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Between Flax and Fabric: Cultivation and Processing of Flax in a Mediaeval Peat Reclamation Settlement Near Midwoud (Prov. Noord Holland)

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Macroscopic remains and pollen of flax (*Linum usitatissimum*) and flax dodder (*Cuscuta epilinum*) along with seeds of *Spergula arvensis* var. *maxima* were found in botanical samples from a 12th century peat reclamation settlement. The composition of the crop remains was such as to justify the interpretation of the samples as the debris from at least two separate stages in the processing of flax, namely beating/rippling and braking or swingling. The possible origin of the flax is discussed on the basis of the weed flora.

Keywords: WEST-FRIESLAND, MEDIAEVAL, PEAT RECLAMATION, PALYNOLOGY, PALAEOETHNOBOTANY, FLAX PROCESSING, FLAX WEEDS.

Introduction

In the early Middle Ages, large parts of the province of Noord-Holland (northwest Netherlands) were covered by raised peat bog, which had developed on top of clay deposits dating to the Calais IVa2 transgression period. Much of the peat has now disappeared, having been eroded, oxidized or extracted. Until the 10th century, mediaeval settlement in this region was limited to the traversable, naturally drier areas. Later, the whole peat area was systematically reclaimed. The drainage ditches dug in this period formed an important element in the regime of water control in the reclaimed area which became necessary in later, wetter periods. That arable farming was carried out on the Noord-Holland peat is well known from both historical (Edelman, 1974; De Boer, 1978; Besteman & Guiran, 1983; Vos, 1983) and palynological sources (Voorrips & Jansma, 1974; Van Geel *et al.*, 1983; Van Dierendonck, 1984; Cremer, 1985).

In order to improve the peat soils for arable purposes, drainage channels were constructed and lime-rich clay was spread out over the land. Dekker (1972, 1974*a,b*) assumes that in the region of Noord-Holland, more generally known as West-Friesland, pits were dug through the peat to extract the clay from underneath it. These pits, known as "*daliegaten*", are visible to this day as depressions in the land surface.

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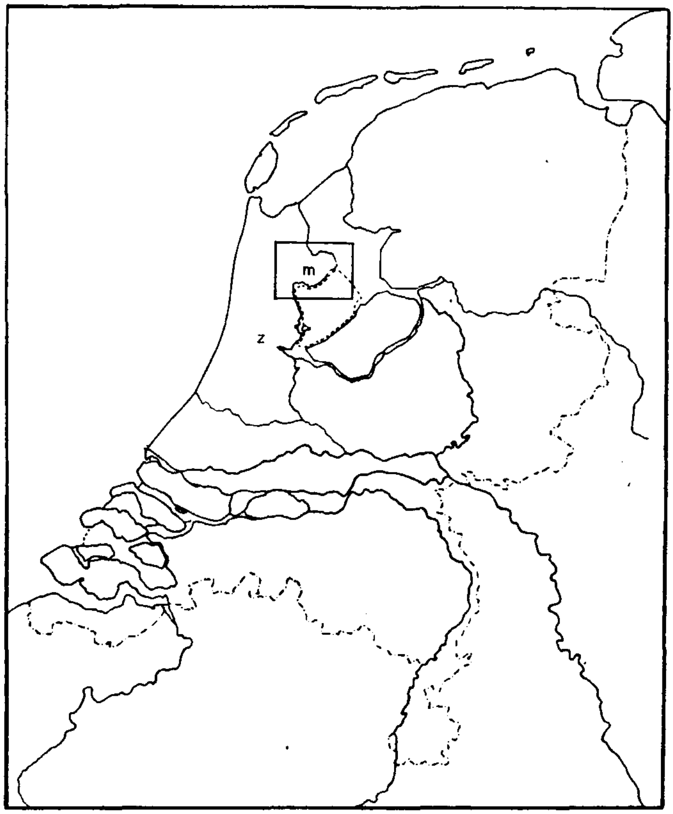

Figure 1. Location of Midwoud (m); West-Friesland (boxed area); Zaanstreek (z).

The Site

One of the peat reclamation settlements in West–Friesland is Midwoud (Figure 1), where excavations by the Albert Egges van Giffen Instituut voor Prae- en Protohistorie (IPP) were carried out between 1977 and 1978. The location of the site on the 1:50,000 Topographic Map of the Netherlands, sheet 14 east is 135·40/525·40.

The site, probably a single farmstead, can be dated to the second half of the 12th century by the artifacts found (Guiran & Hallewas, 1979). The finds (12th century pottery, bone, querns, etc.) were concentrated predominantly in the eastern half of the site. No house plans could be reconstructed from the soil marks, but the stake rows, water wells and the numerous pits are indicative of settlement on the spot.

The area excavated measured *c.* 100 x 100 m. In the eastern section, there was a sandy creek ridge, in the west a depression filled with peat (Figure 2). In this peat, which is a remnant of the original raised bog, numerous pits (*daliegaten*) backfilled with lumps of peat, peat mixed with domestic refuse, dung, etc., were found.

Most of these pits were dug down into the clay and for the most part they contain lumps of peat with occasional domestic refuse (pottery, bones, dung). It would therefore seem most probable that the pits were primarily dug to obtain clay and were only later used as a convenient dump for refuse and waste peat. In the absence of stratigraphy, most pits could in theory date to both before and after the occupation as well as during it. However, those pits containing domestic refuse are most likely to date to the settlement phase. Occasionally, the refuse had a clearly layered structure (e.g. pits 26 and 95, see Figure 3).

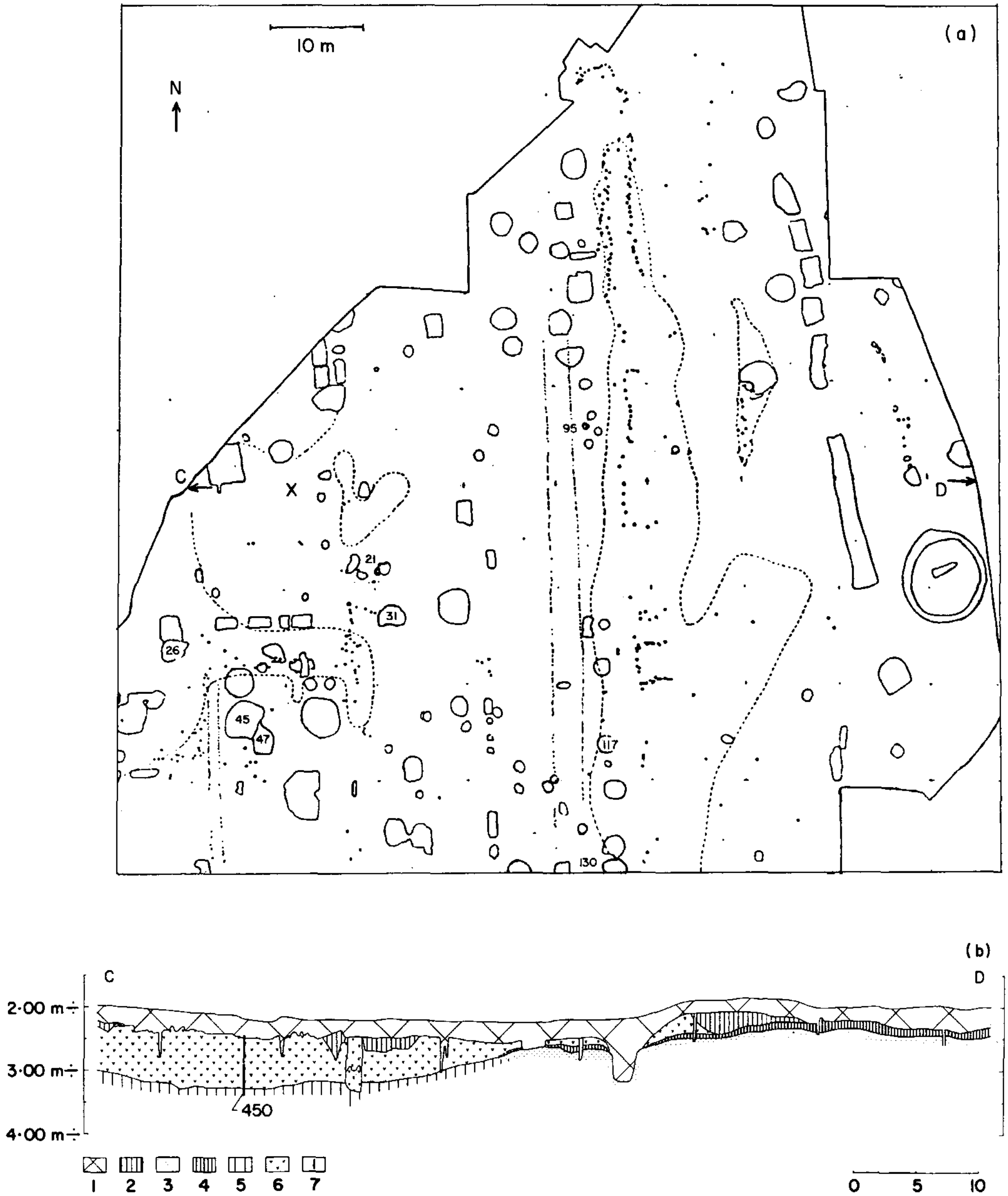

Figure 2. (a) Site plan. Numbers indicate the investigated pits. Section C–D [see Figure 2(b)] with location of monolith tins indicated by X. For explanation see text. (b) Section C–D. 1, recent; 2, disturbed humic clay; 3, sandy clay; 4, very humus-rich clay; 5, undisturbed clay; 6, peat; 7, monolith tins.

One of the pits, no. 26, contained a layer with a massive quantity of seeds and capsules of flax. Layers consisting of flax stem remains were found in pit 95. It is with these pits that this article is concerned.

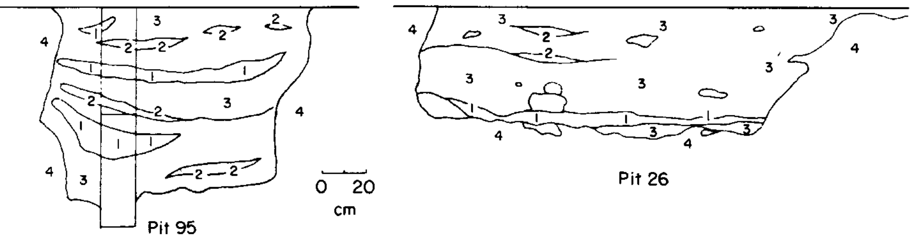

Figure 3. Sections of pits 95 and 26. Pit 95: 1, flax stem fragments (*scheven*); 2, ash; 3, peat; 4, undisturbed clay; 5, monolith tins. Pit 26: 1, flax capsules; 2, reed; 3, clayey peat with lumps of pure peat; 4, undisturbed clay.

Field and Laboratory Procedures

A considerable number of samples were taken specifically for ecological analysis during the course of the excavation. One of the purposes of the procedure was to obtain an insight into the function(s) of the numerous pits via the analysis of both microscopic and macroscopic plant remains. Other objectives were to attempt to identify the crops which had been cultivated and/or processed here as well as establishing whether any of the covering peat had disappeared.

The samples

A complete section of the peat in the depression was sampled for pollen analysis in two 10 × 15 × 50 cm monolith tins (Figure 2), and blocks of material were collected from sections in the pits by individual layer in so far as this was at all visible.

The samples were boiled with 5% KOH and acetolyzed following Erdtman's procedure; samples containing a clay fraction were treated with HF (Faegri & Iversen 1975). Those samples not treated with HF were, if necessary, sieved through a 4 × 10 μ mesh.

A Leitz binocular stereo-microscope was used for identification. The Cerealia pollen was identified at a magnification of × 1000 with phase contrast on the structural criteria as defined by Beug (1961).

The tree pollen sum was based on the arboreal taxa including *Alnus* with a minimum count of 300.

Samples of *c.* 1000 cc were taken from sections in the pits for analysis of the macroscopic organic remains. The material was washed through a stack of four sieves (meshes of 2, 1, 0·5 and 0·25 mm) prior to being sorted and identified under a Wild M5 stereomicroscope with magnification range to × 50. Seeds of Gramineae and Juncaceae were identified with transmitted light and a magnification up to × 400, with the help of the keys and descriptions by Körber-Grohne (1964).

The taxa are arranged in ecological groups using Westhoff & Den Held (1975), Ellenberg (1974) and Oberdorfer (1979). Nomenclature of plant taxa follows Heukels & van der Meijden (1983).

Descriptions of selected micro- and macro-fossils are given below. Samples discussed here are: MP 1052; from a layer with flax capsules in pit 26. This layer was *c.* 10 cm thick and extended for more than 1 m in the profile (see Figure 3). MP 639 a/b; from relatively thick layers (5–15 cm) with flax stem remains (identified as "grass" by the excavators) in pit 95 (see also Figure 3).

Results and Discussion

General results of the palaeobotanical research are presented by the second author (van Dierendonck, 1984); part of the work is still in progress.

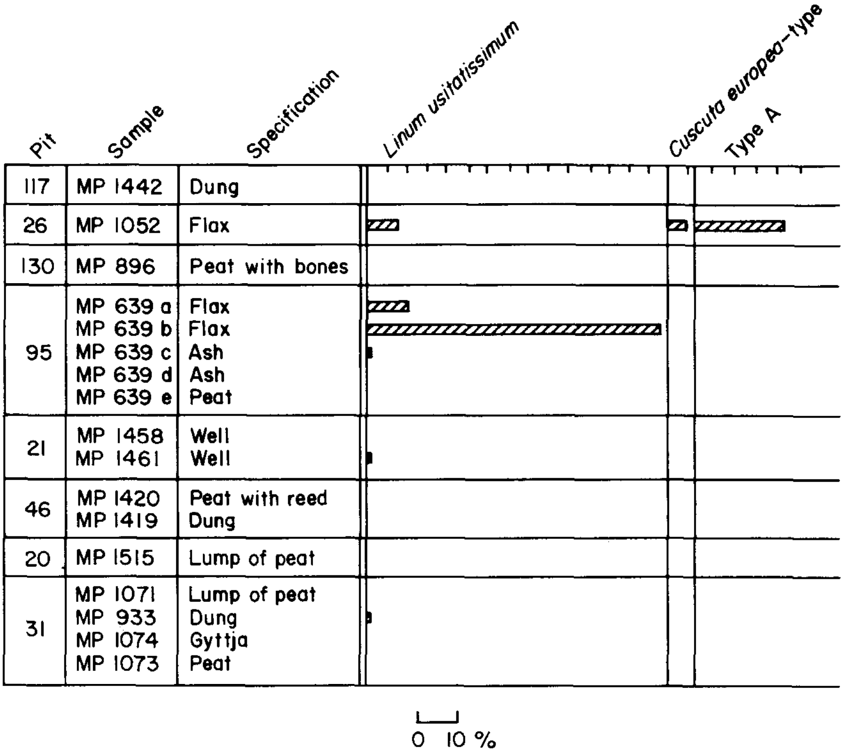

Figure 4. Synopsis of the occurrence of *Linum* and *Cuscuta* pollen and type A spores in the investigated pits.

Comparison of pollen spectra from the peat from the depression (clearly pre-mediaeval: absence of *Secale* and other indicators of cultivation) with that from the pits indicated that the peat lumps in the pits were of later date, probably late mediaeval. We may conclude that, but for the odd lumps which ended up in these pits, the top of the peat which had originally covered the site has entirely disappeared. The pits must therefore have been dug at, or after, the time of the growth of the peat cover.

The pollen spectrum from the flax layer in pit 26 (sample no. MP 1052) differed from the other spectra in the presence of a large amount of pollen of both flax and *Cuscuta europea*-type (*Cuscuta epilinum*, flax dodder, is included in this type). *Cuscuta epilinum* is a parasite specific to flax (Heukels & van der Meijden, 1983; van Ooststroom, 1961) and the pollen of this type was previously unknown in the subfossil material from the Netherlands. It has, however, been recognized in Bronze Age and Iron Age contexts in England (Dimbleby, 1973; Christie, 1978).

In addition, a large number of palynomorphs of an unknown type (possibly spores, provisionally designated type A) as well as egg capsules of *Trichuris trichiura*, a parasite of the human digestive tract, occur almost exclusively in this sample. Other than sample MP 1052, only the samples from the flax stem layers (MP 639a and 639b) contained much *Linum usitatissimum* pollen. These three samples are hardly distinguishable from any of the other pit samples save in the features mentioned (presence of *Linum*, and, in MP 1052 also *Cuscuta* and type A, see Figure 4). The general aspect of the pollen spectra is, therefore, likely to be regional in character (van Dierendonck, 1984).

Table 1. Model of the process flax to linen

	Process	Purpose	Waste	Possible uses of waste
A	Pulling			
B	Drying	Stiffening up the fibres		
C1	Beating	Removal of capsules	Crushed capsules and seeds, weeds and their seeds	Flax seeds: oil, human consumption, fodder, sowing seed
or				
C2	Rippling	Removal of capsules by means of a comb	Whole capsules and seeds, weeds and their seeds	
D	Retting	Breakdown of pectine in the bast by bacterial action in moist conditions	Retting pits with water → detritus; rotting flax remnants; water plants; settlement noise	
E	Drying			
F	Braking	Separation of the woody parts from the bast fibres	Bast remnants: woody parts ("scheven")	
G	Swingling	Cleaning out bits of stem by beating and combing	Bast remnants: woody parts ("scheven")	
H	Hackling	Cleaning and carding	Dust and small woody particles	
I	Spinning, weaving, bleaching, etc.			

The macro-analysis of sample MP 1052 revealed, in addition to the numerous flax remains (almost exclusively seeds and capsules), a large number of *C. epilinum* seeds. Seeds of *Spergula arvensis* in this sample are relatively large and probably belong to the var. *maxima*. In "The macroscopic remains" these finds are discussed in more detail.

Flax processing

In order to illustrate the activities involved in processing flax stems into linen yarn, a model of the various steps in the process with the associated products and waste material was constructed using published information and recent material (DeWilde, 1983; D. Douma, pers. comm., 1984) (see Table 1). Samples of both the products and the waste material of each stage described were obtained from the flax museum "'t Braakhok" in Ee (Friesland) for comparison with the archaeological material.

The remains in sample MP 1052 clearly resemble the sweepings left in stage C1 or C2 of the process (beating or rippling) (see also Table 2).

The material from pit 95 (samples MP 639a and MP 639b) consisted purely of woody fragments (*c*. 5 mm to several centimetres long) of flax stems, the refuse from stage F or G (see also Figure 6.3).

Similar assemblages containing stems and capsules were recorded from habitation mounds from the Roman and early mediaeval periods in northwest Germany (Körber-Grohne, 1967: 147 sqq.; Behre, 1976: 19).

The macroscopic remains

In order to compare the contents of the layer of flax capsules with similar assemblages from other sites, an analysis of macrofossils was carried out.

Table 2. Macro-analysis of sample MP 1052

Species	Number	1	2	3	4	5	6	7
		(ecological groups)*						
Phragmites australis	543	x	x	.	.	.	.	.
Stem fragments		*c.* 10% of sample matrix						
Poaceae	165	x	x	.	.	.	.	.
Scirpus lacustris	9	x	x	.	.	.	.	.
Scirpus maritimus	23	x	x	.	.	.	.	.
Juncus gerardii	651	.	x	x	.	.	.	.
Atriplex prost./patula	117	.	x	.	.	.	.	.
Festuca sp.	+	.	x	.	.	.	.	.
Atriplex littoralis	1	.	x	.	.	.	.	.
Armeria maritima	1	.	x	.	.	.	.	.
Triglochin maritima	43	.	x	.	.	.	.	.
Agrostis sp.	302	.	.	x	.	.	.	.
Lychnis flos-cuculi	13	.	.	x	.	.	.	.
Cirsium sp.	1	.	.	x	.	.	.	.
Elymus repens	+	.	.	x	.	.	.	.
Hordeum cf. *secalimum*	+	.	.	x	.	.	.	.
Ranunculus sardous	9	.	.	x	.	.	.	.
Leontodon autumnalis	2	.	.	x	.	.	.	.
Plantago major	12	.	.	x	.	x	.	.
Alopecurus sp.	39	.	x	x	x	.	.	.
Chenopodium rubrum/glauc.	99	.	.	.	x	.	.	.
Bidens tripartitus	49	.	.	.	x	.	.	.
Juncus bufonius	28	.	.	.	x	.	.	.
Polygonum hydropiper	1	.	.	.	x	x	.	.
Polygonum lapathifolium	154	.	.	.	x	x	.	.
Urtica urens	87	.	.	.	.	x	.	.
Brassica rapa/napus	2	.	.	.	.	x	x	.
Stellaria media	73	.	.	.	.	x	.	.
Spergula arv. var. *maxima*	59	.	.	.	.	x	.	.
Cuscuta epilinum	240	.	.	.	.	x	.	.
Chenopodium album	47	.	.	.	.	x	.	.
Sonchus asper	11	.	.	.	.	x	.	.
Polygonum aviculare	1	.	.	.	.	x	.	.
Linum usitatissimum								
Seeds	1935	.	.	.	.	.	x	.
Capsules		*c.* 50% of sample matrix						
Hordeum vulgare	+	.	.	.	.	.	x	.
Carex rostrata	4	.	.	.	.	.	.	x
Menyanthes trifoliata	3	.	.	.	.	.	.	x
Rumex sp.	2							
cf. *Hieracium*	1							
Charcoal	x							
Mosses	x							
Insect remains	x							

*1, Reedlands (Phragmition); 2, high salt marsh (Asteretea tripolii); 3, damp, possibly brackish grasslands (Lolio-Potentillion, Arrhenateretea); 4, drying, mineral-rich mud (Bidention); 5, weeds (Chenopodietea); 6, crop plants; 7, Mesotrophic peat.

Taphonomy: The original characteristic composition of the waste material from the various processing stages may be modified to a greater or lesser degree by taphonomic processes. It may be mixed with other material at every stage from the sweeping up of waste, during transport, temporary storage and further processing until the final dumping of the refuse. Furthermore, it is likely that flax processing will be only one of the various sources of rubbish in a refuse pit.

The sample analysed (MP1052) contained the following microscopic and macroscopic components:

(a) Peat (*Carex rostrata, Menyanthes trifoliata, Pediastrum, Tilletia*).

(b) Domestic refuse: the *Trichuris* casings indicate human excreta [interpretation of the flax remains as part of a digested human meal on the basis of the presence of *Trichuris* eggs (cf. Helbaek, 1959: 111) is, in view of the abundance of capsule fragments, obviously out of the question].

(c) Plant remains representative of the local vegetation (reed beds, meadows, salt marshes, ruderals).

(d) Flax processing waste, including the weeds associated with flax.

The appearance of indicators for a salt marsh vegetation suggests that this landscape occurred in the vicinity of the site. If so, the possibility that any living raised bog could still have been present in the neighbourhood can be entirely ruled out and the area must have been strongly modified by the effects of human activity around Midwoud and elsewhere in the region. Van Geel *et al.* (1983) argue convincingly that West-Friesland had to contend with increasing problems from sea water, in part as a result of the mediaeval reclamations (due to subsidence and oxidation of the peat).

The following anomalies in the composition of sample MP 1052 may be observed.

(1) The presence of late-flowering weeds such as *Atriplex* and *Bidens,* which begin to flower only in July and usually do not bear ripe fruits until the end of August. Since at present flax is pulled during the first two weeks of July (DeWilde, 1983), one might be inclined to assume that the fruits of these species entered the assemblage not during the harvest, but later, at the time or place of processing for instance. There are, however, considerations which point to a rather different conclusion. At the Feddersen Wierde, *Bidens* was relatively scarce in the samples reflecting the natural vegetation. It occurred most frequently in the threshing remains of flax and other crops. Körber-Grohne concludes that "the role of *Bidens* as a weed and ruderal was of considerable importance". The extremely numerous fruits of *Atriplex* spp. were not specifically associated with crops, but did occur frequently in the threshing remains. There is little doubt that both *Bidens* and *Atriplex* were part of the weed flora at the Feddersen Wierde, and consequently that flax was pulled later in the season. In view of the great resemblance of the weed assemblages, this would also have been the case at Midwoud.

(2) The abundance of reed (*Phragmites australis*) seeds, chaff and internodes in this sample; reed seeds are absent in the samples with flax stem remains (639 a and b) in the "non-flax" samples nr 1442 (dung layer in pit 117) and even 1419 (layer consisting of pure reed in pit 46/47).

Phragmites seeds are not ripe before the second half of December (Bittmann, 1953). This implies that these seeds are secondary in origin. If *Phragmites* grew in the fields, the seeds could never have been ripe at the same time as the flax.

Reed and flax seeds could have been mixed in the pit after the flax processing waste had been dumped. This is improbable since the layer of flax remains was clearly separated from the peat around it, which, moreover, did not contain any reed seeds. Mixing during the processing seems to be the only obvious explanation for the simultaneous occurrence of reed and flax seeds. The stalk fragments, which formed about 10% of the sample, could be indicative for a reed-covered threshing floor.

Table 3. Synopsis of weeds associated with flax

	1	2	3	4	5	6*
Agrostis sp.	x	x	.	.	.	.
Atriplex prost./patula	x	x	x	.	.	.
Bidens tripartitus	x	x	x	.	.	.
Brassica rapa	x	x	.	x	.	.
Chenopodium album	x	x	x	x	x	x
Chenopodium ficifolium	.	x	x	.	.	.
Cuscuta epilinum	x	.	.	.	.	x
Galeopsis tetr./speciosa	.	.	x	.	.	.
Hordeum cf. *secalinum*	x	.	.	x	.	.
Juncus bufonius	x	x	x	.	.	.
Juncus gerardii	x	x	.	x	.	.
Lychnis flos-cuculi	x	x	x	x	.	.
Polygonum aviculare	x	x	x	.	x	x
Polygonum hydropiper	x	.	x	.	.	x
Polygonum lapathifolium	x	x	x	x	x	x
Polygonum persicaria	x	.	x	x	x	x
Scirpus lac./maritimus	x	.	.	x	.	.
Spergula arvensis s.l.	x†	.	x	.	x†	x
Stellaria media	x	x	x	x	.	.
Triglochin maritima	x	x	.	x	.	.
Urtica urens	x	.	x	x	.	.
Other species	17	16	86	27	?	?

*1, Midwoud (11th century), van Dierendonck, 1984; 2, Feddersen Wierde (2nd century), Körber-Grohne, 1967 (only a small part of the seeds); 3, Haithabu (9th–11th centuries), Behre, 1983; 4, Midwoud, "non-flax sample"; 5, carbonized flax finds from Central Europe, Lange, 1978; 6, recent flax fields, Lange, 1978.
†Var. *maxima*.

Flax weeds: Possible ways to determine which weeds—in addition to flax dodder—might be associated with flax are as follows.

(a) Comparison of the macro remains of a "flax sample" and a sample without flax remains from a comparable context at the site.

(b) Comparison of the threshing remains of flax and of other crops. At Midwoud this was not possible, since other crops were not found in any quantity. Körber-Grohne (1967), however, analysed threshing remains of four crop species at the Feddersen Wierde.

(c) Comparison of the assemblages of wild plants in samples containing flax remains from different archaeological sites. Körber-Grohne (1967) and Behre (1976, 1983) have described such samples from waterlogged sites in the salt marsh along the North Sea coast. Lange (1978) presents a synopsis of the archaeological finds of carbonized flax to that date.

(d) Comparison of the assemblage of wild plants in our sample with the weed assemblages in extant flax fields. This might be rather hazardous because of possible differences between the pre/protohistoric and the modern situation with regard to date of harvest, tillage and the like. Recent vegetation surveys of flax fields in Central Europe are presented by Lange (1978).

Table 3 summarizes the species found in Midwoud in comparison to the data collected by Lange, Körber-Grohne and Behre.

Apart from regional differences in the occurrence of typical "linicolous" weeds (cf. Hjelmqvist, 1950), it is obvious that the composition of the flax weed flora is partly dependent on local circumstances; in the coastal area it is characterized by several nitrophilous (*Bidens, Atriplex*) and slightly halophilous species (*Triglochin, Juncus gerardii*). The latter are not present at Haithabu at the Baltic coast, but this is not a typical salt marsh site. The extremely rich weed flora here is largely composed of Secalietea and other species derived from nearby sandy soils and damp fresh water environments (Behre, 1983).

The material from the Feddersen Wierde (Roman period) and Elisenhof (early mediaeval) lacks typical "linicolous" weeds present in the Central European material. Two of these species, however, are present in the Midwoud sample: *C. epilinum* and *S. arvensis* var. *maxima.*

The records of seeds of *C. epilinum* are rather scarce. Lange (1978) reports the presence of *Cuscuta* in a sample of carbonized linseed from Hetzdorf (late La Tène), though with reservations as to the identification as *C. epilinum* on account of the state of preservation. Behre (1976) reviews four finds from the Roman period from coastal settlements in northwestern Germany. At Haithabu, *C. epilinum* was not found "in spite of thorough research" (Behre, 1983).

Spergula arvensis s.l. is scarcely represented in the archaeobotanical record from the Dutch and German North Sea coast. It was found at the Feddersen Wierde (Körber-Grohne, 1967), Elisenhof and Tofting (Behre, 1976), but only sporadically and not associated with flax. It was present in only one of the nine sites (Den Helder, in two samples described as "humic fill of ditch") in the Dutch coastal area investigated by van Zeist (1974) and is absent from the seed samples from the Dutch terpen (Beijerinck, 1929), as well as from Bronze Age Hoogkarspel (Bakker *et al.,* 1977). In Iron Age Assendelft (Beemster, 1984), it was numerous in a sample with carbonized *Camelina sativa,* which was shown to have been cultivated on peat. At Haithabu, where *S. arvensis* was found in reasonable numbers, it was "common especially in flax samples", and "as in some other prehistoric flax finds, also in Haithabu the most common flax weed" (Behre, 1983). *Spergula arvensis,* with its preference for acid soils, is apparently not able to thrive on the clayey, brackish soil of the salt marsh sites. The drying peat of Assendelft and Midwoud and the sandy soil near Haithabu were obviously suitable habitats.

In view of the apparent ecological indicator value of *S. arvensis,* it would seem probable that the flax was cultivated locally on the drained peat soils. Considering the marginal growth conditions, cultivation would have been for domestic use only, and not on a large scale.

Final remarks

The cultivation of flax on peat is rather surprising, since this crop requires a deep, fertile soil enriched with lime (DeWilde, 1983). This corroborates the assumption that the *daliegaten* were dug to extract clay from underneath the peat and work it through the soil in order to improve the possibilities for cultivation, as was stated in the Introduction. In view of the occurrence of *Spergula,* however, the achieved enrichment of the soil cannot have been substantial.

Flax was never cultivated on a large scale on the peat soils of Noord-Holland in later periods, which appears from documentary evidence on flax in Noord-Holland summarized by Ankum (1960). A flourishing industry based on the extraction of linseed oil developed in the Zaanstreek (for location see Figure 1) during the 17th and 18th centuries which was dependent on linseed imported from Zeeland and the Baltic area.

The flax weed flora at Midwoud is remarkable in the presence of *C. epilinum,* which has only been found in Iron Age and Roman contexts and was absent from early mediaeval Elisenhof and Haithabu, sites from more or less the same period.

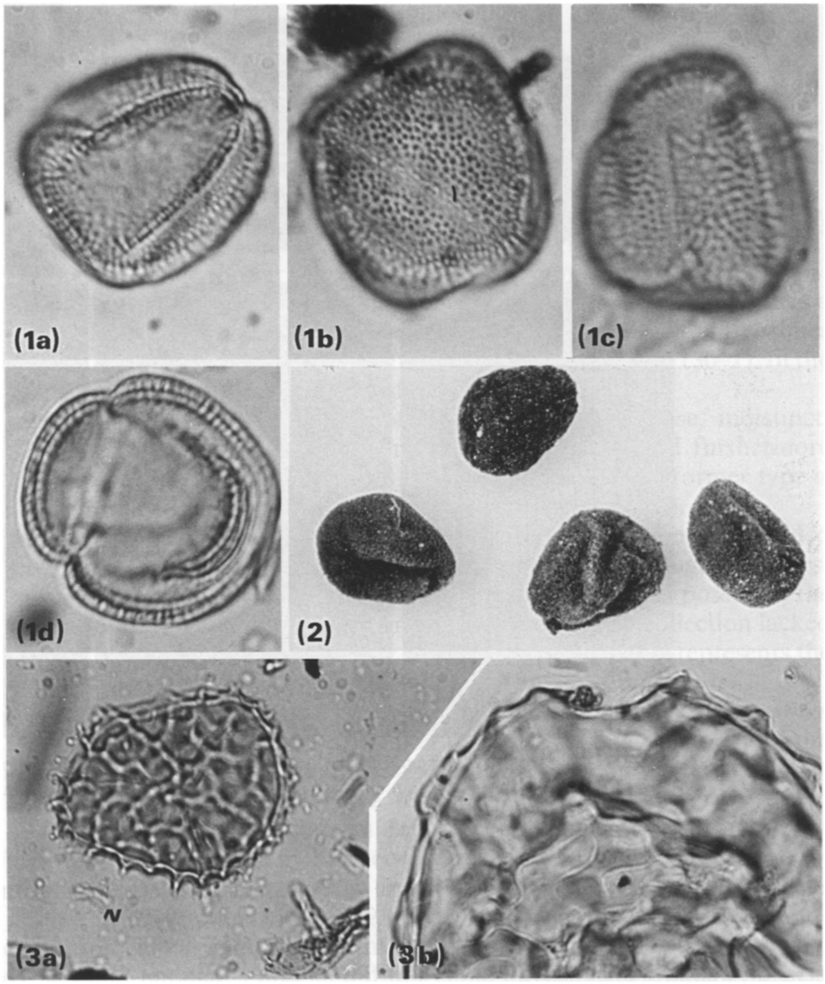

Figure 5. (1a–d) *Cuscuta epilinum* pollen, × 1500. (2) *Cuscuta epilinum* seeds, × 16. (3a) Type A spore (?), × 600. (3b) Type A spore (?), detail of concave end, × 1500.

Description of Selected Micro- and Macro-fossils

Cuscuta epilinum *[pollen, Figure 5.1(a)–(d); seeds, Figure 5.2]*

The pollen of the *Cuscuta europaea*-type, in which *C. epilinum* is included (3-4-zonocolpate with long colpi and thick exine with psilate tectum (Cronk & Clarke, 1981) closely resembles that of *Anemone nemorosa,* as which it was originally identified. However, many of the grains were 4-colpate with the colpi appearing to occur in two pairs so that the pollen grain seems to be composed of two sections [Figure 5.1(b)], a characteristic which is not present in *Anemone.*

The seeds are distinguishable from those of *C. europaea, C. campestre* and *C. epithymum* (which is also markedly deviant in its pollen morphology) by their surface structure and size. The subfossil seeds measured on average 1·38 mm, with standard deviation of 0·34 (25 measurements taken from carefully dried waterlogged seeds), which is larger than the 1–1·2 mm of *C. europea* and *C. epithymum.* They are distinguishable from the similarly

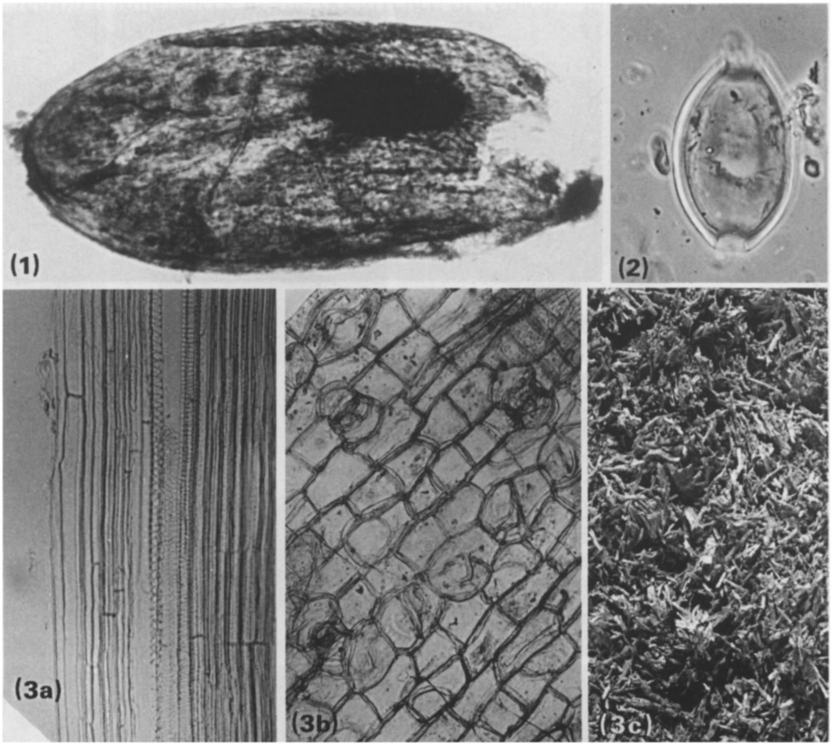

Figure 6. (1) *Phragmites australis* seed, × 60. (2) *Trichuris trichiura*, egg capsule, × 600. (3a) Flax stem, × 150. (3b) Flax epidermis, × 150. (3c) Flax stem fragments (*scheven*), *in situ*.

sized seeds of *C. campestre* by the rough surface caused by the spongy structure of the outer epidermis layer (van Ooststroom, 1961; Tutin *et al.*, 1972).

Type A [Figure 5.3(a)–(b)]
Ellipsoid to virtually orbicular spore (?), length 72·4 μ (σ 8·32), width 56·3 μ (σ 4·64) (20 measurements of specimens embedded in paraffin under coverslip). Extremities often concave with thickened wall [see Figure 5.3(b)]. Surface coarsely reticulate with mesh of irregular size, generally *c.* 9–12 μ. A trilete mark, distinguishable on the photograph, is, curiously enough, not visible under the microscope, even when using phase contrast.

Trichuris trichiura *(Figure 6.2)*
A barrel-shaped worm egg with a thick, double-walled shell; smooth surface and polar plugs at both extremities (Thienpont *et al.*, 1979). Dimensions average 53·1 × 31·0 μ (six measurements).

Flax remains (stalk, Figure 6.3(a); epidermis, Figure 6.3(b); scheven, Figure 6.3(c)
Selected epidermis fragments taken from the subfossil material from Midwoud were compared to recent flax epidermis (from Ee) and with the illustrations of subfossil and recent material published by Körber-Grohne (1967: plates 25–27). The epidermis samples from Midwoud displayed few similarities with the recent material from Ee, but were, on

the other hand, virtually identical to the subfossil and recent material of flax illustrated by Körber-Grohne (l.c.).

Spergula arvensis *cf. var.* maxima *(seeds)*
Lenticular to orbicular seeds with an equatorial margin, surrounded by a narrow list; surface covered with fine warts. Size 1·56 mm (σ 0·13) (16 measurements of waterlogged seeds).

The *S. arvensis* seeds found in the Midwoud material are, though not all measurable, clearly much larger than 1·1 mm, the maximum size for *S. arvensis* var. *arvensis* (cf. Berggren, 1981). The size range for var. *maxima* is 1·4 to 2·2 mm (Lange, 1978: 1·4–1·8; Hjelmqvist, 1950: 1·5–1·8; Berggren, 1981: 1·4–2·2). Christiansen (1953: 207) mentions a forma *linicola* within the var. *maxima*, of which the seeds are "very large, up to three times as large as in the var. *typica*". This size is also mentioned by Heukels (1909: 130–1). In the modern Dutch floras, *S. arvensis* is not subdivided.

Fresh seeds are furnished with two kinds of surface structures: close, indistinct, stelliform papillae (here called "warts" following van Zeist, 1974), and furthermore larger, pale, club-shaped papillae (Berggren, 1981: 53 and plate 32). The former type is present on all varieties, the latter is lacking in the var. *sativa* (Berggren, l.c.).

In the modern reference material available to us, *S. arvensis* is not subdivided into varieties. One population from the reference collection of the Hugo de Vries-Laboratorium, University of Amsterdam, measured 1·08 mm ($n = 19$) and possessed the large papillae, so this is clearly var. *arvensis*. The material from the IPP collection lacked the large papillae and measured 1·60 mm ($n = 20$); this item most probably represents the var. *sativa*. Both items were covered with small stelliform papillae.

The large papillae, which are crucial for the distinction of var. *sativa* from var. *maxima*, have disappeared from the subfossil material, so that only the size remains as a criterion for identification. Since the seeds of var. *sativa* and var. *maxima* show a considerable overlap in size, it is not possible to achieve a reliable distinction between these two varieties. The *S. arvensis* seed described by van Zeist (1974: 267) measured 1·4 mm (var. *sativa* or *maxima*), the one mentioned by Körber-Grohne (1967) 1·0 mm (without doubt var. *arvensis*). Behre (1983) gives a size range from 1·6–2·0 (average 1·76) mm for the material from Haithabu. The size of these seeds, which were "covered with fine papillae", could be indicative for var. *maxima*, but Behre refers only to var. *sativa*, which has "glabrous seeds, without papillae", and so did not come into consideration. Thus, the *S. arvensis* seeds from Midwoud are not unequivocally identifiable as to variety. The connection with flax, however, strongly suggests that we are dealing with the var. *maxima*.

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