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Early Iron Age agriculture: archaeobotanical evidence from an underground granary at Overbygård in northern Jutland, Denmark

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Abstract. In the Late Pre-Roman Iron Age an underground granary in the village of Overbygård was destroyed by fire and the contents were carbonised. Almost 2000 years later, analyses of the macroremains of the granary, which included a range of processed and unprocessed crops and weed seeds, showed that naked barley *(Hordeum vulgare* var. *nudum)* and bread wheat *(Triticum aestivum* s.l.) were the main crops cultivated, hulled barley *(Hordeum vulgare)* and flax *(Linum usitatissimum)* also played a role, whereas emmer *(Triticum dicoccum)* and gold of pleasure *(Camelina sativa)* were present as weeds or contaminants. The arable weed flora suggests that crops were sown in spring and that ecological conditions in the arable fields were very variable. The crops were harvested on the straw and may have spent some time drying and maturing in the fields before being transported home to be stored as severed ears in pest-proof granaries. Winnowing or, more probably, casting appears to have been used to clean the crop after threshing. It could not be ascertained if the crops had been sieved. Large collections of weed seeds in the granary were apparently the result of intentional gathering for food, rather than by-products of crop processing. In the light of the investigation it is suggested that future research into Iron Age agrarian practices should include both the analysis of archaeobotanical finds and a programme of practical experiments. This dual approach will give us a much better understanding of arable agriculture, not only in the Iron Age, but in prehistory as a whole.

Key words: Agrarian practices – Granary – Weeds – Iron Age – Denmark

Introduction

Evidence of prehistoric agriculture in the form of preserved crop plant remains is to be found in varying amounts at almost every settlement excavation from the Neolithic onwards. The plant remains are usually preserved by carbonisation but uncarbonised remains also occur under suitable conditions. Analysis and identification of the remains give information about which crops were cultivated at a site. Gradually, as more and more investigations are carried out, a picture can be built up which reveals developments in arable agriculture through time as well as regional variations (Robinson 1994; Robinson and Mikkelsen 1994). Until recently, archaeobotanical research in Denmark has concentrated on this aspect, i.e. when the various crop plants were introduced and their relative importance in subsequent periods. Little attention has been paid to the methods by which crop plants were cultivated, harvested and processed to produce food and seeds for sowing.

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Archaeobotanical finds and agrarian practices

Cultivation methods, together with soil type and climate, create the ecological conditions prevailing in an arable field. These conditions are reflected to a very great extent in the composition of the arable weed flora growing in the field. Accordingly, we can use arable weed seeds in archaeobotanical finds as ecological indicators, which have the potential to reveal how fields were cultivated, manured, sowed and tended (Jones, M. 1988; Kroll 1987; Wasylikowa 1981).

Arable weeds also give information about harvesting methods. For example, the proportion of seeds from tall and short weeds in the harvested crop will vary according to the height at which the sickle cuts the straw or if the preferred harvesting method involves plucking the ears singly (Hillman 1981). Processing, i.e. threshing and cleaning, is similarly reflected in the composition of the weed seed assemblages in the finished and half-finished products and by-products of processing. The degree to which the weed seeds either accompany the crop through processing or are removed depends on their shape (aerodynamic properties), size and density, and the methods chosen to clean the crop (Engelmark 1989; Hillman 1981, 1984; Henriksen and Robinson, in press; Jones, G. 1984, 1987; Wasylikowa 1981).

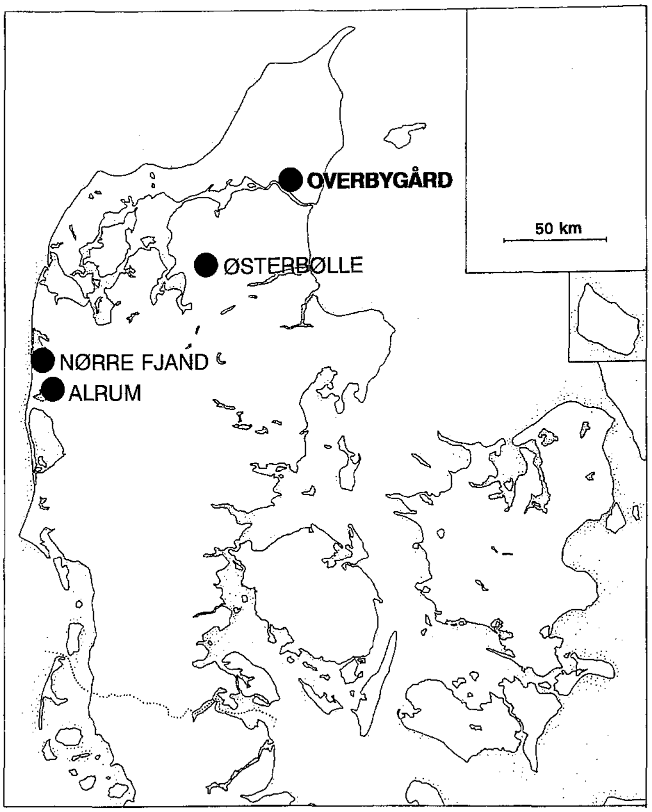

Fig. 1. Map showing location of the sampling sites

The proportions of large and small crop seeds, arable weed seeds and chaff change progressively through processing, i.e. each stage has a filtering effect. In order to use archaeobotanical finds as sources of information about agrarian practices, it is first necessary to understand the techniques and processes that have been used, as well as knowing which stage in the process each individual find represents. Without this knowledge it is not possible to compare finds in a satisfactory way.

Storage deposits containing harvested, but unprocessed, crops are the best material for studying the ecological conditions prevailing in prehistoric fields. However, it is important to note that even at this stage, there can, as a consequence of harvesting techniques, be major differences between the arable weed seed assemblages in the harvested crop and the composition of the original arable weed flora of the field. Remains of unprocessed crops are also a valuable starting point in any investigation where crop processing is the main interest. There is an additional requirement for finds of by-products or waste products, i.e. those removed from the crop. The latter can, of course, also contain information about ecological conditions, but in order to interpret them in this way we need to understand the processes that created them.

Briefly, it can be said that most information about past agrarian practices is to be found in finds of unprocessed crops and of by-products and waste products of crop processing. Finds of cleaned processed crops contain relatively little information in this respect, as the relevant remains, i.e. the weed seeds and chaff, are absent (Henriksen and Robinson, in press).

Archaeobotanical finds from the Danish Iron Age

It was with the above thoughts in mind that in 1992 a survey was made of all publications and available unpublished reports of archaeobotanical finds from the Danish Iron Age (Henriksen 1992).This survey revealed that virtually all analysed finds consisted of storage deposits comprising processed crops. The majority of them was too small or too poorly investigated to be used to give information about agrarian practices. There were no analyses of crop plant remains from pits, refuse layers or other deposits likely to contain crop processing waste. Only four sites appeared to have produced material which merited closer attention, namely Østerbølle, Alrum, Nørre Fjand and Overbygård.

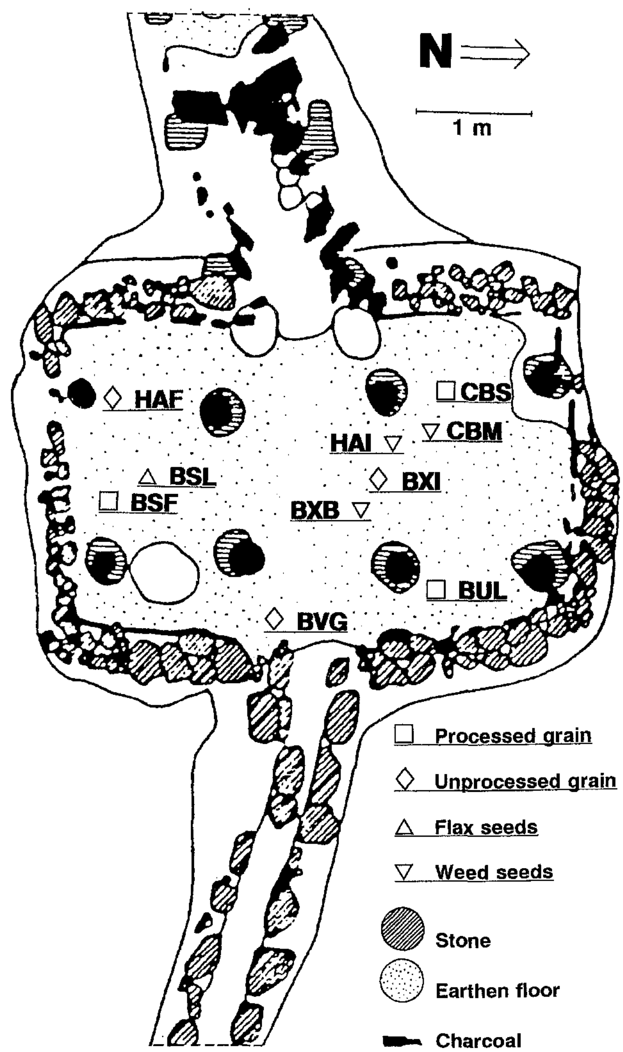

Fig. 2. Plan of the underground granary at Overbygård and the position of the samples on the granary floor

The first three of these sites, Østerbølle, Alrum and Nørre Fjand (Fig. 1), were excavated in the 1930s, and produced large concentrations of grain and weed seeds which were subsequently analysed by Hans Helbæk. With the exception of Østerbølle, the analyses have been only sketchily published (Helbæk in Hatt 1938; Helbæk 1954). Attempts were made to repeat and augment Helbæk's analyses. This proved to be impossible partly due to a lack of documentation, both with regard to the excavation of the material and its subsequent treatment, and partly due to Helbæk's often rather idiosyncratic and impenetrable methods of analysis. With the exception of one sample from Alrum (measurements of barley rachis segments) and one from Nørre Fjand (*Chenopodium album* sample), only the find from Overbygård in Vendsyssel proved suitable for our purposes (Fig. 1).

Overbygård

In the 1970s a village dating from the end of the Pre-Roman Iron Age, i.e. about the birth of Christ, was excavated by Jørgen Lund of the University of Århus. In the remains of a burned-out underground granary, over 100 litres of carbonised grain, weed seeds and other plant remains were found in heaps on the granary floor (Fig. 2). The grain had been stored in pots and leather sacks hung from the roof, and it was possible for the excavators to take up each heap more or less intact. A total of 65 samples, comprising both processed and unprocessed grain and concentrations of weed seeds, presumed at the time to be by-products of grain processing, were recovered. The find was briefly examined by Grethe Jørgensen in the 1970s (Jørgensen in Lund 1978, 1979). In the late 1980s, a number of samples were examined in greater detail by Robinson and Boldsen, but only scantily published (Robinson and Boldsen 1991). Further analyses were carried out in 1993-94 by the present authors. The results of the analyses carried out in the 1980s and 1990s are presented in this paper.

Methods

The 65 samples from Overbygård were examined and a total of 13 samples were chosen for analysis. The remaining samples consisted mostly of small quantities of processed grain, sand and other inorganic material and were therefore only cursorily examined. Sub-samples (normally 5-10 g) were removed using a riffle box. The number of sub-samples examined from each sample depended on the concentration of plant remains. Van der Veen and Fieller (1982) recommend that 400-500 items should be identified in order to give a representative picture of the sample under analysis.

Using a stereo microscope with an eyepiece graticule, measurements were carried out on grains of *Hordeum vulgare*[1] (hulled barley), *Hordeum vulgare* var. *nudum* (naked barley) and *Triticum aestivum* s.l. (bread wheat) and on rachis segments of *H. vulgare* (barley). Measurements were made of the length (minus embryo), breadth and thickness of the grains (Fig. 3). The length of the barley rachis segments was measured from the base of the segment to the point where the grain was attached (Fig. 3).

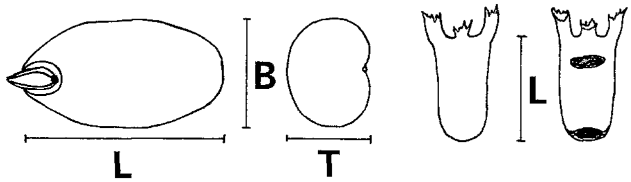

Fig. 3. Measurements on grains and rachis segments. *B*, breadth; *L*, length; *T*, thickness

Results

Botanical analysis

Thirteen samples were analysed. Of these, eight were analysed by D. Robinson and I. Boldsen and the remaining five were analysed by the authors. The samples fall into four categories (for details of results see Table 1):

Threshed and cleaned (i.e. processed) grain. This category consists of five samples containing processed grain. Four came from two large heaps consisting of a mixture of naked six-rowed barley and bread wheat (CBS 17+19, CBS 16, BUL 1 and BUL 3). Clumps of burnt grain with pieces of charred leather adhering to them suggest that the grain had been stored in leather sacks, which presumably had hung from the roof. The clumps of carbonised grain consisted either of naked barley or wheat and not both, suggesting that the two kinds of grain became mixed during or after the fire. A fifth sample (BSF), consisted of naked barley with an admixture of 5% bread wheat. As the sample comprised the contents of an intact pottery vessel, this combination of barley and wheat could not have arisen as a result of the fire.

Unprocessed grain. Three samples consisted of unprocessed naked six-rowed barley. They contained large numbers of rachis segments in addition to weed seeds. One of the samples was found as a large heap on the floor of the granary (HAF); the others were found in pottery vessels (BXI and BVG).

Seeds of Linum usitatissimum *(flax).* One sample (BSL) consisted of a mixture of flax seeds (linseed) and mostly naked barley. Mixing presumably occurred during the fire.

Arable weed seeds. Four samples consisted primarily of arable weed seeds with a minor admixture of barley (BXB, BXT, HAI and CBM 12).

[1] Plant nomenclature follows Hansen (1981)

Table 1. Results of the archaeobotanical analysis of the find from Overbygård expressed as concentration per 100 g of sample

	Processed grain					Unprocessed grain			Flax	Weeds			
Sample No.	CBS (17+19)	CBS 16	BSF	BUL 1	BUL 3	HAF	BXI	BVG	BSL	BXB	BXT	HAI	CBM 12
Original sample size †	***	***	**	***	***	**	**	**	*	**	*	*	**
Hordeum vulgare var. *nudum* (n)	11310	3049	1920	1730	-	7136	6640	8109	470	44	680	28	135
Hordeum vulgare (h)	245	84	166	179	-	585	1146	511	84	-	43	6	32
Hordeum vulgare indet.	-	-	277	487	4086	2773	2490	-	52	162	527	66	590
Hordeum (r)	4	6	2	26	10	2096	1975	2698	-	-	-	-	-
Triticum aestivum	2	3407	120	9640	691	573	-	-	-	-	-	-	7
Triticum dicoccum	-	6	-	cf.359	-	-	-	-	-	-	-	-	-
Triticum (r)	-	-	-	13	-	-	-	-	-	-	-	-	-
Linum usitatissimum	2	-	4	13	-	-	-	-	106	-	-	-	7
Linum usitatissimum (f)	-	-	-	-	-	-	-	-	270	-	-	-	-
Unidentified cereal grain	-	244	-	-	997	-	33	-	-	129	170	-	-
Unidentified cereal grain (f)	-	-	-	-	-	-	-	-	540	-	-	-	-
Ajuga reptans	-	-	-	-	-	3	-	-	-	-	-	-	-
Avena sp.14	5	3	26	7	254	247	29	-	8	-	-	17	
Avena fatua (incl. floret base)	-	2	-	-	-	15	29	-	-	-	-	-	-
Brassica/Raphanus sp.	-	-	-	-	3	-	16	5	-	15	9	-	7
Brassica campestris	-	-	-	-	-	-	-	5	-	-	-	-	-
Bromus sp.	-	-	-	51	3	117	-	cf.29	2	129	21	6	5
Bromus mollis	-	-	-	-	-	-	33	-	-	-	-	-	-
Camelina sativa	-	cf. 2	-	-	-	-	-	-	-	-	-	-	2
Camelina alyssum	-	-	1	-	-	-	-	-	-	-	-	-	-
Capsella bursa-pastoris	-	-	-	-	-	-	-	-	-	-	-	-	2
Carex sp.-	-	-	-	-	-	-	-	-	-	-	-	2	
Caryophyllaceae	-	-	-	-	-	-	-	-	-	750	714	605	-
Cerastium sp.	-	-	-	-	-	-	-	-	-	-	-	-	5
Chenopodium sp.	23	6	-	-	20	-	58	-	-	-	-	66	-
Chenopodium album	29	10	1	-	-	30	-	15	4	705	850	1155	8827
Cruciferae	-	-	-	-	-	-	-	-	2	-	-	-	2
cf. *Echinochloa crus-galli*	-	-	-	-	-	-	-	-	-	-	-	-	2
Eleocharis sp.	-	-	-	-	-	-	-	-	-	-	-	-	2
Ericaceae-	-	1	-	-	-	-	-	-	-	-	-	-	
Erodium circutarium	12	4	-	-	-	-	-	5	-	-	-	22	142
Fabaceae -	-	-	-	-	6	-	-	-	-	-	-	-	
Fumaria officinalis	-	-	-	-	-	-	-	-	-	-	-	6	-
Galeopsis sp.	5	-	6	-	3	-	52	15	2	-	9	-	5
Galeopsis tetrahit agg.	-	-	-	-	-	26	-	-	-	-	-	-	-
Galium sp.	-	-	-	-	-	-	-	-	-	15	17	6	95
Gramineae	-	8	10	-	7	9	49	-	-	106	68	58	105
Juncus sp.	-	-	-	-	-	-	-	-	6	-	-	-	-
Lapsana communis	-	-	-	-	-	-	-	-	-	-	-	-	17
Lolium sp.	-	-	-	-	-	-	14	5	-	-	-	-	-
Luzula sp.	-	-	-	-	-	-	-	-	-	8	9	-	-
Phleum pratense	-	-	-	-	-	-	50	-	-	-	-	-	-
Plantago lanceolata	-	-	-	-	-	11	-	-	-	-	9	-	15
Poa annua	-	-	-	-	-	-	-	-	-	-	-	-	30
Polygonum sp.	-	-	-	-	-	-	-	-	-	30	-	-	-
Polygonum aviculare	-	-	1	76	-	20	-	-	-	44	-	27	7
Polygonum convolvulus	-	-	-	-	cf.23	-	16	-	-	106	153	-	-
Polygonum convolvulus/aviculare	18	6	-	-	-	17	-	56	4	-	-	275	2516
Polygonum minus	-	-	-	-	-	-	-	-	-	-	cf.26	-	-
Polygonum persicaria/lapathifolium	56	42	5	58	150	172	581	451	2	9970	4709	1155	3960
Ranunculus acris	-	-	1	-	-	-	-	-	-	-	-	-	2
Ranunculus repens	-	-	-	-	-	3	-	-	-	-	-	-	-
Raphanus raphanistrum	cf.9	4	-	13	-	-	50	1	-	-	-	-	10
Rumex sp.	2	-	-	-	3	9	-	-	-	44	-	11	-
Rumex acetosella	-	-	-	-	-	-	7	-	-	-	9	-	10
Scirpus sp.	-	-	-	-	-	-	-	-	-	-	-	6	-
Scleranthus annuus	-	-	-	-	-	-	-	-	-	-	-	-	7

Sample No.	Processed grain CBS (17+19)	CBS 16	BSF	BUL 1	BUL 3	Unprocessed grain HAF	BXI	BVG	Flax BSL	Weeds BXB	BXT	HAI	CBM 12
Original sample size †	***	***	**	***	***	**	**	**	*	**	*	*	**
Scleranthus polycarpos	-	-	-	-	-	-	-	-	-	-	-	6	-
Setaria glauca	-	-	-	-	-	-	-	-	-	-	-	-	2
Setaria sp.	-	-	-	-	-	-	-	-	-	-	-	-	5
Spergula arvensis	-	4	14	-	13	55	29	80	64	705	595	292	1691
Stellaria media	4	-	4	-	3	49	145	112	2	1426	1020	176	2598
Thlaspi arvense	-	-	-	-	-	-	7	-	-	-	-	6	5
Trifolium sp.	-	2	-	-	-	3	-	5	-	-	-	-	-
Urtica sp.	-	-	-	-	-	-	-	-	-	15	-	-	-
Verbena officinalis	-	-	-	-	-	-	-	-	cf.2	-	-	-	-
Veronica sp.	-	-	-	-	-	-	-	-	-	15	-	-	-
Veronica agrestis	-	-	-	-	-	-	14	-	-	-	9	6	65
Viola sp. -	-	-	-	-	-	-	-	-	-	-	-	5	
Unidentified seed/fruit	-	2	15	-	33	9	-	29	-	235	68	-	65
Unidentified seed/fruit (f)	-	-	-	-	-	-	-	-	-	-	-	-	9734

(n) - naked, (h) - hulled, (r) - rachis segment, (f) - fraction

† Original sample size is as follows: ***, >10 litres; **, a few litres; *, ca. 1 litre

Size measurements

Size measurements for barley and wheat grains are presented in Table 2. The size of grains of both naked and hulled barley corresponds with that of other finds from Denmark and northern Germany from the Bronze Age (Rowley-Conwy 1984a, 1984b) and Iron Age (Jørgensen 1985; Körber-Grohne 1967). In finds from the Viking Age (Behre 1976; Robinson and Siemen 1988; Robinson and Michaelsen 1989), the barley grains are longer. Unfortunately, the measurements from Overbygård cannot be compared directly to those carried out on Iron Age material by Helbæk (see Helbæk 1957, 1958, 1974). Helbæk included the embryo in his measurements and accordingly achieved grain lengths which are substantially greater than ours.

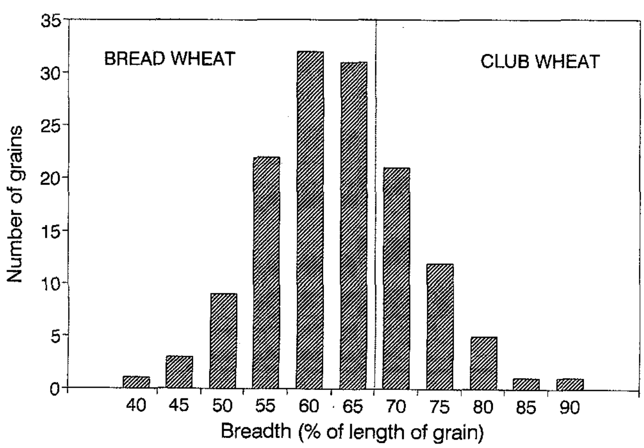

Fig. 4. Relationship between the length and breadth of wheat grains (both bread wheat and club wheat) from Overbygård

In interpreting size differences through time as an expression of genetic development, account should be taken of the fact that size differences between the various finds could be due to soil-type, level of manuring and climatic fluctuations. Similarly, there will be differences in the size distribution between grains in processed crops, in unprocessed crops and in processing by-products and waste products.

The wheat grains from Overbygård are very small. Wheat grains from the northern European Iron Age compiled by Körber-Grohne (1967), the late Pre-Roman Iron Age site of Hodde (Jørgensen 1985), the Danish Bronze Age (Rowley-Conwy 1984a, 1984b) and the Neolithic (Jørgensen 1976), are all considerably larger than those from Overbygård. An average length of 3.5 mm suggests that the grains may be best assigned to *Triticum aestivum* var. *compactum* (club wheat). However, if the ratio between length and breadth is considered (Fig. 4), only a third of the grains, at most, falls into the club wheat category (Körber-Grohne 1967). This is a consequence of the extreme thinness of many of the grains. A probable explanation for this is that growing conditions were extremely poor. The sandy soils which are found over most of the area, immediately adjacent to the Overbygård site, would not have been suited to growing wheat. Also, drought and/or nutrient lack at the end of the growing season may have hindered the development of the grains.

The average rachis segment length for barley in sample HAF was 2.3 mm (1.4-3.5 mm) and in sample BVG 2.6 mm (1.4-3.6 mm; ranges in parentheses). There is a degree of variation in rachis segment length within individual ears, such that the lowest segment is the shortest. A section of rachis made up of seven articulated rachis segments, including the basal segment, gave the following measurements beginning from the base: 2.1, 1.4, 2.3, 2.5, 2.8, 3.1 and 3.2 mm. This corresponds to barley of the lax-eared form (Fig. 5). If we compare these meas-

Table 2. Measurements of barley and wheat grains from Overbygård

Sample No.	Naked six-rowed barley n	length (mm)	breadth (mm)	thickness (mm)	Hulled six-rowed barley n	length (mm)	breadth (mm)	thickness (mm)
Processed barley								
CBS 17+19	50	4.4	2.6	2.1	50	4.8	2.9	2.4
		3.5-5.6	1.6-3.5	1.4-3.0		3.9-5.4	2.1-4.0	1.6-3.0
CBS 16	50	4.2	2.4	1.9	31	4.3	2.5	2.0
		3.1-5.2	1.5-3.1	1.2-2.7		3.3-5.0	1.8-3.2	1.4-2.6
BSL	50	4.3	2.5	1.9	29	4.2	2.4	1.9
		3.4-5.3	1.5-3.2	1.4-2.5		3.4-5.2	1.8-2.9	1.3-2.3
Unprocessed barley								
BVG	50	4.5	2.5	2.0	-	-	-	-
		3.4-6.0	1.6-3.7	1.3-3.2	-	-	-	-
BXI	50	4.0	2.2	1.7	42	4.1	2.2	1.7
		2.4-5.4	1.1-3.2	0.8-2.6		2.9-5.3	1.3-3.0	0.9-2.5
HAF	50	4.0	2.1	1.7	17	4.2	2.4	1.9
		2.6-5.7	1.2-3.5	0.8-2.8		2.6-5.3	1.6-3.5	1.2-2.8
Barley from weed seed samples								
CBM	50	3.8	2.1	1.6	-	-	-	-
		3.2-4.8	1.4-2.8	1.0-2.4	-	-	-	-
HAI	5	4.6	2.6	2.0	9	3.5	1.9	1.4
		4.2-5.1	1.7-3.2	1.4-2.4		2.4-4.4	1.5-2.7	1.1-2.0

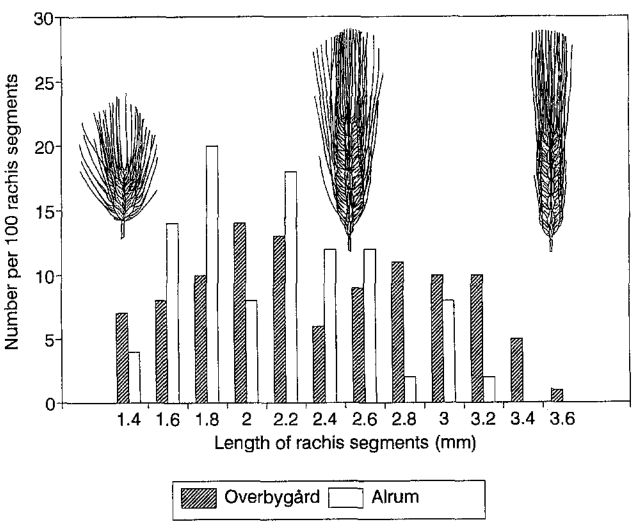

Fig. 5. The length of barley rachis segments from Overbygård and Alrum and the morphology of barley ears having different rachis segment lengths. Left to right: compact-eared with short rachis segments, lax-eared with medium rachis segments and lax-eared with long rachis segments

urements with corresponding measurements of rachis segments from Viking Age finds in Germany [Elisenhof (Behre 1976), Haithabu (Behre 1983)], where all the finds are consigned to the lax-eared form of barley, then we see that at Overbygård and Alrum there is a much greater proportion of very short rachis segments. This means that, in the Danish material, there is much greater variation between individual plants. Some of the barley ears were presumably of the compact-eared form. The measurements show that single finds of short rachis segments cannot be used as evidence of cultivation of compact-eared six-rowed barley, as the basal rachis segments of the lax-eared form may also be very short. Furthermore, there is considerable variation in rachis morphology from completely straight to very curved, in contrast to modern cultivars where uniform rachis segment morphology is a diagnostic character (Andersen 1983).

Discussion

Crop plants

The analyses show that six-rowed barley was the main crop at Overbygård in the period around the birth of Christ. In all the samples analysed, naked barley dominates relative to hulled barley; in the majority of the samples, the former constitutes 92-98% of the barley grains, although in one sample there is only 85% naked barley. Bread wheat is the main component of several samples and it was also an important crop. Grains of *Triticum dicoccum* (emmer) are recorded together with bread wheat. These grains, which were slightly underdeveloped, presumably represent contamination of the seed corn rather than certain evidence of emmer cultivation at Overbygård.

Grains of *Avena* sp. (oat) are present in substantial numbers in two of the unprocessed samples. A small number of the grains were still in their florets and the majority of these could be identified, on the basis of the morphology of the floret base, as *Avena fatua* (wild oat). The remaining few florets are not well enough preserved to enable determination to species level. No floret bases of *Avena sativa* (cultivated oat) were seen. There is, therefore, no evidence that oats was cultivated at Overbygård.

In addition to cereals, flax was cultivated. This is revealed by the presence in two samples (one of which was not analysed in full) of processed linseed and flax is recorded in some of the grain samples where it presumably represents weeds in the grain crop. A few seeds of *Camelina sativa/alyssum* (gold of pleasure) were also found but it is more likely that this plant was a weed of the flax crop rather than a crop in its own right.

Weed flora

The dominant weed species in the samples from Overbygård are *Polygonum persicaria/ lapathifolium, Chenopodium album, Spergula arvensis* and *Stellaria media*. In addition, there are numerous other weed species, the seeds of which are less numerous. The composition of the weed flora, and in particular the dominance of *Polygonum* species, indicates that crops were spring sown (cf. Behre 1983). If we look at the weed flora as a whole, it presents us with a rather ambiguous picture of the ecological conditions in the fields at Overbygård in the late Pre-Roman Iron Age. The presence of *Spergula arvensis, Rumex acetosella* and *Erodium cicutarium* reflect conditions associated with predominantly sandy soil. These finds, as well as the presence of *Raphanus raphanistrum* and *Thlaspi arvense* (and the very small size of the wheat grains), also suggest that the soil was poor in nutrients. In contrast, the general dominance of achenes/seeds of *Polygonum persicaria/ lapathifolium* and *Stellaria media*, as well as achenes/seeds of *Galeopsis* sp., *Polygonum minus* and *Ranunculus acris*, suggest that damp, humus-rich soils were also cultivated. Similarly, the abundance of seeds of *Chenopodium album* and *Stellaria media*, which both thrive on nutrient-rich soils with a high nitrogen content, and seeds of *Veronica agrestis* and *Fumaria officinalis*, which indicate basic soils and heavier soils with a greater clay content, show that all soils were not equally nutrient-poor or acid. The weed flora, therefore, indicates that conditions in the arable fields, i.e. soil-type, moisture content, pH and nutrient content, varied considerably. Well-drained slopes and hilltops as well as damper low-lying areas were cultivated with an apparently uneven application of manure.

Harvesting and crop processing

The samples analysed fall clearly into three categories on the basis of the relationship between grains, rachis segments (chaff) and weed seeds (Fig. 6), i.e. processed grain, unprocessed grain and weed seeds.

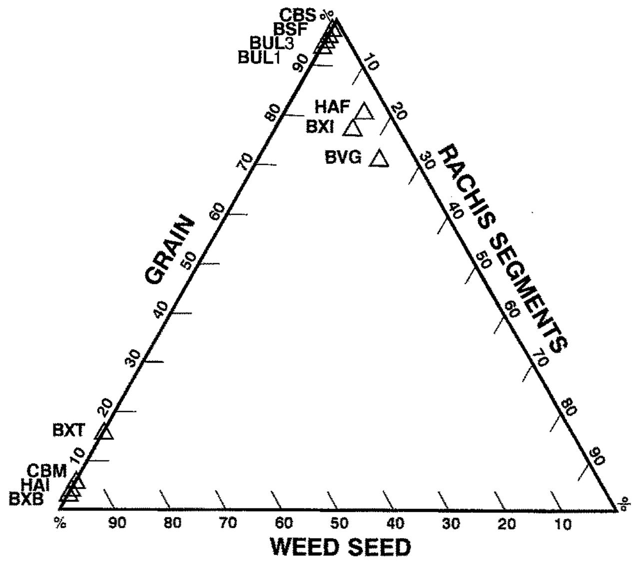

Fig. 6. Triangular scatter plot from Overbygård, showing the relationship between the content of grain, rachis segments and weed seeds

Crop processing must have been very effective, as rachis segments and weed seeds are exceedingly rare in the processed grain. A comparison of grain size in the processed and unprocessed samples (Fig. 7) shows that processing has selectively removed some of the smaller grains. Grain is normally cleaned by winnowing (throwing the threshed grain against the wind so that the lighter chaff and weed seeds are separated from the grain) or casting (the threshed grain is thrown as much as 5 metres along the threshing floor and grain, chaff and weed seeds become separated on the basis of their density and aerodynamic properties). Both methods result in the removal of smaller cereal grains (tail-grain) but the effect is particularly marked when casting is used (Engelmark 1989). This suggests that casting may have been the method employed at Overbygård.

It is not possible, on the basis of the measurements, to ascertain whether the grain has been sieved. To do this, it is necessary to analyse the material removed by sieving. If sieving has taken place, this material should show a sharp upper size limit which is determined by the mesh size of the sieve. Such material either did not exist or is not preserved at Overbygård.

The large number of rachis segments in a number of samples shows that these samples represent unprocessed grain. In one of the samples, barley rachis segments are present in such abundance that they correspond to 94% of the barley grains present (in ears of six-rowed barley, rachis segments and grain are present in a ratio of ca. 1:3). This shows that the sample had not been threshed, as threshing alone results in the loss of a significant pro-

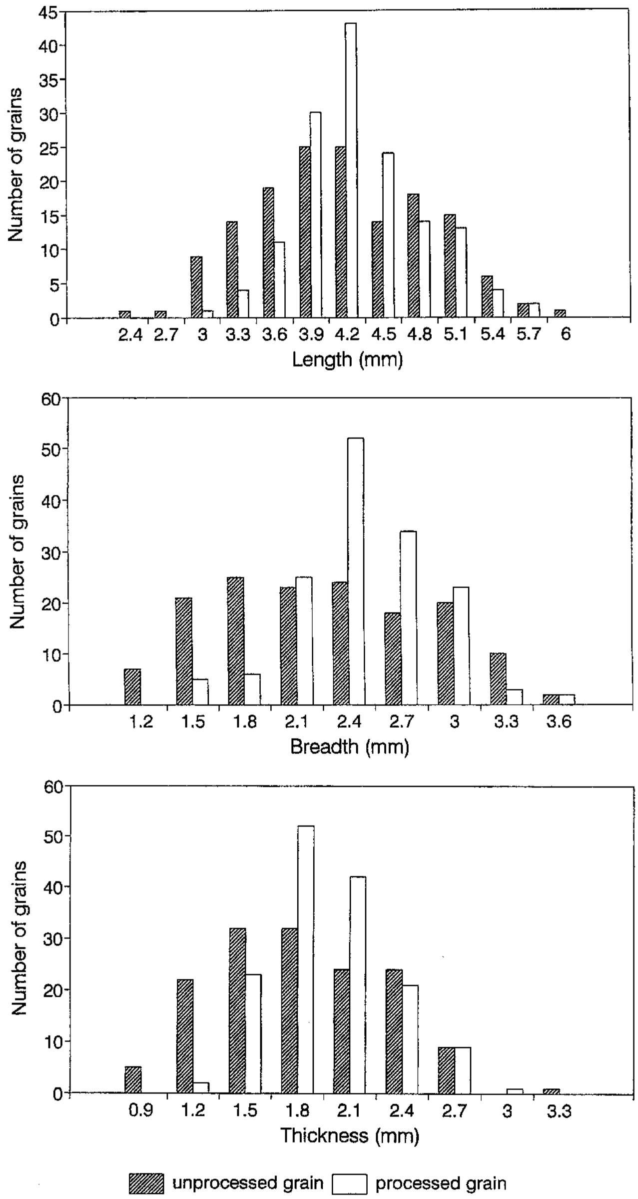

Fig. 7. Measurements of grains of naked barley from a processed and unprocessed grain sample at Overbygård

portion of the rachis segments. Many of the rachis segments remain intact on the straw and were probably later removed with the straw from the threshed grains. This particular sample was found in a pottery vessel and the ears must have been detached from the straw prior to storage in this way. There were, however, some short pieces of straw present, some of them with the lowest rachis segment intact. Amongst the weed seeds present, ca. 20% were from species of low growth form such as *Spergula arvensis, Stellaria media, Erodium cicutarium, Ranunculus repens* and *Ajuga reptans*. The possibility that the barley was harvested by cutting off the ears from the standing straw in the field can therefore be excluded. Rather, the ears must have been separated from the straw at a later stage. A possible sequence of events is as follows. After harvesting at a much less ripe stage than is the case in our modern technological age, the sheaves were allowed to stand in the field to allow the grain to mature and dry. The sheaves were then transported to the village, where the ears were removed in order to reduce the bulk and the harvest stored out of reach of pests and vermin. In the process of cutting off the ears, seeds of weed plants in the sheaves would be released and subsequently become mixed with the detached ears. According to Juel Jensen (1994), wear traces on flint tools suggest that a similar practice was prevalent in the Neolithic.

Four of the samples analysed had weed seeds as their main component. The species in question are mostly from typical arable weed species. They could either have been brought in together with, and later removed from, the harvested crop, or they could have been collected from plants growing in and around the village, i.e. fallow fields and waste areas. We have tried to investigate which of these possibilities is most likely. Firstly, we tried to establish if the material could have been removed from the harvested grain. Table 3 shows the weed seed content in the three categories of sample: processed grain, unprocessed grain and weed seeds. The weed species have been divided into four groups on the basis of the size and density of their seeds as it is these qualities which determine the route which the seeds follow during crop processing (Hillman 1981, 1984; Engelmark 1989). These data are plotted in Fig. 8A and the percentages of weed seeds in the various size categories in the processed grain and weed seeds samples, minus the percentage values in the samples of unprocessed grain, are shown in Fig. 8B. If the weed seed samples represent material removed during processing then the two curves in Fig. 8B should be mirror images about the x-axis. Since this is not the case, it appears that the weed seed samples do not represent material originating from crop processing.

Table 3. Percentage representation of various categories of weed seeds in processed grain, unprocessed grain and weed seed samples

Seed category	Sample type		
	Processed	Unprocessed	Weed seed
Small light	10	24	24
Small free heavy	72	55	71
Large free heavy	13	19	5
Large heavy-headed	5	2	0

Seed category is based on size and density

We tried to check the above interpretation by measuring the few cereal grains in the weed seed samples and comparing them with the corresponding measurements of grains in the processed and unprocessed cereals (Fig. 9; Table 2). For samples BXT and BXB, the measurements were combined because there were so few grains present. Unfortunately, the comparison did not give any clear indications about the relationship between the sample categories. In BXT, the size distribution of the barley grains (naked and hulled) resembles that of the unprocessed naked barley. In CBM, the size distribution

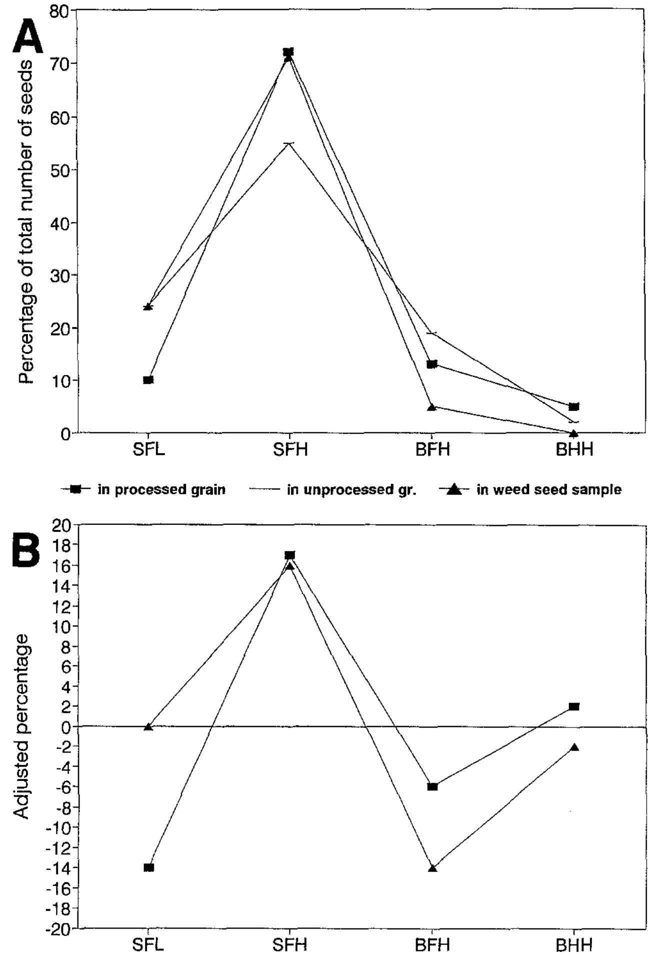

Fig. 8. **A** Percentage values of small free light seeds *(SFL)*, small free heavy seeds *(SFH)*, large free heavy seeds *(BFH)* and large, heavy-headed seeds *(BHH)* in processed grain, unprocessed grain and weed seed samples from Overbygård. **B** Adjusted percentage values, i.e. percentages of weed seeds from the various size categories in the samples of processed grain and of weed seeds, minus the values from the samples of unprocessed grain

of the naked barley grains is very similar to that of the processed naked barley, in that the smallest grains are absent. In BXB, most of the barley grains (naked and hulled) are very small, which suggests that BXB could represent processing waste. This conclusion is very tentative however, as it was only possible to measure 23 grains in BXB. None of the weed seed samples contain cereal rachis segments. One would expect to find these if the samples represented waste products from the processing of threshed grain.

The second and more probable explanation is that the samples represent weed seeds and occasional grains collected intentionally for food, for example from fallow fields. There are several examples of weed seeds from Iron Age contexts in Denmark which were apparently collected. The best example of this is probably that from the site of Nørre Fjand in northern Jutland were a find of 1.5 litres of carbonised *Chenopodium album* seeds was recorded. This find was analysed in full by Helbæk (1954), who found 252 seeds of other species (about half of which were barley grains) among an estimated 2.4 million seeds of *C. album*. He suggested that the find indicated cultivation of *C. album,* which is normally re-

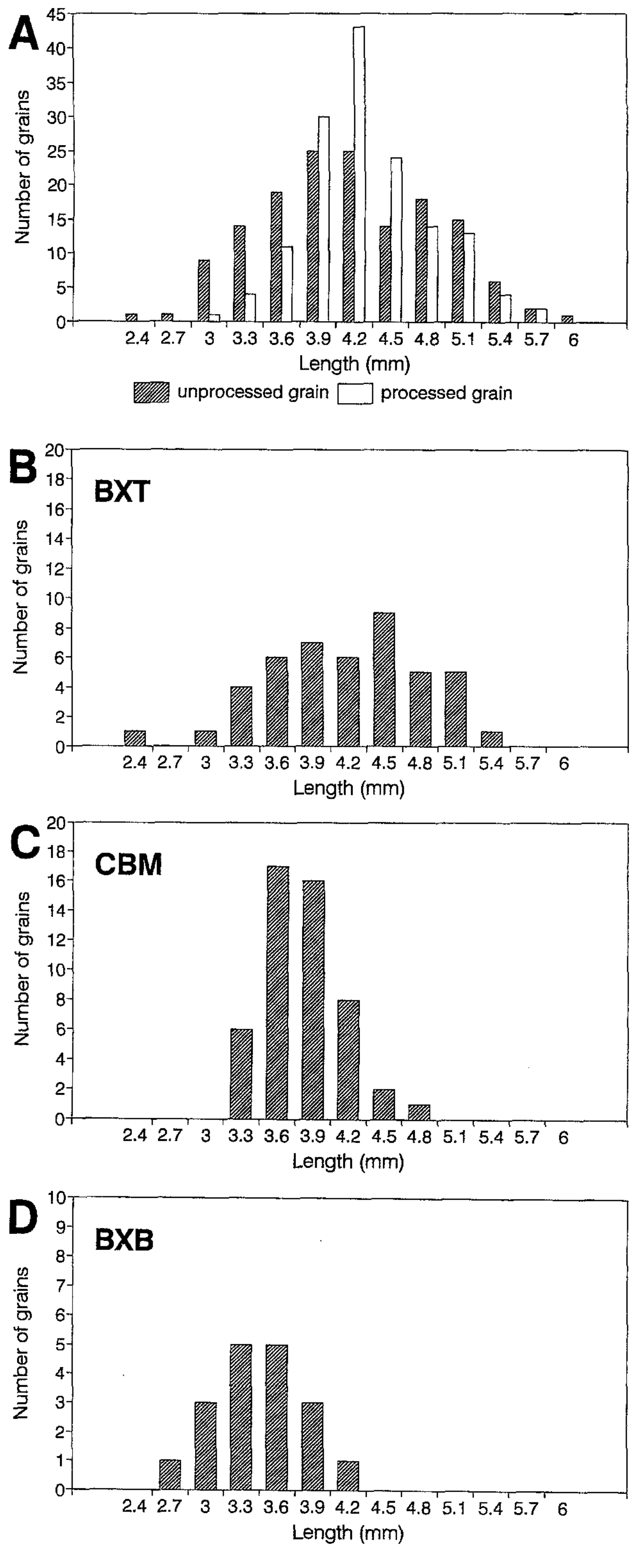

Fig. 9. Size distribution of the barley grains from the weed seed samples (**B**, **C**, **D**) compared with the distribution in processed and unprocessed samples of naked barley (**A**)

garded as a weed. In connection with our examination of archaeobotanical finds from the Danish Iron Age, this find was re-examined and a further 500 seeds of other species were found, giving a total of 750 seeds, i.e. a level of contamination of only 0.03%. This suggests intentional collection of *Chenopodium album* seeds. The plant presumably grew on fallow land on which, during the previous year, barley was grown. According to Korsmo et al. (1981), the average *C. album* plant produces ca. 3000 seeds. The find corresponds therefore to the seed production of ca. 600 plants which, in a dense stand, would occupy about 10 m^2. This does not support the idea that *C. album* was intentionally cultivated as suggested by Helbæk. Cultivation is unlikely to have been necessary, as weed species such as *Chenopodium, Spergula* and *Polygonum* have high productivity and efficient seed dispersal. A few plants that set and disperse their seed have the potential to create a substantial weed population in the following growing season.

The composition of the weed seed samples from Overbygård differs from the *C. album* sample from Nørre Fjand in that several species are present in substantial numbers. This is probably a consequence of differences in the manner in which the weed seeds were collected in the field.

Conclusion

The contents of the Overbygård granary represents the best archaeobotanical material from the Danish Iron Age and probably also from the whole of Danish prehistory. The find consists of a storage deposit and includes a range of processed and unprocessed crops and collections of weed seeds stored in an underground granary that was ravaged by fire. The result was a mass of carbonised plant material preserved for posterity. It gives us a snapshot revealing the situation in the granary on a particular day in a particular year.

Naked barley and bread/club wheat were the main crops. Flax was also cultivated and emmer and gold of pleasure were present as weeds or contaminants. The size of the barley grains corresponds with that of other finds from the north-west European Bronze Age and Iron Age. On the other hand, the bread wheat grains are exceedingly small which is probably the result of nutrient-poor soils. Measurements of barley rachis segments reveal that the barley was predominantly of a lax-eared form but it also showed that there was a much greater variation in form compared with modern cultivars. Also, the diversity in rachis morphology was much greater than is the case with modern barley cultivars.

The arable weed flora suggests that crops were spring sown and that conditions in the arable fields, i.e. soil-type, moisture content, pH and nutrient content, varied considerably. Well-drained slopes and hilltops as well as damper low-lying areas were cultivated and the application of manure seems to have been limited, or at least uneven.

The crops were harvested on the straw and may have spent some time drying and maturing in the fields before being transported home. The crops were stored both as processed grain and as severed ears in 'pestproof' granaries, i.e. in sacks and pottery vessels in cellars. Winnowing or, more probably, casting appears to have been used to clean the crop after threshing. It was not possible to ascertain if the crops had been sieved.

The significance of large amounts of weed seeds stored in the granary is not readily apparent. It appears that these represent weed seeds that were intentionally collected for food, for example from areas of fallow, rather than seeds removed from the cereal crops during processing.

How representative this picture is of the general situation in the Early Iron Age, or even of the general situation in the village of Overbygård itself, is difficult to judge. A broader view of arable agriculture in the centuries around the birth of Christ will require research on two fronts, namely, further analyses of archaeobotanical finds and a programme of practical experiments.

With regard to archaeobotanical analyses, we need to be particularly aware in the future of two kinds of find, namely stored crops from granaries and similar structures (e.g. Overbygård) and waste products from crop processing, which are normally found in refuse pits and middens. The later have largely been ignored at Early Iron Age sites in Denmark. It goes without saying that excavation of these finds should involve meticulous documentation at every stage, thus avoiding the problems which were met at Nørre Fjand and Alrum.

The investigations described here have raised many questions regarding the practical aspects of cultivation, harvesting and processing of crops in the north-west European Iron Age. In response, a number of hypotheses have been proposed. Many of these hypotheses could be tested through practical experiments. It is possible, for example, to investigate how soil preparation methods and manuring influence the arable weed flora, and how different harvesting methods affect the composition of the arable weed seed flora which accompanies the crop. Similarly, analyses can be made of the various fractions and products that arise during crop processing using various combinations of throwing, winnowing and sieving. The possibility of widening the project to include many other aspects of the low input, low technology agriculture, which prevailed in the Iron Age, should also be considered. Through a combination of archaeobotanical analysis and practical experiments it should be possible to achieve a much more detailed interpretation of the fossil plant remains found in Iron Age sites and thus a much deeper understanding of arable agriculture, not only in the Iron Age, but in prehistory as a whole.

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