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Archaeobotanical Investigations of a Middle and Late Bronze Age Settlement Site at Westwoud (West-Friesland)

with contributions by G.F. IJzereef and W.J. Kuijper

Keywords: archaeobotany, seeds, bones, molluscs, correspondence analysis, Middle and Late Bronze Age, Westwoud, West-Friesland, the Netherlands;
85 references.

1 INTRODUCTION

From June 20th until July 6th 1988, the Dutch State Service for Archaeological Investigations (ROB) carried out a small excavation in the village of Westwoud (municipality of Drechterland, prov. of Noord-Holland).[1] At this site[2] the presence of settlement remains in so-called 'kadetjesland'[3] had clearly been demonstrated by dr. W.H. de Vries-Metz by means of aerial photography and field surveys.[4] In the course of the Westwoud reallotment scheme, the parcels concerned were due to be levelled, during which the habitation traces would be totally destroyed.
The excavation at Westwoud was carried out under the direction of the archaeozoologist dr. G.F. IJzereef and the author. The technical direction was in the hands of A. de Haan. The aim of the project was to gain as much information as possible on house-building, the food economy, agricultural activities and the environment from the perspectives of the ecological disciplines. This investigation would make it possible to compare the results of the rather roughly executed, large-scale excavations in the province of Noord-Holland which the ROB carried out at Andijk (1973) and Bovenkarspel-Het Valkje (1974–1978) and which so far have not been published,[5] with those of a small-scale excavation with a detailed sampling programme. Because of delays in working out the archaeological aspects of the Westwoud excavations, the archaeobotanical study will be published separately here. The animal remains are also included in this study.

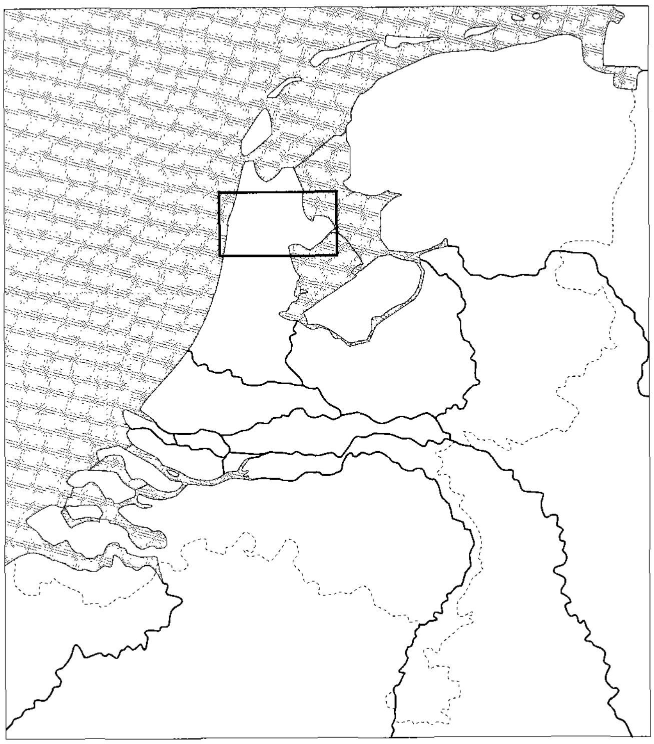

Figure 1 Map of the Netherlands with the area of West-Friesland.

1 IJzereef & Buurman, in: Woltering 1989, 280–2.
2 Map sheet 19F, 139.325/522.850; top of the recent arable 0.58 m -NAP.
3 Uneven terrain resulting from ditches dug before systematic allotment, and (partially) filled in since (Ente 1963, 24, fig. 7).
4 De Vries-Metz 1993.
5 IJzereef & Van Regteren Altena in prep.

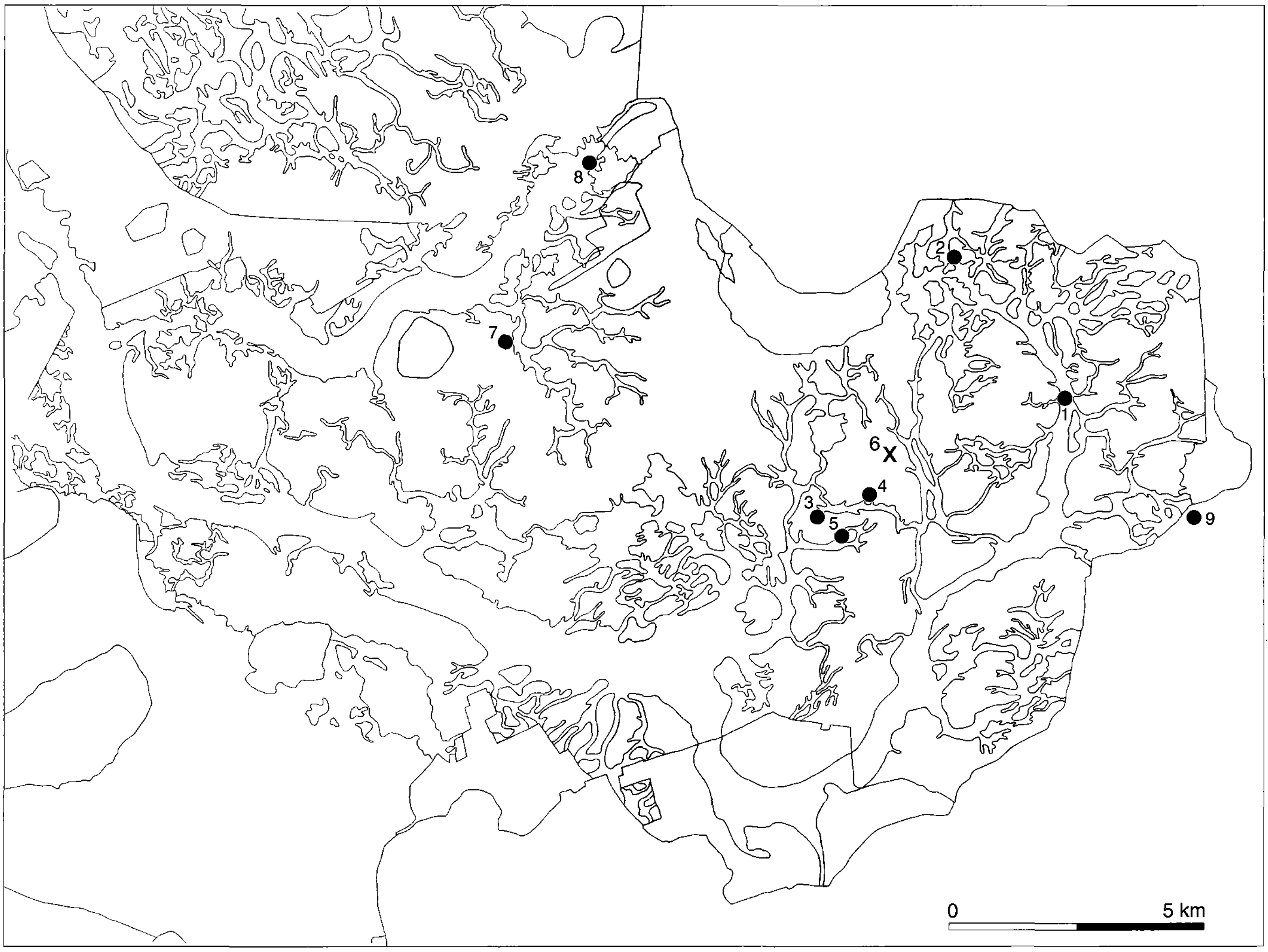

Figure 2 Palaeogeographic map of the eastern part of West-Friesland with the system of creek ridges and location of the mentioned sites (map by D.P. Hallewas).
Legend: 1 Bovenkarspel-Het Valkje; 2 Andijk; 3 Westwoud; 4 Hoogkarspel-Watertoren; 5 Hoogkarspel-Medemblikker Tolhuis; 6 Hoogkarspel-Klokkeweel; 7 Twisk; 8 Opperdoes; 9 Enkhuizen-Westfriese Zeedijk.

2 THE LOCATION OF THE SITE

The Westwoud site is located on a narrow, sandy-loamy creek ridge in the eastern part of the district of West-Friesland, province of Noord-Holland (figs. 1 and 2). In this former tidal flat and saltmarsh area, the wide channel ridges of fine sand and the narrow ones of loamy sand – which arose through relief inversion after silting closed them off from the sea – saw intensive occupation in the Middle and Late Bronze Age. On the same small creek ridge in the near vicinity of the site, other Bronze Age sites had earlier been excavated. About 1.5 km to the east-northeast, there is the site of Hoogkarspel-Watertoren. Here excavations were carried out first by the *Instituut voor Prehistorie, Leiden* (IPL) in 1972,[6] and later (1973–1975) on a large scale by the *A.E. van Giffen Instituut voor Pre- en Protohistorie* (IPP).[7] Between 1966 and 1969 the site of Hoogkarspel-

6 Modderman 1974.
7 Bakker *et al.* 1977.

Medemblikker Tolhuis was excavated by the IPP.[8] This site is located only 500 m southeast of the site of Westwoud, on a small creek ridge which is part of the same system as that which accommodates the Westwoud and Hoogkarspel-Watertoren sites. The sites of Bovenkarspel-Het Valkje and Andijk are situated on a very wide channel ridge which runs north-south. Excavations of Middle and Late Bronze Age settlement sites have also been carried out by the ROB on a more westerly channel ridge at Twisk and Opperdoes. At Opperdoes and in its immediate surroundings, also Iron Age occupation was found.[9]

The author has thus far published reports on archaeobotanical investigations of the site of Twisk,[10] and of aspects of the sites of Bovenkarspel-Het Valkje[11] and Opperdoes.[12] At Andijk, no archaeobotanical investigation was carried out. Carbonized and waterlogged plant remains from Hoogkarspel-Watertoren were studied by Pals, while pollen, spores and molluscs from this site were studied by Bakels, Van Geel and Kuijper.[13] Carbonized plant remains from a few samples of Hoogkarspel-Medemblikker Tolhuis were investigated by Van Zeist but have not yet been published.[14]

Pals *et al.* performed palaeoecological investigations on a peat section from the Klokkeweel bog, which is situated less than one km from the site of Hoogkarspel-Watertoren and less than 2.5 km from the site of Westwoud.[15] Here peat formation took place during the Bronze Age occupation of the area. Under the dike near Enkhuizen peat was preserved which had developed between the Bronze Age and the medieval reclamations. This peat was investigated by Van Geel *et al.*[16] Both studies showed the increasing wetness of the area at the end of the Late Bronze Age, which caused widespread abandonment of settlements.

3 THE SITE

During the excavation of the Westwoud site, the remains of a Middle Bronze Age house site, some Middle and Late Bronze Age circular structures and some Middle and Late Bronze Age ditches were found (fig. 3). On the bases of stratigraphy and pottery, three main habitation phases can be distinguished. Since the study of the archaeological evidence has not yet been completed, the assignment of features to these three phases in this article has been done by the author and must be regarded as provisional. The incomplete, severely disturbed house-plan of *c.* 16 m length, oriented approximately north-south and consisting of two rows of postholes and two house-ditches, dates from the oldest phase (phase I). This phase belongs to IJzereef's Early Period and is dated to the Middle Bronze Age and the beginning of the Late Bronze Age.[17] The circular ditches belong to the next phase (phase II), which also falls in the Early Period. They are about 4 m in diameter and are interpreted as the archaeological remains of drainage ditches around stacks where the cereal harvest (or possibly hay) was kept.[18] At other (larger) sites in the area, such circular structures (ditches and circles of pits) were usually found next to the houses, but they sometimes occur in arable land or pasture as well. Also some ditches belong to phase II. Whether or not these ditches flanked houses is uncertain, because of the small size of the excavation. Wide and mostly deep ditches are reckoned to belong to the last phase (phase III). They are especially characteristic of the Late Period, which is dated to the end of the Late Bronze Age. In this period, the inhabitants adapted to the increasing wetness of the landscape and the rise of the water table[19] by raising their farmsteads with soil from these ditches, thus creating elevated house-sites or *terpen*. The southern ditch is earlier than the middle and northern ditches. It was filled with soil deliberately, since its fill consisted of

8 Bakker & Brandt 1966; Bakker & Metz 1967; Bakker *et al.* 1968.
9 Woltering 1980; 1981; 1985.
10 Buurman 1989.
11 Buurman 1979; 1988; Buurman & Pals 1976; Buurman *et al.* 1995.
12 Buurman 1993.
13 Pals, in: Bakker *et al.* 1977; Bakels 1974; Van Geel 1976; Kuijper, in: Bakels 1974; Kuijper, in: Bakker *et al.* 1977.
14 Personal communication W. van Zeist, BAI (Groningen).
15 Pals *et al.* 1980.
16 Van Geel *et al.* 1982/1983.
17 Chronology of the Bronze Age habitation of the eastern part of Westfriesland according to IJzereef (IJzereef 1981; IJzereef & Van Regteren Altena 1991).
18 Buurman 1979; 1989.
19 Van Geel *et al.* 1996; 1997; Roep & Van Regteren Altena 1988.

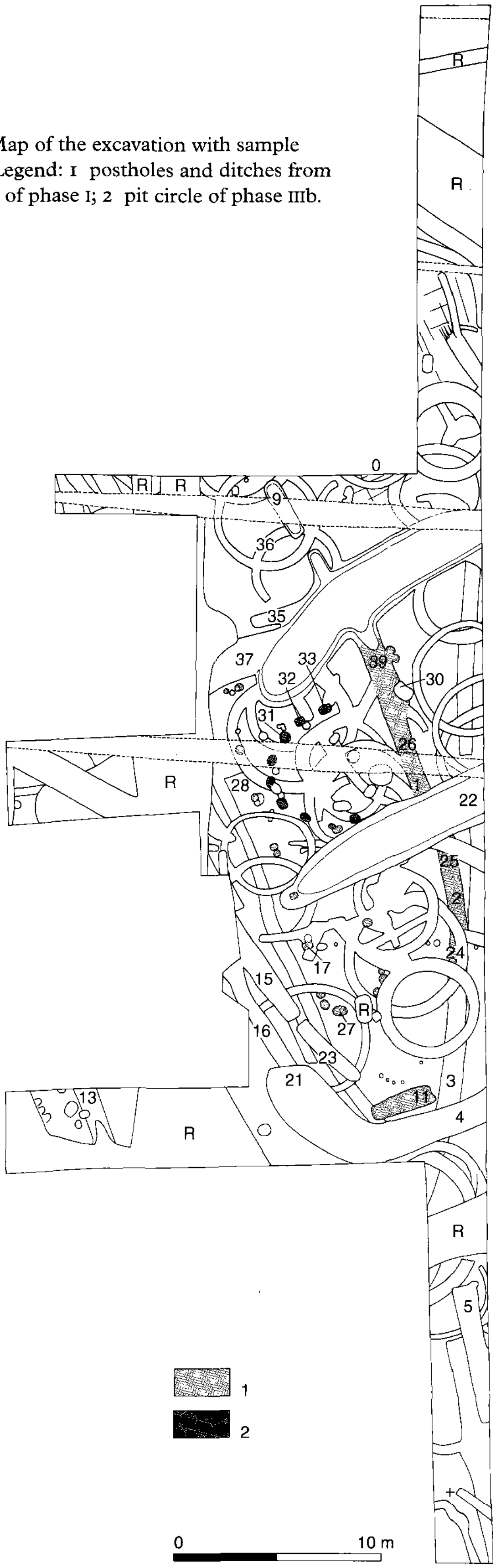

Figure 3 Map of the excavation with sample numbers. Legend: 1 postholes and ditches from house-plan of phase I; 2 pit circle of phase IIIb.

lumps of sandy/loamy soil. Whether this ditch was dug already with the intention of raising the site or simply for drainage purposes is unknown. This southern ditch may have been back-filled during the construction of the *terp* system of which the northern and middle *terp* ditch were part. The upper fill of the northern and middle *terp* ditches consists of medieval clay. These ditches evidently were still open when the site was abandoned at the end of the Late Bronze Age. The pit circle between the ends of the northern and middle *terp* ditches also belongs to this latest phase, as do some other ditches related to the northern *terp* ditch.
Some ard traces were found in the northern part of the excavation. There, the structure of the profile could be studied in section. The *c.* 30 cm thick remains of the prehistoric arable soil are situated immediately beneath the recent arable soil. The prehistoric arable soil consisted of two layers, a grayish-brown bottom layer up to 15 cm thick to which the ard traces are related, and a black upper layer of up to *c.* 10 cm thickness. The latter contained many finds from the Late Period. The ard marks may predate the house.

4 DATING

Ten samples of carbonized plant remains were selected for AMS dating at the R.J. van der Graaff Laboratory of the State University of Utrecht. The dates were calibrated by the CIO Groningen Radiocarbon Calibration Programme, April 1993 version, which is based on the calibration curve of Stuiver *et al.*[20] Only the 1σ calibrated date is given in table 1. The numbers in brackets are the sample codes. In fig. 4 both 1σ (68.3% probability) and 2σ (95.4% probability) calibrated dates are presented. When calibrated dates (cal BC) are given in the text, the 1σ range is used. It appears that the 1σ calibrated dates of the features from phase I, although belonging to a single house-plan, cover a rather long period (1395–1050 cal BC). This is due to the rather flat course of the calibration curve in that period. Only one radiocarbon date is available for phase II with the circular ditches; this date falls totally within the range of the dates for phase I. The dated circular ditch (sample no. 36) happens to be situated just outside the area of the house-plan, and therefore could indeed be contemporary with it.

20 Stuiver *et al.* 1993.

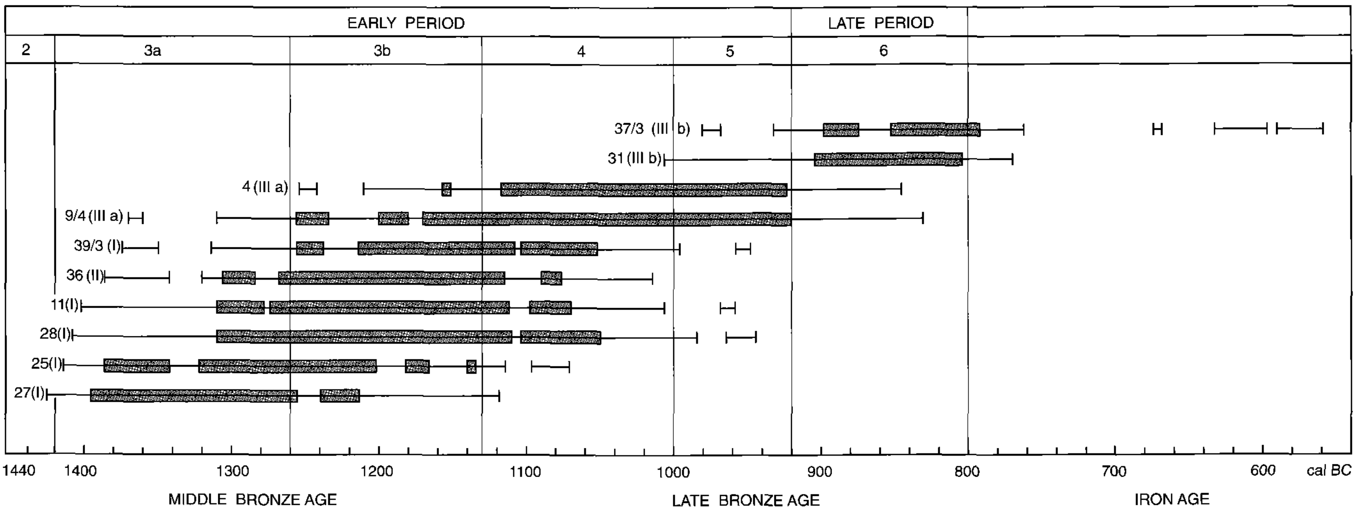

Figure 4 Calibration of radiocarbon dates.

Westwoud-U-I	(11)	carb.seeds	UtC-2347	2980 ± 80 BP	cal BC 1310-1278; 1274-1112; 1098-1056.
Westwoud-U-II	(25)	carb.seeds	UtC-2348	3030 ± 60 BP	cal BC 1386-1342; 1322-1202; 1182-1166; 1140-1134.
Westwoud-U-III	(39/3)	carb.seeds	UtC-2349	2950 ± 60 BP	cal BC 1256-1238; 1214-1108; 1104-1048.
Westwoud-U-IV	(27)	carb.seeds	UtC-2350	3050 ± 60 BP	cal BC 1396-1256; 1240-1214.
Westwoud-U-V	(28)	carb.seeds	UtC-2351	2980 ± 90 BP	cal BC 1310-1110; 1104-1050.
Westwoud-U-VI	(36)	carb.seeds	UtC-2352	2980 ± 60 BP	cal BC 1306-1284; 1268-1115; 1090-1076.
Westwoud-U-VII	(4)	charcoal	UtC-2353	2860 ± 70 BP	cal BC 1154-1146; 1116- 922.
Westwoud-U-VIII	(9/4)	charcoal	UtC-2354	2880 ± 100 BP	cal BC 1258-1234; 1200-1180; 1170-920.
Westwoud-U-IX	(31)	carb.seeds	UtC-2355	2700 ± 70 BP	cal BC 904- 804.
Westwoud-U-X	(37/3)	charcoal	UtC-2356	2660 ± 60 BP	cal BC 898- 874; 852-792.

Table 1 Radiocarbon dates.

The radiocarbon dates for phase III can be classified in two groups. The southern *terp* ditch (sample no. 4) and a short ditch to the north (sample no. 9/4) are dated to the period 1200–920 cal BC, which for the greatest part falls in the beginning of the Late Bronze Age (phase IIIa). The northern *terp* ditch (sample no. 37/3) and the pit circle (sample no. 31) are dated to the end of the Late Bronze Age (910–790 cal BC, phase IIIb).
Given the stratigraphy, pottery dates and radiocarbon dates, the phases can be matched with IJzereef's chronology for Bovenkarspel-Het Valkje[21] as follows:

Westwoud	*Bovenkarspel-Het Valkje*
I,II	Early Period, phase 3a/b, (4) 1395–1050 cal BC;
IIIa	Early Period, phase (3b), 4, 5 1200–920 cal BC;
IIIb	Late Period, phase 6 920–790 cal BC.

5 MATERIAL AND METHODS

5.1 *Sampling*

An elaborate sampling programme was planned in advance in order to collect the maximum number of samples for analyses of plant macroremains, pollen, and small bones and molluscs, and for the recovery of the smallest archaeological finds of inorganic material. The plan was for all features to be sampled, even the unpromising ones. Larger or elongated features would be sampled at regular distances. The standard volume of the samples for macroremains was 10 litres of soil. From small features, such as postholes, it was not always possible to collect this amount of soil. In these cases it would suffice to collect the maximum amount of soil. Distinct concentrations of organic or other archaeological material were collected as pure as

21 IJzereef & Van Regteren Altena in prep.

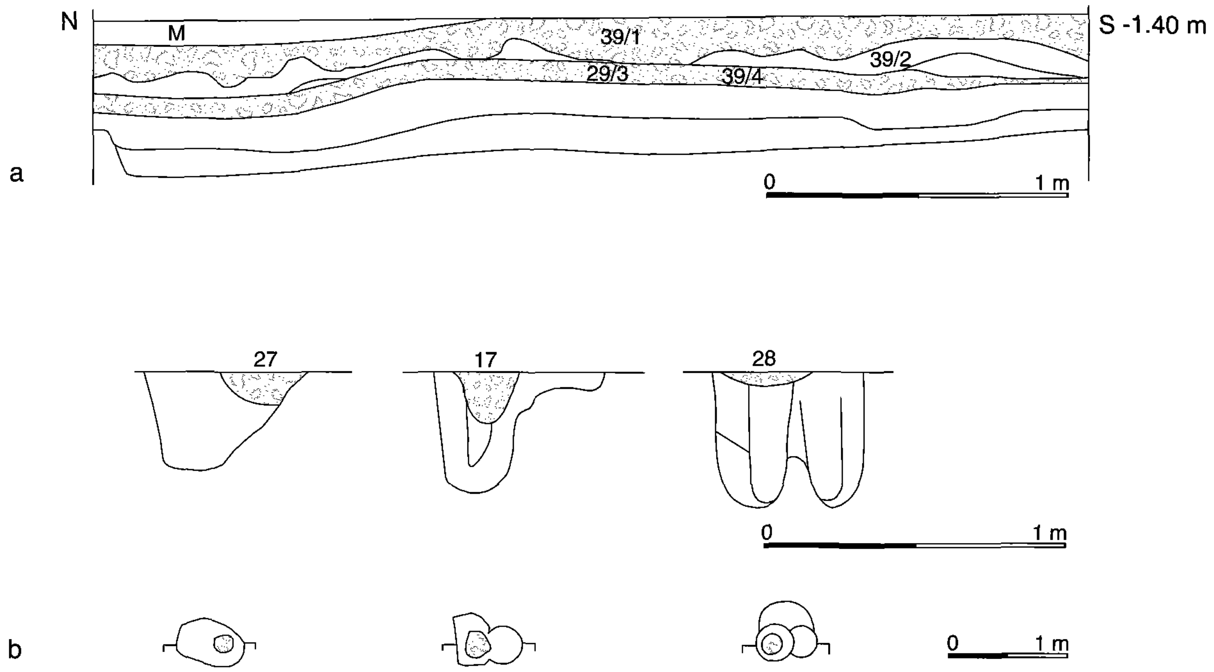

Figure 5 Longitudinal section through the northern part of the house-ditch with sample numbers 39/1–93/4 (a), and sections of postholes 27, 17 and 28 (b).

possible. It was a great disappointment that, owing to the very bad weather throughout the excavations, these sampling objectives could not be fulfilled as planned. The excavation suffered from continuous very heavy rain. Nevertheless, 43 soil samples were still taken from 29 findspots (total volume: 347.5 litres of soil).

5.1.1 Samples from phase I

The house-ditch running roughly north-south along the eastern side of the house was sampled in six locations (sample nos. 24, 2, 25, 1, 26, 39). At the northern end the house-ditch was sampled stratigraphically (fig. 5a): sample no. 39/1 was taken from the topmost, youngest fill which contained plenty of charcoal, sample no. 39/2 from a more-or-less clayey fill, and sample nos. 39/3 and 39/4 both from the lower loose, ashy fill which contained burned loam. Sample no. 3 derives from a continuation of the house-ditch in the south. Whether it belongs to the house-ditch is obscure. From the short house-ditch running east-west at the southern end of the house, three samples were taken since the fill was very rich in carbonized remains (sample nos. 11/1, 11/2, 11/3). Three postholes of the house could be sampled. The samples from the postholes (sample nos. 27, 17, 28) were taken from the ashy secondary fills which must have entered the postholes after the decay of the posts (fig. 5b). In the posthole from which sample no. 28 was taken, the post which had decayed was already a secondary post replacing an earlier one.

5.1.2 Samples from phase II

Only one circular ditch could be sampled, at two spots close together (sample nos. 36/1 and 36/2). As was noted earlier, the location of this circular ditch is beside the house and does not overlie it. Therefore it may be contemporary with the house and not younger, as most of the circular structures are. The radiocarbon date for this circle indicates a similar age as the dates for the house from phase I. However, as has also been remarked, the calibrated dates for the house cover such a long period, that the circular ditch may belong to a later phase within this timespan. Also some ditches and a pit which probably belong to this period were sampled (sample nos. 16, 15, 23, 30). However, stratigraphically they may also date from phase III.

5.1.3 Samples from phase III

Phase IIIa: from the southern *terp* ditch which dates from 1115–920 cal BC, samples were taken at two locations (sample nos. 4 and 21). The area of sample no. 21 was very rich in carbonized plant remains and therefore more than one sample was taken from this spot. Sample no. 21/3 was taken from a clear concentration of carbonized material. The same holds for sample no. 9, which came from a short ditch dated to 1200–920 cal BC.

Phase IIIb: the middle and northern *terp* ditches belong to the Late Period (IJzereef's phase 6) which is dated 920–800 cal BC. The middle *terp* ditch was sampled from the profile. Sample no. 22/1 came from the bottom greyish fill of humic sandy loam of the middle *terp* ditch at a depth of *c.* 85 cm beneath the excavated level (2.29 m - NAP). The topmost fill of the northern and middle *terp* ditches consists of medieval brown clay, which indicates that remains of these ditches were still open when people left the site. Sample no. 22/2 was taken from this medieval brownish clay fill of the middle *terp* ditch (at about 65 cm beneath the excavated level). From a ditch connecting with the northern *terp* ditch, but possibly already existing in the preceding phase IIIa, two samples come from a spot with numerous charred remains (samples no. 37). Also a shorter ditch belonging to this system was sampled (sample no. 35). Three pits from the pit circle belonging to this phase could be sampled (sample nos. 31, 32, 33). A sample from the upper prehistoric arable layer (sample no. 0) also represents this late habitation phase.

5.2 *Processing*

The samples were transported in plastic containers to the archaeobotanical laboratory of the ROB in Amersfoort (prov. of Utrecht). There, the samples containing only carbonized plant remains were flotated and the ones that also contained waterlogged plant material were sieved. This was the case only with sample no. 22/1. The sieves had meshes of 1.0, 0,5 and 0.25 mm. Checking a few flotation residues showed that the 0.25 mm flot only contained a few *Juncus* seeds, or fragments of *Chenopodium* seeds. Therefore the 0.25 mm sieve was omitted during the further flotation procedure. After flotation the remaining residue was sieved as well. It appeared that a 1.0 mm meshed sieve sufficed to retrieve almost all the heavier solid carbonized plant material which remained in the residue after flotation.

5.3 *Analysis of the macroremains*

Forty-one samples were analysed for botanical macroremains, which are primarily seeds and fruits. In the following the term 'seeds' will be used, meaning seeds and fruits. Only two duplicate samples were not analysed. The 1.0 mm flot and the sieved-after-flotation residue were always fully analysed. From some samples with large residues, only a representative part (1/4 or 1/8) of the 0.5 mm flot was analysed. Then the numbers of seeds for each taxon were recalculated for the total sample. Fragments of cereal grains that were smaller than one quarter of a grain were not isolated, but their presence in the residue was noted. Pieces of charred wood and twigs were identified when possible. The analyses of the samples took nine full months. During the analyses any small bones and mollusc remains were also picked out. The bones were examined by dr. G.F. IJzereef and the molluscs by W.J. Kuijper (IPL).

6 RESULTS

Because of the position of the sampled features above the watertable, plant remains had mainly been preserved in carbonized condition. Waterlogged plant remains were only found in sample no. 22/1 from the middle *terp* ditch. They are listed in table 2. Obviously this was the only sampled feature that extended deep enough (*c.* 85 cm beneath the excavated level, 2.29m - NAP) below the ground water level for the plant remains to be preserved in uncarbonized condition. The results of the analysis of the carbonized plant remains are presented in table 3. The carbonized plant remains found in sample no. 22/1 are included in table 3. The carbonized seeds of *Juncus* species in this sample were found in the residue of the 0.25 mm-meshed sieve which for this sample, in contrast to all other samples, was subjected to a full analysis. The plant remains found in this fraction were not included in the calculations of the density of the carbonized remains (table 4) since this was not done with the other

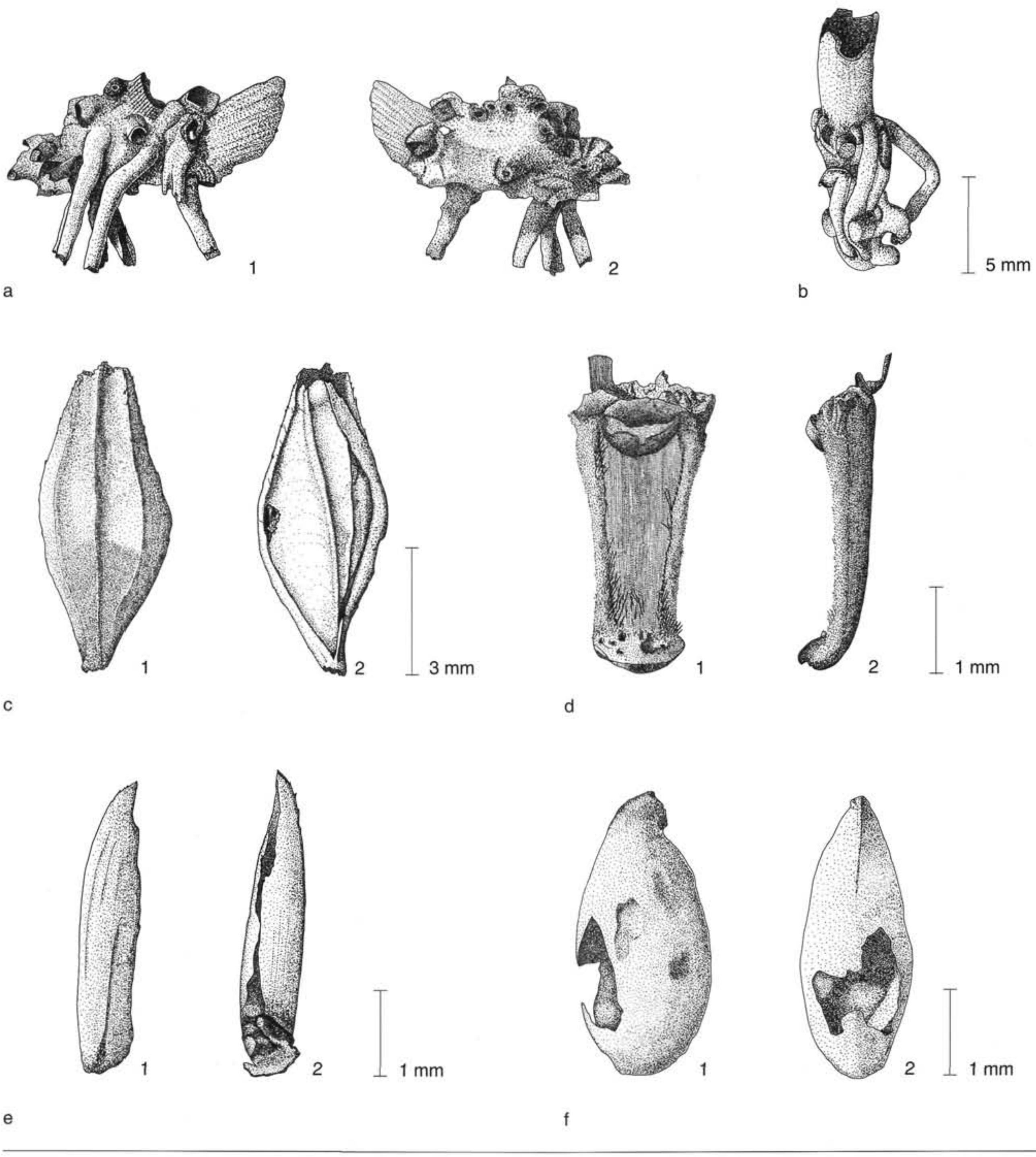

Figure 6 Legend: a,b culm-bases; c grain of *Hordeum vulgare*; d rachis internode of *Hordeum vulgare*; e glume of *Triticum dicoccum*; f seed of *Linum usitatissimum*.

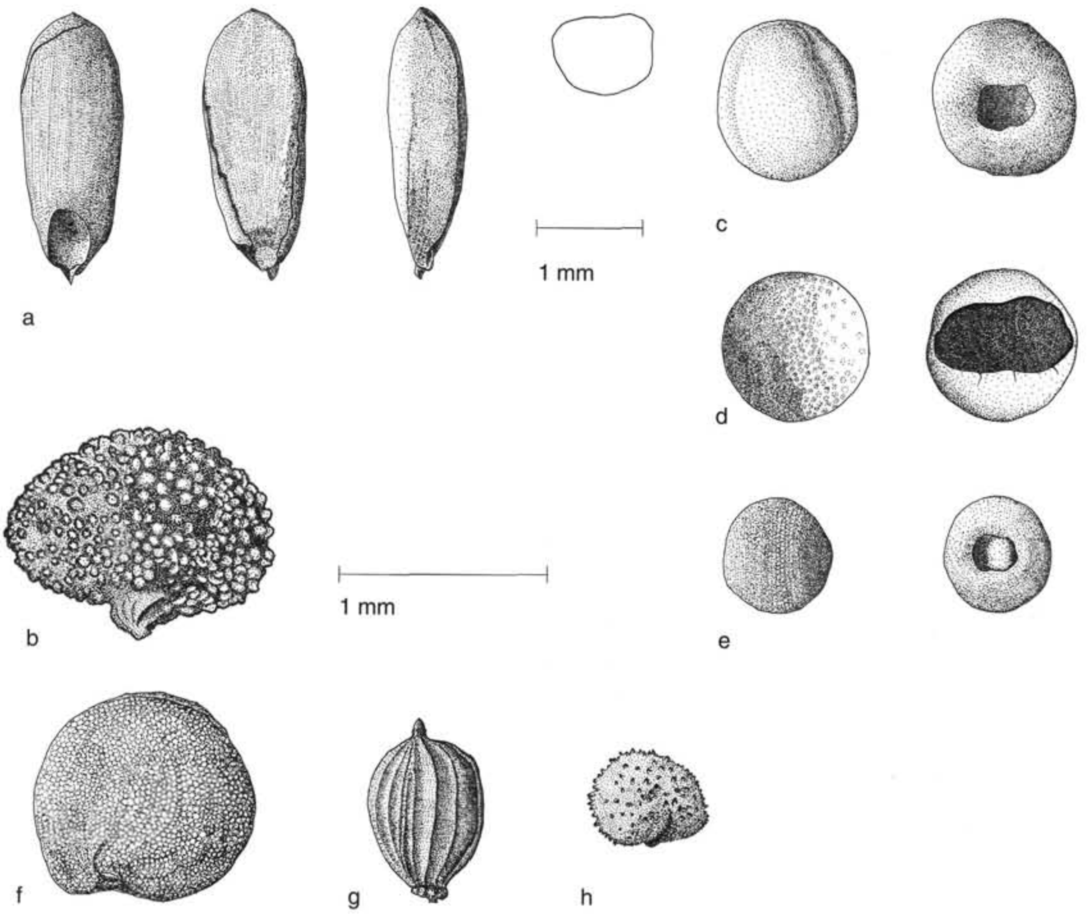

Figure 7
Seeds or fruits of:
a *Lolium/Festuca*-type;
b *Scutellaria galericulata*;
c *Galium aparine*;
d *Galium palustre*;
e *Galium spurium*;
f *Montia fontana*;
g *Scirpus setaceus*;
h *Lychnis flos-cuculi*.

samples either. Some of the better-preserved carbonized seeds are illustrated in figures 6 and 7.
Many of the samples were found also to contain mineralized and (sub)recent seeds. These will also be discussed.

6.1 *Sample size*

For the features from which more than two (sub)samples were analysed it was possible to establish the relation between the size of a sample and the number of taxa of which carbonized remains were found (fig. 8). In these considerations we compare features and not samples. Therefore we assume that the carbonized remains are homogeneously distributed in the features, which is certainly not the fact. The features are the long house-ditch (sample nos. 24, 2, 25, 1, 26), the short house-ditch (sample nos. 11/1,2,3), and the ditches of phase IIIa (sample nos. 9/1,2,3,4 and 21/1,2,3). Also the three samples from the pits of the pit circle of phase IIIb were considered as subsamples from a single feature (sample nos. 31, 32, 33). The standard sample size was ten litres of soil. The total number of taxa identified in all samples is 111 (including chaff and straw). After a relatively steep beginning of the graphs, the curves start to level off at different moments. Theoretically, they would eventually reach a saturation point and become a horizontal line. Common species generally will appear in the steeper part of the curve. Rare species, however, will tend to be found in the more horizontal section. A restricting factor in our case is that the 0.5 mm sieve residue was not always fully analysed. Although analysis of the 0.5 mm sieve residue was continued until no new taxa were found for some time, the possibility remains that more taxa would have been

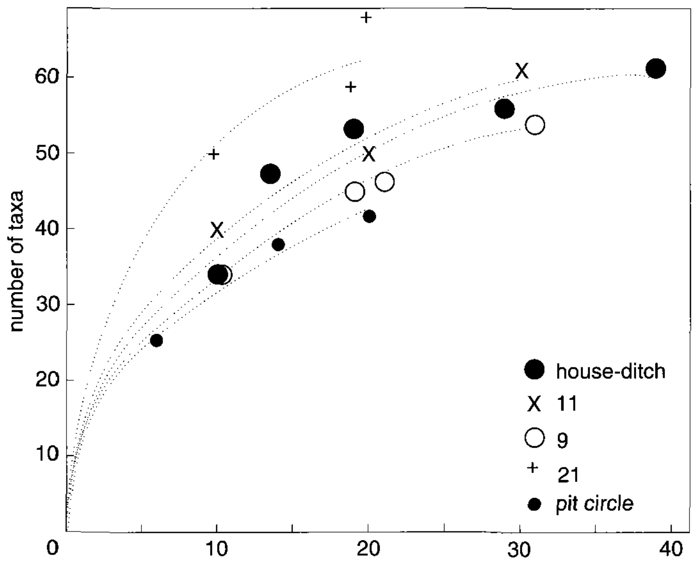

Figure 8 Diagram showing the relation between sample volume and number of species represented in some samples.

found if the residues had been analysed completely. From figure 8 it appears that in the ten-litres samples 29 to 49 taxa were identified. The largest number of taxa was found in the samples from *terp* ditch no. 21 of phase IIIa (where the carbonized material was extremely well preserved, which is a factor to be taken into account). For all features, a large number of new taxa could be identified in the next ten litres of sample. In the third ten litres of soil still new taxa were identified but much fewer than in the preceding ten litres of soil. It will be clear that the sample size of ten litres is in fact too small. For the long house-ditch, the horizontal line was almost reached with 40 litres of soil. From the graphs in figure 8 we may conclude that we would have done better to take samples of at least 20 litres of soil, but only if we were interested solely in the more common species. If our interest concerns the rare species, at least 30 litres of soil should have been investigated. However, these rare species will not contribute to the interpretation of the samples.

arable weeds and plants from ruderal habitats	
Chenopodium album	10
Chenopodium ficifolium	26
Chenopodiaceae	6
Polygonum lapathifolium/persicaria	3
plants from bare, wet, compacted soils	
Juncus bufonius	94
plants from wet, ammonia-rich habitats	
Rorippa palustris	1
Atriplex patula/prostrata	7
Ranunculus sceleratus	14
plants from marshes and banks	
Alisma plantago-aquatica	52
Carex riparia	2
Glyceria maxima	1
Eupatorium cannabinum	2
Veronica anagallis-aquatica	1
wet grasslands	
Juncus articulatus-type	24
Juncus effusus-type	5
Juncus gerardii	7
Ranunculus repens	1
Poa palustris	2
Poa pratensis	2
Carex cuprina/vulpina	
aquatic plants	
Lemna spec.	900
Hippurus vulgaris	1
Ranunculus Batrachium	5
miscellaneous	
cf. Aethusa cynapium	1
Carex spec.	5
Chenopodiaceae	6
Gramineae	5
Juncus spec.	29
cf. Oenanthe spec.	1
Polygonum spec.	1
Umbelliferae	2
Indet.	8

Table 2 Waterlogged plant remains from sample no. 22/1.

6.2 *Conservation of the plant remains*

The carbonized plant remains from the samples from phase I, especially from the house-ditches, are in fairly poor condition. The cereal grains are often puffed and heavily corroded. In some samples it could be observed that the grains were carbonized when they had already been crushed (by grinding or chewing?). Then the 'tarry' material which fluffs out of the grain during charring is seen on fractures of the grains. Often phosphate precipitation covers the grains, indicating the richness in phosphates of the soil. The plant remains from the ditches of phase III generally appear to be

intact and in a better, less corroded condition. They are, however, quite seriously deformed by carbonization. For these reasons, measurements could not be taken. Nevertheless, these grains often are still enveloped in their chaff of which numerous morphological and anatomical details are still present (teeth, glume tips, hairs).
The waterlogged plant remains from sample no. 22/1 were fairly well preserved.

6.3 *Crop plants*
As in all other Middle and Late Bronze Age sites in West-Friesland, the crop plants found are *Hordeum vulgare* (barley), *Triticum dicoccum* (emmer) and *Linum usitatissimum* (linseed/flax).

6.3.1 Cereals
Hordeum vulgare Because of the rather poor condition of the grains in the features of phase I, it could not always be decided whether the barley from this phase was of the naked or of the hulled variety. However, grains with distinct characteristics of hulled barley were present in large amounts. In samples from phase III, where the grains were better preserved, all grains were of the hulled variety and often still enveloped by their husks. Once a lemma was observed with teeth (spicules)[22] on the upper part of its veins (fig. 6c); however, smooth ones were also seen. Occasionally, rachillae are present, connected to the grain. One rachilla was seen to be hairy all around with rather long hairs. Also some loose lodiculae were found. Many grains are more or less lopsided or 'twisted', as is the case in six-row barley *Hordeum vulgare*. Occasionally two grains are still fused in the position they have in the spikelets of six-row barley. Often, small and thin underdeveloped grains occur. These may derive from the top or the base of a fullgrown ear or from unripe ears.
The rachis internodes generally have no pedicels. In a few samples (nos. 11, 32) loose short and stout pedicels were found which are of a different nature[23] than those of naked barley found in the Twisk excavation.[24] They can definitely be ascribed to hulled barley. Internodes were found which were densely haired on both sides (fig. 6d). Long, slender ones as well as short and thick ones were encountered. The majority were long and slender (lax-eared barley). Very thin and narrow underdeveloped internodes also appeared. Rachis segments consisting of two or more (up to seven) internodes were often found.
Basal internodes were also present, sometimes as the first internode of rather long rachis parts (especially in sample no. 4). These basal parts of the ear may also appear underdeveloped. Lemma awns occurred in large quantities, especially in the samples from the house-ditch.

Triticum dicoccum The grains of *Triticum dicoccum* were usually well developed but were sometimes small, thin and underdeveloped (sample nos. 2, 11). They have also been found in spikelets, especially in the samples from the house-ditches and in sample no. 9. One spikelet contained three grains. The grains of *Triticum* that could not be further identified with certainty most probably also belong to *Triticum dicoccum*. Numerous chaff elements (rachis internodes, spikelet forks, glume bases, glume fragments and teethed glume tips) were identified. Also small underdeveloped chaff (spikelet forks or glume bases) was found (sample no. 2). The spikelet forks sometimes bore hairs. Numerous fragments of internodes of this species also occurred, among which also basal ones. Once, a complete empty glume was found (fig. 6e, sample no. 4).
Sample no. 22/2 from the medieval fill of a Late Bronze Age *terp* ditch of phase IIIb contained a single carbonized grain of *Triticum dicoccum*. Although there are no data on this subject so far, it is quite possible that this crop was cultivated here in the Middle Ages. However, this grain may in fact be of prehistoric date and have entered this ditch through redeposition of older material.
Figures 9a and b present the proportions between the grains and the chaff of *Hordeum vulgare* (rachis internodes) and *Triticum dicoccum & Triticum* spec. (spikelet forks and glume bases). Samples with a low density and less than ten identified cereal grains (table 4) have been omitted (sample nos. 0, 3, 9/3, 16, 17, 22, 23, 39/2). For these graphs, the total numbers of grains of the two cereal species were calculated. The share of each species among the unidentified grains was first calculated according to the species' proportions in the identified grains. The outcome was added to the number of identified grains. Also graphs were made of the proportions of the grains and the chaff equivalents, which means the number of grains represented by the

22 Renfrew 1973, 79.
23 Villaret-von Rochow 1967: *unechte Stielchen*.
24 Buurman 1989.

context	house ditches												postholes			ditches		circ.ditch	
sample number	24	2	25	1	26	39/1	39/2	39/3	39/4	11/1	11/2	11/3	27	17	28	3	13	36/1	36/2
phase	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II
volume in ml	10	8	10	10	10	5	2	10	10	10	10	10	10	2.5	5.5	7	10	7	7
density	65	269	141	109	96	94	49	191	256	205	43	119	24	176	28	2	26	35	25
crop plants																			
Hordeum vulgare	22	74	44	28	48	11	2	64	92	52	10	21	10	2	14	3	9	8	9
- rachis internodes	26	48	25	6	15	11	1	12	23	25	9	22	3	5	1	-	3	6	17
- pedicels	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-
- lodiculae	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-
Triticum dicoccum	50	180	99	81	112	27	2	149	206	131	36	40	7	1	10	-	22	6	6
- rachis internodes	20	31	17	31	20	15	3	20	22	23	10	63	3	5	14	-	1	27	3
- spikelet forks	41	99	63	35	42	28	8	45	42	56	8	54	16	5	13	-	22	11	14
- glume bases	150	569	253	492	190	122	24	320	171	266	56	401	44	39	34	-	54	83	56
- glume tips	+	+++	+++	+++	++	++	+	+++	+++	++++	++	++++	+	-	-	-	-	++	-
Triticum spec.	2	18	2	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-
Cerealea indet.	155	442	334	191	132	115	21	666	807	380	45	152	28	8	20	1	56	35	26
- rachis internodes	-	-	-	-	-	-	-	-	-	-	1	4	-	-	-	-	-	-	-
- culm fragments with node	-	9	-	1	-	4	-	-	-	6	-	8	3	-	1	-	-	-	-
- culm bases	-	-	1?	-	-	-	-	-	-	-	+	2	1?	-	-	-	-	-	-
- root fragments	1	-	-	-	-	-	-	-	-	1	+	2	-	-	-	-	-	-	-
- lemma awns	+	++	+++	+++	++	+++	+	+++	+++	++++	++	++++	+	-	-	-	-	++	-
Linum usitatissimum	-	-	1	-	-	-	-	-	1	1	-	2	-	-	-	-	-	-	-
arable weeds and plants from ruderal habitats																			
Atriplex patula/prostrata	-	-	-	-	-	2	-	-	8	2	1	1	-	4	-	-	-	-	-
Avena spec. grains	15	43	7	3	7	2	-	7	-	13	-	2	-	1	1	-	-	3	-
Avena fatua, flower base	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- lemma awns	-	+	-	++	+	+	-	-	-	+	-	-	-	-	-	-	-	+	-
Brassica rapa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capsella bursa-pastoris	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Chenopodium album	29	96	63	46	71	12	10	155	223	266	38	41	11	11	1	-	6	4	6
Chenopodium ficifolium	14	88	33	47	39	10	-	67	137	568	61	52	13	39	4	-	7	2	5
Descurainia sophia	-	-	-	-	-	-	-	-	-	20	3	-	-	-	-	-	-	-	-
Echinochloa crus-galli	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galium aparine	-	2	-	1	-	-	-	14	22	-	-	2	-	-	-	-	-	1	-
Galium spurium	3	4	-	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Polygonum lap./pers.	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum lapathifolium	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Polygonum persicaria	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	2	-	1
Solanum nigrum	2	10	-	-	6	-	-	-	-	15	-	-	1	-	1	-	2	-	-
Sonchus asper	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Stellaria media	-	56	6	14	24	-	3	78	119	-	7	11	3	1	-	-	4	-	3
Urtica urens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Veronica agrestis-type	-	-	-	-	-	2	-	-	4	3	-	-	-	-	-	-	-	-	-
Vicia hirsuta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
tread-resistant plants																			
Alopecurus geniculatus	-	1	-	-	-	2	-	-	4	-	-	1	-	-	-	-	-	-	-
Lolium perenne	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantago major	4	24	3	10	16	4	2	36	35	71	11	28	-	16	1	-	4	-	-
Poa annua	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
plants from bare, wet, compacted soils																			
Juncus bufonius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Montia fontana	1	1	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
Scirpus setaceus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
plants from wet, ammonia-rich habitats																			
Alopecurus aequalis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
cf. Bidens spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rumex maritimus/palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus sceleratus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
plants from marshes and banks																			
Alisma plantago-aquatica	-	-	3	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-
cf. Damasonium alisma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex riparia	-	-	-	-	1	1	-	-	-	-	1	-	-	1	-	-	-	-	-
Carex rostrata/vesicaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis palustris	3	16	3	5	6	4	1	-	4	25	7	-	16	43	2	-	3	1	-
Galium palustre	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Iris pseudacorus	-	1	1	-	-	-	-	-	-	4	-	14	-	2	-	-	-	-	1
Lycopus europaeus	1	-	-	-	4	-	-	-	-	-	2	-	1	1	-	-	-	-	1

context	ditches				pit	ditch				terp ditches						ditch		pit circle			ditch	arable			
sample number	15	23	16	5	30	9/1	9/2	9/3	9/4	4	21/1	21/2	21/3	22/1	22/2	37/1	37/3	31	32	33	35	0			
phase	II	II	II	II	II	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIb	ME	IIIb	IIIb	IIIb	IIIb	IIIb	IIIb	IIIb			
volume in ml	10	10	10	10	10	10	9.5	1	10	10	10	9	1	1.5	1.5	6	9	6	8	6	11	9			
density	13	2	5	34	14	62	91	31	93	177	44	41	138	6	1	121	79	26	27	13	30	16			
crop plants																							N	SF	
Hordeum vulgare	17	5	-	51	17	52	37	5	18	413	33	41	13	1	-	23	96	11	11	10	23	7	1407	39	fig. 6c
- rachis internodes	2	-	3	28	2	18	27	-	13	408	35	17	14	-	-	-	41	14	17	3	3	5	908	35	fig. 6d
- pedicels	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	5	5	
- lodiculae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	
Triticum dicoccum	6	1	1	11	10	4	1	-	18	6	5	8	1	-	1	15	20	5	1	1	3	1	1284	38	
- rachis internodes	3	-	3	6	1	-	9	-	22	-	2	2	-	-	-	1	-	-	5	5	13	2	402	31	
- spikelet forks	1	-	-	18	5	12	16	1	13	2	10	11	-	1	-	12	9	7	-	3	10	1	734	35	
- glume bases	20	-	12	70	29	46	64	3	62	2	38	49	2	2	-	40	61	38	71	7	66	29	4035	38	
- glume tips	-	-	-	-	-	-	-	-	++	-	-	-	+	-	-	+	++	-	-	-	++	+	+++	20	
Triticum spec.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	27	7	
Cerealea indet.	26	7	6	66	36	44	50	3	38	101	42	35	-	2	-	16	92	32	16	13	25	25	4289	39	
- rachis internodes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	6	3	
- culm fragments with node	1	-	-	-	1	11	16	-	95	50	26	20	10	-	-	16	21	-	-	-	2	-	301	19	
- culm bases	-	-	-	-	-	1	4	-	100	120	20	3	10	-	-	-	4	-	-	-	-	-	264	12	fig. 6 a,b
- root fragments	-	-	-	-	-	-	-	-	++	+++	+	1	-	-	-	-	5	-	-	-	-	-	9	8	
- lemma awns	-	+	-	-	++	+	+++	-	++	-	-	-	+	-	-	+++	++	+	+	+	+++	+	+++	27	
Linum usitatissimum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1	-	8	7	fig. 6f
arable weeds and plants from ruderal habitats																									
Atriplex patula/prostrata	-	-	-	2	-	-	-	-	-	7	2	9	-	-	-	-	-	-	-	-	-	-	38	10	
Avena spec. grains	-	-	-	-	2	-	-	-	-	2	1	1	1	-	-	-	-	-	-	-	1	-	112	18	
Avena fatua, flower base	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1	
- lemma awns	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	6	
Brassica rapa	-	-	-	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3	3	
Capsella bursa-pastoris	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	11	2	
Chenopodium album	1	-	-	20	1	-	-	-	32	1	10	3	2	-	-	4	15	1	2	2	2	2	1187	33	
Chenopodium ficifolium	1	-	-	12	3	-	-	2	57	6	12	6	1	-	-	2	9	1	3	-	1	1	1303	32	
Descurainia sophia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	2	
Echinochloa crus-galli	-	-	-	-	-	-	-	-	-	2	2	3	-	-	-	-	-	-	-	-	-	-	8	4	
Galium aparine	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44	8	fig. 7c
Galium spurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	4	fig. 7e
Polygonum lap./pers.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	6	3	
Polygonum lapathifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Polygonum persicaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	9	6	
Solanum nigrum	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	3	42	10	
Sonchus asper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Stellaria media	-	-	-	1	-	4	-	-	37	3	7	-	9	-	-	-	3	2	1	-	-	3	399	23	
Urtica urens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	
Veronica agrestis-type	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	13	5	
Vicia hirsuta	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	
tread-resistant plants																									
Alopecurus geniculatus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	1	11	7	
Lolium perenne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	
Plantago major	-	-	6	3	2	16	9	-	28	6	5	3	6	-	-	2	6	1	4	-	17	2	381	31	
Poa annua	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	2	2	
plants from bare, wet, compacted soils																									
Juncus bufonius	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-	-	-	-	-	-	-	6	2	
Montia fontana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	3	fig. 7f
Scirpus setaceus	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	6	3	fig. 7g
plants from wet, ammonia-rich habitats																									
Alopecurus aequalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
cf. Bidens spec.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	
Rumex maritimus/palustris	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	1	
Ranunculus sceleratus	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	4	2	
plants from marshes and banks																									
Alisma plantago-aquatica	-	-	-	-	-	-	-	-	-	6	13	5	-	1	-	-	6	-	1	-	-	-	37	9	
cf. Damasonium alisma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1	
Carex riparia	-	-	-	-	-	2	-	-	2	1	-	1	-	-	-	-	2	2	-	-	-	-	14	10	
Carex rostrata/vesicaria	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	2	2	
Eleocharis palustris	-	-	2	4	2	5	3	-	4	2	11	7	5	-	-	236	138	-	4	-	14	1	577	30	
Galium palustre	-	-	-	-	-	2	-	-	1	2	-	1	-	-	-	-	-	-	-	-	-	-	7	5	fig. 7d
Iris pseudacorus	1	-	-	-	-	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	28	9	
Lycopus europaeus	-	-	-	1	-	1	-	-	4	3	-	3	-	-	-	-	3	-	-	-	-	-	25	12	

Table 3 Carbonized plant remains. N number of seeds; SF sample frequency.

context	house ditches												postholes			ditches		circ.ditch	
sample number	24	2	25	1	26	39/1	39/2	39/3	39/4	11/1	11/2	11/3	27	17	28	3	13	36/1	36/2
phase	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II
volume in ml	10	8	10	10	10	5	2	10	10	10	10	10	10	2.5	5.5	7	10	7	7
density	65	269	141	109	96	94	49	191	256	205	43	119	24	176	28	2	26	35	25
plants from marshes and banks (continued)																			
Oenanthe aquatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oenanthe fistulosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oenanthe spec.	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Phalaris arundinacea	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scirpus lacustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scirpus spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scutellaria galericulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solanum dulcamara	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-
Sparganium erectum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stellaria uliginosa	-	-	-	-	-	-	-	-	13	-	-	-	-	1	-	-	-	-	-
cf. Senecio paludosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
grassland plants																			
Carex cuprina/vulpina	1	-	1	5	-	3	-	-	9	-	2	1	1	10	-	-	1	-	-
Carex disticha	-	-	-	-	2	-	-	-	-	-	-	-	-	6	-	-	-	-	-
Cerastium spec.	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daucus carota	-	4	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Euphrasia/Odontites	1	-	3	-	4	2	-	-	1	4	2	4	1	7	-	-	1	-	-
Festuca arundinacea-type	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gramineae	-	-	6	12	38	2	-	76	3	-	15	-	2	36	4	-	-	-	-
Lolium/Festuca-type	15	72	7	3	-	11	5	-	202	24	-	15	-	-	-	-	6	1	6
Lychnis flos-cuculi	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-
Lythrum salicaria	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Medicago lupulina	-	-	49	3	-	6	-	7	28	8	-	7	7	-	-	-	8	4	1
Mentha aquatica/arvensis	1	8	15	-	2	1	1	-	-	4	4	6	5	9	-	-	-	2	1
Papilionaceae	30	-	-	29	79	-	4	18	98	-	21	-	-	112	-	-	2	-	5
Phleum pratense	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Plantago lanceolata	2	4	-	-	-	-	-	-	1	-	-	1	-	1	-	-	-	-	-
Poa spec.	5	8	30	5	4	6	-	8	6	-	7	3	-	-	-	-	1	-	-
Prunella vulgaris	-	8	6	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-
Ranunculus acris	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Ranunculus flammula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus repens	-	-	-	-	-	-	-	-	-	1	-	-	1	3	-	-	-	-	-
Rumex crispus	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
Thalictrum flavum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifolium spec.	-	86	211	-	-	16	2	44	-	15	-	18	27	-	12	1	-	18	-
miscellaneous																			
Alopecurus spec.	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromus hordeaceus/secalinus	7	40	43	20	39	3	1	41	84	8	5	11	-	7	2	1	2	-	1
Carex acuta/nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Carex spec.	1	-	1	5	-	-	-	-	2	-	-	2	-	1	-	-	-	-	-
Caryoph/Chenopodiac.	20	28	-	2	20	20	-	29	-	16	-	-	21	10	6	1	9	16	-
Chenopodium spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-
Compositae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cruciferae	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-
Galium spec.	-	5	-	-	-	-	-	-	-	7	-	-	2	-	1	-	2	-	-
Juncus articulatus-type	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus spec.	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Labiatae	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-
cf. Malva spec.	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Rumex acetosella	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Rumex spec.	-	1	1	-	-	2	-	-	-	-	1	1	-	-	-	-	2	-	-
Solanum spec.	-	-	-	-	-	-	-	-	2	4	1	5	-	-	-	-	-	-	-
Umbelliferae	1	16	3	-	-	1	-	-	3	-	3	-	-	-	-	-	1	-	-
cf. Veronica scutellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia spec.	4	2	21	-	4	2	2	1	2	3	-	9	1	-	1	-	-	-	1
Indet.	22	50	50	8	27	16	6	46	170	9	58	174	17	48	4	5	26	13	10
n taxa (excl indet.)	34	39	37	31	31	37	19	25	38	40	32	44	28	33	22	5	25	22	19
twigs	-	1	-	-	-	-	-	-	+	-	+	-	+	-	+	-	-	-	-

context	ditches				pit	ditch				terp ditches						ditch		pit circle			ditch	arable			
sample number	15	23	16	5	30	9/1	9/2	9/3	9/4	4	21/1	21/2	21/3	22/1	22/2	37/1	37/3	31	32	33	35	0			
phase	II	II	II	II	II	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIb	ME	IIIb	IIIb	IIIb	IIIb	IIIb	IIIb	IIIb			
volume in ml	10	10	10	10	10	10	9.5	1	10	10	10	9	1	1.5	1.5	6	9	6	8	6	11	9			
density	13	2	5	34	14	62	91	31	93	177	44	41	138	6	1	121	79	26	27	13	30	16			
plants from marshes and banks (continued)																							N	SF	
Oenanthe aquatica	-	-	-	-	-	-	-	-	-	-	5	2	-	-	-	-	-	-	-	-	-	-	7	2	
Oenanthe fistulosa	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	
Oenanthe spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	
Phalaris arundinacea	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	6	3	
Phragmites australis	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	
Scirpus lacustris	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Scirpus spec.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Scutellaria galericulata	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	fig. 7b
Solanum dulcamara	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2	
Sparganium erectum	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	2	
Stellaria uliginosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	15	3	
cf. Senecio paludosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	1	
grassland plants																									
Carex cuprina/vulpina	-	-	-	-	-	6	9	-	2	2	-	-	-	-	-	-	1	-	-	-	2	-	56	16	
Carex disticha	-	-	-	3	-	-	6	-	4	3	3	3	1	-	-	2	1	1	-	-	4	-	39	13	
Cerastium spec.	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	1	-	-	-	7	3	
Daucus carota	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2	
Euphrasia/Odontites	-	-	-	-	-	9	-	-	12	9	2	9	-	-	-	6	-	1	-	-	6	1	85	20	
Festuca arundinacea-type	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Gramineae	-	-	-	-	1	11	6	-	-	13	-	-	3	-	-	-	15	-	-	2	-	1	246	18	
Lolium/Festuca-type	3	-	1	8	-	1	1	-	1	2	10	3	1	-	-	1	1	-	1	2	2	-	405	27	fig. 7a
Lychnis flos-cuculi	1	-	-	-	-	3	6	-	8	3	3	-	-	-	-	-	-	-	1	-	-	-	28	9	fig. 7h
Lythrum salicaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Medicago lupulina	2	-	4	6	-	-	-	-	-	8	3	6	2	-	-	-	10	-	5	1	11	-	186	22	
Mentha aquatica/arvensis	-	-	-	2	-	-	-	-	8	-	-	3	-	-	-	-	-	-	-	-	-	-	72	16	
Papilionaceae	-	-	-	8	10	137	429	8	108	176	48	-	-	-	-	303	10	-	22	-	-	-	1657	21	
Phleum pratense	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Plantago lanceolata	-	-	-	-	-	-	-	-	-	9	-	1	1	-	-	-	-	-	-	-	-	-	20	8	
Poa spec.	1	-	-	2	1	-	21	-	40	-	-	6	-	-	-	14	-	2	9	3	10	-	192	22	
Prunella vulgaris	-	-	-	-	-	1	-	-	-	3	2	3	1	-	-	-	-	-	-	-	-	-	27	9	
Ranunculus acris	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	1	-	-	-	-	6	5	
Ranunculus flammula	1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	4	2	
Ranunculus repens	-	-	-	-	1	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	9	7	
Rumex crispus	1	-	-	-	-	8	-	-	1	-	-	-	1	-	-	-	-	-	-	-	2	-	17	6	
Thalictrum flavum	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Trifolium spec.	29	1	7	-	1	134	-	-	20	5	3	44	13	1	-	-	78	18	22	11	53	45	935	28	
miscellaneous																									
Alopecurus spec.	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	
Bromus hordeaceus/secalinus	5	-	-	3	3	8	5	-	6	79	7	10	6	-	-	4	7	-	3	1	1	2	465	33	
Carex acuta/nigra	-	-	-	-	-	-	-	-	4	-	1	-	1	-	-	-	-	1	1	-	-	-	9	6	
Carex spec.	-	-	-	-	-	7	3	1	-	-	-	-	1	-	-	-	1	-	-	1	-	-	26	12	
Caryoph/Chenopodiac.	4	1	-	8	8	6	-	1	-	-	-	21	2	-	-	6	6	2	4	4	4	2	277	28	
Chenopodium spec.	-	-	-	-	-	-	-	1	-	-	5	-	-	-	-	-	-	4	-	-	-	-	15	4	
Compositae	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Cruciferae	-	-	-	-	-	-	3	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	14	4	
Galium spec.	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	21	9	
Juncus articulatus-type	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	
Juncus spec.	-	-	-	-	-	1	-	-	-	7	-	1	1	-	-	-	-	-	-	1	-	-	13	6	
Labiatae	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	1	1	-	-	-	10	5	
cf. Malva spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	
Polygonum spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Rumex acetosella	-	-	-	-	-	-	-	-	-	15	-	-	-	-	-	2	-	-	-	-	-	-	18	3	
Rumex spec.	-	-	-	-	-	15	22	2	3	-	3	-	-	-	-	-	9	-	1	-	2	1	66	15	
Solanum spec.	-	-	-	-	-	-	-	-	-	3	-	3	-	-	-	-	-	-	-	-	-	-	18	6	
Umbelliferae	-	-	-	-	-	-	-	2	20	-	-	-	-	-	-	-	-	-	-	-	2	2	54	11	
cf. Veronica scutellata	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	1	
Vicia spec.	-	-	1	-	1	9	8	1	4	3	3	2	-	-	-	-	-	-	2	-	9	1	96	25	
Indet.	3	4	6	6	5	42	98	1	141	267	51	23	22	1	-	19	36	9	5	6	42	3	1549	40	
n taxa (excl indet.)	22	7	12	23	23	35	30	12	38	46	49	36	34	9	1	22	34	24	29	19	30	28			
twigs	-	-	-	-	-	++	++	+	++	++	+++	++	+	-	-	++	++	-	-	-	-	-			

Table 3 Carbonized plant remains (continued).

chaff remains (figs. 10a and b). Internodes of *Hordeum vulgare* bear three grains and thus were counted as three. Glume bases and spikelet forks of *Triticum dicoccum* bear one and two grains respectively and were counted as such. The graphs show a considerable variation in the ratio of grain to chaff, which might be context-related and/or related to differences in discarded crop-processing products or by-products. However, these variations also exist between different samples from the same features. This indicates the inhomogeneous nature of the deposits. In general, the samples from the house site of phase I contain proportionately more grains and less chaff than the other samples, indicating that waste from food preparation or consumption is more abundant in these samples than in others. The distinction becomes even clearer when we consider that very small (less than 1/4) grain fragments which occur (often in large amounts) mainly in the samples from the house ditches, were not included in the calculations. Comparing the graphs of both species shows that there is proportionately less chaff of *Hordeum vulgare* than of *Triticum dicoccum*. The chaff of *Hordeum vulgare* does not survive well after carbonization. Chaff of *Triticum dicoccum* is much more robust and survives better.[25]

In figure 11 the proportions of the grains of *Hordeum vulgare* and *Triticum dicoccum* (including *Triticum* spec.) are given in a stacked bar graph. The data in table 3 can be used to check for the value of the bars in figure 11. The proportions of the two major crop plants change in the course of time. There is a general trend from predominantly *Triticum dicoccum* (up to more than 70%) in the Early Period towards predominantly *Hordeum vulgare* (up to more than 90%) in the Late Period. In phase I *Triticum dicoccum* is the dominant cereal crop with 67–78% in the samples from the house-ditches and from ditch 13. The samples from the postholes show a different composition. There, only about 40% of the cereal grains is of emmer, as in some samples from phase II to which the secondary fill of the postholes may belong. The plant remains in the samples from the postholes will have ended up in the features after the decay or removal of the post. Any material lying on the surface then will simply have fallen in.

In phase II *Hordeum vulgare* becomes the more important cereal crop with 57–71% (in sample no. 5, from a ditch whose dating to phase II is not certain, even 82%). In phase III, *Hordeum vulgare* becomes dominant with 70–98.5%, except for subsample no. 9/4 (phase IIIa) in which the ratio of the two cereals is 50-50%. This again indicates the inhomogeneous

25 Boardman & Jones 1990.

sample no	volume in litres	density	number of identified cereal grains	total number of cereal grains	percentage of identified cereal grains
0	9	16	8	33	24.2
1	10	109	109	300	36.3
2	8	269	272	714	38.1
3	7	2	3	4	75.0
4	10	177	419	520	80.6
5	10	34	62	128	48.4
9/1	10	62	56	100	56.0
9/2	9.5	91	38	88	43.2
9/3	1	31	5	8	62.5
9/4	10	93	36	74	48.6
11/1	10	205	184	564	32.6
11/2	10	43	46	91	50.5
11/3	10	119	63	215	29.3
13	10	26	31	87	35.6
15	10	13	23	50	46.0
16	10	5	1	7	14.3
17	2.5	176	3	11	27.3
21/1	10	44	38	80	47.5
21/2	9	41	49	83	59.0
21/3	1	138	14	14	100...
22/1	1.5	6	1	3	33.3
22/2	1.5	1	1	1	100...
23	10	2	6	13	46.2
24	10	65	74	229	32.3
25	10	141	145	479	30.3
26	10	96	160	292	54.8
27	10	24	17	45	37.8
28	5.5	28	24	44	54.5
30	10	14	27	63	42.9
31	6	26	16	48	33.3
32	8	27	12	28	42.9
33	6	13	11	24	45.8
35 1	1	30	26	51	51.0
36/1	7	35	14	49	28.6
36/2	7	25	15	41	36.6
37/1	6	121	38	54	70.4
37/3	9	79	117	209	56.0
39/1	5	94	38	153	24.8
39/2	2	49	4	25	16.0
39/3	10	191	213	879	24.2
39/4	10	256	298	1105	26.9

Table 4 Volumes of the samples, densities of carbonized plant remains, total number of cereal grains, number of identifiable cereal grains and percentages of identifiable cereal grains.

nature of the fills of the features. The samples from the ditches of phase IIIa contain very special assemblages and will be discussed in more detail below. Also within ditch 37 (phase IIIb) there is quite a wide variation in composition. In this ditch, amalgamation with older material is clearly evident from the archaeological finds.[26] A wide variation in cereal composition also occurs in the pits of the pit circle of phase IIIb. Although we should be aware that we are dealing with samples from different contexts, the general trend from dominance of *Triticum dicoccum* in the earliest phase towards dominance of *Hordeum vulgare* in the last phase is clearly evident. In the large site of Bovenkarspel-Het Valkje the ample number of samples made it possible to compare samples from similar contexts of all habitation phases. There, the same trend became particularly clear.

The shift in the cultivation of emmer, naked and hulled barley to only hulled barley in West-Friesland appears to be a regional phenomenon and in all probability was caused by the increasing wetness of the area and the climatic deterioration which finally led to the exodus at the end of the Late Bronze Age around 800 BC.[27] In other parts of the Netherlands, barley and emmer wheat remained of equal importance during the Bronze Age and later.[28]

6.3.2 Straw

A remarkable find is the relatively large amount of culm nodes and culm bases (fig. 6a and b) especially in the samples from phase IIIa. They occasionally occur also in other samples. During the analysis they were not counted, since the residues of the samples of phase IIIa (especially sample no. 9/4) consisted for the greater part of fragments of culms, culm bases and loose roots. Therefore the numbers given in the table are estimates. The culms are so wide in diameter that they most probably belong to cereal plants or to reed (*Phragmites australis*) stems. However, the possibility that they belong to other large grasses cannot be immediately excluded. The culms of grasses are hollow and are subdivided into internodes by solid nodes. The carbonized hollow culm fragments are very brittle and easily crumble under mechanical pressure except at the nodes and at the base. These solid nodes and bases quite successfully withstand mechanical influences. At a number of culm nodes an adventitious axillary bud was found. This is characteristic of reed stems. Stems of cereal plants are generally known not to have such buds.[29] However, in the recent material of *Triticum dicoccum* and *Hordeum vulgare*, grown at the Schothorst allotments in Amersfoort, it was found that at the one or two lowest nodes of the culm these buds are often present. A number of carbonized stem fragments were studied with the aid of an incident light microscope in an attempt to differentiate between cereal straw and reed stems on the basis of the anatomy of the stem's epidermis.[30] It was found that in the carbonized stems the characteristic cell structure of the epidermis was not visible, so that differentiation was impossible.[31]

The culm bases consist of the solid lowest parts of the culms of the cereals or other great grasses and their roots (fig. 6a and b). Often more than twenty roots or root-scars are counted. In the same samples also numerous loose roots occur. Often the culm bases also include the very short, solid lowest parts of one to six shoots. They become hollow upwards. At the nodes between these lowest culm internodes there also are roots, and, as was said above, adventitious axillary buds occur. In this way sometimes quite large knots of the lowest 'tillering' node, consisting of a few short internodes with many shoots and roots would form.[32] Sometimes the rhizome could be recognized as well. The identification of these culm bases to species level is not possible and it is even very difficult to distinguish between cereals and tall grasses other than cereals, since numerous other species also possess this kind of culm base. This is manifestly clear from the excellent drawings in the handbooks on grasses by Hubbard[33] and Landwehr[34] and in part V on grasses of the *Nederlandse Ecologische Flora* (Ecological Flora of the Netherlands).[35] However, reed can be excluded since this species has creeping rhizomes, which were not encountered in the samples. The size and shape of the culm fragments and

26 Personal communication G.F. IJzereef.
27 Buurman 1988; Van Geel *et al.* 1996; 1997.
28 Van Zeist 1970.
29 Körber-Grohne 1967; Brinkkemper 1991.
30 Brinkkemper 1991.
31 Thanks are due to dr. O. Brinkkemper (ROB, Amersfoort) who, as a specialist in this matter, gave a second opinion of the material, endorsing these findings.
32 Percival 1921 (1974).
33 Hubbard 1968.
34 Landwehr 1976.
35 Weeda *et al.* vol. 5 (1994).

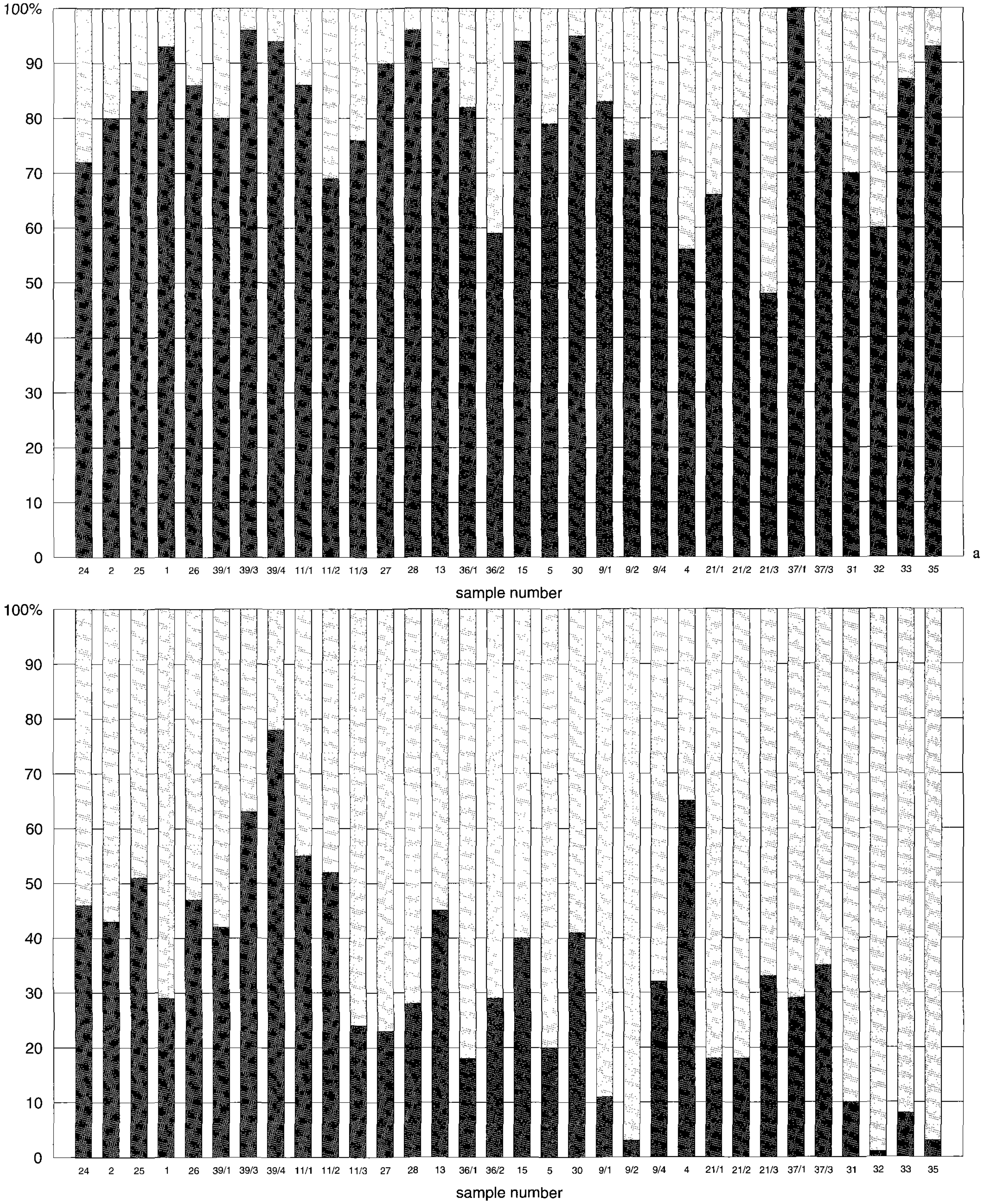

Figure 9a,b Proportions of grains (dark grey) and chaff (light grey) of *Hordeum vulgare* (a) and *Triticum dicoccum* (b) in selected samples.

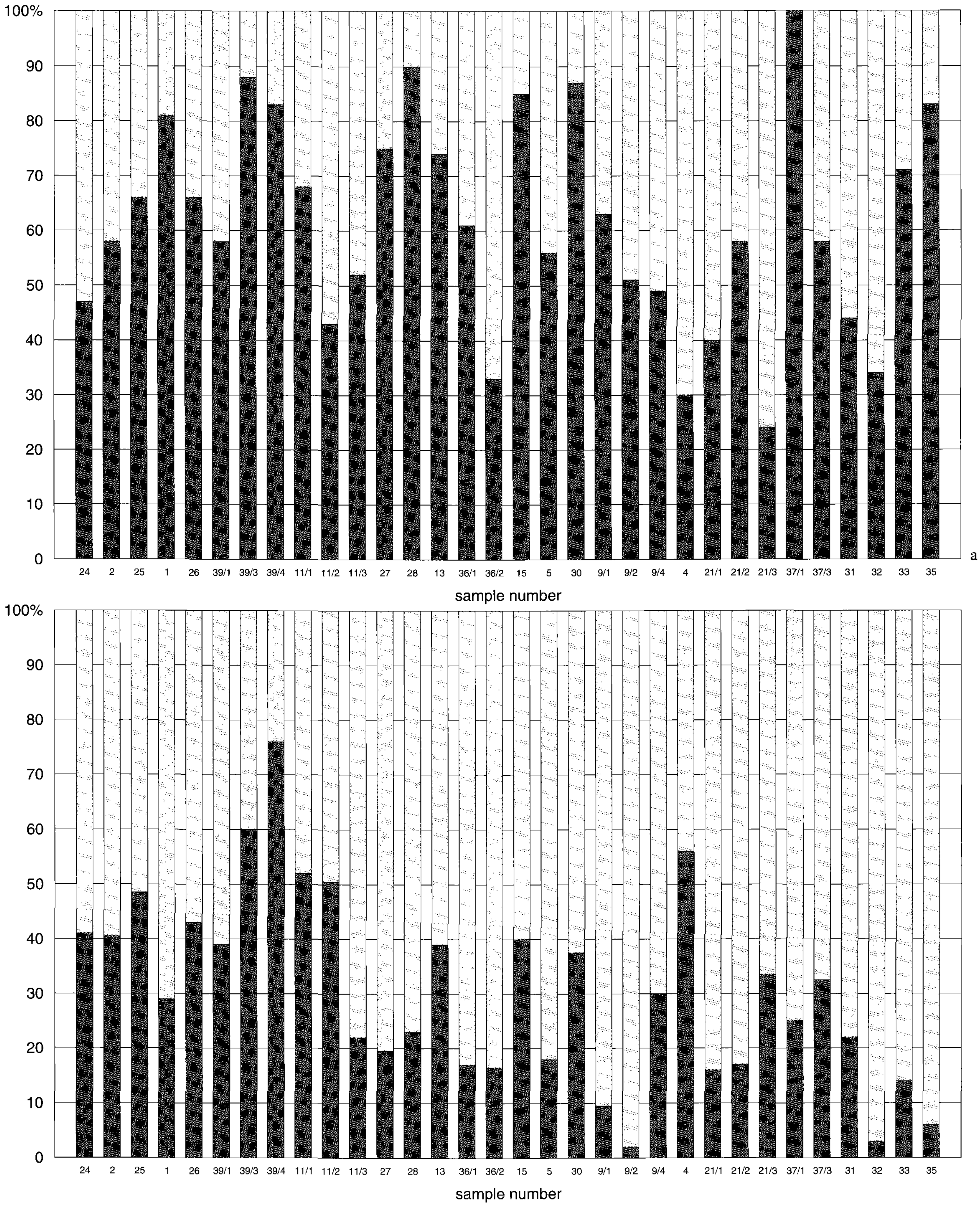

Figure 10a,b Proportions of grains (dark grey) and chaff equivalents (light grey) of *Hordeum vulgare* (a) and *Triticum dicoccum* (b) in selected samples.

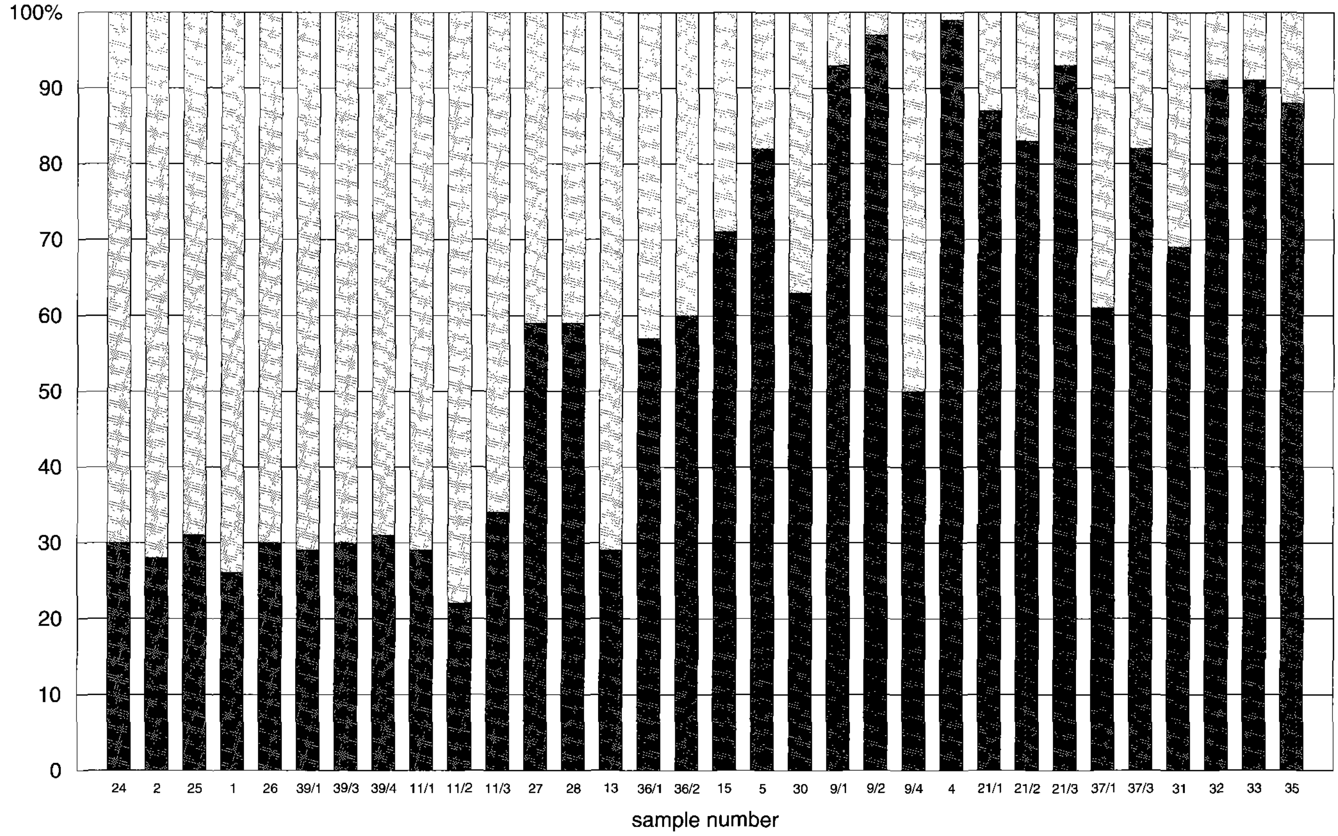

Figure 11 Proportions of cereal grains of *Hordeum vulgare* (dark grey) and *Triticum dicoccum* & *Triticum* spec. (light grey).

the culm bases, together with the presence of all other parts of the cereal plants in the same samples, make it very likely that these parts belong to cereal straw. Circumstantial evidence supporting this view is found in the low score of seeds of arable weeds and the high score of remains of species which may have been used as litter or fodder. This will be discussed below.
Such culm bases have so far not been found in excavations in the Netherlands. They are mentioned in relation to a Late Iron Age and Roman Period farmstead at Cefn Craeanog (Wales) but the results from this site have not yet been published.[36] Mikkelsen found them in straw from iron melting ovens in Denmark, where straw was used to catch the iron slag.[37] The culm bases and nodes play an important role in reconstructing crop-processing activities (see below). Cereal straw is only very rarely encountered in prehistoric contexts, carbonized or uncarbonized. Only a few carbonized remains were found in Feddersen Wierde (Germany), where an extensive search for cereal straw was carried out. Körber-Grohne therefore suggested that straw was used as fuel.[38] Brinkkemper also failed to find straw in the material he investigated from the byres of excavated farms of Iron Age and Roman Voorne-Putten (Z).[39]

6.3.3 Other crop plants

Seeds of *Linum usitatissimum* (fig. 6f) have been found in small numbers and in low frequencies. This species was cultivated for its oleaginous seeds (linseed) and/or for its fibres (flax). Its scarce presence may be due to the slight chance of the seeds becoming carbonized since no fire is involved in processing this crop.[40]
Brassica rapa is often considered a crop plant in prehistory for its oleaginous seeds.[41] At this site it is regarded as an arable weed but the use or even cultivation of this plant cannot be ruled out entirely. Nowadays some strains of this species are cultivated as vegetables of which the leaves or the turnips are eaten. They also make excellent fodder. It is obvious that

36 Hillman 1984a, fig. 5.
37 Personal communication P. Mikkelsen, Århus (Denmark).
38 Körber-Grohne 1967.
39 Brinkkemper 1993.
40 Buurman & Pals 1976.
41 *cf.* The discussion in Brinkkemper 1993, 57.

when *Brassica rapa* is cultivated for its vegetative parts, seeds are not usually produced and thus will not be present in the archaeobotanical dataset, unless from plants run wild.

6.4 *Twigs*

Apart from the remarkably large amount of carbonized remains of straw, the samples from phase IIIa (sample nos. 4, 9 and 21), also contain striking numbers of carbonized small twigs of predominantly *Salix* spec. (willow) as well as of *Alnus* spec. (alder). The twigs generally are only one year old. They bear sessile buds or have scars at the places where buds were lost. The buds are variable in size. They are generally arranged spirally on the stem. Their bracts often bear long hairs, like those of *Salix cinerea* or *Salix alba*.[42] Also some strobili of *Alnus* spec. were found. In the same samples also carbonized leaf fragments occasionally occurred, for the largest part consisting of a fragment of the middle vein and small pieces of leaf attached to it. The twigs, buds and strobili of *Salix* spec. and *Alnus* spec. point to the presence of scrub or woodland.

6.5 *Charcoal*

Apart from the many carbonized twigs in the samples from phase IIIa, mentioned above, charcoal, deriving from trunks or branches, turned up in a large number of samples, mostly in small pieces. The largest pieces of charcoal were picked out for identification.[43] The results are presented in table 5.

These results agree with the results of the charcoal and wood analysis from other sites in West-Friesland so far.[44] Charcoal of oak is very scarce and has only been found occasionally in the Early Period. This wood species might have been imported. Birch was found somewhat more often, also at the other sites. The available wood for construction was predominantly willow and alder. In the Early Period there were also some other tree species. In the Late Period, however, only the 'soft' woods of willow and alder were available for building.[45]

Although the data are scarce, we may conclude that in the early habitation phases there was a wider variety of tree species than in the late phase, for which only wood of willow and alder could be identified. Seed analyses of other sites also produced only sparse remains of catkins or buds of these two tree species and only occasionally hazelnut shells (*Corylus avellana*) or pips of elderberries (*Sambucus nigra*). For a reconstruction of the vegetation of the region, the existing pollen diagrams of Hoogkarspel-Klokkeweel and Enkhuizen cannot be used, as these only present strictly local pictures of the vegetation.[46] A number of Middle Bronze Age pollen spectra from West-Friesland have been published, especially from ditches surrounding burial mounds.[47] The general picture evolving from these analyses is of an open landscape. However, there appears to be a marked influence of 'long distance' transport and bioturbation, and there is serious doubt as to whether the results of these analyses can serve for a reconstruction of the vegetation.[48] For the final habitation phase of Bovenkarspel-Het Valkje, pollen and macrofossil analysis of the fill of a watering-place has shown that the area was almost completely treeless in that habitation phase.[49]

When the immigrants colonized the area, the creek and gully ridges may have carried some carr or woodland in which a restricted variety of tree species were present. It is uncertain whether the land had already ripened so far that oak could grow there locally. In the lower-lying marshy areas there were alder and willow scrub. The reclamation of the land on the ridges for arable farming and for house-building entailed clearance of the ridges. This caused especially the 'hard' woods, which were the best timber, eventually to become extinct since the intensive occupation of the ridges meant that they could not regenerate fast enough. The faster-growing and less demanding willow and alder could grow in scrub and carr in the lower marshy areas where there was a larger potential growing area.

6.6 *Wild plants*

In table 1, the wild plants of which carbonized seeds have been found are arranged in groups according to

42 Godet 1984; Tomlinson 1985.
43 Identifications by R. de Man.
44 Buurman *et al.* 1995; Buurman in prep.
45 IJzereef & Van Regteren Altena 1991.
46 Pals *et al.* 1980; Van Geel *et al.* 1982/1983.
47 Jonker, in: Van Giffen 1944, 180; Van Zeist, in: Van der Waals 1961; Van Zeist, in: Modderman 1964, 28–9; Groenman-van Waateringe, in: Bakker 1959; Groenman-van Waateringe, in: Lehman 1963; Waterbolk 1953; Bakels 1974; Van Geel 1976.
48 Van Geel 1976.
49 Buurman *et al.* 1995.

their present-day occurrence in vegetation types. The waterlogged plant remains from sample no. 22/1 are similarly arranged in table 2. For this classification, the current syntaxonomical grouping by Westhoff & Den Held was primarily used.[50] The use of this classification does require some comment. For the reconstruction of past vegetations, the present occurrence of plants in communities must be considered with caution, as former vegetations may have had a different species composition. Natural or semi-natural habitats may not (or almost not) have changed. But anthropogeneous habitats, such as arable fields, ruderal habitats and grasslands will have changed considerably in historical times. Moreover, many species have a wide ecological amplitude and may grow in different vegetations. Therefore, it is unwise to reconstruct vegetations in great detail on a low hierarchical level, especially those of man-induced habitats. At the highest (class) level considerable changes are less likely to have taken place.
The arable weed species found at Westwoud belong predominantly to the weeds of summer cereals, root crops and vegetable gardens (Class Chenopodietea, Order Polygono-Chenopodietalia). Characteristic species of these vegetations are: *Polygonum persicaria, Avena fatua, Echinochloa crus-galli, Stellaria media, Sonchus asper, Veronica agrestis, Polygonum lapathifolium* (ssp. *tomentosum*), *Chenopodium album, Solanum nigrum,* and *Capsella bursa-pastoris*. A few species grow as a weed in summer crops as well as among autumn-sown winter crops: *Avena fatua, Vicia hirsuta, Galium spurium,* and *Stellaria media* (Class Secalietea). Also *Bromus (hordeaceus)/secalinus* and *Rumex acetosella* which are listed under 'miscellaneous' may have grown in the arable fields. The caryopses of the winter crop weed *Bromus secalinus*, however, cannot be distinguished from the caryopses of the ruderal or grassland species *Bromus hordeaceus*. *Rumex acetosella* grows among winter crops and root crops, in dry poor grasslands and in burnt places.[51] Many of the listed species, however, also grow in ruderal, strongly humic and nitrogen-rich habitats such as waste places, rubbish dumps, dung and compost heaps, but also on dry, sandy and warm soils, in heavily trodden roadsides and in grassland, *etc.*
Species preferring ammonia-rich habitats such as dung hills, rubbish dumps and cesspools (Class Chenopodietea, Order Sisymbrietalia) are: *Urtica urens, Solanum nigrum, Chenopodium album, Chenopodium ficifolium, Atriplex patula, Atriplex prostrata, Poa annua,* and *Capsella bursa-pastoris*.
Vegetation types consisting of tread-resistant plants (Class Plantaginetea majoris) occur on soils which are frequently trodden and are deficient in oxygen through compaction of the soil (Order Lolio-Plantaginion) or through inundation and waterlogging (Order Lolio-Potentillion).[52] Vegetation types of the Lolio-Potentillion include heavily grazed pastures which are inundated in winter and spring. The occurrence of such habitats has so far been demonstrated at any rate for the last habitation phase in Bovenkarspel-Het Valkje at the end of the Late Bronze Age,[53] but, it now appears, also for the earlier habitation phases.[54]
A number of species are characteristic for instable pioneer vegetations on moist, mostly compacted soils, such as moist arables, furrows or at the edges of ditches (ephemeral plants, Class Isoeto-Nanojuncetea).
In wet places rich in nitrogen (or ammonia) which periodically fall dry, as occur along strongly polluted ditches, and in accumulations of compost, dung or liquid manure, vegetation types of nitrophilous pioneers (Class Bidentetea tripartitii) may occur. Apart from the species listed under this vegetation type in tables 1 and 2, one of the subspecies of *Polygonum lapathifolium*, ssp. *lapathifolium*, is also characteristic of this vegetation type. However, it is not possible to identify the seeds to that level. These species are indicative of an excess of nitrogen (N) and hence of extremely nutrient-rich locations, such as cattle resting places or dungheaps (Ellenberg nitrogen figure, N=9).[55]
A wide range of species that are characteristic of vegetation types of eutrophic marshes and banks have been identified (Class Phragmitetea). Also many taxa growing in wet grasslands (Class Molinio-Arrhenathe_retea) were found. Many species from Phragmitetea vegetation types may grow in wet grasslands and the converse is also true: many grassland species may grow in marshy habitats. Species which are characteristic of marshes and banks or of wet grasslands may also occur in heavily grazed, frequently inundated pastures of the Lolio-Potentillion types (*Phalaris arundinacea, Phragmites australis, Eleocharis palustris* ssp.

50 Westhoff & Den Held 1969.
51 Van der Meijden *et al.* 1990.
52 Sykora 1982.
53 Buurman *et al.* 1995.
54 Buurman in prep.
55 Ellenberg *et al.* 1992.

context	house ditches													postholes		ditch
sample nr	24	2	25	1	26	39/1	39/2	39/3	39/4	11/1	11/2	11/3	11/4	27	17	13
phase	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Alnus (elder)	7	2	2	1	1	1	-	-	1	1	6	-	1	-	-	1
Betula (birch)	2	1	1	1	1	-	-	-	-	1	-	-	1	-	-	1
Quercus (oak)	-	-	4	-	-	-	-	-	-	1	1	-	-	4	-	-
Salix (willow)	10	14	2	4	3	3	-	2	1	3	-	12	6	-	2	7
Indet.	1	7	4	-	4	-	2	8	1	-	7	18	2	-	5	2
total nr of pieces	20	24	13	6	9	4	2	10	3	6	14	30	10	4	7	11
weight in grammes	0.2	0.3	0.2	.	.	0.1	.	0.8	.	0.1	1.7	0.8	.	0.1	.	0.2

context	circ. ditch		ditches				pit
sample nr	36/1	36/2	15	23	16	5	30
phase	II	II	II	II	II	II	II
Alnus (elder)	-	-	3	-	-	-	-
Betula (birch)	-	-	-	-	-	1	-
Quercus (oak)	-	-	-	-	-	-	-
Salix (willow)	-	2	4	-	2	4	2
Indet.	-	-	1	-	-	2	-
total nr of pieces	-	2	8	-	2	7	2
weight in grammes	.	.	.	.	.	0.1	.

context	ditches											pit circle		ditch	arable
sample nr	9	9/1	9/2	9/4	4	21/1	21/2	21/3	37/1	37/2	37/3	31	33	35	0
phase	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IIIb	IIIb	IIIb	IIIb	IIIb	IIIb	IIIb
Alnus (elder)	8	-	-	-	17	-	-	-	-	-	-	-	-	3	-
Betula (birch)	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Quercus (oak)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix (willow)	5	12	17	12	55	31	17	28	8	10	3	1	2	1	1
Indet.	6	-	1	12	6	9	3	-	7	5	14	1	-	4	-
total nr of pieces	19	12	18	24	78	40	22	28	15	15	17	2	2	8	1
weight in grammes	0.3	0.1	0.6	0.4	7.6	1.1	0.4	1.2	.	0.4	0.2	.	.	.	.

Table 5 Charcoal (. less than 0.1 gram).

uniglumis, *Scirpus lacustris*, *Galium palustre*, *Carex cuprina*, *Mentha aquatica*, *Ranunculus repens*, and *Rumex crispus*).
Species from aquatic vegetations have only been found in the waterlogged sample no. 22/1. One is struck by the conspicuous presence of many seeds of *Lemna* spec. (duckweed). This species nowadays very rarely bears flowers and fruits. Species of this genus are characteristic of quiet, eutrophic (phosphate- and nitrogen-rich), mostly stagnant water less than one metre deep with a bottom rich in organic material.

6.7 *Multivariate statistics*
The results of the analysis of the carbonized plant remains were subjected to multivariate statistics, using the ordination technique of correspondence analysis.[56] This is a pattern-searching technique in which the samples are arranged along axes on the basis of species composition. The results are presented in biplots which represent a two-dimensional reduction of the multi-dimensional data set (figs. 12 and 13). The first axis accounts for the greatest variation within the data, the second axis for the largest remaining variation, and so on for the third and subsequent axes. The distance between the points in the graph is a measure of the degree of similarity or difference. The direction of the points from the origin of the plot is important in the comparison of samples and species.
This analysis was expected to reveal information on the presence of possible assemblages of crop products or by-products that might shed light on crop farming and grain-processing activities. Also evidence about the function of the excavated structures in terms of these crop-processing activities might be revealed. It was also thought that information might be gained about vegetation types. Any differences in vegetation types in the different phases and/or the different contexts would become more clearly visible. Moreover, such analyses might provide information about habitat for some taxa which could not be identified to a level allowing classification into a specific vegetation type, *e.g.*, the above mentioned *Bromus hordeaceus/secalinus*.
The program used was the CANOCO package designed for the analysis of vegetation survey data.[57] The program used for plotting the results was CANODRAW.[58]
For this correspondence analysis, sample size is not important and standardization by volume is not necessary.[59]
The results from the subsamples were added together (sample nos. 39, 11, 36, 9, 21 and 37), although there is some doubt as to advantages of this. Since the dataset is rather small, all taxa were included, even the rare ones whose seeds were found only in one sample. Because identification problems in some taxa may cause irrelevant outcomes, some taxa were lumped together, for instance all grass taxa (except *Echinochloa crus-galli* and *Phragmites australis*) under Gramineae, and all Papilionaceous taxa (except *Vicia*) under Papilionaceae. *Vicia hirsuta* was included in *Vicia* spec.; *Polygonum persicaria*, *Polygonum lapathifolium* and *Polygonum lapathifolium/persicaria* were taken together, as were the *Oenanthe* species.
Two series of plots are given. In the first series (fig. 12) all samples were used in the analysis. In the second series (fig. 13) sample nos. 3, 17 and 37 were excluded. Separate plots are given for the samples and for the species, since in the combined plots many points were hidden. For the samples, figs. 12a and 13a show the phases and figs. 12b and 13b show the contexts. For the species (figs. 12c,d and 13c,d), the following simplified classification was made from the groups in table 1:
- crop products and by-products:[60] cereal grains of *Hordeum vulgare* and *Triticum dicoccum* and seeds of *Linum usitatissimum*, light chaff (glume tips and awns), heavy chaff (rachis internodes, spikelet forks and glume bases) and straw (culm nodes and bases). Since glume tips and lemma awns were not counted, their numbers have been estimated for the analysis;
- weeds and ruderals;
- grassland plants; this group includes the tread-resistant plants and the plants from bare, wet, compacted soils since these grow in vegetation types which may be grazed or mown;
- plants from marshes and banks;
- plants growing in wet, nitrate-rich habitats;
- twigs (the number of which is estimated);
- taxa impossible to classify.

In the first series, the first (horizontal) ordination axis, which accounts for the greatest variation in species

56 Lange 1990; Jones 1991.
57 *cf.*, Ter Braak 1988 (version 3.12, April 1991).
58 *cf.*, Smilauer 1992 (version 3.00, March 1993).
59 Lange 1990.
60 Hillman 1981; 1984a; 1984b; Jones 1984.

composition, separates the samples from the ditches of phase IIIa in the right side of the plot very distinctly from the rest and especially from the samples of the house-ditches of phase I in the left side of the plot (figs. 12a,b). This is primarily caused by the large amounts of straw (culm nodes and bases) and twigs in the samples of phase IIIa. From figs. 12c,d and table I it becomes apparent that the greater occurrence of species from marshes and banks in the right side of the plot may also be responsible for this separation, as well as the lesser representation of chaff, weeds and ruderal species. Also the nitrophilous species are found in the samples of phase IIIa. Two of the three samples from the postholes (sample nos. 27 and 17) are clearly separated from the samples from the house-ditches (fig. 12b). As an exception in phase I, sample no. 3, from the continuation of the long house-ditch, is found among the samples from phase IIIa. This is certainly caused by the fact that this sample contains only very few seeds. After a new analysis omitting this sample, there were no significant differences in the plot. The samples from phase II are found roughly in the middle of the plot. Four samples from phase IIIb are found clustering there as well, albeit somewhat to the right of the samples from phase II. The samples from the pits of the pit circle of phase IIIb, which archaeologically form one feature, are found very close together. The sample from the arable (no. 0) also belongs to this group. These four samples are quite similar in composition. The two other samples of this phase IIIb (nos. 35 and 37) are found in the upper part of the plot. The second (vertical) axis in the first place separates sample no. 37 in the upper right-hand corner of the plot from all other samples. The extreme separation of this sample is probably caused by the presence of exceptional numbers of nutlets of *Eleocharis palustris* (figs. 12c,d) and many seeds of Papilionaceae (table I). It also contains relatively many light chaff elements. Sample no. 17, is, to a lesser degree, separated in the same direction. This sample also contains relatively many remains of Papilionaceae and *Eleocharis palustris*. The samples from phase IIIa are distinctly separated from each other on the vertical axis, sample no. 4 especially is found in a rather extreme position in the lower right-hand corner of the plot. Sample no. 11 from the short house-ditch of phase I is found in the upper left-hand corner of the plot and is distinctly separated from the samples from the long house-ditch in the lower left-hand corner of the plot.

A second analysis, of which the plots are given in figs. 13a–d, was made excluding sample nos. 3, 17 and 37. This second analysis again shows the distinct separation of the samples from the house-ditches of phase I at the extreme left and the samples from the ditches of phase IIIa at the far right of the plot (figs. 13a,b). In this second analysis, again, the samples from phases II and IIIb are found roughly in the middle of the plot except sample no. 35 which is distinctly separate from the other samples of phase IIIb. The sample from the short house-ditch is again separate from the samples from the long house-ditch, and the samples from the postholes are found just to the right of the samples from the long house-ditch (fig. 13b).

Considering the species data (figs. 12c,d and 13c,d) from both plots, it becomes clear that the greatest variation is caused on the one hand by the high positive scores on the first axis of straw, twigs, and most of the species of marshes and banks at the right-hand side of the plot where the samples from the ditches from phase IIIa are found. Also the nitrophilous species, although rare, are found in these samples. On the other hand, we find negative scores along this axis of grains and heavy and light chaff of *Triticum dicoccum*, and of weeds and ruderal species, associated with the samples from the house-ditches. The differences in cereal species composition play an important role, *Hordeum vulgare* being more important in the later phases. The separation of the rachis internodes of *Hordeum vulgare* from the actual grains and also from the heavy chaff elements of *Triticum dicoccum* is striking and can be explained in two ways: in terms of chronological variation and in terms of variation in crop-processing activities. First, as emmer is the most important crop in phase I to which the samples in the left side of the plot belong, it is obvious that also the chaff elements of emmer will be the most important chaff in that phase. In phase IIIa, barley is the most important, and hence the chaff in these samples will predominantly derive from barley. Secondly, when a bunch of *Hordeum vulgare* is threshed by lashing or flailing, the hulled grains become separated from the straw, to which the rachis remains attached. The fact that the straw nodes and bases and rachis internodes of barley cluster in one group on the right of the plot may indicate that we are here dealing with barley straw, especially in sample no. 4, which also contained many basal rachis parts. However, emmer straw probably was also present; especially in sample no. 9/4, in which relatively many

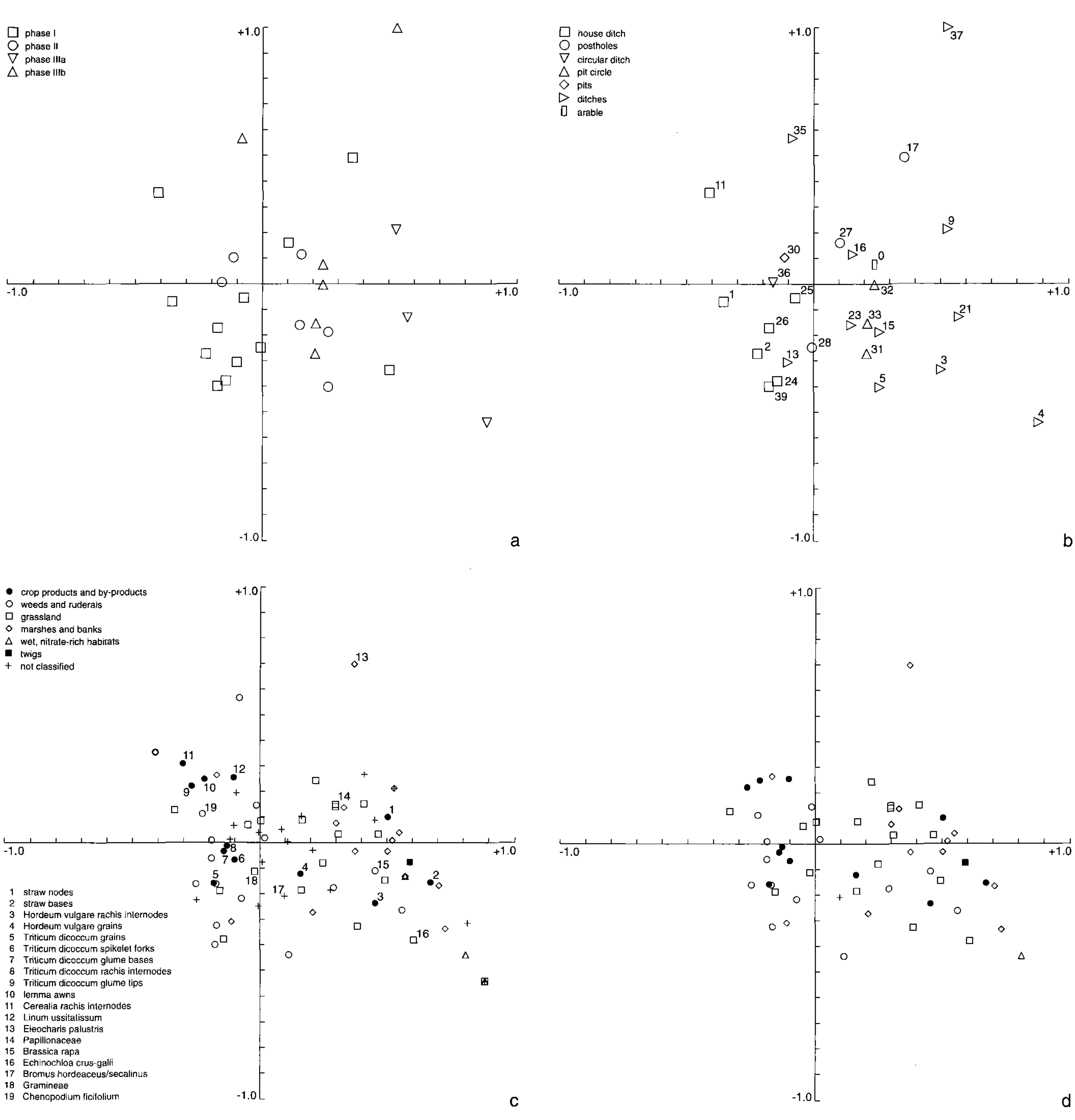

Figure 12a–d Correspondence analysis of carbonized plant remains, all samples.
a Samples and chronology.
b Samples (with sample numbers) and contexts.
c All taxa (important taxa which have been referred to in the text are indicated with numbers).
d Rare taxa and unclassifiable taxa excluded.

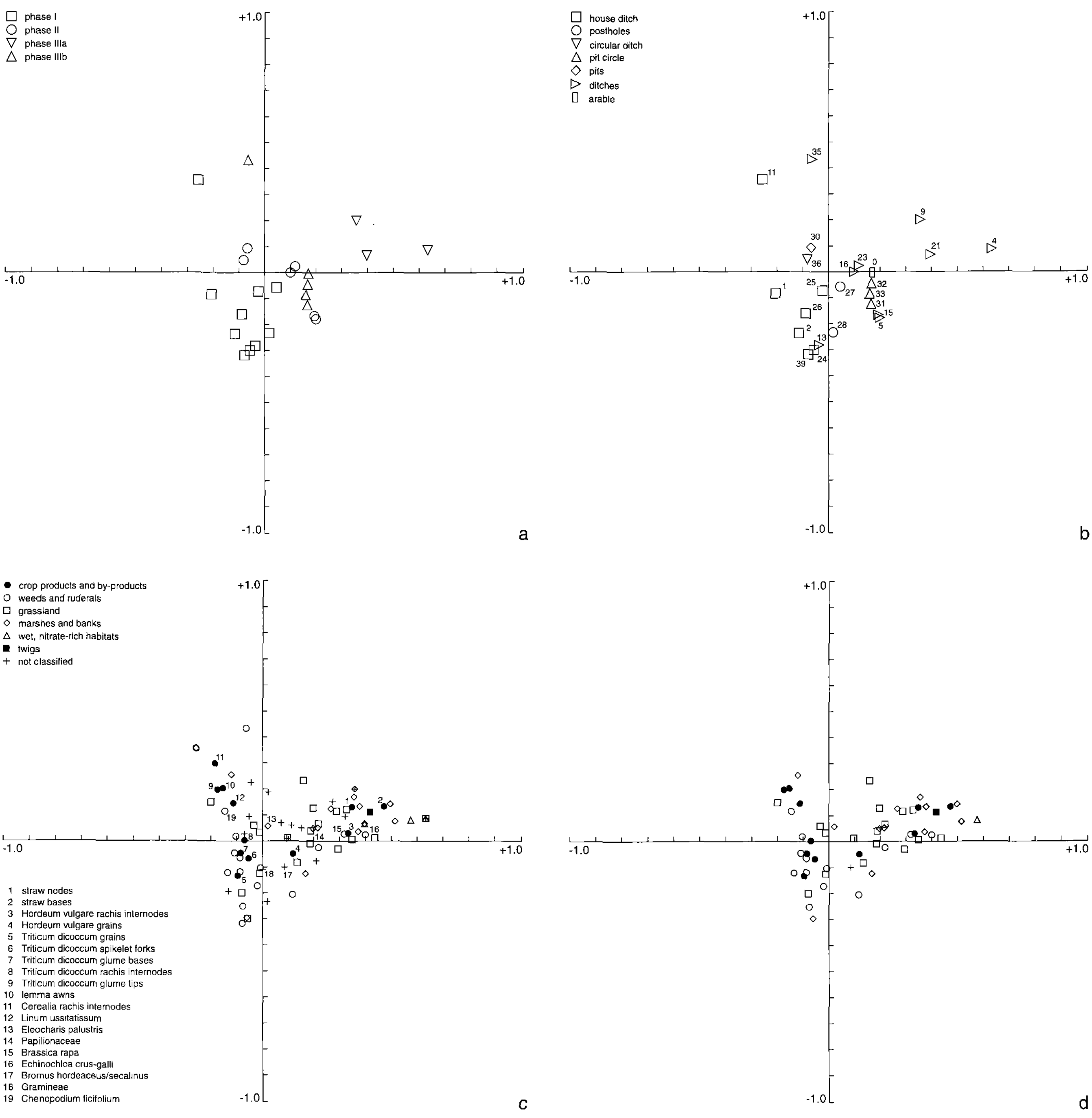

Figure 13a–d Correspondence analysis of carbonized plant remains, without sample nos. 3, 17 and 37.
a Samples and chronology.
b Samples (with sample numbers) and contexts.
c All taxa (important taxa which have been referred to in the text are indicated with numbers).
d Rare taxa and unclassifiable taxa excluded.

grains and chaff elements of emmer were found. The separation of the short house-ditch sample (no. 11) from the samples from the long house-ditch appears to be caused by its high content of the finest chaff elements (awns and glume tips) and of seeds of *Chenopodium ficifolium*. In the samples from both house-ditches the crop products (cereal grains and seeds of *Linum usitatissimum*) and by-products light chaff (awns and tips), heavy chaff (glume bases, spikelet forks, rachis internodes) and weed seeds seem to predominate compared with all the other samples. In these samples culm bases and nodes are present as well, but only occasionally.
Grassland species are distributed over the whole plot. The occurrence of so many seeds of Papilionaceae in sample nos. 9, 4, 37 and 17 is striking and may point to the presence of hay. The majority of the seeds of Gramineae were found in the samples from the house-ditches, especially in sample no. 39/4. The separation of sample no. 35 is probably caused by its high content of light chaff, in comparison with the other samples of phase IIIb.
Echinochloa crus-galli and *Brassica rapa*, both weeds of summer crops and vegetable gardens or ruderal plants, occur at – for arable weeds! – rather extreme positions among the samples of phase IIIa. This may be caused by the fact that both the number of seeds and the number of samples in which they were found are small. However, one may wonder whether these two species were not intentionally gathered as a valuable food source or even cultivated. *Echinochloa crus-galli* (cockspur grass) has edible millet-type caryopses and, as has been said before, *Brassica rapa* may have been gathered or cultivated for its oleaginous seeds or as a vegetable. However, both species may have grown as weeds in the fields and, being tall plants, may have been harvested by uprooting together with the cereals (see below).
Whether we are dealing with *Bromus hordeaceus* or *Bromus secalinus* is still difficult to say. It is quite possible that both species are present. Since the taxon is amply represented in sample no. 4 among the uprooted straw, it is possible that the arable weed *Bromus secalinus* was uprooted together with the crop. However, in this sample the seeds could also derive from the grassland plant *Bromus hordeaceus*, since the large amount of seeds of Papilionaceae strongly suggests that hay was also present. In the samples from the house-ditches too, the taxon is very well represented. Here, the seeds might derive from both species, since the one species may have been present in grazed grassland or in hay and the other species in crop-processing waste that was used as fodder. Thus both may have been eaten by the animals that produced the dung which is assumed to have been used as fuel later (see below).

7 INTERPRETATION

7.1 *Summer crops*

The weed species clearly show that the prehistoric farmers cultivated their cereals as summer crops. Since many weed species from fields of summer cereals and root crops also occur in ruderal habitats it is not possible to be certain whether these plants grew as weeds in fields and therefore are indicative of manuring. They might also have grown in ruderal places on nitrogen-rich soils or even on the dung-heaps themselves.

7.2 *Harvest*

Hillman and Jones composed models of crop processing activities, based on observations in archaic agrarian communities still surviving in Turkey and Greece. They investigated the effects of each step in crop growing and grain processing on the composition of crop products and by-products and summarized them in 'cause and effect' models.[61] Patterns of variation in the composition of remains of equivalent crops recovered from archaeological sites are found to closely resemble those presented in the models. From these observations important data can be drawn to explain the presence of certain parts of the cereal plants. As to the finds of culm bases, the following can be noted. Harvesting may be done by reaping, uprooting or ear plucking. Only through harvesting by uprooting will culm-bases enter the settlement and thus the archaeological record. The possibility that the ears were harvested separately from the straw by plucking or reaping while the straw was harvested later by uprooting, must be excluded. In that case, the rachis internodes would not be among the straw. At Westwoud, rachis internodes are present in the same samples as the culm bases and culm nodes, sometimes even in very large numbers (sample no. 4). Therefore, the conclusion must be that uprooting of the integral straw and ears was the harvesting method for the cereal crops in these samples. From the

61 Hillman 1981; 1984a; 1984b; Jones 1984.

investigations at the other sites in West-Friesland it was concluded that the crop was reaped low on the straw and possibly bound into sheaves.[62] However, in these analyses possibly no attention was paid to the occurrence of culm-bases and rootlets. These samples will be screened again for this in future. The next step in present-day crop processing is the drying of the crop, in the field, in barns or in ovens/kilns. In prehistoric West-Friesland the crop was piled up in stacks next to the houses, probably after an initial drying in sheaves in the field. As Hillman observed, roots and culm-bases (with adhering earth and gravel) were often chopped off at this point.[63] If not, they were included in the next step in the sequence of crop processing, the threshing. Hillman remarks that harvesting by uprooting is today most commonly used for barley, especially for the shorter varieties.[64] It can be done quickly and effectively and is even entrusted to children since no sharp tool is necessary. Emmer is sometimes uprooted in the wetter parts of Turkey, where soils are moist or friable. Also for China there are records of wheat being harvested by this method. In present-day Anatolia deliberately blunted sickles are sometimes used to harvest barley by uprooting. However, Hillman also notes that when cereals are reaped with too blunt a sickle, the effect is the same as with uprooting. Then too, the bases of the plants are pulled out of the soil. If the grain is then carefully threshed by lashing, the primary product, the grain, will not include any culm bases. The straw, however, will contain many of these elements.

For our case in Westwoud we can reconstruct that, at least in phase III, the crops were harvested by uprooting and that the culm bases were not chopped off before threshing. In phase I, the evidence for uprooting is scarce since in the samples from the house ditches culm bases and rootlets were rarely found in contrast to seeds of low-growing weeds. The grain may have been reaped in this phase. However, uprooting cannot be excluded for this phase either, as different strategies in the use of the long straw may also be the reason why it is found more often in phase III than in phase I. Uprooting probably did not cause any problems, as the sandy loamy soil was very loose. Since the ethnographic evidence shows the use of blunt sickles for uprooting cereals, it is tempting to suggest that the blunt flint 'sickles', which are characteristic of the Bronze Age habitation of West-Friesland and are thought to have been used for cutting sods, could also have been used for this method of harvesting. However, Van Gijn convincingly concluded from her investigations on these flint 'sickles' that the most likely use of these implements was the cutting of sods.[65] IJzereef points out that in prehistoric West-Friesland only once a fragment of a bronze sickle has been found.[66] Whether or not bronze implements were available to the prehistoric inhabitants of the eastern part of West-Friesland is not known. They possibly were lost through corrosion. IJzereef suggests the utilization of mandibles of cattle as a sickle.[67] However, to the author's opinion these are too blunt for cutting and the plants will be pulled out of the soil as is the case in uprooting. One may imagine that when no special harvesting implements are available, uprooting the crop is the only option.

If harvesting is done by uprooting, and the cereal plants do not grow too close together, only the tallest weed plants, such as *Echinochloa crus-galli* and *Brassica rapa*, may be harvested together with the cereals. When close stands of cereals are uprooted, most weeds, even the lower-growing ones, will be pulled out of the soil as well.[68]

7.3 *Climate*

Evidence for uprooting as a harvesting method may also be taken as an indication of bad weather in the harvesting season. As we know, cereal crops tend to lodge when the weather is bad and they are subjected to heavy rainfall and violent winds in late summer. Uprooting will then be the only possible harvesting method. This tendency to lodge is more or less genetically determined by the hereditary characteristics of roots and stem. However, it usually is encouraged by external factors and is most frequently associated with weakness of the straw due to crowding of plants. This may be caused by drilling the plants in rows too close together, sowing too much seed, early sowing, the application of large amounts of nitrogenous manure, or other factors which encourage luxuriant growth. Also,

62 Buurman 1979; 1989.
63 Hillman 1984a; 1984b.
64 Hillman 1981, 148–9.
65 Van Gijn 1990.
66 Personal communication G.F. IJzereef.
67 IJzereef 1981.
68 Personal communication P. Mikkelsen, Århus (Denmark).

in spring-sown varieties like those we are dealing with at Westwoud, as opposed to specific winter species, "(...) the root system consists of much thinner, less lignified roots descending almost vertically with very little grip on the surface soil. Plants with these root characteristics are very easily bent to the ground as a whole, although the straw may be as strong and rigid as that of the best winter varieties."[69] Wind and rain only reveal the weaknesses of the stems and roots of the crops but do not cause them.

As uprooting is most evident in the later phases IIIa (sample nos. 9, 4 and 21) and IIIb (sample 37/3), it is tempting to conclude that in these later phases the increasing wetness of the area made lodging cereals a serious problem and uprooting was the only harvesting method possible. There is ample other archaeological and palaeoecological evidence that the area became progressively wetter during habitation, especially in the later phases, probably because of climatic deterioration.[70]

7.4 *Threshing*

In areas with wet summers, threshing is done indoors by flailing or lashing. This produces a bulk of undamaged straw as a by-product which can be used for thatching, flooring, litter, basket-work, *etc.* When threshing is done outdoors by trampling or sledging, as is usual in arid areas, the straw is damaged and can only be used as fuel, fodder or coarse temper.

Whether in prehistoric Westwoud there was a need for undamaged straw, and to what extent, we cannot reconstruct. Presumably straw was not used for thatching, since reed, which provides much better roofing, would have been available in large quantities in the marshes.

Ethnographic evidence from the Orkneys shows a method of threshing sheaves on a small scale by splitting the sheaves into bunches and lashing the heads against a hard or toothed surface.[71] In this way, the straw was kept as whole and unbroken as possible for thatching or making straw articles. From this area also the practice is known of half-threshing a sheaf so that some grain was left on for foddering animals. As sample no. 4 contains relatively many grains and rachis internodes and few weed seeds, the contents may represent the charred remains of unthreshed or half-threshed sheaves. The conspicuous absence of awns, however, may also mean that we are dealing with a batch of straw amalgamated with a grain store of barley. However, if the lashing were carried out outdoors, this finest chaff would have been blown away and would not have become mixed with the other crop products and by-products.

7.5 *After threshing*

The abundance of cereal grains, heavy chaff, light chaff and seeds of arable weeds and ruderals in the house-ditches of phase I indicates that the bulk of the botanical content of the ditches is made up of waste from various stages of crop processing amalgamated with food-preparation waste. The occurrence of broken grains may point to the preparation of groats. Of *Triticum dicoccum* all parts of the spikelets abound in the house-ditches. Grains were also found in spikelet configuration. This suggests the presence of intact spikelets of emmer. Very probably these charred remains of complete spikelets indicate that parching and pounding occurred on a daily basis at the house. Overheating during parching may be responsible for the spikelets becoming charred. This charred waste was thrown into the house-ditch. Another explanation of the occurrence of this charred chaff and weed seeds among house-hold debris is the direct use of this chaff as fuel, or the burning of dung of animals which were fed this chaff (see below).

7.6 *Leaf hay*

The twigs, which were found in large amounts in the same samples as the straw, may likewise have been fodder, although they could also have served other purposes, such as litter or the manufacturing of fish traps, basketry, hurdles, or wattle-work. Finds of twigs, that were definitely fed to livestock are also known from other sites, especially from Swiss Neolithic settlement sites.[72] Here, the analysis of animal faeces showed that the dung-producing animals had been fed on leaf fodder. Analyses by Rasmussen of dung layers in a byre of the Neolithic settlement at Weier showed that these layers contained a wide range of macrofossils of which twig and leaf fragments were the most abundant.[73] In

69 Percival 1921 (1974).
70 Van Geel *et al.* 1996; 1997; Buurman in prep.
71 Fenton 1978.
72 Rasmussen 1989; 1990.
73 Rasmussen 1989, 55.

this settlement also two heaps of leaf-bearing twigs were found. Large quantities of leaf-bearing twigs must have been brought in for the animals. Rasmussen also carried out an experiment involving feeding leaf hay to cattle at the Historical-Archaeological Experimental Centre at Lejre (Denmark).[74] Here, a cow was fed dried ash leaves and twigs. She ate the leaves and the smaller twigs. The larger twigs were not eaten and together with some leaves which were wasted they accumulated behind the cow where they became mixed with dung. If the mixture was allowed to lie for any length of time the cow would trample the twigs to small pieces. Twigs, leaves and dung were thoroughly mixed together, producing something very similar to what was found in the dung layers from Weier. Analyses of the modern dung also showed that leaves and twigs are not completely digested by the animals. Identifiable twig fragments up to 2.5 cm in length and with a diameter of 0.3 cm, and leaf fragments measuring 1.1 x 1.0 cm passed through the animals' digestive systems. The charred twigs found at Westwoud are of the same diameter, but shorter, possibly because of damage during and after carbonization.

The investigations at the Swiss Neolithic sites showed that the farmers' choice of leaf-fodder trees was very broad. They used elm, birch, oak, lime, maple and ash. There was no marked preference for particular trees. This was probably also the case at Westwoud. However, the choice was very limited here. Charcoal identifications at all investigated sites in eastern West-Friesland contemporary with the twigs at Westwoud, only revealed willow and alder and both species were used for leaf hay.

As leaf fragments were found occasionally, we can conclude that the branches were harvested in a leafy state in July or August. After drying they were stored for use as winter fodder.

7.7 *Tree management*

The twigs in the samples of phase IIIa were usually one year old. Only occasionally were two-year old pieces found. This may indicate that some sort of tree management was practised, such as pollarding, shredding or coppicing.[75] Tree management has also been demonstrated for Weier.[76] There the age distribution of the twigs found in dung layers was investigated in detail and compared with the ages of the branches harvested from a modern pollarded tree. It appeared that in the case of willow one-year old twigs, and for alder two- and three-year old twigs were found to be the most common – both among the modern twigs and among the Neolithic twigs from Weier. The same age distribution was found with the twigs of Westwoud. Evidence for the practice of coppicing is also supplied by Lundström-Baudais and Billamboz for lake dwellings in the French Jura and in the region of Lake Constance (Bodensee).[77] Van Zeist suggests tree foliage as a major animal fodder for Iron Age Peelo (prov. of Drenthe), as there must have been quite considerable numbers of livestock – judging from the size of the farmhouses.[78]

7.8 *Animal fodder*

The combination of straw and twigs in the samples from phase IIIa might indicate that we are dealing with the carbonized contents of a byre in which the animals were stabled at least during the winter months and in which straw and leaf hay and possibly also cereals were present as winter fodder. Also grass hay and hay from reedland vegetation could have been present, given the quantity of seeds of grassland and marsh plants. A parallel for the use of marsh plants for hay-making is found in the wetland situation of Iron Age and Roman Voorne-Putten. Here, Brinkkemper found that reedland vegetation was used for hay-making.[79] This could also have been the case at Westwoud. The information on the fodder requirements of livestock, gathered by Gregg, shows that the share of straw in winter fodder may not exceed 40% of the diet of cattle.[80] The remaining 60% of the winter fodder would have to derive from hay or dried leaves. However, there are other possibilities. According to Reynolds, for instance, barley straw may constitute *c.* 80% of the fodder of present-day beef cows.[81]

The animals could also have been fed with cereals. Research on animal dung at Neolithic Weier pointed out that the diet of the animals was supplemented with cereals.[82] From experiments it became clear that if grain

74 Rasmussen 1989, 58.
75 Rackham 1976.
76 Rasmussen 1989.
77 Lundström-Baudais 1983; Billamboz 1985.
78 Van Zeist & Palfenier-Vegter 1991/92.
79 Brinkkemper 1993, 129.
80 Gregg 1988.
81 Cited in Brinkkemper 1993 (personnal communication).
82 Robinson & Rasmussen 1989.

was fed to cattle, it first had to be pounded or soaked or mixed with chaff (to encourage chewing) to make it more digestable. Unthreshed or uncleaned cereals, however, might have been fed directly. Sheep and goat are very able to chew and digest whole grains. If cereals were produced not only for human but also for animal consumption, the economic model of IJzereef may have to be reviewed.[83]
In this interpretation we presume a burnt-down byre, to explain the charring of its contents, which is a rather negative point of view. Especially since domestic refuse from house ditches and *terp* ditches in the other excavated sites in West-Friesland always contains as many carbonized remains,[84] it seems unlikely that all burnt finds originate from burnt-down buildings. The explanation that these remains derive from dung used as fuel is much more plausible.

7.9 *The use of dung as fuel*
When the area was colonized early in the Middle Bronze Age, the landscape was very open (see the section on charcoal above). It is assumed – and there is plenty of evidence for this – that wood was scarce and became even more scarce in the course of the habitation of West-Friesland. Lack of firewood must have made it necessary to find other sources of fuel.
In settlement sites, densities of carbonized seeds are usually low. In the Bronze Age sites of West-Friesland, however, they are often very high and the assemblages include substantial numbers of seeds and chaff which are unlikely to represent the human diet. The direct use of crop-processing waste as fuel would not explain the sometimes large amounts of seeds of grassland and marsh plants in the same samples as the chaff remains. Since seeds, chaff and twigs may pass undamaged through the digestive tract of animals, it is most likely that at Westwoud seeds as well as chaff, small twigs and possibly also cereal grains were carbonized after being eaten by the livestock and becoming incorporated in dung that was used as fuel. Experiments have shown that a high percentage of seeds swallowed by cattle, sheep and goat are excreted and even remain viable.[85] Nor are the more robust chaff elements such as spikelet forks and rachis internodes digested. As we saw above, even twigs can be retrieved from the dung. Culms, however, can no longer be recognised in the dung.[86] Moreover, it is unlikely that the animals ate the culm bases if there was soil still adhering to them. But it is quite possible for some of the stronger culm bases and strongest nodes to pass the digestive tract undamaged and reappear in the dung. Twigs and straw, used as litter or wasted by the animals, will have been mixed with the dung by trampling.
The presence of many seeds of grassland and marsh plants supports the explanation that dung was used as fuel, since the animals may also have been fed hay. In late spring and summer, they could have been grazing in pastures during the daytime and stabled during the night for the purpose of collecting dung. Having them grazing freely in pastures would have meant less fuel. However, if people were desperately in need of dung for fuel, they could have gathered it from the pastures and carried it home, as was the practice in the recent past in Orkney (see below). Dung may also have been necessary for manuring the fields. It is also possible that the animals grazed on stubble and/or weeds in fields after harvest or in fallow fields, which would be a very efficient way of manuring. According to the investigations of IJzereef, livestock was considerable, and there must have been enough dung for both purposes.[87]
Various authors have already proposed that dung was used as fuel.[88] Ethnographic parallels can be found in areas where there is lack of firewood or peat sods, e.g., in the Near East,[89] Orkney[90] and the 'Halligen'.[91] For Orkney, Fenton cites a number of sources in which sometimes very romantic descriptions are given of the preparation and the use of the dung. In a source of about 1800 it was stated that: *Indeed almost every particle of horse and cow-dung was made into cakes about 9 in. (23 cm) in diameter and from 1 to 4 in. (2.5 to 10 cm) thick, dried by being stuck against the walls of buildings or laid on the grass.* Also dried seeweed was used as fuel, but neither fuel made a permanent fire possible. *Mothers might have to lie in bed the whole day with their infants, to keep them warm.* This fuel remained in use here

83 IJzereef 1981.
84 Buurman in prep.
85 Schröder & Baart 1982.
86 Neef & Bottema 1991.
87 IJzereef 1981.
88 Buurman 1992; Lange 1990; Miller 1984; Neef & Bottema 1991; Therkorn *et al.* 1984; Pals 1987; Van Zeist 1974.
89 Bottema 1984.
90 Fenton 1978, 206–9.
91 Wohlenberg 1978.

throughout the nineteenth century and the descriptions speak of the odour that *tickles the inexperienced nostril. If thoroughly dried, however, it burned with a clear flame and with no more smell than wood or grass.* Fenton cites different ways of preparing animal dung for fuel: *It could be taken out of the byre and spread on grass to dry after having been broken up into pieces 9 or 10 in. (23-25 cm) across. For this, only summer dung was used, winter dung being too thick. The scones were made each day, and were turned with the toe during drying, till they were hard enough to be set up in pairs leaning against each other. They were then stored in a dry place till required. The simplest method was to collect the pats of dung from the pasture and carry them home in sacks for drying. The cow-dung was sometimes mixed with turfy earth to form a kind of peat. Thin, almost liquid dung, scattered lightly over the grass as when the cattle were scouring slightly, dried well and was prized as kindling which could easily be set alight with a wisp of straw. Small pieces of it were called 'flinterkins'. Straw dung from the midden was often cut off in squares to be dried as fuel.* Fenton also mentions evidence of animal dung as fuel for other parts of Scotland, Northern England, Ireland, Denmark, Iceland, and further afield.
For the situation in the 'Halligen', the East-Frisian Isles off the northwest coast of Germany, which most closely resembles our situation, the following description was found. Until recently the farmers of the Halligen, living on elevated farmsteads (*terpen*), produced dungcakes for fuel. In spring, the animal dung which was gathered from the stables during the winter, was spread out evenly in a layer of 8–10 cm thickness on the sunny side of the *terp*. There it was tamped and cut into sods which were dried in wind and sun like turves. In summer they were piled up for later use. Each household produced 10 000 to 20 000 of these dungcakes a year for their fuel. Nowadays people still use some of this fuel to 'flavour' their home-baked ryebread – probably only for touristic reasons.

7.10 *Contextual and chronological distribution of the plant remains*

The results show clearly that there are different combinations of plant remains in the different contexts. In the house-ditches of phase I, we find waste from crop-processing activities, especially from the stages after threshing (parching, pounding, winnowing, sieving, hand-sorting) and from food preparation, and probably also remains of burnt dung. The posthole with sample no. 17 also contains remains of burnt dung. In the ditches of phase IIIa and ditch 37 of phase IIIb, threshing waste, leaf hay, and hay predominate, representing litter and animal fodder, probably also in the form of burnt dung. Also there is some crop processing waste from the stages after threshing. The densities of plant remains in these samples are quite high: 41 to 269 (average: 121) per litre. In the other samples, from contexts other than dumped refuse, the densities of plant remains are lower: 1 to 35 (average: 18) per litre. Possibly their contents only represent 'noise', present throughout the settlement.[92] These differences might well represent contextual variation. However, they could also be due to chronological variation. The economic model that IJzereef made for the area of West-Friesland, based on his study of bones from the excavations at Bovenkarspel-Het Valkje and Andijk, shows that in the Early Period cattle breeding was the most important part of the economy, but in the course of this period crop cultivation became increasingly important. The Late Period saw a shift from crop cultivation to animal breeding again.[93] Our findings could very well be explained in agreement with this. We have to take into account, however, that at Westwoud the different contexts may represent different ages and we cannot be certain whether the variation in composition is a chronological or a contextual one or a combination of both. Also, owing to the small scale of the excavation, only a very small part of the settlement was uncovered. From the very limited number of samples, far-reaching conclusions have been drawn, often only on the basis of just one or a few investigated features per context. Therefore, it is possible that these results are coincidental and unrepeatable. Only when the same results are repeatedly found, will our conclusions be substantiated. For these reasons, the conclusions drawn from the investigations at Westwoud must be considered provisional. Comparison with the results from the very large excavation at Bovenkarspel-Het Valkje, where numerous samples could be analysed from the different contexts over the whole period range, will show whether these interpretations and conclusions are justified.

92 Bakels 1991.

93 IJzereef 1981.

8 RECENT, SUBRECENT AND MINERALIZED PLANT REMAINS

In a large number of samples, recent or subrecent and mineralized seeds turned up. These were not investigated in detail but they do merit some comment here. Their occurrence is not surprising, as there were many traces of moles, worms and roots, which must have caused considerable bioturbation. In the samples recent mollusc shells, rootlets and other recent material such as fragments of plastic or brick also occasionally appear. For some taxa (*e.g.*, *Poa annua* and other Gramineae, *Taraxacum* spec.) it was very clear that the seeds were recent, since they still possessed telltale elements such as hairs or hulls which rapidly disappear when buried in the soil. Also the colour and appearance of some taxa made it clear that the seeds were recent (*e.g.*, some seeds of *Stellaria media*, *Solanum nigrum*). For other taxa (*e.g.*, *Chenopodium album*, Cruciferae, *Potentilla* spec., *Menyanthes trifoliata*, *Lemna* spec.) and even for other seeds of the above mentioned species *Stellaria media* and *Solanum nigrum*, this was not always easy to make out.

The occurrence of uncarbonized or unmineralized seeds of certain species which cannot possibly have grown locally in recent times is highly remarkable. This concerns especially *Lemna* spec. (fig. 14a), *Menyanthes trifoliata*, *Alisma plantago-aquatica* (fig. 14b), *Eupatorium cannabinum* (fig. 14c), *Ranunculus* sect. *Batrachium* and *Thalictrum flavum*. They have decayed to a certain extent but are unlikely to be of prehistoric origin. Of *Alisma plantago-aquatica* the horseshoe-shaped embryos have been found which are decayed to the point of being almost transparent. The seeds of *Eupatorium cannabinum* are fragmentary and also often transparent because of advanced decay. In table 6 the presence of these rather puzzling 'fresh' seeds is summed up. Seeds of *Lemna* spec. and *Alisma plantago-aquatica* especially may occur in large quantities. The species in table 6 all grow in water and in waterside habitats. Their seeds do not usually survive for long above the groundwater level. However, seeds of *Alisma plantago-aquatica* for instance, have even been found here as high up as in the prehistoric arable layer. The present-day land use of the site is bulb-growing and cattle-grazing. Some of these species might have grown in and along the canals between the bulb-fields and the pastures. However, the area is so intensively cultivated nowadays that species growing on soils with low or moderate nutrient availability (like *Menyanthes trifoliata* and *Thalictrum flavum*) certainly cannot grow there. An acceptable explanation for their presence could be that they derive from the mud which was dredged from the ditches from medieval times on and which has been used to fertilize the soil. This has been the practice until recent times and therefore the seeds may date from any period since the Middle Ages. Especially the seeds of *Lemna* spec. certainly cannot be recent since nowadays the plant rarely flowers. Another possibility is that these seeds indeed derive from prehistory and belong to the hardiest seed types. Or they may be residues of the wet organic deposits which covered the whole area from the end of the Late Bronze Age (*c.* 800 cal BC) until its reclamation in the Middle Ages. They may have entered the features of the Bronze Age through bioturbation in (sub)recent times after all the peat had oxidized, as a residue covering the prehistoric settlement like a veil. Further investigations on this point are planned with the aid of Accelerator datings of these seeds.

species	sample nos
Alisma plantago-aquatica	0, 4, 15, 16, 21 1, 35, 37/1
Eupatorium cannabinum	0, 9/1, 16, 22/2 27, 31, 32, 33, 35
Lemna spec.	4, 13, 15, 16, 21/1, 2 /1, 22/2, 24, 25, 30, 31, 35, 36/1, 37/1
Menyanthes trifoliata	9/4
Ranunculus sect. Batrachium	15, 23, 16
Thalictrum flavum	4, 21/1

Table 6 Uncarbonized seeds of unknown date.

Differential preservation and corrosion of seeds in different soils has so far not been studied. It is however very important that this phenomenon is better understood, especially if the preservation of plant remains is to be used in the evaluation of sites for the purpose of selection as a basis for recommending conservation, excavation or heritage management of sites in both archaeological and political contexts.

Apart from these 'fresh' seeds, mineralized seeds were found, sometimes in large amounts (over 100 in a sample), especially in the samples from the house-ditches. This type of conservation may occur when seeds and fruits are deposited in calcareous sediments below the groundwater level in the presence of salts (especially phosphates and ureum). Optimal conditions for mineralization are found in latrines. Seeds preserved

Figure 14 Recent or subrecent seeds of: a *Lemna* spec.; b *Alisma plantago-aquatica*; c *Eupatorium cannabinum*.

by mineralization may exhibit a fresh, even modern appearance. They consist of light, inorganic material (mainly calcium phosphate), are brown in colour and show a poor crystalline structure (apatite).[94] They are subject to highly selective preservation and hence are usually extremely corroded and difficult to identify. Often different stages of corrosion are observed. Frequently only the endosperm or part of it has survived.

These mineralized seeds have not been investigated in detail here, since they are very easily confused with modern seeds. One needs to be very careful in using the data of mineralized seeds. Like the uncarbonized seeds discussed in the previous paragraph, they may derive from medieval or subrecent deposits whence they have been transported downwards by moles or earthworms, especially when the archaeological deposits are found only just below the tilth, as is the case here. However, at this site, especially in the house-ditches, most mineralized seeds are very probably of prehistoric origin.

Table 7 lists the occurrence of mineralized seeds of some taxa which could be identified with certainty. The mineralized remains were found of two food plants, *Panicum miliaceum* and *Sambucus nigra*, which had not been found in carbonized condition. However, the occurrence of one mineralized caryopsis of *Panicum miliaceum* (millet) requires some comment. Carbonized seeds of this species were only found occasionally in Bronze Age Bovenkarspel-Het Valkje. Also the Iron Age

species	sample nos
Hordeum vulgare	25
Triticum dicoccum	11/1, 25
Cerealia indet.	2, 21/1
Panicum miliaceum	21/1
Linum usitatissimum	11/1
Bromus hordeaceus/secalinus	11/1, 13, 25, 39/1, 39/3
Conium maculatum	2, 11/1
Labiatae	2, 11/1, 27, 31
Sambucus nigra	28, 36/1, 36/2
Umbelliferae	13, 25, 30, 39/1, 39/2, 39/3

Table 7 Mineralized seeds.

94 Green 1979; Körber-Grohne 1991, 11–2; Willerding 1991, 42.

site at Opperdoes so far has produced only two carbonized grains of *Panicum miliaceum*.[95] At these sites the species is considered an arable weed. The berries of *Sambucus nigra* (elderberry) may have been eaten as fruit or used in the preparation of beverages. Whatever the case may be, the possibility that the millet and the elderberries date from medieval times must be kept in mind.

9 BONES (by G.F. IJzereef)

A total number of 622 animal remains were identified, which can be dated to the phases I, II, IIIa, and IIIb. About 50% are from the larger domestic animals – usually gathered by hand, and visible to the naked eye when excavating – roughly the other half are the remains from animals, which can only be found by sieving soil samples. The results are given in tables 8 and 9.

9.1 *Domestic animals*

The small amounts of bones do not permit a calculation of the frequencies within the phases, only phase IIIa has reasonable numbers. They can be compared very well with the data from Bovenkarspel-Het Valkje.[96] Cattle are the predominant species, followed by sheep/goat and pig.

9.2 *Other animals*

Table 9 presents the results of the remains from the other species recovered. The entire animal spectrum is the same as found in Bovenkarspel-Het Valkje, with the exception of the common shrew (*Sorex araneus*), which is a very widespread species. Why at Bovenkarspel only the water shrew (*Neomys fodiens*) was found, remains unclear.

The occurrence of the water-vole (*Arvicola terrestris*) in phase I is conspicuous, as in Bovenkarspel it was not found in Early Period house ditches. It was found at Westwoud in sample numbers 11/2 and 39/1, which belong to the house ditches of phase I. At least three different animals are present in these samples. If these animals did not dig themselves into the ditches at a later stage (phases IIIa and b), this indicates that wetter areas were not far from the house site, as they do not generally live close to houses. The animal, however, is

phase	I	II	IIIa	IIIb	total	%
cattle (*Bos taurus*)	26	7	80	13	126	70
pig (*Sus domesticus*)	6	5	7	2	2	11
sheep/goat (*Ovis aries/ Capra hircus*)	5	1	21	3	30	17
dog (*Canis familiaris*)	3	-	1	-	4	2
total	40	13	109	18	180	
indet. large (cattle)	15	2	24	5	46	
indet. small (other)	30	8	32	5	75	
total large	41	9	104	18	172	58
total small	44	14	61	10	129	42
total					301	

Table 8 Domestic animals.

able to dig extensive tunnels into the banks of water channels, so it may date from a later period.

The find of the grass snake (*Natrix natrix*) in phase IIIb indicates that sandy dry sands were still present during that time, although the species is also a good swimmer. As was the case in Bovenkarspel-Het Valkje, the eel (*Anguilla anguilla*) was the most favourite fish.

10 MOLLUSCS (by W.J. Kuijper)

The results of the mollusc analysis are given in table 10. *Ceciliodes acicula* was found in almost all samples. This species lives in worm tubes and the like, and occurs here as a recent intrusion in the samples. Of some land and freshwater snails too it is certain that they are recent. Their shells are translucent, shiny and sometimes even contain the dead animal. Where this is not the case, the material may be partly recent and partly fossil. The context and composition of the fauna then are important for judging whether the molluscs belong to the prehistoric period. Occasionally *Peringia ulvae*, *Scrobicularia plana* and *Mya* spec. were found. These are creatures from a marine environment and undoubtedly derive from the subsoil. In table 10, recent and marine species have not been included.

The fauna living in and along the ditches at Westwoud

95 Buurman 1993.

96 IJzereef 1981.

phase	I	II	IIIa	IIIb	total
mammals					
hare (*Lepus capensis*)	6	-	-	-	6
common shrew (*Sorex araneus*)	3	1	-	1	5
nordic vole (*Microtus oeconomus*)3	1	1	1	6	
water-vole (*Arvicola terrestris*)	34	-	-	4	38
house mouse (*Mus musculus*)	4	-	3	1	8
voles (Microtidae unidentif.)	5	5	6	5	21
rodents unidentifiable	4	5	2	-	11
fish					
bream (*Abramis brama*)	-	-	1	-	1
perch (*Perca fluviatilis*)	1	-	2	-	3
pike (*Esox lucius*)	-	1	9	3	13
eal (*Anguilla anguilla*)	7	1	52	28	88
stickleback (*Gasterosteus aculeatus* or *Pungitius pungitius*)	4	2	13	2	21
Cyprinidae, unidentifiable	4	3	26	3	36
unidentifiable	1	-	-	-	1
amphibians and reptiles					
frog (*Rana* spec.)	1	-	2	-	3
common frog (*Rana temporaria*)3	1	3	1	8	
amphibians, unidentifiable	11	12	5	20	48
grass snake (*Natrix natrix*)	-	-	1	2	3
reptiles, unidentifiable	1	-	-	-	1
total					321

Table 9 Other animals.

during the Bronze Age can be divided into two groups: species of freshwater environments and species living on land. The freshwater species *Anisus leucostomus* and *Galba truncatula* survive periods of drought very well. These two only occur sparsely. *Bithynia leachi*, *Valvata cristata* and *Stagnicola palustris* live in marshes and on thickly overgrown banks. The other species also live in such habitats but may occur in various other places as well. Assemblages of freshwater species that point to ditches which fall dry are only scantily represented. The numbers of individuals in the samples from features dating from phases I and II are very small. The species in the samples from features belonging to phase IIIa point to sedimentation in a body of water that does not fall dry. The ditch contained calcareous, eutrophic and stagnant water rich in plants. The many land snails in the samples from phases I and II indicate that there were regularly long periods of drought in that period. The species live in open, moist to wet terrain, rich in vegetation.

There is a clear difference in mollusc fauna between the features of phases I and II and the samples from the ditches of phase IIIa. In general, land snails prevail in phases I and II, and freshwater species in phase IIIa. During the Early Period there were dry ditches or ditches that fell dry periodically, but later on the ditches were constantly filled with water. This corresponds very well with the findings from the mollusc study of Bovenkarspel-Het Valkje.[97]

11 CONCLUDING REMARKS

From the investigations it has become clear that there are great differences in the assemblages of plant remains in the samples of phases I and II on the one hand and the samples of phases IIIa and IIIb on the other hand. The most remarkable is the shift in cereal cultivation from *Triticum dicoccum*, as the most important species in the early phases, to *Hordeum vulgare* as the most important cereal in the later phases. In the early phases, species of weed vegetations are better represented – both qualitatively and quantitatively – than in the later phases. Apparently, the cereals were harvested by uprooting, at least in the later phases. In the later phases there were more species native to marshes and banks. Especially for the later phases, the use of dung as fuel could be demonstrated, but this is also very likely for the early phases. According to the author's interpretation all these changes are related to the changes in environmental conditions during the occupation of the site. It appears that the area became progressively wetter, so that people even had to raise their dwellings. The investigation of the molluscs provides additional evidence of the increased wetness in phase III. The increasing wetness was caused by the gradual increase of the water level, for which two factors may be held responsible: first, the impeded drainage of the area due to the closing of the tidal inlet near the present-day village of Bergen (prov. of Noord-Holland); and second, a sudden deterioration of the climate, which became colder and wetter.[98]

97 Kuijper, in: IJzereef 1981, 127–30.

98 Zagwijn 1986; Van Geel *et al.* 1997; *idem* in press.

sample number	2	11/2	39/3	39/4	17	27	28	3	23	36/1	15	16	4	21/1	21/2
phase	I	I	I	I	I	I	I	I	II	II	II	II	IIIa	IIIa	IIIa
freshwater species															
Bithynia tentaculata	-	-	-	-	-	-	-	-	-	-	15	1	11	47	31
B. tentaculata-opercula	-	-	-	-	-	-	-	-	-	-	-	43	20	1	42
Bithynia leachi	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
B. leachi-opercula	-	-	-	-	-	-	-	-	-	-	-	-	2	-	5
Valvata cristata	-	-	-	-	-	-	-	-	-	-	-	-	3	3	5
Physa fontinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Radix peregra	-	-	-	-	-	-	-	-	2	-	-	-	8	166	127
Lymnaea stagnalis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Stagnicola palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	13	3
Galba truncatula	-	2	-	1	2	5	1	7	4	1	-	-	-	4	3
Planorbarius corneus	-	-	-	-	-	-	-	-	-	-	-	-	1	4	2
Planorbis planorbis	-	-	-	-	-	-	-	-	-	-	-	-	5	76	62
Anisus leucostomus	-	-	-	-	-	-	-	-	-	-	-	-	2	6	2
Anisus vortex	-	-	-	-	-	-	-	-	-	-	-	-	3	15	8
Hippeutis complanatus	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Armiger crista	-	-	-	-	-	-	-	-	1	-	-	-	21	100	26
Pisidium spec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
land species															
Vallonia pulchella	2	7	13	8	5	12	13	184	180	67	13	3	-	7	4
Vallonia costata	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Carychium minimum	-	-	-	-	-	1	-	4	-	-	-	-	-	1	-
Oxyloma spec.	1	-	1	-	-	2	1	2	4	4	1	-	-	-	2
Vertigo pygmaea	-	2	1	-	2	5	1	32	27	5	1	-	-	-	1
Vertigo angustior	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
Vertigo antivertigo	-	-	-	-	1	2	-	-	1	-	-	-	-	-	-
Limacidae	1	-	-	-	-	-	-	1	6	-	1	-	-	-	1
Punctum pygmaeum	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Cepaea nemoralis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1

Table 10 Molluscs.

It becomes clear that human activities were heavily determined by the environment in this area in this period. The environmental changes eventually caused an exodus of the area's population around 800 cal BC.

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