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A Mosaic of Habitation at Zeewijk (the Netherlands)

Late Neolithic Behavioural Variability in a Dynamic Landscape

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7 Botany: local vegetation and crop cultivation

L. Kubiak-Martens

7.1 Introduction

The site at Zeewijk is located 9 km southeast of Keinsmerbrug and 4 km north of Mienakker. It is the third (and the last) site of the Late Neolithic Single Grave Culture which has been the subject of interest during the multidisciplinary NWO Odyssey project in the province of Noord-Holland. When these Late Neolithic sites were occupied, the region was located in a large tidal area with high salt marshes and natural sandy levees that formed along tidal creeks. These slightly elevated grounds in an otherwise low-lying tidal basin were obviously favoured as settlement locations.[257]

In this chapter we will focus on the reconstruction of the local vegetation and discuss various aspects of the site's economy and economic activities such as food production and food processing which took place at the site. Furthermore, we will participate in the ongoing debate concerning crop cultivation in the coastal area during early prehistory. We will present botanical evidence of crop cultivation at Zeewijk. All of these aspects emerged from the recent analysis of the plant macro-remains obtained from the samples collected during the field season in 1992 from two excavated areas, Zeewijk-West and Zeewijk-East. The results of the plant macro-remains analysis completed and published by De Man and Brinkkemper have been incorporated into the current work.[258]

7.2 Methods

Most of the archaeobotanical samples were taken either from the fill of pits or from the postholes; archaeobotanical samples taken from an unspecified context were defined according to cultural layer. For the purpose of archaeobotanical research, 70 soil samples were selected from the entire Zeewijk excavation area. In agreement with the other specialists involved in the project, 46 samples were taken from Zeewijk-West and 24 from Zeewijk-East (to adhere to a 2:1 ratio). The bulk soil samples were stored in the provisional RCE repository in Lelystad and were available for the current research. The location of the squares (on the 1m²-excavation grid) from which the botanical samples were taken is given in Figure 7.1.[259]

Soil sample sizes ranged from approximately 1.5 to 3 litres. The samples were wet-sieved at BIAX *Consult* using a series of sieves with mesh sizes of 2.0 mm, 1.0 mm and 0.5 mm. In addition, a control volume of 0.5 litres from each bulk sample was sieved through a 0.25 mm-mesh to check for very small seeds and chaff remains. All selected samples were sieved and then assessed. During the assessment, the botanical value of each sample was ascertained in terms of the preservation of plant remains and diversity of plant species, and the presence of charred vegetative and non-vegetative parenchyma, and processed plant food remains. The samples from Zeewijk-West revealed far more plant remains and thus had much higher botanical value than the Zeewijk-East samples, which were neither rich nor diverse in plant remains. Subsequently, 21 samples were selected for further analysis (19 from Zeewijk-West and 2 from Zeewijk-East). The seed and fruit remains were studied under a binocular incident light microscope at magnifications of 6x to 50x. With the exception of a few dozen mineralised and only a few waterlogged plant remains, all other remains were preserved by charring (carbonized).

A summary of the data on seeds and fruits, based on a complete analysis, is presented in Appendix VII.

In addition to soil samples, several hundred dried residues collected at Zeewijk and stored in the provincial repository in Wormer were assessed for the presence of plant food remains, particularly those of charred parenchyma and processed plant food.

Potentially identifiable remains of charred parenchyma and specimens of charred processed plant material were subjected to scanning electron microscope examination at the SEM laboratory of the Naturalis Biodiversity Center in Leiden. The specimens were mounted on SEM stubs using double-sided carbon tape strips. They were then gold-coated and examined using a JOEL JSM-5300 scanning electron microscope at magnifications between 35x and 750x. The specimens were photographed and described. A summary of the data for charred parenchyma and processed plant material is given in Appendix VIII.

257 De Mulder & Bosch 1982; Van Ginkel & Hogestijn 1997; Smit 2012.
258 De Man & Brinkkemper 2001.
259 Theunissen, this volume; Nobles, this volume Chapter 3; Bulten 2001.

7.3 Natural vegetation

The macro-remains assemblage of plants which grew in and around the settlement at Zeewijk is mainly dominated by charred seeds; only a few waterlogged remains are present in the record. Charred assemblages are usually associated with human activities and may therefore reflect only selected taxa, so charred plant remains are often of limited interest if a reconstruction of the former vegetation is to be performed. Nevertheless, they can help to identify the nature of the former vegetation in the vicinity of the settlement, provided that it is clear that they are contemporaneous with the archaeological assemblage. For the reconstruction of the vegetation at Zeewijk, we also used evidence from the pollen record available for a nearby site at Mienakker.[260]

The pollen spectra from Mienakker, synchronised with the time of the Neolithic occupation, suggest an open landscape influenced by brackish water. Herbaceous vegetation was dominated by members of the goosefoot family (Chenopodiaceae, probably mostly represented by orache, *Atriplex* and glasswort, *Salicornia*) and accompanied by Poaceae (grasses) and Compositae Tubuliflorae (probably mostly represented by sea aster, *Aster tripolium*). Vegetation including thrift (*Armeria*), common sea-lavender (*Limonium vulgare*), mugwort (*Artemisia*), arrow-grass (*Triglochin*) and sea-spurrey (*Spergularia* type) was also present. Evidence for an open tidal landscape was also documented in the macro-remains analysis. The charred assemblage included seeds of plants which often dominate the vegetation of mudflats and are also found in the lower parts of salt marshes: glasswort (*Salicornia europaea*) and sea-blite (*Suaeda maritima*). Seeds from species of plants growing in higher areas of salt marshes dominated the non-cereal remains. In this group, seeds of marshmallow (*Althaea officinalis*) and sea purslane (*Atriplex portulacoides*) were particularly well represented. They were accompanied by charred seeds of sea aster (*Aster tripolium*), various grasses (*Puccinellia distans, Hordeum marinum, Agrostis, Bromus* possibly *hordeaceus* and *Festuca/Lolium*), and sedges (*Carex distans*, *Carex otrubae*). It can be assumed that high salt marshes with a great diversity of grasses and other herbaceous plants were exploited as grazing pastures, not only near Zeewijk but around all Neolithic sites in the region. The presence of sea purslane (*Atriplex portulacoides*) in the Zeewijk record is particularly interesting, as this species is seldom recorded in archaeobotanical remains. It seems that it was quite common in prehistory in the area studied; the charred seeds were also found at Mienakker. Sea purslane is sometimes referred to as ‘the tree of the coast’ because of its height (the plant can grow up to 150 cm tall) and tough, woody-like stems. Many charred seeds of shore orache (*Atriplex littoralis*) were also present in the samples. Shore orache, together with occasionally recorded sea beet (*Beta vulgaris* subsp. *maritima*) form strong evidence for the presence of drift deposit near the settlement, which would have accumulated after storm surges.

The frequent occurrence of sea club-rush (*Bolboschoenus maritimus*) seeds in the Zeewijk archaeobotanical assemblage and also at other Neolithic sites in the region may indicate that the species would have been commonly found along streams or tidal creeks with brackish water. The abundant presence of charred tubers of sea club-rush in the Zeewijk remains may indicate that they were of economic value (discussed later in the text).

The environmental implications of these results include the fact that during the Neolithic occupation there were also places at and near the settlement where fresh water accumulated. Plants which would have been confined to freshwater wetlands/marshes included great sedge (*Cladium mariscus*) and branched bur-reed (*Sparganium erectum*). Even though freshwater habitats are favourable for broad-leaved pondweed (*Potamogeton natans*), it tolerates some salinity in the water. Two other species, grey club-rush (*Schoenoplectus tabernaemontani*) and common reed (*Phragmites australis*), would have grown in both brackish and freshwater wetland environments. In this otherwise open landscape, there were patches or scatters of small trees or shrubs of willow, alder and aspen growing around the places where fresh water accumulates such as backswamps and gullies.

The Zeewijk seed assemblage also includes species that favour habitats influenced by the presence of man or animals. For example, well-trodden areas around the houses and along the

[260] Van Smeerdijk 2001.

paths would attract plants such as knotgrass (*Polygonum aviculare*). Increased nitrogen in the soil surrounding watering places for domestic animals, or waste deposits and dung heaps would certainly be favourable for species such as fig-leaved goosefoot (*Chenopodium ficifolium*) and common orache (*Atriplex patula*).

7.4 Cereals and other crops

7.4.1 Cereals

It can be seen in Appendix VII that almost every botanical sample contained remains of cereals.

In all the samples analysed, the charred cereals are dominated by emmer (*Triticum dicoccon*) remains, including grains, spikelet forks, glume bases and basal rachis segments. The emmer remains were almost always mixed with those of naked barley (*Hordeum vulgare* var. *nudum*), represented by grains and rachis fragments (including rachis segments and basal rachis). In addition to grain and chaff remains, cereal straw (most likely belonging to both cereals) was found in many samples.

Even though the total numbers of emmer grain and barley grain are similar, emmer chaff clearly predominates over barley chaff. The predominance of emmer chaff in any charred archaeobotanical assemblage (and thus also here at Zeewijk) may result from the fact that in cereal remains preserved by charring, glume wheats – such as emmer – have a tendency to be over-represented in comparison with free-threshing cereals such as naked wheats and barleys. This is due largely to the fact that spikelets of glume wheats have to be parched prior to dehusking (an operation which releases the grain from the glumes), and that during parching they are often accidently charred. Parching is not necessary for free-threshing cereals, the ears of which, when threshed, disintegrate into free grain and chaff.[261] It is therefore probable that at Zeewijk, barley was grown as intensively as emmer, even though the proportions of threshing remains might seem to imply otherwise.

Perhaps the lower quantities of barley chaff are indeed the result of its free-threshing qualities. The chaff of free-threshing cereals (mainly represented by rachis remains) is removed early in the processing sequence, often off-site. As a consequence it is relatively rarely represented in archaeobotanical assemblages.[262] What is significant about the threshing remains of barley found at Zeewijk, however, is that in addition to single rachis segments there were also remains consisting of at least two parts of rachis segments still linked together. Another significant feature is the basal rachis segments of the ear found among the threshing remains (Fig. 7.2a). Such an assemblage of chaff remains, clearly removed early in the processing sequence, suggests that complete ears of barley (or, perhaps, entire plants) were most likely carried into the settlement at Zeewijk and that they were threshed at the site rather than off-site. Furthermore, many samples were rich in straw (most likely derived from both cereals), which cannot be interpreted otherwise than as waste products of the early processing. The

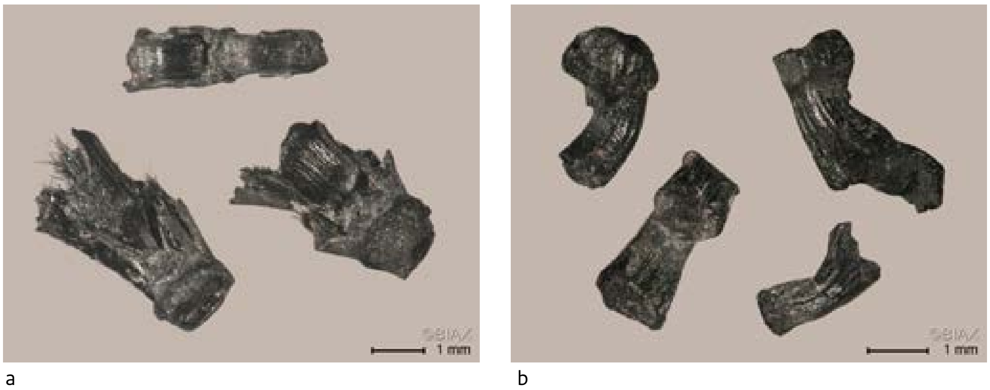


Figure 7.2 a. Charred remains of basal rachis segments of barley ear recovered from Zeewijk-West square 18782, feature 5; b. basal rachis remains of emmer recovered from square 22034.

[261] Van der Veen & Jones 2007.
[262] Van der Veen & Jones 2007.

same was probably true of emmer. The remains of emmer clearly show that spikelet dehusking was a practice taking place at the settlement. Even though the chaff of emmer is largely composed of glume bases and spikelet forks, which are removed at the later stage of processing (and are not persuasive evidence of local cultivation), basal rachis segments were also found in some samples (Fig. 7.2b). This suggests that emmer might also have been brought into the settlement as whole ears or even as entire plants after harvest and then both threshed and dehusked at the settlement.

Residues of cereal processing

At most settlements, the processing remains of cereals (cereal chaff, straw and weed seeds) are recovered either because the processing of the crops took place there or because the threshing by-products were brought into the settlement for various purposes such as fodder, bedding, fuel and building material.[263] At Zeewijk, it is clear that processing took place at the settlement. It seems relevant that the charred seed assemblage of wild taxa from Zeewijk largely comprises plants characteristic of high salt marsh vegetation (see Appendix VII). At least some of these halophytes are likely to have been harvested as arable weeds and then to have arrived on site with harvested cereals. One characteristic feature of the weed assemblage observed in the experimentally cultivated plots in the coastal area of the northern Netherlands was that various halophytes, including annual sea-blite (*Suaeda maritima*), sea milkwort (*Glaux maritima*), glasswort (*Salicornia europaea*) and sea-spurrey (*Spergularia marina/media*), grew in the fields together with weeds characteristic of a freshwater environment such as knotgrass (*Polygonum aviculare*), redshank (*Persicaria maculosa*) and black nightshade (*Solanum nigrum*).[264] At Zeewijk, if we look at the rather scarce assemblage of potential arable weeds from freshwater habitats (incl. *Chenopodium album*, *Persicaria lapathifolia*, *Solanum nigrum*), represented by as few as one or two charred seeds in some samples, we might conclude that if the crop fields were infested by any weeds, they were actually wild plants characteristic of salt marshes, including marshmallow (*Althaea officinalis*), various species from the orache group (*Atriplex portulacoides*, *Atriplex patula/prostrata*, *Atriplex littoralis*), sea aster (*Aster tripolium*), possible various grasses (*Hordeum marinum*, *Puccinellia distans*, *Bromus* and *Festuca/Lolium*) and possible other halophytes. The seeds of the orache group were particularly abundant in the charred assemblage. At any other location, species from the group *Atriplex patula/prostrata* would have been considered potential arable weeds. Here in the coastal area, however, they also occur naturally. Still, some seeds of the orache group may have entered the assemblage as potential arable weeds.

If we are correct in interpreting the charred seed assemblage of halophytic plants as at least partly representing arable weeds at Zeewijk, this would be an indication that the cultivated fields were located in a salt marsh area, most likely on the highest parts of salt marshes and on the levees.

The model of intensive agriculture proposed for Zeewijk

We could not have wished for better supporting evidence for local crop cultivation than plough marks (or ard marks), many of which were found at Zeewijk-East (Fig. 7.3).[265] The Zeewijk plough marks were recorded on the same levels as the Neolithic features; there is therefore no doubt that they are contemporaneous with the Late Neolithic settlement. This would indicate that people who lived at Zeewijk had small fields (or cultivated plots) located close to the settlement and that they were ploughed by ard. The type of agriculture practised at Zeewijk may have resembled one of the models proposed for Neolithic farming in central and southeast Europe, referred to as *intensive* or *garden* cultivation integrated with small-scale animal husbandry practices.[266] In this model, the terms *intensive* or *garden* cultivation are used to indicate the small size of the cultivated fields or plots (located *close to home*) and the high labour input. In this model of *small-scale intensive farming* a relatively small number of animals would be kept – primarily for their meat – close to the settlement.[267] Crop cultivation in this system is relatively high-yielding due to the high input of labour (for example weeding, careful tillage, manuring, etc.), and is small-scale, within the labour capacity of a household rather than extended family groups.[268]

At Zeewijk, sandy levees near the settlement were probably more than sufficient for small-scale, intensive cultivation. The cereal

263 Cf. Van der Veen 2007.
264 Van Zeist *et al.* 1976.
265 Nobles, this volume Chapter 3.
266 Bogaard 2005; Jones 2005.
267 Neolithic cattle hoof marks were found at Zeewijk, Mienakker and Keinsmerbrug.
268 Bogaard 2005.

Figure 7.3 Plough marks in the form of a criss-cross arrangement at Zeewijk-East in 1992.

crops appear to have been sown in spring in order to avoid flooding with salt water during autumn and winter. The use of cattle as tracking animals at Zeewijk should not be ruled out, as the best evidence for the use of the ox-drawn ard dates to the Corded Ware phase (c. 2800-2400 BC) at the end of the Neolithic in the Alpine Foreland.[269] This practice would not alter the scale of cultivation significantly, however.[270]

If we combine all the evidence from Zeewijk – the relatively rich charred crop and weed assemblage, the location of cultivated plots near the settlement, the use of the ard for ploughing – it appears that Zeewijk reflects small-scale, intensively maintained cultivation, and represents the usual pattern of mixed intensive farming practised across much of Neolithic Europe.

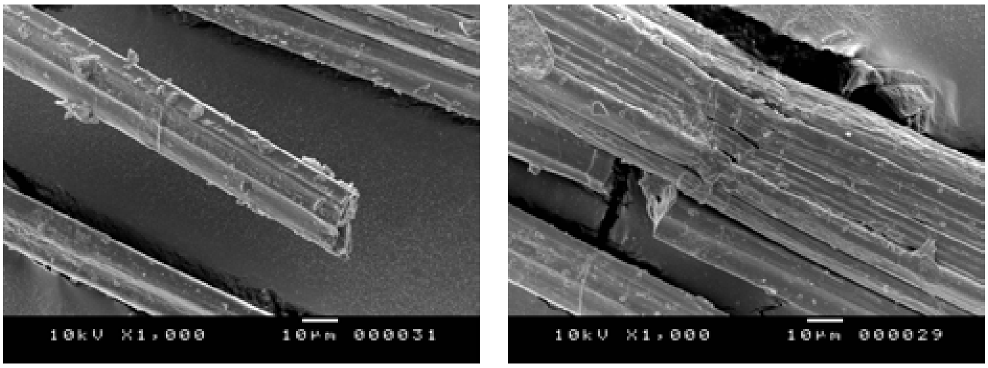
7.4.2 Flax *(Linum usitatissimum)*

Although the cultivation of cereals was the main agricultural activity at Zeewijk, it seems that flax was also important for the settlers. Charred flax seeds were found in most of the samples (Fig. 7.4a) and in one sample a concentration of mineralised seeds was found in addition to the charred seeds. Astonishingly large numbers of charred seeds were also encountered at Aartswoud, another site of the Single Grave Culture in the area.[271] No capsule remains or stem remains were found. At Zeewijk, however, in addition to seed remains, there were also remains of charred cordage (or string) made of flax fibres in which a number of fibres are twined around each other (recovered from trench/ square 22704, feature 55) (Fig. 7.4b). Recent

[269] Schibler & Jacomet 1999.
[270] Halstead 1995; Bogaard 2005.
[271] Pals 1984.

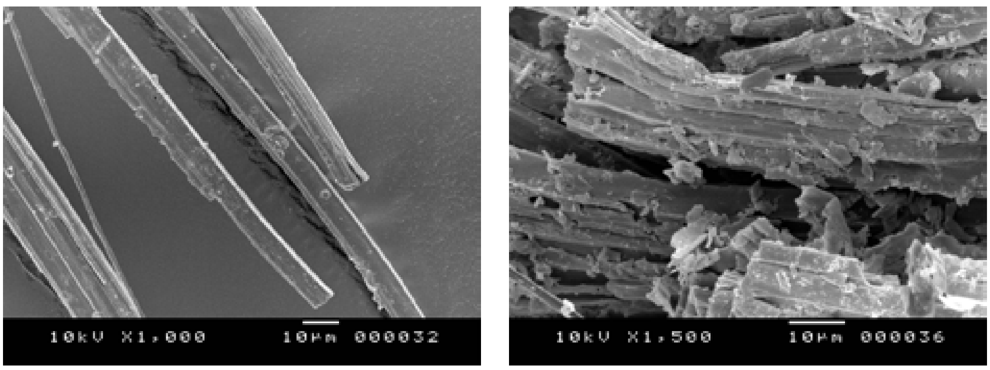
a b

Figure 7.4 a. Remains of charred flax seeds recovered from Zeewijk-West square 18782, feature 5; b. charred cordage or string of flax fibres in which a number of fibres are twined around each other, recovered from square 22704, feature 55, botanical sample. Unfortunately, after the recovery from the archaeobotanical sample and through the process of drying, the individual elements loosened and separated from each other.



a b

Figure 7.5 a. SEM micrographs of experimentally charred flax fibres: individual fibres; b. a group of fibres lumped together; fibre nodes (or dislocations) characteristic of flax fibres are visible on individual fibres.



a b

Figure 7.6 a. SEM micrographs of charred flax fibres from archaeological remains of cordage or string; b. group of flax fibres lumped together (from Zeewijk-West, square 22704, feature 55).

work on Neolithic flax assemblages from Europe provides evidence of the cultivation of different forms of flax for its oil-rich seeds and for fibre production since at least the 3rd millennium BC.[272] Even though the remains of flax found at Zeewijk suggest that flax was used there for

[272] Maier & Schlichtherle 2011.

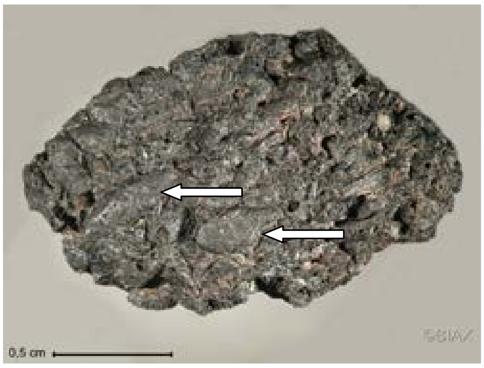


Figure 7.7 Remains of charred processed emmer food (fragmented emmer grains are embedded in the lump , marked by arrows) from Zeewijk-West square 1491, dried residue.

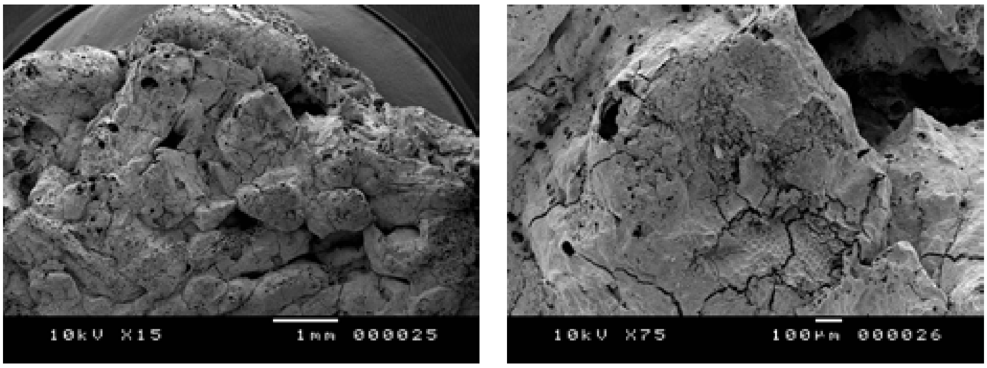
both the seeds and the fibres, it is difficult to specify whether different forms of flax plants were cultivated for different uses. The identification of archaeobotanical fibres was based on comparison with experimentally charred flax fibres (both viewed under an SEM microscope) (Figs 7.5 and 7.6).

7.5 Processed cereal food

At Zeewijk, some 30 charred remains (or lumps) of processed food products were found, which clearly indicates that food was prepared at the settlement. Binocular incident light analysis, accompanied by an SEM microscope, revealed that these consist of cereals. At least two different types of cereal products were identified. Some of the specimens studied revealed fragmented cereal grains lumped together (examples are illustrated in Figs. 7.7 and 7.8), suggesting porridge-like food made of coarsely crushed or ground cereal grains. One of the specimens of this porridge-like food studied was clearly made of emmer grains, which were still recognisable in the lump (Fig. 7.7). The other remains of cereal products showed rather compact or *mushy* matrices suggesting food made of finely ground grain. In one of the specimens studied from this group, the presence of emmer chaff (i.e. glume base) embedded in an otherwise featureless and compact matrix suggests food, possibly mush made of emmer grain (Fig. 7.9).

7.6 Wild plant foods

In addition to the crop plants, a number of wild edible plants were identified at Zeewijk, suggesting that gathering activities also played a role in the economy of the site. These gathered plants included crab apples (*Malus sylvestris*), acorns (*Quercus*), hazelnuts (*Corylus avellana*) and two types of root foods: tubers of sea-club rush (*Bolboschoenus maritimus*) and rhizome of a knotgrass (*Polygonum*). As they were all found in charred remains, they display obvious signs of having been processed by people.



a b

Figure 7.8 a. SEM micrographs of processed cereal food (outlines of fragmented grains are still visible) from Zeewijk-West, square 1498, dried residue; b. possibly orache seed embedded in cereal matrix.

Figure 7.9 a. Processed cereal food (probably emmer mush) with emmer glume base embedded in the matrix; b. detail, recovered from Zeewijk-West, square 22034, feature 7, botanical sample.

7.6.1 Root foods

Tubers of sea club-rush *(Bolboschoenus maritimus)*
More than a few hundred charred intact and fragmented tubers and a few rhizome fragments of sea club-rush (*Bolboschoenus maritimus*) were found at Zeewijk (examples are presented in Fig. 7.10). This is an exceptional number of specimens. The identification of the fragmented tubers, sometimes preserved as isolated parenchyma, was based on the anatomy of parenchymatous and vascular tissue examined under an SEM microscope (Fig. 7.11).

The numerous remains of sea club-rush from Zeewijk inspired the question as to whether such a numerous assemblage might indicate substantial human exploitation of this wild root food. Charred tuber remains of the sea club-rush had been found earlier at the Neolithic coastal site in the Netherlands, where they were considered a source of starchy food in addition to cereals and other edible roots.[273] The plant is also frequently recovered from ancient sites in the Levant and Anatolia.[274] Particularly noteworthy are the high frequencies of both tubers and seeds recovered from domestic contexts of Neolithic Çatalhöyük.[275] Also, charred rhizome remains of a closely related species, common club-rush (*Schoenoplectus lacustris*), were found together with other edible plants at two hunter-gatherer sites in the Netherlands; there they were considered root foods.[276]

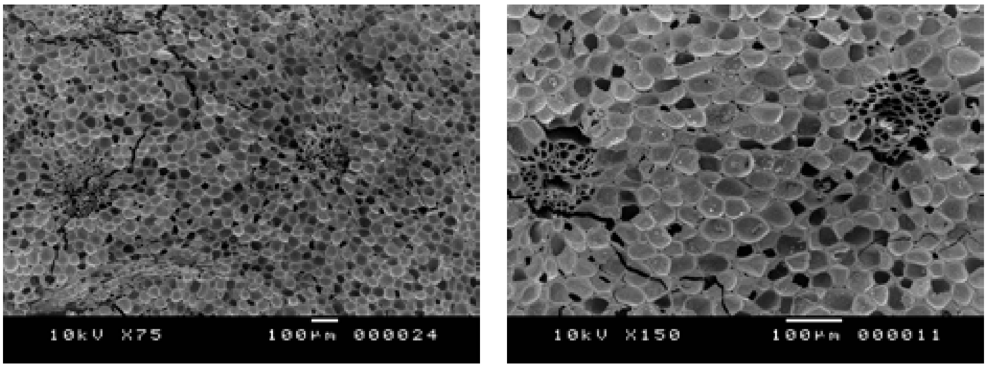
Sea club-rush is a semi-aquatic plant of the sedge family (Cyperaceae) whose optimum conditions are in brackish marsh vegetation, though it can also grow along the edges of fresh water.[277] It is a perennial plant in which the tubers are formed as terminal swellings of the rhizome. The tubers are ovoid, measuring approximately 3 cm in diameter. The tubers and the rhizomes grow in the soil or mud below the water table, while the stems and the leaves protrude above the water.[278] The plant grows in stands that can vary from small patches to stands that cover extensive areas. Sea club-rush must have been quite common around all the sites studied at Keinsmerbrug, Mienakker and Zeewijk during the time of the Neolithic occupation, as the charred seeds of this species were well represented in the macro-remains assemblages.[279] The fact that many charred tubers were found at Zeewijk suggests that they must have been dug out from their muddy habitats and then brought to the site where they were exposed to domestic fires.

The tubers of sea-club rush fit a number of the criteria that make wild root foods suitable for intensive human exploitation.[280] Firstly, the mature tubers are relatively rich in carbohydrates and other nutrients (20% carbohydrate including fibre and starch, 1.4% protein, 0.2% lipid and 0.8% minerals).[281] Secondly, the tubers of sea-club rush are easily accessible and many tubers can be collected from just one plant (personal experience) and from stands that vary in size. Even though the tubers can be collected year-round, their highest nutritional values are found in late summer and early autumn. Wollstonecroft[282] addressed in detail the potential role of sea club-rush tubers in the early human diet, and in conjunction with processing experiments assessed the methods

273 Kubiak-Martens 2006.
274 Wollstonecroft 2009.
275 Fairbairn *et al.* 2002, Wollstonecroft 2009.
276 Perry 1999, 2002; Kubiak-Martens, Kooistra & Verbruggen, in press, 2014.
277 Van der Meijden 2005.
278 Clevering *et al.* 1995.
279 Kubiak-Martens 2012; Kubiak-Martens 2013.
280 Wollstonecroft 2009.
281 Kirk & Sawyer 1991; Wollstonecroft 2009.
282 Wollstonecroft *et al.* 2008; Wollstonecroft 2009.

a b

Figure 7.10 a. Sea club-rush (*Bolboschoenus maritimus*) tuber recovered from Zeewijk-West square 13721, dried residue. The tuber is somewhat flattened, possible crushed before charring; b. sea club-rush tuber from square 22674, dried residue.



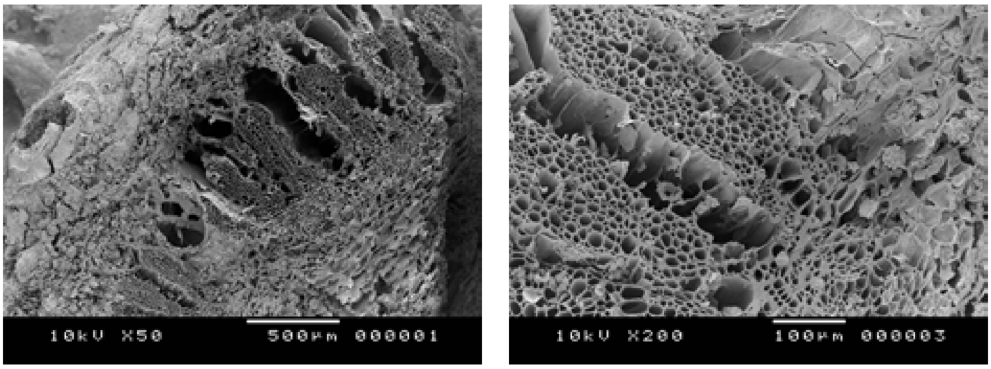
a b

Figure 7.11 a. SEM micrographs of the sea club-rush (*Bolboschoenus maritimus*) tuber parenchyma with vascular bundles randomly arranged within the parenchymatous tissue; b. two individual vascular bundles with fibre sheath surrounding the xylem and phloem tissue (from Zeewijk-West square 22674, dried residue).

which may have been used in the past to prepare the tubers for consumption. The results of this experimental work show that sea club-rush tubers can be prepared to give edible products by applying sequences of processing techniques, including pulverising. This step is necessary in order to disrupt the parenchyma cell walls and consequently to make intercellular nutrients accessible. Cooking alone, even though necessary to make the starches palatable and digestible, does not promote the softening of the tubers. Only tubers which were pulverised (into a kind of flour) and subsequently cooked with water to make a mush or gruel, or baked as bread, produced an edible meal.

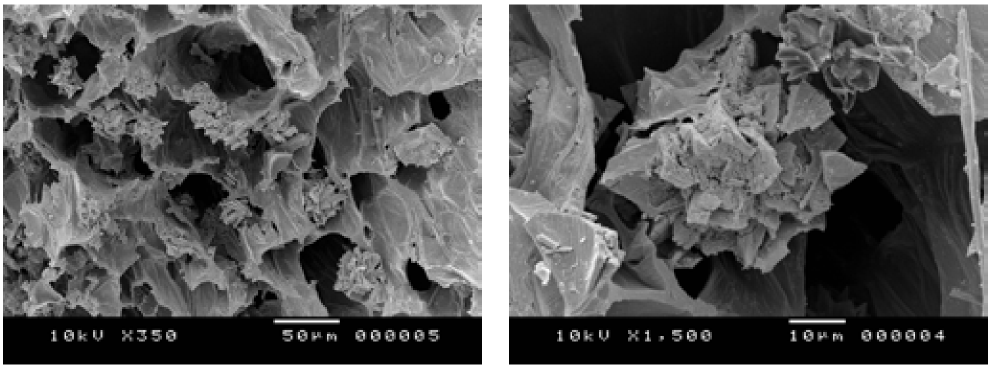
At Zeewijk, the abundant occurrence of sea-club rush tuber remains is significant if we consider their use as food. Whether the tubers were processed in a way similar to that proposed by Wollstonecroft and co-workers is difficult to assess. When we looked at the stone assemblage, we were struck by the fact that many of the stone artefacts recovered at the site appeared to have been used primarily for the processing (pounding or pulverising) of plant material.[283] Even more interesting is that some of the organic residues encrusted on pottery revealed a truly mushy nature, suggesting that the food prepared in at least some of the vessels was well processed (possibly crushed, pounded or even pulverised) and subsequently cooked.[284] All the mushy residues share the well-defined chemical signals for the presence of proteins and polysaccharides, often with the addition of lipids, suggesting that both plant and animal components were used in the cooking of these mushy meals. Sea club-rush tubers might have been one of the starchy foods

283 García-Díaz, this volume.
284 Oudemans & Kubiak-Martens, this volume.



a b

Figure 7.12 SEM micrographs of charred rhizome of knotgrass (*Polygonum*), TS section, recovered from Zeewijk-West, square 19484, dried residue; a. parenchymatous central part with vascular bundles arranged in a ring across the radius of the rhizome; b. radially elongated xylem tissue.



a b

Figure 7.13 a. Parenchymatous tissue with druses (detail of Figure 7.12); b. individual druse.

(besides cereals and acorns) that was processed and then subsequently cooked in ceramic vessels at Zeewijk.

Rhizome of knotgrass *(Polygonum)*

One charred rhizome fragment of a knotgrass (*Polygonum* sp.), approx. 3 cm across was found in one of the dried residue samples from Zeewijk-West (trench/square 19484). The identification was based on anatomical features of vascular tissue observed under an SEM microscope. The vascular tissue was arranged in a ring across the radius of the rhizome (Fig. 7.12a). The vascular bundles were in collateral arrangements with xylem tissue adjacent to the phloem. Radially elongated xylem elements were preserved almost intact, while phloem tissue was reduced to an amorphous mass (Fig. 7.12b).

Many compound crystals consisting of calcium salts (druses) had been preserved within the parenchyma cells of the cortex (Fig. 7.13).

The probability that rhizomes of a knotgrass (*Polygonum* sp) were introduced to the site at Zeewijk as a gathered starchy food is supported by archaeobotanical finds recovered from other archaeological sites. Charred remains of *Polygonum* sp. rhizome were found together with charred remains of other starchy food at Całowanie, an early Mesolithic site in Poland.[285]

There are also historical claims that the rhizomes of various *Polygonum* species are edible. Pierpoint Johanson (1862) reports of bistort (*Polygonum bistorta*):[286] 'Although very bitter and astringent to the taste in the raw state, the root contains an abundance of starch, and, after being steeped in water and subsequently roasted, becomes both edible and nutritious'. The ethnographic records also reveal that several species from the knotgrass family (Polygonaceae) were used as food by the northern people of Canada, and also as

285 Kubiak-Martens 1996.
286 Mears & Hillman 2007.

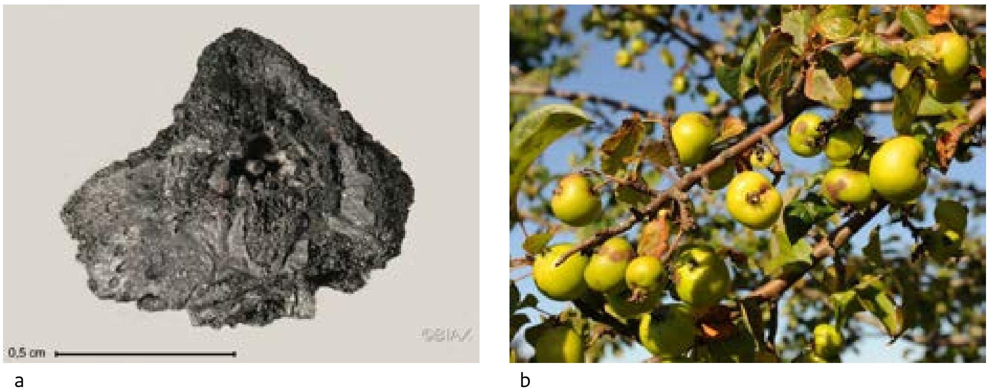


Figure 7.14 a. Fragment of charred crab apple (*Malus sylvestris*) fruit with partially preserved calyx from Zeewijk-West, square 13053, dried residue; b. recent wild crab apples (Wikimedia Commons). Crab apples are very tart but after the first frost or after cooking they become soft and taste sweeter.

emergency food in historical times in Scandinavia and Germany. Bistort (*Polygonum bisorta/Persicaria bistorta*) and alpine bistort (*Polygonum viviparum*) were gathered for their edible young leaves and stems and also for their rhizomes. The rhizomes were eaten either raw or cooked, or roasted over a fire.[287]

Even though the identification of the Zeewijk remains does not reach species level we can predict that neither *Polygonum bistorta* nor *Polygonum viviparum* can be expected in the landscape surrounding the Neolithic site at Zeewijk. One *Polygonum* species – knotgrass (*Polygonum aviculare*) – was found in the macro-remains assemblage. This plant grows very fine rhizomes, however, and should not therefore be considered in our search for a species which grows rhizomes approx. 3 cm in diameter. There is one more *Polygonum* species which might have grown in the coastal area of the Noord-Holland in the Neolithic (even though very rare today) and which might have been collected for its rhizomes: sea knotgrass (*Polygonum maritimum*). Until we have the species in our reference collection of experimentally charred parenchymatous tissue, this will remain no more than a supposition.

7.6.2 Wild fruits and nuts

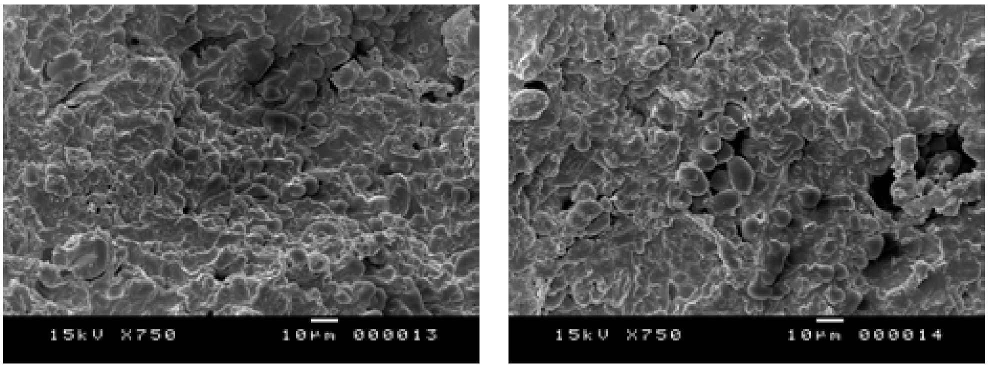
The group of gathered fruits and nuts is represented by crab apple (*Malus sylvestris*), hazelnut (*Corylus avellana*) and acorns of oak (*Quercus*). The remains of crab apple were found in two samples from Zeewijk-West. They were represented by charred fruit flesh fragments; in one of these samples, a partially preserved calyx was found (Fig. 7.14). Charred remains of crab apple were also found at other Single Grave Culture sites in the region: Aartswoud, Kolhorn and Mienakker.[288] The apple halves found at Aartswoud revealed concave margins and wrinkled skin, suggesting that the fruits were dried, possibly for prolonged storage and later use.[289] This feature was also observed on apple remains from other Neolithic sites in the Dutch coastal area.[290] Charred apple remains may also indicate some methods of cooking the crab apples in order to enhance their palatability, such as baking in hot ashes.[291]

The charred remains of acorn (*Quercus*), preserved at Zeewijk as fragmented cotyledons (Fig. 7.15a) and isolated remains of cotyledon parenchyma, suggest that they were also processed at the site (Fig. 7.15b). No pericarp remains were found, suggesting that the acorns' shells were peeled off prior to contact with fire. Charred acorn remains were also found at other Single Grave Culture sites in the region.[292] Unfortunately, the identification of the acorn remains, when based solely on morphological or anatomical features, cannot be specified to the species level. We can only suggest that the acorn remains preserved here derived from one of the two native species in the Netherlands, either from the pedunculate oak (*Quercus robur*) or from the sessile oak (*Quercus petraea*). Both species represent different ecological preferences. Pedunculate oak would prefer nutrient-rich, moist soil, while sessile oak would prefer dry to

287 Kuhlein & Turner 1991; Maurizio 1926; Eidlitz 1969.
288 Pals 1984; Drenth, Brinkkemper & Lauwerier 2008, Kubiak-Martens 2013.
289 Pals 1984.
290 Kubiak-Martens 2006.
291 Kuhnlein & Turner 1991.
292 Pals 1984; Drenth, Brinkkemper & Lauwerier 2008; Kubiak-Martens 2013.

a b

Figure 7.15 a. Charred oak acorn fragment from Zeewijk-West, square 13103, dried residue; b. SEM micrograph of acorn parenchyma from square 20752, dried residue.



a b

Figure 7.16 a.b. SEM micrographs of acorn parenchyma (un-charred) to illustrate how densely packed with starch granules the acorn parenchyma cells are.

fairly moist, acidic, nutrient-poor sandy soils.

The acorns from both species are edible when properly prepared and they are rich in carbohydrates, unlike other nuts, such as hazelnuts, which are mainly rich in fat. Acorns' nutritional content is similar to that of cereals, being largely a source of carbohydrates (mainly starch, Fig. 7.16) with a small amount of protein and fat.[293] Acorns, however, contain varying amounts of tannic acid – depending on the species of oak – which gives them a bitter taste, and which needs to be removed before the acorns can be used for food.[294] Various methods of processing acorns have been described in the ethnographic literature. Acorns can be pounded into flour or gruel, then cooked (with meat) as soup or mush, be used to make acorn bread, or they can be roasted in hot ashes.[295] The detection of acorn parenchyma in organic residues on ceramic vessels from Zeewijk suggests that cooking acorn mush or soup was one of the methods used to prepare acorn meal at Zeewijk.[296] The charred cotyledon remains (fragmented acorn halves) may indicate some method of processing using contact with fire prior to cooking.

7.7 Plants used as raw material

Various grasses, rushes and sedges would have served many purposes such as building materials or furnishings for the dwellings. The stems and leaves of reed (*Phragmites*), great sedge (*Cladium mariscus*) and sea club-rush (*Bolboschoenus maritimus*) may all have been used for thatching roofs and making the walls of shelters and/or houses. Grey club-rush (*Schoenoplectus tabernaemontani*) stems may have been used to make sitting and sleeping mats, floor coverings and to insulate the walls of the houses. Dried

293 Kuhnlein &Turner 1991.
294 Mason 1995.
295 Chestnut 1974, Kuhnlein &Turner 1991.
296 Oudemans & Kubiak-Martens, this volume.

stands of reed, rushes, sedges, and even glasswort (*Salicornia europaea*) and sea aster (*Aster tripolium*) may have been collected for fuel.[297] It would have been poor-quality fuel for domestic fires, but nonetheless a welcome addition to firewood, which was far from abundant near the site, located as it was in an open tidal landscape.

7.8 Conclusions

Like the two other sites studied, at Keinsmerbrug and Mienakker, Zeewijk was located in an open landscape influenced by brackish water. Herbaceous plants characteristic of tidal flats and salt marshes dominated the local vegetation. In this otherwise open landscape, patches or scatters of small trees or shrubs of willow, alder and aspen and possibly birch grew around the places where fresh water accumulated.

The principle crops at Zeewijk were naked barley and emmer. In addition, flax appears to have been an important crop, cultivated both for its oil-rich seeds and for its fibres. The botanical evidence suggests that both barley and emmer were brought to the site as ears of grain and possibly as complete plants. The botanical evidence also suggests that the people who lived at Zeewijk grew, harvested and threshed their own cereal crops.

The charred seed assemblage of wild taxa largely comprises plants characteristic of salt marsh vegetation. At least some of these halophytes are likely to have arrived at the settlement with harvested cereals. If we are correct in interpreting the charred seed assemblage of halophytic plants as (at least partly) representing arable weeds, this would be an indication that the cultivated fields were located in salt marsh areas, most likely on the natural levees. This suggests that people living at Zeewijk had small fields (or cultivated plots) located close or next to their houses.

Various wild plant foods may have supplemented the cereal-based diet. Some might have been collected at some distance from the settlement, possibly on the sandy outcrops at Wieringen to the northeast of Zeewijk (crab apples, acorns, hazelnuts), while others might have been collected near the site (sea-club rush tubers and knotgrass rhizomes, and orache seeds). As these wild plant foods were all found in the charred remains, they carry obvious signs of having been processed by people.

The nature of the agriculture that was practised at Zeewijk may have resembled one of the models proposed for Neolithic farming in Europe referred to as *intensive* or *garden* cultivation. In this model, small plots located close to the settlement were cultivated using the ard. Crop cultivation might have provided relatively high yields due to the high input of labour. At the same time, gathering activities also played a role in the economy of the site. Zeewijk appears to be a settlement site with all the activities characteristic of mixed intensive farming, and bears close similarity to Mienakker.

[297] See Kubiak-Martens 2012.

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Appendix VII: Botanical macro-remains

Botanical macro-remains

Trench/square number		22032	18782	18782	22034	22704	18782	20113	22704	21984	23931	22034
Serial number		4	9	6	2	?	5	7	?	7	102	3
Feature		7	31	5	3	69	5	24	55	18	?	16
Context/location		WIIIB	W3D	W3D	WIIIB	W	W3D	WIIIB	W	W30	WIV	WIIIB
Taxon (all remains are charred unless marked as uncharred or mineralized)												
Cereals and other crop/used plants												
Hordeum vulgare var. nudum	grain	12	65	59	53	43	38	4	12	6	16	8
	rachis internodes	-	89	38	44	20	23	2	7	4	9	16
	basal rachis segments	-	-	-	-	-	-	-	-	-	-	1
Triticum dicoccon	grain	19	26	45	25	57	25	-	2	12	8	11
	glume base	86	167	270	260	250	68	23	38	79	19	92
	spiklet forks	45	126	120	104	193	65	7	12	32	11	28
	basal rachis segments	-	-	-	-	5	-	-	-	4	1	6
Triticum dicoccon	processed emmer food	-	-	-	-	-	-	-	-	-	-	-
Cerealia (cf), straw	culm frg	++	++	++	++	++	+	-	++	-	+	+
Corylus avellana	nut-shell	2frg	3frg	2frg	8frg	-	1frg	-	-	-	-	-
Linum usitatissimum		2	-	7	-	-	1	-	-	-	8	-
Linum usitatissimum (m)		-	-	-	-	-	-	-	-	-	24	-
Linum	fibres (cordage/string)	-	-	-	-	-	-	-	1frg	-	-	-
Quercus	acorn	-	-	-	-	-	1frg	-	1frg	-	-	-
Malus sylvestris	fruit parenchyma	-	-	-	-	-	-	-	-	-	-	-
Salt marsh												
Agrostis/Poa		-	-	-	-	-	-	-	-	-	-	-
Althaea officinalis		78	4	5	1	-	-	1	-	2	-	-
Althaea officinalis (m)		-	-	-	-	-	-	-	-	-	78	-
Aster tripolium		-	-	-	3	-	-	-	-	-	-	-
Atriplex littoralis type		c.175	35	1	4	-	12	2	-	4	-	2
Atriplex portulacoides		65	-	14	1	2	-	-	-	1	-	1
Beta vulgaris (subsp. maritima)	perianth	-	-	-	-	-	-	1	-	-	-	-
Bolboschoenus maritimus		6	9	15	3	-	5	-	-	-	-	-
Bolboschoenus maritimus	tuber	2frg	-	-	-	-	-	4frg	-	-	-	-
Carex distans		-	1	-	-	1	-	-	-	-	-	-
Carex distans (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Festuca/Lolium		2	1	2	-	-	-	-	-	-	-	-
Hordeum marinum		-	2	3	-	-	-	-	-	-	-	-
Puccinellia distans		-	-	-	-	-	-	-	-	-	-	-
Salicornia europaea		-	-	-	-	-	-	-	1	-	1	-
Suaeda maritima		1	-	1	-	-	-	-	-	-	-	1

(+): 2-10; +: 11-50; ++: 51-100; +++: >100

Trench/square number		25223	2327	18782	22034	24573	24574	22704	20503	22993
Serial number		**103**	**?**	**6**	**5**	**3**	**3**	**?**	**13**	**6**
Feature		**103**	**?**	**5**	**7**	**16**	**16**	**41**	**129**	**237**
Context/location		**filling of the pit (north-east part)**	**fill north-east quadrant of pit**	**WIIID**	**WIIIB**	**WIV**	**WIV**	**W**	**EII**	**EII**
Taxon (all remains are charred unless marked as uncharred or mineralized)										
Cereals and other crop/used plants										
Hordeum vulgare var. nudum	grain	12	28	120	35	-	8	8	-	3
	rachis internodes	-	8	175	15	-	2	9	-	4
	basal rachis segments	-	-	5	-	-	-	-	-	-
Triticum dicoccon	grain	12	64	75	45	56	92	12	1	9
	glume base	82	230	c.400	362	225	62	52	-	59
	spiklet forks	34	175	105	50	48	54	21	-	24
	basal rachis segments	-	2	3	4	1	-	-	-	-
Triticum dicoccon	processed emmer food	-	-	-	1 lump	-	-	-	-	-
Cerealia (cf), straw	culm frg	++	+	++	+	-	-	'-	+	+
Corylus avellana	nut-shell	-	-	-	-	-	-	-	-	-
Linum usitatissimum		-	1	18	-	-	-	-	-	-
Linum usitatissimum (m)		-	-	-	-	-	-	-	-	-
Linum	fibres (cordage/string)	-	-	-	-	-	-	-	-	-
Quercus	acorn	-	-	-	-	-	-	2frg	-	-
Malus sylvestris	fruit parenchyma	-	-	-	-	-	-	1frg	-	-
Salt marsh										
Agrostis/Poa		-	-	-	3	-	-	-	-	-
Althaea officinalis		4	4	-	16	3	-	-	1	-
Althaea officinalis (m)		-	-	-	-	-	-	-	-	-
Aster tripolium		-	-	-	-	-	-	-	-	-
Atriplex littoralis type		32	34	-	4	8	3	3	-	4
Atriplex portulacoides		2	2	-	-	-	-	-	-	-
Beta vulgaris (subsp. maritima)	perianth	-	-	-	-	-	-	-	-	-
Bolboschoenus maritimus		-	-	24	-	2	1	1	1	-
Bolboschoenus maritimus	tuber	-	-	-	-	-	8frg	-	-	2frg
Carex distans		1	-	-	-	-	-	-	-	-
Carex distans (un-ch)		-	-	1	-	-	-	-	-	-
Festuca/Lolium		1	-	-	-	-	-	1	-	1
Hordeum marinum		2	-	6	-	-	-	-	-	-
Puccinellia distans		-	-	-	-	1	-	-	-	-
Salicornia europaea		-	-	-	-	1	-	2	-	-
Suaeda maritima		-	-	1	-	-	-	-	-	-

Botanical macro-remains

Trench/square number		**22032**	**18782**	**18782**	**22034**	**22704**	**18782**	**20113**	**22704**	**21984**	**23931**	**22034**
Serial number		**4**	**9**	**6**	**2**	**?**	**5**	**7**	**?**	**7**	**102**	**3**
Feature		**7**	**31**	**5**	**3**	**69**	**5**	**24**	**55**	**18**	**?**	**16**
Context/location		**WIIIB**	**W3D**	**W3D**	**WIIIB**	**W**	**W3D**	**WIIIB**	**W**	**W30**	**WIV**	**WIIIB**
Fresh water marshes/backswamps												
Carex otrubae		-	-	-	-	-	-	-	-	-	-	-
Cladium mariscus		-	-	-	-	-	-	-	-	-	-	-
Phragmites, culm frg	culm frg	+	++	+	-	+	-	-	+	-	+	-
Ranunculus lingua		-	-	-	-	-	-	-	-	-	-	1
Schoenoplectus tabernaemontani		-	1	-	5	-	-	-	-	-	-	-
Weeds/waste places												
Atriplex patula/prostrata		>250	c.150	c.75	26	30	25	8	-	32	-	-
Atriplex patula/prostrata (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Carduus/Cirsium		1	-	-	7	-	-	-	-	-	-	1
Chenopodium album		-	-	-	-	1	1	-	-	-	-	-
Chenopodium album (un-ch)		-	12	46	4	-	-	-	-	-	-	-
Persicaria lapathifolia		-	-	-	1	-	-	-	-	-	-	-
Polygonum aviculare		-	-	-	-	-	1	-	-	-	-	-
Rumex crispus type		-	-	-	2	-	-	-	-	-	-	-
Solanum nigrum		-	-	-	3	-	-	-	-	-	-	-
Solanum nigrum (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Open, moist and enriched soils												
Chenopodium ficifolium (un-ch)		-	9	-	7	-	-	-	-	-	-	-
Chenopodium ficifolium		-	-	-	-	-	-	-	-	-	-	-
Open, dry and enriched soils												
Hyoscyamus niger (un-ch)		-	-	-	-	-	-	-	-	-	-	-
Moist, nutrient rich grasslands												
Ranunculus acris/repens, cf.		-	1	-	-	-	-	-	-	-	-	-
Water plants												
Potamogeton natans		-	-	-	1	-	-	-	-	-	-	-
Sparganium erectum		-	-	-	2	-	-	-	-	-	-	-

(+): 2-10; +: 11-50; ++: 51-100; +++: >100

Trench/square number		25223	2327	18782	22034	24573	24574	22704	20503	22993
Serial number		103	?	6	5	3	3	?	13	6
Feature		103	?	5	7	16	16	41	129	237
Context/location		filling of the pit (north-east part)	fill north-east quadrant of pit	WIIID	WIIIB	WIV	WIV	W	EII	EII
Fresh water marshes/backswamps										
Carex otrubae		1	-	-	-	-	-	-	-	-
Cladium mariscus		-	-	-	2	-	-	-	-	-
Phragmites, culm frg	culm frg	-	+	++	++	+	-	-	+	+
Ranunculus lingua		-	-	-	-	-	-	-	-	-
Schoenoplectus tabernaemontani		-	-	-	-	1	-	-	-	-
Weeds/waste places										
Atriplex patula/prostrata		91	25	c.90	c.200	-	6	25	-	9
Atriplex patula/prostrata (un-ch)		-	-	-	-	-	-	-	-	+
Carduus/Cirsium		-	-	-	-	-	-	-	-	-
Chenopodium album		-	-	-	1	-	-	-	-	-
Chenopodium album (un-ch)		-	-	++	-	-	-	-	-	+
Persicaria lapathifolia		-	-	2	-	1	-	-	-	-
Polygonum aviculare		2	-	1	-	-	-	-	-	-
Rumex crispus type		-	-	-	-	-	-	-	1	-
Solanum nigrum		-	-	-	-	-	-	-	1	-
Solanum nigrum (un-ch)		-	-	2	-	-	-	-	-	-
Open, moist and enriched soils										
Chenopodium ficifolium (un-ch)		-	-	++	-	-	-	-	-	+
Chenopodium ficifolium		-	-	-	-	-	-	-	2	-
Open, dry and enriched soils										
Hyoscyamus niger (un-ch)		-	-	1	-	-	-	-	-	-
Moist, nutrient rich grasslands										
Ranunculus acris/repens, cf.		-	-	-	-	-	-	-	-	-
Water plants										
Potamogeton natans		1	-	-	-	-	-	-	-	-
Sparganium erectum		-	-	-	-	-	-	-	-	-

Botanical macro-remains

Trench/square number		**22032**	**18782**	**18782**	**22034**	**22704**	**18782**	**20113**	**22704**	**21984**	**23931**	**22034**
Serial number		**4**	**9**	**6**	**2**	**?**	**5**	**7**	**?**	**7**	**102**	**3**
Feature		**7**	**31**	**5**	**3**	**69**	**5**	**24**	**55**	**18**	**?**	**16**
Context/location		**WIIIB**	**W3D**	**W3D**	**WIIIB**	**W**	**W3D**	**WIIIB**	**W**	**W30**	**WIV**	**WIIIB**
Ecologically indeterminate												
Carex		-	-	-	1	-	-	-	-	-	-	-
Poaceae		-	-	-	-	-	-	-	-	-	-	-
Bromus		-	-	-	-	-	-	1frg	-	-	3	-
Diverse												
Charcoal		+	+	++	+	+	+	+	(+)	+	+	+
Root/tuber parenchyma indet.		-	-	-	-	-	-	-	2frg	-	-	-
Pottery with crust		-	+	-	+	-	-	-	-	-	-	-
Shells		++	+++	-	-	++	-	+	-	-	-	-

(+): 2-10; +: 11-50; ++: 51-100; +++: >100

Trench/square number		25223	2327	18782	22034	24573	24574	22704	20503	22993
Serial number		103	?	6	5	3	3	?	13	6
Feature		103	?	5	7	16	16	41	129	237
Context/location		filling of the pit (north-east part)	fill north-east quadrant of pit	WIIID	WIIIB	WIV	WIV	W	EII	EII
Ecologically indeterminate										
Carex		-	-	-	-	-	-	-	-	-
Poaceae		-	-	1	-	-	-	-	-	-
Bromus		-	-	-	-	-	-	-	-	-
Diverse										
Charcoal		+	+	++	+	+	(+)	(+)	(+)	+
Root/tuber parenchyma indet.		-	1frg	1frg	-	-	-	-	-	-
Pottery with crust		-	-	-	-	-	-	-	-	-
Shells		+++	+++	-	-	-	-	-	-	+