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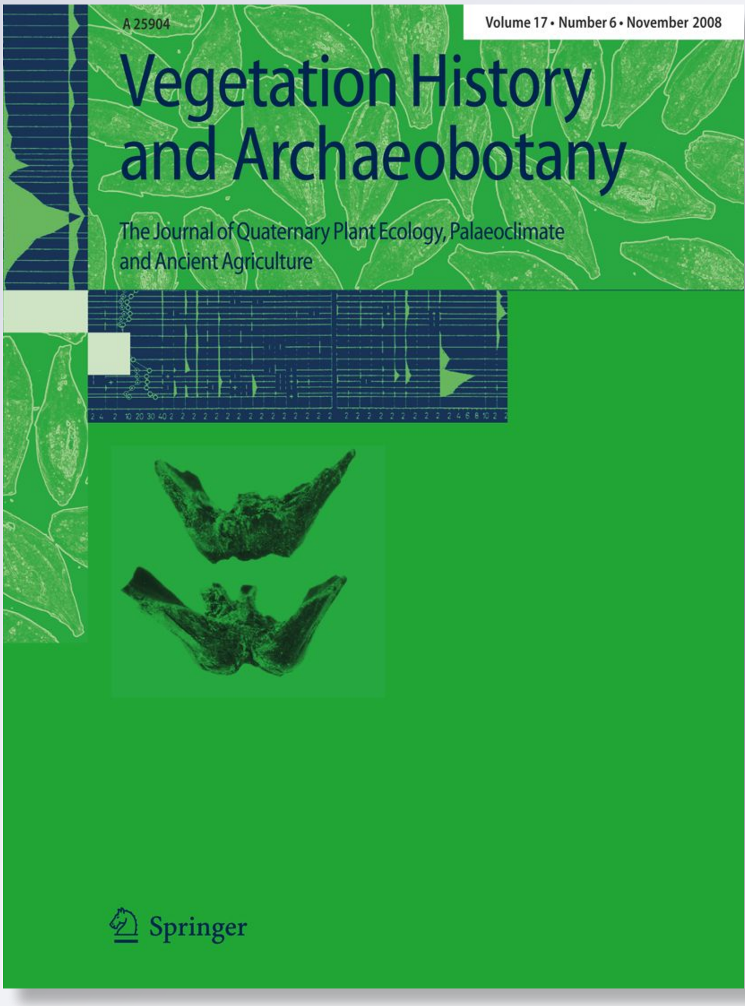

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REVIEW

Crop growing and gathering in the northern German Neolithic: a review supplemented by new results

Wiebke Kirleis · Stefanie Klooß · Helmut Kroll · Johannes Müller

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Abstract New archaeobotanical results from 15 Neolithic sites in northern Germany are presented in a review of the Neolithic plant economy in northern and north-western Europe. Available archaeobotanical data from north-western Europe are evaluated and compared with our new results. In the whole region, barley and emmer were the main crops. Regional and diachronic differences are observed in the cultivation of einkorn, spelt and naked wheat. For oil plants and pulses only rare information from macro remains is available, as we mainly deal with charred material. It is noticeable that gathered plants played an important role in the Funnel Beaker economy. Plant choice, especially the relevance of cultivated versus gathered plants is discussed, based on new and existing data. Based on a structural comparison of charred plant assemblages from domestic sites and tombs, we develop a research hypothesis that settlement finds provide insight into production and consumption of food from crops, while tombs mainly yield evidence of plants gathered in the wild or in semi-wild areas in the vicinity of former settlements. Therefore, we suggest a model of different purposes and meanings of plants, depending on whether primarily an economic or a social/ritual sphere is regarded. But, for all evaluations and interpretations, it is essential to consider the taphonomic processes and conditions. Therefore, further research is necessary to verify our hypothesis, which derives from first insights into new material.

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Introduction

In northern Germany, the process of Neolithisation started around 4100 cal. B.C. when settlers with agrarian food production first appeared during the Funnel Beaker Culture (FBC). The period of transition from hunter-gatherer to agro-pastoralist communities and its social and environmental implications is still under debate (Behre 2007; Hoika 1993; Fischer 2002; Rowley-Conwy 2004; Zvelebil 2005; Müller 2009a). Before 4100 cal. B.C., no reliable evidence of cultivated plants is known for the Baltic region (Hartz et al. 2002), and even until 3600 cal. B.C., the intensity of subsistence economy seems to be low. Around 3600 cal. B.C., however, suddenly, social differentiation is expressed through a new kind of monumentality in which causewayed enclosures and new burial rituals evolve. In quite a short period of time, thousands of megalithic tombs were erected and large enclosures built (Fritsch et al. 2010; Müller 2011a). Together with this development, a change in husbandry seems likely as agricultural products become the main basis of the economies (Furholt 2010; Kirleis et al. 2011; Müller 2009a). However, little is known about the details of husbandry practices in northern Germany for the Neolithic period from an archaeobotanical point of view, up to now. In this paper we will present the archaeobotanical state of the art of northern and north-western Europe and supplement it with recently collected data from 15 Neolithic sites in northern Germany (Fig. 1). This is the first collection from ongoing investigations within the priority programme research project on “Agriculture and environment as basis for early monumentality” (SPP 1400) that aims to extend the number of investigations producing representative data for the northern German Neolithic. The close collaboration with the archaeologists allows for consideration of different archaeological contexts like settlements, tombs and enclosures and thus opens the opportunity to examine the past economy as well as social and ritual aspects of past societies.

Regional settings in northern Germany in the Neolithic

Archaeological background

The FBC covers a rather long time span, starting around 4100 cal. B.C. and ending around 2800 cal. B.C. (Fig. 2). This period lies within the Early and Middle Neolithic periods for northern Europe (left part of Fig. 2; Müller et al. 2010). In the Middle Elbe and Saale region, the southern FBC is already placed within the Younger and Late Neolithic of this area (right part of Fig. 2; TRB).

The distribution area of FBC covers not only western, central and northern Germany, but also the eastern Netherlands, southern Scandinavia and most parts of Poland (Fig. 1; Bakker 1979; Müller 2011a). The northern group of FBC comprises the region of southern Scandinavia, the Cimbric peninsula (Jylland, Denmark and northern Germany) and north-eastern Germany, where the archaeological periods are quite similar (left side of Fig. 2). Further south, at the northern fringe of the central European lower mountain range, a different scheme of archaeological periods is established (right side of Fig. 2).

The FBC is in the north followed by Single Grave groups (SGC) and Late Neolithic Dagger groups. In the neighbouring countries some other archaeological groups are prevalent and will be introduced at the beginning of the relevant section.

Archaeologists separate four different site types for the northern German Neolithic, out of which two are most important for the interpretation of the archaeobotanical data. *Megalithic tombs* (1) are the most prominent Neolithic sites. These are above ground burial chambers, built of large erratic boulders, some covered with earth or with smaller stones, and they have been the subject of intensive archaeological studies since the 19th century (Midgley 2009; Schuldt 1972; Sprockhoff 1966). In contrast, evidence is scarce for Neolithic *domestic sites* (2). On some sites there are amorphous cultural layers with plenty of artefacts, but no other features. However, post-holes indicating former huts or houses have been excavated in southern Scandinavia (Artursson et al. 2003). A further site type is the *enclosure* (3). These are circular to oval ditch and bank systems of variable size and shape, some probably of ritual function. In general, hardly any structures can be identified in the inner part. In addition, re-cuttings and thus superimposed infillings are a common pattern of the ditches (Andersen 1997; Geschwinde and Raetzel-Fabian 2009; Müller 2010). Last but not least, *intentional depositions* (4) of different artefacts have to be mentioned (Koch 1998).

The environment during the Early and Middle Neolithic in northern Germany

Based on off-site pollen data, stable mixed oak woodland and not yet advanced soil development characterised the

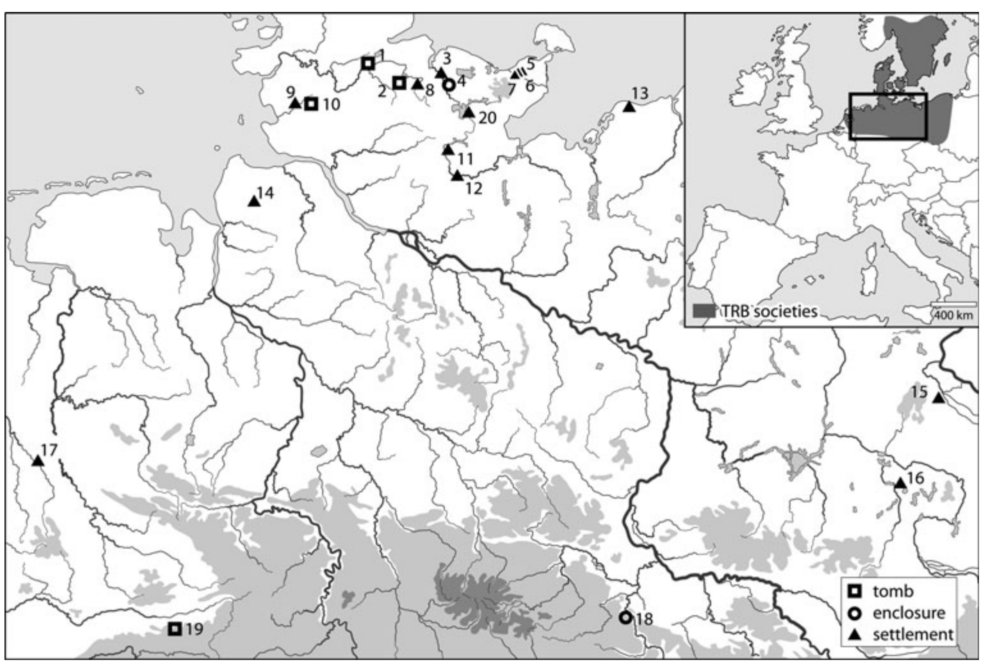

Fig. 1 Map of sites with archaeobotanical investigations at 20 Neolithic sites in northern Germany (sites in *italic* already published): **1** Borgstedt LA 35, **2** Eisendorf LA 42-44, **3** *Rastorf LA 6*, **4** Rastorf LA 73, **5** Oldenburg-Dannau LA 77, **6** *Oldenburg-Dannau LA 191*, **7** *Wangels LA 505*, **8** Flintbek LA 55, **9** Hemmingstedt LA 2, **10** Albersdorf-Brutkamp LA 5, **11** Bad Segeberg LA 93, **12** Bad Oldesloe-Wolkenwehe LA 154, **13** Zweedorf 123, **14** *Flögeln*, **15** Rathsdorf 5, **16** Selchow 10, **17** Nordhorn-Hestrup 6, **18** Belleben I, **19** Schmerlecke, **20** *Bosau*

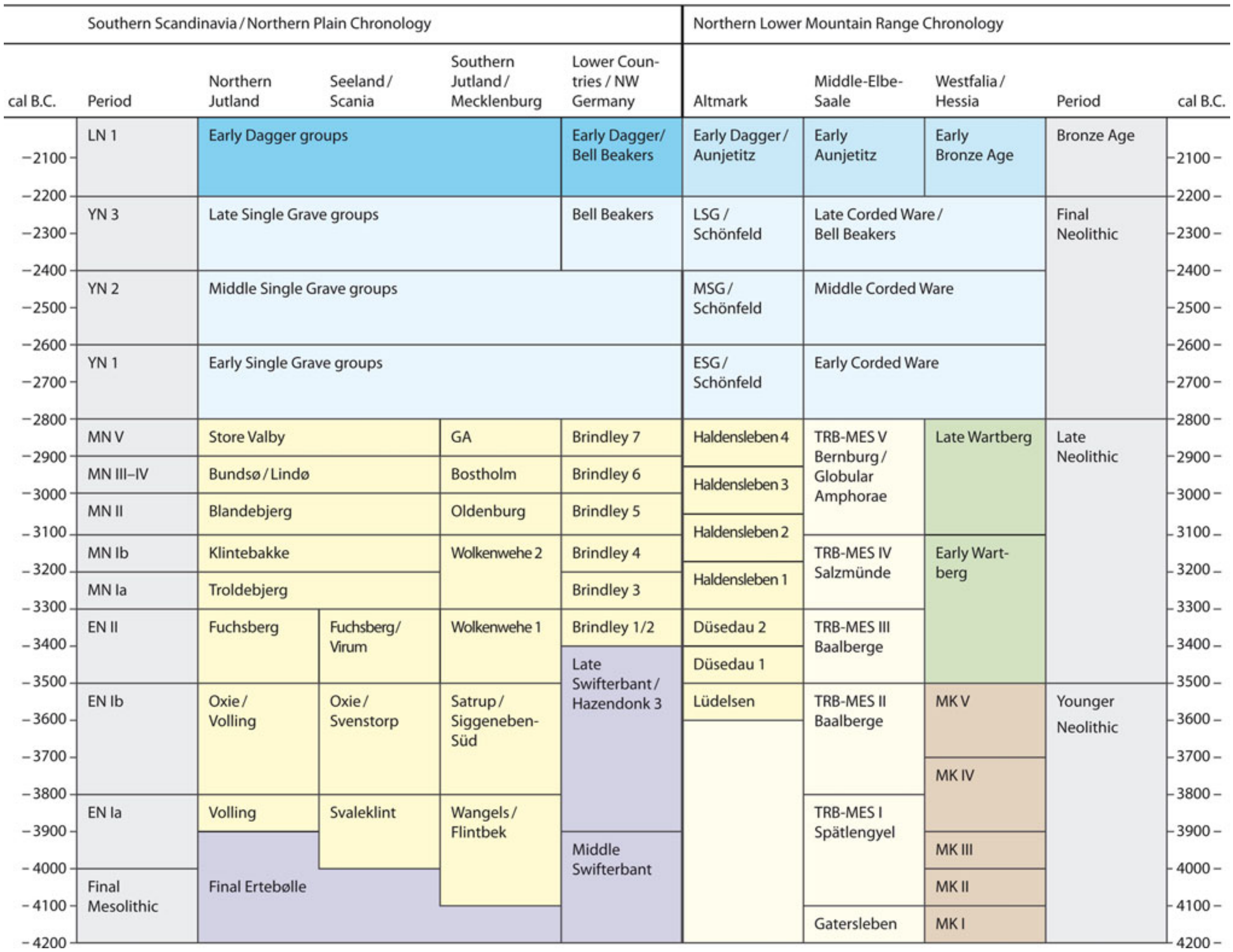

Fig. 2 Schematic chronological table of Central Funnel Beaker Groups and Single Grave development in south Scandinavia, the northern plain and the northern lower mountain range in Germany (Müller et al. 2010); *abbreviations*: *EN* Early Neolithic, *MN* Middle Neolithic, *YN* Younger Neolithic, *LN* Late Neolithic, *LSG* Late Single Grave groups, *MSG* Middle Single Grave groups, *ESG* Early Single Grave groups, *E* Early, *FB* Funnel Beaker, *MK* Michelsberg, *TRB-MES* Funnel Beaker Middle Elbe Saale, *GA* Globular Amphorae, *BB* Bell Beakers. *Yellow-shaded* cell areas: Central Funnel Beaker groups. In Sweden the Swedish-Norwegian Battle Axe culture is contemporary with Single Grave groups (both part of Corded Ware). Bell Beaker influences are present in Dagger groups. In the west Netherlands Vlaardingen is contemporary to the FBC phases 1–7 and Single Grave Groups

rather flat landscape in northern Germany at the beginning of the Neolithic. Around 3800 cal. B.C. the composition of the primeval mixed oak woodland changed when *Ulmus* declined, due to the elm disease, the use of leaf-fodder and a change to more continental-type climatic regime (Behre 2001; Dörfler 2001; Parker et al. 2002; Peglar and Birks 1993). Neolithisation (in an economic sense) in northern Germany is a process of adaptation that lasted for several generations. Well-delimited, small-scale clearings of woodland around settlements, predominantly along the coast and at a few inland sites, characterise the first phase. These activities seem to upgrade Mesolithic traditions by adding small scale agriculture, shown by evidence for domestic animals like goats, sheep and cattle and for cereals, but with limited effect on the landscape (Fischer 2002; Hartz et al. 2002; Hoika 1993). It is not before 3700 cal. B.C. that a rapid increase of *Plantago lanceolata*, pollen grains of Cerealia-type and further human indicators are observed. This “Neolithic landnam” indicates the first large-scale opening of woods and the beginnings of the formation of a cultural landscape (Iversen 1941; Kalis and Meurers-Balke 1998; Lütjens and Wiethold 1999; Behre 2001; Kirleis et al. 2011; Müller et al., in press).

This is the time when the landscape was changed by the addition of megalithic tombs as new monumental features (Müller 2009a; Furholt 2010; Mischka and Demnick 2011). People influenced the woodland composition: synchronously with settlement indicators, since values of *Tilia* (lime) decline in the off-site pollen records. The overall landscape was still dominated by woodland vegetation, but large open areas and hazel groves must have existed around settlements. Phases of woodland regeneration in the pollen records indicate changes in human pressure that vary from site to site (Kalis and Meurers-Balke 1998; Wiethold 1998; Behre 2001, 2008a; Dörfler 2008; Nelle and Dörfler 2008).

Current knowledge of Neolithic plant economy in northern and north-western Europe: a review

The interpretation of our recently collected data is only possible in a supra-regional setting. Thus, in the following we summarize the state of knowledge for northern and north-western Europe based on published investigations. As the data sets are not fully standardized yet, the estimates for the relevance of plants follow the results as given in the respective papers. Further, there is a whole range of taphonomic influences to be considered when comparing the data. For a long time it has been known that depositional and post-depositional processes on domestic and burial sites are quite complex (Willerding 1971, 1991; Bakels 1991; Sommer 1991; van der Veen 2007). The situation is further complicated as preservation conditions for old plant material heavily influence the plant assemblages (Jacomet, in press). Here, our focus is upon charred plant remains, as most evidence originates from dry land sites. Impressions in ceramic shards can hardly be used for quantification and are therefore are not considered. If evidence from waterlogged material is available, we include it in the discussion. However, our calculations are based on charred seeds and fruits only, to allow for comparison and to avoid a mixing of different biases.

The scientific nomenclature of domesticates and of wild plants follows Zander (Erhardt et al. 2002). Grain-based identifications from the literature given as "*Triticum aestivo-compactum*" and "*Triticum aestivum*" are summarised here as *Triticum aestivum/durum* or as naked wheat because a differentiation between hexaploid and tetraploid forms is possible only if threshing remains could be analysed (see identification criteria in Jacomet 2006). The hulled and naked forms of barley are listed as *Hordeum vulgare*, hulled, or *Hordeum vulgare*, naked.

Definitions to understand the early economy: crops, weeds and gathered plants

As a prerequisite to assess the early economy based on macro remains, the plants are grouped as crops, weeds and gathered plants based on ethnographic data. Cereals, home-grown pulses and opium poppy as domesticated taxa are added here to the group of cultivars. As weeds we define those (unwanted) herbs that grow in arable fields and hardly contribute to food production although there may be some exceptions (see below). As the status of *Panicum miliaceum* (broomcorn millet) in the European Neolithic is still under debate (Hunt et al. 2008; Kreuz et al. 2005) and evidence seldom exceeds single grains, we have listed it as a weed here, assuming that it was introduced with seed corn.

As gathered plants we define those that are intentionally collected in the wild, usually in the vicinity of a domestic site to contribute to people's diet (Moerman 1998). It can, however, not totally be excluded that such plants were somehow tended. Their use can be detected by finds in the intestines of bodies, a high frequency in samples as well as storage finds. Based on these facts the most common collected plants in Neolithic assemblages are *Corylus* (hazelnut) and *Malus* (crab apple). In addition, *Prunus spinosa* (sloe), *Rubus idaeus* (raspberry), *R. fruticosus* (blackberry) and others occur. Here, we also allocate the weedy plants *Chenopodium album* (fat hen), *Polygonum lapathifolium/persicaria*, *P. convolvulus* and *Bromus* as gathered plants because they may contribute to the daily diet. The compilation of Behre (2008b) shows their relevance as food from Early Neolithic (Linearbandkeramik) to modern times. There are also really high numbers and large concentrations of such plants for example in Neolithic lakeshore settlements in the surroundings of the Alps (Maier 2001; Jacomet 2009). Worth mentioning are for example, the 54,518 seeds of *Chenopodium album* (fat hen) in a pot from the Neolithic (around 3600 cal. B.C.) lakeshore settlement of Niederwil, Switzerland (van Zeist and Boekschoten-van Helsdingen 1991). In addition, the use of fat hen as a gathered plant for food is proven by finds in the intestines of seven European Iron Age bog bodies (Behre 2008b). Today in India the leaves and young shoots of this plant and even the seeds are used as food, and the same is true for North America (George and Dewer 1999; Board 2004, p. 146).

Northern Germany and southern Scandinavia (North group of Funnel Beaker Culture and Single Grave Culture)

The northern German and southern Scandinavian Neolithic is subdivided into the Early (EN) and Middle Neolithic (MN) with the Funnel Beaker Culture (FBC; Fig. 2, left), followed by the Younger Neolithic (YN) with the Single Grave Culture, and the Late Neolithic (LN) with "dagger groups". In the northern German plain, the results of current research assess the beginning of the EN around 4100 cal. B.C., whereas a slight delay towards 4000/3900 cal. B.C. is observed for Denmark and southern Sweden (Hartz et al. 2002; Fischer 2002; Müller 2011a). The EN can be subdivided into three phases (Fig. 2, left). Although shorter, the MN-FBC between 3300 and 2800 cal. B.C. can be subdivided into five short-lasting periods, based on a rapid development of ceramic decorations. This is followed from 2800 cal. B.C. onwards by the Younger Neolithic with the Single Grave Culture (SGC) and the Swedish-Norwegian Battle Axe Culture, both of which are part of the very widely spread Corded Ware groups, lasting until around 2400 cal. B.C. (Fig. 2). In the Late Neolithic (LN) until around 2000 cal. B.C., Bell Beaker influences (BB) and dagger assemblages are common in the region (Rassmann 1993; Vandkilde 2007).

Until the 1980s, the knowledge about Neolithic crop plants in northern Germany was mainly based on examination of ceramic imprints (Hopf 1982; Kroll 1976). Since then, only four archaeobotanical investigations on plant material from sediment samples from FBC domestic sites have been carried out, supplemented by one site dating to the LN (Table 1). There is the settlement cluster Flögeln-Eekhöltjen on a sandy moraine island surrounded by peat bogs in northwest Germany where comprehensive on-site and off-site archaeobotanical studies were carried out (Behre and Kučan 1994; Zimmermann 2008). Another four investigations deal with sites in the loamy moraine region in the east of Holstein. The settlement layer from below a megalithic tomb at Rastorf LA 6 revealed only charred material (Kroll 2001; Steffens 2009, p. 28). In the domestic site of Bosau charred cereals were concentrated in one storage pit (Kroll 1980). The settlements Oldenburg-Dannau LA 191 and Wangels LA 505 are situated at the waterfront of a former fjord of the Baltic Sea. Thus the sites reveal charred as well as waterlogged material and especially in Wangels LA 505, diverse waterlogged remains of cultivated and gathered plants, weeds and wetland plants were preserved (Kroll 1981, 2001, 2007; Klooß 2008). The periodisation and function of two further sites, the settlements Huntedorf I and Hüde I near Dümmersee in north-western Germany, are still under debate (Kampffmeyer 1991; Kossian 2007) and therefore the archaeobotanical results are not considered in this compilation.

The main cultivated plants in the FBC in northern Germany were *Hordeum vulgare* (naked barley) and *T. dicoccum* (emmer) with an emphasis on barley (Fig. 3). Exceptionally in Flögeln, hulled barley is more important than naked barley. In addition, single grains of *T. monococcum* (einkorn) and *T. aestivum* (naked wheat) occur (Table 1). Seeds of *Papaver somniferum* (opium poppy) were only found at Wangels LA 505, most of them in the waterlogged samples (Kroll 2007). Finds of opium poppy are of relevance if the spatial network of the Neolithic people is regarded. It is the only cultivated plant in the European Neolithic of which the wild ancestors have their natural range in the western Mediterranean. But, as could be shown recently, the domestication of opium poppy most possibly took place in central Europe (Salavert 2011).

The cereal spectra of the LN Bosau cannot be judged because only one single storage find was analysed (Kroll 1980). The dominance of *T. aestivum* there is in strong contrast to the FBC spectra.

In northern Germany, evidence is generally sparse for gathered plants, mainly nut shells from *Corylus*. A few charred weed seeds occur (Table 1).

Information about Neolithic agriculture in Denmark stems from—if compared with northern Germany—some more investigations of charred remains from settlements and from a few graves (Robinson 2003, 2007, p. 368; Klassen 2008). Settlements of the FBC were common on the fertile moraine soils of eastern Jylland (Jutland). Here also, agriculture was based mainly on emmer and naked barley; however, naked barley seems not to be as important as in northern Germany (Fig. 4). Einkorn is present, too. During the following SGC, from 2800 cal. B.C. onwards, for the first time the poor sandy soils of western and middle Jutland were settled. There, naked barley was the main crop grown, whereas emmer and naked wheat played a minor role. Later, when the fertile soils in the eastern part were also colonized at the end of SGC, the importance of emmer increases again (Klassen 2008). In the Late Neolithic finally, emmer, naked wheat and einkorn were of great importance, but naked barley was grown as well. For the first time—as also in other parts of Europe (Jacomet 2007a)—*Triticum spelta* (spelt) appears and reaches considerable proportions that suggest the beginning of its cultivation. But it seems likely to interpret the occurrence of *Panicum miliaceum*, although under debate (Hunt et al. 2008; Kreuz et al. 2005), and of *Avena* (oats) as representing weeds (Robinson 2003, p. 163).

In Denmark, the indications for collected plants are high in Neolithic times. *Corylus avellana* was used intensively. Several other plants were gathered, and finds of *Malus sylvestris*, *Rubus idaeus* and *R. fruticosus* occur with an even higher frequency at Neolithic sites than in the Mesolithic (Robinson 2007, p. 361). Weeds are hardly found in the Neolithic samples. Different harvesting techniques and shifting cultivation are discussed as possible explanations (Regnell and Sjögren 2006a, p. 86; Robinson 2007, p. 369).

The Swedish data on crop plants is based mainly on impressions of cereals in potsherds, supplemented by a few archaeobotanical studies on charred material (Ahlfont et al. 1995; Regnell and Sjögren 2006a, b). Early and Middle Neolithic farming was practised in the southern region and did not spread to the north of central Sweden and beyond before Late Neolithic times (Ahlfont et al. 1995, p. 151). No evidence of crop plants other than cereals has been found so far. In southern Sweden, in the region of Skåne (Scania), which shows many similarities with Denmark, various wheats dominate the material in the Early and the Middle Neolithic (FBC). These are mainly the hulled wheats, especially einkorn

Table 1 Previous archaeobotanical investigations of five Neolithic sites in northern Germany; absolute frequency (total number of remains) of charred and waterlogged plant remains (Behre and Kučan 1994, pp. 26–30; Kroll 1980, 1981, 2007; Steffens 2009, p. 28); Oldenburg water-logged: wetland plants selected; Wangels charred: without handpicked material, wetland plants selected; Wangels waterlogged: without handpicked material, partial selection

Period	EN II	MN I-IV			MN V		LN 1	
	Rastorf LA 6	Flögeln-Eekhöltjen	Oldenburg-Dannau LA 191 (charred)	Oldenburg-Dannau LA 191 (water-logged)	Wangels LA 505 (charred)	Wangels LA 505 (water-logged)	Bosau, Ostholstein	Sum
No. of analysed soil samples	12	111	10		12		6	151
Cultivars								
Hordeum vulgare, hulled		501	1				1	503
H. vulgare, naked	17	51	5,594		49		801	6,512
H. vulgare, rachis segments			4		84	3		91
Triticum monococcum		11	7					18
T. monococcum, glume bases			4					4
T. dicoccum	3	462	1,887		17		2	2,371
T. dicoccum, glume bases	5		699		410	2,720		3,834
T. aestivum/durum	7	7			2		5,339	5,355
T. aestivum, rachis					6			6
Triticum sp.		47						47
Cerealia indeterminata	12	1,378			24			1,414
Papaver somniferum					2	21		23
Sum cultivars	44	2,457	8,196		594	2,744	6,143	20,178
Gathered plants								
Bromus secalinus/ arvensis			3		2	6		11
Corylus avellana	13	45	6		1	30	1	96
Chenopodium album		1		118	4	1,624		1,747
Cornus sanguinea							3	3
Crataegus monogyna/ laevigata						3		3
Daucus carota cf.	1					2		3
Fragaria vesca						120		120
Iris pseudacorus					1			1
Malus sylvestris						94		94
Polygonum convolvulus		5	1			65		71
P. lapathifolium/ persicaria		1	4		1	53		59
Prunus sp.						1		1
Rosa sp.						9		9
Rubus fruticosus	2	4			1	130		137
R. idaeus			2	1		261		264
Sambucus nigra				4				4
Solanum nigrum						4		4
Schoenoplectus lacustris			1	38	1	156		196
Sum gathered plants	16	56	17	161	11	2,558	4	2,823
Weeds								
Atriplex patula				1		445		446
Apiaceae			1					1
Descurainia sophia					1	35		36
Echinochloa crus-galli		1						1
Galium aparine	5							5
Lamiaceae	1	1		14				16
Panicum miliaceum		1						1
Phleum					15	2		17
Poaceae			57		5	17		79
Polygonum aviculare				8		40		48
Ranunculus sp.				2				2
Rumex sanguineus-type			1					1
Solanum dulcamara			5			19		24
Spergula arvensis		1					1	2
Stellaria media		1		112		44		157
Urtica dioica/urens				21		86		107
Vicia sp.	1	3			2			6
Sum weeds	7	8	64	158	23	688	1	949
Others								
Alnus glutinosa					1	135		136
Tilia sp.	10					1		11
Sum others	10				1	136		147
Total	77	2,521	8,277	319	629	6,126	6,148	24,097

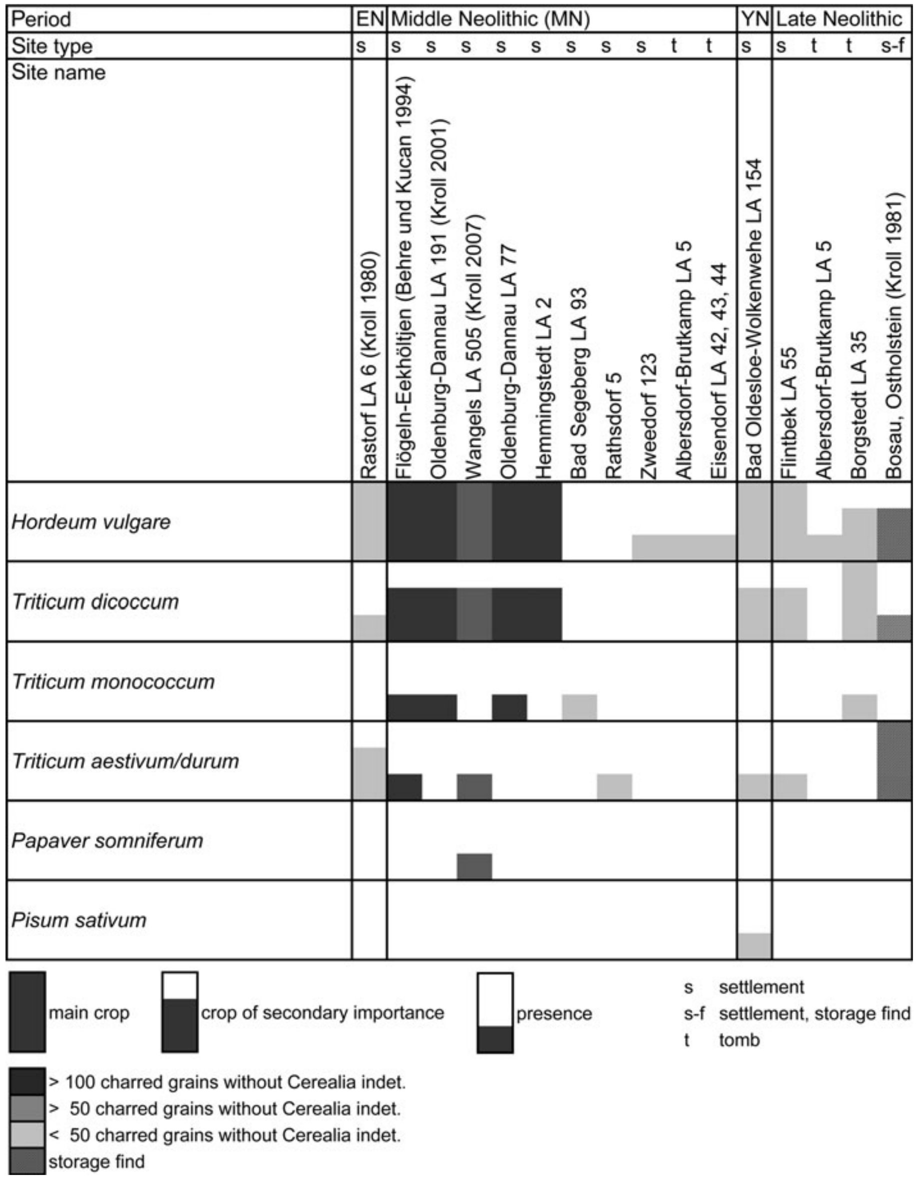

Fig. 3 Crops in the northern German Neolithic. Results of already published sites and new data; *abbreviations*: *EN* Early Neolithic, *YN* Younger Neolithic

and also emmer and possibly spelt (but note that spelt was identified from cereal grains only and thus the identification is questionable). In addition, naked wheat and naked barley were grown frequently (Engelmark 1992; Regnell and Sjögren 2006b, Fig. 32). In contrast, in the other regions of southern and central Sweden, mainly barley was grown. That can be observed at the MN pile dwelling of Alvastra in the southern Swedish region of Östergötland, where naked barley and emmer were cultivated with a clear emphasis on barley. In the YN and LN, charred finds are very few, but naked barley seems to be most common followed by emmer. Thus, beside chronological observations, barley shows a clear geographical trend and was the preferred cereal at higher latitudes and on poor soils, although it is difficult to trace general trends due to the restricted data available (Ahlfont et al. 1995, pp. 152–160; Regnell and Sjögren 2006b, p. 132).

In Alvastra the charred crop plant remains are supplemented by gathered plant remains from hazel, crab apple and others. Even though waterlogged plant material is preserved in Alvastra, cereals and gathered plants were found in a charred condition (Göransson 1995). Evidence of gathered plant remains from other sites is sparse and restricted to hazel nut shells. Evidence of weed seeds in charred assemblages is very scarce and uniform (Engelmark 1992; Regnell and Sjögren 2006a).

The Netherlands (Swifterbant, Vlaardingen and west group of FBC)

During the Neolithic period in the Netherlands, various archaeological groups are distinguished. Their distribution seems to be dependent on the natural settings of the area:

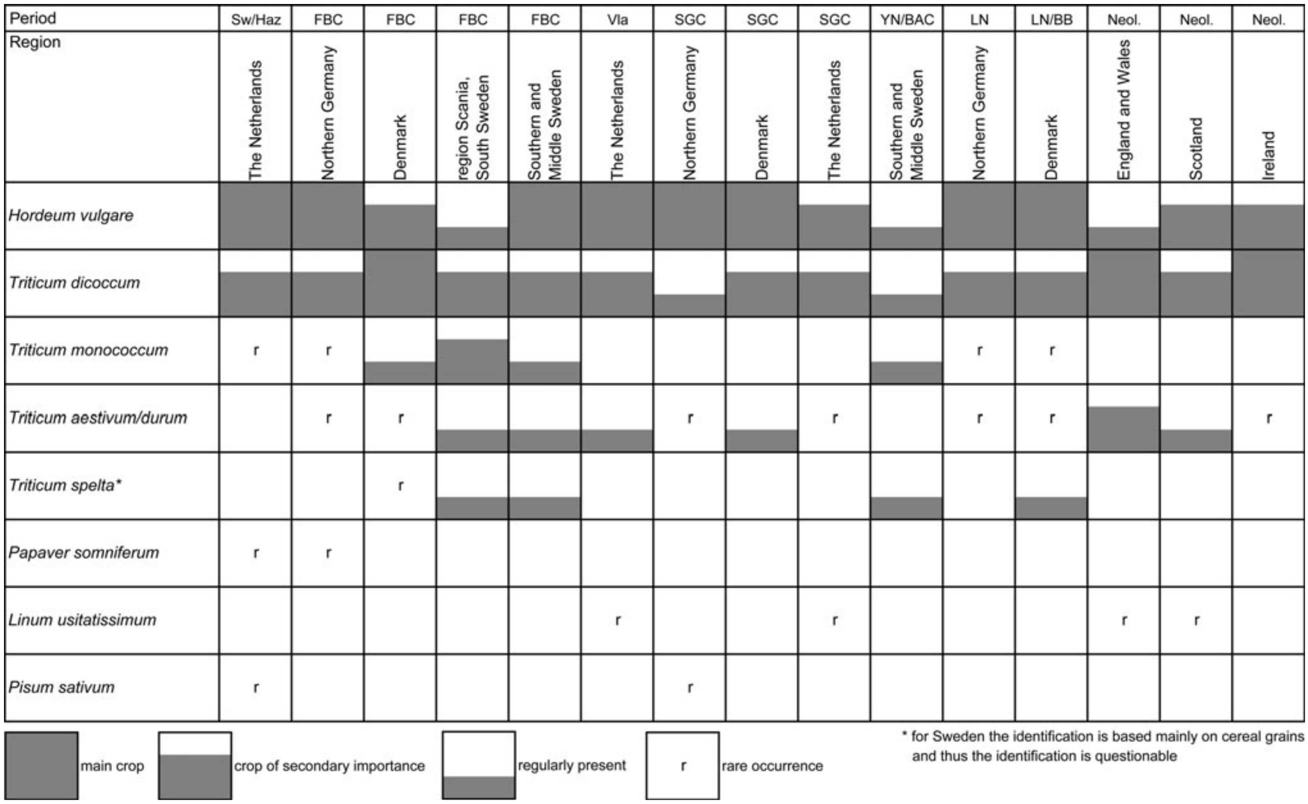

Fig. 4 Crops in northern and western Europe (references given in the text for each country); *abbreviations*: *FBC* Funnel Beaker Culture, *SGC* Single Grave Culture, *LN* Late Neolithic, *BBC* Bell Beaker Culture, *YN* Younger Neolithic, *BAC* Battle Axe Culture, *Sw* Swifterbant, *Haz* Hazendonk, *Vla* Vlaardingen, *Neol* Neolithic, *r* rare occurrence

the coastal dune areas in the centre and north, the western floodplains and southern Limburg loess areas.

The loess areas (mainly in southern Limburg) were settled since the 6th millennium cal. B.C. by farmers of pre-FBC cultures such as Linearbandkeramik, Rössen and Michelsberg (Bakels 2009). The wet river floodplains seem to have been settled around 5000 cal. B.C. until 3500 cal. B.C. by people of the Swifterbant and later Hazendonk groups. During the MN, the western group of FBC is traced in the coastal dune area in the north (Fig. 2, Brindley phases) while in the western Netherlands the Vlaardingen group in the floodplains existed at the same time as all FBC Brindley phases and the Single Grave groups. In the north of the Netherlands the SGC can be traced from 2900 cal. B.C., and from 2400 cal. B.C. Bell Beakers were prevalent in nearly all parts of the Netherlands (van Gijn and Louwe Kooijmans 2005, pp. 207 ff.).

The transition from Mesolithic to Neolithic economy in the Netherlands developed from 4900 cal. B.C. onwards and is interpreted as a process of gradual acculturation connected to Swifterbant (Out 2009, p. 443; Louwe Kooijmans 2009). Especially in the wet areas, where the possibility for crop cultivation is restricted, an extended broad-spectrum economy was present, and thus the importance of gathered plants was high. However, agricultural products were used earlier than in the area of FBC adjacent to the west. During Swifterbant, mainly naked barley and emmer occur, and these may have been taken to other regions which were unsuitable for farming. In addition, in some regions of the Netherlands, einkorn, pea and opium poppy were present, whereas no reliable evidence for naked wheat exists at this time (Out 2009, pp. 405, 444). It was not before 3400 cal. B.C. that agriculture was established as the basis for subsistence with the FBC and the Vlaardingen groups in large parts of the Netherlands. For the FBC information is limited to impressions in ceramics. Through all Neolithic time naked barley and emmer continue to be the most important crop plants (Fig. 4). Small amounts of *Triticum aestivum* and *Linum usitatissimum* (flax) occur, too (Bakels and Zeiler 2005). In the floodplains the subsistence pattern of the MN-Vlaardingen group and the YN-SGC was based on a combination of crop cultivation and foraging. The collected plants range from staple foods like hazel nut, *Quercus* (acorn) and *Trapa natans* (water chestnut) to fruits, seeds, rhizomes and roots that were consumed raw. The latter include sloe, crab apple, *Crataegus* (hawthorn) and *Ranunculus ficaria* (lesser celandine). All these were regularly found in a carbonized state. If the waterlogged remains are considered, the importance of gathered plants for the wetland site economy is even more obvious; this may however be due to a better representation of most of the gathered plants when preservation is waterlogged (Cappers and Raemaekers 2008; Out 2008, 2009, p. 442).

Great Britain and Ireland

In southeast England, Neolithic agriculture began around 4100/4000 cal. B.C. and spread by about 3800 cal. B.C. to most other areas of Great Britain and Ireland (Whittle et al. 2011). An Early Neolithic can be separated from a Late Neolithic that started around 3300 cal. B.C. The importance of cereal cultivation in the British and Irish Neolithic is unquestioned (Jones 2000; Rowley-Conwy 2004; Jones and Rowley-Conwy 2007; Bishop et al. 2009). Nevertheless, collected fruits like crab apple, blackberry, sloe and hawthorn have been regularly found in charred plant assemblages. Investigations of Moffett et al. (1989) and Robinson (Hey et al. 2003) have revealed a clear dominance of hazelnut shells in the plant spectra at several sites. Based on this, a debate on the sedentary or mobile character of the Neolithic society was initiated. However, assumptions about transience are out-dated, since plant remains from several house structures have now been analyzed (Fairweather and Ralston 1993; Monk 2000). The distinct over-representation of the gathered hazelnuts in particular, is due to taphonomic factors in most of the cases. Compared with northern Germany, the numbers of nutshell fragments are very high, up to more than 1,000 per site (Moffett et al. 1989; Monk 2000; Robinson 2000).

In England and Wales, emmer, naked wheat and barley are the main crops found, but there is no certain evidence for einkorn (Moffett et al. 1989; Robinson 2000). In contrast, in Scotland, naked barley was the main cereal, especially in the Atlantic region, most possibly due to poor soil qualities and wet climatic conditions (Bishop et al. 2009). Few flax seeds have been found either in England or in Scotland (Fairweather and Ralston 1993, p. 316; Bishop et al. 2009, p. 89). A special case here are cereal finds from Early Neolithic house sites such as Tankardstown in Ireland and Balbridie in Scotland, in which emmer dominates with minor contributions of barley and naked wheat (Fairweather and Ralston 1993; Monk 2000). In Ireland, the archaeobotanical state of the art is recently updated within the ongoing “Cultivating Societies” project funded through the INSTAR programme by the Heritage Council, Ireland and hosted at Queen’s University Belfast. Emmer, naked and hulled barley and small quantities of naked wheat were cultivated in Ireland (Monk 2000; McClatchie 2007; McClatchie et al. 2009).

Summarizing Neolithic plant economies in north-western and northern Europe

Archaeobotanical evidence is limited because rather few sites have been investigated and Neolithic sediment samples usually contain small numbers of plant remains (Figs. 5, 6). Nevertheless, some general results can be summarized for northern and north-western Europe. Ongoing studies as in Ireland (McClatchie et al. 2009), Denmark (Karg 2011) and The Netherlands (Oudemans and Kubiak-Martens 2010; Brinkkemper 2011) will broaden our knowledge on northwest European Neolithic economies in the near future, and will make it possible to corroborate or supplement the data presented here.

As carbonized material is present in all of the sites, we refer to the charred remains only to evaluate the plant economy. We are aware of the fact that gathered plants may be especially underrepresented by doing so, although in the entire area, results suggest that they were used to a considerable extent. In particular, *Corylus* nutshells have been found regularly and *Malus sylvestris* played an important role too. In contrast, evidence of weeds is limited.

In general, the main cultivated plants were *Hordeum vulgare*, mainly naked, and *Triticum dicoccum* (Fig. 4). These two cereal taxa appear in changing proportions through time and region. In southern Scandinavia, hulled wheats were prominent, whereas naked barley seems to have been more important in northern Germany and The Netherlands. Additionally, *T. monococcum*, *T. spelta* and

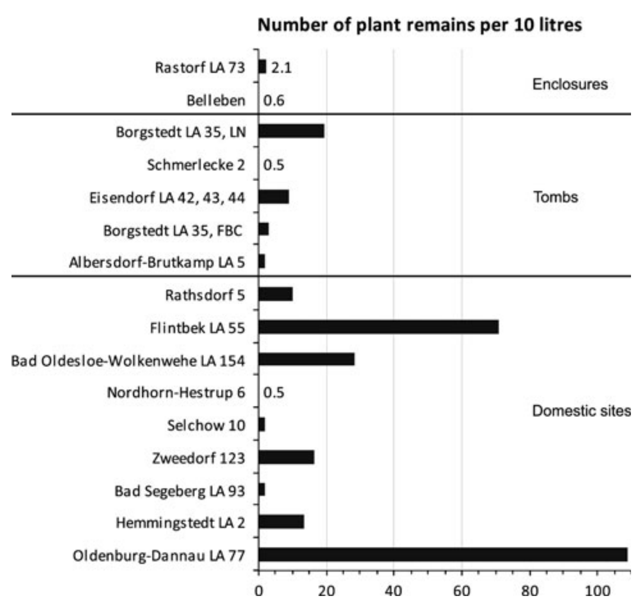

Fig. 5 Charred plant remain concentrations and archaeological context of the newly investigated Neolithic samples

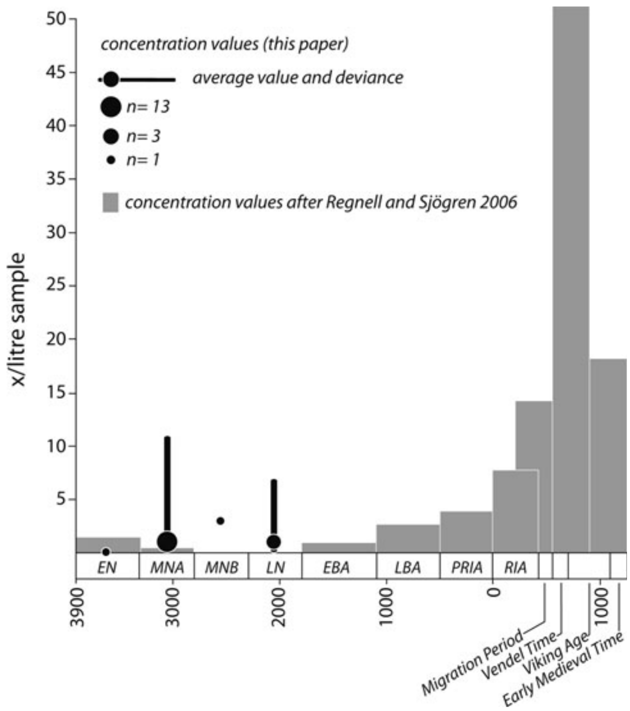

Fig. 6 A diachronic view on plant remain concentrations for charred plant remains for southern Sweden supplemented by own data (after Regnell and Sjögren 2006a, b); *abbreviations* for the Swedish chronology: *EN* Early Neolithic, *MNA* Middle Neolithic A, *MNB* Middle Neolithic B, *LN* Late Neolithic, *EBA* Early Bronze Age, *LBA* Late Bronze Age, *PRI* Pre-Roman Iron Age, *RIA* Roman Iron Age

T. aestivum/durum occur, but not everywhere and also at different times (Fig. 4); in the British Isles, *T. monococcum* is mostly absent. The occurrence of *T. spelta* is observed for southern Scandinavia only, in Sweden since EN and in Denmark at the very end of the Neolithic. *T. aestivum/durum* is absent from large parts of The Netherlands. Oil plants like *Papaver somniferum* or *Linum usitatissimum* are generally rare but present. As shown by many analyses of waterlogged Neolithic cultural layers, usually only 1–5% of *Papaver* and *Linum* remains are preserved in a charred state (Jacomet 2007b). A small number of charred remains may therefore indicate a great importance. Single finds of *Pisum sativum* (pea) represent the pulses.

Natural conditions seem to have been a main cause of the expansion of barley cultivation as it is the crop with the widest ecological amplitude that can cope with extreme ecological conditions (Brouwer 1972, pp. 309 ff.). Thus, throughout the Neolithic, we detect a spread of barley cultivation towards the climatologically less favourable central Sweden. The same tendency can be observed in the British Isles, where wet climate and poor soil qualities seem to have hindered the spread of cereals other then barley into the Atlantic region in Scotland.

Table 2 New archaeobotanical investigations of 15 Neolithic sites ▶ (equivalent to 17 chronologically separated plant assemblages) in northern Germany. Absolute frequency (total number of remains) of charred plant remains; *abbreviations*: *p.p.* pro parte, * Early Wartberg, period Late Neolithic according to the chronology for the northern lower mountain range (Fig. 2); ** TRB-MES II Baalberge, period Younger Neolithic according to the chronology for the northern lower mountain range (Fig. 2)

New archaeobotanical investigations on material from 15 Neolithic sites in northern Germany

The sites

The results of new archaeobotanical investigations of 15 archaeological sites which consist of 17 chronologically differentiated plant assemblages are shown in Table 2. Thirteen sites are distributed in the northern German lowlands, while the sites Belleben I and Schmerlecke 2 are situated in the central German lower mountain range (Fig. 1).

The investigations carried out are the first results of the archaeobotanical contribution to the current Priority programme "Early monumentality and social differentiation" funded by the German Research Foundation (DFG). The investigated material was recovered at current research excavations (Brozio 2010; Dibbern and Hage 2010; Schierhold et al. 2010; Müller 2009b; Mischka et al. 2007) and rescue excavations (Lübke 2010; Guldin 2010; Lehmphul 2010; Fries 2010). It was supplemented by material from archives and museums (Hemmingstedt LA 2).

Most of the sites date to the Early and Middle Neolithic FBC between 3600 and 2800 cal. B.C. (Figs. 2, 7). Belleben I in the central Elbe-Saale region belongs to Baalberge, and Schmerlecke 2 in Westfalen to the Wartberg group. The samples from the megalithic tomb Albersdorf-Brutkamp LA 5 have to be differentiated, because it was built around 3600 cal. B.C. during the late Early Neolithic FBC and was re-used during the Late Neolithic. The grave mound in Borgstedt LA 35 was also used from the time of the FBC and expanded into the Late Neolithic.

The investigated samples from Bad Oldesloe-Wolkenwehe LA 154 date to the Younger and Late Neolithic and belong to the Late Single Grave Culture (SGC) with Bell Beaker influences (BB), although the site reveals even earlier periods.

Materials and methods interpretation: sampling strategy and sample processing

Different archaeological contexts require specific sampling strategies. In general, a standard sample size of about 10 l of sediment was established for sites on dry mineral soil to

Period	Late Early Neolithic + Middle Neolithic																Younger + Late Neolithic								
	Settlements	Oldenburg-Dannau LA 77	Hemmingstedt LA 2	Bad Segeberg LA 93	Selchow 10	Rathsdorf 5	Nordhorn-Hestrup 6	Zweedorf 123	Tombs	Albersdorf-Brutkamp LA 5	Eisendorf LA 42, 43, 44	Schmerlecke 2 *	Borgstedt LA 35	Enclosures	Belleben I **	Rastorf LA 73	Settlements	Bad Oldesloe-Wolkenwehe LA 154	Flintbek LA 55	Tombs	Borgstedt LA 35	Albersdorf-Brutkamp LA 5	Sums Early – Middle Neolithic	Sums Younger – Late Neolithic	Total
Vol. of analysed soil samples [l]		93	280	40	39	5	41	20		400	23	480	58		870	24		24	10		81	160	2,373	275	2,648
No. of analysed soil samples		19	24	58	6	1	3	2		40	7	48	6		87	4		8	1		6	16	305	31	336
Cultivars																									
Hordeum vulgare, hulled										1								2	1		5		1	8	9
H. vulgare, naked		498	82																11		1		580	12	592
H. vulgare		64	131					2			2	2						28	4			1	201	33	234
H. vulgare, rachis segments		4																	1				4	1	5
Triticum monococcum		2		1											3						1		6	1	7
T. monococcum, glume bases				1																			1		1
T. dicoccum		35	3												4			4	3		13		42	20	62
T. dicoccum, glume bases		48		2															10		26		50	36	86
T. aestivum/durum						1												2	1				1	4	5
Triticum sp.		28				1									2								31	1	32
Cerealia indet.		304	133	1				1		1	2	8	2		29	1		9	7		16	1	482	33	515
Pisum sativum																		2						2	2
Leguminosae sativae indet.												1											1		1
Sum cultivars		983	349	5		2		3		2	4	11	2		38	1		47	38		62	2	1,400	151	1,551
Gathered plants																									
Bromus secalinus															2				8				2	8	10
Corylus avellana		8	11	1	1		5			49		1	1			2		17			7	19	79	43	122
C. avellana, immature																						2		2	2
Polygonum convolvulus			1		2										1								4		4
P. lapathifolium/ persicaria				1						2			1						1		12		4	13	17
Prunus spinosa																						1		1	1
Rubus sp.										1												1	1	1	2
R. ideaus										1												1	1	1	2
R. fruticosus		2									13												15		15
Chenopodium album		2					1					6	8		3	1			5		40		21	45	66
Nymphaea sp.																		1						1	1
Nuphar sp.																		3						3	3
Schoenoplectus sp.																		1						1	1
Sum gathered plants		12	12	2	3		6			53	13	7	10		6	3		22	14		59	24	127	119	246
Weeds																									
Avena sp., glume												1											1		1
Bromus arvensis																			4					4	4
Carex sp.		1																					1		1
Echinochloa crus-galli																			1					1	1
Euphorbia helioscopa						1																	1	1	2
Fabaceae																					1			1	1
Galium aparine										3	1								5				4	5	9
G. spurium		1									1										1		2	1	3
Galium sp.											1	1											2		2
Hypericum sp.																			1					1	1
Lapsana communis										1													1		1
Lamiaceae											1												1		1
Lolium sp.															1								1		1
Panicum miliaceum																		2	1					3	3
Plantago lanceolata																					3			3	3
Poa annua		8																	2				8	2	10
Poaceae p.p.		3										2							4		2		5	6	11
Polygonaceae p.p.												1									1		1	1	2
Rumex acetosella																					2			2	2
R. crispus															1								1		1
Vicia sp.		1	1													1					1		3	1	4
Sum weeds		14	1			1				4	4	5			2	1		2	18		11		32	32	64
Others																									
Tilia sp.. fruit																			1					1	1
Tilia sp., immature fruit										2													2		2
Tree fruit, immature																					1			1	1
Alnus sp., inflorescens (axis)										1													1		1
Arrhenatherum elatius ssp. *bulbosum*, bulbs																						14		14	14
Tuber/bulb															2								2		2
Bud										2													2		2
Short shoot						1				3			4			2					23		10	23	33
Straw fragment			2							1												1	3	1	4
Needle fragment										1													1		1
Parenchyma, ground tissue			1																				1		1
Spongy tissue																		2						2	2
Mice faeces			8		4	1							2								1		15	1	16
Sum others			11		4	2				10			6		2	2		2	1		25	15	37	43	80
Total		1,009	373	7	7	5	6	3		69	21	23	18		48	7		73	71		157	41	1,596	345	1,941

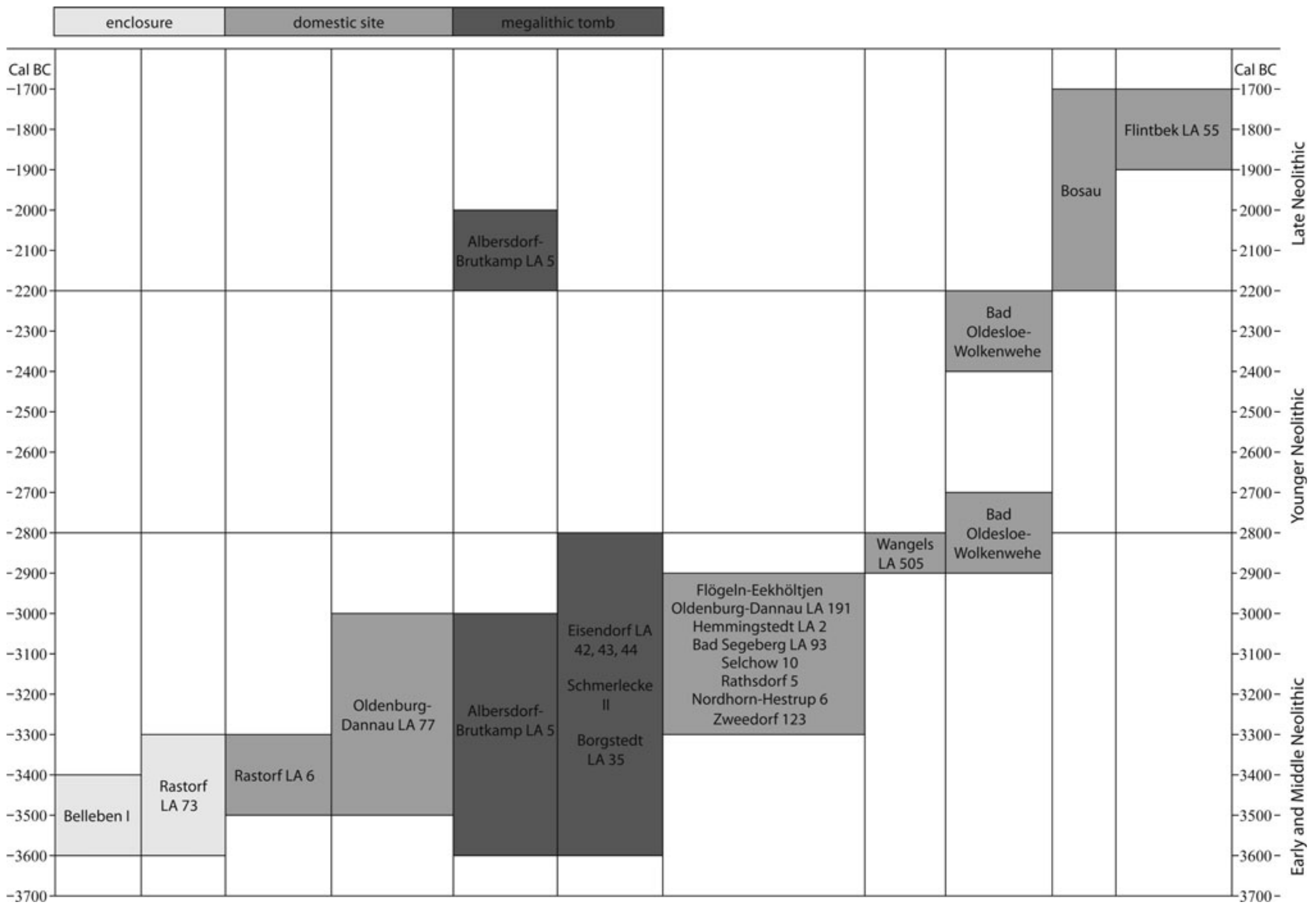

Fig. 7 Chronological settings of the investigated archaeological sites

obtain the charred plant remains. For settlement sites, quadrant- and cut-wise sampling was applied to amorphous cultural layers and to special features. Enclosures demanded sampling of ditch profiles in layers (regular ditch-profile sampling at 5 m distance was applied) plus sampling of pits in a system of quadrants and cuts, and complete sampling of postholes. At tomb sites, sampling was carried out for every square metre and, depending on excavation techniques, every layer or every 10 cm. In close collaboration with the archaeologists, these sampling strategies were adapted to the specific needs of each excavation. To extract the charred plant material, flotation was used. The derived charred material was collected on a sieve with a mesh size of 0.3 mm and dried. The heavy residue from flotation was broadly scanned for further remains, but as we mainly deal with sandy soils that easily release the charred macro-remains, there were only insignificant black particles, mainly vitrified unidentifiable charcoal.

Only the YN/LN wetland site of Bad Oldesloe-Wolkenwehe LA 154 had the potential for waterlogged material, but almost completely failed in this (Mischka et al. 2007). The inhabitants there had settled on peat layers, which were periodically flooded by the nearby river Trave, but dried out for a considerable time, probably periodically. Here, samples of 300 ml of bulk material were taken from the peaty cultural layers in a grid of every second square metre and in 10 cm layers from cuts. Wet sieving of the bulk material resulted in very few finds of waterlogged Cyperaceae fruits plus some charred cereal grains. Then a further three litres of bulk material was washed on sieves with mesh widths of 2 and 1 mm to collect further charred plant remains. The residue was dried and scanned for charred macro-remains that were hidden in dense root mats. This additional treatment also resulted in very few (charred) finds.

The plant remains were sorted and identified with Olympus SZ 51 stereomicroscopes at magnifications of ×10–40. The huge reference collection of modern seeds and fruits at the Institute of Prehistoric and Protohistoric Archaeology at Kiel University was visited regularly. Important identification keys which were also used include Jacomet (2006), Beijerinck (1947) and Cappers et al. (2006).

Results on plant economy based upon new investigations of charred plant remains

In total, 336 samples equivalent to about 2,650 l of soil from nine domestic sites, four tomb sites and two enclosures were recently investigated (Table 2), thus tripling the number of investigated Neolithic sites in northern Germany. The total sum of charred plant remains is 1,941, revealing an overall density of <1/l of sediment, which is extremely low. Density of plant remains per 10 l differs depending on the archaeological context they originate from (Fig. 5). Enclosures show the lowest concentrations (0.6–2 remains/10 l), tombs are intermediate (0.5–19 remains/10 l) whereas settlements show the highest plant remain concentrations with up to 109 remains/10 l. The generally low concentrations are common for the northern Early to Late Neolithic, when systematic sampling and flotation work is carried out (Greig 1991, p. 300; Robinson 2003; Regnell and Sjögren 2006b; Jones and Rowley-Conwy 2007, p. 401; Bogaard and Jones 2007). This is shown by comparison with Swedish data (Fig. 6).

Domesticates (Table 2)

In general, barley is the most important cereal in the newly investigated samples. Much rarer, but in second place is emmer, whereas einkorn and naked wheat have minor relevance. Leguminosae sativae (not more closely identifiable, but most probably domestic legumes) and *Pisum sativum* complement the spectrum of cultivated plants.

In the late Early to Middle Neolithic (ca. 3600–2800 cal. B.C.; FBC) samples from settlements, *Hordeum vulgare* (naked) is the most common species, but *Triticum dicoccum* occurs in somewhat larger numbers in at least one site. *T. monococcum* and *T. aestivum/durum* are rare. In the tombs of the same period there are only five (!) *Hordeum* grains from almost 1,000 l of sediment, of which only one can be attributed to hulled barley, and one piece of a not more closely identifiable seed, but probably a cultivated legume. Somewhat richer are the samples from enclosures which revealed some finds of *T. dicoccum* and *T. monococcum*, but no finds of *Hordeum*; however, most of the cereals were too damaged to be identified surely. But here as well, only 39 finds out of almost 900 l of sediment reveal an extremely low find density.

In the YN and early LN (ca. 2800–2200 cal. B.C.) settlement layers, *Hordeum vulgare* (naked) and *T. dicoccum* are the most common cereals as well and very small numbers of *H. vulgare* (hulled) and *T. aestivum/durum* grains appear, too. Two *Pisum* seeds were identified in Bad Oldesloe-Wolkenwehe LA 154. Single grains of *Panicum miliaceum* were found in both investigated settlements. The spectra from the tombs are—at least in one case—somewhat richer than in the earlier phases. They contain *T. dicoccum*, *H. vulgare* (naked and hulled). As only a few samples from just two settlements and two tombs have been investigated, the absolute find numbers are hardly comparable with the earlier phases.

Weeds

Altogether 21 different weed taxa—without *Chenopodium album, Polygonum lapathifolium/persicaria*, *Bromus* and *P. convolvulus* (which are included in the gathered plants, see definitions above)—were detected (including four identifications at family level). More than half of them occur only once or twice. So far, the number of detected weed remains is low and altogether does not exceed 70 finds (Table 2). Somewhat larger numbers stem from Poaceae p.p., *Poa annua* and *Galium aparine*. On more than two sites *G. aparine, G. spurium*, *Vicia* and Poaceae p.p. were found. *Panicum miliaceum* was found in two sites of the Younger and the Late Neolithic and is listed as a weed here (for reasons see above). *Rumex acetosella* and the perennial *Plantago lanceolata* were only found in the LN layers of the grave mound at Borgstedt LA 35.

Gathered plants

Most of the investigated Neolithic sites show evidence for gathered seeds or fruits (Table 2). It is the common taxa like *Corylus* or *Rubus idaeus* that we find here and which occur through all Neolithic periods, without showing distinct diachronic developments. On just two EN/MN sites no remains of collected plants were found.

Charred nutshells of *Corylus* were detected on two thirds of the sites. However, in most of the sites the number of nutshell fragments is low. For two settlements and two grave sites only single nutshell fragments are recorded. The highest values were obtained at the megalithic grave of Albersdorf-Brutkamp LA 5 with 68 shell fragments altogether (both phases).

Gathered fruits and seeds other than hazelnuts, including seeds of weedy plants, are recorded for 12 out of 15 sites (equivalent to 17 chronologically separated plant assemblages). “Classical” gathered fruits like *Rubus fruticosus*, *R. idaeus* and *Prunus spinosa* occur only at two megalithic grave sites and at one settlement. In the samples from the tomb at Borgstedt LA 35 charred *Chenopodium* seeds occur regularly, particularly in the burnt layer dating to the LN, then associated with charred cereal grains and nutshells of *Corylus*. At the settlement of Bad Oldesloe-Wolkenwehe LA 154, situated on a peaty island in a wet area, charred seeds of *Nymphaea* (water lily), *Nuphar* (yellow pond lily) and *Schoenoplectus* (club rush) were detected. Additionally, two sites contain only seeds of weedy plants which we list as gathered plants here.

Other charred remains

Altogether 80 further charred remains were recovered from the soil samples (Table 2). Among these are fruits of *Tilia* (lime), one inflorescence axis from *Alnus* (alder), vegetative plant parts, tissues and mouse faeces. Exciting finds are 14 bulbs of *Arrhenatherum elatius* ssp. *bulbosum* (false oat grass), as they are the first (at least first published) finds in Germany. The charred bulbs were found in the filling layer of the tomb Albersdorf-Brutkamp LA 5 and date from the time of re-use of the grave in the LN. What we call spongy tissue are fragments of roots or rhizomes. There is no sign of amorphous objects like remains from porridge or bread.

Discussion

The formation of the Early Neolithic FBC was a result of contacts between foragers and early farmers as has been discussed for the FBC-North Group (Fischer 2002; Klassen 2004; Rowley-Conwy 2004; Hartz et al. 2007a, b). It is highly possible that people merged innovative new economic strategies, where a surplus could be expected, with favourable habits that continued to be followed. The acculturation of foragers and the establishment of a "Neolithic ideology" are initially processes of gradual change-over (Louwe Kooijmans 2009; Kirleis et al. 2011; Müller 2011b). In this sense, a transition from collecting plants in the wild to crop growing might indicate the improvement of this process. Therefore, we discuss below the possible significance of gathered plants in the northern German Neolithic. The observation of the occurrences of gathered versus cultivated plant remains on different site types is also tackled below and the assumption of different activities is commented.

Upgrading the current state of knowledge of Neolithic crop growing in northern Germany

The previous state of knowledge of the FBC in northern Germany was limited to archaeobotanical information from four sites, two of them with good representation of charred remains (Oldenburg-Dannau LA 191 and Flögeln-Eekhöltjen) and Wangels LA 505 with waterlogged and charred seeds, fruits and chaff. Now, the evidence of plant remains from the northern German Neolithic is upgraded with the results from 15 new sites. Out of these, two settlement sites give representative data (Oldenburg-Dannau LA 77 and Hemmingstedt LA 2; Table 2). Additionally, data from sites with fewer plant remains confirm the conclusions. Moreover, it is possible for the first time to apply a structural approach by distinguishing between settlements, graves and enclosures (Fig. 7). The storage find from Bosau (Table 1) was formerly the only investigated material from the Late Neolithic. Four data sets for the YN and LN in northern Germany are added to the state of the art.

All data sets confirm the high importance of naked barley, with emmer as the second most common cereal in the FBC (Fig. 3). Only in Flögeln-Eekhöltjen, hulled barley plays a prominent role. Opium poppy could be proven up to now only at the site Wangels LA 505, but these very small and oil containing seeds are underrepresented in charred assemblages. For the YN and LN the data suggests the continued growing of naked barley as a main crop. Additionally, there is evidence for the cultivation of pea during SGC. Millet occurs in very small amounts in YN and LN sites and cannot really be interpreted as a crop yet. Finds of einkorn and naked wheat are present throughout the Neolithic in small numbers.

How to estimate the importance of gathered plants in charred assemblages?

The formation of the archaeobotanical record is of special interest when the importance of cultivated versus gathered plants is assessed. Depositional factors and factors related to the preservation of plant remains have to be considered (Bishop et al. 2009). First of all, in any archaeological context the archaeobotanical sample is influenced by human activity (Bakels 1991; Jacomet 2007b; van der Veen 2007; Schiffer 2010). Charred remains from settlement sites originate from layers and structures, which are mainly formed from rubbish deposits or storage during settlement activities. Thus, archaeobotanical remains—even if biased—generally represent food procuring activities, linked to processing and consumption of crops and other plants.

Under normal dry soil conditions, only charred plant remains survive for thousands of years. Therefore, the chance of plant parts to become charred fundamentally determines their occurrence in the samples (Willerding 1971, 1991). Cereals have usually good chances to survive because heating was required during their preparation. Grains and even chaff may therefore be well represented. However, as the find numbers of domesticates are low compared to those of medieval times (Fig. 6), it seems that cereal preparation (oven-drying, dehusking, crushing and grinding) in the Neolithic took place in a very careful manner and in small portions as part of a day-to-day routine.

In contrast to cereals, many gathered fruits do not need processing with heat because they are eaten raw. In general, gathered plants are therefore usually underrepresented in charred material, except when whole houses or settlements had burnt down (Maier 2001). Under "normal" circumstances the only well represented collected plant in dry land sites is hazelnut. Its nutshells are notably overrepresented in charred plant assemblages. The main reason for this may be their use as fuel. The large, dense and heavy nutshells survive well in a fire, because within the fuel they will find their way down to the ashy bottom of the fire where conditions are oxygen-poor, and therefore they do not burn to ash (Jones 2000). The real role of gathered plants we can estimate best when looking at spectra from waterlogged cultural layers. There we observe an increased diversity not only of gathered plants but also of weeds and other remains of the surrounding vegetation (Willerding 1971, 1991; Out 2009; Kroll 1981, 2007; Jacomet, in press).

When looking at the charred plant assemblages of the northern German Neolithic (Tables 1, 2) there is evidence—although sparse—for gathered plants, and there are not only the resistant nutshells of hazel but also charred fruits and seeds of *Prunus spinosa, Chenopodium album, Rubus, Schoenoplectus, Nuphar* and *Nymphaea*. Although small in number, the finds suggest the former use of these plants, because they are charred. However, most of the investigated sites in northern Germany are not very well suited to quantify the role of gathered plants in the diet. However, tendencies in the relation of domesticates versus gathered plants can be estimated if representative sites (>50 seeds and fruits for settlements and >10 for tombs) are considered. Furthermore, the lack of the usually well- or even over-represented cereal grains in the charred plant assemblages serves to show the function of a site. If charred cereal remains are hardly present and at the same time charred remains of gathered plants dominate the spectra, as is the case in the megalithic tomb Albersdorf-Brutkamp (Table 2), activities linked to agrarian food production and food processing can be said not to be characteristic for this site.

The possible relevance of plant gathering for the Neolithic economy in northern Germany

Gathered plants have supplemented people's daily diet at least throughout the Neolithic period and even today they may play an important role in non-industrialised societies. As we have learned above, collected plants are well represented only in waterlogged plant assemblages. However, they may also occur in charred assemblages. This is shown for the YN layer at Bad Oldesloe-Wolkenwehe LA 154, a non-permanent functional site within a wider settlement system that is situated in the peaty area of the Brenner Moor bog adjacent to the river Trave (Mischka et al. 2007). Although low in numbers, as well as the common charred nutshells of hazel, charred seeds of *Nymphaea* (water lily) and *Nuphar* (yellow pond lily) plus charred storage tissue were detected. The fact that all these finds originating from the natural vegetation around the settlements became charred may indicate the use of these aquatic plants as a food source. The potential of these plants as a food supply is shown by the example of North American native people of the Klamath tribe in Oregon who harvest seeds of *Nuphar lutea* ssp. *polysepala* (yellow pond lily). The seeds are ground and the resulting flour is used for bread and porridge preparation. Like cereals, the dried seeds are stored for later use. The seeds of pond lily are even reported to have the status of a delicacy (Moerman 1998, p. 358). For an ethnobotanical comparison of the use of *Schoenoplectus* we consider both *Bolboschoenus maritimus* (sea club rush) and *Scirpus* (wood club rush), as the nomenclature of *Schoenoplectus* has changed quite a lot within the family of Cyperaceae. Sea club rush is recovered frequently from ancient sites in the Middle East and interpreted as a wild food plant (Wollstonecroft et al. 2008, 2011). Seeds from several species of the genus *Scirpus* are used by Native Americans in the same way as described for water lily and pond lily (Moerman 1998, pp. 522 ff.). Thus, its listing as a gathered plant is reasonable.

Being aware of all the shortcomings of the charred material, we observe diversity in the relation of domesticates versus gathered plants (Fig. 8). There are some settlements that show almost no evidence for gathered plants and there are some sites where about 30% of the charred remains belong to gathered plants. Thus, we may ask why there are some sites with a slightly higher representation of gathered plants. At the Early Neolithic site of Rastorf, gathered plant remains (29%) are restricted to nutshells of *Corylus*. Their presence may either be attributed to taphonomic reasons or it may indicate a greater importance of foraging practices in the EN. In Middle Neolithic FBC settlements with representative results from dry land, like Flögeln-Eekhöltjen, Hemmingstedt LA 2, Oldenburg LA 77 and Oldenburg LA 191, gathered plants reach values of only 0–3%. The case of the settlement Wangels LA 505 (dating to the final stage of the FBC; Fig. 7) is more complicated because material is partly preserved under waterlogged conditions. As a necessary precondition for the calculations, only the charred finds that dominate the northern German material are considered for comparison. In Wangels LA 505 the ratio of gathered to cultivated charred plants then is 1:9 (Fig. 8). If we would include the waterlogged seeds and fruits for Wangels LA 505 (see Kroll 2001 for a complete taxa list), the relation is turned upside down. Now, cultivated seeds and fruits show an

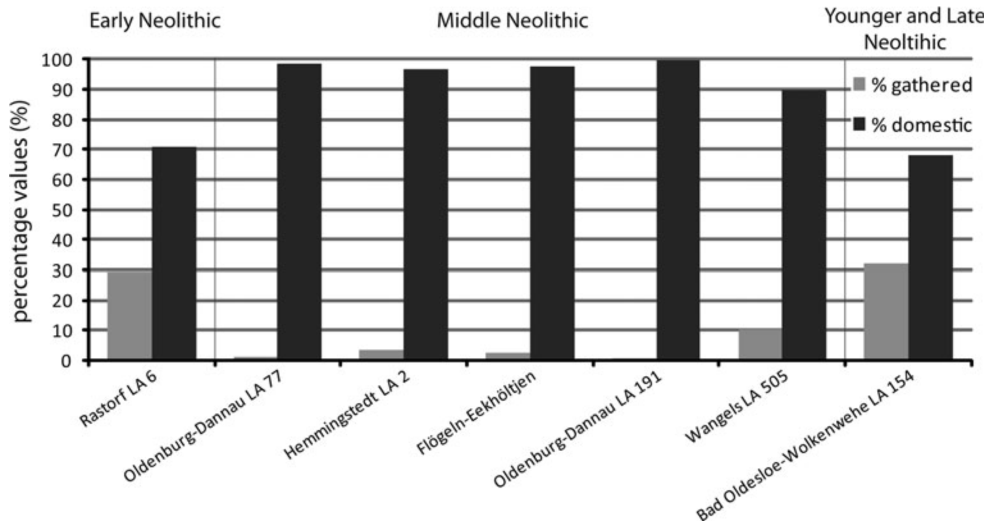

Fig. 8 Domestic versus gathered plants: proportions (%) of charred seeds/fruits from German Neolithic settlement sites with more than 50 seeds/fruits

average proportion of 7% and gathered plants one of 93%. This seems to suggest a special character of the site and fits with the over-representation of wild rather than domesticated animals in the archaeozoological record (Schmölcke 2000; Klooß 2008). However, if chaff is considered, we end up with a balanced ratio that indicates an area of the site where cereal processing took place next to other economic and social activities.

At the non-permanent functional site of Bad Oldesloe-Wolkenwehe LA 154, a tendency towards a greater representation of gathered plants is observed, if compared with the other settlement sites, although further investigations to enlarge the data base are needed here. From this example, we carefully assume (and will continue to test) that an obvious over-representation of cereals in settlements may be less evident if sites of specialized function are considered. As from a chronological point of view Wangels LA 55 belongs to a late FBC (MN) phase and Bad Oldesloe-Wolkenwehe LA 154 to a YN and LN phase (see Fig. 7), another hypothesis to be tested further on could state that the botanical evidence suggests a diversification of plant use in the early centuries of the third millennium B.C.

The possible origin of plant remains in megalithic tombs

In contrast to settlements, the history of plant assemblages in graves is even more difficult to trace. This is one reason why there are only very few archaeobotanical investigations available on Neolithic tombs. An important taphonomic aspect is that there are different functions of the plant remains in settlements and tombs (Kreuz 1995). We have to separate several single deposition events at tombs and in contrast, a longer time span of deposition in settlements. This may be one reason for the extremely divergent find numbers (Tables 1, 2). Diverse intentional activities by people influence the deposition, like grave building, funeral ceremonies or feasting, where food or plants were processed and eaten or burnt, and finally deposited near the grave or inside the grave chamber, possibly as a kind of grave goods or sacrifice. Thus, they offer the possibility of tracing the use of plants in ritual activities. But they could also have been deposited by other unintentional human factors like accidental burning. In very poor samples, such as the ones we deal with here, it might be extremely difficult to distinguish ritual activities from such unintentional factors.

At the megalithic tomb of Albersdorf-Brutkamp (Table 2), the presence of *Arrhenatherum* bulbs in archaeobotanical assemblages from the cover layer of the tomb offers various options for interpretation. Presumably, false oat grass was part of the local vegetation in the LN. The fact that the bulbs are charred suggests past fire activity. This allows for two possible interpretations; either the cover layer of the tomb consisted of turf sods that originated from an area in the surroundings that underwent fire clearance beforehand or more likely, the tomb itself was covered by *Arrhenatherum* that was burnt down when the tomb was destroyed, after which the bulbs were worked into the soil. This interpretation is supported by the finds from the megalithic tomb of Borgstedt LA 35 (Table 2; Lübke 2010). Here, 23 charred short shoots—probably of *Calluna* (heather)—indicate a ritual fire clearing on the grave mound surface before it was re-used in the LN. But, a use of *Arrhenatherum* as a gathered plant and intentional deposition of the bulbs during ritual activities cannot be excluded because the starch-rich, swollen stem internodes may have contributed to people's diet (Engelmark 1984; Preiss et al. 2005; Viklund 2002).

The only available archaeobotanical report on a central German Neolithic tomb is about the mass find of

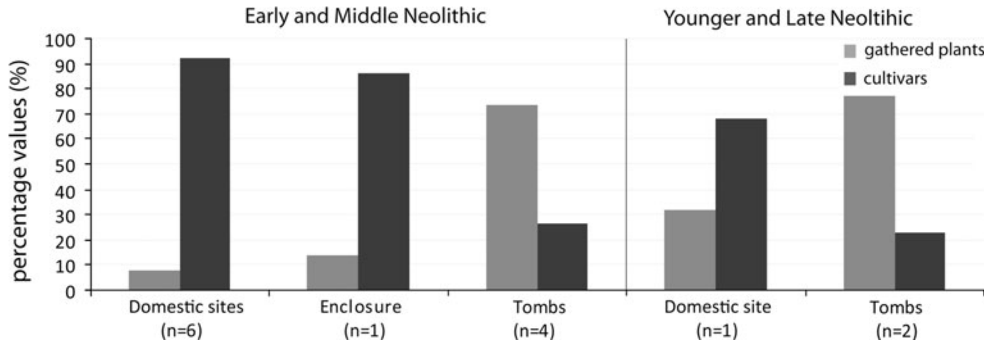

Fig. 9 Domestic versus gathered plants: average of proportions (%) of charred seeds/fruits from different archaeological site types: domestic sites, enclosures and tombs. Previous and recent archaeobotanical investigations with more than 50 seeds/fruits for settlements and more than 10 seeds and fruits for enclosures/tombs included, chaff remains are disregarded (data base: Tables 1, 2)

Onopordum acanthium seeds at the non-megalithic stone chamber grave Kreienkopp II close to Ditfurt, Sachsen-Anhalt dating to 3440–2840 cal. B.C. (Hellmund 2008). The ruderals dominate the plant assemblage, while *Triticum monococcum*, *T. dicoccum* and *Hordeum vulgare* were also present, mainly as chaff. In addition, gathered plants such as *Prunus spinosa* and *P.* cf. *padus* occurred. All the finds are interpreted as grave goods. As most of the *Prunus* stones had been opened by rodents before charring, it is assumed that the grains were deposited before the burning of the grave chamber and therefore in general, grains are hardly preserved in burial contexts.

To conclude from this, too few Neolithic tombs have been investigated so far to come up with a general picture of the relevance of plants in Neolithic burial contexts. However, these very first results show that plant assemblages in the burial ritual differ from assemblages of economic plant use in domestic sites.

Formulating a research hypothesis for future research based on a structural approach: comparing plant remain assemblages from tombs and settlements

Although the numbers of finds are low, and the origin of the plant remains in the assemblages is extremely difficult to trace, we have developed a research hypothesis that we can apply to our preliminary results here. Therefore, apart from being connected to the economy, we can place the meaning of plant husbandry and gathering within the proportion of domestic to ritual activities at the sites (see Parker Pearson 2003; Twiss 2007).

From the more representative results of the new investigations plus the results on charred material from the published sites (Fig. 9; Tables 1, 2) we assume that charred plant assemblages from differing archaeological contexts show dissimilar biases. Based on this assumption, a separation of the archaeobotanical finds according to their different contexts in the archaeological sites and periods is possible. In the EN and MN, crops (cereals and pulses) account for more than 90% of the plant remains in settlements which for this calculation are not separated into common and specialized sites. In the megalithic tombs of the FBC, 74% of the charred remains belong to wild plants that may have been gathered. Although the data base for the YN and LN is still sparse, settlements show the same pattern of an over-representation of cultivated plants. Results for YN and LN tombs are still not very clear, because only two sites have been analyzed so far. Our results from the settlement sites are consistent with the expectation that cereals dominate the domestic plant assemblages. However megalithic tombs have hardly been investigated systematically so far. We have to admit that we deal with a maximum of 130 finds per tomb site only, although intensive flotation work was carried out, and these remains may have been deposited coincidentally. But, it is shown that gathered plants can be preserved as charred remains if the circumstances during deposition are suitable. Furthermore, this is the only new evidence for Neolithic tomb sites that we have and thus worth consideration—with utmost care.

Interestingly, the emergence of new burial customs at the beginning of the late EN, expressed through the erection of the huge monumental megalithic tombs, may have been accompanied by ritual customs that were not deeply linked to the dominating subsistence activities. Such differences between main economic activities and an over-representation of "wild" activities are also known from many other archaeological sites, for example Petit Chasseur Sion (Heyd 2007). To conclude, these observations lead us to a model that has to be further tested, that in economical and in ritual spheres different activities were carried out which allocated different meanings to plants at the same time. The different "meanings" of plants as well as the different activity frequencies that are represented in the extreme differences of average numbers of plant remains in tombs and in domestic sites under discussion, describe the different roles plants have played in the ideological differentiation of Funnel Beaker societies. Not only economic reasons (as in the case of the functional site of Bad Oldesloe-Wolkenwehe) but mainly ideological reasons may have been responsible for the fact that certain plants are found in different site types. However, the hypothesis that food production and daily food consumption is shown by finds from settlements, whereas insight into rituals is given by the finds from the tombs, has to be and currently is being tested by further ongoing investigations. But, our first evidence so far clearly contrasts the opposite hypothesis, which would link the ritual sphere mainly with symbols of new agrarian activities.

Conclusions

In northern Germany, agriculture has to be assumed to have started around 4100 cal. B.C. with the formation of FBC, but archaeobotanical evidence is sparse for the first 500 years of the Neolithic. The macro-remain record indicates an intensification of crop cultivation for the late EN, around the middle of the 4th millennium cal. B.C., when social differentiation is expressed through a new kind of monumentality. Based on a compilation of old and new archaeobotanical data we present our research hypothesis on plant use in different social spheres (domestic and ritual) in northern Germany during the period 3600–2200 cal. B.C. The general view on crop growing in northern Germany is summarized as follows: in the late Early and Middle Neolithic FBC (3600–2800 cal. B.C.), *Hordeum vulgare* (naked) and *Triticum dicoccum* were the main crops, as is also common in north-western Europe. The ratio of *Hordeum* and *Triticum* however differs from region to region and is influenced by the natural settings. At the current state of knowledge, on a macro-regional scale, the northern German crops grown during the Neolithic, show the most similarities with those of The Netherlands. Evidence for weeds is very limited in northern Germany, as is generally the case in north-western Europe. The first occurrence of *Panicum miliaceum* is observed for the YN and LN after 2800 cal. B.C. Here, the finds of single grains only lead to the assumption that millet was still an introduced seed corn and not yet a crop plant. Throughout the Neolithic, collected fruits were a welcome addition to people's daily diet which supplied extra nutrients like starch, minerals and vitamins. However, it seems that the foragers' practice of fruit and seed gathering in the northern German Neolithic was carried out not only in an economic way but also in a ritual context. However its real importance is difficult to evaluate due to taphonomic factors. Further ongoing investigations will prove to what extent the use of plants is meaningful for economic as well as for ideological reasons.

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References

Ahlfont K, Guinard M, Gustafsson E, Olson C, Welinder S (1995) Patterns of Neolithic farming in Sweden. TOR 27:133–184

Andersen NH (1997) Sarup Vol. 1, The Sarup Enclosures: The Funnel Beaker Culture of the Sarup site, including two causewayed camps compared to the contemporary settlements in the area and other European enclosures. (Jutland Archaeol Soc Publ 33.1). Aarhus University Press, Århus

Artursson M, Linderoth T, Nilsson M-L, Svensson M (2003) Byggnadskultur i södra och mellersta Skandinavien. In: Svensson M (ed) I det neolitiska rummet. Skånska spår. National Heritage Board, Sweden, pp 40–171

Bakels C (1991) Tracing crop processing in the Bandkeramik culture. In: Renfrew JM (ed) New light on early farming. Recent developments in palaeoethnobotany. Edinburgh University Press, Edinburgh, pp 281–288

Bakels C (2009) The Western European loess belt: agrarian history, 5300 B.C.–A.D. 1000. Springer, Dordrecht

Bakels C, Zeiler J (2005) The fruits of the land. Neolithic subsistence. In: Louwe Kooijmans LP, van den Breoke PW, Fokkens H, van Gijn AL (eds) The prehistory of the Netherlands, vol 1. Amsterdam University Press, Amsterdam, pp 311–335

Bakker JA (1979) The TRB West Group. Studies in the chronology and geography of the makers of Hunebeds and Tiefstich Pottery. Sidestone Press, Leiden

Behre K-E (2001) Umwelt und Wirtschaftsweisen in Norddeutschland während der Trichterbecherzeit. In: Kelm R (ed) Zurück zur Steinzeitlandschaft, Archäologische und ökologische Forschung zur jungsteinzeitlichen Kulturlandschaft und ihrer Nutzung in Nordwestdeutschland. (Albersdorfer Forschungen zur Archäologie und Umweltgeschichte 2). Boyens, Heide, pp 27–38

Behre K-E (2007) Evidence for Mesolithic agriculture in and around central Europe? Veget Hist Archaeobot 16:203–219

Behre K-E (2008a) Landschaftsgeschichte Norddeutschlands. Umwelt und Siedlung von der Steinzeit bis zur Gegenwart, Wachholtz

Behre K-E (2008b) Collected seeds and fruits from herbs as prehistoric food. Veget Hist Archaeobot 17:65–73

Behre K-E, Kučan D (1994) Die Geschichte der Kulturlandschaft und des Ackerbaus in der Siedlungskammer Flögeln, Niedersachsen, seit der Jungsteinzeit. (Probl Küstenforsch südl Nordseegebiet 21). Isensee, Oldenburg

Beijerinck W (1947) Zadenatlas der nederlandsche flora: ten behoeve van de botanie, palaeontologie, bodemcultuur en warenkennis. Wageningen, Veenman

Bishop RR, Church MJ, Rowly-Conwy PA (2009) Cereals, fruits and nuts in the Scottish Neolithic. Proc Soc Antiqu Scotl 139:47–103

Board N (2004) Handbook on herbs cultivation and processing. Asia Pacific Business Press Inc, Delhi

Bogaard A, Jones G (2007) Neolithic farming in Britain and central Europe: contrast or continuity? In: Whittle A, Cummings V (eds) Going over: the Mesolithic–Neolithic transition in north-west Europe. Oxford University Press, Oxford, pp 357–375

Brinkkemper O (2011) An outline of the subsistence and site location of the Funnel Beaker culture (TRB) in the Netherlands. Abstract 1760, INQUA 2011, Bern, http://www.inqua2011.ch/?a=programme&subnavi=abstractlist. Assessed 2 Apr 2011

Brouwer W (1972) Handbuch des speziellen Pflanzenbaues, Band 1. Weizen, Roggen, Gerste, Hafer, Mais, Parey

Brozio J-P (2010) Neue Untersuchungen zu trichterbecherzeitlichen Organisationsformen in Ostholstein. Archäol Nachr Schleswig-Holstein 16:30–33

Cappers RTJ, Raemaekers DCM (2008) Cereal cultivation at Swifterbant? Neolithic wetland farming on the North European plain. Curr Anthropol 49:385–402

Cappers RTJ, Bekker RM, Jans JEA (2006) Digitale Zadenatlas van Nederland. Groningen Archaeological Studies. Groningen Institute of Archaeology, Groningen

Dibbern H, Hage F (2010) Erdwerk und Megalithgräber in der Region Albersdorf – Vorbericht zu den Grabungskampagnen am Dieksknöll und Brutkamp. Archäol Nachr Schleswig-Holstein 16:34–37

Dörfler W (2001) Von der Parklandschaft zum Landschaftspark, Rekonstruktion der neolithischen Landschaft anhand von Pollenanalysen aus Schleswig Holstein. In: Kelm R (ed) Zurück zur Steinzeitlandschaft. Archäologische und ökologische Forschung zur jungsteinzeitlichen Kulturlandschaft und ihrer Nutzung in Nordwestdeutschland. (Albersdorfer Forschungen zur Archäologie und Umweltgeschichte 2). Boyens, Heide, pp 39–56

Dörfler W (2008) Das dritte vorchristliche Jahrtausend in hochauflösenden Pollendiagrammen aus Norddeutschland. In: Müller J, Dörfler W (eds) Umwelt – Wirtschaft – Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens. Wachholtz, Neumünster, pp 135–148

Engelmark R (1984) Two useful plants from Iron Age graves in Central Sweden. In: Baudou E (ed) Papers in Northern Archaeology. (Archaeology and Environment 2) Umeå, pp 87–92

Engelmark R (1992) A review of the farming economy in South Scania based on botanical evidence. In: Larsson L, Callmer J, Stjernquist B (eds) The archaeology of the cultural landscape. Field work and research in a south Swedish rural region. Almquist & Wiksell, Stockholm, pp 369–376

Erhardt W, Götz E, Bödeker N, Seybold S (2002) Zander: Handwörterbuch der Pflanzennamen, 17th edn. Ulmer, Stuttgart

Fairweather AD, Ralston IBM (1993) The Neolithic timber hall at Balbridie, Grampian Region, Scotland: the building, the date, the plant macrofossils. Antiquity 67:313–323

Fischer A (2002) Food for feasting? An evaluation of explanations of the Neolithisation of Denmark and southern Sweden. In: Anders F, Kristiansen K (eds) The Neolithisation of Denmark. Collis, Sheffield, pp 341–364

Fries JE (2010) Bericht der archäologischen Denkmalpflege 2009. Oldenburger Jahrbuch 111:205–222

Fritsch B, Furholt M, Hinz M, Lorenz L, Nelson H, Schafferer G, Schiesberg S, Sjögren K-G (2010) Dichtezentren und lokale Gruppierungen - Eine Karte zu den Großsteingräbern Mittel- und Nordeuropas. www.jungsteinsite.de. Accessed 20 Oct 2010

Furholt M (2010) A Virtual and a practiced Neolithic? Material culture symbolism, monumentality and identities in the western Baltic region. In: Furholt M, Lüth F, Müller J, Scarre C (eds) Megaliths and identities. 3rd European Megalithic Studies Group Meeting, Kiel 2010, www.jungsteinsite.uni-kiel.de. Accessed 31 Aug 2010

George DR, Dewer RE (1999) *Chenopodium* in Connecticut prehistory: wild, weedy, cultivated, or domesticated? In: Hart JP (ed) Current northeast paleoethnobotany. (The New York State Education Department, New York State Museum bulletin 494). New York State Education Department, New York, pp 121–132

Geschwinde M, Raetzel-Fabian D (2009) EWBSL. Eine Fallstudie zu den jungneolithischen Erdwerken am Nordrand der Mittelgebirge. (Beiträge zur Archäologie in Niedersachsen 14). Leidorf, Rahden/Westfalen

Göransson H (1995) Alvastra pile dwelling. Palaeoethnobotanical Studies. (Theses and Papers in Archaeology N.S. A 6) Lund University Press, Lund

Greig J (1991) The British Isles. In: Van Zeist W, Wasylikowa K, Behre K-E (eds) Progress in Old World palaeoethnobotany. Balkema, Rotterdam, pp 299–334

Guldin A (2010) Viele Funde – kein Haus. Archäologie in Schleswig-Holstein 16:38–40

Hartz S, Heinrich D, Lübke H (2002) Coastal farmers: the Neolithisation of northernmost Germany. In: Anders F, Kristiansen K (eds) The Neolithisation of Denmark. Collis, Sheffield, pp 321–340

Hartz S, Lübke H, Terberger T (2007a) From fish and seal to sheep and cattle: new research into the process of neolithisation in northern Germany. In: Whittle A, Cummings V (eds) Going over: The Mesolithic–Neolithic transition in north-west Europe. Proceedings of the British Academy 144. Oxford University Press, Oxford, pp 567–594

Hartz S, Mischka D, Müller J (2007b) Die neolithische Feuchtbodensiedlung Bad Oldesloe-Wolkenwehe: Resultate der Untersuchungen 1950–1952. Offa 61(62):7–25

Hellmund M (2008) The Neolithic records of *Onopordum acanthium, Agrostemma githago, Adonis* cf. *aestivalis* and *Claviceps purpurea* in Sachsen-Anhalt, Germany. Veget Hist Archaeobot 17:S123–S130

Hey G, Mulville J, Robinson M (2003) Diet and culture in southern Britain: the evidence from Yarnton. In: Pearson MP (ed) Food, culture and identity in the Neolithic and early Bronze Age (BAR Int Ser 1, 117). Archaeopress, Oxford, pp 79–88

Heyd V (2007) Families, prestige goods, warriors and complex societies: beaker groups and the 3rd millennium cal. B.C. Proc Prehist Soc 73:327–380

Hoika J (1993) Grenzfragen oder: James Watt und die Neolithisierung. Archäol Inf 16:6–19

Hopf M (1982) Vor- und frühgeschichtliche Kulturpflanzen aus dem nördlichen Deutschland. Kataloge vor- und frühgeschichtlicher Altertümer 22. RGZM, Mainz

Hunt HV, van der Linden M, Liu X, Motuzaite-Matuzeviciute G, Colledge S, Jones M (2008) Millets across Eurasia: chronology and context of early records of the genera *Panicum* and *Setaria* from archaeological sites in the Old World. Veget Hist Archaeobot 17:5–18

Iversen J (1941) Landnam i Danmarks Stenalder, en pollenanalytisk undersøgelse over det første landbrugs indvirking på vegetationsudviklingen. (Danmarks Geologiske Undersøgelse, Række 2) 66, København, pp 1–68

Jacomet S (2006) Prähistorische Getreidefunde. http://ipna.unibas.ch/archbot/pdf/Getreidebestimmung_D.pdf

Jacomet S (2007a) Neolithic plant economies in the northern alpine foreland (central Europe) from 5500–3500 B.C. cal. In: Colledge S, Conolly J (eds) The origin and spread of domestic plants in southwest Asia and Europe. Left Coast Press, Walnut Creek, pp 221–258

Jacomet S (2007b) Plant macrofossil methods and studies: use in environmental archaeology. In: Elias SA (ed) Encyclopedia of quaternary science. Elsevier, Amsterdam, pp 2,384–2,411

Jacomet S (2009) Plant economy and village life in Neolithic lake dwellings at the time of the Alpine Iceman. Veget Hist Archaeobot 18:47–59

Jacomet S (in press) Archaeobotany: the potential of analyses of plant remains from waterlogged archaeological sites. In: Menotti F, O'Sullivan A (eds) Handbook of wetland archaeology. Oxford University Press, Oxford

Jones G (2000) Evaluating the importance of cultivation and collecting in Neolithic Britain. In: Fairbairn A (ed) Plants in Neolithic Britain and beyond. Neolithic Studies Group Seminar Papers 5. Oxbow Books, Oxford, pp 79–84

Jones G, Rowley-Conwy P (2007) On the importance of cereal cultivation in the British Neolithic. In: Colledge S, Conolly J (eds) The origin and spread of domestic plants in southwest Asia and Europe. Left Coast Press, Walnut Creek, pp 391–419

Kalis AJ, Meurers-Balke J (1998) Die "Landnam"-Modelle von Iversen und Troels-Smith zur Neolithisierung des westlichen Ostseegebietes, ein Versuch ihrer Aktualisierung. Prähist Zeitschr 73:1–24

Kampffmeyer U (1991) Die Keramik der Siedlung Hüde I am Dümmer. Untersuchungen zur Neolithisierung des nordwestdeutschen Flachlands. Dissertation, Universität Göttingen

Karg S (2011) New perspectives on the speed of the neolithisation process in Southern Scandinavia: subsistence and exchange networks. Abstract 2330, INQUA 2011, Bern, http://www.inqua2011.ch/?a=programme&subnavi=abstractlist. Assessed 2 Apr 2011

Kirleis W, Feeser I, Klooß S (2011) Umwelt und Ökonomie. Schwerpunkt: Frühe Bauern im Norden. Archäologie in Deutschland 2:34–37

Klassen L (2004) Jade und Kupfer: Untersuchungen zum Neolithisierungsprozess im westlichen Ostseeraum unter besonderer Berücksichtigung der Kulturentwicklung Europas 5500–3500 B.C. Aarhus University Press, Århus

Klassen L (2008) Zur Bedeutung von Getreide in der Einzelgrabkultur Jütlands. In: Dörfler W, Müller J (eds) Umwelt – Wirtschaft – Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens. Wachholtz, Neumünster, pp 49–65

Klooß R (2008) Ein Fundplatz des Übergangs vom Mittelneolithikum A zum Mittelneolithikum B aus Wangels LA 505, Kreis Ostholstein. Ein Vorbericht. In: Dörfler W, Müller J (eds) Umwelt – Wirtschaft – Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens. Wachholtz, Neumünster, pp 127–134

Koch E (1998) Neolithic bog pots from Zealand, Møn, Falster, vol 16. (Nordisk fortidsminder ser B) Kongelige Nordiske Oldskriftselskab, København

Kossian R (2007) Hunte 1: ein mittel- bis spätneolithischer und frühbronzezeitlicher Siedlungsplatz am Dümmer, Ldkr. Diepholz (Niedersachsen). Die Ergebnisse der Ausgrabungen des Reichsamtes für Vorgeschichte in den Jahren 1938 bis 1940. (Veröffentlichungen der archäologischen Sammlungen des Landesmuseums Hannover 52) Welt und Erde Verlag, Kerpen-Loogh

Kreuz A (1995) Funktionale und konzeptionelle archäobotanische Daten aus römerzeitlichen Brandbestattungen. Ber Komm Arch Landesforsch Hessen 3:93–97

Kreuz A, Marinova E, Schäfer E, Wiethold J (2005) A comparison of early Neolithic crop and weed assemblages from the Linearbandkeramik and the Bulgarian Neolithic cultures: differences and similarities. Veget Hist Archaeobot 14:237–258

Kroll H (1976) Pflanzliche Abdrücke in der Keramik der befestigten neolithischen Siedlung Büdelsdorf, Kreis Rendsburg-Eckernförde. Offa 33:61–65

Kroll H (1980) Einige vorgeschichtliche Vorratsfunde von Kulturpflanzen aus Norddeutschland. Offa 37:372–383

Kroll H (1981) Mittelneolithisches Getreide aus Dannau. Offa 38:85–90

Kroll H (2001) Der Mohn, die Trichterbecherkultur und das südwestliche Ostseegebiet. Zu den Pflanzenfunden aus der mittelneolithischen Fundschicht von Wangels LA 505, Kr. Ostholstein. In: Kelm R (ed) Zurück zur Steinzeitlandschaft, Archäologische und ökologische Forschung zur jungsteinzeitlichen Kulturlandschaft und ihrer Nutzung in Nordwestdeutschland. (Albersdorfer Forschungen zur Archäologie und Umweltgeschichte 2). Boyens, Heide, pp 70–76

Kroll H (2007) The plant remains from the Neolithic Funnel Beaker site of Wangels in Holsatia, northern Germany. In: Colledge S, Conolly J (eds) The origins and spread of domestic plants in southwest Asia and Europe. Left Coast Press, Walnut Creek, pp 349–357

Lehmphul R (2010) Grab, Gruben, Grabenwerk. Ein mehrperiodiger Fundplatz bei Rathsdorf, Lkr. Märkisch-Oderland. Archäologie in Berlin und Brandenburg 2008:40–43

Louwe Kooijmans LP (2009) The agency factor in the process of Neolithisation—a Dutch case study. J Arch Low Ctries 1:27–54

Lübke C (2010) Von Häusern und Gräbern. Bauliche Konstruktionen. Archäologie in Schleswig-Holstein 16:41–45

Lütjens I, Wiethold J (1999) Vegetationsgeschichtliche und archäologische Untersuchungen zur Besiedlung des Bornhöveder Seengebietes im Neolithikum. Arch Nachr Schleswig-Holstein 9:30–67

Maier U (2001) Untersuchungen in der neolithischen Ufersiedlung Hornstaadt Hörnle IA am Bodensee. (Siedlungsarchäologie im Alpenvorland 6). Forsch Ber Vor- Frühgesch Bad-Württ, Stuttgart, pp 11–384

McClatchie M (2007) The study of non-wood plant macro-remains: investigating past societies and landscapes. In: Murphy EM, Whitehouse NJ (eds) Environmental archaeology in Ireland. Oxbow, Oxford, pp 194–220

McClatchie M, Whitehouse N, Schulting R, Bogaard A, Barratt P (2009) Cultivating societies: new insights into agriculture in Neolithic Ireland. In: Stanley M, Danaher E, Eogan J (eds) Dining and dwelling—archaeology and the National Roads. (Authority Monograph Series 6). Wordwell, Dublin, pp 1–8

Midgley M (2009) Antiquarians at the megaliths. (BAR Int Ser 1,956). Archaeopress, Oxford

Mischka D, Demnick D (2011) Totenlandschaften für ein Leben in Ewigkeit. Archäologie in Deutschland 2011:26–29

Mischka D, Dörfler W, Grootes P, Heinrich D, Müller J, Nelle O (2007) Die Neolithische Feuchtbodensiedlung Bad Oldesloe-Wolkenwehe LA 154. Vorbericht zu den Untersuchungen 2006. Offa 61(62):25–64

Moerman DE (1998) Native American ethnobotany. Timber Press, Portland

Moffett L, Robinson MA, Straker V (1989) Cereals, fruits and nuts: charred plant remains from Neolithic sites in England and Wales and the Neolithic economy. In: Milles A, Williams D, Gardner N (eds) The beginnings of agriculture. BAR Int Ser 496. Archaeopress, Oxford, pp 243–261

Monk MA (2000) Seeds and soils of discontent: an environmental archaeological contribution to the nature of the early Neolithic. In: Desmond A, Johnson G, McCarthy M, Sheehan J, Shee Twohig E (eds) New agendas in Irish prehistory: papers in commemoration of Liz Anderson. Bray, Wordwell, pp 67–87

Müller J (2009a) Neolithische Monumente und neolithische Gesellschaften. In: Beier H-J, Classen E, Doppler T, Ramminger B (eds) Neolithische Monumente und neolithische Gesellschaften. (Varia Neolithica 6). Beier & Beran, Langenweissbach, pp 7–16

Müller J (2009b) Monumente und Gesellschaft. Archäol Nachr Schleswig-Holstein 15:30–33

Müller J (2010) Dorfanlagen, Siedlungssysteme – Die europäische Perspektive: Südosteuropa und Mitteleuropa. Aufbruch in eine neue Zeit. Europas Mitte um 4000 v. Chr. (Ausstellungskatalog). C. Lichter, Karlsruhe, pp 22–29

Müller J (2011a) Megaliths and Funnel Beakers: societies in change 4100–2700 BC. (Kroon-Vordaacht 13). Amsterdams Archaeologisch Centrum van der Universiteit, Amsterdam

Müller J (2011b) Early pottery in the north—a southern perspective. Ber RGK 89(2008):287–299

Müller J, Brozio J-P, Demnick D, Dibbern H, Fritsch B, Furholt M, Hage F, Hinz M, Lorenz L, Mischka D, Rinne C (2010) Periodisierung der Trichterbecher-Gesellschaften. Ein Arbeitsentwurf. JungsteinSite. www.jungsteinsite.uni-kiel.de/2010_chrono_tbk.pdf. Accessed 31 Aug 2010

Müller J, Bork HR, Brozio J-P et al (in press) Landscapes as social spaces and ritual meaning: some new results on TRB in northern Germany. Borger-Conference 2009

Nelle O, Dörfler W (2008) A summary of the late- and post-glacial vegetation history of Schleswig-Holstein. Mitt Arbeitsgem Geobot Schleswig-Holstein Hamburg 65:45–68

Oudemans T, Kubiak-Martens L (2010) Porridge with fat. In: Treasure chest. Unlocking Noord-Holland's Late Neolithic. Newsletter 1/2:6. http://www.singlegrave.nl/sgc_new/themes/SGC_MK1/newsletter/en/download2.php?f=Treasure_chest_winter_2010.pdf. Accessed 4 Feb 2011

Out W (2008) Gathered food plants at Dutch Mesolithic and Neolithic wetland sites. In: Baker S, Allen M, Middle S, Poole K (eds) Food and drink in archaeology. Prospect Books, Nottingham, pp 84–95

Out W (2009) Sowing the seed? Human impact and plant subsistence in Dutch wetlands during the Late Mesolithic and Early and Middle Neolithic (5500–23400 cal. B.C.). (Archaeological Studies Leiden University 18). Leiden University Press, Leiden

Parker Pearson M (2003) Food, culture and identity in the Neolithic and Early Bronze Age. Archaeopress, Oxford

Parker AG, Goudie AS, Anderson DE, Robinson MA, Bonsall C (2002) A review of the mid-Holocene elm decline in the British Isles. Progr Phys Geogr 26:1–45

Peglar SM, Birks HJB (1993) The mid-Holocene *Ulmus* fall at Diss Mere, South-East England, disease and human impact? Veget Hist Archaeobot 2:61–68

Preiss S, Matterne V, Latron F (2005) An approach to funerary rituals in the Roman provinces: plant remains from a Gallo-Roman cemetery at Faulquemont (Moselle, France). Veget Hist Archaeobot 14:362–372

Rassmann K (1993) Spätneolithikum und frühe Bronzezeit im Flachland zwischen Elbe und Oder. (Beiträge zur Ur- und Frühgeschichte Mecklenburg-Vorpommerns 28). Archäologisches Landesmuseum Mecklenburg-Vorpommern, Lübstorf

Regnell M, Sjögren K-G (2006a) Use of wild plants and wood. In: Sjögren K-G (ed) Ecology and economy in Stone Age and Bronze Age Scania. National Heritage Board, Archaeological Excavations Dep, Lund, pp 80–105

Regnell M, Sjögren K-G (2006b) Introduction and development of agriculture. In: Sjögren K-G (ed) Ecology and economy in Stone Age and Bronze Age Scania. National Heritage Board, Archaeological Excavations Dep, Lund, pp 106–169

Robinson MA (2000) Further consideration of Neolithic charred cereals, fruits and nuts. In: Fairbairn AS (ed) Plants in Neolithic Britain and beyond. (Neolithic Studies Group Seminar Papers 5). Oxbow, Oxford, pp 85–90

Robinson DE (2003) Neolithic and Bronze Age agriculture in southern Scandinavia. Recent archaeobotanical evidence from Denmark. Env Arch 8:145–165

Robinson DE (2007) Exploitation of plant resources in the Mesolithic and Neolithic of southern Scandinavia: from gathering to harvesting. In: Colledge S, Conolly J (eds) The origins and spread of domestic plants in southwest Asia and Europe. Left Coast Press, Walnut Creek, pp 359–374

Rowley-Conwy P (2004) How the west was lost. A reconsideration of agricultural origins in Britain, Ireland, and southern Scandinavia. Curr Anthropol 45:83–113

Salavert A (2011) Plant economy of the first farmers of central Belgium (Linearbandkeramik, 5200–5000 B.C.). Veget Hist Archaeobot 20:321–332

Schierhold K, Baales M, Cichy E (2010) Spätneolithischen Großsteingräbern auf der Spur - Geomagnetik in Erwitte-Schmerlecke. In: Otten T, Hellenkemper H, Kunow J, Rind M (eds) Fundgeschichten. Archäologie in Nordrhein-Westfalen. Philipp von Zabern, Mainz, pp 74–77

Schiffer MB (2010) Behavioral archaeology. Principles and practice. Equinox Publishing, London

Schmölcke U (2000) Die Fauna des endmittelneolithischen Wohnplatzes Wangels LA 505 aus paläoökologischer Sicht. Arch Nachr Schleswig-Holstein 11:24–33

Schuldt E (1972) Die mecklenburgischen Megalithgräber. Untersuchungen zu ihrer Architektur und Funktion. Deutscher Verlag der Wissenschaften, Berlin

Sommer U (1991) Zur Entstehung archäologischer Fundvergesellschaftungen: Versuch einer archäologischen Taphonomie. In: Mattheuser E (ed) Die geographische Ausrichtung bandkeramischer Häuser. Studien zur Siedlungsarchäologie 1. (Universitätsforsch prähist Archäol 6). Habelt, Bonn, pp 51–193

Sprockhoff E (1966) Atlas der Megalithgräber Deutschlands 1: Schleswig-Holstein. Habelt, Bonn

Steffens J (2009) Die neolithischen Fundplätze von Rastorf, Kreis Plön. (Universitätsforsch prähist Archäol 170). Habelt, Bonn

Twiss CC (ed) (2007) The Archaeology of food and identity. Southern Illinois University, Carbondale, (Occasional Paper no. 34). Southern Illinois University, Carbondale

Van der Veen M (2007) Formation processes of desiccated and carbonized plant remains—the identification of routine practice. J Archaeol Sci 34:968–990

Van Gijn A, Louwe Kooijmans LP (2005) Early and Middle Neolithic: introduction. In: Louwe Kooijmans LP, van den Breoke PW, Fokkens H, van Gijn AL (eds) The prehistory of the Netherlands, vol 1. Amsterdam University Press, Amsterdam, pp 203–218

Van Zeist W, Boekschoten-van Helsdingen AM (1991) Samen und Früchte aus Niederwil. In: Waterbolk HAT, van Zeist W (eds) Niederwil, eine Siedlung der Pfyner Kultur. Haupt, Bern, pp 49–113

Vandkilde H (2007) A review of the early late Neolithic period in Denmark. Offa 61(62):75–110

Viklund K (2002) Issues in Swedish archaeobotany—a guide through twenty years of archaeobotanical research at the University of Umeå. In: Vikund K (ed) Nordic Archaeobotany—NAG 2000 in Umeå. Archaeol and Env 15:193–202

Whittle A, Healy F, Bayliss A (2011) Gathering time: dating the early Neolithic enclosures of southern Britain and Ireland. Oxbow Books, Oxford

Wiethold J (1998) Studien zur jüngeren postglazialen Vegetations- und Siedlungsgeschichte im östlichen Schleswig-Holstein. (Universitätsforsch prähist Archäol 45). Habelt, Bonn

Willerding U (1971) Methodische Probleme bei der Untersuchung und Auswertung von Pflanzenfunden in vor- und frühgeschichtlichen Siedlungen. Nachr Nieders Urgesch 40:180–198

Willerding U (1991) Präsenz, Erhaltung und Repräsentanz von Pflanzenresten in archäologischem Fundgut. In: Van Zeist W, Wasylikowa K, Behre K-E (eds) Progress in Old World palaeoethnobotany. Balkema, Rotterdam, pp 25–51

Wollstonecroft MM, Ellis PR, Hillman GC, Fuller D (2008) Advances in food processing in the Near Eastern Epipalaeolithic and implications for improved edibility and nutrient bioaccessibility: an experimental assessment of *Bolboschoenus maritimus* (L.) Palla (sea club rush). Veget Hist Archaeobot 17:19–27

Wollstonecroft M, Hroudová Z, Hillman G, Fuller D (2011) *Bolboschoenus glaucus* (Lam.) S.G. Smith, a new species in the flora of the ancient Near East. Veget Hist Archaeobot 20:459–470

Zimmermann WH (2008) Phosphate mapping of a Funnel Beaker Culture house from Flögeln-Eekhöltjen, district of Cuxhaven, Lower Saxony. In: Fokkens H, Coles BJ, van Gijn AL, Kleijne JP, Ponjee HH, Slapp Endel CG (eds) Between foraging and farming. (Acta Praehistorica Leidensia 40) Leiden, pp 123–129

Zvelebil M (2005) Homo habitus: agency, structure and the transformation of tradition in the constitution of the TRB foraging farming communities in the North European Plain (ca. 4500–2000 B.C.). Doc Praehist 32:87–101