

Oil-rich seeds from prehistoric contexts in southern Scandinavia – reflections on archaeobotanical records of flax, hemp, gold of pleasure, and corn spurrey

SABINE KARG

University of Copenhagen SAXO Institute, Archaeology, Njalsgade 80, DK-2300 Copenhagen S, Denmark;
e-mail karg@hum.ku.dk

Received 15 February 2012; accepted for publication 4 May 2012

ABSTRACT. Plant oils are essential for human nutrition, as their seeds contain high concentrations of valuable fatty acids. Since prehistoric times plant oils have been used for many more purposes, such as lighting, medicines, and as a binding agent for cosmetics, colours, and putty, amongst other things. Although archaeobotanical records of oil plants are in most cases found in small numbers, they are often abundant at excavations in southern Scandinavia. This paper presents a diachronic review of plant records of flax (*Linum usitatissimum* L.) and hemp (*Cannabis sativa* L.), both known for the dual use of their fibres for textile production and for their oil-containing seeds. In addition, the finds of gold of pleasure (*Camelina sativa* (L.) Crantz,) is discussed. This plant was cultivated for the use of its oil containing seeds for at least 2000 years but has totally fallen into oblivion. The fourth oil plant we present is corn spurrey (*Spergula arvensis* L.), a formerly widespread weed on lime-poor sandy soils. Given the high frequency in the investigated archaeological sites the seeds had obviously been an important raw material in southern Scandinavia. No study has been made on the question as to whether corn spurrey had been a cultivar or if the seeds had been collected from wild populations.

KEYWORDS: Archaeobotany, oil-rich seeds, flax, hemp, gold of pleasure, corn spurrey, southern Scandinavia

INTRODUCTION

Sustainable crop diversity is a hot issue in today's global political debate. Archaeobotanical research can help to shed light on the huge spectrum of useful plants that were cultivated and/or collected in nature by our ancestors (Karg 2008, 2010). In addition, the molecular genetic approach will definitely have a direct impact on the methods and strategies employed in preserving the genetic diversity of plant resources for future generations.

Plant finds from archaeological contexts reflect former knowledge on plant use but also cultural differences in economy and subsistence strategies. The intention of this article, dedicated to Professor Wasylikowa, is to give inspiration for further projects in a fringe research area of the archaeobotanical study

of oil plants and to attract attention on the huge research potential that is hidden in many museum archives around the world.

MATERIAL AND METHODS

During the last 15 years an archaeobotanical database has been established at the National Museum of Denmark. Every single plant remain found at more than 135 archaeological sites has been registered. This valuable tool now allows us to produce maps and diachronic reviews on single plant taxa. The maps and tables (Fig. 1, Table 1) in this article are based on the scientific data held in this database (ARBOREG).

Archaeological records of oil plants are relatively rare compared with those of cereal finds. One reason for this might be that oil seeds are not roasted before being consumed and therefore do not get into

contact with fire as often as cereal grains do before being ground. A second reason could be that oil-containing seeds easily burn to ashes. Plant remains from archaeological contexts are in most cases preserved in charred condition. Only when being quickly covered and deposited waterlogged (under the modern ground water level) there is a chance for plant remains to persist in uncharred condition. The most optimal find circumstances to reconstruct former diet habits is the find of a stomach content in a bog body. In special cases dried out plant remains can be discovered, as for example in false ceilings of medieval houses, mineralisation can happen in latrine deposits. In addition imprints of plants are often recovered in all kind of prehistoric and medieval burnt clay objects.

The following review presents the records of the four most important oil plants according to the

current state of the database. These are macroscopic plant remains, such as seeds and capsule fragments of oil plants from 100 archaeological sites dated from the Late Mesolithic (4200 cal. BC) to Modern Times (1850 AD). Table 1 provides an overview in a chronological order, starting with the oldest finds. As most of the sites are dated typochronologically, which means by the archaeological findings and only a few absolute dates (radiocarbon dates) are available, the chronological groupings of the finds are in relatively large time-spans, thus: Late Mesolithic to Late Neolithic (4200–1800 BC), Bronze Age, which stretches in Scandinavia from 1800 BC to 500 BC. The chronology of the Iron Age period (500 BC – 750 AD) has a higher time resolution: Pre-Roman Iron Age (500–100 BC), and Roman Iron Age (100 BC – 400 AD), followed by Germanic Iron Age (400–750 AD). Finds from the Viking Age are dated from 750 to 1050 AD. In addition,

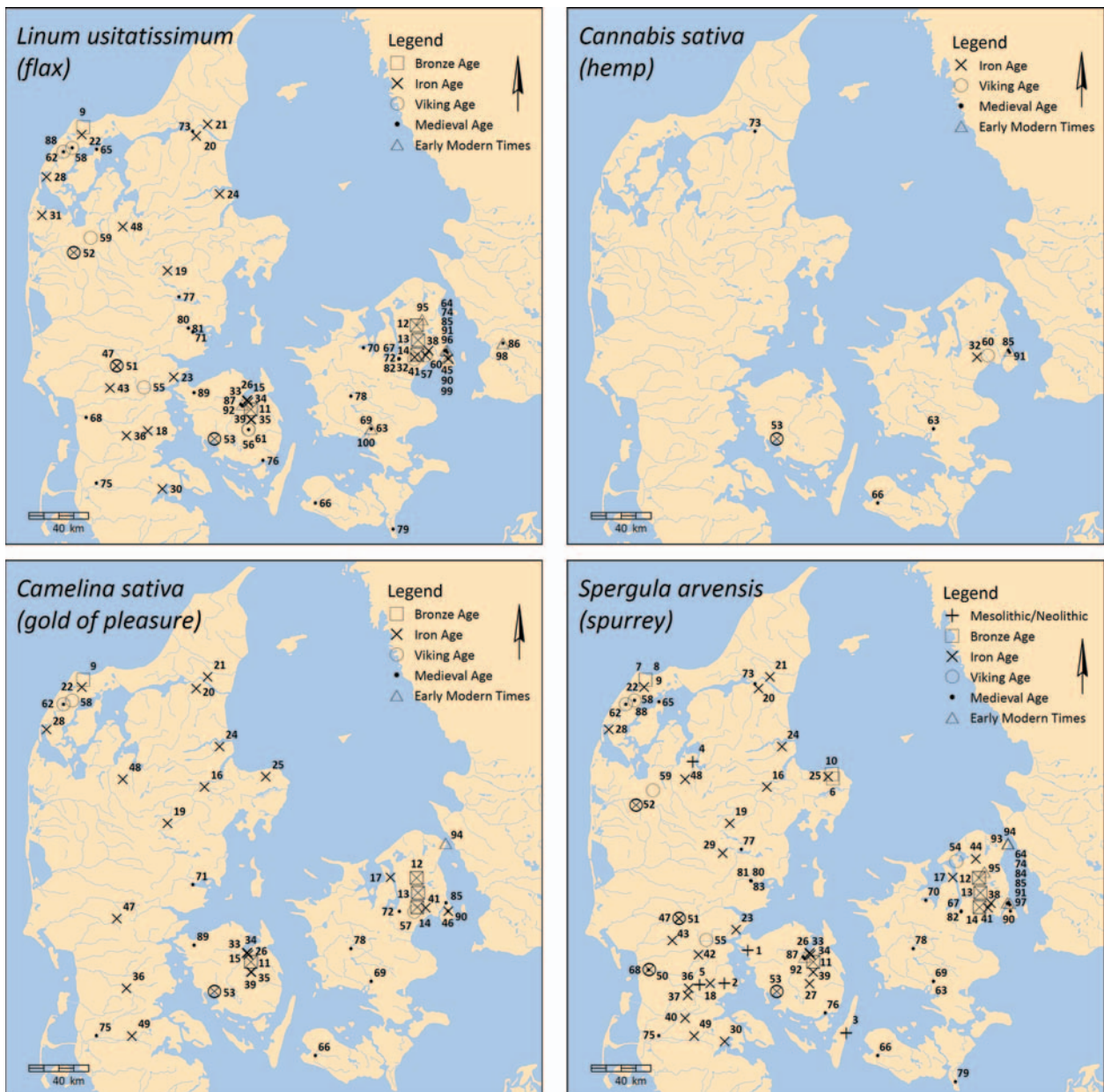


Fig. 1. Maps showing the sites with archaeobotanical data of oil plants in southern Scandinavia discussed in this article

Table 1. Archaeobotanical records of oil plants in Southern Scandinavia. The sites are mapped in Figure 1. **c** – charred, **w** – water logged, **m** – mineralised

Number on oil plant map	<i>Linum usitatissimum</i>	<i>Camelina sativa</i>	<i>Camelina sativa</i>	<i>Spergularia arvensis</i>	Locality name	Archaeological dating	Context	Preservation condition	Reference
1				x	Gamborg Fjord, Ronæs Skov	Late Mesolithic	settlement	w	Harild & Karg 2009
2				x	Lønt	Funnel Beaker Culture	ritual	c	Robinson 1996
3				x	Spodsbjerg	Late Funnel Beaker Culture	settlement	w, c	Robinson et al. 1995, 1998
4				x	Strandet Hovedgaard	Bell Beaker Culture	settlement	c	Robinson & Boldsen 2000
5				x	Brd. Gram, Vojens	Late Neolithic	house	c	Robinson & Harild 1999
6				x	Selkær	Early Bronze Age	settlement	c	Robinson & Karg 2001
7				x	Bjerre 4	Late Bronze Age	settlement	c	Robinson et al. 1995
8				x	Bjerre 6	Late Bronze Age	settlement	c	Kelertas 1997
9	x		x	x	Bjerre 7	Late Bronze Age	settlement	c	Henriksen 2003a
10				x	Hemmed Kirke	Late Bronze Age	settlement	c	Robinson & Karg 2001
11	x		x	x	Frydenlund	Late Bronze Age/Pre Roman Iron Age	settlement, retting pits	w	Runge & Henriksen 2007; Andresen & Karg 2011
12	x		x	x	Lynge, Kærhøjgårdsvej	Late Bronze/Pre Roman Age	settlement	c	Robinson unpubl.
13	x		x	x	Kong Svends Park	Bronze/Iron Age	settlement	c	Henriksen 2003b
14	x		x	x	Helgeshøj	Late Bronze Age/Iron Age	settlement	c	Henriksen 2003b
15	x		x	x	Helstedgård Sydvest	Early Pre Roman Iron Age	settlement, retting pit	w	Henriksen & Harild 2005; Andresen & Karg 2011
16			x	x	Frederiksdalsvej, Randers	Pre Roman Iron Age	settlement	c	Robinson & Pedersen 1994
17			x	x	Færgelunden	Pre Roman Iron Age	ritual	c	Henriksen 2009a
18	x			x	Melskov II	Pre Roman Iron Age	unknown	c	Henriksen unpubl.
19	x		x	x	Nebelgårds mose, Grauballe	Pre Roman Iron Age	bog body	w	Helbæk 1958; Harild et al. 2007; Robinson et al. 2009
20	x		x	x	Nr. Hedegård, Smedegård????	Pre Roman Iron Age	settlement	c	Henriksen & Harild 2002; Robinson et al. 2009; Henriksen et al. 2009
21	x		x	x	Overbygård	Pre Roman Iron Age	settlement	c	Henriksen & Robinson 1994, 1996; Robinson et al. 2009
22	x		x	x	Smedegård	Pre Roman Iron Age	settlement	c, m	Henriksen & Harild 2002; Robinson et al. 2009
23	x			x	Stoustrup	Pre Roman Iron Age	pot	c	Robinson 1993; Robinson et al. 2009
24	x		x	x	Fuglsøgård Mose	Pre Roman/Roman Iron Age	pits	w	Karg 2003a; 2003b; in prep.
25			x	x	Glesborg	Early Iron Age	settlement	c	Robinson & Karg 2002
26	x		x	x	Bjerggården	Early Roman Iron Age	settlement, retting pits	w	Henriksen & Harild 2005; Andresen & Karg 2011
27				x	Bolteskov 2	Roman Iron Age	well	c	Henriksen unpubl.
28	x		x	x	Vestervig,Thy	Roman Iron Age	settlement	c	Robinson 1999a
29				x	Vinding	Roman Iron Age	grave	c	Robinson 1992b
30	x			x	Vårhøj	Late Roman Iron Age	settlement	c	Henriksen 2002
31	x				Heldumbøl	Late Roman/Early Germanic Iron Age	castle	c	Harild 1997; Robinson et al. 2009
32	x	x			Høje Taastrup, Kragehavegård	Late Roman/Early Germanic Iron Age	settlement, retting pits	w	Robinson et al. 2001; Andresen & Karg 2011
33	x		x	x	Odense, Seden Syd	Late Roman Iron/Early Germanic Iron Age	settlement, retting pits	w	Henriksen & Harild 2005; Andresen & Karg 2011
34	x		x	x	Toruplund	Late Roman/Early Germanic Iron Age	settlement, well	w	Harild 2005
35	x		x		Horsemosegaard	Late Roman/Germanic Iron Age	settlement	c	Harild unpubl.
36	x		x	x	Lerdal	Late Roman Iron/Germanic Age	settlement	c	Henriksen 2003b; Karg et al. 2004; Robinson et al. 2009
37				x	Østergård	Roman Iron Age/Germanic Iron Age	settlement	c	Karg et al. 2004
38	x			x	Hvissinge Vest	Early Germanic Iron Age	settlement, retting pits	w	Harild & Pedersen 2001; Andresen & Karg 2011; Robinson et al. 2009
39	x		x	x	Hestehavevej 1	Germanic Iron Age	settlement, well	c	Harild 2006
40				x	Hvidhøjgård	Germanic Iron Age	ovens	c	Mikkelsen 2000; Robinson et al. 2009
41	x		x	x	Ragnesminde III	Germanic Iron Age	settlement	c	Robinson unpubl.
42				x	Skovborglund II	Germanic Iron Age	settlement	c	Moltsen et al. 1999; Robinson et al. 2009
43	x			x	Solvang	Germanic Iron Age	settlement		Robinson & Harild 1994
44				x	Sophienborg V	Germanic Iron Age	settlement	c	Henriksen 2002
45	x				Tårnby, Vinkelhusene	Germanic Iron Age	settlement	c	Robinson & Harild 1997a, 2005
46			x		Tårnby, Vinkelhusene	Late Bronze Age	settlement	c	Robinson & Harild 1997a, 2005
47	x		x	x	Vorbasse	Germanic Iron Age	settlement	c, w	Boltsen unpubl.
48	x		x	x	Tinghøj I	Iron Age	settlement	c	Henriksen 2007a
49			x	x	Tinglev Kirke	Late Iron Age	settlement	c	Henriksen 2004
50			x	x	Ribe Posthus	Germanic Iron Age/Viking Age	settlement	c, w	Robinson & Boldsen 1993
51	x		x	x	Vorbasse	Germanic Iron Age/Viking Age	settlement, well	c, w	Henriksen 2007b
52	x			x	Nr. Felding	Late Germanic Iron Age/Viking Age	settlement	c	Harild 1999; Robinson et al. 2009
53	x	x	x	x	Strandby Gammeltoft	Late Germanic Iron/Viking Age	settlement, retting pit	w	Henriksen & Harild 2005; Andresen & Karg 2011
54				x	Birkely, Kregme	Viking Age	settlement	c	Robinson & Moltsen 1992
55	x			x	Havgaard	Viking Age	settlement	c	Robinson et al. 2009
56	x				Rynkebyvej Vest	Viking Age	well	w	Henriksen & Harild 2008
57	x		x		Samson Nord	Viking Age	settlement	c	Henriksen 2003b
58	x		x	x	Tinggård	Viking Age	settlement	c	Henriksen 2009b
59	x			x	Trabjerg	Viking Age	settlement	w, c	Aaby et al. 1992
60	x	x			Vallensbæk Nordmark	Viking Age	settlement, well	w	Robinson et al. 2000, 2001; Robinson et al. 2009
61	x				Rynkeby Mølle	Viking Age/Early Medieval Age	well	w	Henriksen & Harild 2008
62	x		x	x	Hundborg	Viking/Medieval Age	settlement	c	Henriksen 2006
63	x	x		x	Næstved, Susåen	Medieval Age (1000–1250)	town	w	Karg 2001a, 2005, 2007
64	x		x	x	København, Kompagnistræde 28/Rådhusstræde 6	Medieval Age (1050–1250)	town	w	Boldsen 1994; Karg 2007
65	x			x	Mors, Skarreborg	Medieval Age (1100–1200)	rural site	w	Robinson unpubl.; Karg 2007
66	x	x	x	x	Hollenæs, Arninge	Medieval Age (1100–1300)	rural site	w, c	Karg 2007
67	x			x	Roskilde, Skomagergade 19	Medieval Age (1100–1300)	town	w	Robinson & Harild 1999; Robinson et al. 2002; Karg 2007
68	x			x	Ribe, Gråbrødrekloster	Medieval Age (1100–1400)	frairy	w	Harild 1997; Karg 2007
69	x		x	x	Næstved, Kompagnistræde	Medieval Age (1100–1600)	town	w	Robinson & Harild 1997a; Karg 2007
70	x			x	Holbæk Ahlgade 15–17	Medieval Age (1200–1400)	town	c	Robinson & Boldsen 1991
71	x			x	Horsens, Boller Slot	Medieval Age (1200–1400)	castle	w	Karg 2007
72	x			x	Roskilde, Sct. Peder Stræde og Algade	Medieval Age (1200–1400)	town	w	Robinson & Harild 1996a; Karg 2007
73	x	x		x	Ålborg, Møllegade	Medieval Age (1200–1400)	town	w	Robinson & Harild 2002; Karg 2007
74	x			x	København, Nytorv 17	Medieval Age (1200–1500)	town	w	Robinson unpubl.; Karg 2007
75	x		x	x	Tønderhus	Medieval Age (1200–1500)	castle	w, c	Harild & Andreasen 1999; Karg 2007
76	x			x	Svendborg, Brogade	Medieval Age (1200–1550)	town	w	Karg 2007
77	x			x	Øm Kloster	Medieval Age (1200–1550)	abbey	w	Robinson et al. unpubl.; Karg 2007
78	x		x	x	Sorø, Akademi	Medieval Age (1200–1600)	abbey	w, c	Karg 2007
79	x			x	Gedesby, Falster	Medieval Age (1250–1300)	ship	w	Robinson & Aaby 1994; Karg 2007
80	x			x	Horsens, Nørregade	Medieval Age (1250–1500)	town	w	Karg 2007
81	x			x	Horsens, Søndergade	Medieval Age (1300–1400)	town	w	Karg 2007
82	x			x	Roskilde, Provstevænget	Medieval Age (1300–1450)	town	w	Robinson & Harild 1996b; Karg 2007
83				x	Horsens, Kirketorvet	Medieval Age (1400–1500)	town	c	Karg 2007
84				x	København, Højbro Plads	Medieval Age	town	w	Karg 2007
85	x	x	x	x	København, Kongens Nytorv	Medieval Age	town	w	Moltsen & Henriksen 1998
86	x				Lund, Mårtenstorget	Medieval Age	town	w	Moltsen 1999b; Karg 2007
87	x			x	Odense, Lotzes have	Medieval Age	town	w	Robinson & Harild 1996c; Karg 2011
88	x			x	Tinggård	Medieval Age	settlement	c	Henriksen 2006a
89	x		x		Tværvejen	Medieval Age	rural site, well	w	Harild unpubl.
90	x		x	x	Tårnby Torv	Medieval Age	rural site	c	Robinson & Harild 1997b, 2005; Karg 2007
91	x	x		x	København, Admiralgade	Medieval Age/Early Modern Times (1500–1600)	town	w	Moltsen 1999a; Karg 2007
92	x			x	Odense, Lotzes have	Medieval Age/Early Modern Times	town	w	Robinson & Harild 1996c
93				x	Helsingør Domkirke	Early Modern Times	graves	d	Karg 2001
94			x	x	Helsingør Kulturværft	Early Modern Times	settlement	m	Karg & Flensburg 2010
95	x			x	Hillerød, Østergade 15–21	Early Modern Times	town	w	Karg 2007
96	x				København, Kongens Nytorv	Early Modern Times	town	w	Moltsen & Henriksen 1998; Karg 2007
97				x	København, Nina Bangs Plads/Pilestræde	Early Modern Times	town	w	Moltsen 1999c
98	x				Lund, Mårtenstorget	Early Modern Times	town	w	Moltsen 1999b; Karg 2007
99	x				Tårnby Torv	Early Modern Times	rural site	c, w	Robinson & Harild 1997b, 2005; Karg 2007
100	x				Næstved, Gasværket/Susåen	Early Modern Times	town	w	Karg 2007

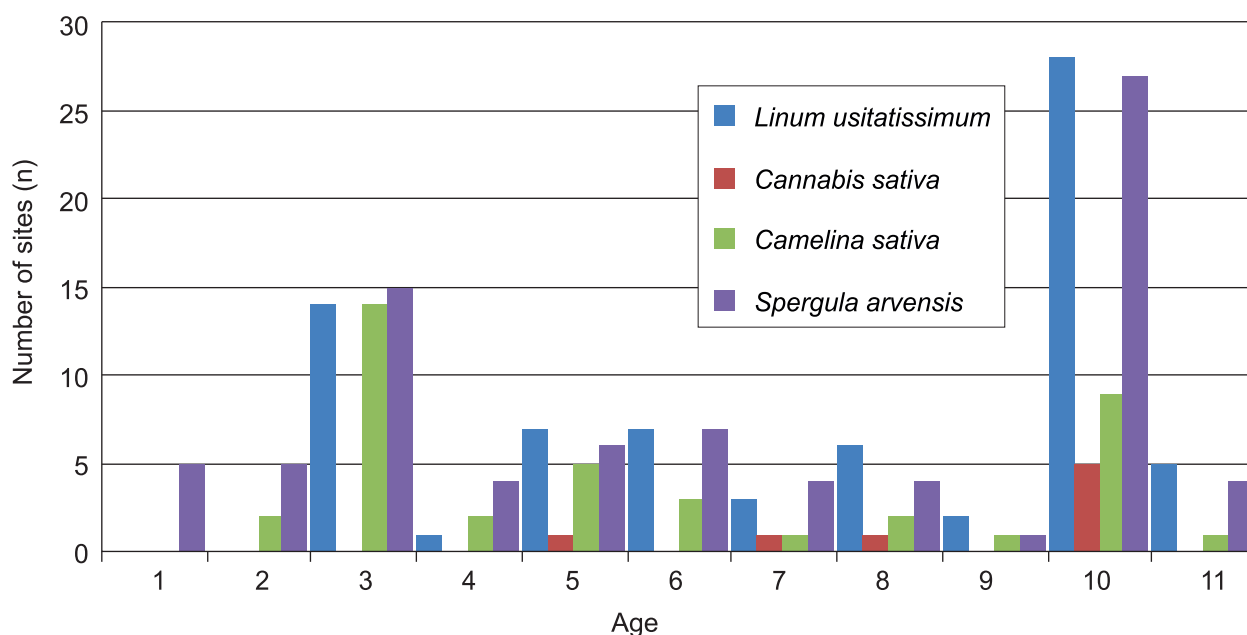


Fig. 2. Frequency of oil rich plants in 100 sites in southern Scandinavia dated between 4200 BC – 1850 AD.

1 – Late Mesolithic (4200 cal. BC) – Late Neolithic (1800 BC), n = 5; 2 – Early Bronze Age (1800 BC) – Late Bronze Age (500 BC), n = 5; 3 – Late Bronze Age (500 BC) – Pre Roman Iron Age (100 BC), n = 17; 4 – Roman Iron Age (100 BC – 400 AD), n = 4; 5 – Late Roman Iron Age (400 AD) – Early Germanic Iron Age (500 AD), n = 10; 6 – Germanic Iron Age (400–750 AD), n = 8; 7 – Late Germanic Iron Age (750 AD) – Viking Age (750–1050 AD), n = 4; 8 – Viking Age (750–1050 AD), n = 7; 9 – Viking Age (750–1050 AD) – Early Medieval Age (1050–1100 AD), n = 2; 10 – Medieval Age (1050–1550 AD), n = 28; 11 – Modern Times (1550–1850 AD), n = 10.

Table 1 and Figure 2, include plant material from the Middle Ages and Modern Times.

The contexts in which the oil plants were found (settlement, ritual etc.) are listed in Table 1, as well as the preservation condition (charred or waterlogged) and the references to published accounts. The frequency of the four different oil plant species within the single time periods is shown in Figure 2.

Flax (*Linum usitatissimum* L.)

Today, different varieties of oil and fibre flax are cultivated, but astonishingly little is known about the time and place of the evolution of these varieties (Karg (ed.) 2011). Flax seeds contain up to 40% fat with a high proportion of short-chain omega-3 fatty acids. In addition, the seeds are rich in vitamins, such as vitamin E and biotin, as well as minerals, such as magnesium, iron and manganese (der Brockhaus 2004, 423).

Flax remains are recorded at 73 archaeological sites in Denmark, of which the oldest is dated to the Late Bronze Age/Early Iron Age (Fig. 1, Tab. 1). The plant has a dual use of oil produced from the seeds and fibres gained from the stems. According to the latest molecular genetic research results, flax was first cultivated for the use of its oil (Allaby et al. 2005). The fact that only single seeds have until now been detected from late Bronze Age contexts in southern Scandinavia, supports Helbæk's statement that flax was firstly used in Northern Europe for its oil (Helbæk 1938). New measurements of flax seeds from Neolithic wetland sites in the Northern Alpine Foreland shows that different forms of flax for oil and for fibre exploitation were already known and cultivated since at least the 3rd millennium BC (Herbig

& Maier 2011). In Scandinavia, the production of textiles made of plant fibres was a common practice in many settlements from the Roman period onwards (Viklund 2011). From this time we have abundant plant finds but also archaeological evidence for plant fibre production, so-called retting pits (Andresen & Karg 2011). The process of flax and hemp retting, where the whole plants are soaked in water in order to break down the tissues and thereby make access to the fibres easier is evidenced at several Danish archaeological sites dated to the span from the late Bronze Age to the Viking Age (Andresen & Karg 2011). Offerings of small stem bundles of flax and gold of pleasure are documented for the Roman Iron Age (Karg 2003a, 2003b).

Hemp (*Cannabis sativa* L.)

Hemp finds are documented in the database of the National Museum from eight archaeological sites located within the modern geographical frame of Denmark (Fig. 1, Tab. 1, more sites are cited in Jessen 1951). In addition, hemp fruits and textiles were detected in the famous Queen's grave in the Oseberg ship (Norway), dated to the Viking Age (Holmboe 1927).

The seed and pollen records from Denmark can be dated back to the Roman Iron Age (Robinson et al. 2001, 2002). Interestingly these finds derive from fibre plant retting pits (Andresen & Karg 2011), which could mean that hempseed oil did not play a role in human consumption in Northern Europe at this time. The oldest Central European textiles made of hemp were found in the grave of the celtic "Fürst of Hochdorf" dated to 500 BC (Körber-Grohne 1987, 391).

Gold of Pleasure (*Camelina sativa* (L.) Crantz)

As early as 1899, Saraauw reported the discovery of a huge number of gold of pleasure seeds from a Roman context on the island of Gotland, clumped in a solid brown cake (Jessen 1933). Helbæk (1951) systematically measured *Camelina* seeds and Hjelmqvist discussed in detail the arguments for the possibility that *Camelina* had been a crop, at least in Scandinavia, being cultivated for the use of its oil. The Scandinavian finds suggest that *Camelina* had been cultivated as a single crop in the beginning and later as a mixed cropping together with flax (Helbæk 1953, Hjelmqvist 1955). Körber-Grohne reports on pure cultivation of gold of pleasure at the site of Feddersen Wierde (Northern Germany) that was inhabited from c. the birth of Christ until 300 AD (Körber-Grohne 1987, 393).

The relatively high frequency of 40% of *Camelina* records across all the investigated sites examined here indicates the importance of this forgotten cultivated plant.

Corn Spurrey (*Spergula arvensis* L.)

This annual plant is still today known as a weed in flax fields. As the seeds retain their germination ability for several hundred years (Oberdorfer 2001), spurrey has survived as a severe crop weed to the present day.

Spurrey seeds are rich in oil and were used in human nutrition, as huge numbers of seed fragments document in the stomachs of the Danish bog bodies, Grauballe Man and Tollund Man, both dated to Pre-Roman Iron Age (Helbæk 1950, 1958, Harild et al. 2007). From historical times it is known that the seeds were used as famine food, mixed with flour, although they contain saponins (<http://www.pfaf.org/user/Plant.aspx?LatinName=Spergula+arvensis>).

Spurrey seeds and pod remains are recorded at 82 out of 100 sites covering all time periods (Fig. 1, Tab. 1). As early as 1938, Helbæk reported finds dated to the Bronze Age. The high frequency points to the fact that the oil-containing spurrey seeds may have been an important food supplement in Scandinavia throughout centuries. Two storage finds of spurrey seeds dated to the Early Iron Age period are reported by Jessen (1933) and Fredskild (1966) and these seem very likely to represent use of the seeds as food.

Spurrey is an annual crop weed that favours row-crop husbandry and lime-poor soils. One plant of *Spergula arvensis* can produce between 1000 and 10 000 seeds. Observations on the competitive ability of spurrey were made by the author during cultivation experiments with flax. The plots, on which flax had been harvested the year before, were totally overgrown with spurrey in the following summer with a degree of coverage of 80%.

As several subspecies of spurrey exist, amongst them *Spergula arvensis* ssp. *sativa*, it could be interesting to analyse the abundant seeds from the archaeological contexts more closely, in order to see differences in seed size, morphology, or in their molecular genetic code.

DISCUSSION AND PERSPECTIVES

According to our current knowledge, flax seems to be introduced in Scandinavia 3000 years belated than in Central Europe, where flax cultivation is evidenced from the Early Neolithic period (Viklund 2011, Kreuz 2007). However, one imprint of a flax seed was recently detected in a potsherd dated to the Funnel Beaker Culture in Northern Germany (Kirleis et al. 2011). Since the evidence for flax is rare and only single seeds have so far been excavated in southern Scandinavia it is assumed that flax was introduced for consumption reasons and not for textile production.

Hemp obviously played a less important role for both oil and fibre production, although less research has been undertaken to trace and map palaeobotanical records in natural deposits, such as pollen finds in water bodies. The picture might change when more systematic studies are available.

The two additional oil plants discussed in this article, gold of pleasure and spurrey, might have played a role for human economy and consumption that has so far been totally underestimated. Figure 2 clearly documents the high frequency of archaeobotanical finds of both plants. The cultivation increases (probably starts) around 800 BC, a period of severe climatic deterioration with cold and wet years (Aaby 1976). Deteriorating climatic conditions might have favoured both plants, which have relatively short growing periods, over the more demanding crop plants like flax. However, the systematic measurements of seed sizes and molecular genetic studies that would deliver information about different varieties of gold of pleasure and spurrey that might have existed during prehistoric times are still lacking. The material is waiting in the archives for further investigations.

We suggest that all four plants had been cultivated in southern Scandinavia for at least 2000 years and played a yet underestimated role in both, human economy and consumption.

ACKNOWLEDGEMENTS

I want to thank Professor Leon Stuchlik for to publish the manuscript that is an outcome of the Carlsberg Grant 2008_01_0251. Allan Hall has revised my English and given valuable comments on the text. I want to thank Aldona Mueller-Bieniek and one anonymous reviewer for comments on the manuscript.

REFERENCES

- AABY B. 1976. Cyclic climatic variations in climate over the past 5,500 yr reflected in raised bogs. *Nature*, 262: 281–284.
- AABY B., ROBINSON D.E. & BOLDSSEN I. 1992. Pollen- og makrofossilanalyse fra vikingetidsbrønd ved Trabjerg, Ringkøbing Amt. NNU Report 26. The National Museum, Copenhagen.
- ALLABY RG, PETERSON GW, MERRIWETHER DA & FU VB. 2005. Evidence of the domestication history of flax (*Linum usitatissimum* L.) from genetic diversity of the sad2locus. *Theor. Appl. Genet.*, 112: 58–65.
- ANDRESEN S. & KARG S. 2011. Retting pits for textile fibre plants at Danish prehistoric sites dated between 800 BC–1050 AD. *Veget. Hist. Archaeobot.*, 20: 507–508. DOI 10.1007/s00334-011-0324-0.
- BOLDSSEN I. 1994. Plantemakrofossil-analyse fra det tidligste København, Kompagnistræde 28 & Rådhusstræde 6. NNU Report 11. The National Museum, Copenhagen.
- der BROCKHAUS F.A. 2004. Leinsamen. In: Lexikonredaktion des Verlages F.A. Brockhaus (ed.) *Ernährung 2004. Gesund essen, bewusst leben.* F.A. Brockhaus, Mannheim, Leipzig.
- FREDSKILD B. 1966. Unpublished Report. NNU J.nr. A5358. The National Museum of Denmark. Copenhagen.
- HARILD J.A. 1997. Arkæobotaniske analyser af prøver fra Heldumbøl, HOL 20.227 NNU J.nr. A7846. NNU Report 22. The National Museum of Denmark. Copenhagen.
- HARILD J.A. 1999. Arkæobotaniske undersøgelser af flotationsprøver fra Nr. Felding. NNU Report 29. The National Museum, Copenhagen.
- HARILD J.A. 2005. Unpublished report. Toruplund. The National Museum of Denmark. Copenhagen.
- HARILD J.A. 2007. Arkæobotaniske analyser af prøver fra to fynske brønde fra Hestehavevej 1 og Horsemosegaard. NNU Report 18. The National Museum, Copenhagen.
- HARILD J.A. & ANDREASEN E.R. 1999. Arkæobotanisk og pollenanalytiske undersøgelser af prøver fra voldstedet Tønderhus. NNU Report 5. The National Museum, Copenhagen.
- HARILD J.A. & KARG S. 2009. Makrofossilanalyse af gytjaprøver fra Ronæs Skov. In: Andersen S.H. (ed.), *Ronæs Skov. Marinarkæologiske undersøgelser af en kystboplads fra Ertebølletid.* Jysk Arkæologisk Selskabs Skrifter, 64: 231–236.
- HARILD J.A. & PEDERSEN L.H. 2001. Makrofossil- og pollenanalyse af materiale fra tre brønde ved Hvissinge Vest, Glostrup. NNU Report 18. The National Museum, Copenhagen.
- HARILD J.A. & ROBINSON D.E. 2002. Plantemakrofossilanalyse af materiale fra middelalderlige lag (o. 1200-1600) fra Møllegade 8-10, Aalborg (ÅHM 3536; NNU j.nr. A 7993). NNU Report 3. The National Museum, Copenhagen.
- HARILD J.A., ROBINSON D.E. & HUDLEBUSCH J. 2007. New Analyses of Grauballe Man's Gut Contents: 154–187. In: Asingh P. & Lynnerup N. (eds.), *Grauballe Man. An Iron Age Bog Body Revisited.* Aarhus University Press, Aarhus.
- HELBÆK H. 1938. Planteavl. In: G. Hatt (ed.) *Jernalders Bopladser i Himmerland.* Aarb. f. nord. Oldkynd. og Hist., 1938: 113, 165, 216, 249.
- HELBÆK H. 1950. Tollund Mandens sidste Maaltid. Et botanisk bidrag til belysning af oldtidens kost. Aarb. f. nord. Oldkynd. og Hist., 1950: 311–341.
- HELBÆK H. 1951. Ukrudtsfrø som Næringsmiddel i forromersk Jernalder. KUMML, 1951: 65–74.
- HELBÆK H. 1953. Sæddodder og Korn paa Bornholm i det 13. Aarhundrede. *Bornholmske Samlinger*, 33: 9–15.
- HELBÆK H. 1958. Grauballemandens sidste måltid. KUMML, 1958: 83–116.
- HENRIKSEN P.S. 2002. Arkæobotanisk undersøgelse af materiale fra yngre jernalder fra fire lokaliteter udgravet af Haderslev Museum. NNU Report 7. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2003a. Arkæobotaniske undersøgelser af materiale fra Bjerre Plads 7, en hustomt fra yngre bronzealder i Thy. NNU Report 6. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2003b. Arkæobotaniske undersøgelser af materiale fra Kroppedal. Museum for Astronomi, Nyere Tid og Arkæologi. NNU Report 12. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2004. Tinglev Kirke, arkæobotanisk undersøgelse af en hustomt fra yngre jernalder. NNU Report 5. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2006a. Hundborg,Thy. De arkæobotaniske undersøgelser. NNU Report 17. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2006b. Tinggård,Thy. De arkæobotaniske undersøgelser NNU Report 16. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2007a. Tinghøj I, SMS 927A. Gennemsyn af makrofossilprøverne. NNU Report 7. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2007b. Makrofossilanalyserne fra Hus CCCXV, Vorbasse. NNU Report 8. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2009a. Færgelunden. MFG 372/06/MFG 395/06. Arkæobotaniske analyser. NNU Report 8. The National Museum, Copenhagen.
- HENRIKSEN P.S. 2009b. Tinggård, Thy. Gennemsyn af makrofossilprøver 2009. NNU Report 22. The National Museum, Copenhagen.
- HENRIKSEN P.S. & HARILD J.A. 2002. Smedegård, en byhøj fra Thy. Arkæobotaniske under-

- søgelser. NNU Report 20. The National Museum, Copenhagen.
- HENRIKSEN P.S. & HARILD J. A. 2005. Hør-industrien på Fyn i yngre jernalder. NNU Report 13. The National Museum, Copenhagen.
- HENRIKSEN P.S. & HARILD J.A. 2008. Rynkeby Mølle. Makrofossilanalyser fra brønd DMT. NNU Report 15. The National Museum, Copenhagen.
- HENRIKSEN P.S. & ROBINSON D.E. 1994. Arkæobotaniske analyser af kornfundet fra Overbygård, Østerbølle, Fjand og Alrum. NNU Report 12. The National Museum, Copenhagen.
- HENRIKSEN P.S. & ROBINSON D.E. 1996. Early Iron Age Agriculture: archaeobotanical evidence from an underground granary at Overbygård, Northern Jutland, Denmark. *Veget. Hist. Archaeobot.*, 5: 1–11.
- HENRIKSEN P.S., HARILD J.A. & JENSEN P.M. 2009. De arkæobotaniske analyser af materialet fra Nr. Hedegård. In: M. Runge (ed.) *Nørre Hedegård. En nordjysk byhøj fra ældre jernalder*. Jysk Arkæologisk Selskabs Skrifter, 66: 247–252.
- HERBIG C. & MAIER U. 2011. Flax for oil or fibre? Morphometric analysis of flax seeds and new aspects of flax cultivation in Late Neolithic wetland settlements in southwest Germany. *Veget. Hist. Archaeobot.*, 20: 527–533. DOI 10.1007/s00334-011-0289-z.
- HJELMQVIST H. 1955. Die älteste Geschichte der Kulturpflanzen in Schweden. *Opera Botanica*, 1:3.
- HOLMBOE J. 1927. Nytteplanter og ugræs i Osebergfundet. *Osebergfundet* 5: 1–78. Universitetets Oldsaksamling, Oslo.
- JESSEN K. 1933. Planterester fra ældre Jernalder i Thy. *Bot. Tidsskr.*, 42: 257–288.
- JESSEN K. 1951. Oldtidens korndyrkning i Danmark. *Viking, Tidsskrift*, 50: 125.
- KARG S. 2001a. Tværfaglige undersøgelser af middelalderlige aflejringer og anlæg ved Susåen i Næstved, Sydsjælland (NÆM 1998:113, NNU j.nr. A8163). NNU Report 28. The National Museum, Copenhagen.
- KARG S. 2001b. Blomster til de døde. Urter og blomster fra 14 renaissance-, barok- og rokokobegravelser i Helsingør Domkirke. Skt. Olai Kirke. Restaureringen af Helsingør Domkirke 2000–2001 og undersøgelserne af de borgerlige begravelser (Flowers for the dead. Herbs and flowers from 14 renaissance, baroque and rococo graves from Helsingør Cathedral. St Olai church. Restoration of Helsingør Cathedral 2000–2001 and investigations of the civil graves). Helsingør Kommunes Museer. Helsingør, 2001, 133–142.
- KARG S. 2003a. Friggas hellige plante – hør i offerkar fra jernalderen [Freias holy plant – flax in a offering pot dated to the Iron Age]. *NYT (News from the National Museum of Denmark)*, 100: 10–13.
- KARG S. 2003b. Seltsame Gruben in einem Feuchtgebiet in Jütland, Dänemark. *NAU (Nachrichtenblatt Arbeitskreis Unterwasserarchäologie)*, 10: 43–46.
- KARG S. 2005. Tørskoet langs Susåen? Tværfaglige undersøgelser af middelalderlige aflejringer og deres tolkning [Dry-shod along the Suså river? Interdisciplinary investigations of medieval deposits and features in Næstved, Southern Sealand]. In: T. Roland (ed.) *Bolværker – fra middelalderen og nyere tid [Wharfs – from the Medieval Age and the Early Modern Times]*. Næstved Museum 2005, 131–138.
- KARG S. (ed.). 2007. *Medieval Food Traditions in Northern Europe*. PNM Series of the National Museum of Denmark. *Studies in Archaeology and History* 12. Copenhagen, 2007, 230 pages
- KARG S. 2008. Diversität der Nutzpflanzen im Mittelalter Nordeuropas. *Archäologische Informationen*, 31: 97–102.
- KARG S. 2010. Food from gardens in Northern Europe – Archaeobotanical and written records dated to the medieval period and early modern times, pp. 115–125. In: Bakels C., Fennema K., Out W.A., Vermeeren C. (eds). *Van Planten en Slakken – of Plants and Snails*. Festschrift for Wim Kuijper. Sidestone Press, Leiden.
- KARG S. (ed.) 2011. *FLAX – New research on the cultural history of the useful plant *Linum usitatissimum* L.* Special issue of the *Springer Journal Veget. Hist. Archaeob.*, 20/6.
- KARG S. 2011. New research on the cultural history of the useful plant *Linum usitatissimum* L. (flax), a resource for food and textiles for 8,000 years. *Veget. Hist. Archaeob.*, 20: 517–526. DOI 10.1007/s00334-011-0326-y.
- KARG S., FLENSBORG C. 2010. Plantefund fra latriner dateret til Nyere tid fra Helsingør Kulturværft, Helsingør Kommune, Nord Sjælland GIM 3907 og GIM 3920, NNU J.nr. A8837. NNU Report 21, 2010. The National Museum. Copenhagen.
- KARG S., HENRIKSEN P.S., ETHELBERG P. & SØRENSEN A.B. 2004. Gården og markerne i jernalderen. Fosfatanalyser og forkullet korn fortæller om gårdenes indretning og om agerbrug fra yngre romersk og ældre germansk jernalder i Sønderjylland [Iron Age farms and fields in Southern Jutland]. Nationalmuseets Arbejdsmark, 2004, 139–151.
- KELERTAS K. 1997. *Agricultural Food Systems and Social Inequality: The Archaeobotany of Late Neolithic and Bronze Age Thy, Denmark*. Unpublished PhD Thesis. University of California, Los Angeles.
- KIRLEIS W., FEESER I. & KLOOSS S. 2011. Umwelt und Ökonomie, Frühe Bauern in Norddeutschland. *Archäologie in Deutschland*, 2: 34–37.
- KÖRBER-GROHNE U. 1987. *Nutzpflanzen in Deutschland*. Theiss. Stuttgart.
- KREUZ A. 2007. Archaeobotanical perspectives on the beginning of agriculture north of the Alps. 259–294. In: Colledge S, Conolly J (eds), *Archaeobotanical*

- perspectives on the origin and spread of agriculture in southwest Asia and Europe. Left Coast Press, Walnut Creek.
- MIKKELSEN P.H. 2000. Arkæobotanisk undersøgelse af materiale fra Hvidhøjgård, Sønderjylland - foreløbige resultater. NNU Report 34. The National Museum, Copenhagen.
- MOLTSEN A. 1999a. Lag- og makrofossilanalyse fra Admiralgade i København NNU Report 58. The National Museum, Copenhagen.
- MOLTSEN A. 1999b. Makrofossilanalyse af jordprøver fra Mårtenstorget i Lund. NNU Report 14. The National Museum, Copenhagen.
- MOLTSEN A. 1999c. Rester af gammelt staldmiljø fra Ninna Bangs Plads (Pilestræde i København G.nr. KBM 2030) NNU Report 11. The National Museum, Copenhagen.
- MOLTSEN A. & HENRIKSEN P.S. 1998. Arkæobotaniske undersøgelser fra Kgs. Nytorv, København. NNU Report 29. The National Museum, Copenhagen.
- MOLTSEN A.M., HARILD J.A. & MALMROS C. 1999. Funktionsinddeling af to jernalderhuse baseret på indholdet af frø i stolpehuller (Skovborglund II) & Analyse af et trækar fra vikingetiden (Skovborglund III). NNU Report 22. The National Museum, Copenhagen.
- OBERDORFER E. 2001. Pflanzensoziologische Exkursionsflora für Deutschland und angrenzende Gebiete. Ulmer, Stuttgart.
- ROBINSON D.E. 1992. Plantemakrofossilanalyse af indholdet af seks brandgrave fra ældre romersk jernalder ved Vinding, Silkeborg. NNU Report 24. The National Museum, Copenhagen.
- ROBINSON D.E. 1993. En samenbrændt klump af hørfrø i et førromersk kar fra Stoustrup ved Fredericia. NNU Report 5. The National Museum, Copenhagen.
- ROBINSON D.E. 1995. Arkæobotanisk analyse af bronzealder gårdsanlæg og marksystemer ved Bjerre Enge, Hanstholm, Thy. NNU Report 15. The National Museum, Copenhagen.
- ROBINSON D.E. 1996. Analyser af forkullet korn og kornaftryk fra neolitisk anlæg ved Lønt, Sønderjylland. NNU Report 21. The National Museum, Copenhagen.
- ROBINSON D.E. 1998. Plantemakrofossiler fra Spodsbjergpladsen (Plantmacrofossils from the Spodsbjerg settlement). In: Sørensen H. (ed.) Spodsbjerg - en yngre stenalders boplads på Langeland. Rubkøbing, Langelands Museum 175-189.
- ROBINSON D.E. 1999a. Arkæobotaniske analyser af forkullet materiale fra byhøjen Vestervig, Thy. NNU Report 17. The National Museum, Copenhagen.
- ROBINSON D.E. 1999b. Vestervig. Arkæologiske udgravninger i Danmark 1999, 360. Det Arkæologiske Nævn, Copenhagen.
- ROBINSON D.E. & AABY B. 1994. Botanical analyses from the Gedesby Ship - a medieval shipwreck from Falster, Denmark. *Veget. Hist. and Archaeob.*, 3: 167-182.
- ROBINSON D.E. & BOLDSSEN I. 1991. Plantemakrofossil-analyser fra det middelalderlige Holbæk. NNU Report 3. The National Museum, Copenhagen.
- ROBINSON D.E. & BOLDSSEN I. 1992. Planterester fra et vikingetidsgrubehus ved "Birkely", Kregme i Nordsjælland. NNU Report 23. The National Museum, Copenhagen.
- ROBINSON D.E. & BOLDSSEN I. 1993. Botaniske analyser af prøver fra udgravningen ved Ribe Posthus. NNU Report 32. The National Museum, Copenhagen.
- ROBINSON D.E. & BOLDSSEN I. 2000. Arkæobotaniske undersøgelser af materiale fra enkeltgravshustomter ved Strandet Hovedgaard. NNU Report 5. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 1994. Analyse af forkullede planterester fra en boplads fra sen ældre germansk jernalder ved Solvang, Brørup Sogn, Malt Herred, Ribe amt. NNU Report 8. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 1996a. Arkæobotaniske analyser af jordprøver fra Sct. Pederstræde og Algade, Roskilde NNU Report 8. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 1996b. Arkæobotaniske analyser af jordprøver fra Provstevænget, Roskilde. NNU Report 9. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 1996c. Arkæobotaniske analyser af jordprøver fra Lotzes Have, Odense. NNU Report 16. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 1997a. Arkæobotaniske analyser af jordprøver fra Tårnby Torv, Amager. (SØL 457b) Foreløbige resultater. NNU Report 25. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 1997b. Arkæobotaniske analyser af jordprøver fra Kompanistræde, Næstved. NNU Report 6. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 1999. Arkæobotaniske analyser af forkullede planterester fra sen-neolitikum og ældre Bronzealder ved Brd. Gram, Vojens. NNU Report 21. The National Museum, Copenhagen.
- ROBINSON D.E. & HARILD J.A. 2005. Agrarøkonomi og omgivende landskab (Agrarian economy and surrounding landscape). In M.S. Kristiansen (ed.) Tårnby. Gård and landsby gennem 1000 år. *Jysk Arkæologiske Selskabs Skrifter* 54: 423-446.
- ROBINSON D.E. & KARG S. 2001. Arkæobotaniske analyser, Nationalmuseet 2001. *Archaeobotanical analyses 2001. Arkæologiske udgravninger i Danmark 2000*: 369-380. Det Arkæologiske Nævn, Copenhagen.

- ROBINSON D.E. & KARG S. 2002. Arkæobotaniske analyser, Nationalmuseet 2001. Archaeobotanical analyses 2001. Arkæologiske udgravninger i Danmark 2001: 323–332. Det Arkæologiske Nævn, Copenhagen.
- ROBINSON D.E. & PEDERSEN L.H. 1994. Undersøgelse af planterester i en affaldsgrube fra førromersk jernalder ved Frederiksdalvej, Randers. NNU Report 10. The National Museum, Copenhagen.
- ROBINSON D.E., BOLDSSEN I. & HARILD J.A. 1995. Makrofossilanalyse af materiale fra Spodsbjerg, en boplads fra mellem-neolitikum (MNV) på Langeland. NNU Report 7. The National Museum, Copenhagen.
- ROBINSON D.E. HARILD J.A. & NANSEN P. 2002. Plantemakrofossil- og parasitanalyse af materiale fra et lokum og fra en formodet skelgrøft fra 1100-tallet samt fra et lag med smedeaffald fra 1200-tallet ved Skomagergade 19, Roskilde (Plant macrofossil and parasiteanalysis of material from a latrine and a presumed property boundary from the 12th century together with smithing waste from the 13th century at Skomagergade19, Roskilde). NNU Report 1. The National Museum, Copenhagen.
- ROBINSON D.E., HARILD J.A. & PEDERSEN L.H. 2000. Arkæobotaniske undersøgelser af materiale fra en brønd ved Vallensbæk Nordmark. NNU Report 30. The National Museum, Copenhagen.
- ROBINSON D.E., HARILD J.A. & PEDERSEN L.H. 2001. Arkæobotaniske analyser af materiale fra to brønde ved Kragehavegård, Høje Taastrup. NNU Report 10. The National Museum, Copenhagen.
- ROBINSON D.E., MIKKELSEN P.H. & MALMROS C. 2009. Agerbrug, driftsformer og planteressourcer i jernalder og vikingetid (500 f.Kr.-1100 e.Kr.): 117–142. In: Odgaard, B. & Rømer J.R. Danske landbrugslandskaber gennem 2000 år. Fra digevoldinger til støtteordninger. Aarhus University Press.
- ROBINSON D.E., MOLTSEN A. & J.A. HARILD. 1995. Arkæobotaniske analyser af bronzealder gårdsanlæg og marksystemer ved Bjerre Enge, Hanstholm, Thy. NNU Report 15. The National Museum, Copenhagen.
- RUNGE M. & HENRIKSEN P.S. 2007. Danmarks ældste hørindustri. Fynske Minder 2007: 145–165. Odense City Museum.
- SARAUW G.F. 1899. De ældste spor af Sædarternes Dyrkning i Sverige. Förh. V. d. 15. skand. Naturforkarem. I Stockholm 1889: 293.
- VIKLUND K. 2011. Flax in Sweden: the archaeobotanical, archaeological and historical evidence. *Veget. Hist. Archaeobot.*, 20: 509-519. DOI 10.1007/s00334-011-0325-z.