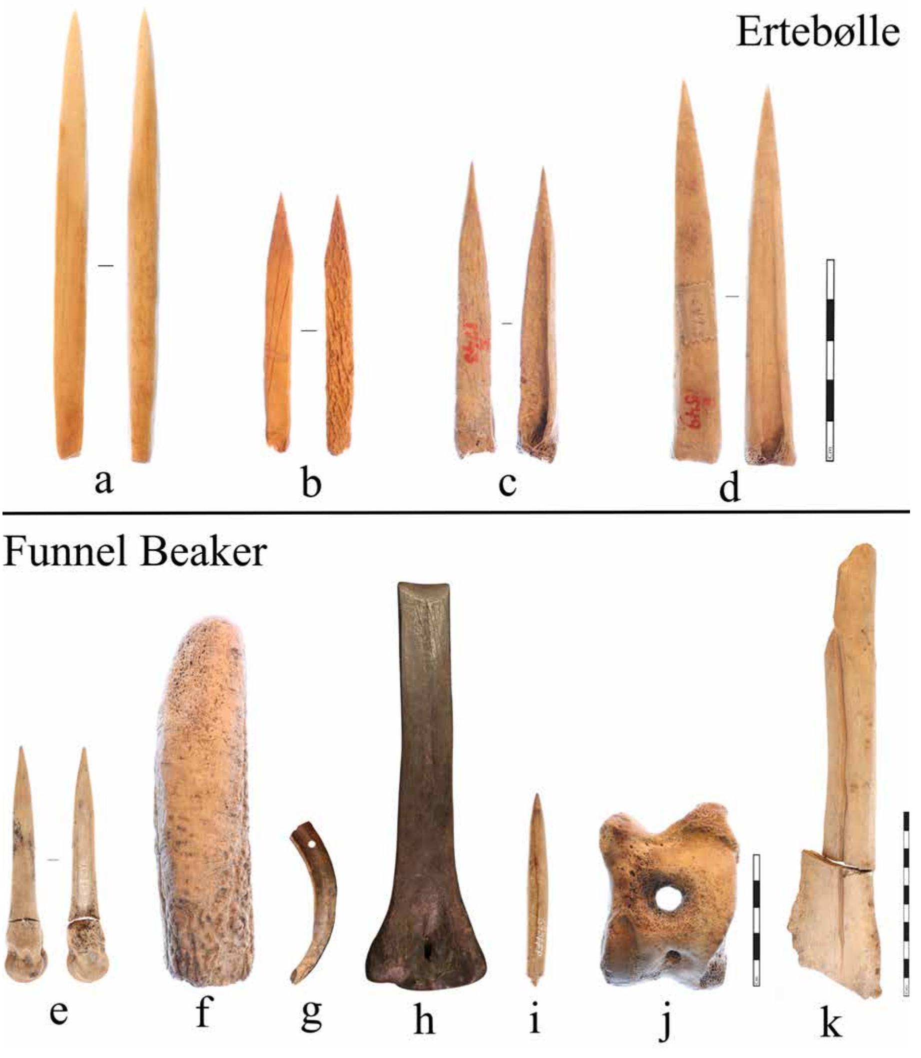

Figure 2. Osseous artefact types from the Ertebølle and Funnel Beaker Cultures. a: X6, Tudse Hage; b: X22091, Syltholm II (MLF00906-III); c – d: E1743 and E1549, Ertebølle; e: EYR, Gadegaard Skævinge; f: A5246, Lindø 4; g: X3665, Syltholm II (MLF00906-III); h: A40970, Ferle Enge; i: FFP, Gadegaard Skævinge; j: A6994, Troldebjerg X; k: DUZ, Gadegaard Skævinge (manufacturing product) (photos: Solveig Chaudesaigues-Clausen, finds from Museum Lolland-Falster, Langelands Museum, Nationalmuseet, Museum Nordsjælland, Museum Vestsjælland).

diameter, with a distal end of 25 mm in width. These dimensions and characteristics match those of similar objects from Funnel Beaker settlements, such as Lindø (fig. 2f) (Winther 1926; 1928). One perforated segment of suid lower canine (fig. 2g) is also present. The perforation is situated towards the root of the tooth, and this type is, for example, known from the kitchen midden at Ørum Å. Lastly, two objects that belong mostly to the Early Neolithic (4000–3300 BCE) were also found. The first is a distal fragment of a cutting tool from a cattle (*Bos taurus*) long bone with a concave edge. This type is usually made from the posterior (fig. 2h) or lateral (fig. 3h) segment

	Ertebølle	Funnel Beaker
Metapodials	Extensive use of medium-sized (*Capreolus*) and large ruminant (*Cervus*) metapodials	Use of medium-sized (*Ovis*, *Capra*) and large ruminant (*Bos*) metapodials
	On both large and medium-sized ruminant metapodials: retaining of the proximal epiphysis discard of the distal epiphysis	Keeping of: the distal epiphysis on medium-sized ruminant metapodials the proximal epiphysis on large ruminant metapodials
Other bones	More sporadic use of other bones/species (ribs, ulnae, bird long bones, *etc.*)	Common use of a large variety of bones from domesticates (tibiae, radii, astragali, phalanges, ulnae, fibulae, scapulae, *etc.*). Use of bird long bones as well
Debitage techniques	Mostly sawing, a little percussion	Sawing and percussion
Shaping techniques	Scraping	Scraping and grinding

Table 1. Some general characteristics of the Ertebølle and Funnel Beaker bone industries.

of cattle metapodials, and the concave edge ranges between 4 and 19 mm in width (Becker 1962). The second Early Neolithic type is a tanged bone point (fig. 2i). This type is square or round in cross-section, and the tang is long, flat, and can be more or less defined. It can be quite long, up to 127 mm in length for one of the points from Porsmose (Becker 1952). As for the artefact from Syltholm IX (MLF00935-I), the cattle (*Bos taurus*) astragalus with central perforation (fig. 2j), this type is very common at numerous Funnel Beaker settlements, such as Troldebjerg (Winther 1935).

A short technology of selected types

In the Ertebølle Culture, the main technique used for the debitage of the two categories of pointed artefacts presented earlier is longitudinal sawing. This technique consists of continuously, progressively and deeply incising the bone with a flint tool in either a back-and-forth movement, or in a single direction, in order to separate the bone into two or more segments (Sénépart *et al.* 2004, 153; Sidéra 1993, 132–137). Typical indications of sawing are long parallel striations where the flint tool has been working, sideslips, as well as a V-shaped groove. Sawing can take place longitudinally to the osseous fibres, or transversally (Sénépart *et al.* 2004; Sidéra 1993, 132–137; 2004, 165).

For the first type of pointed artefact made from mammal long bone, manufacturing products that are found at Ertebølle settlements suggest that this type was often produced from red deer (*Cervus elaphus*) metapodial. A good example is a red deer metacarpal from Lollikhuse (Zealand, Denmark), on which longitudinal sawing was performed along the bone matrix to remove long, thin bone strips (fig. 3a). In one instance, convergent sawing was performed down the side of the distal epiphysis in order to directly remove a pointed bone strip, which requires less work to reshape into a point. When made from flat bone, bone points seem also to have been sawn within the bone matrix. As for the second type of bone point made from medium-sized ruminant metapodial (fig. 3c), it was obtained by longitudinally sawing the bone into two, three or four blanks, with the removal of the distal end by transversal sawing. Such waste can be found at settlements such as Ertebølle (Madsen *et al.* 1900). Scraping is involved in further shaping or reshaping of the points.

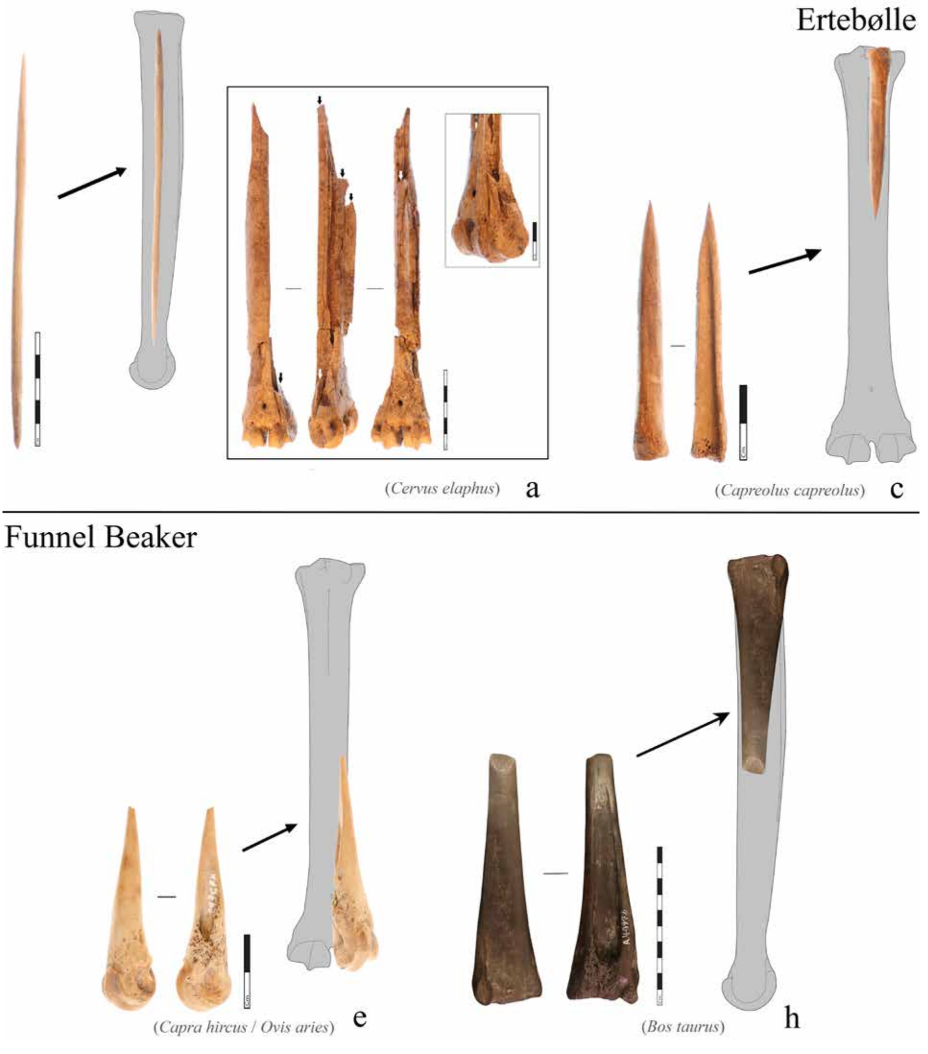

Figure 3. Examples of the use of large and medium-sized ruminant metapodials in the Ertebølle and Funnel Beaker Cultures, with the location of the different pointed artefacts in the bone matrix. The species indicated are the commonly selected ones within each type. The same letters as in fig. 2 are reused for clarity purposes. a: X18260, Syltholm II (MLF00906-III) and worked red deer metacarpal from Lollikhuse; c: X8944, Syltholm II (MLF00906-III); e: CFH, Gadegaard Skævinge; h: A40972, Ferle Enge (photos: Solveig Chaudesaigues-Clausen, finds from Museum Lolland-Falster, Nationalmuseet, Museum Nordsjælland, Færgegården).

As for the Funnel Beaker artefacts present at Syltholm, several were also obtained from sawing the metapodial in half, such as pointed artefacts from a half segment of metapodial with a distal epiphysis, and cutting tools with a proximal epiphysis (fig. 3e.h). On artefact types at other Funnel Beaker settlements, percussion is also a very common debitage technique. Scraping and grinding are used to different degrees.

All in all, typologically and technologically, there are similarities but also major differences between the Ertebølle and Funnel Beaker bone industries, which include differences in the use of metapodials and other bones, and in the application of techniques (tab. 1).

Bovine bones

There are several artefacts and manufacturing products that are made from bovine (*Bos* sp.) bones at Syltholm, but a more precise taxonomic identification needs to be made with caution for these sites as there can be a certain overlap in size between aurochs (*Bos primigenius*) and domestic cattle (*Bos taurus*) bones (Scheu *et al.* 2008). This identification problem can be difficult for the artefacts that are more culturally ambiguous and hard to assign to an Ertebølle or Funnel Beaker tradition. Indeed, even though aurochs became extinct on the eastern Danish islands at the start of the Atlantic period (Aaris-Sørensen 1980), aurochs bones could theoretically have been imported by hunter-gatherers from Germany on the other side of the Fehmarn Belt as small aurochs are, for instance, known from Rosenhof (Scheu *et al.* 2008). In the Ertebølle Culture in Jutland, where aurochs are still present, it is their scapulae that are usually worked, together with one find of an aurochs metatarsus from Ringkloster (Andersen 1975, 74; 1994/95). In the Funnel Beaker Culture, a wide range of cattle bones were commonly used in the osseous industry, including radii, metapodials, scapulae, ulnae, astragali, and phalanges (tab. 1).

Amongst the ambiguous manufacturing products from Syltholm II (MLF00906-III) are, for instance, three sawn bovine tibiae, which are reminiscent of a worked cattle long bone from the Neolithic site of Gadegaard Skævinge (fig. 2k; fig. 4: X1664). Another find, X502 from Syltholm VII (MLF00933-III), is a cattle metapodial with traces of longitudinal and convergent sawing on the side of the distal epiphysis (fig. 4; tab. 2). This object may be a blank for the production of bone points and is reminiscent of the Ertebølle red deer metacarpal from Lollikhuse (fig. 3a). Several Ertebølle-type bone points also have a thickness that may indicate the use of *Bos* sp. bone (*e.g.* fig. 4: X9907).

Radiocarbon dates

The results of the radiocarbon datings are visible in fig. 5 and tab. 2. They cover the Late Ertebølle to the Late Middle Neolithic, with a concentration of dates during the 500 years after 4000 BCE, which is due to sample selection.

The first phase is represented by three bone points from the underwater and transition area. They range between *c.* 4600–4200 BCE and correspond to the Late Ertebølle Culture (fig. 6: 1).

The following phase, which spans the 500 years after 4000 BCE, is more mixed. Immediately after the transition, two bone points of Ertebølle tradition are used *c.* 3900–3700 BCE (fig. 6: 2). After this initial period, some seemingly hunter-gatherer-related finds (X1660, X9907, X8033) extend up to 3500 BCE (fig. 6: 3). As for the artefacts of Funnel Beaker tradition, they all appear simultaneously at 3700 BCE at the earliest, and increase in frequency until the end of the Early Neolithic, *c.* 3300 BCE (fig. 6: 3).

Lastly, one bone point is dated to Middle Neolithic B II, *c.* 2600–2400 BCE (fig. 6: 4). This outlier is not unique, as other finds from Syltholm II are dated to this time frame (S. A. Sørensen, pers. comm. 2022), suggesting a return of activity on the site during this period.

Figure 4. Radiocarbon-dated artefacts from Syltholm II (MLF00906-III), VII (MLF00933-III) and IX (MLF00935-I) (photos: Museum Lolland-Falster (X8832, X9498, X17499, X1145) and Solveig Chaudesaigues-Clausen (all others)).

Discussion and conclusion

The study of the osseous artefacts from Syltholm II, VII and IX has provided the opportunity to investigate how this industry evolved during the Neolithisation of the southern coast of Lolland. It seems that the occupation phase of Syltholm II by hunter-gatherers covers roughly 1000 years, and that some aspects of their industry, such as bone points, persisted on the coast until the end of Early Neolithic I, *c.* 3500 BCE. During the period 4000–3700 BCE, the ways of shaping and producing these artefacts seem to have changed little, as the same techniques and bone types (*e.g.* metapodials) remain in use (fig. 6: 1–2). The worked bovine metapodial (X502) from Syltholm VII (MLF00933-III) (fig. 4; tab. 2), which is dated to *c.* 3900–3600 BCE, suggests this continuity of hunter-gatherer practices. This survivance seems to continue even after this initial period, as hunter-gatherer-related finds (X1660, X9907, X8033) are dated up to 3500 BCE (fig. 6: 3).

The only change in these hunter-gatherer artefacts after 4000 BCE would be the potential integration of metapodials/bones from domesticated animals. The bone point X1660 (fig. 4; tab. 2) is, for instance, produced from a quarter metatarsus of sheep/goat

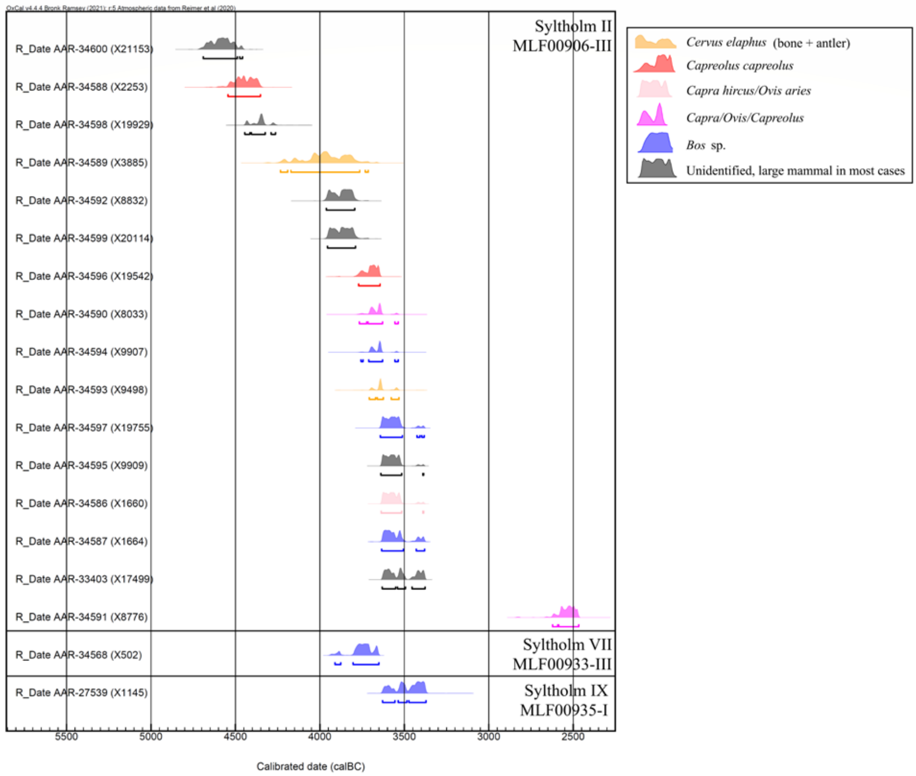

Figure 5. Calibrated dates of osseous artefacts from Syltholm II (MLF00906-III), Syltholm VII (MLF00933-III) and Syltholm IX (MLF00935-I), coloured by animal species. Calibrated with OxCal v4.4.4 Bronk Ramsey (2021): r:5 Atmospheric data from Reimer *et al*. 2020.

(*Ovis/Capra*). It is also possible that domestic cattle (*Bos taurus*) bone could have been used as well. This is, for instance, indicated by the worked cattle metapodial X502 from Syltholm VII (MLF00933-III) and possibly also by bone point X9907 from Syltholm II (MLF00906-III). This aspect of the use of bones from domestic animals needs to be further investigated in the future, using palaeoproteomics for species identification (Coutu *et al.* 2021), as well as DNA for *Bos* sp. bones (Scheu *et al.* 2008).

All these findings suggest a continuity of practices that span well into Gron and Sørensen's (2018) homogenisation phase (after *c.* 3700 BCE), indicating the possible survivance within the Neolithic of a local enclave of hunter-gatherer traditions on the northern side of the Femern belt. Such a continuity of traditions also fits well with the discovery at Syltholm II (MLF00906-II) of a fully Western Hunter-Gatherer genome of a female dated to 3933–3710 cal BC (birch pitch, GrM-13305: 5007 ± 11 BP) (Jensen *et al.* 2019). Moreover, continued practices in ritual depositions are also seen in Structure A at the neighbouring site of Syltholm I, dated to between 4700–3600 BCE (Sørensen 2020, 402).

As for the artefacts that are typical of a Neolithic tradition, except for one date, they all fall between 3700–3300 BCE (X9498, X1145, X17500, X19542, X19755), suggesting that the beach, where most of these tools are found, became an area for carrying out domestic activities (fig. 6: 3). There is, however, a gap of 300 years between the transition to the Neolithic (4000 BCE) and the first occurrence of artefacts of clearly Funnel Beaker tradition at Syltholm II and IX. It seems therefore that, concerning osseous artefacts, there may have

Site	Find ID	Type/material/species	Lab-number	Date BP	Calibrated age BC (95.4%)
Syltholm II (MLF00906-III)	X21153	Bone point, long bone and worked spongy tissue, large mammal	AAR-34600	5734 ± 40	4691–4489 (92.5%) 4475–4459 (3%)
	X2253	Bone point, quarter metapodial with crude proximal epiphysis, *Capreolus capreolus*	AAR-34588	5622 ± 48	4545–4353 (95.4%)
	X19929	Bone point, long bone, large mammal	AAR-34598	5505 ± 33	4445–4415 (16.6%) 4406–4324 (69.9%) 4289–4264 (8.9%)
	X3885	Metatarsus with longitudinal sawing, *Cervus elaphus*	AAR-34589	5156 ± 85	4234–4191 (4.4%) 4172–3764 (90.1%) 3732–3714 (1%)
	X8832	Bone point, probably rib, large mammal	AAR-34592	5083 ± 34	3962–3795 (95.4%)
	X20114	Bone point, long bone and worked spongy tissue, mammal	AAR-34599	5067 ± 30	3956–3790 (95.4%)
	X19542	Bone point, half metatarsus with distal epiphysis, *Capreolus capreolus*	AAR-34596	4929 ± 31	3771–3644 (95.4%)
	X8033	Metapodial with longitudinal sawing, *Capra/Ovis/Capreolus*	AAR-34590	4883 ± 36	3767–3723 (6.8%) 3716–3629 (84.9%) 3556–3537 (3.7%)
	X9907	Bone point, long bone and worked spongy tissue, *Bos taurus*?	AAR-34594	4878 ± 31	3708–3671 (18.2%) 3661–3625 (59.8%) 3578–3532 (17.5%)
	X9498	Tine with rounded diffuse active end and smooth side, *Cervus elaphus*	AAR-34593	4860 ± 30	3708–3671 (18.2%) 3661–3625 (59.8%) 3578–3532 (17.5%)
	X19755	Cutting tool with concave edge, probably *Bos taurus*	AAR-34597	4780 ± 38	3643–3512 (90.9%) 3426–3408 (2.6%) 3397–3383 (2%)
	X9909	Worked rib with sawing traces, large mammal	AAR-34595	4773 ± 29	3639–3516 (94.9%) 3391–3386 (0.5%)
	X1660	Bone point, quarter metatarsus with unworked proximal epiphysis, *Capra/Ovis*	AAR-34586	4769 ± 28	3638–3516 (94.8%) 3391–3386 (0.7%)
	X1664	Tibia distal epiphysis with sawing, *Bos taurus*	AAR-34587	4750 ± 30	3635–3507 (81.5%) 3430–3381 (14%)
	X17499 (dated leister prong)	X17500. Tanged bone point, long bone, large mammal	AAR-33403	4732 ± 32	3632–3552 (41.3%) 3541–3495 (21.8%) 3455–3377 (32.3%)
	X8776	Bone point, half metacarpus with distal epiphysis, *Capra/Ovis/Capreolus*	AAR-34591	4025 ± 30	2623–2593 (7.7%) 2586–2468 (87.8%)
Syltholm VII (MLF00933-III)	X502	Metapodial with longitudinal and convergent sawing, *Bos taurus*	AAR-34568	4979 ± 30	3911–3877 (6.5%) 3804–3652 (88.9%)
Syltholm IX (MLF00935-I)	X1145	Worked astragalus, *Bos taurus*	AAR-27539	4710 ± 42	3629–3556 (22.9%) 3537–3486 (23%) 3474–3372 (49.5%)

Table 2. Dated osseous artefacts from Syltholm, calibrated with OxCal v4.4.4 Bronk Ramsey (2021): r:5 Atmospheric data from Reimer *et al*. 2020. All dates are cited after Måge *et al.* this volume.

been limited contact and influence between hunter-gatherers and farmers at Syltholm II and IX during these 300 years. This gap could, however, be contextualised through further future studies of the Syltholm sites. The appearance of Neolithic artefacts on the beach from *c.* 3700 BCE at Syltholm II and IX, which are to some degree contemporaneous with the last hunter-gatherers, suggests the possible beginning of more extensive contact between populations there, whether through the mingling of groups with different backgrounds, the obtention/manufacture of farmer-related objects by hunter-gatherers, or simply the use of the beach by early farmers.

It is also possible that boundaries between groups became porous. For instance, the Neolithic tanged bone point X17500, of a type also used as an arrowhead for the execution of the Porsmose individual (Becker 1952), is used as a leister point at Syltholm II, being associated with hunter-fisher subsistence there. Moreover, it is interesting to note that bone point X19542 is made from roe deer (*Capreolus capreolus*)

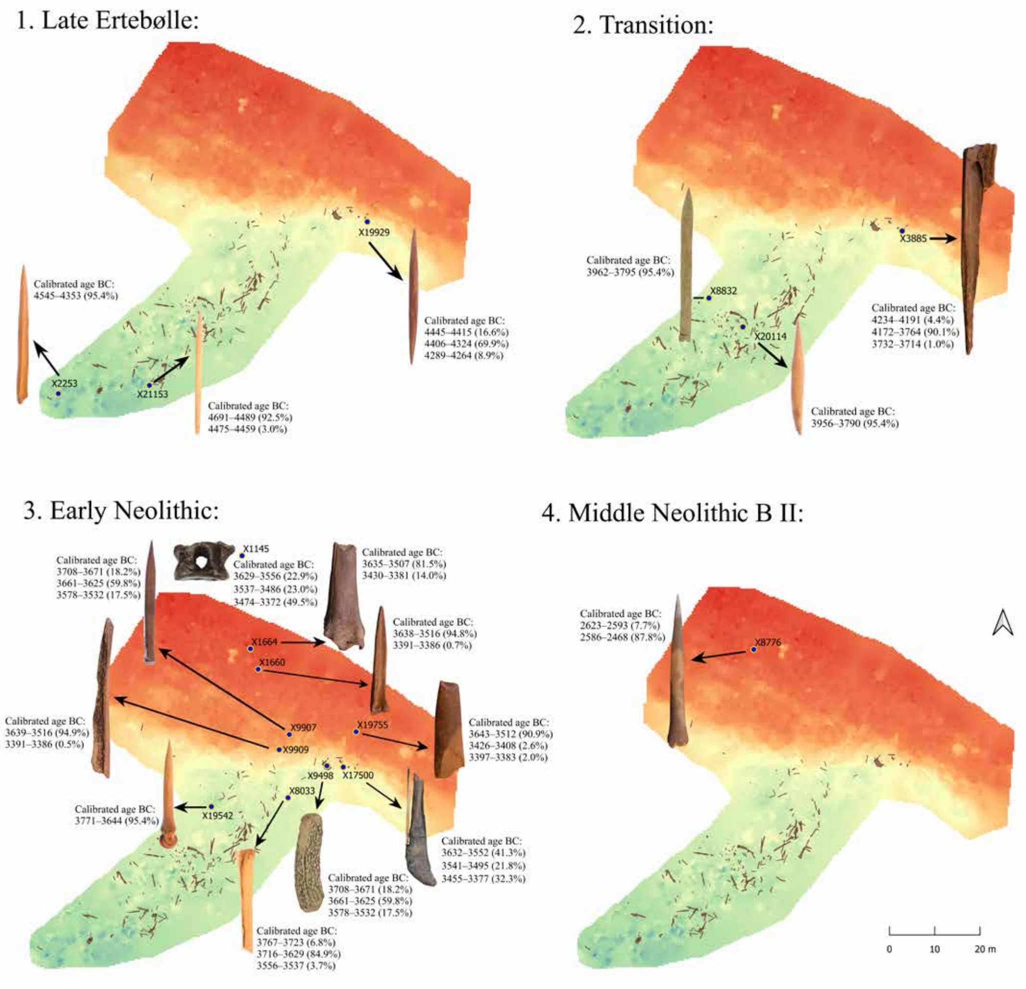

Figure 6. Temporalities of Syltholm II (MLF00906-III) and IX (MLF00935-I) (X1145).

metatarsus, and not from sheep/goat, as this type is usually found at Funnel Beaker sites (Ebbesen 2011; Winther 1926; 1928; 1935). These examples may suggest the blending of hunter-gatherer and farmer ways of doing.

Lastly, some manufacturing products are more complicated to interpret, as their lack of clear characteristics makes it difficult to assign them to a specific tradition. One is the worked red deer metatarsus blank (X3885), which covers the span of the transition and has a quite wide date range (figs. 4–6). The dated worked rib (X9909) is difficult to interpret as well but could represent a blank for producing bone points. Finally, the worked cattle tibia (X1664) is ambiguous as, even though such a blank may be Neolithic, the start of the longitudinal sawing of a thin bone strip may represent either an attempt to reshape the blank, or to produce a bone point of unknown type.

All in all, the analysis of osseous artefacts from Syltholm suggests a complex picture of persisting traditions and adaptation to a changing world, for both hunter-gatherers and farmers. In this study, the focus has been on the representativity of artefact types. Future investigations should concentrate on the bone points alone to create a more general picture, since they constitute the majority of worked osseous finds at Syltholm II.

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Neolithisation in Denmark from a depositional perspective

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Abstract
The changes that took place in southern Scandinavia around 4000 BCE were in most ways very radical, with a rapidly changing ceramic style, the introduction of agriculture and husbandry and the introduction of polished flint axes *etc.* However, if one looks deeper into the material, there are also areas where a continuation in lifestyle and handicraft seems to have lasted for at least a couple of hundred years after the introduction of the Neolithic in Denmark. The excavations carried out in the Syltholm Fjord on the southern part of Lolland revealed a huge amount of material covering those crucial centuries around the beginning of Neolithic and, by looking not only at changes/continuity in the material culture but also at the practice used for the deposition of certain artefacts, we might throw a little light on this intriguing period by looking at the depositional practice. I conclude that the Syltholm Fjord was an area where we can see the continuation of Mesolithic culture even long after the introduction of the Neolithic. However, after a couple of hundred years, the indigenous Mesolithic population seems to have disappeared.

Femern project; ritual; Ertebølle Culture; Funnel Beaker Culture; invasion theory

Neolithisation from a Danish perspective
In Denmark, it is well documented that a sharp shift in ceramic style occurred around 4000 BCE, when Funnel Beaker ceramics were introduced, but was this at the same time as the sharp shift in the economic strategy? In 1986, Thorsten Madsen described the transition from hunting and gathering to farming as a “black box problem” meaning that “we can observe and describe what goes in, and what comes out, but cannot follow the process of creation itself” (Madsen 1986, 237). Historically, there have been two contradicting explanations for the Neolithisation in Denmark, one that sees the local Ertebølle population adopting Neolithic elements through contacts with Neolithic tribes from Continental Europe (Troels-Smith 1982; Zvelebil 2001), and one

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Current Studies on the Stone Age around 4000 BCE. Leiden: Sidestone Press, 165–176.

that sees the Neolithisation as the result of an invading Neolithic culture (Becker 1973). For a more detailed historical overview, see Fischer and Kristiansen 2002. An alternative interpretation that is a compromise between the two opposing standpoints has been put forward lately suggesting that scouting groups from the Michelsberg Culture had already come to southern Scandinavia during the late Ertebølle Culture (EBC) and later pursued a larger invasion (Sørensen 2014, 266). The answer to the question of invasion or local adoption has just recently been tackled through a new approach using human DNA to demonstrate mobility in different human populations (Allentoft *et al.* 2022). This study has shown a nearly complete replacement of hunter-gatherers in Denmark following the introduction of the Neolithic economy, but the very sporadic material from the first two – three centuries of the Neolithic period is worth noting. To throw a little light on this dark period, the material from the Femern project will be analysed for information about continuity and change in both objects and practices in the centuries around the introduction of the Neolithic in Denmark *c.* 4000 BCE. Especially within the depositional practice, we can see a continuity from the late Mesolithic into the early Neolithic, which cannot be seen as anything but a continuation of the Mesolithic population until at least a couple of hundred years after the introduction of the Neolithic.

The Syltholm sites

The excavations in the Syltholm Fjord (cf. Måge *et al.* this volume) revealed a concentration of objects from the period around the introduction of the Neolithic in Denmark *c.* 4700–3500 BCE at Syltholm II (MLF00906). The excavations described in this article covered approximately 11,000 m^2, of which only about one third was intensively investigated. Most of the material was found in what at that time was shallow water just off the settlements and, because of the rising sea level that followed, most of the dry parts of these settlements had been severely disturbed during the transgression. The shallow waters off the Stone Age settlements have often been described as an outcast zone, where waste from the settlement ended up, but detailed studies of the distribution of objects and the depositional practice used for some objects shows another picture that reveals certain patterns in the depositional practice (fig. 1; Sørensen 2019; 2020; 2021). On top of this, several intact objects have been found that can hardly be considered as discarded waste, in fact they are very similar to objects often found in bogs that are interpreted as offerings (Karsten 1994). A large number of directly dated wooden objects from the Syltholm Fjord make it possible to follow this practice of deposition in detail for some of the artefacts throughout the period when Funnel Beaker ceramics were being introduced and to see if the practice changed when Neolithic pottery was introduced (fig. 2). At the same time, direct dates obtained from domestic animal bones allow us to say when these were introduced into southern Denmark for the first time.

If we turn our attention to Syltholm and the littoral area just next to the settlement, often described as the “refuse zone”, which contains all the waste from the settlement, one area had already attracted our attention during the excavation, mainly because there was a clear concentration of mandibles from different species. Besides a concentration of mandibles, this *c.* 4x5 m area contained several unique artefacts, such as two antler axes, both with parts of the wooden handle still preserved, one decorated piece of wood, the only one of its kind known from Denmark, one decorated antler shaft and a concentration

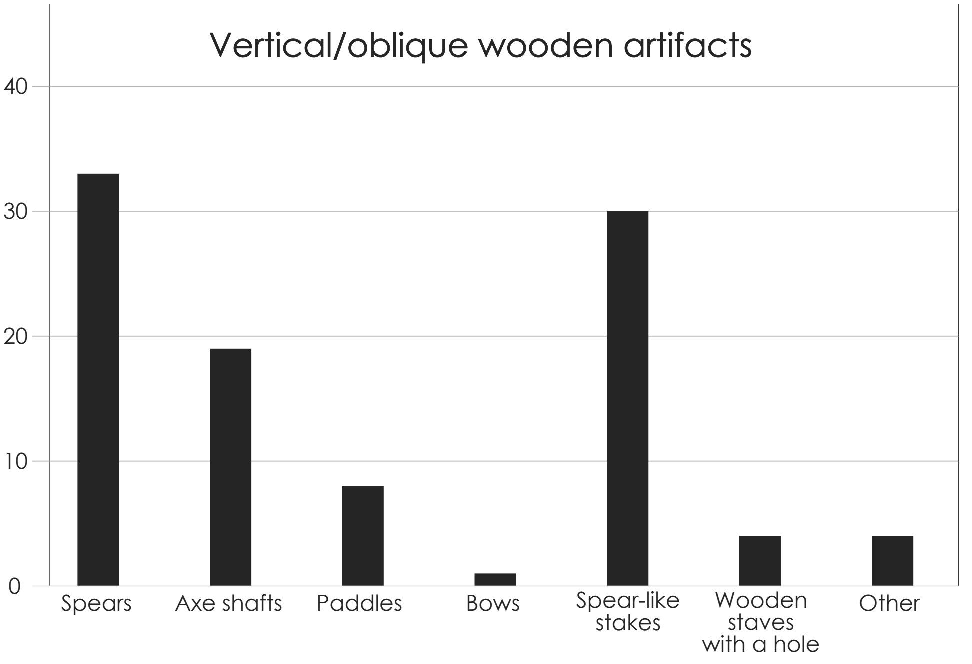
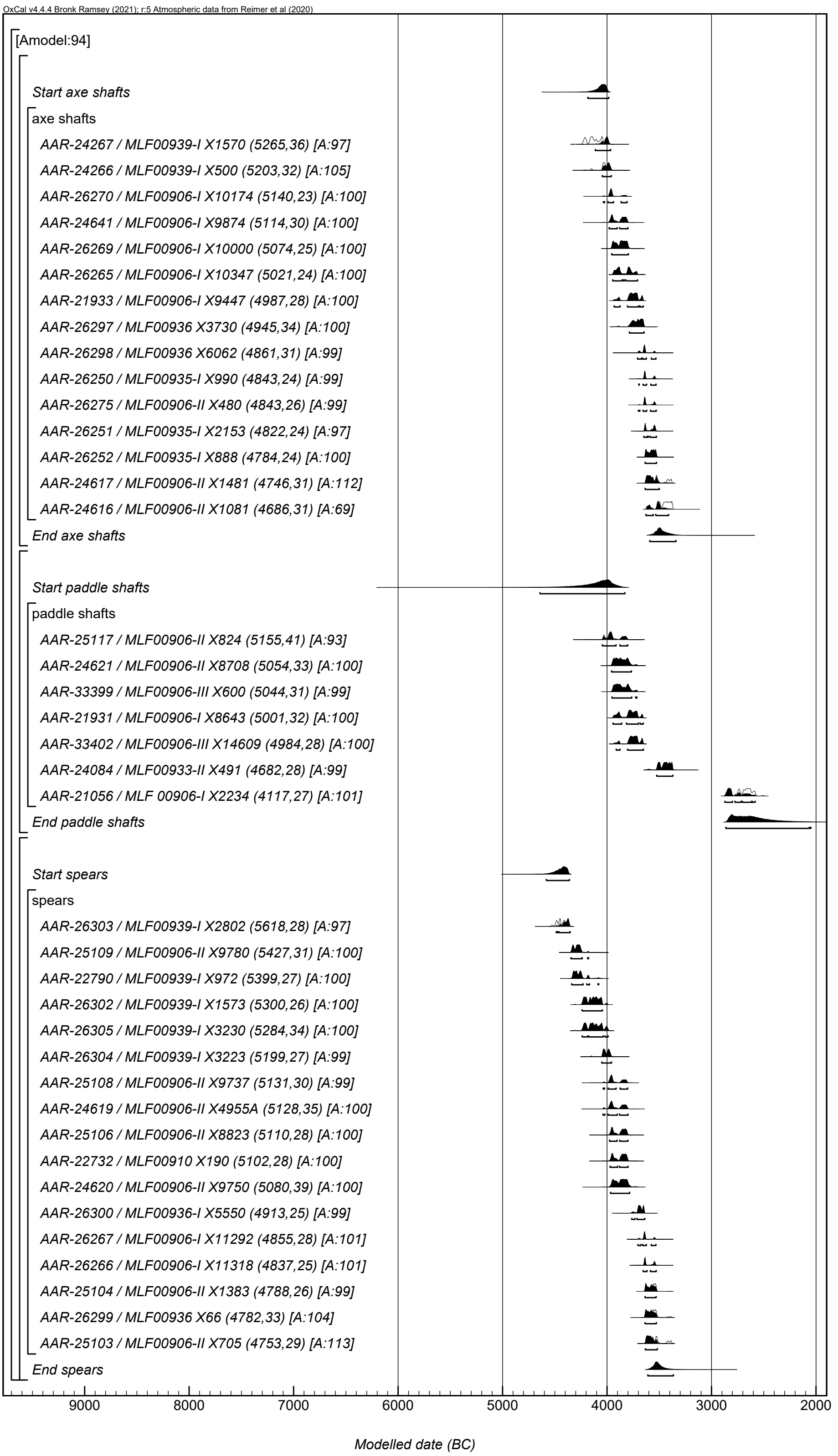


Figure 1. During the excavations in the Syltholm Fjord, no less than 105 different wooden artefacts were found pressed down into the seabed. In the table, you can see that spears and spear-like artefacts are dominant, but axe shafts and paddles also appear frequently in the material.

of tinder fungus and red deer antler. Besides these finds, the area called Structure A was characterized by 52 vertical or slightly oblique stakes pressed down into the seabed. Such vertical stakes, when found in shallow water, have mostly been interpreted as parts of fish weirs, even when only a few are found and when they do not show any straight lines. Such an interpretation seems to be too simple, as vertical stakes could have had several different functions and, in the Syltholm Fjord, a couple of thousands of such vertical stakes have been found besides the ones found in well-documented fish weirs. All these vertical stakes were unsystematically spread out over the whole fjord, except for the one concentration found around the depositional area called Structure A. In this case, this concentration of stakes was most often seen as an integrated part of Structure A, either as plain marking posts or as posts that had objects tied to them for some time before they decomposed and collapsed.

Directly dated mandibles, stakes and spectacular objects from this structure have revealed that we are dealing with an accumulation of finds covering about 1000 years from *c.* 4700 until *c.* 3600 BCE. The dated stakes cover the same time frame. In other words, the feature does not represent a single episode of deposition, which would not have created such a massive accumulation of material and would therefore easily have been overlooked. It is only because the depositions took place over such a long period that the number of spectacular objects and mandibles rendered the feature extraordinary. If one accepts this concentration of objects as the result of a depositional practice, there is no visible break in this practice from the late EBC to the end of the Early Neolithic Funnel Beaker Culture (TRB).


OxCal v4.4.4 Bronk Ramsey (2021); r:5 Atmospheric data from Reimer et al (2020)
[Amodel:94]
Start axe shafts
axe shafts
AAR-24267 / MLF00939-I X1570 (5265,36) [A:97]
AAR-24266 / MLF00939-I X500 (5203,32) [A:105]
AAR-26270 / MLF00906-I X10174 (5140,23) [A:100]
AAR-24641 / MLF00906-I X9874 (5114,30) [A:100]
AAR-26269 / MLF00906-I X10000 (5074,25) [A:100]
AAR-26265 / MLF00906-I X10347 (5021,24) [A:100]
AAR-21933 / MLF00906-I X9447 (4987,28) [A:100]
AAR-26297 / MLF00936 X3730 (4945,34) [A:100]
AAR-26298 / MLF00936 X6062 (4861,31) [A:99]
AAR-26250 / MLF00935-I X990 (4843,24) [A:99]
AAR-26275 / MLF00906-II X480 (4843,26) [A:99]
AAR-26251 / MLF00935-I X2153 (4822,24) [A:97]
AAR-26252 / MLF00935-I X888 (4784,24) [A:100]
AAR-24617 / MLF00906-II X1481 (4746,31) [A:112]
AAR-24616 / MLF00906-II X1081 (4686,31) [A:69]
End axe shafts
Start paddle shafts
paddle shafts
AAR-25117 / MLF00906-II X824 (5155,41) [A:93]
AAR-24621 / MLF00906-II X8708 (5054,33) [A:100]
AAR-33399 / MLF00906-III X600 (5044,31) [A:99]
AAR-21931 / MLF00906-I X8643 (5001,32) [A:100]
AAR-33402 / MLF00906-III X14609 (4984,28) [A:100]
AAR-24084 / MLF00933-II X491 (4682,28) [A:99]
AAR-21056 / MLF 00906-I X2234 (4117,27) [A:101]
End paddle shafts
Start spears
spears
AAR-26303 / MLF00939-I X2802 (5618,28) [A:97]
AAR-25109 / MLF00906-II X9780 (5427,31) [A:100]
AAR-22790 / MLF00939-I X972 (5399,27) [A:100]
AAR-26302 / MLF00939-I X1573 (5300,26) [A:100]
AAR-26305 / MLF00939-I X3230 (5284,34) [A:100]
AAR-26304 / MLF00939-I X3223 (5199,27) [A:99]
AAR-25108 / MLF00906-II X9737 (5131,30) [A:99]
AAR-24619 / MLF00906-II X4955A (5128,35) [A:100]
AAR-25106 / MLF00906-II X8823 (5110,28) [A:100]
AAR-22732 / MLF00910 X190 (5102,28) [A:100]
AAR-24620 / MLF00906-II X9750 (5080,39) [A:100]
AAR-26300 / MLF00936-I X5550 (4913,25) [A:99]
AAR-26267 / MLF00906-I X11292 (4855,28) [A:101]
AAR-26266 / MLF00906-I X11318 (4837,25) [A:101]
AAR-25104 / MLF00906-II X1383 (4788,26) [A:99]
AAR-26299 / MLF00936 X66 (4782,33) [A:104]
AAR-25103 / MLF00906-II X705 (4753,29) [A:113]
End spears
9000
8000
7000
6000
5000
4000
3000
2000
Modelled date (BC)

Another, even better, documented depositional practice at the site is the deposition of wooden artefacts pressed down into the seabed. The total number of objects representing this practice is 105, and 53 of these have been directly dated (fig. 1). These dates show an unbroken sequence of depositions starting *c.* 4500 BCE and ending *c.* 3500 BCE, with a couple of exceptions of a younger date (fig. 2). The continuing execution of such a specific practice as placing wooden objects into the seabed points in the direction of a continuity of the indigenous population in this area even after the introduction of agriculture. Such an interpretation is further strengthened by the study of bone and antler technology (cf. Chaudesaigues-Clausen this volume). Furthermore, we see no changes in either the flint technology or the manufacturing of small flint tools, such as arrowheads, knifes, burins, scrapers, *etc.*, even after the introduction of agriculture. It is well documented from other sites that the flint inventories at many early Neolithic sites clearly represent a continuation rooted in Ertebølle technology (Nielsen 1985; Skousen 2008).

It is, of course, possible that new groups of people, immigrants from other places, have adopted these depositional practices, and that they were carried on for generations by different populations. However, even if newcomers may have embraced or appropriated local religious customs (and corresponding belief systems), which cannot be entirely ruled out, it seems more likely that the local religion, bound to the local landscape, was handed over from generation to generation within the indigenous Mesolithic population. This interpretation is strengthened by the continuity that is also seen in flint and bone technology.

If one accepts that the wooden artefacts described above are the result of a certain depositional practice, the next question would logically be whether it is of a functional or ritual character? The given limitation for this paper forbids a thorough discussion of the use of terms such as "ritual and ritual deposition" for material found in a prehistoric context and, while being well aware that both ritual and religion are post enlightenment concepts (Brück 1999), they are used in this paper for convenience. If what is known as "ritual destruction" (Zeeb-Lanz 2016) has been practiced it becomes even more difficult to differentiate between ordinary waste and ritual depositions, so in this paper I have focused on: 1) completely undamaged artefacts, 2) artefacts that are marked but not destroyed by fire, 3) artefacts found in close context, 4) artefacts found in an unnatural position *e.g.*, in vertical position. On top of this, all depositions mentioned are found in the liminal zone at the threshold between land and sea, "which is the focus of ritual activity" (Leach 1976, 82).

When vertically deposited wooden artefacts have previously been found, they have most often been interpreted as "artefacts reused in a fish weir", even though fish weirs were rarely present or documented nearby (Andersen 2009, 92; Price and Gebauer 2005, 84; Troels-Smith 1959, 92; Vang Petersen 1979, 72).

Among the wooden artefacts from Syltholm II, the leister prongs are not included in this analysis because they could easily have been lost during use when stuck into the seabed for catching eels.

(Opposite page) Figure 2. Directly dated wooden artefacts stuck down into the seabed show an unbroken continuity in the depositional practice from the Ertebølle Culture into the Early Funnel Beaker Culture. Calibrated with OxCal v4.4.4 Bronk Ramsey (2021); r:5 Atmospheric data from Reimer et al (2020).

Figure 3. *In situ* picture of a thin-butted flint axe (MLF00906-II, X3150) pressed into the seabed with the axe head at the bottom. Both typology and a ^{14}C-date of the haft confirm that it dates to the early Neolithic period (3520–3370 cal BC; AAR-22730: 4663 ± 26 BP (Måge *et al.* this volume)).

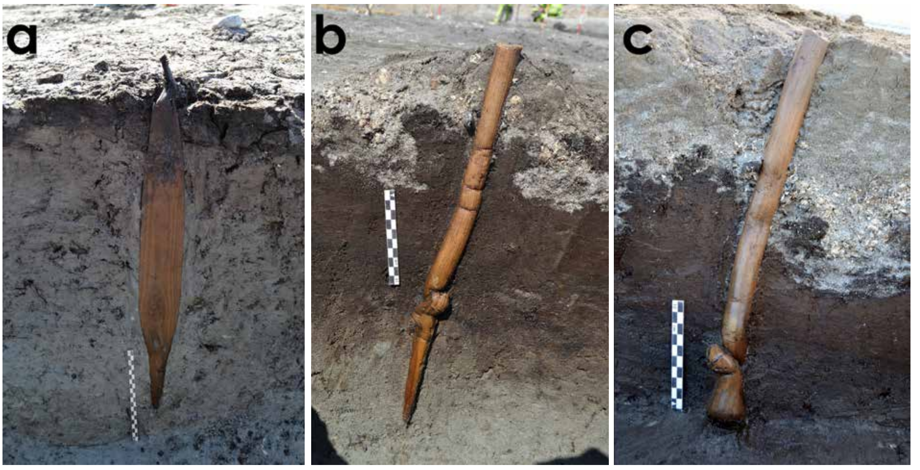


Figure 4. Examples of artefacts from Syltholm II stuck down into the seabed: a) a paddle blade (MLF00906-I, X8643), b) a spear made from split ash wood (MLF00906-II, X705; after Bennike *et al.* 2022, fig. 7) and c) an axe shaft with a knop-shaped end (MLF00906-II, X1481).

Probably the most convincing ritual deposition of a wooden object is the hafted thin-butted flint axe found pressed down into the mud with the axe head at the bottom (fig. 3). But the diversity of types is much broader, with wooden spears as the most frequent type followed by axe shafts and paddles (fig. 4). An additional argument for seeing the vertical wooden objects in a ritual perspective is that some of them show clear signs of scorching before they were deposited; as both water and fire are frequently used media for ritual actions, this is seen as a second argument for a ritual interpretation. Similar depositions of wooden objects are known from a few Ertebølle sites on the German side of the Fehmarn Belt, such as Timmendorf-Nordmole III and Babe; here, spears made from ash wood have been found in a vertical position pressed down into the seabed (Klooß 2015, 144 and 179). It is worth noting that both German examples have also been marked by fire, just like many of the deposited wooden objects from Syltholm. Another peculiarity among the wooden objects is the very diverse shapes of the paddle blades, which is often taken as a sign of chronological changes, but at Syltholm we find many different and hitherto unknown shapes all dating to the early Neolithic period (fig. 5).

Whether or not one accepts the ritual interpretation, the next question would be why there are so many wooden artefacts found at Syltholm II while similar depositions, although known from other sites, are relatively rare. One reason could of course be the extent of the excavation carried out in the coastal area. Another reason could be based on the unique geographical position of the prehistoric Syltholm Fjord, the only place in eastern Denmark with visual contact across the Baltic to mainland Europe, which today is represented by the island of Fehmarn, Germany. This position makes it plausible to see the Syltholm area as the most obvious “gateway to Europe”, something the finds from the site do support. Documentation for such contacts is found in two T-antler axes: only two others of this type are found in the rest of eastern Scandinavia, while they are frequently found in western Denmark and northern Germany. Also, the high number of shoelast axes on Lolland, one of which was found

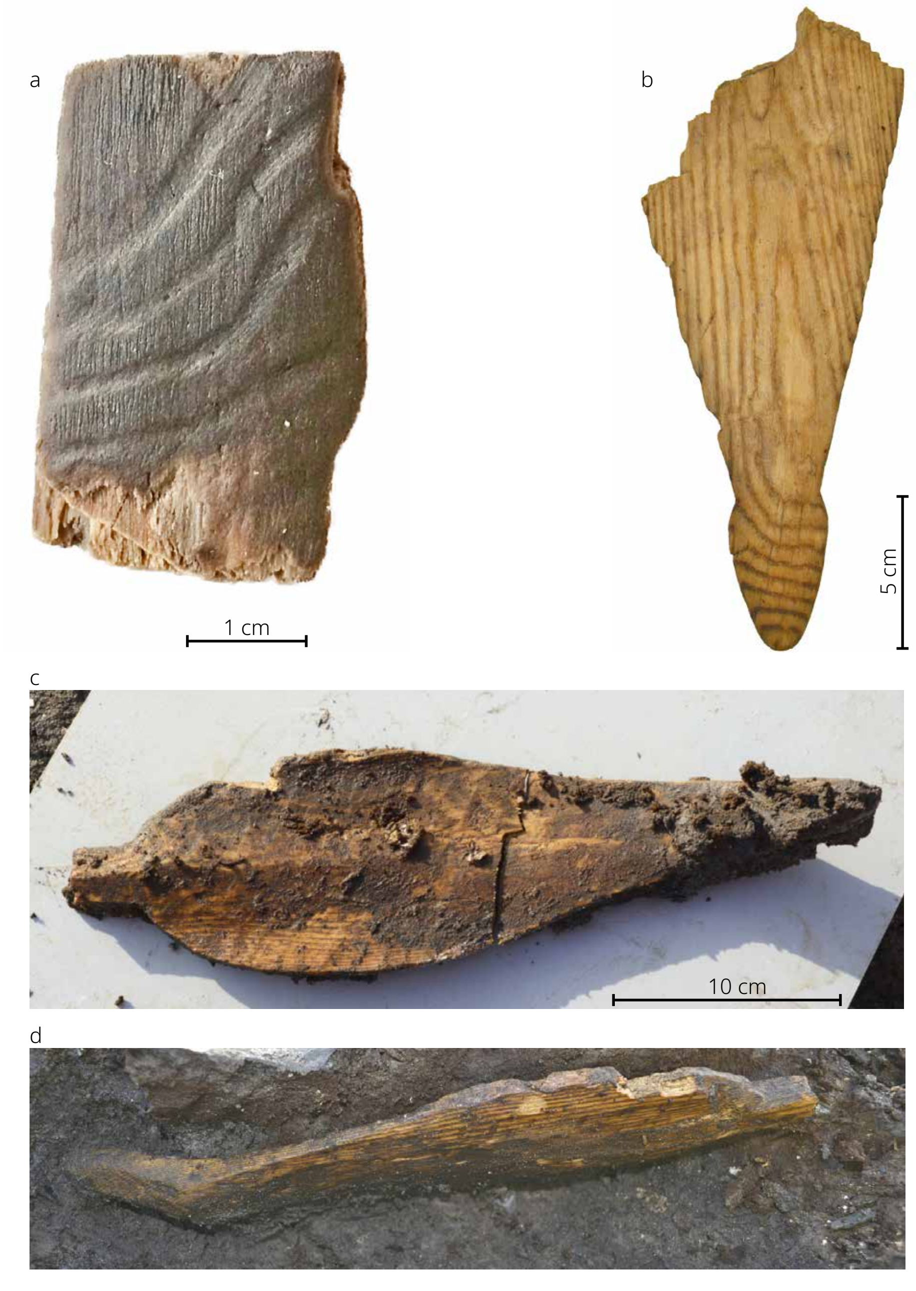


Figure 5. Examples of the very diversely shaped paddle blades from early Neolithic paddles found at Syltholm (a: MLF00906-III, X18089; b: MLF00906-II, X8708; c – d: MLF00906-III, X600 during excavation), see also fig. 2. Such a diversity in shapes indicates that people from different areas met at Syltholm but, as these paddles are unique, we cannot yet say where they came from. The decorated piece (a) is a small part of a decorated paddle and the only one of its kind in western Denmark. Note that c) and d) are oriented in opposing directions.

at Syltholm, can be seen as the result of regular contacts across the Fehmarn Belt. On top of this, Syltholm shows the first occurrence in Denmark of bones from goat/sheep, the oldest one so far is dated to 4310–4050 cal BC (AAR-33778: 5313 ± 32 BP (Måge *et al.* this volume)), which places it in the final EBC, and therefore contemporaneous with the first appearance of sheep/goat in northern Germany (Glykou 2020, 19). Also, some of the earliest cattle bones found in Denmark have been found at Syltholm, the oldest dating to 4040–3800 cal BC (AAR-33785: 5144 ± 34 BP (Måge *et al.* this volume)). These finds are indisputably of non-local character but there could be much more if one scrutinizes the material; for example, the presence of a so-far undated brown bear bone (*Ursus arctos*) may have a continental origin as it went extinct in eastern Denmark at the beginning of the Atlantic period (Aaris-Sørensen 1980).

Conclusion

One of the unanswered questions concerning the Neolithisation in Denmark is the role of the indigenous Ertebølle population in this process and why they genetically disappeared within a couple of hundred years after the introduction of the Neolithic economy? The excavations at Syltholm may throw a little light on this dark period, but the material is still far from studied thoroughly enough to redeem its great potential. Nevertheless, I will try to point at some trajectories towards a deeper understanding of what went on at the southern coast of Lolland some 6000 years ago.

The site at the prehistoric Syltholm Fjord may have been the key site for contact between eastern Scandinavia and Continental Europe. This status is documented by the presence of both artefacts and fauna of continental origin. The function as an important contact point from where risky journeys, some 20 km across open water, took place may also have influenced the intensification of sacrifices, revealed as ritual depositions made before and after dangerous crossings. The great variety found in the shape of paddle blades from Syltholm seems to be based on more than just chronological changes and could indicate that people from various places met here bringing their local characteristic paddles with them. Some of the paddle blade shapes are unknown from other sites around the Baltic and cannot therefore be linked to any specific region except for southern Lolland.

The direct dating of bones from domestic species such as sheep/goat has shown for the first time that these species were already present in the late EBC in Denmark. If it had not been for the recent DNA-study (Allentoft *et al.* 2022) showing the total extinction of the EBC-genes within a couple of hundred years after the introduction of the Neolithic in Denmark, one could easily have taken this as a sign of gradual Neolithisation, with increased contacts between Neolithic cultures in Europe and hunters in Denmark. Now it seems more likely that the first contacts and exchanges of goods with Neolithic cultures were gradually accompanied by an immigration of farmers, which explains the fast expansion of the TRB throughout southern Scandinavia. These farmers brought new types of ceramics with them, which were immediately adopted by the EBC population, but in most other aspects they continued their old lifestyle and made their traditional small tools of flint, antler and bone and continued making ritual depositions in the shallow water off the settlement in the EBC tradition. This interpretation is somewhat confirmed in the results of the study of some birch pitch found at Syltholm, which dated directly to the early Neolithic TRB and contained the DNA of a woman with western hunter gatherer ancestry who had been eating a typical hunter-gatherer meal of duck, hazelnut, and eel (Jensen *et al.* 2019).

Changes in the material culture can happen quickly, and the introduction of new artefact types will often spread rapidly over vast distances. This provides the basis for defining material cultural groups ("archaeological cultures"), but other aspects of culture are more resistant, such as subsistence strategies, handicraft and rituals and it is in exactly these matters we see a continuation in the material from Syltholm, crossing the line between the Mesolithic and the Neolithic. A similar continuation is also seen in many stratified Danish kitchen middens, which have a top level dated to the Neolithic by direct dates and the presence of TRB ceramics, but in all other aspects show a continuation of Mesolithic economies and tools (Andersen and Rasmussen 1991; Skaarup 1973). This could be seen as indirect evidence for the "old Mesolithic population" living on the coast even some hundreds of years after the introduction of the Neolithic, but with regular contacts with Neolithic farmers coming from the south in search for arable land. Such an interpretation agrees with the hypothesis put forward by Sørensen (2014), which sees the Neolithic as a step-by-step invasion of foreign farmers rooted in the Michelsberg Culture, starting with small groups bringing new technology and domestic animals with them, but slowly taking over and within a couple of hundred years completely taking over. Syltholm, with its unique location is the perfect link between the incoming farmers from the south and the local hunter-gathers from southeast Scandinavia. Since such a place would have attracted people from a vast area, not just from the nearest surroundings, it most probably functioned as an aggregation site that was different in character to most other possible aggregation sites, such as Hüde I, Rosenhof and Tybrind Vig, to mention just a few (Andersen 2013; Goldhammer 2008; Hartz 1999; Kampffmeyer 1991).

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Lola's people hunted wild boar; their neighbours kept domestic pigs

Analysis of the Syltholm pigs

Peter Rowley-Conwy

Abstract

Pig mandibles from Syltholm II and Syltholm X produced small samples of measurable teeth, mainly dating from 3900–3600 BCE: the Early Neolithic period. All twelve diagnostic teeth from Syltholm II came from wild boar killed in winter, while the four from Syltholm X came from domestic pigs killed in summer. Syltholm II produced the complete genome of 'Lola', a genetic Western Hunter-Gatherer with a forager diet, but dating to the Early Neolithic period. This study of the pigs supports the suggestion that foragers survived into Early Neolithic times, and that foragers and farmers may have maintained separate economic and cultural identities for a couple of centuries after the farming colonisation.

Femern project; wild boar; domestic pig; Mesolithic; Neolithic

Introduction

In this contribution, I examine the dental remains of *Sus scrofa* from two sites at the Danish end of the Fehmarn Belt tunnel: Syltholm II (MLF00906) and Syltholm X (MLF00936) (abbreviated below to S-II and S-X). I consider two aspects: first, whether the animals were wild or domestic; second, whether pig killing was concentrated in a particular season.

S-II and S-X are some 300 m apart and are approximately contemporary; radiocarbon dates from both fall mainly into the period 3900–3600 BCE (see Måge *et al.* this volume). This is conventionally in Early Neolithic times, and the find material from S-X is culturally almost entirely Funnel Beaker Culture. S-II, however, contains a mix of Mesolithic Ertebølle and Funnel Beaker material (Søren Anker Sørensen pers. comm.). At least some of the S-II Ertebølle material falls into Early Neolithic times because the site produced

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birch tar chewing gum dated to 3900–3700 BCE: the human genome from the preserved saliva came from a female (nicknamed ‘Lola’) who had recently eaten duck and hazel nuts, and who was genetically entirely Western Hunter-Gatherer (WHG), with no admixture from farmers (Jensen *et al.* 2019).

number	**side**	**dp4**				**P4**	**M1**				**M2**				**M3**				**age**
		ews	**L**	**WA**	**WM**	**ews**	**ews**	**L**	**WA**	**WP**	**ews**	**L**	**WA**	**WP**	**ews**	**L**	**WA**	**WP**	
MANDIBLES																			
SYLTHOLM II MLF00906-I																			
X12223	R	g	18.9	6.6	8.9		b	16.9	9.6	10.6	V								8–9
X6873A	R	e	21.0	(6.5)	9.3		a	19.7	12.1	13.1	V								7–8
X6869	L	g	21.2	7.2	9.8		c	19.3	11.2	12.9	E								9–10
X6861	R	e	22.8	7.6	10.0		b	21.3	12.2	13.1	V								8–9
X6868A	L						b	19.5	12.3	13.1									
X6860A	L	d	21.3	6.9	9.5		b	19.3	11.8	12.5	V								8–9
	R	d	21.1	7.0	9.8		b	19.1	11.6	12.8	(V)								8–9
X10062	L	c/d				c/d	x	(19.6)	x	x	e	26.6	x	18.9	c	41.7	19.3	x	23–27
X6858A	L					d	g	17.7	12.1	12.7	d	24.5	15.4	16.4	a	42.7	17.8	18.0	21–23
X6830	R														b	44.6	20.0	18.9	23–25
X4991	R										U	24.6	14.8	15.5					
SYLTHOLM II MLF00906-II																			
X9428	L														d	47.8	19.6	19.1	
X7319	R														a	43.1	18.2	17.5	
X5450	L										e	24.2	16.7	x					
SYLTHOLM II MLF00906-III																			
X1500	L					e	j	(17.5)	10.7	12.1	f/g	22.9	14.6	(15.1)	c	43.7	18.0	17.5	21–23
	R					e	h	(17.5)	11.2	-									
X6210	R						d	18.3	-	11.6	a	23.9	14.5	15.3	$^1/_2$				19–21
MLF00001-VII X304 (Maribo Museum)																			
VIII	L					a	d	19.5	11.5	12.6	a/b	24.2	15.3	16.5	V				
	R					a	d	19.7	11.7	12.6	a	24.1	15.5	16.7	V				
SYLTHOLM X MLF00936																			
X4751	R					a	d	18.5	11.6	12.1	b	22.9	14.8	15.5	E	(38.2)	(17.0)	(16.1)	17–19
X2959	L					b	d	17.9	10.6	11.5	a	22.4	13.5	13.3	V				16–17
	R					a	d	17.9	10.2	11.3	a	22.6	13.6	14.0	V				16–17
MAXILLAE																			
SYLTHOLM II MLF00906-I																			
X11246	L						a	18.1	13.4	13.3	(V/E)								
SYLTHOLM II MLF00906-III																			
X4989	R						(k)	-	-	15.8	h	21.8	18.9	17.4	c	34.1	19.8	16.0	21–23
SYLTHOLM XIII MLF00939-II																			
X872	L					b	d	19.2	15.7	16.0	b	24.9	20.1	20.5	$^1/_2$	41.1	22.6	18.0	19–21

Table 1. Measurements of the suid teeth from Syltholm sites II and X. Values in brackets are estimated; x indicates the measurement could not be taken (measurements are as defined by Payne and Bull (1988)): L=length, WA=Width Anterior, WP=Width Posterior. Eruption and wear stages (ews) follow Grant (1982) for wear (lower case letters), and Ewbank (1964) for eruption (upper case letters). Age in months follows Higham (1967).

Wild or Domestic?

Table 1 lists the measurements of the rearmost milk tooth, dp4, and the permanent molars M1, M2 and M3 from Syltholm (measurements follow the definitions of Payne and Bull (1988)). The most useful teeth for separating wild and domestic animals are M2 and M3, and they will be the focus of discussion here. The three maxillae are too few to be helpful and are not discussed further. The mandible X304 (on display in Maribo Museum) comes from the pre-excavations (MLF00001-VII) and is also excluded. This leaves just six M2 and six M3 teeth from S-II, and three M2s and one M3 from S-X. It must be born in mind throughout the following that this is a very small sample, and only the most tentative conclusions can be drawn. Nevertheless, the results are suggestive.

Two methods will be used. First, the calculation of Pearson's Coefficient of Variation (V), which is the standard deviation as a percentage of the mean. This results in a measure of the range of each measurement, which is independent of absolute size. Second, the plotting of the individual measurements on charts alongside comparative specimens from other populations allows individual teeth to be considered. This is much preferable to presentations limited to log ratios, 'box-and-whisker' charts of means and standard deviations *etc*.

Table 2 presents V for the Syltholm teeth. The sample is so small that S-II and S-X are considered together. Also listed are various comparative populations. The modern wild boar population from Kızılcahamam in Turkey forms the standard wild population (Payne and Bull 1988), the Neolithic one from Durrington Walls in England forms the domestic standard (Albarella and Payne 2005). V of all measurements in these populations is under 6.0.

Table 2 also presents the sample from Middle Neolithic Gomolava in present-day Serbia. In her pioneering publication of the fauna from this site, Anneke Clason published the tooth measurements and argued that the population comprised a mixture of wild boar and domestic pigs (Clason 1979). Table 2 shows that Clason was right: V is in all cases much larger than those from Kızılcahamam and Durrington Walls. This confirms that Gomolava comprises *two* populations of suids, which were of different sizes. These can only be wild boar and domestic pigs. They evidently did not interbreed much, or the size of the populations would have converged, resulting in a smaller V value. Clason's published data in fact show that the two populations were treated differently, the domestic animals being killed on average younger than the wild boar (Rowley-Conwy *et al.* 2012, 20–21).

Also presented in Table 2 are the V values from four other Danish sites: domestic pigs from Neolithic Troldebjerg (on Langeland), and three Mesolithic samples from Bloksbjerg and Nivå (on Zealand), and Sludegaard (on Fyn). The Troldebjerg V values are low, supporting the suggestion that only one pig population was present. Their small size, comparable to that of Durrington Walls, confirms that these were domestic. The Mesolithic animals are larger, which is typical for wild boar. Nivå and Sludegaard conform to what is expected of single populations, while some of the Bloksbjerg Vs are somewhat larger than those from Kızılcahamam and Durrington Walls. The Syltholm Vs are also somewhat higher, suggesting that the size range may be too great to come from one prehistoric population.

Fig. 1 plots two measurements of M2 from the Danish comparative sites, showing that there is little overlap between the Mesolithic wild boar and the Neolithic domestic pigs from Troldebjerg: the wild boar are much larger. Two Mesolithic teeth from Bloksbjerg, however, stand out, as they fall into the Troldebjerg domestic size range. Since there are

			Syltholm	Durrington *domestic*	Kızılcahamam *wild boar*	Gomolava *mixed*	Troldebjerg *Neolithic*	Bloksbjerg *Mesolithic*	Nivaa *Mesolithic*	Sludegaard *Mesolithic*
M2	L	N	11	81	15	28	47	9	4	11
		x̄	23.9	21.8	24.9	20.5	21.9	25.2	-	25.3
		V	**5.3**	**4.6**	**3.7**	**11.6**	**6.0**	**5.0**	-	**6.5**
	WA	N	10	74	15		47	9	4	13
		x̄	14.9	13.7	15.4		13.6	15.9	-	16.1
		V	**6.3**	**4.3**	**3.4**		**5.2**	**8.2**	-	**6.3**
	WP	N	10	68	15	28	47	9	4	11
		x̄	15.7	14.2	16.3	14.9	14.2	16.8	-	16.5
		V	**9.9**	**4.5**	**3.7**	**19.1**	**4.7**	**8.2**	-	**5.5**
M3	L	N	6	39	5	19	68	10	7	6
		x̄	43.3	34.5	-	39.2	35.9	44.8	43.9	43.0
		V	**7.2**	**5.5**	-	**21.8**	**7.2**	**8.8**	**5.1**	**6.3**
	WA	N	6	42	5	19	68	10	7	6
		x̄	17.8	15.7	-	18.2	16.0	18.1	18.8	18.6
		V	**6.1**	**6.0**	-	**15.9**	**6.1**	**4.8**	**4.8**	**8.0**

Table 2. Metrical attributes of the Syltholm pig mandibular M2 and M3 teeth, compared to other populations. Reference populations comprise domestic pigs from Durrington Walls (Albarella and Payne 2005, tab. 2), wild boar from Kızılcahamam (Payne and Bull 1988, tab. 1b, where V is calculated only to the nearest whole number; here, Payne and Bull's figures are used to recalculate values to the nearest 0.1), and the mixed Neolithic population from Gomolava (Clason 1979, tab. 6). Danish comparatives measured by Keith Dobney and me as part of the Durham Pig Project.

Neolithic layers above the Mesolithic ones at Bloksbjerg, these teeth may have intruded from above (though this has not been tested by direct radiocarbon dating). These teeth are the reason that the Bloksbjerg Vs for M2 WA and WP are larger than expected from a single population. Fig. 1 shows the power of graphs as a visual tool for diagnosing individual teeth, because it also plots one Mesolithic specimen from Rosenhof in northern Germany. On the basis of aDNA, this animal was argued to be domestic (Krause-Kyora *et al.* 2012), but metrically it is far too large to be a domestic animal acquired by hunter-gatherers from Neolithic farmers to the south. Most likely, this animal was a (possibly quite distant) descendant of a feral individual that escaped from the farmers and interbred with wild boar, and which ended up at Mesolithic Rosenhof as the result of conventional hunting (Rowley-Conwy and Zeder 2014).

Fig. 2 plots the Syltholm M2 teeth against the same comparative populations, S-II and S-X being differentiated. Only five of the six S-II teeth have WP measurements, X5450 being broken at this point. The scatter spans both the domestic and the wild comparative ranges, confirming the conclusion from Table 2 that both wild and domestic animals are present. The sample is small, but the difference between the S-II and S-X distributions is striking: the S-II teeth fall mainly into the wild zone, the S-X

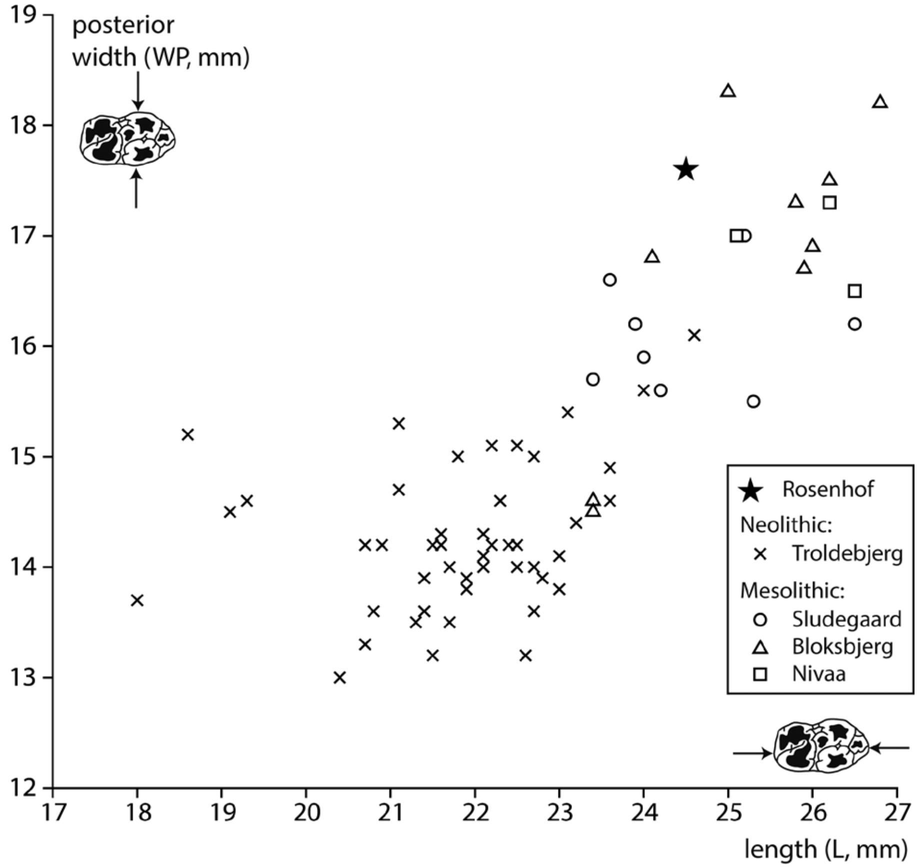

Figure 1. Measurements L and WP of suid M2 from various sites in Denmark and northern Germany (modified from Rowley-Conwy and Zeder 2014, fig. 2). The Rosenhof measurements were kindly provided by Ulrich Schmölcke.

ones into the domestic zone. There is a slight overlap, the smallest S-II tooth, specimen X1500, falling just below the largest S-X tooth. However, for reasons explained below, X1500 was most probably a wild boar, albeit with a small M2. Thus, at S-II the five measurable M2 teeth all come from wild boar. The broken specimen X5450 has an L of 24.2 (as well as the largest WA measurement in the entire assemblage) and thus certainly also comes from wild boar, bringing the S-II total to six. At culturally Neolithic S-X the three available teeth are all from domestic pigs.

Mandible MLF00001-VII X304, on display in Maribo Museum, is not plotted in fig. 2. But inspection of the values in Table 1 reveals that both the left and right sides fall clearly into the wild scatter.

Fig. 3 plots the available M3 measurements from Syltholm, compared to those from the same group of Mesolithic and Neolithic sites. As with M2, there is hardly any overlap between the wild and domestic distributions. The Syltholm sample is again small, but divides in the same way as M2. The single specimen from S-X falls into the domestic range, the six from S-II into the wild range. Mandible X1500, marked in fig. 3, is in the lower part

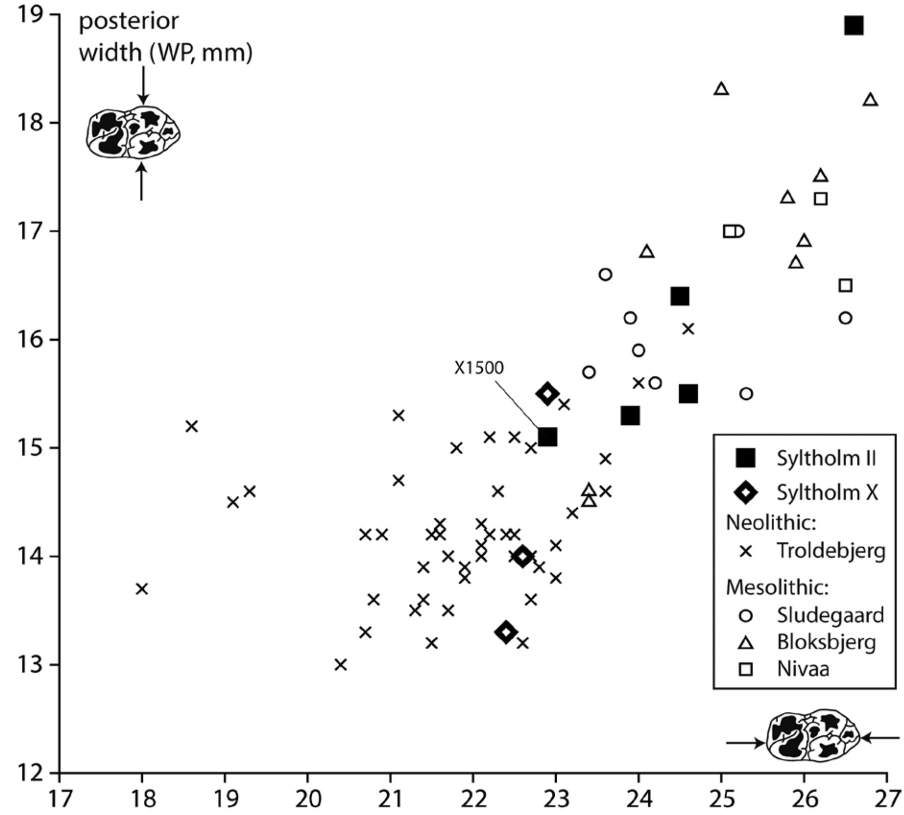

Figure 2. The Syltholm M2 measurements plotted against those from the comparative sites listed in Table 2.

of the wild range but outside the domestic range; this suggests that the M2 next to it in the same jaw (marked in fig. 2) really is from a wild boar.

The Syltholm assemblage, although small, thus presents a remarkable pattern: twelve diagnostic teeth from S-II, where Lola's birch tar was found, come from wild boar, while four diagnostic teeth from S-X, just 300 metres away, come from domestic pig.

Seasonality

Many of the mandibles listed in Table 1 come from immature animals, which means that reasonably precise ages at death can be assigned to them. Tooth eruption in pigs is now quite well understood. It used to be thought that modern, 'improved' domestic breeds erupted their teeth faster, *i.e.* at younger ages than earlier 'unimproved' domestic animals (Silver 1969). However, wild boar erupt their teeth at the same ages as modern domestic pigs (*e.g.* Matschke 1967). The claims that earlier domestic animals erupted their teeth at older ages have been shown to be incorrect, and the eruption ages of molar teeth are remarkably constant between the domestic breeds, and wild boar (Legge 2013). The ages listed in Table 1 are based on the age stages for modern domestic pigs put forward by Higham (1967).

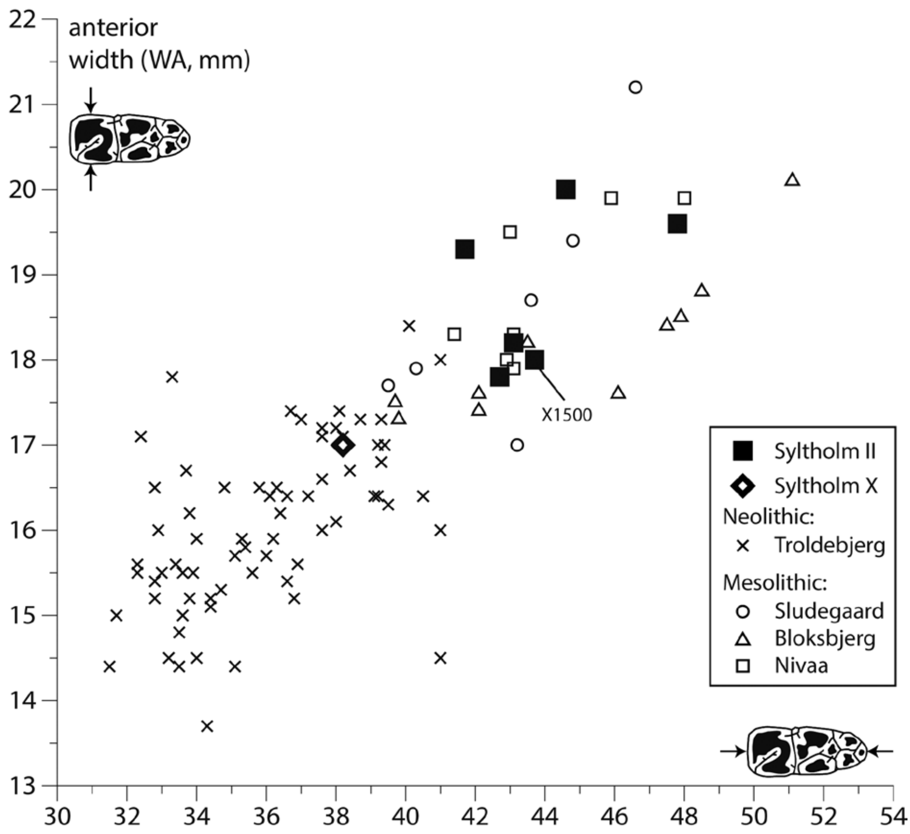

Figure 3. The Syltholm M3 measurements plotted against those from the comparative sites listed in tab. 2.

Wild boar in Denmark now mainly give birth in late March and early April (Møhl 1978). If a notional birth date of 1st April is assumed, the approximate season of death of juvenile wild boar can be calculated. This method has been used at other Mesolithic sites in Denmark, and where other lines of seasonal evidence are available the wild boar are in agreement with them (*e.g.* Rowley-Conwy 1998; 2001). Early domestic pigs are also likely to have been born in a restricted season in spring, and where Neolithic sites have been examined a pattern of slaughter has emerged that is at least plausible (Rowley-Conwy 1986). Seasonal determination for both wild and domestic animals is therefore likely to be reliable.

Fig. 4 plots the aged mandibles (and the two ageable maxillae) from Syltholm on a seasonal chart, assuming a 1st April birth date. Each line represents one ageable individual and covers the time range *at some point within which* the individual was probably killed – it does not of course mean that the site was occupied *throughout* the months covered by the line. Samples are small, but there are indications of an interesting pattern. At S-II, six mandibles fall tightly into the first winter; they could all have been slaughtered over a very short period in late December/early January. There is then a gap, followed by renewed killing in the second winter. Five specimens could have been killed at the same time as the first winter animals, while the remaining two

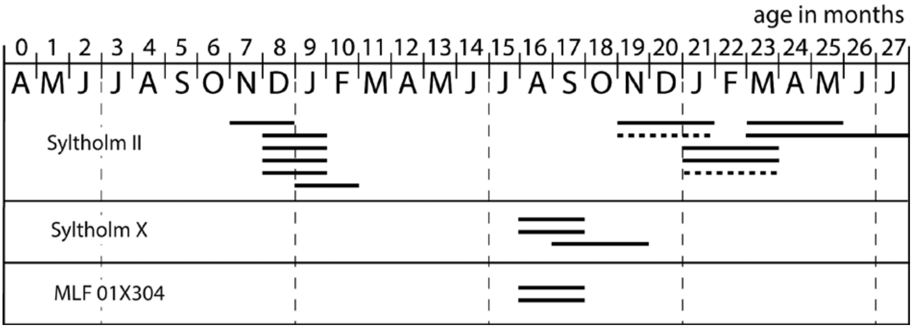

Figure 4. Ageable dentitions from the Syltholm sites, showing season of death assuming a birth date of 1st April. Each line represents one mandible, dotted lines indicate the maxillae.

fall into late winter or spring. (These later age stages are the least likely to be accurate, as they depend on the rate at which M3 came into wear). The three domestic mandibles from S-X contrast with this, having been killed in late summer or early autumn.

Mandible MLF00001-VII X304 also falls into late summer. This aligns it with the domestic pigs from S-X – although (as discussed above) this animal is a wild boar and might therefore have been expected to align with the wild boar from S-II. It is not clear at the moment what this means.

Discussion and conclusions

The Syltholm suids help to elucidate the transition from Mesolithic foragers to Neolithic farmers. This was for decades regarded as an indigenous development, with foragers gradually adopting farming. For a long period, the Late Mesolithic was therefore searched for 'pre-Neolithic' activities, such as a small number of domestic animals or plants. The Mesolithic archaeological record has, however, failed to produce any such evidence, and the few claimed cases called into doubt – the mandible from Rosenhof plotted in fig. 1 being a case in point. The transition has therefore increasingly been viewed as abrupt, brought about by colonists from outside (*e.g.* Sørensen and Karg 2014). This has received support from recent studies of aDNA, which show a massive population replacement (Allentoft *et al.* 2022). Similar developments took place in Britain, seen in the aDNA (Brace *et al.* 2019) coming into line with the archaeological view of a rapid colonisation process (*e.g.* Rowley-Conwy 2011; Sheridan 2010).

Colonisation raises the possibility that indigenous foragers survived for a few centuries *after* the arrival of farmers from *c.* 4000 BCE. There is increasing evidence in Denmark for such an overlap. A skeleton from the Rødhals site on the offshore island of Sejerø falls into Early Neolithic times but had a marine diet similar to that of the Late Mesolithic people (Fischer 2007), and the fauna from Rødhals is dominated by fish, with a small admixture of wild and domestic mammal bones (Fischer *et al.* 2021). A wider survey of Early Neolithic Denmark has revealed that some sites show remarkable continuity from the Mesolithic, and are best interpreted as the settlements of surviving foragers (Gron and Sørensen 2018). Once again, hints of something similar may be appearing in Britain: hunter-gatherers may have been present at an Early Neolithic feast at Coneybury in Wiltshire (Gron *et al.* 2018), and an overlap is one possible scenario in western Scotland (Mithen 2022).

This is the context into which the Syltholm sites fall. S-II and S-X are *archaeologically* contemporary. This need not mean that they are *literally* contemporary: they could actually be a century or more apart in time. But they are both geographically and chronologically close enough to suggest that foragers and farmers did live in close proximity around Syltholm. Lola shows no genetic admixture from the colonising farmers, and her diet was of the 'Mesolithic type' (Jensen *et al.* 2019). The Syltholm suids have implications for other aspects of life. It must be stressed yet again that the samples are very small; but so far as they go, they do suggest that indigenes and colonists maintained separate terrestrial subsistence economies, and thus presumably separate cultural identities, for a few centuries after the arrival of the colonising farmers. Lola's people hunted wild boar in winter, while their farming near-neighbours kept domestic pigs and killed at least some in summer.

Much more work needs to be done: we need larger samples of animal bones, and detailed considerations of the material culture, to confirm or refute this in the future. But for the time being, the Syltholm suids support the 'two culture' model.

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Neolithic farming in forager-resource systems

A case from southern Norway

Svein Vatsvåg Nielsen and Jo-Simon Frøshaug Stokke

Abstract

In southern Norway, evidence of hunting, fishing and gathering is highly visible in the archaeological record from the Early and Middle Neolithic (3900–2350 BCE) periods, suggesting continuity in economic practices across the Mesolithic-Neolithic divide. Yet contours of a more complex economic trajectory have emerged in recent years. A growing body of evidence suggests that an Early Neolithic farming economy spread to Norway as part of the Neolithisation process in southern Scandinavia, and that locally adapted forager-resource systems in the north sustained low-level agriculture for centuries, ending around 2800 BCE. This paper reviews the evidence supporting this new model, with a particular focus on the site of Kvastad A2 on the central Skagerrak coast in Norway, where plant cultivation took place during the Middle Neolithic A (3300–2800 BCE). We discuss the realism of foragers adopting and adapting farming economies in the Scandinavian Neolithic.

Neolithisation; horticulture; low-level cultivation; foraging; mixed economies

Introduction

In southern Norway, evidence of hunting, fishing and gathering is highly visible in the archaeological record from the Early (3900–3300 BCE) and Middle Neolithic (3300–2350 BCE) periods. On the face of it, continuity in economic practices across the Mesolithic-Neolithic divide is apparent, yet there is evidence today suggesting that a Neolithic mode of production appeared on the fertile and well-drained soils surrounding the Oslo fjord (eastern Norway) shortly after 3900 BCE (Amundsen *et al.* 2006; Nielsen 2021a; Solheim 2021). This paper follows the hypothesis that farming spread further west during the Middle Neolithic (MN), and that it became integrated

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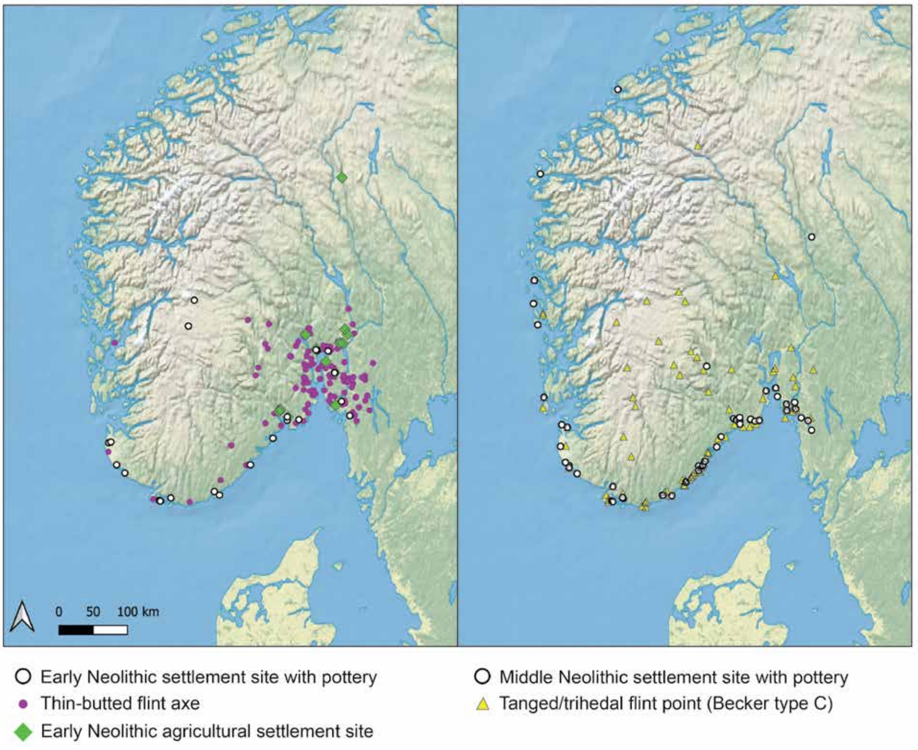

Figure 1. Distribution maps of selected artefact and site types in southern Norway (based on data in Nielsen 2022). Left: EN (3900–3300 cal BC). Right: MN (3300–2350 BCE). Corresponding distributions in Sweden and Denmark not mapped. Illustration: S. V. Nielsen.

in coastally adapted population patches that were organized structurally into forager-resource systems. One of these patches was located on the central Skagerrak coast in southern Norway. Here, we review the evidence of foraging and farming that dates to the MN period in this specific region, with an emphasis on the farming site of Kvastad A2 (MN A, 3300–2800 BCE). We present an empirically based, spatial model of a mixed economy, and we engage in a discussion that concerns the realism of foragers adopting farming and enculturation theory in general.

Background

Numerous Neolithic settlements reflecting a forager economy have been excavated along the coast and in the interior of southern Norway, including the high-mountain plateaus (Bergsvik 2002; Færø Olsen 2020; Glørstad 2004; Glørstad *et al.* 2020; Indrelid 1994; Juhl 2001; Kristoffersen 1995; Kristoffersen and Warren 2001; Mansrud and Berg-Hansen 2021; Nielsen and Persson 2020; Nummedal and Bjørn 1930; Nærøy 1994; Reitan 2014; Reitan and Sundström 2018). At the same time, the appearance of pottery technology and imported flint axes from southern Scandinavia, particularly surrounding the Oslo fjord in eastern Norway, indicates a shift in modes of production shortly after *c.* 3900 BCE (fig. 1). Bjørn (1924) argued that many axes had been found in Early Neolithic flat graves, and Brøgger (1925, 128)

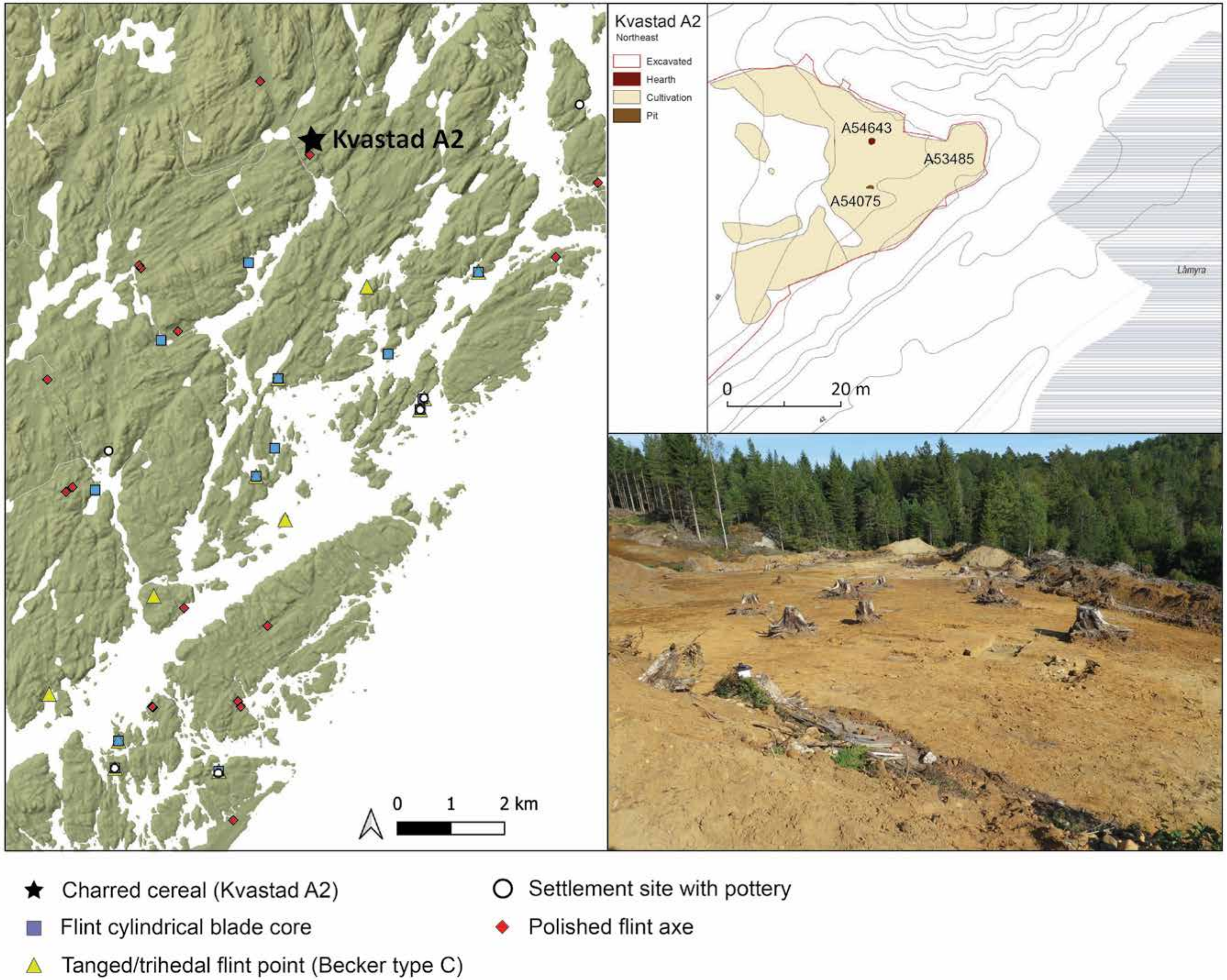

Figure 2. Location of the site of Kvastad A2. Sea level elevated to 12 masl (*c.* 3000 BCE). Excavation area based on site drawing in Stokke and Reitan (2018, 405, fig. 2.5.5.33) (photo: Museum of Cultural History (Cf34801_82, CC BY-SA 4.0)). Illustration: S. V. Nielsen.

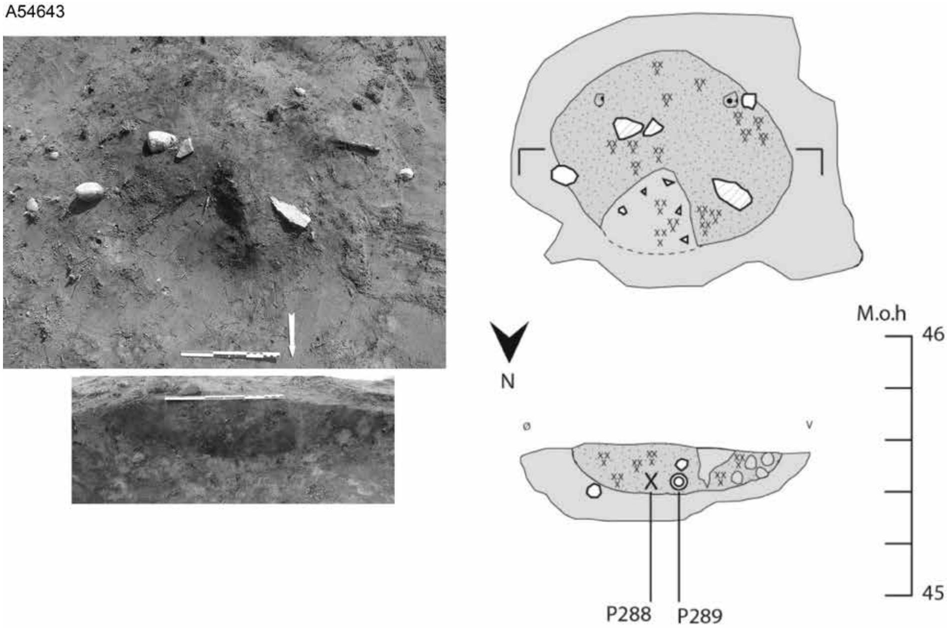

Figure 3. Structure A54643 at Kvastad A2. The structure contained charcoal and burnt stone and was interpreted as a hearth. Two charred cereals dating to the Middle Neolithic A (3300–2800 BCE) were identified inside a soil sample (P289) collected from the profile. Structure photos by Museum of Cultural History (Cf34801_062–3, CC BY-SA 4.0). Original field drawing modified from Stokke and Bjørkli (2016, 24, fig. 16). Illustration: S. V. Nielsen.

described a 'colony' of farmers in western Sweden and eastern Norway who had migrated from southern Scandinavia. There is now a consensus that foraging continued in most regions of southern Norway until the Late Neolithic, while a Neolithic economy was introduced in the Oslo fjord region in the EN I (Glørstad 2012; Glørstad *et al.* 2020; Nielsen 2021a; Nielsen *et al.* 2019; Prescott 1996; Reitan *et al.* 2018). Around the transition from the EN II to the MN A (3300–2800 BCE), the distribution of TRB-type stone battle-axes and flint axes become coastally oriented, which is interpreted by Hinsch (1955) as a fundamental economic changeover. However, recently uncovered evidence from the central Skagerrak coast, at the site of Kvastad A2, suggests a westward expansion of farming practices during this period.

Farming at Kvastad A2

The open-air site of Kvastad A2 (fig. 2) was surveyed due to land development plans in 2013 and was fully excavated by the Museum of Cultural History in Oslo in 2015 (Eskeland 2013, 382–385; Stokke and Bjørkli 2016; Stokke and Reitan 2018). Kvastad A2 was situated on a *c.* 2500 m^2 east facing and gently sloping promontory on well-drained and sandy soils, about 70 m from the large Låmyr bog. Based on the height above sea level (44–50 m) and a majority of the lithic artefacts, it was assumed that Kvastad A2 represented only a Mesolithic occupation area. However, patches with slight concentrations of charcoal particles, interpreted as a cultivation layer (A53485), were observed on the lowest and most even part of the site, where a few Late Neolithic flint tools and pottery sherds also occurred

(Stokke and Reitan 2018, 402). Samples from A53485 and a pit with charcoal and burnt rocks (A54643, interpreted as a hearth) contained charred cereals of barley, oats and emmer wheat. One sample of oats (*Avena* sp.) from the cultivation layer, and two of oats and one of barley (*Hordeum vulgare* var. *nudum*) from the hearth, dated to *c.* 1900–1700 BCE (Late Neolithic). In addition, one barley and one emmer wheat sample (*Triticum dicoccum*) from A54643 dated to 3496–3033 cal BC (Ua-52925: 4551 ± 56 BP) and 3316–2882 cal BC (Ua-52926: 4351 ± 55 BP) respectively (fig. 3; Reitan *et al.* 2018). It is unknown at which point in time, Middle Neolithic or Late Neolithic, hearth A54643 was formed. A second pit within the same excavation area (A54075) was dated to the Middle Mesolithic period.

A drilling core was sampled from the bog, and 54 pollen samples were counted at a depth of between 356 cm and 170 cm. An increase in charcoal occurred at three depths dating to 4361–4260 cal BC (Beta-455054: 5470 ± 30 BP), 3331–2931 cal BC (Beta-455053: 4440 ± 30 BP), and 1955–1767 cal BC (Beta-455052: 3540 ± 30 BP) (Reitan *et al.* 2018). The two upper levels corresponded well with the evidence of farming at Kvastad A2, suggesting woodland clearing by the use of fire to open up crop fields. An increase in grasses (*Poaceae*) and sorrel (*Rumex acetosa*), and a decrease in birch (*Betula*) and pine (*Pinus*) in the Neolithic sequence supported this interpretation. Thus, the traces of cultivation at Kvastad A2 may stem from a form of horticulture where cultivation is small-scale but intensive, requiring minimum field clearing (*e.g.* removing of stones, arding, etc.) (Leach 1997; van der Veen 2005, 160). Due to the small-scale nature of this practice, it is difficult to observe archaeologically. In addition, no cereal pollen was identified in the pollen sequence from Låmyra, illustrating the limits of using pollen core analyses for discussions of early farming in Norway.

Discussion

The dating of two Kvastad A2 charred cereals to the MN A period brings new life to an old debate about early farming in Norway, one that used to be based on either indicative or (allegedly) badly documented evidence (see review in Prescott 1996). Among the disputed evidence was the 'askelinser' (spots of ash) documented at the coastal forager site of Kotedalen (1985–87) on the central western coast (Olsen 1992). These features contained pollen from barley (*Hordeum*) and ribwort (*Plantago lanceolata*) and were dated with reference to stratigraphic observations to the MN A. This was confirmed by one charcoal sample dated to 3349–2879 cal BC (Beta-3995: 4410 ± 90 BP) (Hjelle 1992; Olsen 1992, 266). Later, a tooth from a domesticated ox (*Bos taurus*) found at the rock shelter site of Stangelandshelleren on the southwest coast was dated to 3335–2904 cal BC (TUa-2854, 4404 ± 65 BP) (Høgestøl and Prøsch-Danielsen 2006, 23). Although many consider this as evidence of mixed economies during the MN A (Bergsvik 2001; Bergsvik *et al.* 2020; Hjelle *et al.* 2018; Kaland 2014; Nielsen 2021b), critics have pointed to one-sided data and low documentation quality (Prescott 1996; 2009; Rowley-Conwy 1995). Kvastad A2, on the other hand, leaves no doubt that plant cultivation was practiced immediately west of the Oslo fjord region during the MN A.

Setting previous empirical disputes aside, we still need to explain how and why foragers adopted farming (Bergsvik *et al.* 2020, 340). The coast and its abundance of marine resources was important to prehistoric foragers in many regions of northern Europe (Bailey *et al.* 2020). On the central Skagerrak coast, MN settlements are coastal oriented, often located on islands, and contain an abundance of lithic, ceramic and sometimes organic artefacts

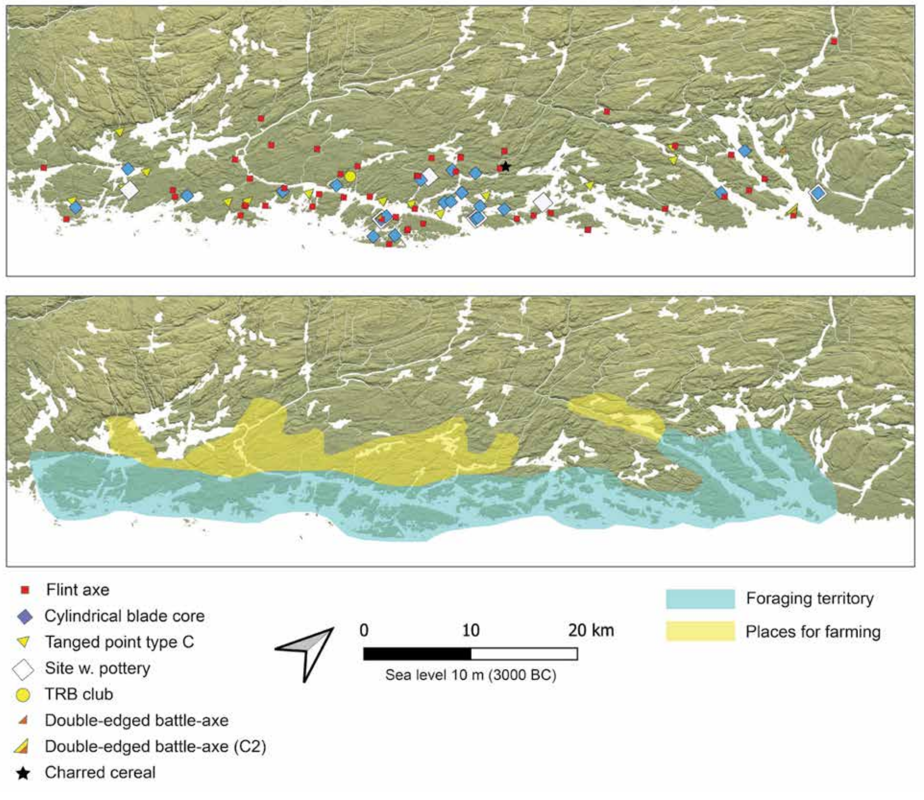

Figure 4. Distribution of selected artefact and site types along the central Skagerrak coast, with sea level elevated to 10 m, corresponding approximately with the sea level in this region around 3000 BCE. Illustration: S. V. Nielsen.

(*e.g.* Mansrud and Berg-Hansen 2021; Nielsen and Persson 2020). Considering that these forager-resource systems adopted farming and practiced it at specific sites located in the hinterland (fig. 4), we are arguably dealing with a central element in Bettinger's 'traveller-processor model', which posits a functional relation between population density and diet breadth among foragers. Following Bettinger and Baumhoff (1982, 487), higher population and increased sedentism leads to low dependence on big game and increased dependence on plants and smaller game (see also Binford 2001, 312).

Given the importance of low depletion rates of local resources among high density forager populations, Gallagher *et al.* (2019) found that the emergence of crop cultivation could have been 'a new means of reducing the depletion rate and increasing the replenishment rate' among high density forager populations. In other words, farming could had been adopted by MN foragers simply as a means to continue with foraging. A main function of crop cultivation at Kvastad A2 and similar sites in the region would have been to reduce depletion rates but, in order to replenish their supplies, maintenance of distant social relations would also be required (Freeman 2012, 3009; Sørensen 2014, 33). The inflow of flint axes and long-blade caches with a southern Scandinavian origin could reflect this social networking (Nielsen 2017a; 2017b; Nielsen and Åkerstrøm 2016).

Thus, it seems as if the EN population did not fundamentally change its economy at the transition to the MN but responded by increasing its diet breadth. This brings to light the interpretation of the de-Neolithisation hypothesis by Bostwick-Bjerck (1988a; 1988b, 47), who concluded that 'Middle Neolithic groups in eastern Norway moved to the coast not because they stopped all agricultural activity, but because they reduced their traditional dependence on forest hunting and fishing resources and started to use the forest in a much more efficient manner'. We cannot support the proposition that woodland farming in the MN was 'much more efficient' compared to farming around the Oslo fjord in the EN (cf. Göransson 1994; Innes *et al.* 2013; Kristiansen 1993; Out *et al.* 2022). However, the general model of farming integrating with forager-resource systems does fit the current state of the evidence.

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IDENTITIES OF CHANGE

Mesolithic hunters in mixed oak forests

Differences in hunting strategy and hunting behaviour

Ulrich Schmölcke

Abstract

The selection of prey by Mesolithic foragers touches on important basic aspects of hunter-gatherer research. According to the Optimal Foraging Theory, hunter-gatherer groups always try to make their foraging "optimal" – but what exactly does "optimal" mean? The comparison of five sites in the north German lowlands, covering large parts of the Mesolithic, shows that there were obvious changes in the hunting behaviour of the foragers. While hunters at the beginning of the Mesolithic concentrated on smaller, non-dangerous species, particularly large and thus dangerous animals were later the dominant hunting prey. At the end of the Mesolithic, when people increasingly moved from inland lakes and rivers to the Baltic Sea coast, seals briefly became very important. At the same time, terrestrial hunting began to focus increasingly on red deer.

In general, the results show very clearly that Mesolithic hunting in the study area seems to have become more and more specialized. However, questions remain: do the results demonstrate transition processes in hunting strategies or do they reflect either adaptations to regional ecological conditions or different traditions of local human groups?

Hunting strategy; Optimal Foraging Theory; zooarchaeology; transformation

Introduction

The question of prey selection by Mesolithic foragers touches on various basic aspects of hunter-gatherer research: how large were the hunting groups, were hunting dogs used, and how large were the territories of individual communities? These are only some of the questions related to prey choice. In general, the larger and the better equipped with weapons and well-trained hunting dogs a group of hunters was, the more likely they

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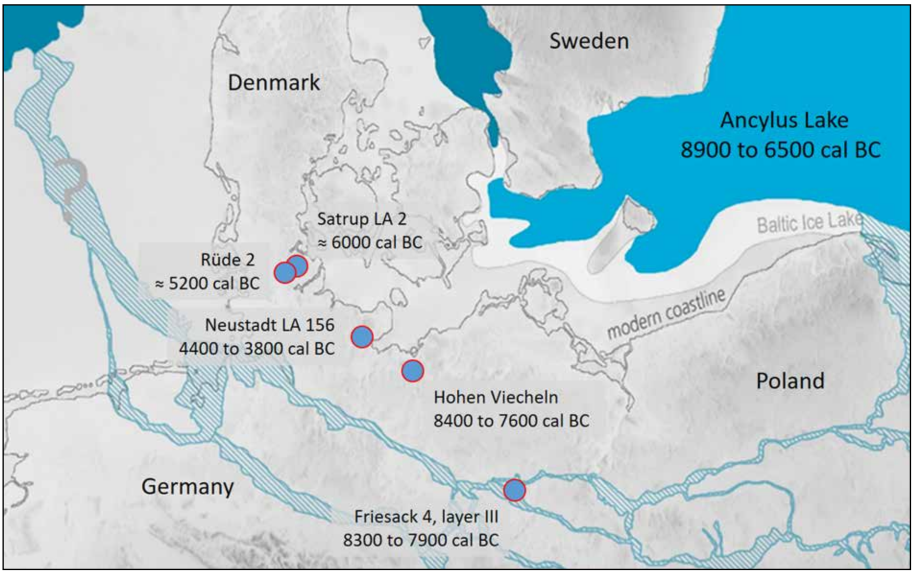

Figure 1. Location and dating of the Mesolithic sites discussed in the text (background map: Grimm 2009).

selected large, potentially dangerous prey as targets. However, especially in the early Holocene, as in central Europe and southern Scandinavia, forests evolved from sparse pine-birch into dense oak woodlands, hunting methods and targets will also have adapted to changing environmental conditions.

According to the Optimal Foraging Theory – which describes a hypothetical scenario open to debate – foragers always try to make their foraging successful, be it to maximise the return concerning foraging time, to maximise the hunter's prestige, to minimise the amount of time spent while foraging, or to minimise the hunter's risk (*e.g.* Bettinger *et al.* 2015; Bliege Bird *et al.* 2005; McGuire and Hildebrandt 2005; Smith 1983, 626–628). Consequently, for "optimal" hunters, their hunting strategy is almost always aiming for the optimal yield. What does this scenario mean for Mesolithic forager groups? Hunter-gatherer societies have a special view of their prey, which is far more than a mere commodity, but a person, with whom humans could form communicative and mutually constitutive relationships (cf. De Castro 2019; Hill 2011; Willerslev 2004). As a consequence, hunting was always more than just getting food for the day (cf. Grimm and Schmölcke 2013), which is one of several unconsidered aspects in the Optimal Foraging Theory (Grøn 2017).

Besides such spiritual guidelines, an "optimal" hunting strategy certainly takes into account first and foremost the composition of the hunter group (number, experience, physical strength, endurance, etc.). This paper aims to pursue the questions of which hunting strategies the Mesolithic people at different places and at different times judged as "optimal", and whether there was something like a general development in the course of the Mesolithic towards a certain, more standardized hunting strategy.

Indeed, recently it was verified that up until today traditional human food systems have been based in general on large mammals (Brammer *et al.* 2022). According to the authors of the study, this is because large animals are more available and accessible to hunters than smaller species. Additionally, the large prey provides more kilograms per catch. Following the mentioned study, smaller animals play in general a more supplementary role in traditional human food systems. Although they provide more consistent caloric returns than large animals, they are harvested in particular during documented shortages of prey (Brammer *et al.* 2022).

Changes in subsistence have been repeatedly observed and contextualized as part of an ongoing research focus on transformation phenomena in the Mesolithic on the North European Plain, conducted at the Collaborative Research Centre 1266 at Kiel University (Groß *et al.* 2018; 2019a; 2021; Meadows *et al.* 2018; Sørensen *et al.* 2018). In the following, some of our results will be examined in an attempt to answer the questions posed at the outset. The conclusions have to be concise, given the very limited length of the text. Therefore, the paper is intended as a stimulus for further discussions.

Materials and Results

The present study focuses on comparisons of five selected Mesolithic sites (fig. 1). Their dating covers large parts of the Mesolithic, with the Early Mesolithic Hohen Viecheln and Friesack 4 as the oldest sites and the Final Mesolithic/Early Neolithic Neustadt LA 156 as the youngest site. The sites were mostly located in similar biotope types, namely, inland by lakes or rivers; only one of them (Neustadt LA 156) was located by a marine lagoon. Thanks to very good preservation conditions in the excavated waste zones (cf. Sørensen this volume), all of the sites yielded numerous animal bones (all given numbers are numbers of identified specimens (NISP) excluding shed antlers), but the archaeozoological analysis of some of them is unpublished so far. The present paper cannot present the archaeozoological results in full; the results will only relate to the question posed by the paper.

Friesack 4, layer III

Archaeozoological analysis from the site of Friesack 4, located in central northeastern Germany (fig. 1), has been presented in detail (Schmölcke 2016 with all references therein). Here, we will focus on the local find layer III with 2950 determined mammal bones (NISP). This layer has the largest amount of animal bones of all the local find horizons, so it is statistically the most significant. It dates to the centuries between 8300 and 7900 BCE. At that time, the camp was located on an island in a wide river valley; the regional vegetation was dominated by hazel (*Corylus avellana*) (for the local landscape: Groß 2017, 70–74).

A very brief summary of the hunting behaviour of the people from Friesack 4 could be: “Meat is the main thing, no matter how much”. Forty-one per cent of the bones, which in comparison to other Mesolithic sites is an amazing and unusually high value, comes from the quite small and harmless roe deer (*Capreolus capreolus*) (Schmölcke 2016, tab. 2). In this case, but also for wild boar and red deer, the hunt focused on young, often female animals (fig. 2). Seasonally, the latter were hunted in May and June (for more details: Schmölcke 2019). Concerning the human hunting behaviour at Friesack 4 around 8000 BCE, the archaeozoological record suggests pragmatic and opportunistic hunting. Hunting success had priority – even if it was relatively small. Dangerous animals such as aurochs, moose or adult wild boar were avoided. There are

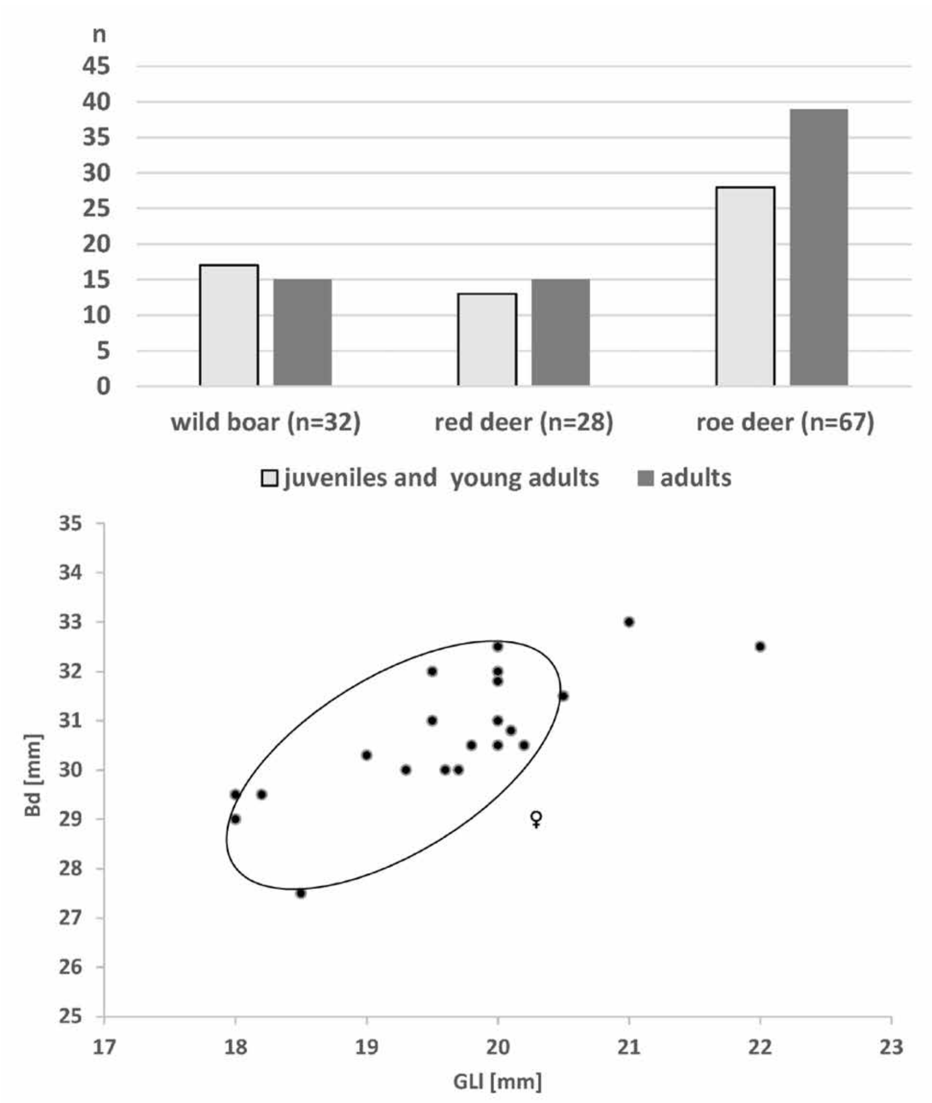

Figure 2. Friesack 4. Top: Distribution of bone finds across young/juvenile and adult animals, respectively, in wild boar (limit 24 months), red deer (12 months), and roe deer (18 months). Bottom: Sex distinction in roe deer based on the talus (GLl: greatest lateral length, Bd: distal breadth; method: Jensen 1993).

many indications that hunter teams were normally small, composed of various, but only limited members of the community. Is it not also feasible that women were quite significantly involved in hunting at this site?

Hohen Viecheln

The Hohen Viecheln site existed at the same time as Friesack 4 (layer III), with the main occupation phase from 8400 to 7600 BCE (Groß *et al.* 2019b, fig. 26). The 1278 mammal bones (Gehl 1961) give a somewhat similar and yet different picture of the human hunting behaviour. One could call it: “Much meat, little risk”. In Hohen Viecheln, 78%

of the bones derive from red and roe deer. The hunters had little interest in any other species, in particular wild boar. The deer they killed were nearly exclusively not only adult but were even old specimens. To characterise the human hunting behaviour at Hohen Viecheln, we can say: The focus was on meat-rich adult deer, even if such meat was not of optimal quality. In comparison to Friesack 4 (layer III), the intention was to increase the effectiveness of individual hunting trips. The dangerous prey species of wild boar, aurochs or moose were again avoided. All three species together account for only 14% of the finds.

Satrup LA 2

Satrup LA 2 (Bondebrück) was a site of very daring hunters. It was occupied around 6000 BCE at a small lake amid an oak forest. All in all, 837 mammal remains were identified. The local species spectrum (not yet published in detail) demonstrates a strict focus on only a few, specific animals. The vast majority of the bones derive from large, adult, but not old animals. Strong animals such as wild boar and aurochs are the most frequent species, followed by moose and red deer. Such a selection of prey clearly shows the great experience and courage of the hunters. The greatest possible meat yield took precedence over the danger of wounded, aggressive big animals. It also refers to a collective (driving) hunt of a larger group of hunters, probably with the help of dogs.

Rüde 2

The archaeozoological record suggests that “quantity, not quality” was obviously the motto of the hunters at Rüde 2, located next to Satrup 2, but occupied between 5200 and 4820 BCE (Feulner 2011, fig. 2), *i.e.* about 900 years later. The archaeozoological results of the excavations have never been published. In total, a NISP of 813 was identified to high taxonomic levels. The dominating species are as in Satrup LA 2 wild boar and aurochs. In both cases the hunter’s focus was clearly on the adult specimen, whereas young or juvenile animals were ignored completely (fig. 3). There are similar results for moose and red deer, although here the database is much smaller and somewhat less meaningful. It is remarkable that roe deer hunting – the by far dominant prey species earlier in Friesack – played no role at all. Only seven of the 813 determinable mammal finds derive from roe deer.

Neustadt LA 156

During the occupation of Satrup LA 2, the Baltic Sea had already developed, and in the meantime fully marine conditions had become established in the former lowlands north of the study area. Marine mammals such as seals had migrated and represented – at least potentially – a new nutrient resource for humans. However, no or only very few seal bones are found in the coastal settlements of this early period (fig. 4). Either it took the hunters quite a long time to develop successful hunting methods for seals, or they were not hunted for other reasons. It was not until around 4100 BCE that seal bones began to appear in large numbers in the waste layers of coastal settlements. Timmendorf-Nordmole I and Timmendorf-Nordmole III are examples of this, and so is Neustadt LA 156.

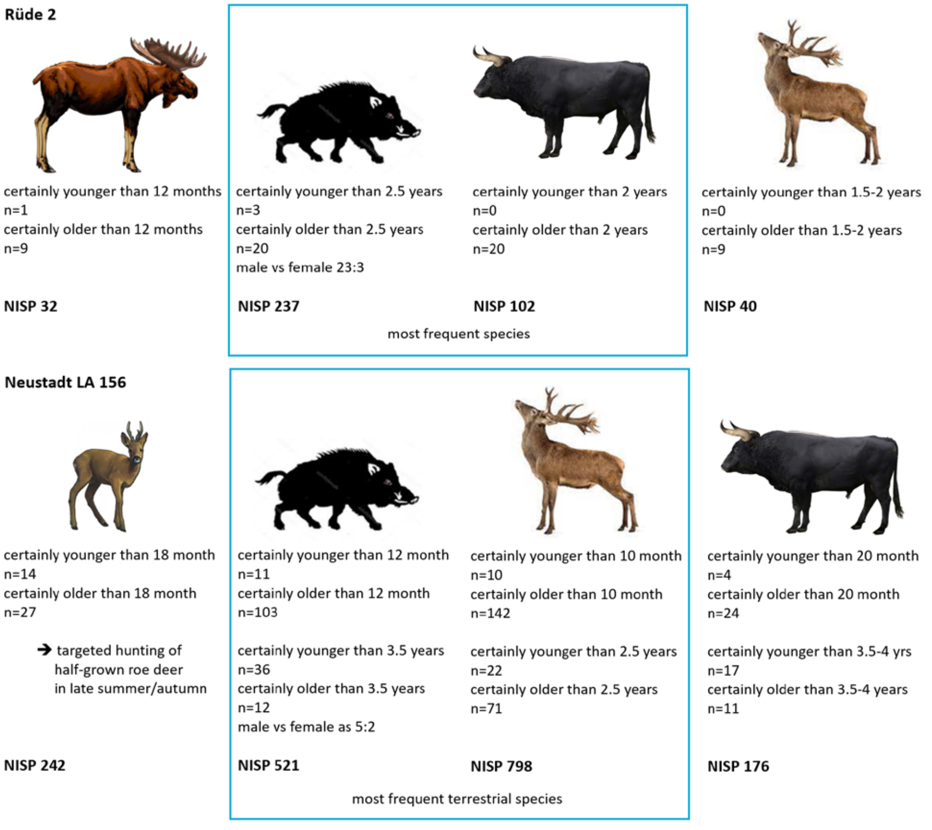

Figure 3. Results of age analysis on limb bones and the NISP in the four most frequent mammal species in Rüde 2 (top) and Neustadt LA 156 (bottom).

Naturally, the Late Mesolithic foragers of Neustadt LA 156 also hunted on land. Their premise seems to have been: "Young adults as optimal prey: meat of good quality and a lot of it". From the site, occupied between 4400 and 3800 BCE, a NISP of 3617 mammal remains has been analysed (Glykou 2016). The hunt was often for wild boar – at this point, the tradition of the Middle Mesolithic continued – but to an even greater extent for red deer. The latter then remained the most important hunting prey for many centuries in the Neolithic. As regards hunting behaviour, there was a selective hunting of semi-adult roe deer in late summer/fall, but the constant focus was especially on adult, but not old, animals. This pattern is found for all four major terrestrial prey species (fig. 3).

Discussion and conclusion: Hunting strategies during the Mesolithic

The decision to hunt a particular animal was certainly not made by the Mesolithic people on the basis of economic motives alone. For an "optimal" prey to be possible, circumstances had to be observed that today are difficult to prove with archaeozoological methods. We have to expect that, besides size and potential danger, completely different aspects were also taken into account when choosing prey. Thus,

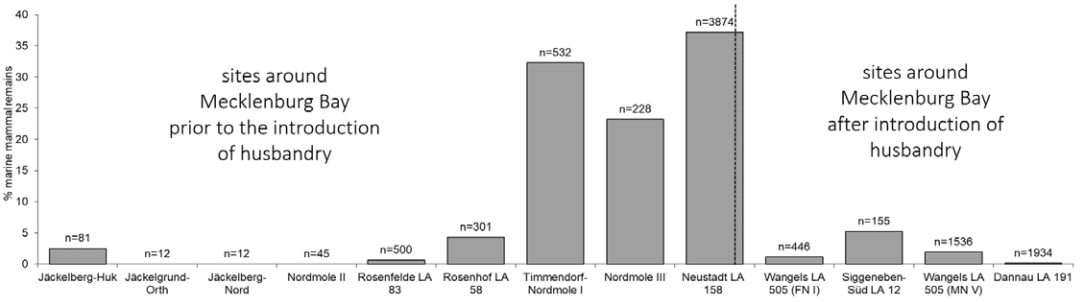

Figure 4. Proportions of bones from marine mammals (especially seals) in mammal remains from sites on the shore of the newly formed Mecklenburg Bay (modified and supplemented after Hartz and Schmölcke 2013, fig. 13).

specifications in the sense of a "management strategy" within the territory of the forager group and a reduction of hunting periods or spatial hunting reservations are likely (summarized by Dürr 2010; Grøn 2017). At the same time, there were certainly "cosmological" factors for Mesolithic foragers to consider, which could, for example, concern the age or sex of the prey or include specific hunting prohibitions for certain group members or animal species.

The most important result, presented here in brief, is that no single case proves indiscriminate, random hunting (cf. Vogt *et al.* 2022). Instead, there was generally a very targeted, selective hunting, but the targeted prey spectrum changed significantly during the course of the Mesolithic. The results presented here show a threefold division of the Mesolithic (fig. 5). In the Early Mesolithic period, during the occupation of Friesack 4 (layer III) and Hohen Viecheln, hunting was concentrated on roe deer and partly also red deer. Large specimens or even species played nearly no role. In the foreground of the strategic considerations of the hunters was the constant supply of meat for the human groups. Presumably, people hunted during this period in very small groups or even alone and probably without trained hunting dogs.

The Middle Mesolithic, represented here by Satrup LA 2 and Rüde 2 was, in contrast, the epoch of daring and reckless hunters. It is very likely that they worked closely with hunting dogs and intentionally tracked dangerous big game. Their hunting goal was the largest prey in sight, it was only very old animals that were not considered.

In the Late Mesolithic, when people largely retreated from inland areas to the coasts, sealing played an important role. In addition – if the results from Neustadt LA 156 can be generalized – young adult terrestrial game specimens were hunted, too. In the Late Mesolithic, the hunters began to turn to red deer, a species which then became by far the most important hunting prey over the long Neolithic period (Overton 2021).

Taken together, these results show a growing willingness among hunters to take risks from the Early Mesolithic onwards (fig. 5). The idea of hunting large prey in itself suggests that we are dealing with increasingly specialised (possibly even professional) hunters. Probably, there were experts in every human group who were highly specialized in hunting dangerous animals, and they would have hunted within a group, working closely with specially trained dogs.

	Friesack 4 layer 3	Hohen Viecheln	Satrup LA 2	Rüde 2	Neustadt LA 156
red deer	25	32	13	8	35
roe deer	47	53	11	1	13
moose	5	3	15	6	3
aurochs	2	6	27	35	20
wild boar	21	6	34	49	29
	n=2595	n=1177	n=786	n=387	n=1816
	➔ ➔ ➔ growing willingness to take risks ➔ ➔ ➔ ➔ ➔ ➔ professionalisation of hunters ➔ ➔ ➔ ➔ ➔ ➔ training of hunting dogs ➔ ➔ ➔				

Figure 5. Proportions of the five most important game species from Early (left) to Late (right) Mesolithic sites and three related hypotheses.

However, although we believe that we see clear developments, and although strong differences in hunting behaviour are becoming apparent, important questions remain: Are we perhaps only observing adaptations to the specific ecological conditions of a particular region? Do the differences reflect dissimilar compositions of human groups rather than generalizable trends? Or were these generalizable transformations in the course of the Mesolithic in the study area? Vogt *et al.* (2022) pointed out how strongly hunting behaviour depends on topography; landscape conditions influence whether passive hunting (with pitfall systems and traps) or active hunting is prioritized. Accordingly, the archaeozoological evidence for prey can be entirely different, even though the hunters may have belonged to the same group. These considerations show that the here presented hypothesis must be tested by further comparisons and investigations.

Other aspects cannot be discussed here but are crucial for our understanding of hunting decisions in the Mesolithic: What role do factors such as local group size, the relationship between certain sites and certain animals, or even seasonal, sexual, or species-specific hunting taboos play in the composition of the archaeozoological find material? Such phenomena are well known from ethnoarchaeological research but are difficult to trace archaeozoologically (*e.g.* Grøn 2017; Willerslev 2004). Only research that includes ethnologists, archaeologists, scholars of religion, and zoologists will yield substantial progress in our knowledge.

Acknowledgement

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Changing diet during the Mesolithic-Neolithic transition

An examination of the carbon and nitrogen isotope ratios of late Mesolithic and early Neolithic humans in Denmark

Rikke Maring, Jesper Olsen and Marcello A. Mannino

Abstract

The change in subsistence from hunting, gathering and fishing to farming was a key transition in European prehistory. One of the regions with the richest archaeological record for this momentous shift in subsistence is southern Scandinavia. During the last 40 years, our knowledge about this transition has been complemented by data from the stable isotope analyses of bone collagen. Since the first studies conducted by Henrik Tauber in the 1980s, it has become increasingly clear that the dietary change that occurred between the late Mesolithic Ertebølle Culture and the early Neolithic Funnel Beaker Culture was of such a scale as to question the idea that the transition to agriculture was marked by continuity across the whole of present-day Denmark. In this short contribution, we highlight other aspects of the dietary shift between the Mesolithic and the Neolithic, which entailed, for instance, a reduction in gender-based diversity in diet and a narrowing of the dietary spectrum towards isotopically more homogeneous diets. The use of Bayesian mixing models and compound-specific single amino acid isotopic analyses may help to nuance this scenario further in the near future.

Stable isotopes; diet; late Mesolithic; early Neolithic; Denmark

Introduction

The transition from hunter-fisher-gatherers to a society based on farming is probably the most significant change to human subsistence to have happened in southern Scandinavia, as in the rest of north-western Europe (Schulting 2011).

in: Groß, D., Rothstein, M. (eds.). Changing Identity in a Changing World.
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In Denmark, the archaeological debate concerning the Mesolithic-Neolithic transition has primarily revolved around key methodological and theme-based topics: chronology, livestock, food crisis, prestige, exchange, climate change *etc*. (Fischer and Kristiansen 2002; Sørensen 2014). Diet, however, has long been a point of convergence, mainly due to the line of research introduced by Tauber (1989; 1981a; 1981b). In several papers, Tauber has presented carbon isotope values of both Mesolithic and Neolithic human bones, demonstrating a major shift in the diet, from a diet in the late Mesolithic mainly based on marine foods to a diet consisting of terrestrial food in the early Neolithic. Several subsequent studies and methodological refinements have added to the empirical basis of isotope studies but have not affected the overall picture (Fischer *et al.* 2007a; van der Sluis and Reimer 2021). Similar shifts in diet have been observed in numerous places in northern and western Europe (Richards *et al.* 2003b; Schulting 2011).

Tauber's studies have established the understanding that the majority of the late Mesolithic diet was based on marine resources, while in the early Neolithic humans mostly relied on terrestrial resources. In this paper, we aim to go a bit further into the many isotope studies published on human bone material from the Ertebølle and Funnel Beaker Cultures, focusing specifically on the area of present-day Denmark. We examine how uniform the diet of the late Mesolithic hunter-gatherer-fishers and early farmers actually was, when considering geographical area and timespan. Finally, this paper seeks to contribute to a more informed understanding of dietary variations and development during the Mesolithic-Neolithic transition.

Diet reconstruction using stable isotopes

Stable isotopes can be used to reconstruct the diet of past populations and have, for almost half a century, been useful in revealing which food sources were consumed by prehistoric humans (*e.g.* Lee-Thorp 2008). In this paper, only carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios are used (fig. 1). Carbon and nitrogen isotope ratios in bone collagen are particularly useful when investigating the diet composition, as they discriminate between marine, freshwater and terrestrial food intake (*e.g.* Mannino *et al.* 2015), though collagen primarily reflects the protein intake of the diet (Hedges *et al.* 2004; Schoeninger and Moore 1992). The carbon value of the bone collagen of humans and animals will closely resemble the isotope values of their diet, enriched by approximately one permille (1.0‰). The nitrogen values of humans and animals are potentially enriched by 3.0–6.0‰ compared to their diet (Bocherens and Drucker 2003; Hedges and Reynard 2007; O'Connell *et al.* 2012). Assumptions concerning which diets correspond to different carbon and nitrogen values are based on generalised baselines. It is, in fact, assumed that a local and contemporary isotopic baseline provides the soundest basis on which to interpret the nuances in the diet and its variability (Vaiglova *et al.* 2022). Stable isotope ratios may vary, however, within the same geographic region due to local eco-physiological, edaphic and microclimatic factors (*e.g.* Bird *et al.* 2022). In a Danish Mesolithic-Neolithic setting, the established interpretation of carbon and nitrogen values in humans is that a carbon value of around -16 ‰ indicates an intake of half marine and half terrestrial resources. Humans with carbon values around -10 ‰ mainly consumed marine protein and humans with carbon values around -21‰ mainly fed on terrestrial

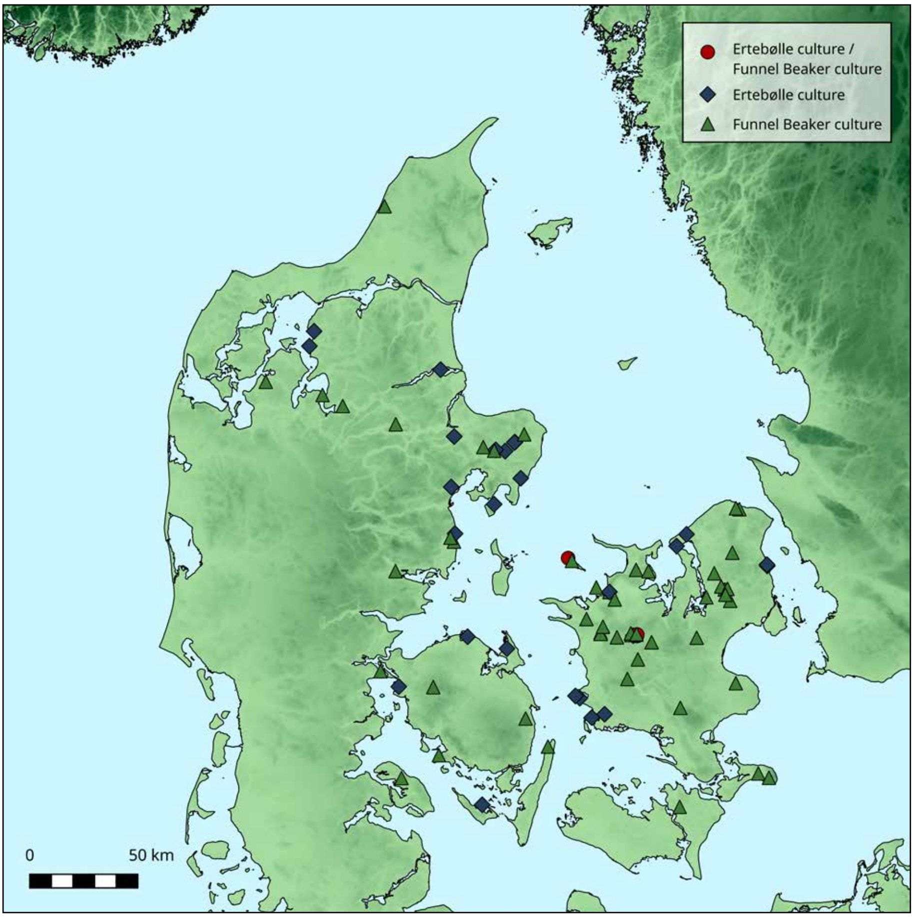

Figure 1. Map of present-day Denmark showing Ertebølle Culture and Funnel Beaker Culture settlements where stable isotope analysis on human bone material has been conducted.

resources. Humans with carbon values even lower than -22‰ may have consumed freshwater fish. Moreover, the higher the nitrogen values, the higher up the food chain an individual was feeding (Fischer 2005; Fischer *et al.* 2007a; Olsen *et al.* 2008).

The Ertebølle Culture

During the Ertebølle period (5400–4000 BCE), the last Mesolithic groups whose subsistence was based on specialized hunter-gatherer-fisher adaptations were living in the area of modern-day Denmark, northern Germany and southern Sweden. The Late Mesolithic groups led a way of life defined by activities connected with fishing, hunting and gathering (Blankholm 2008), living in large coastal sites and minor settlements along lakes and riverbanks (Johansen 2006).

Approximately 58 individuals from the Ertebølle Culture in Denmark have been the object of isotope analyses and ^{14}C dating (Allentoft *et al.* 2022; Brinch Petersen 2015; Fischer *et al.* 2007a; 2007b; Maring and Riede 2019; Maring *et al.* in prep. a; b; Richards

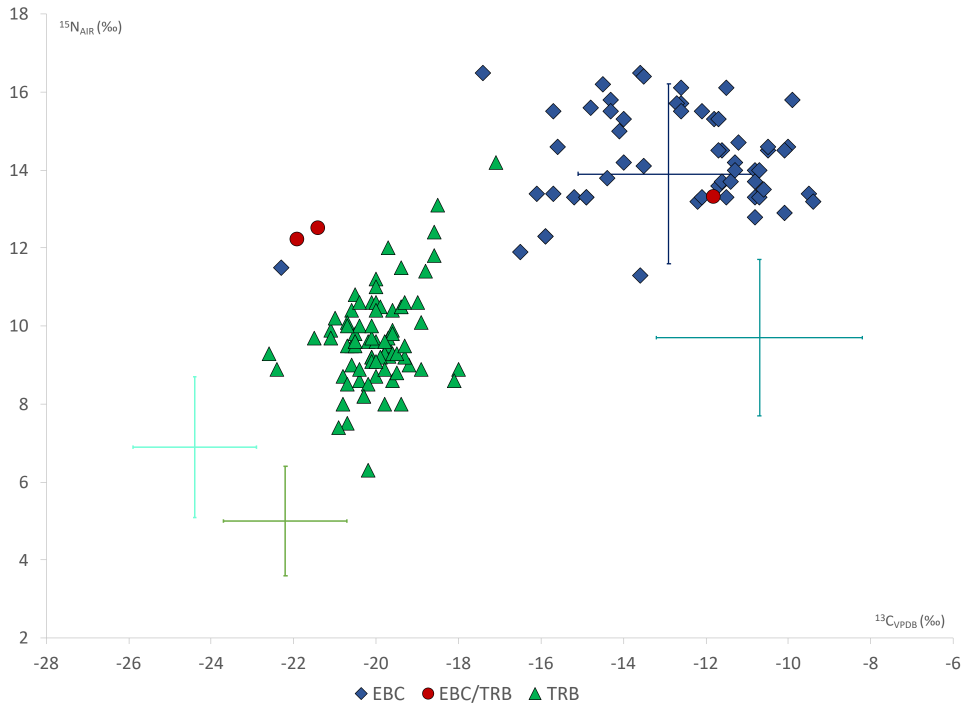

Figure 2. $\delta^{13}C$ and $\delta^{15}N$ isotope values for humans from the late Mesolithic Ertebølle Culture (EBC) and early Neolithic Funnel Beaker Culture (TRB) from the current geographical area of Denmark (Allentoft *et al.* 2022; Brinch Petersen 2015; Fischer *et al.* 2007a; 2007b; Maring *et al.* in prep. a; b; Price *et al.* 2007; Richards and Koch 2001; Richards *et al.* 2003a; Richter and Noe-Nygaard 2003; van der Sluis *et al.* 2019; van der Sluis and Reimer 2021). Ertebølle humans (blue diamond), Ertebølle/Funnel Beaker humans (red circle) and Funnel Beaker humans (green triangle). For baseline comparisons, isotopic measurements of different animals are plotted as mean values (± 1σ) (Craig *et al.* 2006; Fischer *et al.* 2007a; Gron and Rowley-Conwy 2017; Maring and Riede 2019; Ritchie *et al.* 2013; Robson *et al.* 2012; van der Sluis *et al.* 2019). From left to right: turquoise cross: freshwater fish (n=29); green cross: terrestrial animals (n=192), dark blue cross: marine mammals (n=12); petroleum blue: fish (n=78).

et al. 2003a; Richter and Noe-Nygaard 2003; Ritchie *et al.* 2013; van der Sluis *et al.* 2019; van der Sluis and Reimer 2021). These human remains derive from diverse contexts: some individuals are represented by complete skeletons and others only by single bones. About a third of the Ertebølle individuals originate from shell midden assemblages, either in the form of inhumations around or beneath shell middens, complete skeletons found in the shell middens or as stray finds. Another third represents burials, with Vedbæk on the island of Zealand constituting the largest burial ground from the Ertebølle period in Denmark (Brinch Petersen 2015). The rest originates from submarine finds, settlement contexts and stray contexts.

The $\delta^{13}C$ and $\delta^{15}N$ values of these Mesolithic humans are proof of a population that relied heavily on marine protein. Specifically, the carbon values range between -16‰ and -9‰ and nitrogen values range between 11‰ and 17‰ (fig. 2). The isotope ratios do, thus, show some degree of variability. Some individuals had diets consisting almost exclusively of marine

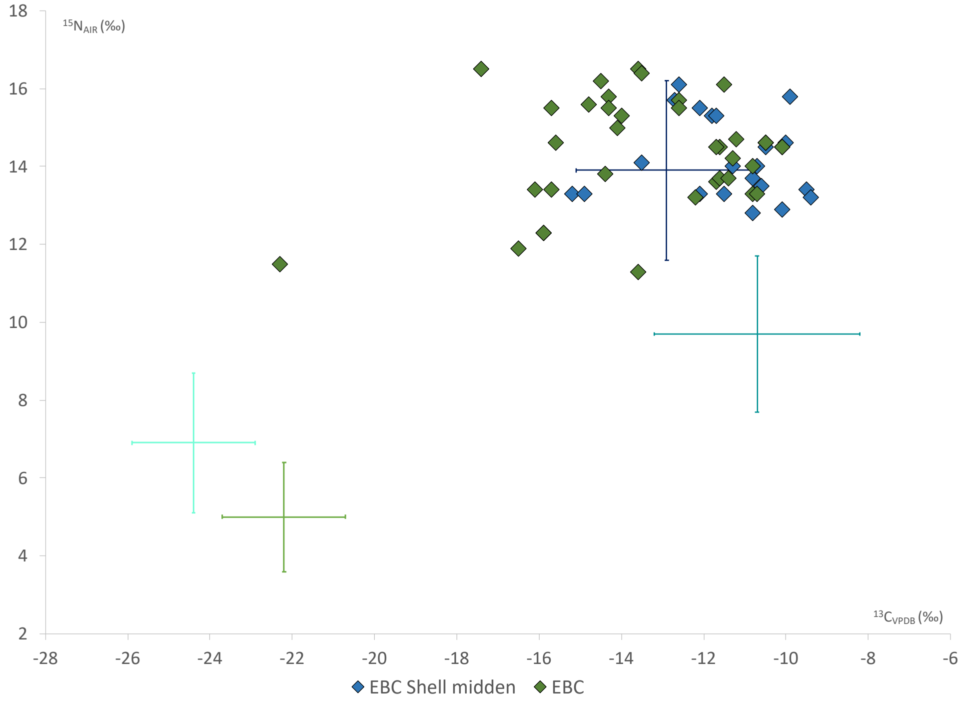

Figure 3. δ13C and δ15N isotope values of humans from the Ertebølle Culture (EBC), here assigned based on their provenance from shell middens (blue diamond) or other site types (green diamond).

resources, whilst others had higher intakes of terrestrial resources. No clear progression in the diet is seen during the Ertebølle period, but there is variation between different sites, which points to regional differences rather than a chronological development. In general, there are no significant differences in the diet when comparing shell middens to other sites (fig. 3).

Of the 58 Ertebølle humans analysed so far, the biological sex has been established for 14 female and 15 male specimens. In terms of variations related to gender, the analyses hint that females of the Ertebølle Culture were consuming more marine foods than the males (fig. 4) (t-test: carbon, $p=0.0020$). This is potentially an interesting finding, as differences in food preferences between the genders have been described in several ethnographic accounts of hunter-gatherer societies (*e.g.* Berbesque and Marlowe 2009; Eerkens and Bartelink 2013), but never really shown for the Ertebølle Culture. The data can, however, also be interpreted as indicative of two separate groups of males with different diets – one that is similar to the females' and one that includes more terrestrial foods. Unfortunately, due to the limited number of Ertebølle individuals from the same settlement, it is not statistically significant nor justifiable to go into more detail at present.

In this paper, three humans date either to the Ertebølle or Funnel Beaker Cultures, and as it is not possible to narrow their chronology further, these specimens are not part of our interpretations; Rødhals: $\delta^{13}C$ value -11.8‰, $\delta^{15}N$ value 13.3‰, Tingbjerggård Vest: $\delta^{13}C$ value -21.9‰, $\delta^{15}N$ value 12.2‰, Ravnsbjerggård II: $\delta^{13}C$ value -21.4‰, $\delta^{15}N$ value 12.5‰ (Allentoft *et al.* 2022; Fischer *et al.* 2007a).

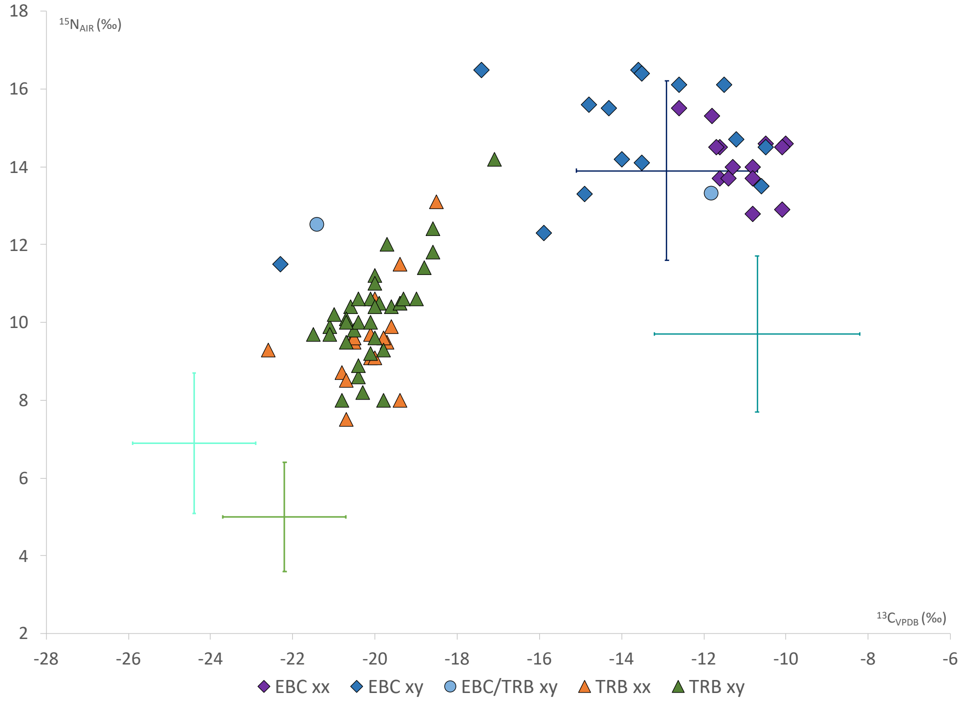

Figure 4. δ13C and δ15N isotope values of humans from the Ertebølle Culture (EBC) and the Funnel Beaker Culture (TRB), here assigned based on their biological sex attributions: Ertebølle males (blue diamond), Ertebølle females (purple diamond), Funnel Beaker males (green triangle) and Funnel Beaker females (orange triangle).

The Funnel Beaker Culture

Agriculture arrived with the Funnel Beaker Culture at around 4000 BCE in the current Danish area (Gron and Sørensen 2018). During the Funnel Beaker period (4000–2800 BCE), the agro-pastoralist groups led a lifestyle with an economy and management of resources prevailingly focused on domesticated animals and agriculture, yet some wild resources were continuously exploited throughout the period (Andersen 2008; Koch 1998; Nielsen and Sørensen 2018; Sørensen 2014).

Approximately 81 individuals from the Funnel Beaker Culture in Denmark have been the object of isotope analyses and ^{14}C dating (Allentoft *et al.* 2022; Fischer *et al.* 2007a; Maring *et al.* in prep. b; Richards *et al.* 2003a; Richards and Koch 2001; Richter and Noe-Nygaard 2003; van der Sluis *et al.* 2019; van der Sluis and Reimer 2021). Similarly, to the Ertebølle materials, they also derive from a variety of archaeological contexts. Again, some individuals are represented by complete skeletons and others only by single bones. Finds originate in almost equal proportions from bogs, megalithic tombs and settlements, burials, submarine contexts and causewayed enclosures.

The carbon values range between -22‰ and -18‰ and nitrogen values range between 7‰ and 14‰ (see fig. 2). The δ^{13}C and δ^{15}N values show that early farmers in Denmark relied predominantly on terrestrial resources, including plant foods, terrestrial meat and some fish.

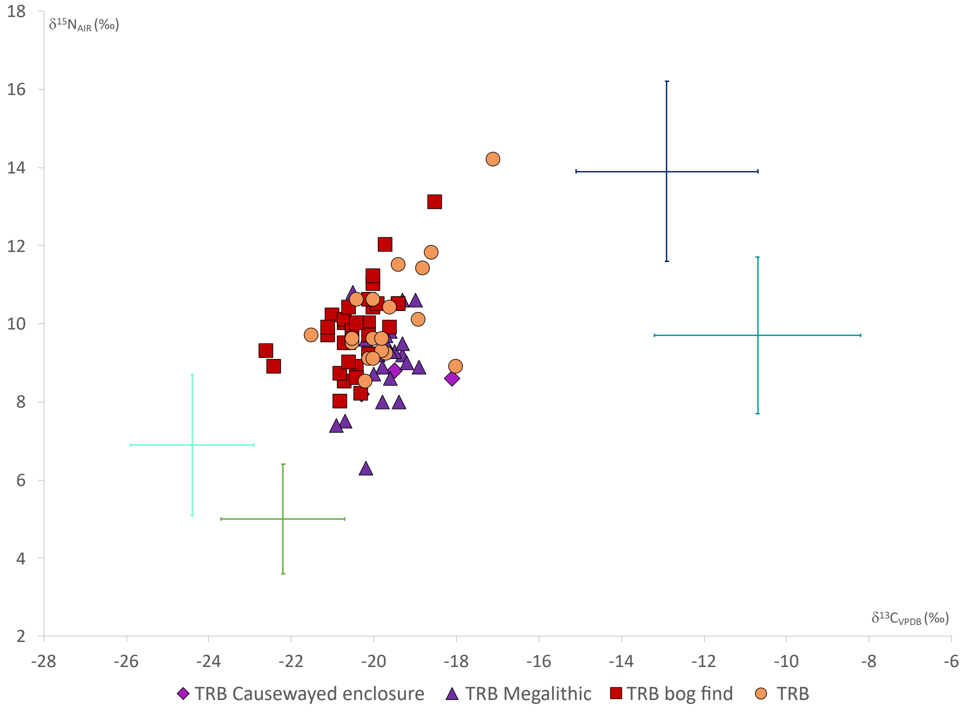

Figure 5. $\delta^{13}C$ and $\delta^{15}N$ isotope values of humans from the Funnel Beaker Culture (TRB), here divided based on whether they originated from a causewayed enclosure (light purple diamond), megalithic tombs (dark purple triangle), bogs (red square) and other site types (orange circle).

Overall, the Neolithic diet was probably more homogeneous compared to that of the Ertebølle period, but marine protein was a supplementary component. Yet there is a greater variation concerning where in the food chain resources originated. Some individuals had a small intake of meat protein while others must have consumed aquatic resources. A minor variation in the values between humans found in bogs and humans from megalithic graves could indicate that there was a small shift in the diet during the first part of the Neolithic period (see fig. 5; t-test: carbon, $p=0.0002$ and nitrogen, $p=0.0057$), or suggest that the humans from bogs were simply eating more freshwater fish.

Of the 81 Funnel Beaker Culture humans, 19 were identified as females and 34 as males, but no difference in isotopic composition and, thus, diet was found between the genders (see fig. 4) (t-test $p>0.5000$).

Concluding remarks

This paper has emphasized the distinction in dietary resources by the late Mesolithic hunter-gatherer-fishers and early Neolithic farmers in the area of present-day Denmark, by showing that the Ertebølle population was mainly living from the sea. The diet variability among individuals from the Ertebølle Culture seems to indicate regional differences more than a chronological trend. This is in contrast to the fairly uniform diet of the Funnel Beaker population, who lived off the land with a negligible inclusion of aquatic resources.

Though the debate on the dietary shift that occurred with the transition to agriculture has been ongoing for more than four decades, there is really no end in sight to it. This does not mean that there has been no progress, as for instance lipid residue analysis has confirmed that aquatic resources were consumed regularly by Neolithic people (Craig *et al.* 2011; Robson *et al.* 2021; Saul *et al.* 2014). Our contribution shows that late Mesolithic diets were varied and suggests that there may have been gender-based differences, whilst such differences were not present in the Neolithic. The Mesolithic-Neolithic transition requires a more finely resolved chronology to further our full understanding of the dietary change. This could be achieved with the radiocarbon dating of more human bone samples from around that time period, yet these are not available at the moment. Even then, more detailed chronological framing may require more precise estimations of the contribution of different kinds of aquatic foods to the diet, which may be achievable through the adoption of Bayesian mixing models (Fernandes *et al.* 2014). Mixing models have in other studies on European Mesolithic and Neolithic groups led to a greater insight into the use of freshwater resources and the consumption of plant foods (Bickle 2018; Boethius and Ahlström 2018; Bownes *et al.* 2017; Fernandes *et al.* 2015; le Roy *et al.* 2021; Meadows *et al.* 2016; Pickard and Bonsall 2020; Sjögren 2017; van der Sluis *et al.* 2019). Perhaps, also compound-specific isotopic analyses of individual amino acids can disclose a new and better understanding of the diet (Itahashi *et al.* 2019; Naito *et al.* 2013; Rey *et al.* 2022; Webb *et al.* 2015).

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Going against the grain?

The transition to farming in the Dutch wetlands re-examined (5000–4000 BCE)

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and J. Hans M. Peeters

Abstract

In general, the fifth millennium BCE in the Dutch wetlands and southern Scandinavia might be described in similar terms regarding the presence of ceramic hunter-gatherers who evidently had contacts of some kind with central European farming communities. Whereas the end of this millennium saw a relatively swift transition to farming in southern Scandinavia, the Dutch wetlands seem to have taken a different route. Here, the dominant opinion is that of a gradual and earlier start of animal husbandry and cereal cultivation, albeit of a limited economic importance. This contribution will question the Dutch dataset and discuss new data on the use of ceramics and the date and scale of the start of animal husbandry and cereal cultivation. We conclude that the transition to farming (cereal cultivation and animal husbandry) occurred around 4200 BCE, predating the transition to farming in the UK and southern Scandinavia.

Neolithisation; Swifterbant Culture; zooarchaeology; archaeobotany; ceramics

Introduction

Mapping the transition to farming might seem a rather straightforward process: one simply maps the earliest presence of domesticated plants and/or animals in a certain area. Nevertheless, for the Dutch wetlands there are currently three competing models to describe the transition to farming, notwithstanding the relatively high resolution of our dataset. The first model is the Long Transition Model (LTM), advocated by Louwe Kooijmans from the 1970's onwards and adopted by his Leiden-based pupils (*e.g.* Amkreutz 2013; Amkreutz and Dusseldorp 2020; Louwe Kooijmans 1976; 1993; Raemaekers 1999; Verhart 2000).

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Central to this model is the presence of sites in the wetlands with a low percentage of bones from domesticated animals until at least the end of the fourth millennium BCE (Vlaardingen-Stein Culture), creating a transition period of more than 1000 years.

The second model, the (Early) Short Transition Model (Raemaekers 2003), interprets these 'semi-Neolithic' sites as wetland elements of a logistical mobility system: throughout the 1000 years under study in the LTM, the bone assemblages of the wetland sites are rather similar, with 'true Neolithic' sites restricted to the coastal dune area. Because the fifth millennium coastal zone has been eroded, this allows for hypothetical early 'true Neolithic' sites on the coast, cutting down the long transition to a swift, fifth millennium transition (see Amkreutz 2013, 407–408 for a rebuttal).

The third model, the Late Short Transition Model, dismisses all fifth millennium finds of domestic animals (Rowley-Conwy 2016), and positions the transition to farming at the start of the fourth millennium. It is especially this third model that ties in very well with the renewed view of the transition to farming as a change driven by demography. Shennan's 2018 continental overview identifies the Dutch wetlands as a singular exception to his demographic narrative. When one dismisses the fifth millennium Neolithic assemblages, the singular position can be dismissed as well. These three competing models imply that the dataset is difficult to interpret (Çakirlar *et al.* 2020). What are the underlying problems?

Problems with the dataset

Dating evidence

The dataset comprises wetland sites embedded in Holocene sediments. As a result, focus has been on dating the sites or the phases of these sites by means of context dates. In other words, there are hardly any direct dates for the bones of domesticated animals or cereal grains. When we realise that the proposed early start of animal husbandry is based on small numbers of bones from domesticated animals, how can we be certain that these bones are an integral part of the (phase of) sites? How certain are we that they were not added to the assemblage at a later date as a result of site formation processes or revisits?

Dating precision

All available ^{14}C dates predate the current standards of high-precision dating and thus have relatively large margins of error. On top of that, there are relatively small sets of dates per site, presented with little attention to their quality and without statistical analysis (Bayesian modelling). Moreover, the crucial final part of the fifth millennium BCE is characterised by a plateau in the calibration curve. The resulting chronology is therefore rather coarse (Dreshaj *et al.* 2022).

Ambiguity of the zooarchaeological remains

Until recently, the start of animal husbandry was solely based on traditional zooarchaeological methods, such as size measurements and kill-off patterns. The fact that, in our area, aurochs and wild boar occur implies that we need to be very cautious in dating the start of animal husbandry by these methods alone. The Rosenhof assemblage is the best cautionary tale: aDNA analysis of the *Bos* bones made clear that the small bones found there were not from domestic cattle but from small female aurochs (Scheu *et al.* 2008). Another cautionary tale is the fact that there was interbreeding between incoming domestic pigs and local European wild boar, making size measurements alone not sufficient to determine domestic status (Frantz *et al.* 2019).

The EDAN project

We used the Rowley-Conwy 2016 paper as a wakeup call: the relevance of the Dutch dataset for the international debate on the transition to farming required action. The Dutch Research Council (NWO) funded a large project that focused on the fifth millennium dataset. It allowed us to study the chronology (with new dates and Bayesian modelling), aDNA, and diet (C and N isotopes) of *Bos* and *Sus* from this period. Major sites are the two Late Mesolithic sites at Hardinxveld-Giessendam (Louwe Kooijmans 2003), covering the period 5400–4250 BCE. The final centuries of this millennium were studied on the basis of the Swifterbant site cluster, especially the largest assemblage, S3 (Zeiler 1997). The Emergence of Domestic Animals in the Netherlands project (EDAN) is taking place in the period 2020–2024. Here, we present our preliminary results (fig. 1).

Stage 1: Ceramic Late Mesolithic

Our analysis is based on the two sites of Hardinxveld-Giessendam (Polderweg and De Bruin). The new ^{14}C analysis re-dates these phased sites to the period 5400–4650 BCE (Dreshaj *et al.* 2023). Size measurements on the *Sus* from this period indicate they were wild boar, which is substantiated by their aDNA and isotopic signals. There is no isotopic evidence for animal husbandry in this period. Interestingly, the kill-off patterns of the various phases are not the same, indicating that people varied their hunting practices through time, perhaps according to the changing environmental conditions (Brusgaard *et al.* 2022). The pots were used to cook meals that consisted of fish and ruminants (Demirci *et al.* 2021). We have no evidence for cereal cultivation at this stage.

Stage 2: Mist in the middle

The final stage of De Bruin (phase 3) is re-dated to 4450–4250 BCE (Dreshaj *et al.* 2023). It is difficult to interpret because it concerns a small assemblage and the aDNA analysis failed to produce any useful data. The stable isotope results of the *Sus* are congruent with a wild boar diet. However, the size measurements indicate a number of significantly small suids at the site in this period, which would be domestic pigs (or butchered parts thereof) (Brusgaard *et al.* 2022). One of the pots of this phase may have been used for dairy (Demirci *et al.* 2021). We have no evidence for cereal cultivation at this stage.

Stage 3: Early Neolithic wetland farmers

Our analysis focused on two sites of the Swifterbant cluster, namely S3 and S4. The new ^{14}C analysis has tackled the problems with the plateau in the calibration curve by making use of high-precision dating, smart sampling, the minimal age difference between all the new ^{14}C dates and Bayesian modelling. It is now clear that S4 dates to 4250–4150 BCE, whereas S3 has a slightly younger date range of 4200–4000 BCE (Dreshaj *et al.* in prep.). The pig data are as of yet difficult to interpret. The assemblage consists of relatively small *Sus*, including many piglets, and had a diffuse isotope signature, while the aDNA results

Figure 1. Palaeogeographic setting of the sites discussed (after Vos 2015).

indicate that one *Sus* had a small percentage of domestic ancestry, indicating either contact with neighbouring domestic pig populations or perhaps that this *Sus* was heavily interbred with local European wild boar. In contrast, the *Bos* data clearly point to domestic cattle. The size of the bones is consistent with domestic cattle populations and aDNA analysis points at genetically domestic animals. The isotopic analysis reveals that some of the cattle were herded in an environment with elevated nitrogen values, while another part of the herd has a local nitrogen signal (Brusgaard *et al.* in prep). The lipid analysis of the S3 pottery suggests that meals with pork or beef were not produced in pots – we only have evidence of meals with fish (Demirci *et al.* 2020). Plant remains in pots (using SEM analysis) testify to the presence of emmer wheat in these same pots (Raemaekers *et al.* 2013), giving a more complete view of the cuisine at this site. The importance of cereal cultivation is clear from

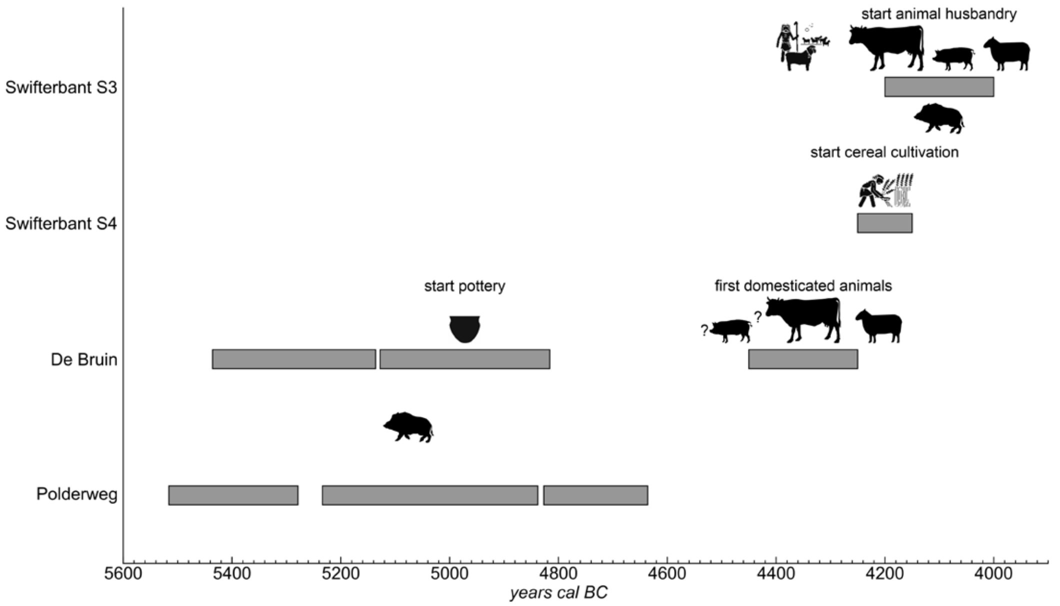

Figure 2. Overview of developments in animal husbandry and cereal cultivation in the fifth millennium BCE in the Dutch wetlands (figure: E. Bolhuis).

the presence of cultivated fields (Huisman *et al.* 2009; Raemaekers and De Roever 2020), botanical macroremains (see Schepers and Bottema-Mac Gillavry 2020 for the most recent overview) and coprolites (Kubiak-Martens and Van der Linden 2022).

Conclusions

The EDAN project has put flesh on the bones. The various types of analyses point to a start of both animal husbandry and cereal cultivation from *c.* 4200 BCE onwards (fig. 2). The domestic character of the *Bos* at Swifterbant is based on the small bone size, the stable isotopes and aDNA. Moreover, the isotopes suggest that there were two herds, one of which grazed in an area with high nitrogen values and was transported to Swifterbant. These high values are consistent with herbivores grazing in a salt-marsh region (Britton *et al.* 2008; Prummel *et al.* in prep.), which would make these bones the first clues of coastal exploitation at the end of the fifth millennium BCE – a landscape zone that cannot be studied directly due to its erosion. The isotope analysis included some sheep/goat bones with a similar 'coastal' signature, suggesting that pastoralism was an activity that included both types of animals. The *Sus* at Swifterbant remain difficult to interpret in terms of wild or domestic: both the isotopes and the aDNA are highly variable. These patterns might suggest a palimpsest of different human-pig relations or individual pig life histories, or both. Cereal cultivation is attested from the same time onwards.

The start of the Neolithic in the Dutch wetlands can now clearly be interpreted as a Short Transition Model, where both animal husbandry and cereal cultivation should not be interpreted as sort of 'play farming' (Graeber and Wengrow 2021, 266–273). The pastoralism of cattle and sheep/goat, and the abundance of evidence for cereal cultivation, imply mobility strategies and knowledge exchange that go beyond incidental subsistence activities as envisaged in the use of the term ‘extended broad spectrum economy’ to describe these communities at Swifterbant (Louwe Kooijmans 1993). These were not hunter-gatherers with farming carried out on the side, but wetland farmers.

The impression is that this new type of Neolithic Package is rather similar to that of the Early Neolithic Funnel Beaker Culture in terms of subsistence data (Sørensen and Karg 2014 for Denmark; Demirci 2021, chapter 6 for a comparison between the two regions). For the same time and place, Swifterbant S3 yielded ceramic vessels that fall within the morphological and technological range of Early Neolithic Funnel Beaker Culture ceramics in Denmark and northern Germany (Raemaekers 2015; Demirci *et al.* 2022 for an inter-regional comparison), but predate these by some two centuries. This raises the question of the role played by the Swifterbant communities in the transition to farming in northern Europe.

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Stone Age Fishing in the prehistoric Syltholm Fjord

Terje Stafseth and Daniel Groß

Abstract

The prehistoric Syltholm Fjord was used for many generations as a prime spot for acquiring aquatic resources. This is witnessed through several (semi-)stationary fishing constructions and a large number of fishing tools. In this contribution, we present a short overview of the main groups of fishing equipment from the excavations of the Femern project and introduce the different find groups. These include active fishing tools, such as leisters and leister prongs (cf. Chaudesaigues-Clausen this volume), as well as passive tools, such as fish traps and weirs.

We present the finds and constructions from the different excavations to provide an overview of the existing material and briefly discuss constructional details and locations. It is shown that different fishing methods have been used in different periods, with leisters being already present in the material during the Middle Mesolithic, while the first fish traps date to no earlier than the Late Mesolithic or, in archaeo-cultural terms, the Ertebølle Culture. Fish weirs, on the other hand, date to no earlier than 3300 BCE and hence to the Middle Neolithic.

The use of aquatic resources still played a relevant role in the area after the introduction of agriculture and served as a protein source in the human diet. But it also becomes clear that more in-detail studies are necessary to fully understand the typo-chronological details and, presumably, the functional differences among the material.

Femern project; aquatic resources; fish weirs; seascapes; subsistence; organic preservation

Introduction

Around 4000 BCE, the shallow Syltholm Fjord was sheltered by an elongated barrier coast (Bennike and Jessen this volume; Mortensen *et al.* 2015) and thus formed an ideal habitat for fish and birds. Consequently, it was also attractive to prehistoric people for exploiting these resources. In this contribution, we focus on the range of active and passive fishing gear and

in: Groß, D., Rothstein, M. (eds.). Changing Identity in a Changing World.
Current Studies on the Stone Age around 4000 BCE. Leiden: Sidestone Press, 235–248.

Figure 1. Complete proximal part of a leister found *in situ* at Strandholm I (MLF00909-II, find number X197) (photo: Museum Lolland-Falster).

techniques that were recorded during several excavations in the prehistoric Syltholm Fjord, mainly at the site complexes 4 and 5 (for an overview of the sites, see Måge *et al.* this volume).

Active fishing gear is composed of hooks, leisters, and spears, as they involve an active searching and/or luring of the fish, while passive fishing gear, such as the fixed trap, allows the possibility of catching and collecting fish without direct human involvement (Brinkhuizen 1983). The excavations in the Syltholm Fjord have revealed several traces of both methods from the Neolithic. The finding of large numbers of individual leister prongs and bone points – as well as intact leisters – are clear signs of active fishing (cf. Chaudesaigues-Clausen this volume). Bone points have been used for various purposes, including terrestrial hunting (*e.g.* Groß 2017, 106; Vang Petersen 2005), but in this context are generally believed to have been used as gorges (*i.e.* a transverse fishing 'hook'; cf. Auler 2021) and centred points in leisters. One reason for this are the numerous fishing structures and indicators of limnic exploitation as well as leister finds.

The presence of several *in situ* preserved fish weirs, fish traps, single wattle panels, and many vertical poles are clear indications of extensive passive fishing using (semi-) permanent structures. The excavations have unveiled different types of fish weirs and variations in design, but common to all of them is that fish are caught by swimming into a fixed container or trap. A fish weir is an artificial obstruction (*i.e.* fence) placed in water to divert and direct the path of passing fish towards a fixed container or trap. The excavations have revealed several variations in types and design.

This contribution gives a short and preliminary overview of the different features and finds, as analyses are still ongoing. Consequently, not all details can be discussed here and some descriptions, especially with respect to constructional details, will be provided in future publications.

Active Fishing in the Syltholm Fjord

One of the highlights from the site of Strandholm I (MLF00909-II) was the discovery of an *in situ* fishing leister. It was preserved with both lateral prongs and a central bone point (fig. 1). Finds of intact prehistoric leisters – including the lateral prongs, bone points, and fastenings such as pitch and winding – are extremely rare in Denmark. Previously, only one find of this quality was known from the locality of Næbbet near Ærø (Skaarup and Grøn 2004, 111; see also Rimantienė 2005, fig. 37). Unlike the Strandholm specimen, no bone tip was preserved at Næbbet.

The number of bone points and leister prongs varies between the sites in the Syltholm Fjord, and it is remarkable that there are almost no finds of these artefacts in areas where passive fishing structures are located. One hypothetical explanation for this could be that spearing fish happened mainly during winter, as recorded in historic sources (Nellemann 2000, 50–51), when the fish weirs were not in use, or during the night with the help of torches away from the weir structures (cf. Pickard and Bonsall 2007, 181), but this demands further study.

Passive fishing structures in the Syltholm Fjord

In the prehistoric Syltholm Fjord, the most extensive features for catching marine resources are the passive fishing structures. Fishing with fixed installations in the Stone Age is known from several places in Denmark (*e.g.* Fischer 2005; 2007; Pedersen 1997a; 1997b; 2013; Pedersen *et al.* 1997; Prangsgaard 2008) and has been a common way to acquire food. The construction and installation of fish weir-systems is time and resource consuming but has similarly rendered it possible to passively catch large quantities of fish throughout the seasons. Although the basic principle of fish weirs is globally largely the same, local and functional differences can be observed, due to the specific nature of the coast, the supply of raw material, and the targeted species in the different locations. Additionally, the time of the year the fishing is carried out may demand adjustments (Hjorth Rasmussen 1968; Højrup 1955).

The archaeological excavations at the prehistoric Syltholm Fjord have uncovered seven sites with traces of passive fishing structures:

- Femern Bælt (MLF00001) – fish trap
- Syltholm II (MLF00906) – wattle mat, fish traps
- Strandholm I (MLF00909) – wattle mats
- Syltholm VII (MLF00933) – standing fish weir
- Syltholm X (MLF00936) – fish traps
- Syltholm XIII (MLF00939) – fish trap (?)
- Fehmarnbelt (MLF01362) – fish weirs and wattle mats

At two of the sites, the fishing structures consist of single wattle mats, woven panels that were presumably used in fish weirs, but were recovered from the former seabed (at MLF00906-I, MLF00909-II). Yet, some of the structures were also found *in situ* (at MLF00933-II, -III and MLF01362).

Fish Traps

Three fish traps and four fragmented ones were recorded during the excavations. Additionally, five sticks from fish trap baskets have been found (three at MLF00936, one at MLF00906-I and one at MLF00001-VII). Two fish traps come from the site of Syltholm II (MLF00906-II). The site also produced three sticks and four fragments that likely belonged to three different traps, based on their location. Two more sticks are known from Syltholm XIII (MLF00939-II) and another fish trap comes from Syltholm X (MLF00936-I). This trap is dated to the Early Neolithic Funnel Beaker Culture and wood anatomical analyses showed that it is woven from branches of common dogwood (*Cornus sanguinea*), while its transverse stiffeners are made of elder (*Alnus* sp.). The use of common dogwood for this purpose differs from other traps in Denmark (Pedersen 1995, 82), but is similar to the German and Dutch material (Klooß 2015, 242–247; Out 2008).

Even though several stationary fishing constructions and traps are known from Stone Age Denmark, most of the fish traps are dated to the Mesolithic (Klooß 2015, 240–255; Pedersen 1995; 1997a). In total, nine radiocarbon dates were obtained from fish traps from the excavations, dating the use of this technology to *c.* 4700–3100 BCE (see below).

The fish traps may have been used as single features attached to a stake, potentially also for keeping fish alive until further processing, but were more likely part of a larger system where they were located at the funnel end of fish weirs. To date, however, no fish trap has been found in relation to the stationary installations in the prehistoric Syltholm Fjord.

Fish weirs

The fish weirs in the prehistoric Syltholm Fjord date exclusively to the Neolithic and hence mark the youngest fishing gear. In the following, we will briefly discuss the construction of the different features and highlight some of the constructional aspects.

Fish weirs are basically constructed with a leader, which is a barrier that is constructed perpendicular to the current or migration route of fish, and an arm, which guides the prey into the catching device, for instance, a fish trap. Three different types have been identified in the excavations (fig. 2).

Syltholm VII (MLF00933)

Three constructions were recorded at this site (MLF00933-II), which more or less directly overlie each other. This indicates activity and the use of the same location over a longer period of time. Based on stratigraphy, spatial relation and dating, three phases can be separated: K1, K2 and K3. Note that “K” describes a site-specific construction event, not a feature identification for all excavations (*i.e.* K1 at Syltholm VII is a different feature to K1 at Syltholm II). Seven wattle mats have been recorded.

K1 is the oldest and best-preserved fish weir at the site. The structure was initially interpreted as a V-shaped structure, with one 12 m long arm extending to the southwest. The leader still measured 15 metres in length but was not fully recorded as

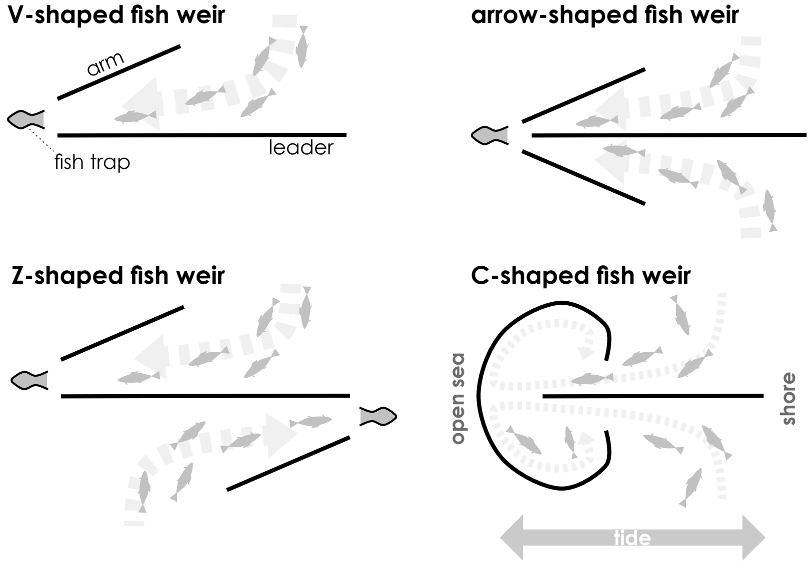

Figure 2. Four different types of fish weirs: V-shaped fish weirs are useful for catching fish that are predominantly migrating in one direction, the arrow and Z-shaped styles are more flexible with regard to current and direction. The C-shaped fish weir utilises the tidal currents for trapping fish; note that the leader is optional in this variant.

it continued beyond the limit of excavation. Consequently, we do not know the landfast connection – if there was one.

Overall, relatively few supporting stakes or poles were recorded, and these are not placed in a clear pattern with fixed intervals. One of the reasons for this may be that the depth of the uprights in sections reaching down to 80 cm into the clay was sufficient for support.

The angle between the arm and leader is set at ~45°. At the funnel, where the fish trap would be expected, split planks were recorded that formed the ending of the weirs. This observation is relevant as planks were not detected elsewhere in the structure. An identical use of planks is also recorded at Femern Bælt I (MLF01362), which is roughly contemporaneous with K1. At both sites, the plank at the end of the leader is set in the longitudinal direction of the weir, while the plank is transversely placed at the end of the arm.

It is thus clear that the planks served a specific function in the construction. Since the planks are set at the point where the trap is expected to have been, their function is most likely linked to it. Furthermore, at the funnel between the arm and the leader, a pit was recorded that likely represents washout, as can be seen on the Wadden Sea coast (Møller 2006, 101–106): here, due to the high difference in tide, it was crucial to place the fish traps in channels, depressions or pits so that they were lying under water to protect the catch from birds and to prevent it from drying out.

K2 represents the second phase of fish weir at the site. Due to a varying preservation, it is difficult to interpret its relation to the other features, but it likely represents an intermediate phase, *i.e.* a repair of the weir before it was once more replaced or

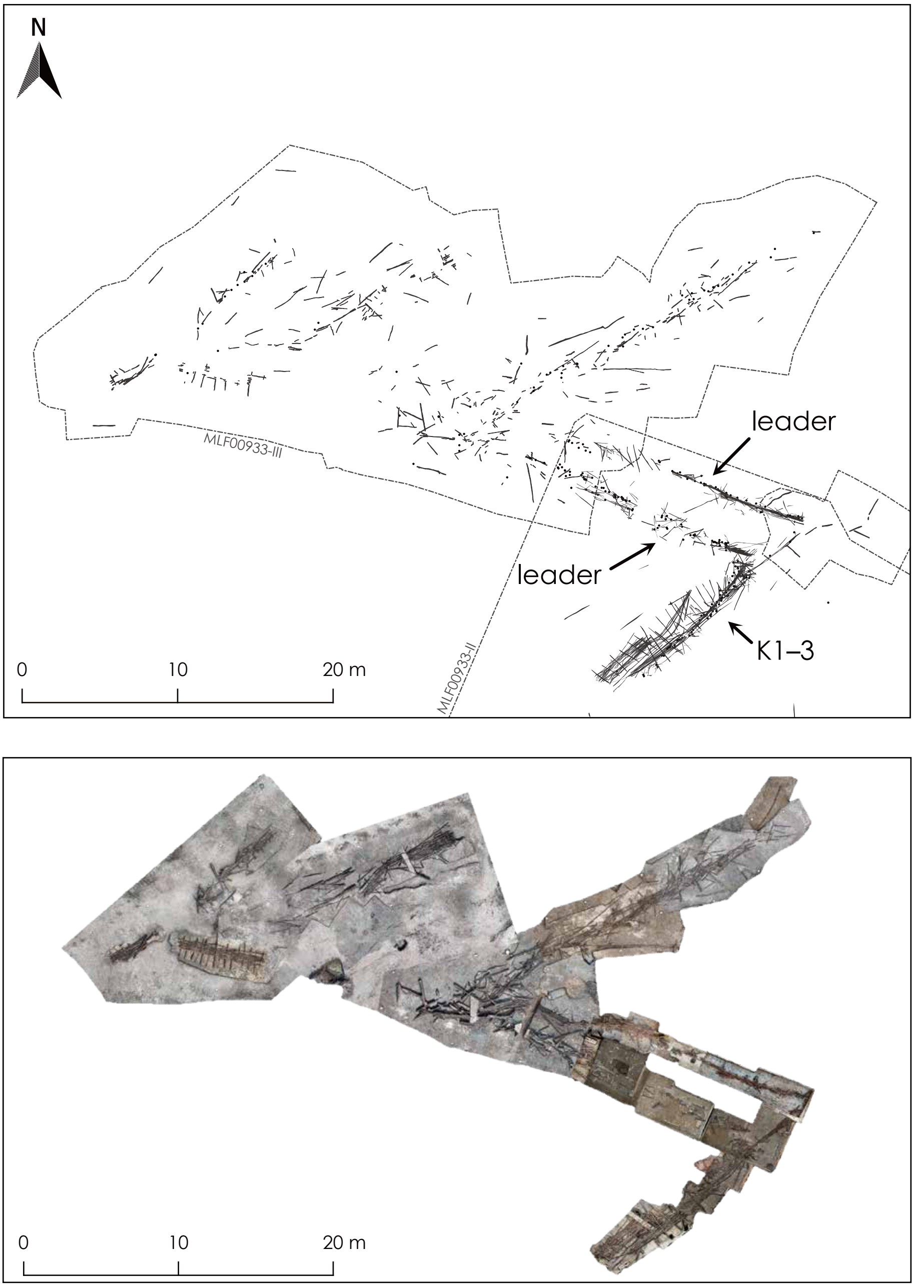

Figure 3. Z-shaped fish weir at Syltholm VII (MLF00933). The structure spreads over two excavation trenches. Above: map of the wooden stakes; below: photogrammetric mosaic of the structure. Note that several wattle mats in the western part were only photogrammically documented and not individually drawn (photos: Museum Lolland-Falster).

substantially repaired (K3). The uncovered part consists of two rows of stakes and partly horizontally-lying wattle mats. It is constructed of sticks and twigs/branches of varying shape and size – forming a northwest-oriented leader and a southwest-oriented arm in a V-shaped form. At the junction between the leader and the arm, several planks and heavy poles were hammered down into the ground at an oblique angle. As K1, K2 and K3 show clear reference to each other, it can be assumed that they represent different (repair?) phases of one big fish weir that was in use for a longer time.

Another arm was furthermore recovered in MLF00933-III, *c.* 25 m further to the west. Here, a standing section of wattle mat oriented in a SW-NE direction was recorded. As the parallel leader connects both features, this part mirrors K1–3, but points in the opposite direction, so that a Z-shaped fish weir is created (fig. 3).

Four more segments of fish weirs/wattle mats were excavated in the western part (A8, A10, A14, A15) that probably belonged to the structures further to the east, as they were positioned in the same orientation. But since no dates are available yet for them, a possible contemporaneity is not proven.

Femern Bælt I (MLF01362-I)

The excavation at this site uncovered two rows of upright stakes/wattle mats and supporting stakes of 33 and 63 m length, respectively. The rows form a V-shaped fish weir. The degree of preservation varies widely: the lower layers of the wattle are only preserved in some areas.

On one of the mats, the bindings were preserved. Two of the lower horizontal sticks were both wrapped around the vertical upright at each end and around the adjacent stick. A binding form of this type is not known from prehistoric fishing sites in Denmark (fig. 4).

About 75 metres northeast of the fish weir, a probably unrelated horizontally-lying wattle mat was recorded (K2). It is *c.* 6.60 m long and *c.* 1 m wide and constructed from a series of upright stakes tapered at the base, around which a series of long sticks of varying thickness are woven. The interesting feature of this mat is that the proximal parts of the branches are placed towards the ends of the wattle mat, while the thinner, distal parts are braided towards its centre.

Another wattle mat (K3) was discovered about two metres from the stake rows. It was 3 m long and woven of finer and thinner branches. Whether this mat was part of the *in situ* standing weirs cannot yet be determined but is probable due to its similar age (see below).

Syltholm II (MLF00906-I)

The wattle mat, K1, at this site was lying on the seabed and hence *ex situ*. It is very poorly preserved but was, in general, made from finer branches than the other mats (cf. Klooß 2015, 266–68). As it also has a significantly younger date than the fish trap from the site, the wattle mat represents another construction.

Strandholm I (MLF00909-II)

Semi-circular or C-shaped fishing structures are known from both prehistoric and historic times. They function by trapping fish in an enclosed space, rather than in a trap (see schematic in fig. 4). Usually, they are found in areas with large tidal differences, so that

Figure 4. A detail of the fish weir at MLF01362-I, note the binding of the horizontal sticks around the vertical stake. This constructional detail was discovered at both ends of the segment, underlining that it was intentionally done. Each ruler segment measures 10 cm (photo: Museum Lolland-Falster).

fish is caught when the water is receding with the lowering tide (*e.g.* Langdon 2006, 65; O'Sullivan 2004).

At the site, structure K1 (fig. 5) probably did not use the aforementioned method, as its opening faced the wrong way. Yet, it is possible that most of the structure was not preserved, so only a part of it is recorded. If this is the case, its opening can be assumed to have pointed towards the shore. However, it is possible that the structure is found *ex situ* as support poles are missing. Since the dating corresponds with most material from the site, and due to its rather fragile construction, it is, however, most likely that it was excavated in its original position.

Additionally, another wattle mat was found *c.* 25 m north of K1. It was badly and incompletely preserved but still measured 16 m in length. As the constructional details are similar to K1, it is fair to assume that both were part of the same structure.

Chronology

Fishing with stationary as well as mobile fishing equipment was a persistent tradition in the prehistoric Syltholm Fjord. Usually, wooden leisters have been dated to the Late Mesolithic and early Neolithic (*e.g.* Klooß 2015, 232; Pedersen 1995), although the method and form has been used until the present (Krause 1904; Nellemann 2000, 50). While many leisters are especially known from the Late Mesolithic (*e.g.* Gummesson 2018; Klooß 2015; Olson 2008; Pickard and Bonsall 2007), the radiocarbon dates (Måge *et al.* this volume, supplementary material) show that such tools were already in use during the Middle Mesolithic at the time of the Kongemose Culture and were a substantial means

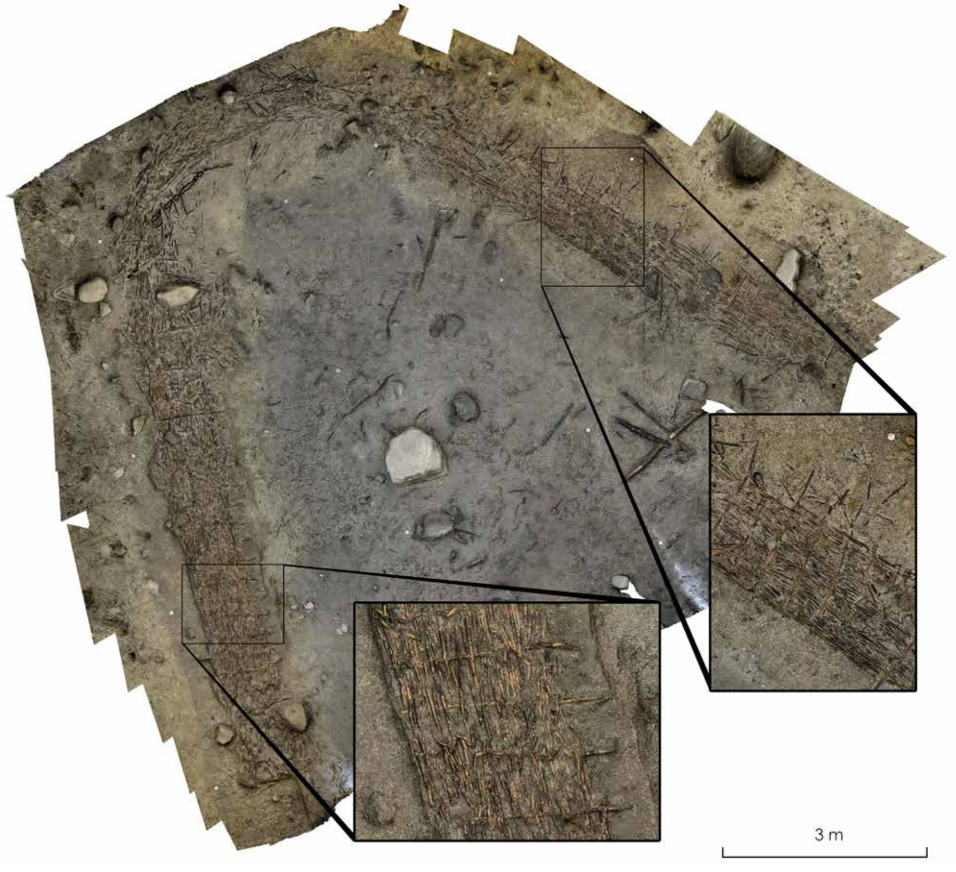

Figure 5. Photograph of the *in situ* structure K1 at Strandholm I (MLF00909-II). Note that the preservation of the wood is good, but it is highly fragmented. The fish weir is woven as one continuous mat (photos: Museum Lolland-Falster).

for acquiring aquatic resources in the Late Mesolithic and Early Neolithic, while being sporadically present until the Late Neolithic Single Grave Culture.

Direct dating of the several features and constructional elements rendered it possible to develop a local chronology for the respective methods in use. In the time when the number of datings for leisters increases, the first direct dates for fish traps in the material are available, whereas the oldest fish weir from the fjord, with an age of 3330–2910 cal BC (AAR-24654: 4404 ± 47 BP / MLF00933-II K2), shows that these constructions were not in use earlier than the Middle Neolithic.

While the dated leister prongs date to the Middle Mesolithic to the Final Neolithic, fish weirs were in use for only a rather limited time frame during the Neolithic. It has yet to be investigated whether environmental changes and/or cultural transformations caused the uptake and abandonment of this technology.

Fig. 7 shows a phase and sequence model for the different fish weirs from the excavations. The different phases render it possible to date them more precisely, indicating that some structures might have been in use for a few hundred years. However, given that there are only two or three direct dates for most of the fish weirs, the modelled

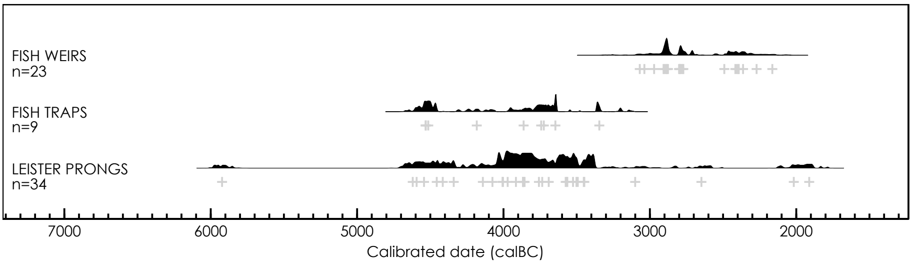

Figure 6. The sum calibration of the radiocarbon dates show different chronological phases for different methods (the crosses show the medians of the measurements, calibrated with OxCal v4.4.4 (Bronk Ramsey 2021, see Bronk Ramsey 2009), atmospheric data from Reimer *et al.* 2020; for date list see Måge *et al.* this volume, supplementary material).

lifespans of 200–300 years are probably too long as they are not properly constrained. The three-phased, and thus better constrained, fish weir from MLF00933-II is modelled to a notably shorter use, with up to 16 years for the first (K1), 13 years for the second (K2), and a maximum of 24 years for the third (K3) construction phase.

Conclusions

The analysis of fishing in the prehistoric Syltholm Fjord stands in a long line of research on the exploitation of aquatic resources in Denmark (*e.g.* Enghoff 1994; Fischer 2007; Fischer *et al.* 2007; Hjorth Rasmussen 1968; Holm 2003; Lundbæk 1975; Pickard and Bonsall 2007; Prangsgaard 2008; Ritchie *et al.* 2013; Robson and Ritchie 2019). Due to its quality and abundance, the material provides opportunities to increase our understanding of human interaction with the sea and the importance of marine resources in this period. Furthermore, it provides insights into traditions and changes inside an intensely used micro region.

As a food source, fish (and marine mammals) are particularly important and have been – as witnessed by the elaborate constructions – a stable complement to agriculture.

While this study can only provide an overview of the existing stationary fishing constructions in the area, it underlines the importance of an in-depth analysis of the material and constructional details. Variations in design may also be due to the use of different raw materials or other ways of obtaining them and thus may reflect different uses of vegetation. Not least do the features from the prehistoric Syltholm Fjord show specific typological differences that may be connected with larger changes in the socio-cultural spheres and ecological changes in the area during the Atlantic biozone. As an in-depth analysis of the faunal composition lies beyond the scope of this paper, it must be integrated into future studies.

It furthermore becomes clear that the different techniques applied for fishing bear great potential for understanding the prehistoric perception of the environment. The active hunting for fish by using leisters has been a method that has been applied until recently. But the chronologically rather limited usage of fish weirs demands a little more attention, as their implementation and renouncement during the Neolithic may be connected to society within a larger scheme. During the Middle Neolithic, the Funnel

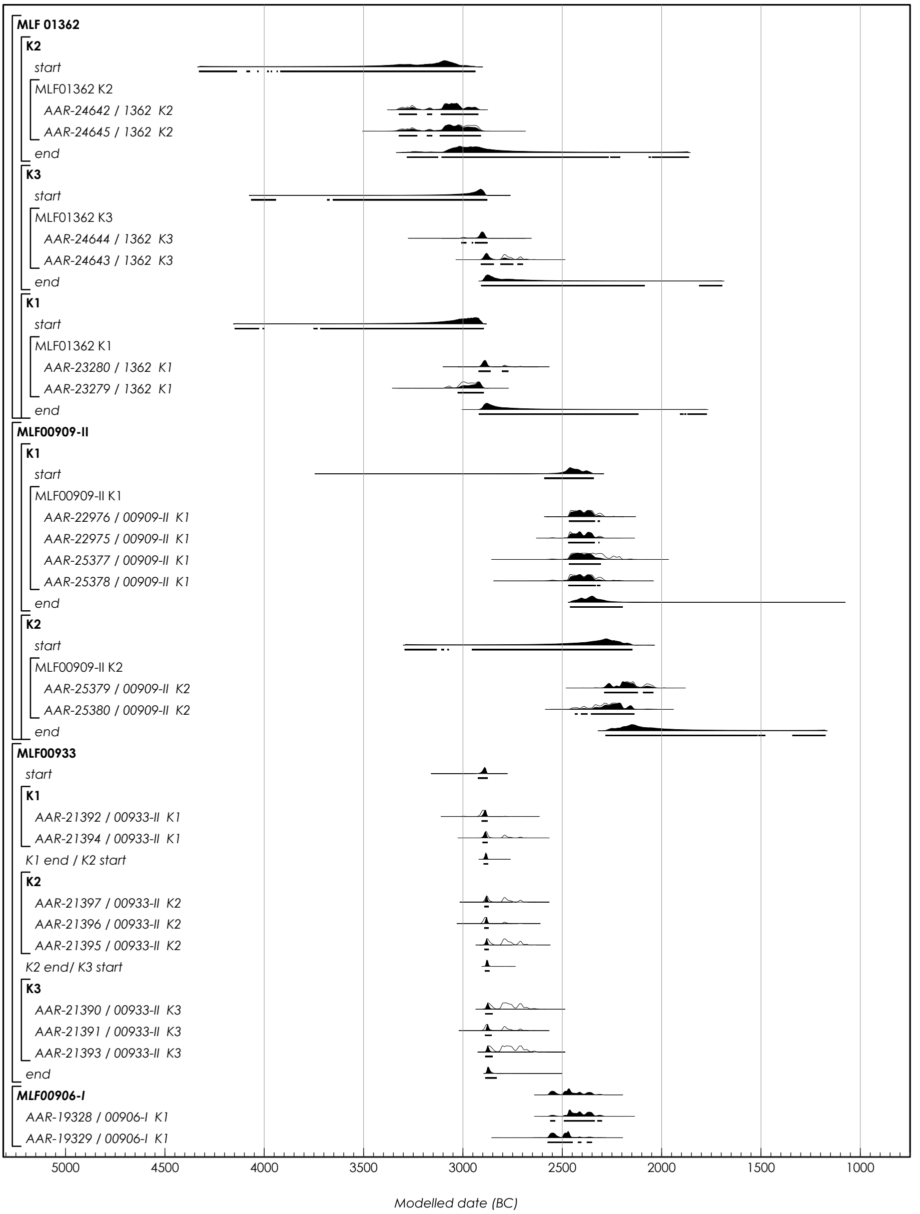

Figure 7. Phase and sequence model for the different fish weirs (calibrated with OxCal 4.4.4 (Bronk Ramsey 2021, see Bronk Ramsey 2009; atmospheric data from Reimer *et al.* 2020).

Beaker Culture on Lolland was subject to significant social changes which, similar to other areas, saw the building of megalithic passage graves (Wunderlich *et al.* 2019). Apparently not only the landscape was further transformed through the large grave complexes during this period, but also the waterscape.

Supplementary material

The OxCal code for fig. 7 is available at 10.5281/zenodo.7541002.

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CRediT statement

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The Unbeknownst Pottery Craft at Alvastra Pile Dwelling

Nathalie Hinders

Abstract

Alvastra pile dwelling is one of the richest Middle Neolithic sites known in Sweden regarding the preservation of organic material and the display of different types of artifacts. The pottery assemblage in particular has been discussed more extensively than other materials in previous research. Funnel beaker and Pitted Ware pottery have been found at the site, together with the so-called pile dwelling pottery – a hitherto uncharacterised pottery type. Due to the fact that the pottery has played a big part in the interpretations of the site, the presented results concerning pottery and pottery craft also affect the understanding of the pile dwelling as a whole. Visual analyses of the pottery, based on the recording of craft specific parameters, have resulted in the categorization of the previously debated pile dwelling pottery. Furthermore, the results point to pottery production at the site and are strengthened by the presence of other material assemblages from the same cultural layer, such as bone artifacts and lithics. Pottery and other specialized crafts are suggested to have been a part of the activities at the pile dwelling. Moving towards an understanding that Alvastra pile dwelling was, among other things, a place for craft, challenges previous interpretations of the site as being foremost a ritualistic space and a place for the dead.

Neolithic; Funnel Beaker Culture; Pitted Ware Culture; chaîne opératoire; wetland archaeology

Introduction

At the end of the Middle Neolithic A (MN A; 3300–2700 BCE), Alvastra pile dwelling (APD) was constructed in the Dagsmosse wetland, at the foot of Mount Omberg in Sweden. The structure can be described as a wooden platform connected to the mainland by wooden causeways. The platform was made of floor-like, horizontal poles, anchored in the mire by vertical poles that quite possibly could have been a part of facades or wall-like structures.

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The construction is a man-made platform built for the activities that were carried out in the spring-fed mire. Artifacts typical for the Swedish MN A, such as pottery, double-edged battle axes, and osteological remains of animals and humans were recovered at the pile dwelling. Moreover, the wetland conditions allowed the preservation of a large number of organic objects, such as rope, a possible basket, bone artifacts, gathered and deposited seeds, apples, and hazelnuts (Alvastraportalen 2022; Browall 2011). The number of organic materials and their diversity are unique to the Swedish Neolithic.

The site was discovered in 1908, resulting in archaeological investigations during the 20th century. Firstly, by Otto Frödin (1909–1930), followed by Mats P. Malmer (1976–1980). The results from Frödin's investigations remained unpublished until 2011 (Browall 2011), and the results from Malmer's investigations were first published in part (Browall 2016) and then in their entirety as a result of a five-year-long (2015–2020) research-infrastructure project at the Swedish History Museum (SHM). The aim of the latter project was to publish all the results from Malmer's investigations, including the recording and characterization of the archaeological material for the museum database. The project was successful with this aim, and determinations of artifacts, written documentation, photos, and drawings were published digitally on the SHM webpage – *the Alvastra portal* (*i.e. Alvastraportalen*).[1] A particular focus for the project were detailed investigations of the flint and pottery material (see Hinders 2019*a-d*; Strand Tanner 2019; Strand Tanner and Söderlind 2019; Söderlind 2019*a-b*). The main research aim of the work with the pottery assemblage, which is central to this text, was to determine the sherds as Funnel Beaker Culture (TRB) pottery and/or Pitted Ware Culture (PWC) pottery and, if possible, categorize and record the traits connected to a third type of pottery, the so-called pile dwelling pottery (PDP). As a result, new information about the deposited artifacts at the pile dwelling can now be put forward and this text represents the first lengthy discussion based on these results.

Previous research

Results from the investigations at APD remained unrecorded and unpublished for more than 80 years in the museum storerooms until the completion of the project at the SHM in 2020 (Alvastraportalen 2022). Previous studies of the site have focused on understanding the entire site and what the pile dwelling represents on a large scale, since the artefacts have been unavailiable for research (*e.g.* Browall 1986; Carlsson 1998; Gill 2003; Malmer 2002). In the following paragraphs, previous research will be discussed in order to disentangle the many interpretations of the site, since they have affected the chosen methodology within the project.

Most of the previous interpretations orbit the deposition of TRB and PWC artifacts in the same cultural layer; a combination of materials that are rarely found in Sweden. Attempts have therefore been made to understand these depositions at APD in relation to supposed economic transformations from farming to hunter-gathering at a time when

1 The work within the infrastructure-project has only been published as separate texts, accessible through the Swedish History Museum's webpage (see list of references). In order to clarify what texts that are indicated, the specific authors are referred to in the text and in the list of references. The present paper is one of the first texts that discuss the results outside the project, and other references to the recent results are therefore lacking. Throughout the text, *Alvastraportalen* will be referred to, both in general terms as well as through the specific texts, much in the same way that separate articles would in other circumstances.

agriculture had been practiced in the area for centuries (*e.g.* Browall 1991; Carlsson 1998; Edenmo *et al.* 1997; Gill 2003 Welinder *et al.* 1998). Consequently, the pile dwelling has been thought to represent a place where "[...] the collectivist ideology of the Funnel Beaker culture was transformed to the more individual ideology of the Pitted Ware culture" (Carlsson 1998, 56; own translation). Since the pottery assemblage at the site has been subject to the most scrutiny in previous works (compared to other materials), the sherds have regrettably been seen as evidence of the APD being the very place where TRB pottery (practice/phenomenon) was transformed to PWC pottery (practice/phenomenon; Browall 1991; Carlsson 1998, 57; Gill 2003, 144). As an addition to these largely extrapolated interpretations, Malmer argued that the site should be understood as a ritual place for skeletonization as well (Malmer 1984; 2002), and was thus a ritual platform where people from the TRB and the PWC performed different activities, including the deposition of fragmented pottery, lithics, bone tools, seeds, osteological material, bisected apples, and the remains of the dead, including an emplaced, scalped cranium at the eastern entrance (Alvastraportalen 2022; Browall 2011; 2016; Carlsson 1998; During and Nilsson 1991).

Even though several hundred pile dwellings have been found around Europe (Menotti 2004; Pranckėnaitė *et al.* 2021; Taffinder 2019), APD is currently the only known pile dwelling in Sweden. Subsequently, the site has been thought to represent something unique and ritualistic (Carlsson 1998; Gill 2003; Malmer 2002; Molin and Stenvall 2010; Papmehl-Dufay 2006; Vanhanen *et al.* 2019). As described above, however, most previous interpretations are based on the fact that artifacts from two Stone Age groups have been deposited or, more correctly, scattered and intermingled in the same cultural layer. The finding of fragmented artefacts, including human remains, scattered in cultural layers from TRB or PWC contexts is not uncommon (Hallgren 2008, 112; Larsson 2009, 345–347); however, the finding of material from both groups intermingled is what sets the APD context apart from other sites in this sense. Malmer (1999, 332) discusses the meeting of these two groups at the site, and according to Browall (1991), the mixing of artefacts from two groups make the APD a *strategic find* (Browall 1991) when discussing the relatively complex period of time when farmers of the TRB possibly interacted with the marine hunter-gatherers of the PWC (see Browall 1991 for further discussion). Due to the ritualistic cloak that shrouds previous interpretations, artefacts that are found at the site, or artefacts similar to objects found at the site, are by association considered to be ritual or connected to feasting (*e.g.* Vanhanen *et al.* 2019). Out *et al.* (2022) present a parallel discussion of botanical materials and the interpretations thereof, highlighting the problem with the material being unpublished yet well-known for the larger part of the 1900's. Thus, these previous texts need attention and scrutiny and the archaeological material requires thorough analysis to add more data to the discussion.

Middle Neolithic Pottery at the Pile Dwelling

It is suggested that the de-Neolithization from the TRB to the PWC that was previously proposed (Browall 1991; Carlsson 1998, 57; Gill 2003) can be discerned in the different pottery craft traditions within the TRB and the PWC (Hallgren 2008; Larsson 2009, 44–45.58). Of particular interest for this study is that APD is suggested to be the very place where this transformation took place (Browall 1991; Carlsson 1998, 57; Gill 2003, 144). The

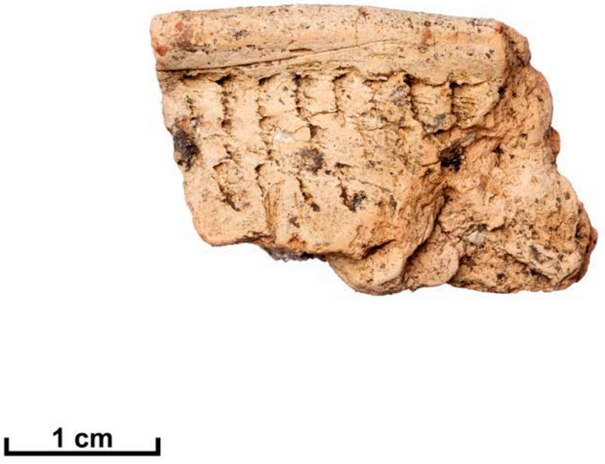

Figure 1. Rim sherd of Funnel Beaker pottery (FID1284551) from Alvastra pile dwelling. Decorated with stamp impressions in three rows underneath the rim (photo: Ola Myrin, Swedish History Museum/ SHM, CCBY 4.0).

Figure 2. Rim sherd of Pitted Ware pottery (FID120644) from Alvastra pile dwelling. Decorated with a characteristic herring-bone motif and impressed pits. The decoration is typical for the Fagervik III stage of the PWC pottery (photo: Ola Myrin, Swedish History Museum/SHM, CCBY 4.0).

Figure 3. Rim sherd of pile dwelling pottery (FID1198895), Alvastra pile dwelling, decorated with irregular impressions in two rows under the rim. Note the large grain of rounded gravel (temper) on the rim, to the right (photo: Ola Myrin, Swedish History Museum/SHM, CCBY 4.0).

background to these conclusions can partly be found in past research concerning the MN pottery materials found foremost in the south of Sweden. The different types of pottery connected to the Swedish MN A, TRB and PWC are therefore summarized below.

TRB pottery vessels were coiled, ranging from large vessels with funnel-shaped necks from the beginning of the fourth millennia BCE to smaller and intricately shaped and decorated vessels during the third millennia BCE, such as brimmed beakers (fig. 1; Hallgren 2008, Stilborg 2002a; 2002b). TRB pottery is tempered with larger pieces of crushed granite of roughly the same size as a result of deliberate work with the temper (Hallgren 2008, 178). The vessel walls were commonly meticulously ornated with string impressions and geometric patterns (Hallgren 2008; Stilborg 2002a; 2002b).

The PWC pottery vessels were also coiled and variations in décor and shape changed over time: however, the most common attributes are conical vessels with carinated shoulders and pointed/rounded bases (Larsson 2009, 46.114; Papmehl-Dufay 2006, 49). PWC pottery vessels are for the most part tempered with finely crushed calcareous material, primarily shells – often thought to be of chronological significance (Bagge 1951); however, finely crushed temper of mineralogical origin occurs as well. The most common decorations are impressions of pits and combs in alternating zig-zag patterns (fig. 2; Bagge 1951; Larsson 2009, 47; Papmehl-Dufay 2006).

A third type of pottery, the so-called PDP, has only briefly been discussed in previous research, and more as a footnote than anything else. It should be stressed that 'the pile dwelling pottery at Alvastra' or similar descriptions may occur. However, in these instances (*e.g*. Browall 1991; Hulthén 1998), the entire ceramic material at the site is targeted, not the one specific type discussed in this text as well as in Browall (2011) and Hinders (2017; 2019a; 2019b; 2019c; 2019d). Browall (2011, 289) originally provided the name as well as the lengthiest description of the pottery type prior to this study: '*the majority of the pottery found at the pile dwelling cannot be determined as either funnel beaker pottery or pitted ware pottery but is rather inspired by both*' (Browall 2011, 289, own translation). The pottery has also been described as '*household ware*' with varying shapes, sizes, building techniques (u-/n-technique) and décor (Browall 2011, 289). The décor is sparse and often applied in rows under the rim or near the shoulder (Browall 2011, 289). The first use of the terminology PDP was chosen by Browall (2011) in order to distinguish the type from the TRB and PWC pottery at the site (Browall 2011, 289).

Based on technological and visual analyses, Hulthén (1998) made the first attempt to understand the pottery assemblage from the APD. She argues for two types of pottery at the site, one is homogenous and made by the u-technique and the other is heterogenous and made by the n-technique (Hulthén 1998). The ceramic craft at the pile dwelling (*i.e*. the larger assemblage) is thus presented as evolving from using the u-technique to using the n-technique (Hulthén 1998). The conclusion is, according to Hulthén (1998), strengthened by the stratigraphical relationship between the sherds. Browall (2011), however, disagrees, pointing to other stratigraphical sequences and argues that TRB and PWC pottery were both made by the n-technique and that the PDP was made by the u-technique. That is, both techniques were used at the same time (Browall 2011, 256–291). It should be noted that the PDP (or what has corresponded to the PDP) was not discussed in Hulthén's work as a separate type of pottery, neither were the sherds with rounded gravel mentioned in the study, nor were any of the sherds selected for the thin sections by Hulthén (1998).

Materials and Method

The investigated material encompasses the entire pottery assemblage unearthed during Malmer's investigations of APD. Due to the the variation of previous interpretations it was considered necessary to record parameters that illuminate as many aspects of the assemblage as possible, without forcing the material to fit the mould of predetermined types. The observations of the ceramic material were therefore performed in two phases. The first phase involved the recording of parameters, suggested by this study to represent nodes in the ceramic craft (see below). The second phase involved the evaluation of the data from the first phase, leading to the interpretation of each sherd. The two-part process was chosen to allow differences in the material to be crystallized through the parameters recorded, foremost the unspecified but debated third type (PDP). This was carried out with the aim of answering the following questions: how large is the TRB and PWC pottery material respectively, what types of TRB pottery and PWC pottery are represented in the material? Is there a third type of pottery at the APD and, if so, is it possible to determine this third type?

The point of departure for the chosen parameters argued to represent nodes in the craft are the known *chaînes opératoires* for Neolithic pottery (see Larsson 2009; Papmehl-Dufay 2006, 138–149; Roux 2017; Stilborg 2002a; 2002b; 2002c) as well as the personal experience of reconstructing prehistoric pottery by coiling. The following parameters for visual analysis and measurement in phase one were chosen: number of sherds, weight, temper, ware, max. grain size (temper), vessel building technique, sherd thickness, vessel shape, décor, and colour. Additional parameters were added to highlight as many aspects of the material as possible, such as the measuring of rim sherds to establish the maximum width of the vessel and notes on firing, probable charred organic residue and/or soot (Hinders 2019a). The recording of the craft specific parameters enables further discussions on the production process, starting with the choice and the processing of the temper (temper, ware, max. grain size), working through the production process of coiling (vessel building technique, sherd thickness) and forming the vessel and decorating it (vessel shape, décor). These parameters formed the basis of the recording of each individual sherd and were documented in the museum database. Furthermore, visual analyses and measurements of dissolved pottery, unburned-/burned clay and daub were also made in order to fully understand the use of clay at APD (Hinders 2019a; 2019b; 2019c; 2019d).

It should be noted in relation to theories on the *chaîne opératoire* (*i.e.* the production of the pottery) that a particular sub-type of small awl has been identified within the bone artefact assemblage. One of these awls corresponds to the décor on at least one TRB sherd from the pile dwelling, suggesting that this particular awl had been used as a pottery decoration tool (see Hinders 2017 for further discussion).

The second phase of the recording process involved the evaluation of the parameters (mentioned above) as well as determinations of the different pottery types and their characteristics. When the interpretation of each sherd was made, the data was yet again collected, analysed, and summarized. The entire process can be described as an iterative qualitative clustering for the different types. The full database is accessible through the SHM, and the summary of the analyses are published as texts on the website (Alvastraportalen 2022).

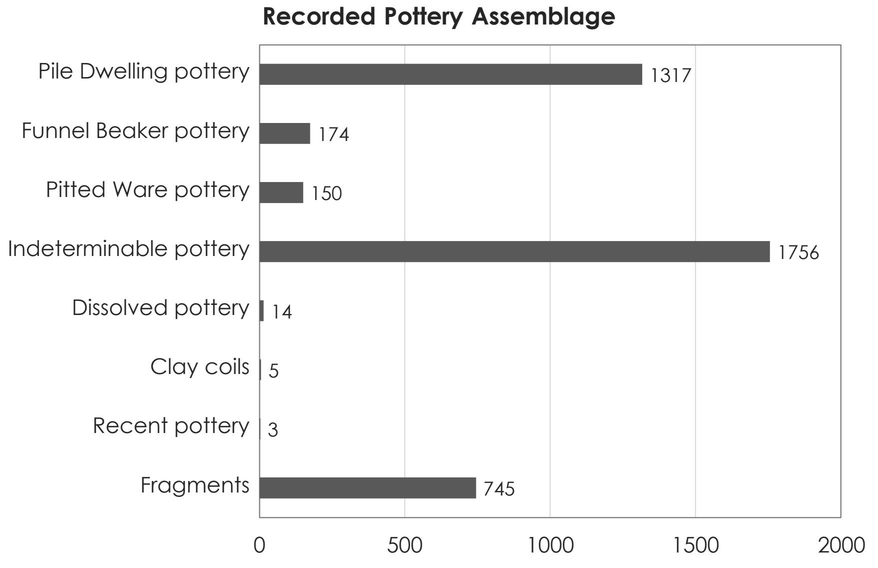

Figure 4. Graph displaying the results of the recorded pottery assemblage (3419 sherds and 745 fragments) from the Alvastra pile dwelling.

As a direct result of the recording strategy, a large number of sherds were 'indeterminable' when it comes to type. This was anticipated and accepted in order to record the material in the most detailed and objective way possible as well as to avoid a statistical type 1 error. Accepting that sherds can be labelled as 'indeterminable' enables the data to be evaluated without pressing the assemblage into a mould.

Results

When summarized, the investigated material displays three different types of Neolithic pottery at the site (Hinders 2019b), where the PDP is in a definite majority (fig. 4). Out of a total of 3419 recorded sherds and 745 fragments,[2] TRB and PWC pottery represent a mere 6% and 4% of all recorded sherds, respectively: the PDP represents 39% of the recorded sherds. Nevertheless, a large amount of the sherds was recorded as 'indeterminable' (51%; see below). It should be noted that the focus of this text is the results concerning the PDP; however, results from the entire study of the ceramic material will be presented and discussed briefly as well.

2 It was decided to distinguish between sherds and fragments since a large quantity of the ceramic assemblage was broken, either intentionally or through post-depositional events. In the current study, fragments are defined as pieces of pottery that measure less than 1cm^2. Fragments have only been recorded with respect to their weight and ware. Pieces of pottery larger than fragments are determined as sherds and were thus more thoroughly recorded, all in line with other recordings of mostly PWC pottery (see Papmehl-Dufay 2006, 157).

The Funnel Beaker Culture and Pitted Ware Culture pottery assemblages

The TRB pottery sherds recorded within the material amount to 117 sherds, representing 6% of the total assemblage. The sherds are tempered with crushed granite or rounded gravel (n=6; Hinders 2019b). The vessels were coiled by means of the u-, n-, and u-/n-technique and the sherd thickness varies from 5 mm to 13 mm (Hinders 2019b). The majority of the sherds (n=106) were difficult to determine when it comes to vessel shape. However, one mini vessel (one sherd) and brimmed beakers (24 sherds) were identified (Hinders 2019b). No base sherds were identified in the material. A majority of the TRB pottery sherds were decorated (60%), the most common motifs being 'vertical strokes with stamp' (n=26), 'vertical lines or strokes' (n=22), *and* 'imprints with wooden chip' (n=14; Hinders 2019b).

Sherds determined as PWC pottery amount to 150 sherds, representing 4% of the total material. Even though the PWC pottery is generally linked to calcareous temper resulting in a poriferous ware, the PWC pottery sherds within this study are mainly tempered with crushed granite (n=108; Hinders 2019b). Vessels made by means of the n-technique or the combination of the u-/n-technique dominate the material. No PWC sherds have been made exclusively through the u-technique (Hinders 2019b). The sherd thickness of the PWC pottery ranges from 6–11 mm. Less than half of the sherds could be determined to a specific vessel shape. The majority of the distinguishable sherds were rim sherds (n=18). No base sherds or sherds of mini vessels were identified among the PWC pottery (Hinders 2019b). Most of the PWC pottery sherds were decorated (n=97; 65%). The décor identified in the PWC material corresponds to other PWC assemblages from the MN in Sweden, but one decorative element reoccurs more than others, namely, the characteristic pits (76 sherds). Another common PWC pottery décor is the vertical zig-zag comb impression, *i.e.* herringbone motif (40 sherds; fig. 3), typical for the Fagervik III-typology for PWC pottery (Bagge 1951, M. Larsson 2009, 97).

The third type – pile dwelling pottery

The PDP represents the largest group of determinable sherds within the study with 1317 sherds, which represent 39% of the material. Temper varies in both size and material; however, combinations including crushed granite are most frequently used (Hinders 2019b). Some vessels are tempered with rounded, unprocessed gravel (sometimes 10 mm Ø; fig. 3). Still, it should be noted that not all PDP sherds are tempered with rounded gravel; a quarter of the PDP sherds were tempered solely with rounded gravel (n=365), and a small number of sherds (n=12) were tempered with a crushed granite/rounded gravel combination (Hinders 2019b). Both the n-technique and the u-technique have been used in equal measure (n=420 and 425, respectively); some sherds have been coil-built by both techniques. The maximum sherd thickness of the PDP is 18 mm (one sherd measures 31 mm; Hinders 2019b).

Most PDP sherds were unable to be determined to a specific vessel shape, albeit rim sherds and sherds from the body are the most frequent in the material. No base sherds were identified in the material. A mere 10% of the PDP sherds are decorated. However, a vast array of motifs was used, showing that only a few sherds carry each decorative element. Out of a total of 132 sherds within this group that are decorated, 115 are decorated with variations of pits (Hinders 2019b).

Indeterminable pottery

The recording strategy resulted in a large portion of indeterminable sherds (n=1753), representing 51% of the total ceramic assemblage recorded. For the most part, the indeterminable sherds are tempered with crushed granite and rounded gravel (Hinders 2019b). The sherds are mostly made by means of the n-technique, followed by the u-technique and combinations of both techniques (Hinders 2019b). Sherd thickness ranges from quite thin vessels of 3.4 mm to 8 mm. The majority of the indeterminable sherds have an undetermined vessel shape (n=1642). However, rim, shoulder and body sherds were identified in the material, but no base sherds. Even though only a mere 5% of the sherds were decorated, several motifs are represented within the group. Variations of pits and vertical lines or strokes are among the most common decorative elements.

Discussion

The pottery at APD is a well-known material assemblage, or rather a well-used example of something rarely found in Swedish archaeological contexts: depositions of pottery from both TRB and PWC pottery in the same cultural layer. There has been debate about whether or not these groups coincided in prehistory (Browall 1991; Malmer 1999) and, consequently, since the cultural layer at the APD contains depositions of pottery from both groups, this has given rise to a lot of interpretations concerning the site itself and what it represents for the understanding of the MN (Browall 1986; Carlsson 1998; Gill 2003; Malmer 2002). The pile dwelling thus has a lot to carry, as it is suggested to be the very platform where the ideologies of the farming TRB were transformed to the hunting PWC, mediated through the pottery craft (Browall 1991; Carlsson 1998, 57; Gill 2003). Subsequently, the pottery at APD has previously been presented as the *transformation in action* of the changing ideologies as the pottery has been thought to reflect how the TRB taught the PWC to make pottery (Browall 1991; Carlsson 1998, 57; Gill 2003, 144).

Central to this text is the pottery material unearthed during Malmer's excavations (1976–1989). As shown through many aspects above, the pottery material at the APD has been indirectly interpreted through works that focus on the larger context and a few sherds, but not on the entire ceramic material (Browall 1986; Carlsson 1998; Gill 2003; Malmer 2002). It has therefore been considered important to record the material as thoroughly and as objectively as possible. There are potential problems with not scrutinizing previous research and/or the parameters conventionally used. Most important is the risk of producing data and interpretations that confirm previous assumptions, without reading the material at all (*i.e.* typical type 1 errors).

Previous work on the pottery points to an evolving pottery craft focusing on vessel making technique and stratigraphy (Hulthén 1998). Based on these two main points, Hulthén argues that u-technique-oriented potters produced pottery before producing n-technique pottery, thus implying that the APD pottery craft evolved (Hulthén 1998). Even though Hulthén (1998) has conducted thorough analyses of the material, no sherds tempered with rounded gravel appear in her samples, nor are they discussed, which is merely one point of these previous studies that show that more work is needed. Browall (2011) has also investigated the ceramic material, arguing against Hulthén (1998), mostly based on a stratigraphical misunderstanding (Browall 2011, 256–291), and the fact that the u- and n-techniques are used for the same sherds, consequently challenging Hulthén's (1998) results (Browall 2011).

This study has its point of departure in previous research and has, because of the rather eclectic interpretations, deemed it important to not press the material into a mould that would amount to little new information. Thus, a two-part recording strategy was constructed for the specific material, based on parameters that are argued to represent nodes in the known Neolithic ceramic *chaîne opératoire* (Larsson 2009; Papmehl-Dufay 2006, 138–149; Stilborg 2002a; 2002b; 2002c) as well as on experimental work producing coiled vessels according to the same body of work. The parameters chosen represent different phases of Neolithic ceramic technology, such as the choice and processing of the temper, working through the production-process of coiling and forming the vessel as well as decorating it. The method was chosen to provide objective, technical input to the material with the idea of determining TRB and/or PWC pottery and, if possible, categorizing and recording traits connected to a third type of pottery, the so-called pile dwelling pottery (PDP). The results from the craft-specific recording strategy show that there are three different types of pottery present at the site, TRB and PWC pottery as well as PDP (Hinders 2019b). Browall (2011) argues for three types of pottery within the ceramic material from Frödin's investigations as well. However, this without the craft-specific focus and without an active strategy to allow the PDP to be identified as a third group in its own right. Rather, Browall (2011) argues for a third type that is not TRB or PWC, which was an important discovery, yet the PDP discussed in Browall (2011) was, in effect, the 'rest' that did not correlate with the conventional TRB and/or PWC characteristics/groups. Something that this study has overcome due to the recording strategy outlined above.

One of the major aims of the present study was to determine the different pottery types at the site. Three determined types were distinguished for which the TRB and PWC pottery sherds (6% and 4%, respectively) are in a definite minority when compared to the PDP (39%) and indeterminable sherds (51%). The TRB pottery at APD can be summarized as a late MN Funnel Beaker pottery that includes brimmed beakers (Stilborg 2002b, 64). The Pitted Ware pottery can be summarized as a quite homogenous material that corresponds well with the Fagervik III typology suggested by Bagge (1951; for further discussion on the TRB and PWC pottery see Hinders 2019a; 2019b). With these two groups as a backdrop – correlating with material from other sites –, the PDP fits well into our current understanding of Neolithic pottery craft during the MN A in Sweden. In general, the PDP vessels have a flat base, long belly, slightly pronounced shoulder, and a straight rim. The temper varies in both size and material; however, combinations including crushed granite are most frequently used. The décor is varied and is applied sparsely to the upper parts of the vessels (Hinders 2019b).

However, there are aspects of the PDP that clearly set the assemblage apart from every known craft tradition in the Swedish Neolithic. One of the most tangible aspects is that some vessels are tempered with rounded, unprocessed gravel (sometimes 10 mm Ø; fig. 3). It should be noted, however, that six TRB-sherds from the site were tempered with rounded gravel as well. Most importantly, not all PDP sherds are tempered with rounded gravel; a quarter of the PDP material was tempered solely with rounded gravel (365 sherds), and a small number of sherds (12) were tempered with a crushed granite/rounded gravel combination.

Another noticeable aspect of the PDP is the crudeness in shape and in the overall craft. This is not normally seen in other Middle Neolithic pottery craft traditions where the temper grains are of roughly the same size and the vessels are neatly built with rather complex vessel shapes. As an example, the maximum wall thickness of the PDP is 18 mm (one sherd measures 31 mm), to be contrasted with 13 mm for the TRB and 11 mm for the PWC pottery at the site (Hinders 2019b). The sizes of the temper grains vary within the PDP sherds as well, implying that less time has been spent on working with the temper. A third example is that the vessel shape of the PDP is straight, with only a slightly pronounced shoulder, to be contrasted with the complex vessel shapes of the TRB and PWC (Hallgren 2008, Stilborg 2002a; 2002b; Larsson 2009; Papmehl-Dufay 2006). When scrutinizing the results concerning the PDP, a pattern concerning the PDP craft process emerges in contrast to the TRB and PWC pottery assemblages. It is here argued that the PDP potters chose to hasten the production of the vessels, quickly moving on to the next phase in the process. In order to produce an TRB brimmed beaker or a Fagervik III pottery vessel in general, as well as at APD (as shown by the results of this study), the *chaîne opératoire* requires time: gathering clay, gathering temper, processing the clay, working the temper into the clay matrix, making and joining coils together, creating the vessel shape by means of the coils, leaving it to dry, producing the tools needed for decoration, decorating the vessel, leaving it to dry and firing the pot in an open fire. All these steps in the pottery production take time, together with the procurement of the raw material. Here, I argue that the crudeness in the craft seen in the PDP assemblage are the results of a hurried production sequence. This is again in contrast to the TRB and PWP pottery at the site.

The rounded gravel-temper, which is one of the most tangible traits of the PDP, is one of the best examples of this accelerated production. The size of the temper in some of the PDP sherds is heterogenous in size and in colour, most visible in sherds tempered with rounded gravel, indicating that little or no attention was paid to the processing of the temper before adding it to the clay matrix. Processing the temper carefully and consequently obtaining a homogenous ware is generally the final product within the TRB and PWC pottery craft – seen in the assemblages from the TRB and PWC at APD as well (Hinders 2019b).

Traces of pottery production on the platform are represented by uses of clay at different stages of dryness and/or process, such as the dissolved pottery and clay coils (Hinders 2019d). The latter are seen as a direct indication of pottery production. Furthermore, variations of a particular sub-type of small bone awl have been documented at the site. One of these awls is bifurcated (FID1254459) and corresponds perfectly with the décor on one of the TRB sherds (Hinders 2017). Even though not all of the awls, or at least not all the awls of this type, are suggested to have been used for pottery production, this one artefact clearly indicates that a larger system of artifacts was produced and/or used in/for pottery production at the site (Hinders 2017).

The results clearly point to pottery production at APD, previously unbeknownst within archaeological research. One of the main advantages of the craft specific parameter approach was that interpretations of cultural traits were largely omitted until the second phase of recording, illuminating aspects of craft-specific choices made by the Neolithic potters. However, it is evidently clear that most of the sherds are not identified as TRB, PWC or even PDP but remain undetermined. As mentioned above, the category of indeterminable sherds was accepted and seen as important to ascertain that the interpretations were largely based on data and not on previous research, in an attempt to avoid type 1 errors. Nevertheless, it is unfortunate that such a large portion of the material is undetermined. Still, it should be noted that the ceramic material is heavily fragmented, resulting in a large portion of fragments and small sherds and making the task of recording the material difficult whatever strategy is used. Furthermore, due to the preferred vessel shapes during the Neolithic, with large bodies in comparison to brimmed rims and carinated shoulders, along with many undecorated, indistinctly shaped sherds, the context and temper become important to understand the sherds. As APD is a complex context, with archeologically complex material remains, a large undetermined population of sherds is more acceptable. For this reason, the pottery material at APD needs to be investigated further, complementing the present types with a larger sample from Frödin's (1909–1930) investigations, together with a battery of scientific analyses to further scrutinize the choices of raw materials and use.

Conclusion

The present study has recorded and determined the pottery assemblage from Malmer's (1976–1980) investigations of APD. The pottery at the site has been known within Neolithic research for a long time, and it has been suggested that it reflects the meeting of the TRB and PWC. The PDP has been a part of this equation, and it has been suggested that it represents an ideological transformation from the FBC to the PWC in the region. However, the ceramic type was not characterized until the work with *Alvastraportalen*. As a result of this study, the PDP has been categorized, as a rather crude type of pottery that was partly tempered with rounded gravel, with flat bases, and straight vessel walls with slightly inclined shoulders and which clearly stands out from the late MN TRB pottery and Fagervik III PWC pottery, which has also been identified in the material. One of the strongest characteristics of the PDP is the fact that some vessels have been tempered with rounded gravel, meaning that the temper was not processed (*i.e.* crushed and/or sieved) before being added to the clay matrix and therefore display an overall rushed pottery-making process, indicated by the lack of time spent on the vessels.

Why the potters chose to rush the production of the PDP is difficult to interpret. Nevertheless, the fine quality of the TRB and PWC pottery found in the same cultural layer point to the PDP being the result of conscious choices. There is a possibility that the potters who made the PDP did so at the site, for the site, which suggests that the potters made objects that suited the activities and/or the practises at APD. Objects such as clay coils, clay in different stages of process and possible pottery decoration tools indicate pottery production at the APD. Consequently, the crudeness of the PDP might have been chosen or at least accepted; the vessels have, after all, been fired and used.

APD is currently the only known pile dwelling in Sweden. However, the question is if the construction and the practice of a Swedish pile dwelling was in fact an isolated event? Were the activities there governed by ritual and myth? Even though aspects of the deposited material, such as a scalped cranium and scattered human remains, do point to rituals being performed, this text argues that craft played a big part in the activities at the pile dwelling as well – especially pottery production. I argue that pottery production was an important part of the activities at APD. Whether the pile dwelling was in fact a ritual platform transforming ideologies as well as a place for the dead cannot be discussed here. Nevertheless, the presented results of the analyses show that the activities at the site included pottery production, as well as other crafts within the same space. It would not be surprising that the ritualization of craft and of everyday activities were a part of the MN A – it is on the contrary rather likely. Nevertheless, it is important to take traces of craft into consideration when discussing APD before discussing possible rituals that *could* have been a part of the activities; interpretations of APD need to include craft and the networks connected to craft specialization. Most probably, APD was not a closed space, the material rather implies that the potters performed a collective production of pottery, influenced by both the TRB and PWC, creating a new type of pottery that is in fact unique for the Alvastra pile dwelling.

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Evidence of a base model for Neolithic depositions in Central and Northern Europe

Michael Müller

Abstract

For several central and northern European Neolithic periods, intentionally deposited stone implements can be detected. Beginning with the Linear Pottery Culture (5500–5000 BCE) and increasing in number in the populations of the following central European Middle Neolithic period, these depositions were made in the same way over millennia. They all show a recurring selection of objects, which were mostly different types of axe heads, including their preforms, or raw materials. The items are often of extraordinary size and were placed in special arrangements at the borders of the inhabited areas. In central and northern Europe, the most diverse types of depositions, and at the same time the largest number, occurred in the Funnel Beaker Culture period (4100–2800 BCE; hereafter TRB). While depositions of amber beads, ceramic vessels, copper items or flint blades were also put into the ground here, the most frequently occurring object in the depositions were flint axe heads. It is rather unlikely that the beginnings of the TRB deposition practice can be linked to the preceding Ertebølle Culture (5500–4100 BCE), where recurring depositions of stone tools are missing. More convincing is to connect the depositions of the TRB Period and the succeeding Younger and Late Neolithic to the traditions of central European Neolithic groups, since they show the same patterns in many details. This paper tries to redraw the outlines of what appears to be a base model of Neolithic depositions.

Northern Europe; Central Europe; Funnel Beaker Culture; Axe heads

Introduction

During the Neolithisation, a find category appeared in Europe for the first time that had not been seen in this form and intensity during the Mesolithic: depositions of heavy stone tools. These were deposited individually or in groups with the intention that it should

in: Groß, D., Rothstein, M. (eds.). Changing Identity in a Changing World.
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be permanent and the items never retrieved. An interpretation of these as craftsmen's camps, hiding places in times of crisis or traders' depots can be rejected as the depositions often show a combination of used, unfinished, and also unusable items; the shafts were removed from used axe heads before they were deposited. Also, the recurring patterns of selection, combination, arrangement and placing mark a clear difference between grave goods or legacies and settlements. Instead, we can assume that they were consecrated to imbue them with supernatural powers at selected sites (Müller 2020, 61–62; Müller and Schirren 2022). In central Europe, depositions with heavy stone implements dating to the second half of the fifth millennium BCE can be regularly recorded for the first time, along with the appearance of Linear Pottery, (Müller and Schirren 2022), and they can be traced up to the Bronze Age at the turn of the third to the second millennium BCE, during which they were finally replaced by bronze objects. The stone implements deposited over a period of 3500 years in central and northern Europe almost exclusively include axe heads, shaft-hole axe heads, and adze heads, as well as preforms and raw materials. According to current sources, the intensity of deposition varied among the different Stone Age communities, and for some it was never determined. In this context, the question will be discussed as to whether all these depositions might have been related in some way or might even have followed the same idea, *i.e.* whether a 'base model' of a Neolithic deposition can be identified. For this purpose, the depositional behaviour of selected central and northern Europe Neolithic groups will be summarized and compared. The focus of this comparison is the selection of deposited objects (orchestration) and their placing (localization) as well as the arrangement and special emphasis of these objects (staging). In the course of these investigations, it will be determined whether connections and points of contact can be suggested between the Neolithic communities for which the deposition of heavy stone implements is attested.

Depositions of the central European Early Neolithic (5500–5000 BCE)

The first depositions with stone tools, their preforms or raw materials can be recognized in central Europe along with Linear Pottery (hereafter LBK). A total of 30 depositions could be identified, which were found on the borders of modern-day Slovakia, the Czech Republic and Germany (fig. 1). A large part of these finds has been presented in several papers (Quitta 1955; Salaš 1986; Vencl 1975) and have again been summarized (Müller and Schirren 2022).

Orchestration: The central object of the LBK-period depositions were various types of adze heads, often referred to in the literature as *Schuhleistenkeil* and *Flachhacken*, and their preforms or raw materials. Only two of the depositions contained pottery sherds or bone in addition to stone objects; the Linear Pottery depositions are otherwise comprised purely of stone implements. In four depositions, all from Germany, six to 15 flint blades were uncovered (Quitta 1955, 29 no. 4; 33 no. 12; 44 no. 37; 45 no. 41), although these were associated with heavy stone implements in only two cases. The average number of heavy stone objects within the Linear Pottery depositions is 4.6, including single and multi-object depositions containing up to nine documented objects. The majority, however, contained between three and four objects. There is a high proportion of preforms and raw materials for heavy stone tools within the depositions and they often occur combined only with

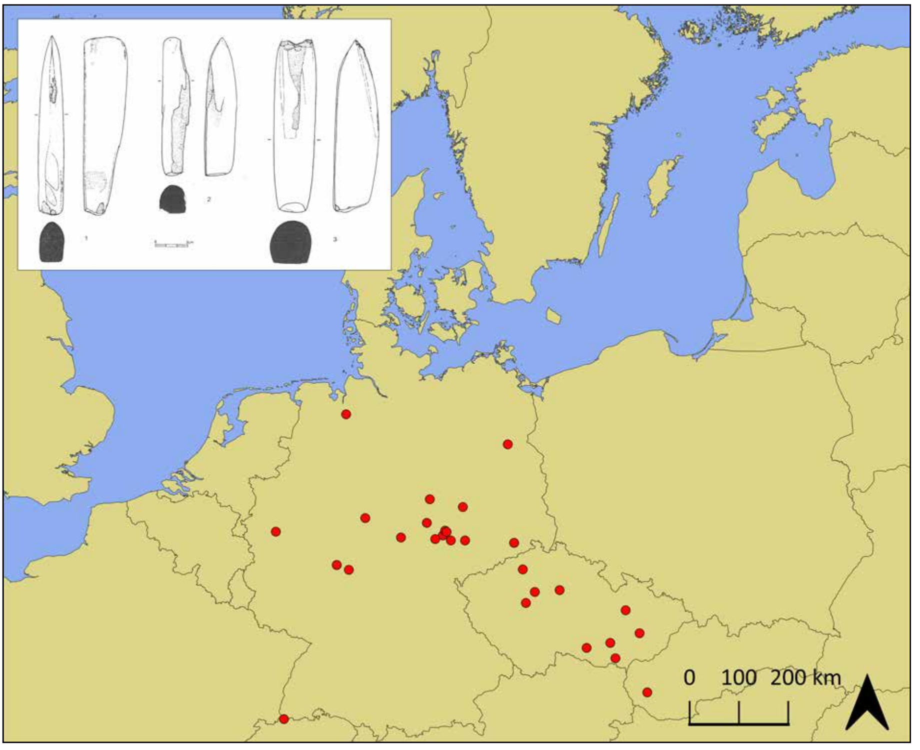

Figure 1. The hoard of Liteň (Czech Republic; Vencl 1975, 32 fig. 13) and the distribution of central European Early Neolithic depositions.

themselves (n=8) and less frequently with finished products. The average length of all finished adze blades in the depositions ranges from 6 to 32 cm, with an average of 18.2 cm. This exceeds the average length of adze blades found in graves, in some cases significantly, which, varying regionally, ranges between 10 and 16 cm (Ramminger 2007, 165 fig. 151). Although it is often emphasized that traces of use cannot be observed on the finished implements, there are also counterexamples (Quitta 1955, 37–38 no. 19).

Localization: More than half of the Early Neolithic depositions were found within or near a Linear Pottery settlement, but many were at the same time placed on the edges of dense settlement clusters (Müller and Schirren 2022). However, since the majority of the other depositions were recovered by laymen and not by archaeological investigations, this kind of find context cannot be safely excluded for these. Nevertheless, for three of these depositions, placement under a large stone or boulder has been noted, including an individually deposited adze blade (Quitta 1955, 45 no. 41).

Staging: When an arrangement of implements within the deposition was noted and conveyed, it was most frequently observed that they were lined up side by side. Eight axe-blade or hoe-shaped implements from the Rositz site (Thuringia, Germany) lay in a semicircle on a sherd pavement made of Bandkeramik settlement ware (Quitta 1955, 37–38 no. 19). Two adze blades from Dolní Věstonice (Czech Republic) were found overlapping in a criss-cross formation (Salaš 1986, 24; Vencl 1975, 50).

Central European Middle Neolithic (5000–4400 BCE)

The situation described for Linear Pottery changes considerably during the subsequent Middle Neolithic period. From the study area, 83 depositions have become known from this period, which were found within the borders of modern-day Germany, the Czech Republic, Poland and Denmark (fig. 2). They can be assigned to the Rössen and Stroke-Ornamented Pottery Cultures as well as to other Neolithic groups of this period. Even if Denmark was not part of the settlement area of central European Neolithic groups in the fifth millennium BC, it can be assumed that members of those groups deposited items there (Müller and Schirren 2022). A large part of the depositions was also presented in the above-mentioned papers (Quitta 1955; Salaš 1986; Vencl 1975). For the areas of Poland, northern Germany, and Denmark, other sources can be cited (*inter alia* Berlekamp 1966; Kaflińska 2006; Rech 1979).

Orchestration: The main items featured in the Middle Neolithic depositions are, as in the Early Neolithic, stone tools and their preforms, now mainly in the form of shaft-hole axe heads first appearing in the Middle Neolithic. Adze heads such as *Schuhleistenkeile* and *Flachhacken* continue to occur, as well as axe heads. Besides pure stone tool hoards, one deposition is known that additionally contained undetermined bones (Vencl 1975, 33–37), and another that contained a copper axe head alongside the stone tools (Berlekamp 1966, 122). In addition to the heavy stone implements, one deposition consisted only of flint blades (Quitta 1955, 45 no. 43). The average number of heavy implements per deposition is higher than in the Early Neolithic at about 4.9, but this value is strongly influenced by an ensemble of 50 objects (Vencl 1975, 13–18), without which it would be somewhat lower than in the Early Neolithic at about 4.3. About half of the depositions contained two or three objects. Single depositions were unable to be determined. The proportion of preforms and especially of raw material for stone implements is much lower compared to the Early Neolithic. Pure shaft-hole axe head hoards were detected 26 times, pure adze head hoards twelve times. The other depositions show various combinations of shaft-hole axes, axes, and adze heads, with all three tool types rarely occurring together in an ensemble. The average length of the dominant implement in these depositions, shaft-hole axe heads, was determined from 77 specimens and, at 30 cm, is exceptional compared to items from settlements and burials (Vencl 1975, 70). The length spectrum, therefore, ranges from 14 to 54 cm. In comparison, the average length of shaft-hole axe heads traded from Neolithic central Europe to Mesolithic northern Europe, and reaching the settlements there, is only 16 cm (Müller and Schirren 2022). As with the Early Neolithic implements, a systematic use-wear analysis has not yet been carried out on the items from the Middle Neolithic depositions. Nevertheless, there is evidence that implements were put into the ground in a used condition. Quitta tries to argue against possible observed traces of use as unfinished grinding or recent damage (Quitta 1955, 33). However, a detailed analysis of the hoard of Friedefeld (unpublished) revealed a wide spectrum of primary and secondary use-wear traces on almost all of the implements. A similar pattern was observed on the Wollin hoard items (Mecklenburg-Vorpommern, Germany) (Quitta 1955, 41–42 no. 31).

Localization: Only 20 % of the depositions were discovered within or near contemporaneous settlements. The deposition sites are partly located in the peripheral

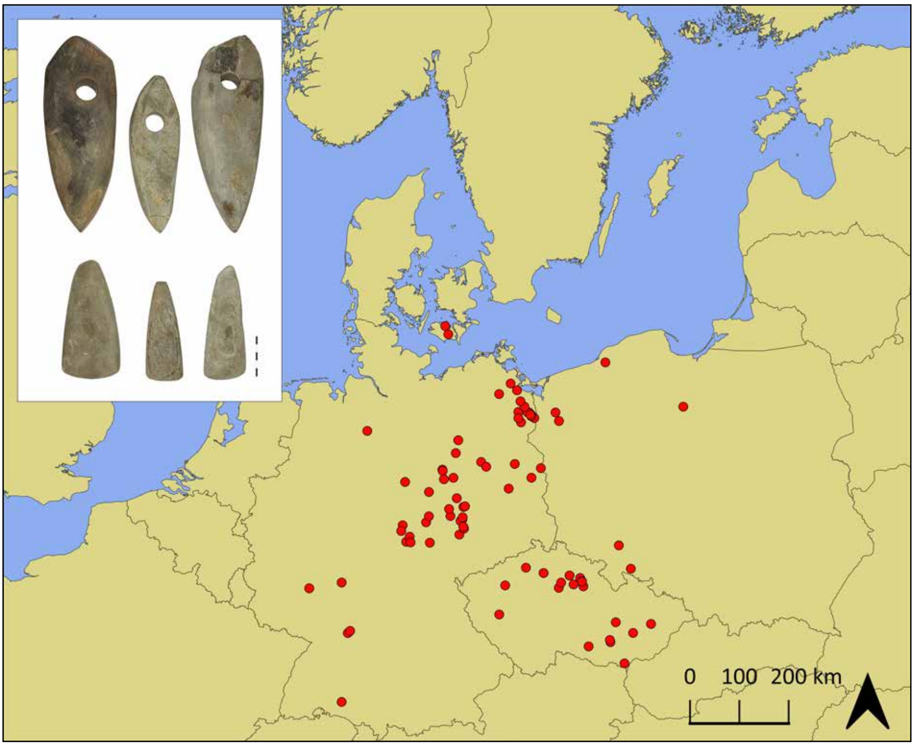

Figure 2. The hoard of Bagemühl (Germany; photo: Michael Müller; copyright: Staatliche Museen zu Berlin, Museum für Vor- und Frühgeschichte) and distribution of central European Middle Neolithic depositions.

areas and partly far away from the Middle Neolithic settlement centers (Müller and Schirren 2022).

Staging: Available observations on the arrangement of objects indicate that they were most frequently encountered lying side by side, but two hoards are known in which the axe heads stood vertically, in one case demonstrably with the cutting edges pointing downward (Quitta 1955, 34–35 no. 13). Similarly, a star-shaped arrangement of shaft-hole axe heads with the cutting edges pointing inward could be observed (Quitta 1955, 41–42 no. 31). A total of six hoards were deposited under a large stone and one between large stones. For only five hoards, out of a total of 59 with a known context, an immediate wet find environment was determined, while the remaining hoards were discovered on dry ground.

Central European Younger Neolithic (4400–3500 BCE)

For the Younger Neolithic, only 22 depositions are known for the study area. They form a coherent distribution area, which extends from central Germany via Belgium and Luxembourg to eastern France and essentially coincides with the distribution area of the Michelsberg Culture, with one hoard also found in Denmark (fig. 3). Most of the finds were presented in detail in the catalogue of Pétrequin *et al.* (2012).

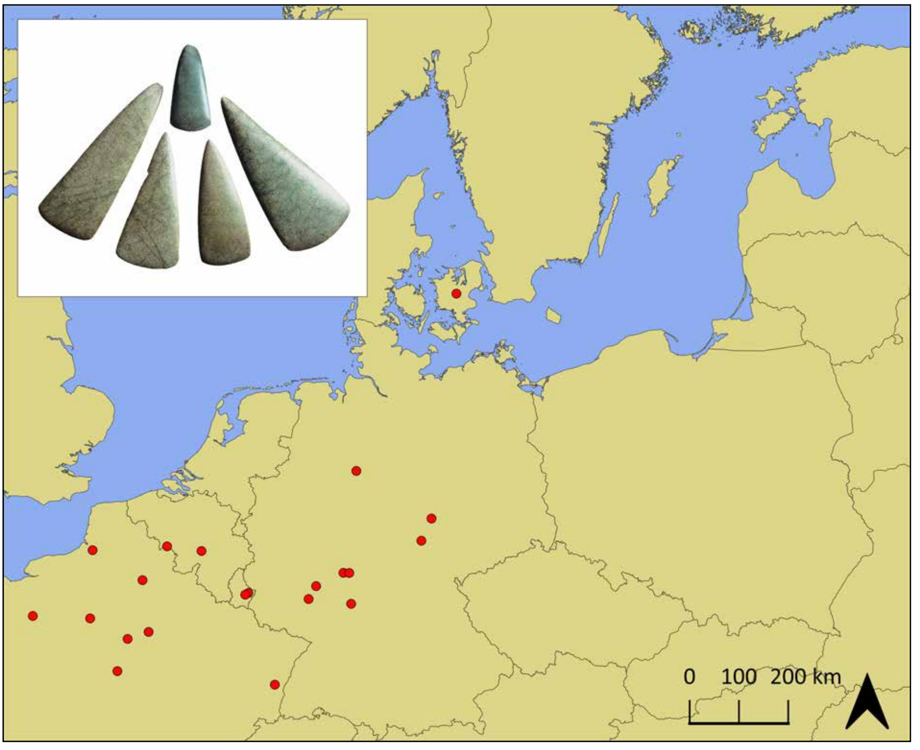

Figure 3. The Mainz-Gonsenheim hoard (Germany; Jeunesse 2010, 54) and the distribution of central European Younger Neolithic depositions.

Orchestration: Twenty depositions represent pure stone implement hoards, while two consist of a combination of stone and copper implements. The heavy tools found within the depositions were exclusively axe heads, in contrast to the Middle Neolithic. They are made of a type of stone that is often referred to as *jade*, for which the correct names are jadeitite, omphacitite, or eclogite (Pétrequin *et al.* 2008, 261). In addition to other stone types, flint and copper rarely occur. Preforms occur in only one deposit (Pétrequin *et al.* 2012, 1448–1451). The average number of heavy tools per deposit is around 3.8. Depositions with two or three axe heads are most common, while larger ensembles are rare. An exception is the Bennwihr (France) deposit, with 16 stone axe heads and preforms but only two of these are of jadeitite (Pétrequin *et al.* 2012, 1448–1451). Single depositions have not been reliably documented to date. The average length of the axe blades is 20.6 cm, ranging from 9.8 to 39.0 cm, and about 45 % of the axe blades are longer than 20 cm. Jade axe heads from burial contexts are absent from the study area. The average size spectrum of jade axe blades described as *working axes*, which can only rarely be connected to settlements, ranges from two to 14 cm (Jacobs and Löhr 2003, 155–157). The deposited jade axe heads are too slim in proportion to their length to allow their practical use without breaking (Jacobs and Löhr 2003, 155–156). The damage to these axe heads, which is nevertheless observed more frequently, is attributed to intentional actions (*inter alia* Klassen 2012, 1304; Knoche 2013, 299 footnote 4).

Localization: The depositions with jade axe blades in the area under consideration could not yet be connected to the contemporaneous settlements of the Michelsberg Culture, which also makes their cultural attribution difficult.

Staging: The few observations of the arrangement of the axe blades show that they were often deposited side by side, in one case with the edges pointing in alternating directions (Pétrequin *et al.* 2012, 1440–1443). In another case, axe heads were encountered standing vertically, with the cutting edges pointing upward (Pétrequin *et al.* 2012, 1458–1459). Large stones have not yet been identified as depositional sites. Most depositions were recovered from dry ground, but in one case were found in a bog (Pétrequin *et al.* 2012, 1442–1443).

Northern European Early and Middle Neolithic (4100–2800 BCE)

The Neolithisation of northern Europe and northern Germany began long after the appearance of the first farmers in central Europe and was significantly shaped by the Funnel Beaker Culture. The depositional behaviour of the TRB is very complex (Müller 2022) and cannot be presented in a short summary. In the TRB, depositions from within settlements as well as from the immediate vicinity of megalithic graves and from enclosures, can be distinguished from those at a further distance from any structures (fig. 4).

Orchestration: Depositions are known from more than 1200 sites and they contain objects made of flint, stone, pottery, amber, copper, and human and animal bones. Among these, the depositions with stone implements are the dominant group at over 85% of sites. Overall, it can be stated that objects of different materials were rarely combined. The depositions with stone objects consist mainly of flint axe heads (72%), followed by simple flint blades and knives (10%), chisel blades (5%), and flint planks (5%). Other object groups, such as shaft-hole axe heads, axe heads made of rock or flint halberds (*dicke Spitzen*), made up less than 3% of the items. Pure flint axe head depositions, with well over 700 known sites, are the central theme of the Funnelbeaker period and occur everywhere in the distribution area of the TRB, while hoards containing other materials show regional distribution emphases. Based on the shape of their end opposing the edge, the axe blades of the Funnelbeaker period are divided into pointed-butted, thin-butted, and thick-butted types, which succeed each other chronologically with almost no overlap. Within the hoards, two to four, or an average of just over three axe heads are mostly deposited over the entire TRB period. However, while depositions with pointed and thick-butted axe blades usually do not contain more than a dozen objects, hoards with thin-butted axe heads may contain up to 24 specimens. Many thin-butted flint axe heads from TRB hoards are notable for their extraordinary length, often exceeding 20 cm. The largest specimens, which come almost exclusively from Danish or Swedish hoards, even reach lengths of over 40 cm. The average length varies greatly from region to region and is 16.4 cm for thin-butted flint axe heads from Poland to 27.8 cm for those in the Great Swedish Lakes region. The average length range of thin-butted flint axe heads from settlements and graves in northern Germany, in comparison, is between 14 and 16 cm (Lüth 2003). While half of all flint axe heads were deposited unground, *i.e.*, not in a ready-to-use condition, the longest flint axe blades in particular were mostly completely ground, their production taking a great deal of time. Even though the longest of the deposited flint axe heads, as is already shown with the jade axe blades, show much too small a thickness

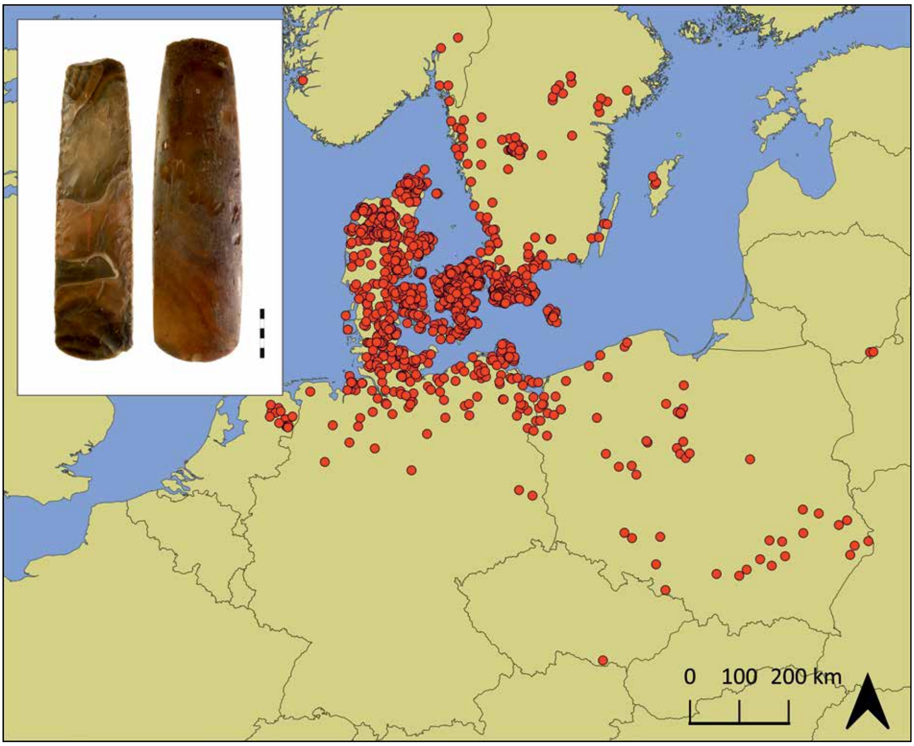

Figure 4. The hoard of Bohlendorf (Germany; photo: Michael Müller, copyright: Stralsund Museum) and the distribution of TRB depositions.

in proportion to their length to be practically usable, they, together with axe blades of other size classes, regularly show direct and indirect traces of use (Müller 2022). Overall, such traces could be detected on more than half of the axe heads deposited that were ready for use, although they appeared less frequently on the largest specimens.

Localization: About three quarters of all depositions away from TRB period structures came to light in or near a water body, with axe head depositions most often being deposited at a distance of no more than 300 m from streams, a zone presumably within the range of seasonal flooding (Müller 2022). In addition, the sites selected for these depositions always appear to have been located on the boundaries of the populated areas at the time (Müller 2020).

Staging: About 8% of the depositions were laid down underneath and beside large stones. The axe heads were set in very diverse arrangements. They were deposited parallel to each other, lying in a circle, semicircle or star shape, piled on top of each other or standing upright, whereby many variations were possible due to the different orientation of the blades.

Northern European Younger Neolithic (2800–2200 BCE)

Around 2800 BCE, the TRB was followed by cultural 'offshoots' of the Corded Ware Pottery Cultural Complex in northern Europe, marking the beginning of the Nordic Younger

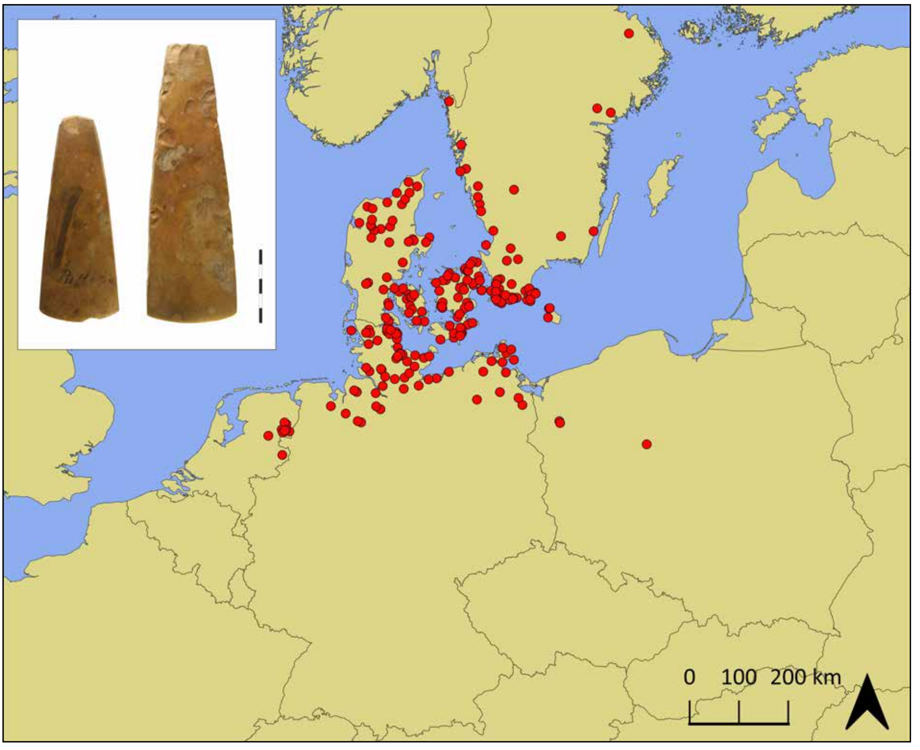

Figure 5. The hoard of Pütte (Germany; photo: Michael Müller, copyright: Stralsund Museum) and the distribution of northern European Younger Neolithic depositions.

Neolithic. In total, 80% of the altogether 250 Younger Neolithic hoards (fig. 5) contain flint axe heads, and in 70 % of all the hoards they even represent the only artefacts, which makes flint axe heads, as they already were in the TRB period, the central element of the depositions (Müller 2022).

Orchestration: The number of items in the pure axe head hoards ranges from two to 40 objects, but most hoards have between two and four items. The high average of 4.6 axe heads per hoard is due to the existence of some hoards with a high number of objects. In contrast to the TRB period, twice as many unground as ground flint axe blades were deposited. The percentage of use-wear seen on the deposited, finished axe heads is 71 %. Only a few Younger Neolithic axe heads are longer than 30 cm and only about 14 % of them are longer than 20 cm. Their total average length amounts to only 16 cm

Localization: Most of the depositions were located away from areas with structures and were related to wet ground. In addition, 9% of the finds were deposited under or next to a large stone. As in the TRB period, however, isolated depositions were also found within enclosures, in the vicinity of graves, or in settlements.

Staging: The arrangements of the axe blades are reminiscent of those of the TRB Period, as they were deposited side by side, stacked on top of each other, in a circular or star-shaped arrangement, and vertically.

Discussion and Conclusion

I have demonstrated in this paper that the theme of depositions runs like a red thread through the various Neolithic epochs of central and northern Europe. Despite some differences, it is above all the numerous similarities that stand out particularly clearly as a kind of basic model of Neolithic deposition. These include the clear preference for heavy stone tools as objects within depositions. More precisely, they are always tools that were used for felling trees and the further processing of wood, *i.e.* adzes, axes and shaft-hole axes. These were deposited without hafts and, up to the TRB period, were mostly of above-average size and were selected for the depositions either in a finished or preworked state. In addition to being oversized, they were accompanied by either a slim shape or a particularly heavy weight, rendering their use as practical implements during their use-life near unimaginable. However, presumed or proven use-wear on the stone implements suggest their use, although we can only speculate as for what. The fact that many objects of extraordinary size or shape were used for the depositions does not mean that these were made only for the purpose of being deposited. It could have rather been the last phase in their object biography, while their meaning and use before that particular last step remains unknown to us. However, possibly due to their exceptionality, these objects seem to have been the ideal item to choose for depositing. Nevertheless, for some reason, a great number of depositions do not show extraordinary or even finished items. The often-encountered compositions of raw materials, coarse to fine preforms, unused, lightly and heavily used finished products as well as objects with unfinished repairments further suggest that the timing of the depositions was rather spontaneous. Only finished products could otherwise have been selected, or at least those with signs of use could have been re-sharpened. This, however, rather gives the impression that the contents of the deposits were impulsively decided upon. This would also explain why sometimes objects other than those seen frequently, and sometimes even made of other materials, ended up in some of the depositions. These perhaps compensate for the lack of better or ideal objects.

As was shown for the different times and regions, the arrangements show the same patterns over and over again. For the most part, they were simply deposited side by side, but in some cases they were placed in specific patterns, such as circles or stars. Furthermore, within each ensemble, the orientation of the blades could be varied. From all Neolithic periods, there are also upright-deposited heavy tools, whose cutting edges could point upwards or downwards. However, the lack of observations must be taken into consideration; since it was mostly laymen who discovered the depositions in the late 19th and early 20th centuries, the results gathered from only a part of the material need to be projected onto the rest.

The number of deposited objects was often between two and four. Nevertheless, it is possible to prove the existence of single depositions at all times. Large stones were often used as sites for some of the Neolithic depositions. However, the contents of these ensembles did not differ from those of other places. These monoliths, mostly oversized relics of the ice ages, must have been given special importance in order to be chosen as depositional sites. As has been demonstrated above for most of the examined

Neolithic groups, the deposition sites were located away from the settled area or on its borders. Here, speculations can be made about the meaning of this choice of sites and the functions associated with it. For the TRB depositions, these places at the edge of the inhabited area were interpreted as possible markers of boundaries between the inner, inhabited, and the outer, 'other', world (Müller 2020). From the time after the deposition process, they can be imagined as places of remembrance, which were revisited, at least from time to time, which is proven by the fact that some sites show depositions from the Neolithic to Bronze Age (Müller 2020). In the overall picture, these depositions were obviously manifestations of common ideas, which spread over vast areas and were carried out in the same way over a very long period of time. This reading also makes it clear that the phenomenon of Neolithic depositions in central and northern Europe cannot be the independent developments of different regional groups. On the contrary, the function of these acts was so strong that they were carried out, but also refined, in many Neolithic groups in Europe. For the TRB, there was a great diversity of depositions both in terms of their contents and the chosen sites. Just from the similarities of the TRB and the central European Neolithic depositions, it becomes clear that these did not originate in the north itself but represent the result of immigration in the same way as their achievements (Malmström *et al.* 2015; Skoglund *et al.* 2012). The large contribution of the Michelsberg Culture to the origin of the TRB has already been analysed and discussed in detail (cf. *inter alia* Klassen 2004; Sørensen 2014). The occurrence of enclosures as sites of ritual acts in the Michelsberg and Funnel Beaker Cultures as well as the two- and four-sided pointed-butted flint axe heads of the TRB, which presumably imitated jade axe heads, are further arguments presenting strong connections between both Neolithic Cultures (Sørensen 2014). These pointed-butted axe heads were also the first heavy stone tools occurring in the depositions of the early TRB phase, besides one hoard of two true jade axe heads from Denmark (Klassen 2004, 84–86). Thus, it can be surmised that the Michelsberg Culture could have carried the basic model of Neolithic depositions to the north. However, this interpretation ignores some ambiguities that still need further research. For example, the hoards with jade axe heads could not yet be clearly assigned to the Michelsberg Culture, even if this could be a plausible explanation of their distribution (fig. 3). Moreover, it is not clear how this basic model could become part of the Michelsberg Culture, which originated in the Paris Basin. However, it was known in the preceding Morbihan Culture to the west (Klassen *et al.* 2011) and the Middle Neolithic Cultures to the east of the Michelsberg Culture and could thus have passed into this newly forming Neolithic community.

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People, contacts and identities

The sixth-fifth millennium BCE south of the western Baltic Sea

Thomas Terberger, Andreas Kotula and Henny Piezonka

Abstract

With the spread of Linearbandkeramik farmers into the north-central European lowlands *c.* 5200 BCE, a contact zone with late hunter-gatherer communities was established for *c.* 1000 years. First contacts between the different groups are indicated by artefacts in a foreign context in the period 5000–4900 BCE. About 400 years later, such contacts considerably increased. However, during the first half of the fifth millennium BCE, burials and the establishment of local pottery traditions indicate a strong Mesolithic hunter-gatherer identity for the area of northeastern Germany. This is confirmed by a Mesolithic diet with a regular consumption of freshwater resources. Accordingly, no Neolithic admixture could be verified by palaeogenetic analyses of Mesolithic human remains for that time in the north. By the mid-fifth millennium BCE, a new phase of co-existence began. This is probably corroborated by the presence of a person with Mesolithic ancestry in a Neolithic burial context (Rössen type) for the first time at the Wittmar site, Lower Saxony.

Late hunter-fisher-gatherers; Linearbandkeramik; Neolithisation

Introduction

Around 5400 BCE, the Linearbandkeramik (LBK) became established in central Europe. Settlements of the early phase, with large wooden houses and evidence of farming and animal husbandry, have been discovered in the area between the Rhineland in the west and the lower Vistula river, Poland, in the east. Palaeogenetic results indicate that farmers from southwestern Europe spread across much of central Europe within a few generations (*e.g.* Bramanti *et al.* 2009; Haak *et al.* 2010; Mathieson *et al.* 2018). It has also been argued that local hunter-gatherer populations contributed considerably to the Neolithisation process (*e.g.* Cziesla 2022, 19; Hofmann *et al.* 2022; Kind 1998; Terberger

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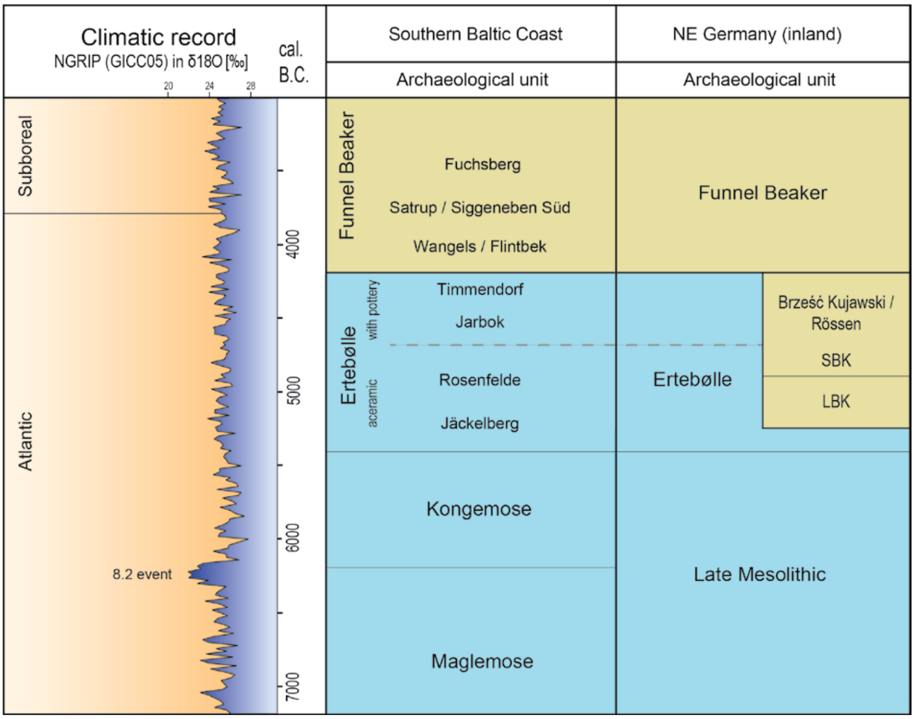

Figure 1. Chronology of the Late Mesolithic and Early Neolithic in northern and northeastern Germany. LBK: Linearbandkeramik. SBK: Stichbandkeramik (Stroke-ornamented Pottery Culture; graph: T. Terberger).

et al. 2018). At the LBK site of Brunn am Gebirge, lower Austria, palaeogenetic results for two out of three human individuals analysed provide evidence for admixture during the formative phase of the LBK (Nikitin *et al.* 2019). Individual 2 shows Mesolithic haplotype U5 and a high proportion of western hunter-gatherer ancestry. Accordingly, the Sr isotopic value suggests a non-local origin of this person. It is likely that the individual was the offspring of a recent admixture of late hunter-gatherers and the incoming farming population. Despite such cases, altogether only a small (recent) admixture in the LBK population of central Europe could be identified (Hofmanová *et al.* 2022). New palaeogenetic studies on the hepatitis B virus confirm this impression since the virus type in early European farming communities does not descend from Mesolithic hunter-gatherers (Kocher *et al.* 2021).

In order to better understand the relationship between early farmers and late hunter-gatherers, the study of contact zones is of great interest (*e.g.* Stäuble *et al.* 2021). At the northern border of the LBK, farmers were living next to Mesolithic groups for more than 1000 years (fig. 1; *e.g.* Amkreutz 2022; Klimscha *et al.* 2022; Sørensen 2014).

LBK outposts

The northern border between late hunter-gatherers and early farmers was not static. Soon after the initial phase, LBK farmers expanded their territories by moving to fertile

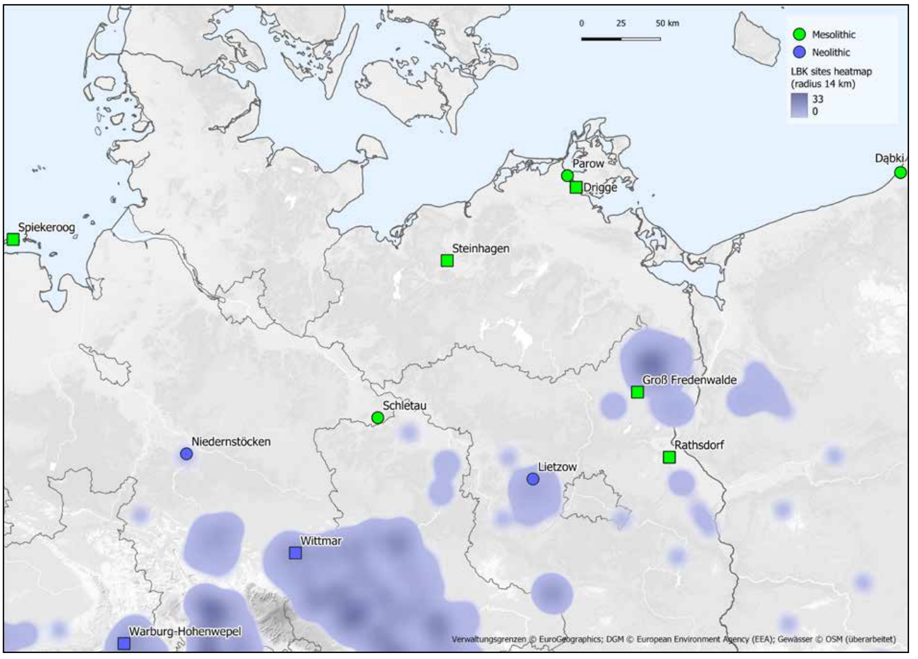

Figure 2. Northern Germany *c.* 5200–4900 BCE with the extension of the Linearbandkeramik (LBK) and Late Mesolithic sites mentioned in the text (dots: settlements; rectangles: burials/human remains; map: A. Kotula).

areas further north. A few years ago, about 50 km north of the established settlement area, an isolated LBK settlement was detected at Niedernstöcken in Lower Saxony (fig. 2) (Gerken and Nelson 2016; Gerken *et al.* 2022). The site seems to represent an outpost, and further LBK sites north of the loess area might be discovered.

The expansion of the early farming communities can also be recognised further east. A first account of LBK sites east of the lower Oder river has already been provided by Dorka (1936). Today, about 190 sites are known from the Uckermark and Havelland regions west of the Oder (Cziesla 2008; Ismail-Weber 2017, 176). The LBK presence in the Uckermark started in 5300–5200 BCE (Heußner 1988; Jahns *et al.* 2018; Terberger *et al.* 2021; Wetzel 2021).

Some years ago, Cziesla (2008) questioned the presence of long houses and a true farming economy and raised doubt on the Neolithic roots of these sites. There is increasing evidence, however, that we are indeed dealing with true LBK settlements with an economy dominated by farming and animal husbandry (Heußner 1988; Mischka *et al.* 2016; Wetzel 2021, 153). This goes hand in hand with frequent evidence for a certain amount of wild game hunting at LBK sites. Next to these settlements, hunter-fisher-gatherers found promising wetland areas for their lifestyle. The mosaic pattern of the landscape and the presence of different societies make this region very relevant for the study of their relationship (Ismail-Weber 2017).

It has been suggested that we may presume hostile encounters between hunter-gatherers and early farmers (Golitko 2015; Keeley 1996), but there is no evidence for this in the area under discussion. While massacres are reported for the late LBK *c.* 5000 cal BCE in various regions, they were probably the results of violent encounters between different LBK groups (*e.g.* Hansen 2022; Meyer *et al.* 2015).

Late hunter-fisher-gatherers

In the last two decades, various Late Mesolithic settlements, including important submerged sites, have been investigated in the area between Schleswig-Holstein in the west and Pomerania in the east (*e.g.* Glykou 2016; Jöns *et al.* 2010; Kabaciński *et al.* 2015). They enable a reliable reconstruction of the sea level rise of the Baltic Sea and provide insights into the socio-economy of the local hunter-fisher-gatherers. The material culture of the early Atlantic period in northern Germany shows similarities to the Kongemose Culture in southern Scandinavia. Around *c.* 5400 BCE, the Mesolithic sites can be assigned to the Ertebølle Culture. Pottery was introduced in the (south)western Baltic probably from the east *c.* 4650 BCE (*e.g.* Hartz 2022; Hartz *et al.* 2011a; Piezonka 2015). A more precise chronology of this innovation is hampered by radiocarbon dates affected by reservoir effects (*e.g.* Kotula *et al.* 2015).

Due to the transgression of the North Sea and the dynamic Holocene landscape development, little information on Late Mesolithic sites is available from the North Sea coast (see Meyer 2018, fig. 1). Only a few stray finds were found on the beaches of Lower Saxony (Mahlstedt *et al.* 2022). By contrast, many Mesolithic finds were collected on the beaches further west, which had been dredged from the North Sea floor (Amkreutz 2022, 311; van der Plicht *et al.* 2016). The only important inland site of Lower Saxony remains Hüde 1, located at Lake Dümmer (fig. 3). Today, the site is assigned to a (late) Swifterbant context (*e.g.* Heumüller *et al.* 2022; ten Anscher 2015). Swifterbant pottery appeared *c.* 5000 BCE, about 300 years earlier than the Ertebølle pottery present at the river Elbe and on the southern Baltic coast. At first sight, both Swifterbant and Ertebølle pointed-bottom pots look similar (Raemaekers 1997). Oval bowls (lamps) are, however, only present at the Elbe (Boberg sites) and further east/northeast (Thielen 2022). Both pottery styles have a hunter-gatherer-fisher background, but probably do not share a common origin. Nevertheless, Swifterbant societies might have contributed to the Neolithisation process further east (Kotula *et al.* 2015; ten Anscher 2012).

The coastal Ertebølle sites demonstrate that fish and seal were important food sources. The first domesticates such as sheep/goat and cattle were introduced *c.* 4200 BCE, but in the beginning, they had little impact on the economy (*e.g.* Glykou 2016; Sørensen 2014). A critical evaluation of the evidence from the Swifterbant culture suggests the introduction of the first sheep at the site of Hardinxveld-Giessendam De Bruin by *c.* 4500 BCE. Animal husbandry and farming became more relevant after *c.* 4300 BCE, and by 4000 BCE it had become "a major activity in the Rhine-Meuse delta" (Raemaekers 2022; Raemaekers *et al.* 2021; ten Anscher 2022).

It is becoming increasingly clear that the expansion of people related to the Bischheim and Michelsberg Cultures that originated in the west played an important role for the Neolithisation process and specifically the origin of the Funnel Beaker Culture in the north (*e.g.* Hülsebusch and Jockenhövel 2022; Klassen 2004; Müller 2011, 294; Philippi 2022; ten Anscher 2022).

In northeastern Germany, limited information on the Late Mesolithic is available from the inland area. In many cases, we are dealing with Late Mesolithic surface sites, which

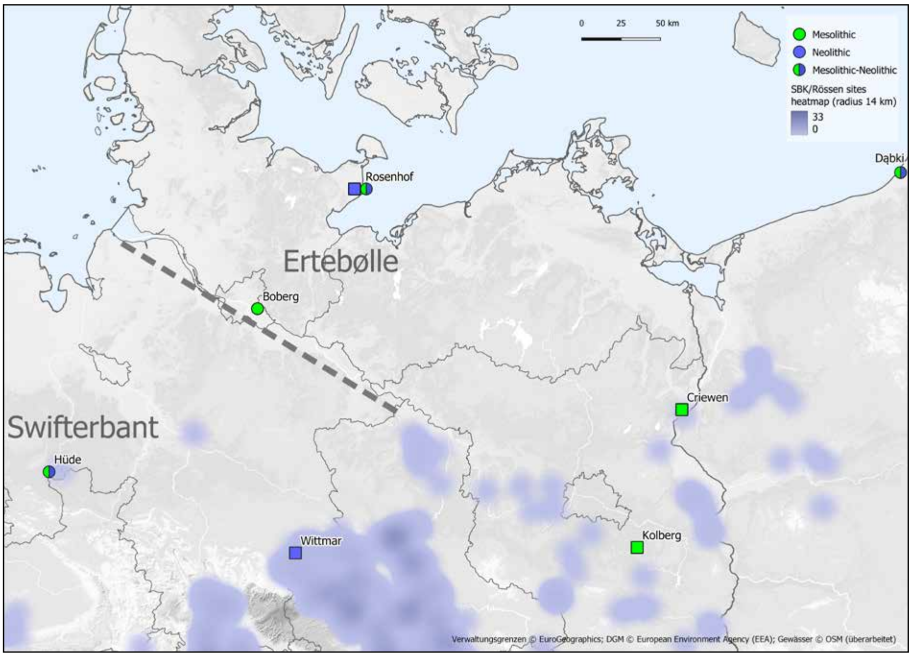

Figure 3. Northern Germany *c.* 4900–4200 BCE with extension of the SBK/Rössen Culture and sites mentioned in the text (dots: settlements; rectangles: burials/human remains; dotted line: border area between Ertebølle and Swifterbant pottery; map: A. Kotula).

were identified by regular blade technology and trapezes (Wechler 1993). When LBK settlements and Late Mesolithic sites from the same region are mapped together, in many cases it remains unclear if they really date to the same period.

More solid information on the Late Mesolithic society is available from burials. Most important is Groß Fredenwalde in the Uckermark (Brandenburg), which is located on a prominent hill (111 m a.s.l.) in a water-rich landscape. In 1962, the first human bones were detected at the site and new fieldwork uncovered further burials (Gramsch and Schoknecht 2003; Jungklaus *et al.* 2016). Up until today, 12 individuals from at least eight burials have been documented in a small area (fig. 4). Most of the interments date to *c.* 6200–5800 BCE, while one individual was buried about one thousand years later (Terberger *et al.* 2015). Of the eleven individuals of the first phase, five are children aged between one and ten years. Whether this is a normal proportion or whether we are dealing with an accumulation of (child) burials due to unfavourable living conditions remains an open question. Chronologically, the burials fall close to the horizon of the 8.2 ka BP event when dry conditions and a drop in temperature of 3–6 °C took hold for *c.* 150 years. This cooling period around 6200 BCE might have been responsible for the development of the cemetery and a crisis in the Mesolithic society (Crombé 2019; Schulting *et al.* 2022). Thus, the prominent position of the cemetery in the landscape might be understood as a territorial marker in difficult times.

The burials are characterised by single and double/multiple interments. The bodies were buried in a supine or flexed position and ochre was regularly used in the rite. Grave goods include fragments of a slotted dagger that has parallels in southern Scandinavia.

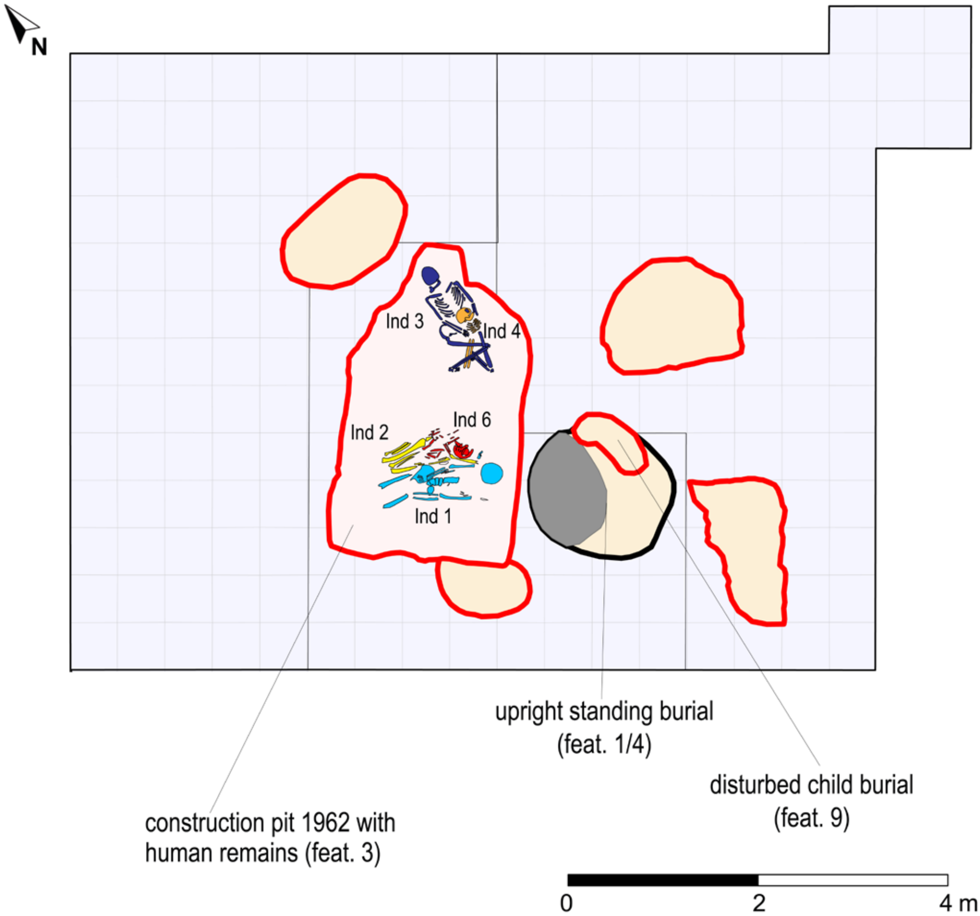

Figure 4. The Late Mesolithic burial site of Groß Fredenwalde with phase I (red outline: 11 individuals; *c.* 6000 BCE) and phase II (black outline: one individual; *c.* 5000–4900 BCE; graph: A. Kotula).

The dagger is the only specimen of this Kongemose type south of the Baltic Sea (Gramsch and Schoknecht 2003; Kotula *et al.* 2020). A truncated flint blade was probably made of flint from the coast and underlines inland-coastal contacts.

The results of stable isotope analysis of the Groß Fredenwalde individuals confirm a Mesolithic diet with consumption of freshwater fish (Terberger *et al.* 2015; 2018) in accordance with the preferred location of Late Mesolithic sites at rivers and lakes. The Mesolithic ancestry of the individuals of the first burial phase is confirmed by palaeogenetic results (Posth *et al.* 2023; Terberger *et al.* 2015).

Early Contacts (*c.* 5400–4200 BCE)

There is an ongoing debate on the nature and impact of contacts between early farmers and local hunter-gatherers. It is widely accepted that such contacts played an important role for the Neolithisation in the north (*e.g.* Gronenborn 1997; Hofmann *et al.* 2022; Klassen 2004; Sørensen 2014; Verhart 2000; Zvelebil 1998).

Evidence from material culture

Evidence for first contacts between LBK farmers and the indigenous population is rare. At the Late Mesolithic sites of Parow (western Pomerania) and Dąbki 9 (Pomerania) (fig. 2), isolated fragments of LBK pottery were found. These probably testify to exchange contacts between the lower Oder region and Kuyavia and the Baltic Sea coast *c.* 5000–4900 BCE (Czekaj-Zastawny *et al.* 2013; Klassen 2004; Mertens and Schirren 2000; Terberger *et al.* 2009; 2021). Personal encounters between farmers and Late Mesolithic individuals are probably (also) documented by a few Mesolithic finds, including three trapezes found in a pit with younger LBK pottery at the site of Lietzow 10, Havelland (fig. 5) (Hahn-Weishaupt 2012; Ismail-Weber 2017; Terberger *et al.* 2021). The context of an unperforated axe found at the Late Mesolithic site of Schletau, Lower Saxony, remains unfortunately vague (Breest and Veil 2001, 245; Terberger *et al.* 2021, 174). More reliable finds of amphibolite axes at Late Mesolithic sites come from a Stroke-ornamented Pottery Culture (SBK) context dated to *c.* 4850 BCE (Hartz *et al.* 2011b, 45; Klassen 2004; Terberger 2022). Contacts with SBK communities are corroborated by isolated pottery fragments from the Ertebølle sites of Parow, Dąbki 9 (fig. 6) and Boberg (Czekaj-Zastawny *et al.* 2013; Klassen 2004; Mertens and Schirren 2000; Terberger *et al.* 2021; Thielen 2022).

Contacts between Mesolithic groups and Neolithic Rössen communities further south are attested by a small, decorated pot from the site of Boberg 20 on the Elbe river (Klassen 2004; Thielen 2022). A marble mace head found with the Mesolithic burial 1 at the Criewen site located at the Oder river, Brandenburg, is probably also of Rössen origin (see below). Clay analysis of the Rössen and Stroke-ornamented ware from Boberg suggests the production of the pots with local clay by foreign potters and the temporary presence of Neolithic people at such Late Mesolithic sites (Thielen 2022, 199). The Elbe was an important communication route and the same can be said for the Oder at that time. The relevance of the lower Oder region as a zone of contact is confirmed by depositions of perforated amphibolite axes in the Uckermark region. These are interpreted as social territorial markers of the Neolithic population (Müller and Schirren 2022).

By *c.* 4500–4000 BCE, increasing contacts between farming communities and Mesolithic groups can be seen in the various pottery fragments, stone axes and a few exotic objects made of bone or copper at Late Mesolithic sites (*e.g.* Klassen 2004; Terberger *et al.* 2009). At Dąbki 9, several Brześć Kujawski-type pottery fragments were discovered, which find their parallels in Kuyavia (fig. 6; Czekay-Zastawny *et al.* 2013). Most of the perforated amphibolite axes found at Ertebølle sites in the western Baltic can be assigned to this time period. Surprisingly, at Dąbki 9 there is even evidence for long-distance contacts with the Carpathian basin, attested by fragments of Bodrogkeresztūr pottery that date to *c.* 4000 BCE. This was also the time when the first copper objects arrived in the north (Czekaj-Zastawny *et al.* 2011; 2013; Klassen 2004). It has been argued that innovations of that time could not be adopted as long as Mesolithic society lacked “a mandatory sociotechnological substructure” (Klimscha and Neumann 2022, 375).

Evidence from burials, isotopes and palaeogenetics

Only a few LBK burial sites were discovered on the northern fringes of the LBK settlement area. Some years ago, at Warburg-Hohenwepel, the first LBK burial site in Westphalia was

Figure 5. LBK site Lietzow 10, feature 32. Mesolithic finds: 1–3: trapezes, 4: deer tooth pendant ("Hirschgrandel"), 5: horse tooth pendant (photo: A. Kotula).

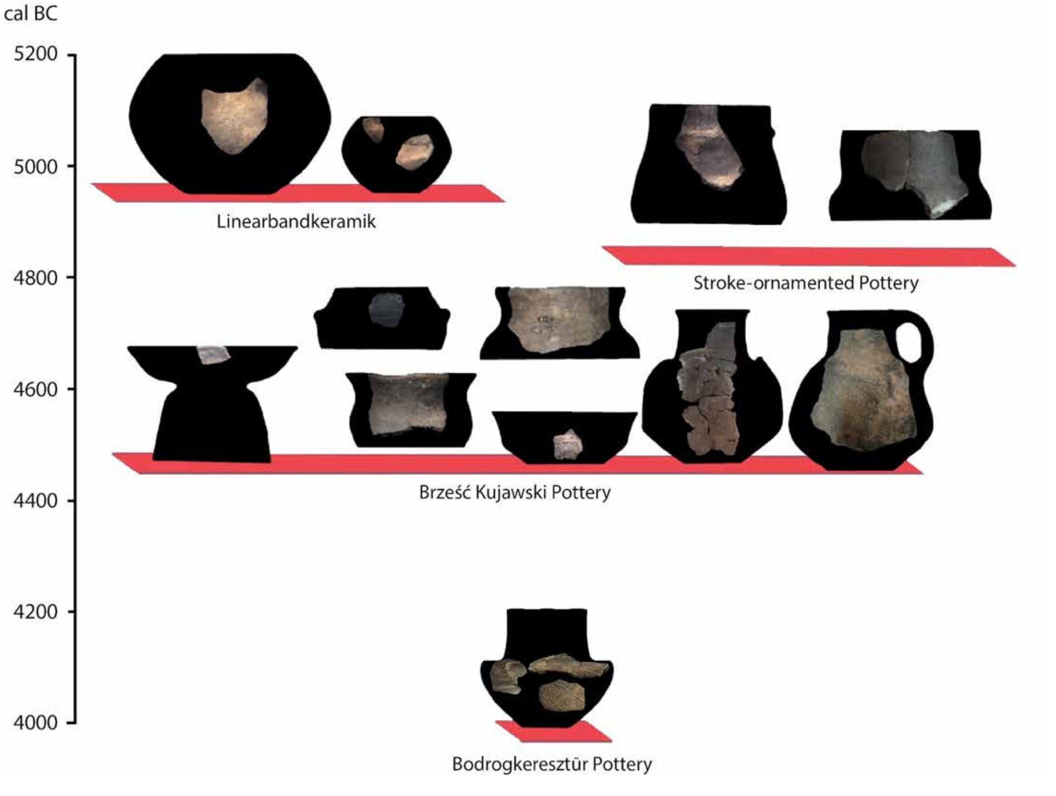

Figure 6. Imported Neolithic pottery at the Late Mesolithic site of Dąbki 9 (graph: A. Czekaj-Zastawny).

discovered (Pollmann 2012; 2015). Probably, hundreds of burials of the younger LBK phase are present at the site, but unfortunately only a few human remains are preserved. At the Wittmar site, located in Lower Saxony further east, 51 graves of the LBK (n=16), Rössen (n=36) and SBK (n=1) were discovered (Krause-Kyora and Rinne 2014; Rötting 1983). It is likely that the site was continuously used (Krause-Kyora and Rinne 2014, 37). The preservation of six Rössen individuals allowed palaeogenetic analysis (mtDNA) (see below). Unfortunately, no information is available for the LKB individuals. So far, only isolated human remains of the LBK and the subsequent farming communities from the fifth millennium BCE have been discovered in the Havelland and Uckermark (Cziesla 2008, 422): they do not provide material for the discussion of contacts.

As mentioned before, some Late Mesolithic burials in northern central Europe at sites such as Groß Fredenwalde and Rothenklempenow are present (Gramsch 2016). Evidence from more recent Mesolithic times (*c.* 5400–4200 BCE) is limited. Not a single burial is known from Lower Saxony (Terberger 2022). A mandible fragment from Spiekeroog (fig. 2) dated to *c.* 5500–5400 BCE originates from a submerged site. Isotope values indicate the consumption of fish, suggesting a Mesolithic lifestyle in line with what is known about the diets of other Mesolithic individuals in this period (Mahlstedt *et al.* 2022; Terberger *et al.* 2018). No palaeogenetic results are available for the specimen so far.

Further east at Steinhagen, Mecklenburg, a Mesolithic burial was found in the 1980s (Heußner and Heußner 1990). The male individual was buried in supine position and furnished with eleven aurochs tooth pendants. A ^{14}C-date assigns the burial to *c.* 5600–5400 BCE (Terberger *et al.* 2018, tab. 1), but some reservoir effect caused by freshwater fish consumption can be expected, and the true age of the individual might be *c.* 100–200 years younger. The Mesolithic ancestry is suggested by the mt-haplotype U5b2b1a, commonly found in Mesolithic hunter-gather populations (Bramanti *et al.* 2009; Schulz 2015; Terberger *et al.* 2015, 151). The fact that the skeleton does not show Neolithic ancestry is not surprising as the individual was living more than 200 km from the nearest LBK settlements.

The burial at Rathsdorf in Brandenburg was discovered in 2008 west of the Oder river. It is dated to about the same time, *c.* 5300 BCE (Ismail-Weber 2016). The ^{14}C-date was obtained on a charcoal sample from the pit filling and a direct date of the individual or grave goods might provide a different result. The female individual was buried in ochre-stained sediments with her back upright (half-seated position) (Ismail-Weber 2016). A bone dagger (or point), three flint artefacts and a minimum of 132 animal tooth pendants of different species reflect a richly-furnished interment for the woman. The bone preservation is rather poor and no isotope or palaeogenetic results are available for the burial. The wetland environment lets us assume a typical Mesolithic lifestyle for the individual. Again, no traces of the incoming farmers are reflected in this Mesolithic burial, which is located only *c.* 30 km from the nearest LBK sites.

Most interesting is a more recent burial found at the site of Groß Fredenwalde in the Uckermark mentioned above (Terberger *et al.* 2015). The individual grave (feature 1/4) was found amidst the earlier burials, and its pit disturbed a child burial of the first phase (fig. 4). The associated community was probably not aware of the exact position of the former burials. The bones of the buried young adult male were not in their anatomically correct position (fig. 7) and a few traces of carnivore activities could be identified on the skeletal parts of the upper body. The leg bones were in a more vertical position, and they suggest that the young man was placed in a pit *c.* 1.6 m deep standing almost upright (Terberger *et al.* 2015). After decomposition, the corpse collapsed and the burial was filled in with sand and sealed by a fire place. No ochre was used in the burial rite. The man was equipped with typical Mesolithic grave goods, comprising two bone points (or needles), some flint blades including two large knives and a small hammer stone. ^{14}C-dates suggest that this individual was buried *c.* 5000–4900 BCE when LBK farmers settled in the neighbourhood about 11 km to the north. It is very likely that the individual had personal encounters with the early farmers in his lifetime. The Mesolithic lifestyle of the individual is underlined by heavily worn front teeth, suggesting their use as tools (*e.g.* Clement 2008). A slightly elevated ^{15}N-isotope value of 11.3‰ (^{13}C: -19.9‰) suggests a Mesolithic diet that included moderate freshwater fish consumption (Terberger *et al.* 2015; 2018). Palaeogenetic studies confirm the Mesolithic ancestry of the individual and his genes show no admixture with early farmers (Posth *et al.* 2023).

A skull cap dredged from Strelasund, close to Drigge, Rügen Island, is dated to about the same time period (*c.* 5000 BCE; Terberger 1998) and shows the same genetic pattern (mt-haplotype U5b2b; Posth *et al.* 2023).

Of more recent date are two burials at the Criewen site (no. 4) in Brandenburg, which were located in two dunes close to the Oder and documented during rescue excavations (Geisler and Wetzel 1999). The skeletons were partly disturbed and were lying in a supine position in red sand. Many molluscs were found on the upper body part of burial 2, which probably served as dress decoration. Most interesting is a marble mace head detected in burial 1, which finds parallels in a Rössen context (Geisler and Wetzel 1999; Wetzel 2021, 163). Evidence for SBK and Rössen pottery in the Havelland is scattered for that time (fig. 3; Terberger and Kabaciński 2010; Wetzel 2021). Direct dates of the Criewen individuals suggest a dating to 4696–4491 cal BC (burial 1; KIA-4346: 5740 ± 40 BP) and 4882–4685 cal BC (burial 2; KIA-4347: 5890 ± 40 BP) (Geisler and Wetzel 1999). The isotope values prove some consumption of freshwater resources and the true date of the burials is probably somewhat younger (Terberger *et al.* 2018). Palaeogenetic studies show Mesolithic mt-haplotypes for the two individuals and no sign of admixture with farmers (Posth *et al.* 2023; Schulz 2015; Terberger *et al.* 2015, 151).

The results for six Rössen burials at the Wittmar site in Lower Saxony (see above) provide a somewhat different perspective. In five cases, haplotypes of early farmers were identified (3x HV0a, 1x H5, 1x K), but the individual of burial 34 shows haplotype U5, which is typical for Mesolithic individuals (Krause-Kyora and Rinne 2014), and the position of the body compares to the other Rössen burials. The individual probably testifies to the first admixture with late hunter-gatherers in the middle of the fifth millennium BCE (Terberger *et al.* 2018, 70).

Finally, the burial at Kolberg in the Havelland, Brandenburg, can be mentioned, where a female individual dated to 4947–4542 cal BC (OxA-2920: 5880 ± 80 BP) was buried in a seated position (Gramsch 2016, 388; Hohmann 1956). No isotope or palaeogenetic studies have been published for the individual yet. The sitting position finds parallels in other Mesolithic burials. Further Mesolithic graves were uncovered in northeast Germany (Gramsch 2016), but these are dated outside of the period of interest here and/or are poorly preserved.

Figure 7. Groß Fredenwalde. Jumbled bones of a Late Mesolithic burial (feature 1/4) dated to *c*. 5000–4900 cal BCE (photo: A. Kotula).

Discussion and conclusion

By 5300–5200 BCE, LBK farmers expanded their territory to the north, outside of the loess zone. In the Havelland and Uckermark areas, the mixture of fertile soils and wetlands created neighbouring ecological niches both for Early Neolithic and late hunter-gatherer communities. Encounters between the different societies are reflected by a few trapeze microliths and tooth pendants at the LBK site of Lietzow 10 (Havelland) and by isolated LBK pottery fragments at Late Mesolithic coastal sites (Parow and Dąbki 9) *c.* 5000–4900 BCE. Late forager burials (*c.* 5400–4200 BCE) show Mesolithic rites with a considerable variability in body position, such as supine, (half-)sitting and standing almost upright. In most cases, ochre or red sand was used in the burial rite. Most burial goods are of Mesolithic character with flint artefacts, bone points/daggers and animal tooth pedants or molluscs in varying numbers. The only "foreign" object is a marble mace head, probably of Rössen origin, found at Criewen burial 1 and dated to *c.* 600 years after the first meetings with early farmers.

This is in accordance with isotope results, which show a typical Mesolithic diet including fresh water resources. Palaeogenetic studies corroborate the persistence of a Mesolithic parallel society with only limited contacts with the farmers for a long time: no admixture is visible in the young male individual at Groß Fredenwalde (feature 1/4), the Drigge individual and the Criewen skeletons. After several generations of contacts with sporadic exchange, we see no impact on the mating strategy except from the Wittmar site, where one individual of the Rössen phase is probably of Mesolithic ancestry.

During this period of early contacts, we see Mesolithic burials that are richly furnished (Rathsdorf, Criewen) or with unusual rites (Groß Fredenwalde, feature 1/4). These burials indicate a strong Mesolithic identity in times of major changes in their neighbourhood. The same might be true for the start of Mesolithic pottery production (*c.* 4700–4600 BCE) about 300 years after the first LBK pots arrived at Mesolithic sites. The remains of Ertebølle pots and lamps were also found in the lower Oder region and the Havelland at a few sites (Kotula *et al.* 2015; Thielen 2022; Wetzel 2021).

The local pottery traditions, which were established from 5000–4600 BCE in the contact zone of early farmers and late hunter-gatherers between the Upper Rhine valley in the west and Pomerania in the east, might be interpreted as a response to a situation of indifference, competition and/or confrontation. Mesolithic individuals at that time were probably very aware of their different identity by their appearance, language, and material culture. In the mid-fifth millennium BCE, they entered a new phase of coexistence, interaction, and initial admixture. Palaeogenetic results obtained on a piece of birch pitch from Syltholm II (MLF00906), southern Denmark, dated to *c.* 3700 BCE, demonstrate, however, that the individual with mt-haplogroup K1e "does not carry any Neolithic farmer ancestry suggesting that the genetic impact of Neolithic farming communities in southern Scandinavia might not have been as instant or pervasive as once thought" (Jensen *et al.* 2019, 5). This result is in accordance with a Mesolithic individual (mt-haplotype U5a1) from the Grube-Rosenhof LA 58 site, Schleswig-Holstein, dated to *c.* 4000 BCE (Schulz 2015; Terberger *et al.* 2018, Table 1). Becoming Neolithic was not (as) attractive as often suggested, and in the northern lowlands the period of coexistence lasted for about another 1000 years (Bollongino *et al.* 2013; Posth *et al.* 2023; Terberger *et al.* 2018).

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Perceptions of Stone Age Landscapes?

A note on how humans of the Stone Age may have experienced their surroundings

Mikael Rothstein

Abstract

The overall supposition is that similar lifeways trigger similar ways of relating to the surroundings, and that landscape perceptions in the late Mesolithic and early Neolithic therefore, all things considered, included aspects akin to what we can observe among present day hunter-gatherers. In some instances, concrete answers can be derived from ethnographic analogies, but in most cases the result of the investigation amounts to little more than improved hypotheses. This is particularly true with relation to abstract subjects such as perception, classification, language, historiography and description. Departing from ethnographic data on the Penan, hunter-gatherers of central Borneo, this article offers a sketch of how humans of the Stone Age hypothetically may have experienced their landscapes.

Ethnographic analogy; perception; language; marking the landscape; movement; storytelling; Penan [people]; hunter-gatherers; topography; classification; soundscape; historiography.

Introduction

It is commonly recognized that people's physical *milieu* and their practical way of living, provide the substrate and building blocks for how they think. The environment in conjunction with the mind creates a certain psychogeography (Ellard 2015; Ingold 2000, 58–59; Ingold *et al.* 1988). When approaching living or historical societies it is possible to see how such phenomena unfold, but penetrating the mechanisms of the late Mesolithic or early Neolithic is quite another challenge, particularly when it comes to human landscape

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responses that are not materially manifested (*e.g.* stories, myths, movements in the terrain, but also markings in trees, temporary signs etc.) and thus undetectable in the archaeological record. Hunter-gatherers produce "multiple layers of landscape knowledge, transmitting that knowledge across generations, embedding it differently across age and sex groups, creating formal naming systems, and updating [...] these knowledge sets as regularly as necessary or possible" (Whallon and Lewis 2016, 280), which renders any simple understanding of landscape perception pointless. Many layers are invisible to the archaeological eye. The situation is somewhat comparable to other areas, where the absence of finds necessitates audacious archaeological conjectures: for instance, when the importance of skin and fur is assessed, even if organic materials of that kind are very scarce in the finds (*e.g.* Klokkernes 2022; Makarewicz and Pleuger 2020, 303). In order to move forward and understand the interplay between lithic materials (found in abundance), and skin and fur (which is rarely found), it is helpful to employ "ethnographic observations and data to bring balance to this picture, describing and quantifying resources devoted to skin and fur material objects as opposed to lithic material objects" (Klokkernes 2022, 153). The same would apply to plaited objects, fabric etc.

In the same vein, ethnographic analogies, based on what we know about hunter-gatherers of the present or recent historical times, may aid our understanding of the interplay between the landscape and human's lifeways 6000 years ago, when it comes to undetectable ways of relating to the surroundings. At the very least, it can serve as an additional source of inspiration for explaining intangible aspects of the archaeological record. To that end I have collected a small sample of themes that are archaeologically undetectable but observable among present day hunter-gatherers, as inspiration for further theorizing and analysis of Stone Age sources. These themes (summarized at the end) are not all-embracing, neither are they thoroughly argued, but they are meant to give incentive to further considerations. One might argue, that such an "archaeology of the invisible" is rather pointless, as it will never amount to more than mere speculation. On the other hand, we should allow well-argued hypotheses to play a part in complex, archaeological interpretation, and work of this kind will never yield more than precisely that.

Ethnographic analogy

Positions for and against the employment of ethnographic data in archaeological analysis – ethnoarchaeology – are well known (to mention a few: Asher 1961; Berggren 2010; Carlie 2013; Cummings 2014; Dias 2014; Gosselain 2016; Lane 2014; Oras 2013). The basic argument against ethnoarchaeology is that the gap in time is too wide to justify the method. Modern hunter-gatherers, for instance, usually interact with farmers, but there were no farmers in the larger part of the Stone Age, or, they are outset to the modern world and marginalised and hence not representing "original" societies or behaviours. However, advantages, I believe, supersede problems, as long as the interpretation of the archaeological record respects the limitations of analogical analysis (Currie 2015; Hayter 1994; McGranaghan 2017).

One of the most lucid contributions in favour of analogy as an analytical tool is Adrian Currie's article "Ethnographic analogy, the comparative method, and archaeological special pleading" (Currie 2015). Currie notes that many archaeologists reject the viability of the method, which he claims is rather strange, as “the use of comparative data in archaeology is the same pattern of reasoning as the ‘comparative method’ in biology, which is a well-developed and robust set of inferences which play a central role in discovering the biological past” (article abstract). What emerges from ethnographic analogies, “count as one line of evidence which archaeologists can exploit”, as there is “no systematic differences between archaeological method, or archaeological targets, and their biological analogues” (Currie 2015, 93). We could add that comparative research in anthropology, history of religions and other social-scientific disciplines abide to the same principles. In other words, “there are no epistemic issues unique to archaeological comparative data” (Currie 2015, 91) which is why the method, when conducted carefully, can be safely employed.

This, in an academic nutshell, is also my point of view. The ply of ethnographic analogy is (with a paradoxical phrase) to study living culture from archaeological perspectives. The sub-discipline of ethnoarchaeology goes beyond the level of mere description in order to flesh out hypotheses on how ancient societies were as living cultures. As it is, the ethnographic analogy works pretty much as a mathematical problem: There are always X’s to be accounted for, and the question is what should or could be inserted based on the archaeological record. The idea is that apt suggestions are found in comparable societies from historical and present times. If living conditions are similar, they are likely to yield the same type of cultural expressions, and when modern data are introduced experimentally into the equation, our interpretation will be potentially improved.

In this connection it is worthwhile to bear in mind that the archaeological interpretation always departs from something else than the finds themselves; by necessity “prior categories of meaning” (Droogan 2013, 48) are applied to the silent past. We have to think on the basis of *something*, and the finds themselves will rarely offer such a point of analytical departure. Such categories (our “something”), however, should not be randomly selected. Rather they should be inspired by what we know about societies somehow comparable to those we are examining. With respect to landscape perception with no archaeological trace, the themes listed towards the end of this chapter offer examples of such prior categories of meaning.

The contention in the following is that what we see among present day hunter-gatherers, or those of a not-too-distant past, mirrors in theory how people during the late Mesolithic and early Neolithic would orient themselves in their physical surroundings – practically as well as cognitively. To be clear, I shall abstain from any detailed parallelisation, but rather think in conceptual and principle terms in order to stimulate theories of what cannot be seen in the archaeological record but is probable to have been part of people’s experience 6000 years ago. In the absence of actual evidence, what I have to offer is predominantly food for thoughts, but that, I believe, is of value itself. At the very least it offers possibilities or suggestions with respect to the reconstruction of how humans in 4000 BCE thought and felt about their physical domain. I depart from data collected among the Penan, hunter-gatherers of Sarawak, Malaysian Borneo, but also include other examples in order to draw a more comprehensive picture (for a general reference: Rothstein 2016). Obviously, hunter-gatherers from rainforest environments cannot be directly compared with people from Mesolithic or Neolithic Scandinavia or Northern Europe. In this case, however, the issue transcends materiality and practical living, as focus will be laid on conceptualizations and perceptions. My point of departure is that the common denominator – the nomadic process, people not being sedentary – will lead humans to analogous abstractions and patterns of observation. An exhaustive discussion of how modern hunter-gatherers comprehend space and place is found in a special issue of *Hunter-Gatherer Research* (2020; no. 4/3). For a systematic elaboration, see O'Meara *et al.* (2020) and Lovis and Whallon (2016).

The Penan of Central Borneo

Traditionally, the Penan lived in nomadic clusters of 15–30 individuals and primarily hunted and foraged in a certain area, their *pengurip*. The word *urip* means "life" or "lifespan" and thus *pengurip* designates the place where your life unfolds. The word refers specifically to the social life of humans, but the *pengurip* also encompasses other beings: animals, the dead, different kinds of spirits, etc. A typical *pengurip* covers approximately 300 km^2, and within its confinements people have precise knowledge of where to locate resources and where to expect danger. A camp is maintained for a few weeks, perhaps a little more, before the group continues its nomadic path. When a new place is reached, several *lamins* – basically elevated platform shelters with a roof and no walls – are built, and people tend to their daily business, preparing darts, mending blowpipes, producing dart poison, weaving baskets and blankets, cooking, or setting out to hunt and collect. The egalitarian group consists of people of all ages. Those who are experienced or particularly good at something will take the lead when relevant, but traditionally the group has no formal leadership. Prior to logging, the forest provided everything needed to stay alive and be well, and in most aspects the Penan have been self-sufficient. They have always traded with other indigenous peoples of the area but do so more extensively now as the boundaries previously created by the rainforest have been weakened (from Rothstein 2020).

Language and topographical classification

The archaeological Stone Age data is silent, but linguistics provide indispensable access into any living culture (regarding the Penan, see Sercombe 1996). The Penans' way of talking of the forest in which they live, their entire environment, is one example, but it is no easy subject to approach:

> "*Although landscapes vary (sometimes dramatically), all human communities inhabit one and must have strategies of representing it in language and thought. The geophysical domain is interesting because it does not typically offer our human perception any clear-cut classes of entities with crisp borders and inherent properties or identities, ready for straightforward linguistic labelling (unlike the domains of plants and animals, for example). Instead it forms a variable but continuous surface which can be conceptually segmented and given meaning in myriad ways. In a sense, languages are free to employ vastly different strategies for categorizing geophysical features, and recent research shows that they do.*" O'Meara *et al.* 2020, 291.

With respect to the Penan there is no nominal single term to denote "forest". I can be said in many ways depending on what precisely is relevant. The nuanced language use reveals a nuanced pattern of classification. In English we can use the term "forest" in a very general sense, but the Penan cannot. To us, bluntly speaking, the forest is something out there, part of "nature", in contrast to what we perceive of as "society" or "culture". To the Penan the forest is not what we would deem "nature", but rather a socio-cultural setting where life unfolds. As a matter of fact, the Penan have no word for "nature". What we would think of as "nature" is of an entirely different order to them. The forest is described, classified, interpreted, denominated, experienced, utilized, managed and shared as the Penans' *cultural* space. In fact, what we call "forest" cannot be comprehended by the Penan without including themselves; they do not *inhabit* the forest. They are part and parcel of it, co-constituents of it, as are the trees, bushes, flowers, animals, insects, various spirits and monsters, the dead and so forth. Hence, the forest is not really a place in contrast to other places. It is a *spatial condition*, the only place, "the world" in effect. A similar understanding may have been at play during the Meso- and Neolithic before clearly demarcated villages or, later on, various types of built frontiers, allowed "nature" to emerge conceptually by representing something different.

This perception of the landscape is revealed in the Penans' language: The basic term to denote "forest" and the word meaning "the world" are the same: *tong tana*. The face of the earth is *tana*, land in general is *tana*, an area not covered by water is *tana*, but a certain conglomerate of things and beings is "forest"; *tong tana*, *i.e.* (in an approximate translation) "*the* land", "*the* world". Traditionally the forest was all the Penan knew, and conceptually it therefore overlaps with their notion of the world. From there on a line of specific expressions is used to specify what *tana*-aspect or *tana*-kind is considered: a place with shade is: *tana lihep*, a place cowered with trees: *tana kayeu*, a watery place in the forest: *tana bawang*, a forest river: *ba*, a large river: *ba ja'au*, a river that flows in the forest: *atong ba*, a river flowing steeply in the forest: *ba éh pejek atong*, a shallow and weak flowing river: *atong ba éh melui*, a heavily flowing forest river: *atong ba éh kasi*, a river bank: *sa dipa ba*, a river bed: *sa ra ba*, a small stream: *ba matong* or *ba si'ik*, a pool: *ba bawang*, a slope: *apé* – and the list goes on and on. All landscape formations or landscape types have a generic designation, but that is not all. Uncountable rivers, riverbanks, caves, streams, large trees, rocks, clearings, waterfalls, boulders, depressions etc. have their own specific designations. Even the bend of a small river, or a small boulder or rock formation may have its own linguistic tagging. With all probability the landscape of Stone Age people was similarly classified, named and understood as a cultural setting. The landscape was not formed by humans, but it was probably under some kind of conceptual control.

Landscape and history

The Penans' labelling of sites and significant objects will usually refer to incidents that took place at that very spot, or things that are characteristic for that particular location. The landscape carries almost as many stories as there are named places or landscape markers: "The cave where Paya was hurt", "The tree where Mutang shot four monkeys with his blowpipe", "The dangerous drowning place", "The good eating area", "Snake-bite place", "Where Arau was lost", "Smelly cave" etc. Sometimes designations refer to actual events, at other times they rise from myth and legend, but in conjunction they mould a type of landscape-based historiography, which links the physical landscape with humans as social and sentient beings. This is why the Penan typically will describe the past by referring to geographical and topographical locations. The *ba Puak*-group, for instance, is named after the river (*ba*) Puak, as they used to live in close proximity to that particular watercourse, and they will describe their history through narratives that correspond with locations along the river's trajectory.

The Penan are great storytellers, and as they link their narratives to specific places in the landscape, they will systematically gesticulate to explain where in the topography the story belongs. Sometimes with zealous energy. Directions, distance, travel time etc. are stressed, and listeners are narratively transported to said location with the storyteller as medium. In fact, travel time between specific locations, is a very common way of communicating about time – distance and bodily movement is concrete, and implies the fuzzy concept of time. In that sense, because storytelling is intimately connected to places, and thus to time structures, the physical landscape becomes embodied in the narrator, and made almost tangible to his or her audience. In the absence of other historiographical options, the topography thus becomes an external memory device by which people collectively remember their history. People of the Stone Age certainly had the cognitive capacity to act in a similar manner, and it is difficult to imagine that they did not. The landscape would carry their history, and they would be inclined to share memories and experiences about it.

Landscape and religion

The concept of "religion" is a Western construct and we should not assume hunter-gatherers to comprehend its semantics (Smith 1988). "Religion", like "nature", takes its meaning from its opposite ("not-religion"), but there is rarely such thing as "not-religion" in traditional hunter-gatherers' societies. What we deem "religion" or "religious" is part and parcel of their everyday life, wholly embedded in practical and social living, and therefore not a phenomenon in its own right. Consequently, what appears "religious" to the Western mind is of another kind to many other communities; it is how the world is, what you do, and – incidentally – the Penan have no concept that easily translates "religion" (Rothstein 2016, 42–48 and 83–118). However, in the following I shall maintain the word "religion" (and its equivalents) for reasons of understandability.

A typical picture of how religion and landscape conflate in hunter-gatherer societies is drawn by Peter D. Jordan based on his study of the Siberian Khanty:

> "*The Khanty believe that the high god Torum resides in the upper world of the sky, but that many of his first-generation offspring, each a major deity, dwell in particular river basins. There each acts as a patron who protects the river's human community, and ensures health, welfare and hunting success. The first-generation offspring of these patron deities reside in a series of sacred local shrines* [...], *each associated with a corresponding patrilineal settlement. In the deep taiga, other sacred places are associated with forest spirits, who must be left material offerings when humans re-enter particular tracts of the landscape, usually at the start of the hunting season. Hunting and trapping is explicitly regulated through patrilineal territoriality, and there are also exclusion-zones around sacred sites and cemeteries; hunting on these lands of the sacred and the dead is an offence comparable with hunting on the land of another patrilineage. Holy sites and the rituals enacted at them are closely associated with particular lineages, so that the communities' responsibilities to the sacred places express, map and validate broader patterns of landscape ownership.*" Jordan 2002, 33–34.

The deities and the dead occupy the landscape to a degree where places and demarcations are defined by them. The landscape mirrors a cosmology, and designated places in the environment regulate human behaviour. The landscape is not a physical framework in which life unfolds, or a practical platform where resources are obtained. The landscape is common ground for humans and deities alike, not a reflection of a religious ideal or the abode of the gods. Humans, consequently, live in an environment where more than meets the eye is in play, or rather, the Khanty will meet the landscape in ways that are determined by their religious perception of the world. To some degree the Khanty religion will leave material traces for future archaeologists to ponder over (the local shrines are constructions built of wood), but their religious perception of the landscape will not survive in the finds. Remnants of Mesolithic or Neolithic religion have reached us, but when it comes to cosmologies and religious notions of spatiality from the remote past, we only have ethnographic analogies to stimulate our imagination.

An extraordinary example from the Jahai, hunter-gatherers from the borderland between Malaysia and Thailand, shows how complex the religion/landscape matrix can be. It was well known to researchers that the Jahai ancestors are important, and that they occupy an important position in Jahai cosmology. It was, however, not recognised *how* they are related to the landscape until GIS technology was applied. Jahai consultants were asked to walk along traditional paths and talk about their surroundings. Each person carried a special camera, fixed to their chest, and what they saw and what they said was correlated with their location through advanced GPS systems (see further below). To sum up, the study showed:

> *"Jahai placenames are the personal names of subterranean beings, embodied and gendered individuals connected through kinship, whose physical manifestation is largely indirect and takes the form of permanent waterflow. The named beings do not straightforwardly coincide physically with observable features in the terrain, and there is no co-referential one-to-one mapping between names and generic Jahai labels (or "appellatives") referring to landforms."* Villette *et al.* 2022, 4.

As it appears, mythological beings, otherwise known from religious narrative, not simply manifest as the landscape. Rather, they are *in* the landscape. In a sense the Jahai move on the crust of the subterranean beings' world, and even if these beings somehow become tangible through floating rivers and streams, they remain hidden beneath the visible terrain. The Jahais' perception offers yet another cosmological model, yet another type of relationship between humans, their gods and the landscape, and again we must assume that similar features could have played a role in belief systems among hunter-gatherers in the Meso- and/or Neolithic.

The emergence of "place"

We tend to see a correspondence between the surroundings and what people think and say as rooted in the physical landscape: The landscape triggers certain ideas and interpretations. Yet, a dialectical process is also unfolding: The landscape sometimes takes its significance from the way people talk about it, not in a physical sense of course, but with regard to how it is perceived and comprehended.

To give another example from the Penan (paraphrased from the material underlying the analysis in Rothstein 2020): A small and peripheral watershed is said to be the dwelling of a sinister monster, and the place is avoided. As seen from the outside the place itself is not dangerous, but it becomes a high-risk landmark due to the beliefs associated with it. Or more precisely, the site becomes a *place* or a *locus*, because people attach meaning to it, and describe it in stories. When people avoid the place during trips along the river, they respond in fact to beliefs and narratives, not to (in this example) the small ridge as a natural occurring formation. The place has become the focal point for a narrative and thus carrier of meaning, but it is impossible to know from the mere appearance of the site. Accordingly, places of importance need not be visible as such, nor marked to be meaningful, but they need to be identified and socially embedded.

To assess how the Penan describe and understand their physical milieu, we have asked people to carry GPS-based audiovisual recording devices while walking in the landscape. Thus we have been able to integrate behavioural, linguistic and geospatial data on a timeline, and draw a nuanced picture of people's movements in the landscape and register the meaning they ascribed to it (Larsson *et al.* 2021). Here, I briefly refer one example where two men were traversing a plateau, following a well-known Penan path while talking about the landscape. With reference to the video footage, our initial report reads:

> *"At one point a rocky, tree-clad eminence is about to come into the view of the men and the cameras, which triggers immediate commentary by one of the men. He mentions its Kelabit name, Pawan, and goes on to explain that in Penan it is referred to as Gerusu* '*Rocky*'*. After a few minutes of silent motion towards the feature, and upon reaching it, he starts to recount traditional ways associated with the site and the area, first commenting on the site's significance as a frequent dwelling place when the Penan were still nomadic. He then explains what local camps and households were like. After a short period of silence, he describes the traditional way of calling out to people at a distance for the purpose of meeting up."* Larsson *et al.* 2021, 5.

Other recordings revealed where hunting-perimeters were, where events had taken place, why a topographical spot was named in a certain way, places of no interest at all, places of a special beauty, and sites that were known for particular resources, an important event etc. We must assume that Stone Age people, traveling through the landscape, had the same level of detailed knowledge, and that they would relate it to others depending on where they were and what they experienced, and we must assume that their locomotion would draw more or less similar traces in the landscape. What we identify is what Ingold, with an ecological emphasis, has called "the living organism-person in its environment" (Ingold 2003, 54), a phrase that indicates a crucial fact: nomadic people do not live in a place, they are *creating* places during what I deem 'the nomadic process', and as they leave, sites may either be forgotten, or remembered and stored in language and naratives (cf. Ingold 2007, 101). In that sense it is the nomadic process that creates the Penans' physical environment, and the same process reveals traces of their whereabouts (Ingold 2007, 43). The landscape unfolds as a line of registered places and events as people precede, and it is very likely that humans 6000 or 10000 years ago had a similar connection with the environment.

Ownership

The Penan also talk about the landscape with reference to ownership (prerogatives more precisely, as no real right of ownership applies). The *tana pengurip*, "the place where [our] lives unfold", or simply *tana lepu'un*, "the place where [we] belong", links themselves intimately to the land. But these terms also maintain awareness of geospatial demarcations and stress that their survival depends on their continued access to the area. The *pengurip* of a nomadic Penan group is not marked by artefacts (*e.g.* signs or posts), but defined by natural landmarks such as large trees, mountain ridges, rivers and boulders. Most importantly it will be known and recognized by neighbouring bands from those landmarks. Previously, it has been impossible to determine the perimeter of a *pengurip*, but thanks to the GPS-based audio-visual recordings, we are learning much more about people's movements and their perceptions of the surroundings. A similar dependence on land was effective in prehistoric times, and it is therefore fair to assume that humans of the Meso- and Neolithic, in principle, had similar points of orientations in the landscape.

This is also true when it comes to the demarcation of human habitation. As soon as camp is set up, the Penan will place a number of sticks with mandibles from the bearded pig (*Sus barbatus*) in the vicinity. The signs serve two purposes: they tell strangers to announce their presence as they approach, and they keep demons at bay. Using bones as landscape markers is not at all uncommon and may sometimes amount to what Gustavo Politis (with reference to South American foragers) calls 'bonescapes' (Politis 2016). Mandibles, as well as other animal bones, are well known in Stone Age finds (see Sørensen this volume) and comparing to what ethnography has registered is an obvious analytical move.

Soundscapes

The same methodology has revealed hitherto unknown patterns in humans' responses to auditive stimuli. Landscapes are not silent, and any locomotion in the terrain will entail that things are heard. Among the Penan a divinatory system known as *amén juhit*, *i.e.* "bird signs", is constantly active. By watching a number of different bird species, and being attentive to their calls, the Penan will determine what direction to head, especially when it comes to hunting. The system introduces randomness in situations when regularity, resulting from deliberate control, could be detrimental. For instance, *amén juhit* will prevent foragers from exhausting the same area by too intensive hunting (Rothstein 2019, 624–631). For the present purpose it should be noted that the system ties together humans, birds and the landscape, particularly with respect to direction. The landscape is not simply what meets the eye, or what can be felt during strenuous walks. The landscape is also what the bird oracle dictates, a soundscape carrying the oracle's directives. Among the Kaluli of Papua New Guinea, birds *are* essentially sounds, their physical shape being of secondary or no relevance at all. Birds, consequently, are primarily present in the Kaluli landscape as part of the soundscape (Feld 1982, 45), and this example reminds us that the auditive sometimes supersede the visual in humans' perceptual hierarchy. The reconstruction of ancient soundscapes, therefore, cannot be understood disconnected from the three-dimensional areas where they occur. They are invisible, intangible but very real aspects of the landscape experience. And again, from what we must assume, these environments, were not "nature" in our sense of the word in the Stone Ages, but in fact cultural locations with culturally contextualized acoustic sceneries. According to Sonia Modica the idea of soundscape

> *"…refers to both the natural acoustic environment (consisting of natural sounds, including animal vocalisations and, for instance, the sounds of weather and other natural elements) and environmental sounds created by humans, through musical composition and other ordinary human activities including conversation, work, and sounds of mechanical origin resulting from the use of technology."* Modica 2014, 1.

The principle is elementary – Stone Age people were hearing and listening – but what precisely they heard, and what it meant to them, is difficult to assess. Analysis of musical instruments and their sound is relatively easy when such items are recovered, but analysing the sound of ancient landscapes is a more daring venture. However, GIS has now been utilized to model soundscapes and to explore how people 'heard their landscape'. The sound of the environment in a remote past does not exist, but it may be reconstructed and tested against what can be registered and measured today (cf. Primeau and Witt 2018; Sheets and Mahoney 2022). If we imagine that Mesolithic hunter-gatherers, like many hunter-gatherers do, would pay particular attention to bird calls and bird songs, a zoo-archaeological survey of a given area would suggest what acoustic input people experienced, and data could be compared to modern examples (cf. Whitehouse 2015).

Marking the landscape

Hunter-gatherers' markings of their landscape and the meaning they attach to it, whether intentionally or not, is multidimensional, very complex and cannot be dealt with here in any satisfactory way. As evidenced in Lovis and Whalton's edited volume on the subject, perspectives are innumerable and often interconnected (Lovis and Whalton 2016). We have already seen how animal bones may be used for particular purposes. Here I shall restrict the discussion to one single example, or one single strain: the *oro'o* of the Penan. This is a system where twigs, sticks, leaves and other plant items in intricate combinations form signs by which wayfarers communicate.

For argument's sake, I imply that humans of the late Mesolithic and early Neolithic may have known something similar, and that it would somehow have affected their locomotions in the landscape and their perception of the environment altogether. The Penan-system is rather elaborate, but a much simpler system also exists: *serata*. When using that, the Penan simply lay out pointers on trodden paths, in order to indicate direction for one purpose or another (Lye 2016; Rothstein 2016, 296–297). We believe that boulders and other lithic structures (apart from other functions) were used as landmarks in the Stone Age (*e.g.* Mennenga *et al.* this volume), but it is likely that people would also mark the landscape and their whereabouts in more immediate ways, such as those described here. As the Penan, they would make their landscape legible and conceptually control it.

An *oro'o* is technically easy to set up, although it takes some practice. The challenge is to know the vocabulary and the grammar of the system, including the ability to discern when the sign was set up, depending on the decay of the materials. The items used (paralleling words), and the way they are placed (paralleling grammar), create the meaning, and changes in either materials or placement will alter everything. To give one example: one particular set of leaves, twigs and sticks may include the following semantic components: 1) people waiting, 2) matter is urgent, 3) direction, 4) I went ahead, 5) follow me, 6) blood related (+ decay). As a full sentence it would read: "People are urgently awaiting you.

I went ahead in [that] direction. Follow me. I am of your kin (+ time)". Another set of materials may display the following signs: 1) meat, 2) camp, 3) river, 4) direction (+ decay) meaning: "I (or we) have set up camp by the river in [that] direction. I (or we) have meat to share (+ time)". A third example: 1) sick, 2) help, 3) direction means (+ decay): "I'm ill and need help, find me in [that] direction (+ time)". In all three examples direction and time (based on decay estimates) is essential, in this case defined not from the position of the speaker but from the position of the *oro'o.*

Spatial orientation builds first and foremost on two frameworks: The egocentric, where the individual's orientation is based on their own position, and the allocentric which, conversely, relies on remembering, recalling, and recognizing landmarks of different kinds. Thus the *oro'o* system serves as an expansion of the active "speaker", who, at some point, was situated at the same spot where the sign is placed, but at the same time it is an object awaiting detection. It is a trace of human action, and it is a temporary addition to the natural landscape.

Conclusion

Experimenting with the archaeology of the unseen or clueless is an abstract venture, but the challenge is not futile. As we have seen, ethnoarchaeological reflections provide ideas about the silent past that enable us to pose theories, or simply imagine more about what life was like 6000 or 10000 years ago. By means of hard archaeological data certain things are known beyond doubt, others are debatable, but when it comes to areas where no traces are left in the archaeological record, well qualified imagination is our only tool. And the qualification is derived from comparison, from ethnographic analogies.

On that basis, even if this article is little more than a sketch, we are able to sum up a number of (overlapping) themes, all undetectable in the archaeological record, that should ideally be built into archaeological interpretation of Meso- and Neolithic finds:

- Humans think of the world in accordance with the physical and practical conditions under which they live. The landscape is not a passive backdrop for people's lives, it is part of it, and should be appreciated as such.
- The landscape is reflected and managed through language. By naming or denoting landscape features, the physical surroundings become structured and classified. Language (words, names, designations etc.) applied to the topography, makes the landscape anything but a random layout.
- Places of importance need not be visible as such, nor marked to stress their significance. To the uneducated or uninitiated, a place may appear neutral or devoid of meaning, but to others the same location will be of the utmost tenor. Hence, the perception of the landscape is intimately linked with cultural knowledge and thus the transmission of tradition.
- Quite to the contrary, the landscape, at other instances, is marked with perishable items. In doing so people may reveal their presence in the landscape, but to many hunter-gatherers such markings are also expressions of themselves being *part of* the landscape.
- The landscape is not simply met visually and perceived through body movement; it always carries a soundscape and it is experienced through olfaction. Whatever humans think of the landscape, it is the result of a multi-sensory encounter. Giving

priority to vision, as we do, is not always in line with people's cultural habits. In some instances the landscape is something you hear or smell.

- The landscape may conflate with myths and mythological beings to an extend where rivers, boulders or large trees are somehow believed to embody divinities or other imagined creatures. This renders the landscape a complex dwelling for many different species alike.
- Distance is equal to time. Moving in a three-dimensional landscape implies ideas of how time-consuming a journey from A to B will be. The structure of the landscape, therefore, is not simply measured by distance. It is also estimated in time sequences.

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CHANGING IDENTITY IN A CHANGING WORLD

From 2013-2022 the largest Stone Age excavation ever undertaken in Denmark, uncovered an entire fjord landscape beneath marine sediments at Rødbyhavn on the island of Lolland. Based on the excavations, Museum Lolland-Falster, in collaboration with Aarhus University and the Danish National Museum, organised an international conference on the topic of "LOST 2022 – Changing Identity in a Changing World" on 16 and 17 June 2022 to discuss the time around 4000 BCE in Denmark and beyond from different angles.

This book summarizes the conference and presents its main outcomes. It also gives an overview of the current state of research within the Femern project and sets them into context with the wider area. By including contributions from the Netherlands to Finland, the central position of Lolland as a corridor in the Stone Age is highlighted and discussed. The topics covered in this book deal with technological change, archaeological analyses of identity, aspects of landscape interaction and perception in the Late Mesolithic and Early Neolithic.

This book is aimed at specialists, students and the interested public alike, as it provides the first complete overview of the excavations of the Femern project and places them in context. At the same time, it serves as a basis for further studies on the material and highlights the challenges and possibilities of the archaeological record from the period around 4000 BCE.

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