BOTANICAL MACRO-REMAINS OF VASCULAR PLANTS OF THE HEVESKESKLOOSTER *TERP* (THE NETHERLANDS) AS TOOLS TO CHARACTERIZE THE PAST ENVIRONMENT

R.T.J. CAPPERS
Cito, Arnhem, Netherlands
Vakgroep Archeologie en Vakgroep Plantenoecologie, Groningen, Netherlands

ABSTRACT: The aim of this study is to present the archaeobotanical results of the Heveskesklooster *terp* located in the northeastern part of the Netherlands. The samples that have been analyzed are dated to one of the four habitation periods: 1) c. 50 BC-c. 400 AD, 2) c. 800-c. 1300, 3) c. 1300-1610 and 4) 1610-1975.

The samples yielded many plant remains, in which the species composition proved to be determined particularly by age (period), feature type and depth. Though distinguishable on a small scale, the species composition of samples of the first two habitation periods turned out to be very much alike. Environmental changes, reflected by a shift in species composition of the samples, have been demonstrated for the transition of: 1) the second and third periods and 2) the third and last periods, though there was a limited number of samples of the last period.

The environment has been analyzed for the following characteristics: 1) salinity, 2) moisture, 3) nutrient availability and 4) structure of vegetation and succession. During all four periods of habitation, both halophytic and glycophytic species are well represented. There is a slight decrease of halophytes in favour of glycophytes in the course of time. Salt-marsh vegetations of the first period have been treated in detail. All four periods are dominated by plants indicative of moist and wet conditions, whereas a clear increase of dry conditions can be demonstrated for the last period only. As to nutrient availability, all four periods are represented by species indicating poor, moderate and rich soils, and there was evidence of an increase of taxa indicating moderate soils from the first period onwards. Dominant vegetation types for all periods are grasslands and pioneer vegetation. The environmental characterization of the periods shows on the one hand a considerable overlap on the level of individual samples, but can be differentiated by external factors of samples, viz. location and feature type. If other Dutch *terps* are compared to the Heveskesklooster *terp* on the basis of indicator taxa, it shows that the environmental characterization fits in quite well with the overall picture, though indicator taxa for saline and dry conditions and for all three classes of moisture regimes are relatively well represented.

Important agricultural plants cultivated by the *terp* dwellers are: *Hordeum vulgare* (in the third period also ssp. *distichum*), *Avena sativa*, *Linum usitatissimum*, *Camelina sativa*, *Vicia faba* var. *minor* and probably also *Brassica rapa* and *Cannabis sativa*. Though written sources give the consumption of *Hordeum vulgare*, *Avena sativa*, *Secale cereale* and *Triticum aestivum* for the third habitation period, samples of this period yielded only quite large amounts of the first two species. But samples of the third and last periods yielded many other economically important plants as well, including rare species like *Atropa bella-donna* and *Aframomum melegueta*. Compared with the subfossil records of other *terps*, this botanical richness is only found in medieval Leeuwarden and reflects the presence of a commandery of the Johanniter order in Heveskesklooster.

KEYWORDS: Archaeobotany, crop plants, environmental characterization, Heveskesklooster, identification of taxa, Johanniters, pollen analysis, Roman Period, Middle Ages, Modern Times, *terp*.

1. INTRODUCTION

1.1. The excavation of Heveskesklooster

Even though the *terp* (dwelling mound) of Heveskesklooster is remotely situated in the northeastern part of Groningen (see fig. 1), it has some interesting features showing great promise for archaeological research. Written sources give that a commandery of the Johanniter order was established at Oosterwierum after the Crusades, which explains the change of its name to 'Heveskesklooster', after the nearby located Heveskes *terp*. Archaeological finds justify the assertion that the cloister was thriving. The recovery of a megalithic grave under the *terp*, the only Dutch representative of a dolmen characterized by the position of the entrance in the narrow side (Bakker, 1992), was a surprise. A stone cist of the same period was also found. It was the first time that the presence of agricultural land on the *terp* proper, called valg(e), was established during an archaeological excavation.

The archaeological excavation of the Heveskesklooster *terp* was an 'emergency excavation' due to industrial development plans nearby Delfzijl. A few

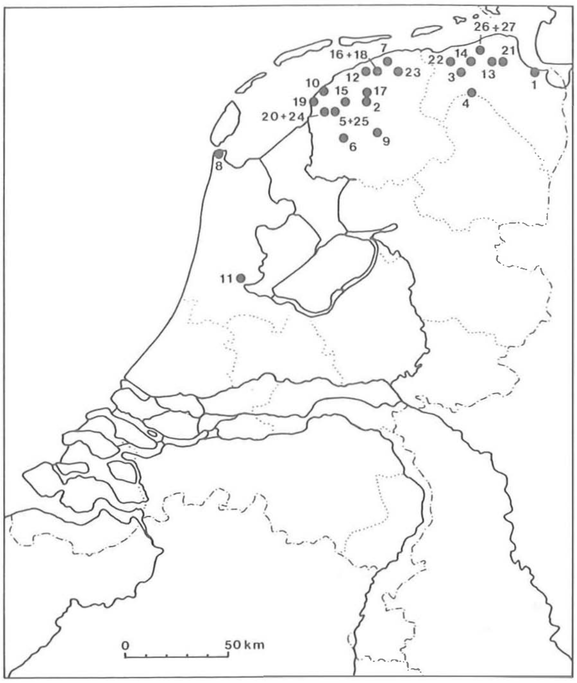


Fig. 1. Location of Heveskesklooster (No. 1) and other *terps* (Nos 2-27) that are analyzed for environmental characteristics and economically important plants. See for the names of *terps*: table 9.

years before, in 1976, the Heveskesklooster *terp* had already been listed as being of historical importance, a status which was to guarantee protection and scientific research when, for some reason, it had to be destroyed. Industrial expansion resulted in the excavation of the northern part of the *terp*, as this was the only part taken on a long-term lease. Under supervision of J.W. Boersma the excavation started as a survey in 1982 and was completed in 1988. By then, economic recession had caused stagnation of industrial expansion with the result that the levelled northern part of the *terp* remained unused.

During the excavation of the *terp*, soil samples were collected for botanical and zoological research. The faunal remains have partly been studied now and revealed information on the death of calves and foals (Prummel, 1988). In this study, the remains of vascular plants are analyzed, with the exception of charcoal and non-carbonized wood. The subfossil mosses will be published separately (Cappers & van Zanten, in press).

The botanical remains consist of wild plant species and cultivated plants. As for wild plant species, the aim is to present an ecological characterization, both exploring patterns in space and through time. The reconstruction of environmental characteristics is based on the floristic composition rather than on phyto-sociological reflections, as I assume that ecological characteristics of plant species are changed less than the composition of plant associations. Agricultural and other economically important plants are analyzed in connection with cultivation in other parts of the Netherlands and with other *terps* in particular. In addition, the archaeobotanical record is compared with evidence of written sources. An intermediate group of plants involves those which mainly grow in natural environments, but which may also have been used by men. They are dealt with in both groups.

The nomenclature of plant names follows van der Meijden (1990), whereas that of the syntaxa follows Westhoff & den Held (1975). The dates cited in the text are conventional radiocarbon dates, followed by the range in calendar years obtained by calibration at 2σ according to van der Plicht (1993).

1.2. The sedimentary records

The sedimentary succession of the Groningen coastal area diverges from other parts of the Dutch coast. One important difference is the presence of Holland peat (or Holland deposits) along the greater part of the west coast of the Netherlands, and which separates Dunkerque Deposits from Calais Deposits, whereas in the Groningen district this peat layer is either absent or, reversely, several peat layers are present (Griede & Roeleveld, 1982). There are even regional differences in the sedimentary record in the Groningen coastal area; these differences can often be explained in connection with the surface of the Pleistocene substrate (Roeleveld, 1974). Roeleveld classified the Holocene deposits of the Groningen district in the Wold Formation and the Groningen Formation. The Wold Formation is composed of basal peat (or basis peat) and the main peat member. The Groningen Formation consists of clay layers, which in some parts of the Groningen district is intercalated by the main peat member, and for this reason further subdivided by Roeleveld into a lower clastic member (GlF) and an upper clastic member (GuF).

The Heveskesklooster *terp* is located on an ice-pushed ridge formed during the Saale glaciation. Because of this ridge, the Pleistocene surface is at a depth of c. -2.00 to c. -1.60 m NAP (Dutch Ordnance Level). Owing to this relatively high position of the Pleistocene subsoil, the basal peat is directly overlaid by a clay layer belonging to the upper clastic member of the Groningen Formation (GuF).

According to Roeleveld (1974), the lower part of the basal peat usually consists of *Alnus* and/or *Betula* fen-wood peat and occasionally *Phragmites*. This peat had gradually changed into *Carex*, *Carex*/*Phragmites* and pure *Phragmites* peat. It is possible that *Eriophorum*, Ericaceae and even *Sphagnum* in the middle part of this peat may have developed as a result of oligotrophic conditions. Schoute (1984), who studied an exposure at the excavation site of Heveskesklooster, stated that the basal peat layer at this site is about 1 m thick and mainly consists of *Phragmites* peat. The clay layers were deposited during Dunkerque I-B, Dunkerque II and

Dunkerque III and were separated from each other by a vegetation horizon. The oldest clay bed can be subdivided on the basis of an intercalated *Phragmites/Scirpus* horizon, c. 20-25 cm thick (Schoute, 1984). This indicates a temporary decline in the rate of sea level rise during the Dunkerque I-B transgression. The lower and upper vegetation horizons were formed during the Holland VII and Holland VIII regression intervals respectively. The formation of these sediments, characterized by a given concentration of organic material, had probably taken place in a semi-terrestrial environment. Bohncke (1984) studied the botanical composition of the vegetation horizons from the Schildmeer area by means of pollen analysis and identification of macro-remains. Considering the long-distance transport of the dominant *Juncus gerardi* and *Salicornia europaea* from salt-marshes seaward of the study area, the composition shows major affinities with recently occurring Phragmitetalia, Molinietalia and Angelicion litoralis. Clay layers that belong to the Dunkerque III transgression were not found in the Heveskesklooster *terp*. They have probably been incorporated into the plough layer (Boersma, 1988).

1.3. Colonization

Colonization of the coastal area can be explained by the geological development of this area which made it suitable for habitation, and some processes in habitable regions which caused serious problems for survival. The colonization of newly formed Holocene deposits in the Groningen coastal area started at the beginning of the Holland VI regression (2600 ^{14}C-yrs BP). During this period, the salt-marshes that were formed during the preceding D-1A transgression became relatively well drained as a result of the progressive decrease in the rate of sea level rise (Roeleveld, 1974; Griede & Roeleveld, 1982). The beginning of the colonization of the Friesland and Groningen salt-marshes was probably caused by the combined effects of sand-drifts, the formation of raised bogs and soil exhaustion (Waterbolk, 1979; van Gijn & Waterbolk, 1984). These processes may have reduced the habitable area in the Drenthe Plateau (northern Netherlands) to such extent that, during the Iron Age, migration started towards the northern salt-marshes that had become suitable for settlement. As the salt-marsh area was separated from the sandy region by a peat area, it could only be reached by navigable waterways and along special routes overland. The Delfzijl area was connected with the sandy district by small sandy outcrops between Groningen and Delfzijl. The beginning of the settling in the salt-marsh area dates to the early Iron Age and the first part of the middle Iron Age. When during the middle Iron Age the area had become permanently inhabited, agricultural activities had started too (van Gijn & Waterbolk, 1984).

Several agricultural experiments were carried out along the North Sea coast to investigate whether crops could be cultivated in unprotected salt-marshes (Körber-Grohne, 1967; van Zeist et al., 1976; Bottema et al., 1980). *Camelina sativa* in particular could produce reasonable yields, even when salt water flooding had taken place during the growing season. More sensitive to inundations, particularly during the germination stage and therefore not risk-free in producing yields, are *Hordeum vulgare* ssp. *vulgare*, *Avena sativa*, *Vicia faba* var. *minor*, *Linum usitatissimum* and *Brassica rapa*. Moreover, some crops were damaged by winds, cattle, birds and insects. On the other hand, manuring the fields improved the yield of particularly *H. vulgare*, *A. sativa* and *V. faba* var. *minor*. Crops like *H. vulgare* ssp. *distichum*, *Triticum monococcum*, *T. aestivum* (including *T. spelta*) and *Panicum miliaceum* proved to be less suitable or even unfit for brackish conditions. The experiments showed that only the highest sandy parts of the unprotected salt-marshes were suitable for agriculture. There was a valg on the *terp* proper, but also on the coastal ridges and along creeks fields were probably laid out.

1.4. Periods of habitation of Heveskesklooster

As only a preliminary study of the archaeological record of the Heveskesklooster *terp* has been published (Boersma, 1988), a detailed dating of the habitation layers of the *terp* is not available as yet. The periodization is restricted to four main habitation periods that have been distinguished by Boersma. Additionally, Boersma subdivided the first habitation period into three phases; most botanical samples, however, could not be allotted to any of these phases. Therefore, Boersma's subdivision will be left aside in this study. The global periodization does not alter the fact that the samples that have been analyzed, represent a time resolution comparable with botanical samples of other archaeological sites.

1.4.1. *Period I (c. 50 BC-c. 400 AD)*

The habitation of Heveskesklooster begun during the second half of the first century BC. From the very beginning of habitation, a small *terp* was present, indicating that floodings were considered to be a serious threat. This idea is supported because of the *Phragmites/Scirpus* horizon which was used to build the *terp* on in the beginning of the habitation (fig. 2). In contrast with the vegetation horizons, which were formed in a semi-terrestrial environment, the *Phragmites/Scirpus* clay bed indicates wetter conditions. *Phragmites australis* can grow in places with a variety of water levels ranging from deep water to dry places. Inland reed marshes may occur in dry places subject to flooding for several months annually (van der Toorn, 1972). Nevertheless, the location of the *terp* was favourably situated as to water control. The *terp* was built just above the highest part of the Pleistocene ridge (Kortekaas, 1988), and a

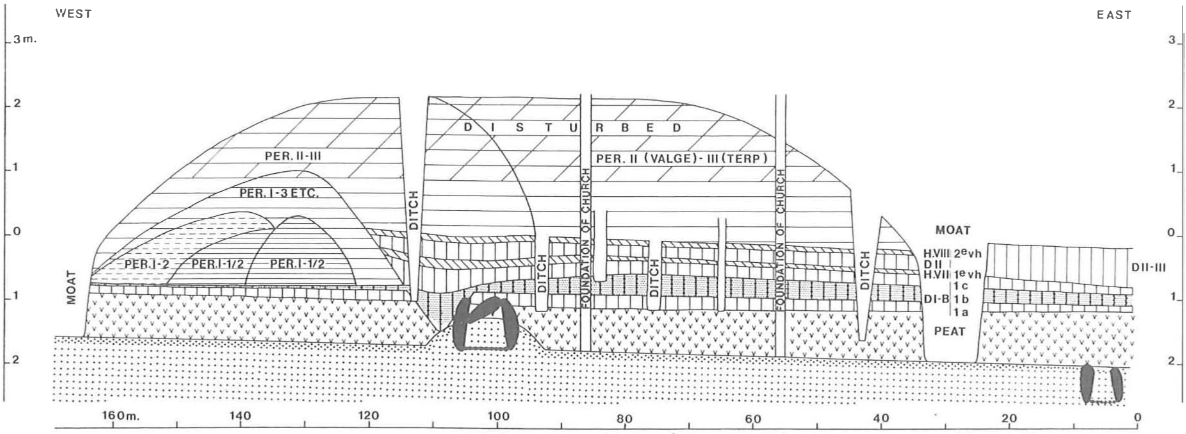


Fig. 2. Vertical section of the Heveskesklooster *terp* showing the development of the expansion of the *terp*. The dolmen and stone cist, both out of proportion in horizontal direction, are located in sand and overlaid with peat. The basal peat layer is covered with clay layers (DI-B Ia, c and DII), a *Phragmites/Scirpus* horizon (DI-B Ib) and vegetation horizons (H-VII and H-VIII).

marsh creek bordered both the north and the east side of the *terp* to guarantee drainage. On the *terp* were several trenches that drained into this creek. The drainage outside the *terp* partly displayed a right-angled pattern, indicating that the drainage was improved by ditches (fig. 3). A secondary function of these ditches may have been the protection of crops against cattle grazing, although it is not quite sure whether crops were cultivated at that place.

From the first period of habitation the remnants of two different farmhouses were found, probably occupied in succession. Before the second farmhouse was built, the *terp* was raised with clay that was deposited during D-IBc. Especially during this last phase of the Dunkerque IB transgression, the environment had become wetter or, at any rate, flooding frequencies increased. During the next Holland VII, the environment became relatively dry and it is likely that the first habitation period continued until the end of this regression phase.

It is not sure whether the habitation continued during the D-IBc transgression. During this period, the environment was covered with nearly 20 cm of clay sediment. Archaeobotanical evidence for the continuation of habitation should be based on the presence of sufficient numbers of remains of economic plants in samples that are dated to the second, third and fourth centuries AD. However, samples dated to these centuries were not available.

1.4.2. *Period 2 (c. 800-c. 1300)*

During the Dunkerque II, the habitation of the coastal area was interrupted in many settlements. It is quite possible that the occupation of the Heveskesklooster *terp* was discontinued too. Worked wood found in a bordering ditch was dated to 1480±20 BP (GrN-15098; 553-635 AD) and had probably originated from the nearby creek (Boersma, 1988). There is, however, no strong evidence for this, since it may have been transported by water over a long distance, particularly during this transgression phase.

The second period of habitation begun when the Holland VIII regression had set in for almost 200 years. In between the first and second habitation period, c. 20 cm of clay and a relatively thick vegetation horizon of 8 cm were deposited (Schoute, 1984). During the second habitation period, the *terp* had been enlarged in both northern and eastern direction. Remnants of farmhouses were found on two locations (fig. 4).

The floor plan clearly displays agricultural land on the *terp* (valg), parcelled out by ditches (fig. 4). The parcels nearby the farmhouses were small (c. 120-160 m^2), the more distant parcels larger. During the ninth century the valg had not artificially been raised, and was located on the natural elevation of the vegetation horizon. The circumference of the valg is mapped at the north, east and south sides and bordered by the following coordinates: O40, Y42, C'26 and G21 (fig. 4). The total area of the valg within the excavated area is almost 0,7 hectare. The area north of the road crossing the *terp* in a east-west direction had not been elevated and dissected by ditches, implying that it did not belong to the valg. Because of the increase in the rate of sea level rise during the Dunkerque III period and the gradual lowering of the surface due to reclamation of the vegetation horizon, the valg was elevated several times from the tenth century onwards. During the first raisings it was still necessary to intersect the valg with ditches. Later on, the surface had a somewhat convex shape, which made drainage without ditches possible (Boersma, 1988).

Reliable evidence of written sources about storm surges that could have affected the area around Heveskesklooster are scarce from the ninth to twelfth

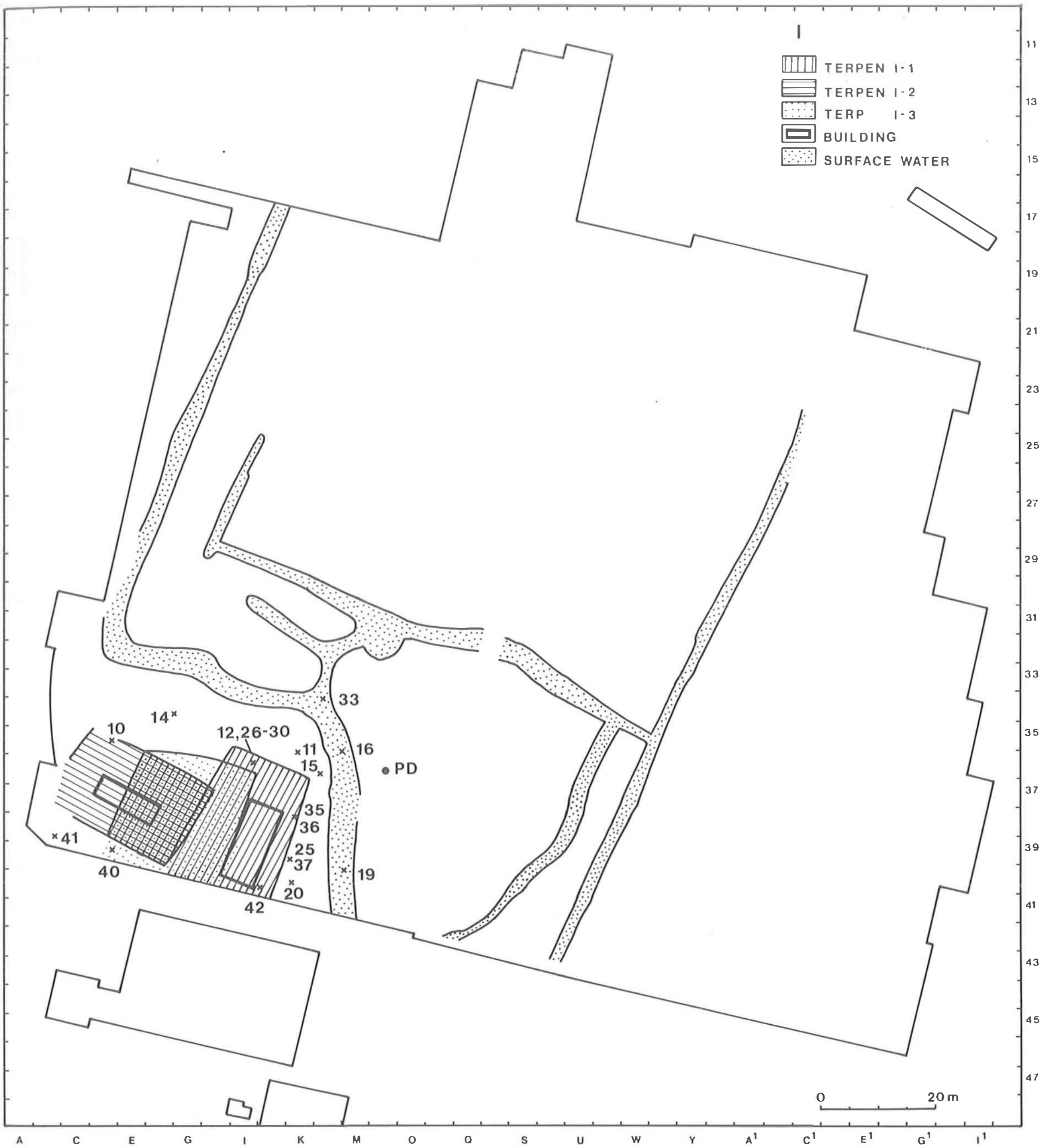


Fig. 3. Floor plan of the Heveskesklooster *terp* during habitation period 1. The farmhouses are labelled according to the sequence in which they were built. Beyond the *terp* parts of the creek and ditches are visible. The numbers refer to the samples (see table 1). Also indicated is the location where samples were taken for the pollen analysis.

centuries, whereas several storm surges have been mentioned for the thirteenth century (Gottschalk, 1971). The only dates of storm surges that could have caused floodings during the first four centuries of this habitation period are fixed on: 838, 1164 (probably) and 1196. Gottschalk mentioned the following years that would have caused flood disasters at Heveskesklooster in the thirteenth century: 1219, 1220, 1221 (two times), 1246 (probably), 1248 (two times), 1249, 1262, 1287, 1288 and 1290. The actual number may of course be higher, as only storm surges that caused serious damage had been documented.

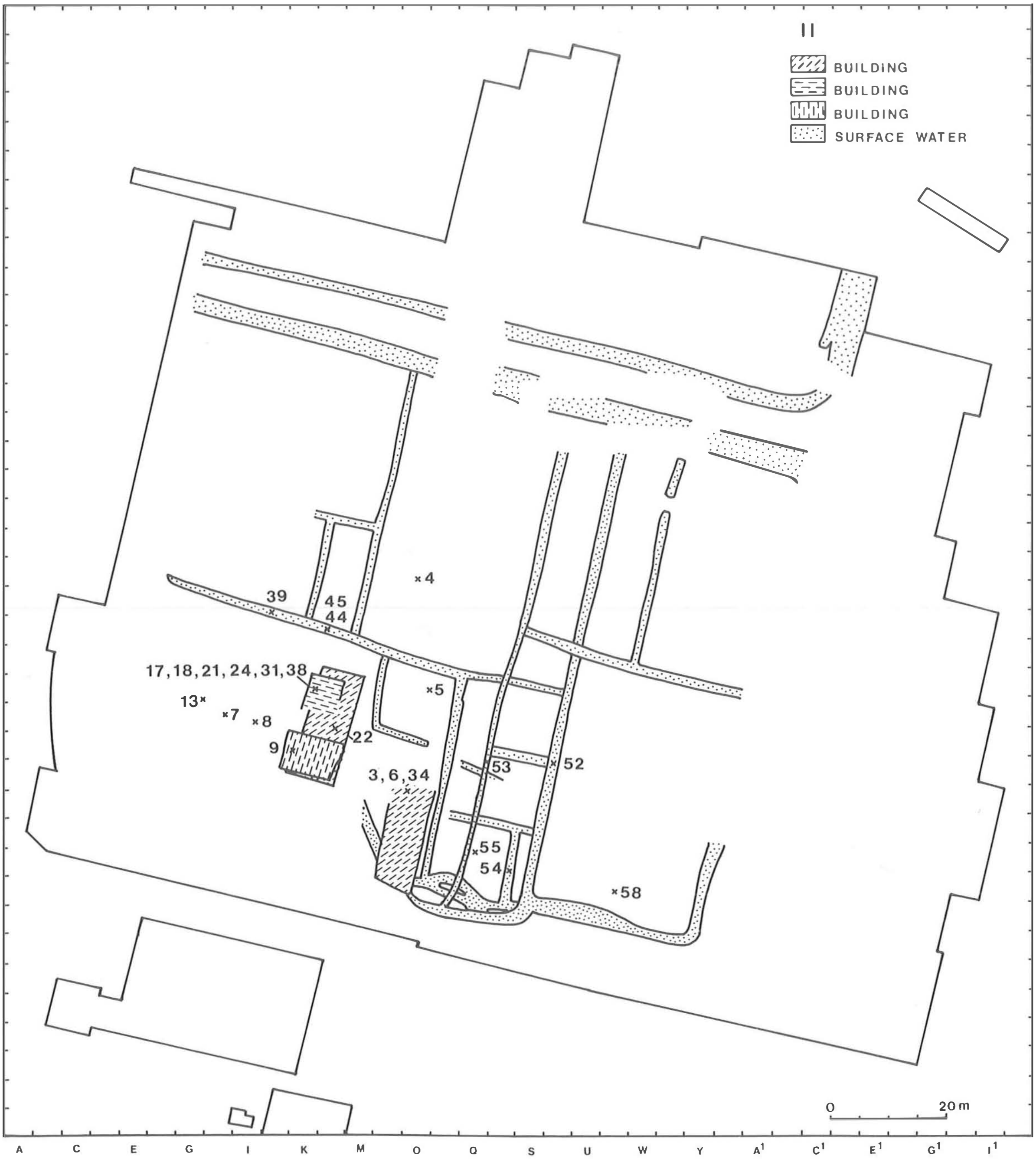


Fig. 4. Floor plan of the Heveskesklooster *terp* during habitation period 2. At the north and east sides of the farmhouses the valg is visible, dissected by ditches. Two broad ditches border the road in a east-west direction. The numbers refer to the samples (see table 1).

1.4.3. *Period 3 (c. 1300-1610)*

The late medieval habitation period is characterized by the presence of a commandery inhabited by both nuns and monks of the Johanniter order. In c. 1481, under the influence of the Reformation, it changed into a monastery (Noordhuis, 1990). The foundation is dated back to the end of the thirteenth century, its liquidation to 1610. The order of Johanniters had been established during the Crusades and they gained properties spread all over Asia and Europe in return for medical treatment. Important information is available from written sources on Heveskesklooster, which was still called 'Oosterwierum' in that period. Periodical rounds were made by delegations to draw up a statement of assets and

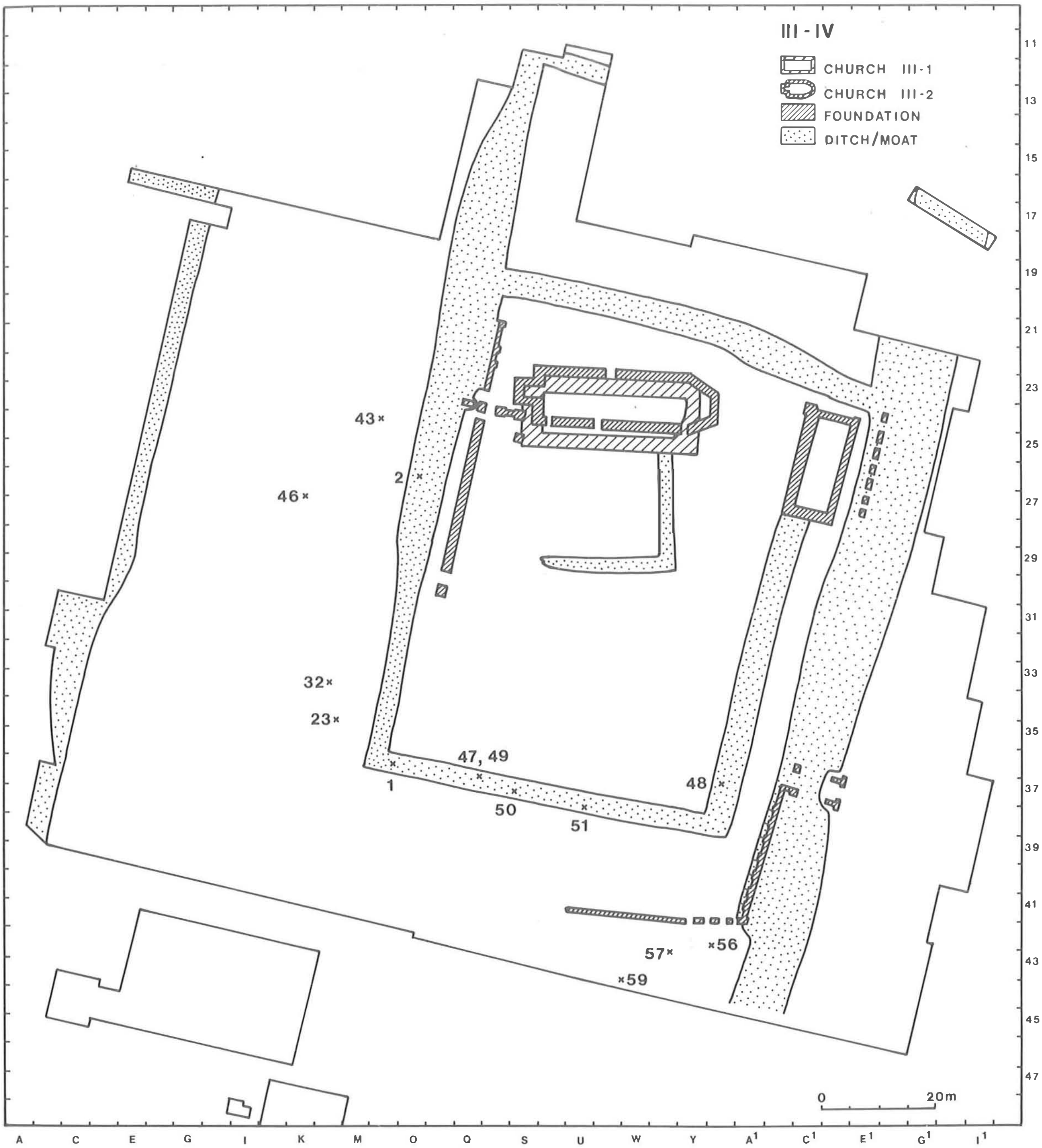


Fig. 5. Floor plan of the Heveskesklooster *terp* during habitation periods 3 and 4. On the former valg two foundations of churches and a churchyard surrounded by a ditch and a moat are present. Only fragments were found of other buildings. The numbers refer to the samples (see table 1).

liabilities. Unfortunately, only two of these reports, drawn up in 1495 and 1540, survived acts of war. Both reports indicate that at that time Heveskesklooster was a thriving settlement, but it should be mentioned that most of the monastic orders of Johanniters in the Netherlands were govemed by an economic management (Noordhuis, 1990). The information on the archaeobotanical records from these reports and from those drawn up when the commandery was closed down, is dealt with in the sections concerned.

Written sources are silent on the kind and number of buildings on the Heveskesklooster *terp*. The excavation of the *terp* revealed only traces of buildings with deep foundations. They are remnants of two churches, a stone house, a stone fence, a double moat and a churchyard (Boersma, 1988). Both church and churchyard, the latter south of the church and surrounded by a ditch, were situated on the northern part on the former valg (fig. 5). The agricultural use of this part of the *terp* was stopped. The location of Heveskesklooster along the route from Groningen via Appingedam and Oterdum to Emden (Germany) can be connected with the prosperity of the *terp* thanks to the cloister, and is of special interest for the archaeobotanical records.

In this third habitation period a number of storm surges taking place along the northeast coast of Groningen had been documented. They may have affected the area around Heveskesklooster and took place in the following years: 1424, 1426, 1436, 1446, 1499, 1507, 1508, 1509, 1514, 1516, 1520, 1524, 1554, 1570, 1578, 1585, 1586, 1587, 1588, 1590, 1592, 1597 and 1610 (Gottschalk, 1975, 1977). Gottschalk points out that dykes in Groningen were grossly neglected because of wars, as a result of which dyke breaches and floods took place frequently. It appears that the commander of Oosterwierum was responsible for water control in the Oterdum polder board because of the vastness of the properties. It should be mentioned, however, that particularly the Dollard area south of Heveskesklooster was inundated. For this period, Heveskesklooster itself is explicitly mentioned twice. In August 1524, the Koedijk at Heveskesklooster was damaged and in 1587, in the summer and the autumn, the water poured over the new quay at Heveskesklooster into the country. As the quay rested upon peat there was also much seepage (Gottschalk, 1975). The land belonging to the monastery was scattered all over the surrounding area, and great quantities of the crop may have been lost. It is not likely that the *terp* was further elevated during this third period of habitation (Boersma, 1988).

1.4.4. *Period 4 (1610-1975)*

During the last habitation period up to five farmhouses have been built on the *terp*. The last *terp* dwellers left in 1975. With the exception of some wells, only few traces of this period were found (Boersma, 1988).

In the seventeenth century, the last century documented by Gottschalk's standard work, the following years are mentioned during which storm surges had probably affected the area around Heveskesklooster: 1621, 1625, 1651, 1665, 1685 and 1686, the last one being particularly severe, destroying all dykes along the coast of Groningen (Gottschalk, 1977). Although the water penetrated far inland, no losses for Heveskesklooster were documented.

2. MATERIALS AND METHODS

2.1. Processing of samples

During the excavation years, many soil samples were collected for archaeobotanical research. Mixed with some formalin as a disinfectant, the samples were stored at the Biologisch-Archaeologisch Instituut in Groningen. To assess the potential botanical richness, some samples were analyzed by W. van Zeist and R.M. Palfenier-Vegter during the excavation. After the excavation had been concluded, the archaeobotanical research was continued. Until now, samples have been dated back to the four periods mentioned, some even to a combination of two periods. Only those samples were investigated that were dated with certainty to one of the four habitation periods (table 1). The distribution of the samples over the four periods is: 21 samples of period 1, 24 samples of period 2, 12 samples of period 3 and 2 samples of period 4. The low number of samples of the last period can be attributed to disturbances of the layers concerned, and therefore relatively few samples were taken. Due to the absence of organic sediments such as dung layers and difficulties in dating, only two samples were left that could be attributed to this period with certainty. The location of the samples is indicated on figures 3-6. Initially, 35 samples were selected, being representative of these four periods. From these samples usually 3 litres were examined. In a second phase, only 150 ml from the remaining accurately dated samples were investigated. On the basis of these analyses, another 8 samples were selected for further research.

The samples were soaked in water for one or two weeks, depending on the compactness of the soil. The samples were then poured into a stack of sieves with mesh sizes 2.0 mm, 1.0 mm, 0.5 mm and 0.2 mm. The sieve contents were sorted out under a dissecting microscope with 0.7-45 magnification. The coarse fractions of most samples (2.0 and 1.0) were completely analyzed, whereas only a representative part of the fine fractions was analyzed. The number of plant remains of these sample surveys were corrected in accordance with the fraction that was analyzed.

Identification was performed with a dissecting microscope and a high-power microscope. The latter was used not only for the transparent envelopes of grass fruits and small seeds such as *Juncus* spp., but also to examine the cell pattern of larger seeds with incident light. Macroscopic plant remains that consisted of both diaspores and vegetative remains, in as far as they were considered to be sufficiently characteristic for a specific identification, were isolated and identified with the help of a private reference collection and relevant literature. In each sample, however, several plant parts remained unidentified. In the last part of this study identification remarks are made on some plant remains.

The pollen analysis was carried out by van Klinken (1986) on samples that were taken from a profile northeast of the oldest part of the *terp* in August 1982 (see for location fig. 3). From the same section, samples were also taken to identify botanical macro-remains, in which subsamples of c. 100 g soil were analyzed at regular intervals. Samples for pollen analysis were analyzed at intervals varying from 1-7 cm. The samples

Table 1. Description of samples from Heveskesklooster. P. Period of habitation; Vol. Volume in litres.

No.	Label	P.	Vol.	Feature	Location
1	HK\0079	3	3,000	Moat	On *terp* top
2	HK\0082	3	3,000	Moat	On *terp* top
3	HK\0095	2	3,000	Waste pit	On slope (*terp*)
4	HK\0139	2	3,000	Well	On *terp* (farmland)
5	HK\0223	2	3,000	Waste pit	On slope (*terp*)
6	HK\0270	2	3,000	Waste pit	On slope (*terp*)
7	HK\0416	2	3,000	Waste layer	On *terp* top
8	HK\0421	2	3,000	Waste layer	On *terp* top
9	HK\0448	2	3,000	Waste layer	On *terp* top
10	HK\0599	1	3,000	Trench	Beyond *terp*
11	HK\0622	1	3,000	Trench	Beyond *terp*
12	HK\0735	1	3,000	Waste layer	On slope
13	HK\0791	2	3,000	Well	On *terp* top
14	HK\0820	1	3,000	Trench	Beyond *terp*
15	HK\0844	1	0,150	Posthole	Beyond *terp*
16	HK\0930	1	0,150	Marsh creek	Beyond *terp*
17	HK\1073	2	0,150	Well	On slope (*terp*)
18	HK\1074	2	3,000	Well	On slope (*terp*)
19	HK\1227	1	0,150	Gully	Beyond *terp*
20	HK\1237	1	0,150	Bank of creek	Beyond *terp*
21	HK\1276	2	0,150	Well	On slope (*terp*)
22	HK\1293	2	3,000	Waste pit	On slope (*terp*)
23	HK\1294	3	1,000	Well casing	On slope (*terp*)
24	HK\1298	2	3,000	Waste layer	On slope (*terp*)
25	HK\1437	1	3,000	Well	Beyond *terp*
26	HK\1484	1	3,000	Waste layer	On *terp* top
27	HK\1489	1	3,150	Waste layer	On *terp* top
28	HK\1555	1	3,000	Waste layer	On *terp* top
29	HK\1560	1	3,000	Waste layer	On *terp* top
30	HK\1562	1	3,000	Well	On *terp* top
31	HK\1579	2	3,000	Well	On slope (*terp*)
32	HK\1584	3	3,000	Well casing	On slope (*terp*)
33	HK\1635	1	0,150	Gully	Beyond *terp*
34	HK\1638	2	3,000	Well	On slope (*terp*)
35	HK\1670	1	3,000	Well	Beyond *terp*
36	HK\1671	1	3,000	Well	Beyond *terp*
37	HK\1680	1	3,000	Well	Beyond *terp*
38	HK\1698	2	0,150	Well	On slope (*terp*)
39	HK\1760	2	3,000	Ditch	On slope (*terp*)
40	HK\1840	1	3,000	Well	On slope
41	HK\1842	1	5,000	Well	Beyond *terp*
42	HK\1961	1	0,150	Waste layer	On slope (*terp*)
43	HK\1995	4	3,000	Waste pit	On slope
44	HK\2025	2	0,150	Waste pit	On slope (*terp*)
45	HK\2032	2	0,150	Ditch	On slope (*terp*)
46	HK\2098	4	3,000	Ditch	On *terp* top
47	HK\2283	3	3,000	Moat	On *terp* top
48	HK\2284	3	3,000	Moat	On slope
49	HK\2332	3	3,000	Moat	On *terp* top
50	HK\2379	3	3,000	Moat	On *terp* top
51	HK\2392	3	3,000	Moat	On *terp* top
52	HK\2595	2	0,150	Ditch	On slope (farmland)
53	HK\2597	2	0,150	Ditch	On slope (farmland)
54	HK\3319	2	0,150	Waste pit	On slope (farmland)
55	HK\3321	2	0,150	Waste pit	On slope (farmland)
56	HK\3351	3	3,000	Well	On slope
57	HK\3354	3	3,000	Well	On slope
58	HK\3357	2	0,150	Well	On slope (farmland)
59	HK\3359	3	3,000	Well	On slope

taken from the clay sediments were prepared by heavy-liquid separation (bromoform-alcohol mixture) followed by standard procedures as described by Faegri & Iversen (1975). The samples taken from the peat layer were boiled in a weak KOH solution before acetolysis.

2.2. Correspondence Analyses

Correspondence Analyses (Canoco version 3.12; ter Braak, 1993) were used to explore the species composition of the samples. With this type of analysis, an ordination is performed to summarize and subsequently arrange the data, looking for an underlying structure.

In contrast with data matrices of recent relevés, archaeobotanical data are not linked with environmental information such as ecological parameters. The sample information is restricted to extrinsic characters such as date and feature type (Lange, 1990). For that reason, indirect gradient analyses were performed, by which ordination axes and graphs are derived from variation within the vegetation data (Kent & Coker, 1992). The following environmental data were used: 1) period, 2) location and 3) feature type. The periodization is restricted to the four main habitation periods as described above. The location of the samples is indicated with respect to depth (fig. 6) and to the following three locations: samples collected from the flat, central part of the *terp*, samples from the slope and samples from beyond the *terp* (table 1; figs 3-5). The location of the valg has not been taken into account, as this distinction applies only to the second period of habitation. As to feature types, 10 kinds of contexts were used corresponding with the descriptions in table 1.

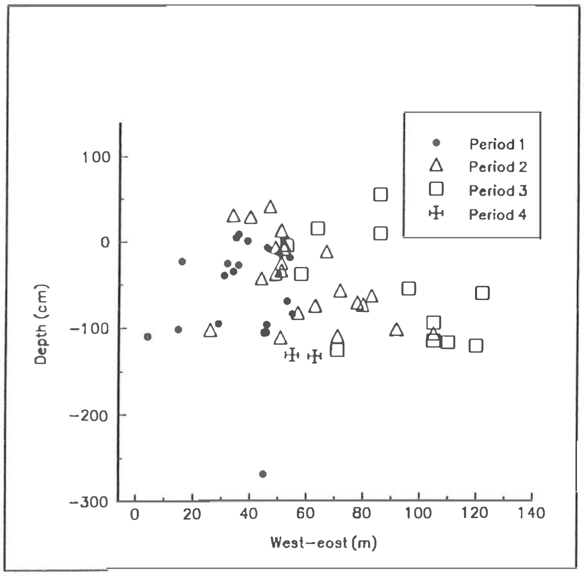


Fig. 6. Position of samples in relation to depth in the west-east direction. Depth is indicated according to Dutch Ordnance Level (NAP).

To reduce redundancy due to different levels of identification for the same clusters of taxa, standardization was performed on the data matrices used for Correspondence Analyses. Differences in identification are the result of differential preservation and the presence of different kind of plant parts of the same taxon, such as *Lemna* seeds in some samples and whole plants of *Lemna minor* and *Lemna trisulca* in others. The following rules were applied: 1) cereals were not converted to other taxonomic levels, 2) if a taxon is present at both species and subspecies levels, it is dealt with at species level (this applies to *Zannichellia palustris* only), 3) if a taxon is present at both genus and species level, it is dealt with at genus level when it is assumed that the genus represents the same (group of) species (e.g. *Betula* and *Bromus*), 4) families and genera are excluded if several taxa at species level are identified, except if taxa clearly represent unique taxa (e.g. Solanaceae in sample HK\2098, No.46). Only positively identified taxa are used in analyses. The total number of taxa was thus reduced from 288 to 251.

Correspondence Analyses were carried out on the basis of the number of diaspores. Exception was made for taxa that are preserved only by vegetative remains (e.g. calyces from *Armeria maritima*) and taxa that are frequently represented by both generative and vegetative parts (e.g. *Erica tetralix*). Of the latter, the sum of both kinds of remains are taken into account. In order to reduce large differences in numbers of plant remains, exceptional values were reduced to the maximum of 99999 in several samples for *Juncus gerardi* and in one sample for *Atriplex patula/prostrata*. Data sets were analyzed with Correspondence Analyses without data transformation, after ln-transformation and on the basis of presence/absence.

Separate Correspondence Analyses were carried out to determine the influence of small samples (150 ml) on the outcome, as they particularly represent the more frequent taxa, and samples with less than 10 taxa per sample, as Correspondence Analysis may be sensitive to frequencies (ter Braak, 1987). As a result of the last reduction, the minimum number is 16 taxa in 150 ml and 14 taxa in 3 litres. Charred and waterlogged data sets were treated separately via Correspondence Analysis but these analyses have been left aside as they revealed no extra information.

2.3. Characterization of the environment

The environment has been analyzed for the following characteristics: 1) salinity, 2) moisture, 3) nutrient availability and 4) structure of vegetation and succession. The classification system of ecological groups by van der Meijden et al. (1991) was used for labelling taxa with respect to each category. The advantage of this classification system is twofold: it takes into account the ecological range of taxa and it is based on the analyses of Dutch relevés.

The environmental characterization has been performed on two levels. In some analyses all taxa were used and eventually reduced to taxa with a small ecological range. In these analyses each taxon is of the same weight, but not the same frequency. The second approach was based on a select number of indicator taxa for each environmental characteristic, whereby the change of recovery by means of taxon weights is taken into account (Cappers, 1994).

3. RESULTS AND DISCUSSION

In this section the subfossil records of Heveskesklooster are presented and analyzed. In the first section the taxa are presented and some general remarks are made. In the following sections, samples are analyzed for species composition, external environmental variables and indicator values of the taxa. Attention is focused on salt-marsh vegetations and the environment is compared with the environment of other Dutch *terps*. Finally, the economically important plants are discussed, both in relation with the subfossil records of the Netherlands and with the *terps* in the northern part of the Netherlands in particular.

To some extent, the broad dating of the analyzed samples of Heveskesklooster limits a detailed reconstruction of the environment. However, due to complex taphonomic processes, many archaeobotanical samples contain a mixture of plants that require a variety of ecological conditions. For that reason, even when samples can be dated to a relatively small period, species within groups of samples are frequently merged in order to reconstruct phytosociological units or to characterize the abiotic environment (e.g. Körber-Grohne, 1967; van Zeist, 1974; van Zeist et al., 1987; Behre, 1991).

Another problem with interpreting the plant remains of Heveskesklooster is the representativeness of the species for this site. On the one hand, differential preservation causes selective loss of species, on the other, plants may have arrived at the site from remote places as a result of natural dispersal or human interference (Cappers, 1993, 1994).

The environment of the site can be distinguished into two areas: the *terp* proper and its immediate surroundings. As the excavation of the *terp* was restricted to the inhabited area, the macro-remains will, in any event, produce information about the vegetation on the *terp*, whereas the immediate surroundings can be deduced from the remains that can be interpreted as transported from elsewhere. As the *terp* was enlarged during the second and third period of habitation, samples of the first period that were once located beyond the *terp*, were available too. These samples will mainly provide information on the environment around the *terp*. As to the surroundings, the samples of the slope of the *terp* are of special interest too, for they may contain remains of former tidal marks.

3.1. Catalogue of taxa

Most samples proved to be rich in botanical remains. The taxa are separately presented for uncharred and charred remains. Taxa that are preserved by uncharred remains are conjoined in three parts: period 1 (table 2), period 2 (table 3) and a combination of period 3 and 4 (table 4). Taxa that are preserved by charred remains are compiled for all periods in table 5. In each table, taxa are arranged in systematic order. Because the number of plant remains displays a wide range, it was preferred to transform the numbers into a range from 1 to 10. The sample frequency, the characterization of the botanical remains as to the distinction between diaspores and non-diaspores, as well as the total number of plant parts, standardized to the volume examined, are presented in the last three columns of each table for each taxon.

In all, 288 different taxa were identified in the 59 analyzed samples of Heveskesklooster. Twelve taxa could not be positively identified, including the following taxa on species level: *Carex divulsa*, *Carex paniculata*, *Chelidonium majus*, *Elymus caninus*, *Eriophorum angustifolium*, *Potamogeton pusillus*, *Senecio viscosus* and *Stellaria uliginosa*. The taxa represent 184 genera spread over 51 families. Listed in decreasing order, the five best represented families are: Gramineae (33 taxa), Compositae (27 taxa), Cyperaceae (20 taxa), Caryophyllaceae (16 taxa) and Cruciferae (15 taxa). This enumeration corresponds with the species richness of the recent flora, with the exception of Leguminosae and Scrophulariaceae which are represented in Heveskesklooster by far less taxa.

Although sixteen species of Heveskesklooster have not been mentioned before in the subfossil record of the Netherlands, it is stressed that most of them were found in samples of the late Middle Ages and Modern Times. Two exceptions, both dated to the first habitation period, are *Isatis tinctoria* and *Symphytum officinale*. The latter reduces the number of taxa that on the basis of their current distribution and ecological requirements were expected to be part of the Dutch subfossil records, but had not been mentioned as yet (Cappers, 1994). Two other species date back from the second habitation period: *Dipsacus fullonum* and *Eleocharis quinqueflora*, while the latter was found more frequently in samples of the following period. The following new species belong to the third period too: *Aframomum melegueta* (identified by H. van Haaster), *Carex extensa*, *Ceratocapnos claviculata*, *Lemna trisulca*, *Malva neglecta*, and *Salix viminalis*. *Lemna trisulca* could be identified because the plant itself was preserved. Normally only duckweeds seeds are found, making identification to a species level unreliable. Noordam & Pals (1987) also mentioned *Malva neglecta* for the early Roman settlement of Valkenburg (ZH), but identification narrowed to species level is uncertain. Together with *Aframomum melegueta*, the following new taxa date of the last habitation period: *Berteroa incana*, *Chenopodium hybridum*, *Echium vulgare*, *Nigella arvensis*,

Table 2. Taxa of Heveskesklooster preserved by uncharred macro-remains of period 1. F. Sample frequency; P. Plant parts; N. Total number of plant parts.

Range	Specimen(s)	Identification
1 =	1	N^1 = uncertain at species level
2 =	2-5	N^2 = uncertain at genus level
3 =	6-10	
4 =	11-50	Plant parts
5 =	51-100	D = diaspore
6 =	101-500	O = parts other than diaspores
7 =	501-1000	B = both diaspores and non-diaspores
8 =	1001-5000	
9 =	5001-10000	
10 =	>10000	

Taxon	Sample 10	11	12	14	15	16	19	20	25	26	27	28	29	30	33	35	36	37	40	41	42	F	P	N
Thelypteris palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	1	O	120
Betula pubescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	2	B	3
Urtica dioica	2	4	-	4	-	-	-	-	4	-	-	-	-	4	-	6	7	8	-	-	-	8	D	3771
Urtica urens	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-	-	3	D	26
Polygonum aviculare	-	2	4	2	-	-	-	1	5	-	-	-	-	4	5	4	5	4	2	4	-	12	D	299
Polygonum convolvulus	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Polygonum lapathifolium	-	2^1	-	-	-	-	-	-	2	-	-	-	2	-	-	-	1	-	-	-	-	4	D	7
Polygonum persicaria	-	-	4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	D	*48*
Rumex	2	-	-	-	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-	-	3	D	20
Rumex acetosella	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	1	D	45
Rumex crispus	3	-	-	-	-	-	-	-	-	-	4	3^1	-	-	-	2	4	-	-	4	-	6	D	72
Rumex hydrolapathum	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	D	48
Rumex maritimus	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	1	D	10
Rumex obtusifolius	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	4	-	-	-	2	D	32
Atriplex litt./prostrata	3	-	3	4	-	2	-	-	6	-	-	-	-	3	-	4	2	4	-	4	-	10	D	286
Atriplex patula/prostrata	6	6	8	8	4	1	2	6	9	5	5	5	6	8	5	7	8	7	4	8	-	20	D	21801
Chenopodiaceae	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	1	D	26
Chenopodium album	-	2	5	-	-	-	-	1	4	-	-	-	-	2	1	5	6	8	-	3	-	10	D	1945
Chenopodium ficifolium	3	3	6	5	2	-	-	4	6	-	1	-	3	6	-	6	6	6	-	-	-	13	D	1518
Chenopodium glaucum/rubrum	6	4	-	6	3	-	-	4	8	-	4	-	-	7	1	3	7	5	4	5	1	15	D	4664
Salicornia europaea s.l.	4	2	4	6	1	-	-	-	8	-	4	-	-	5	6	5	6	3	-	4	-	13	D	2845
Suaeda maritima	1	2	4	5	2	1	-	2	7	2	-	-	-	5	5	6	4	-	-	6	-	14	D	1806
Lychnis flos-cuculi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	1	D	7
Silene dioica	-	-	3	-	-	-	-	-	-	-	1	-	-	-	-	-	-	3	-	-	-	3	D	16
Spergula arvensis	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Spergularia maritima/salina	5	-	-	8	-	-	-	2	8	-	10	-	-	6	8	6	6	-	4	4	-	11	D	18179
Stellaria media	-	-	1	2	-	-	-	-	4	-	4	-	3	5	-	6	6	7	-	-	-	9	D	1642
Ceratophyllum	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Ranunculus repens	-	-	6	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-	3	D	174
Ranunculus sceleratus	4	2	-	4	1	-	-	-	4	-	6	-	5	4	-	5	5	6	-	4	-	12	D	930
Camelina sativa	-	-	-	2	-	-	-	-	4	-	-	-	-	2	-	6	6	-	-	-	-	5	D	336
Capsella bursa-pastoris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	4	4	-	-	-	3	D	56
Descurainia sophia	-	-	-	3	-	1	-	-	-	-	-	-	-	-	-	7	6	7	-	-	-	5	D	1369
Isatis tinctoria	-	-	-	-	-	-	-	-	2	-	-	-	-	2	-	4	-	2	2	-	-	5	D	26
Sinapis arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	D	1
Potentilla	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	1	D	9
Potentilla anserina	3	4	6	-	2	-	-	-	5	3	4	-	4	2	-	4	4	4	-	5	-	13	B	474
Potentilla erecta	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	7
Prunus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	D	1
Rubus fruticosus s.l.	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	-	-	-	-	3	D	21
Rubus idaeus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	3	D	3
Trifolium repens	-	-	-	-	-	-	-	-	1	-	4	-	4	2	-	1	2	-	-	-	-	6	O	60
Vicia faba var. minor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	D	3
Linum usitatissimum	-	2	2	-	-	-	-	2	4	-	-	-	-	2	-	5	4	-	-	-	-	7	D	132
Euphorbia helioscopia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Euphorbia palustris	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	D	1
Althaea officinalis	-	-	-	-	-	-	-	-	4	-	-	-	4	-	-	4	4	-	-	2	-	5	D	95
Malvaceae	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	D	3
Viola	1	-	4	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	3	D	21
Lythrum salicaria	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	1	D	875
Myriophyllum spicatum	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	D	7
Myriophyllum verticillatum	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Apium graveolens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	1	D	7

Table 2 (Continued).

Taxon	Sample 10	11	12	14	15	16	19	20	25	26	27	28	29	30	33	35	36	37	40	41	42	F	P	N
Berula erecta	-	-	-	-	-	-	-	-	-	-	7	3	-	-	-	-	-	-	-	-	-	2	D	556
Conium maculatum	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	2	4	-	-	-	4	D	23
Daucus carota	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	D	1
Hydrocotyle vulgaris	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	D	2
Oenanthe	-	-	-	-	-	-	-	1^2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Oenanthe lachenalii	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	D	1
Umbelliferae-	-	-	-	-	-	-	-	-	4	-	-	-	-	4	-	-	-	-	-	-	-	2	D	27
Andromeda polifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	1	D	16
Calluna vulgaris	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	3	O	52
Erica tetralix	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	3	-	-	-	3	B	378
Empetrum nigrum	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	D	1
Anagallis arvensis	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	2
Glaux maritima	3	2	-	-	-	-	-	-	6	4	-	-	-	4	3	5	5	-	-	4	-	9	B	324
Limonium vulgare	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	1	1	-	-	-	-	3	O	16
Galium palustre	-	-	-	-	-	-	-	-	-	-	6	-	2	-	-	1	1	-	-	-	-	4	D	171
Cuscuta epilinum-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-	-	-	2	D	9
Symphytum officinale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Lamium amplexicaule	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	D	
Lamium purpureum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	4	-	-	-	3	D	45
Lycopus europaeus	-	-	-	-	-	-	-	-	-	-	5	-	4	-	-	-	-	-	-	-	-	2	D	91
Mentha aquatica/arvensis	4	2	4	4	-	-	-	1	4	5	6	4	7	4	-	5	6	4	-	-	-	14	D	1483
Stachys palustris	-	-	4	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	2	D	24
Solanum dulcamara	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	2	D	8
Solanum nigrum	1	-	1	-	-	-	-	1	2	-	-	-	-	-	-	2	3	6	-	-	-	7	D	163
Odontites vernus	-	-	-	3^2	-	-	-	-	-	-	2	-	-	-	-	3	1	-	-	-	-	4	D	19
Plantago major	2	4	4	6	2	-	-	4	6	-	5	-	3	6	2	6	6	3	-	5	-	15	D	1307
Plantago maritima	1	-	1	4	-	-	-	-	6	-	-	-	-	6	1	6	6	-	-	5	-	9	D	902
Artemisia vulgaris	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	16
Aster tripolium	4	-	-	2	-	2	-	-	2	-	-	-	4	4	3	4	4	-	-	6	-	10	D	567
Bidens tripartita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	D	1
Carduus crispus	4	-	-	2	-	-	-	-	2	3	-	-	-	-	-	-	3	-	-	-	-	5	D	36
Cirsium arvense	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2^1	1	-	-	-	-	3	D	5
Cirsium vulgare	2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	3	D	18
Compositae	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	D	2
Eupatorium cannabinum	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	3	4	-	-	-	-	3	D	50
Leontodon autumnalis	-	-	-	-	-	-	-	-	2	2	2	-	-	3	-	3	2	-	-	-	-	6	D	27
Matricaria maritima	-	-	-	4	-	-	-	-	5	-	1	-	4	4	2	4	5	2	-	6	-	10	D	367
Sonchus	-	-	-	-	-	-	-	1^2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Sonchus arvensis	2	2	-	2	-	-	-	-	1	-	-	-	2	2	2	-	2	-	2	-	-	9	D	28
Sonchus asper	2	-	4	3	3	-	-	-	6	-	2	-	-	6	-	4	6	-	2	6	-	11	D	622
Sonchus oleraceus	-	2	-	-	1	-	-	-	4	-	1	-	-	4	-	-	2	-	2^1	-	-	7	D	77
Taraxacum officinale s.l.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Triglochin maritima	4	5	-	6	4	4	-	5	8	-	4	-	3	8	3	8	7	4	4	8	-	16	B	6651
Triglochin palustris	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	D	3
Potamogeton pectinatus	2	-	-	-	-	-	-	-	1	-	-	-	-	3	-	-	1	-	-	-	-	4	D	11
Ruppia maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	2	D	3
Zannichellia palustris	-	2	-	3	-	-	-	-	4	-	-	-	-	-	-	4	4	-	2	-	-	6	D	93
Zannichellia pal. ssp. *pal.*	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	D	24
Zannichellia pal. ssp. *ped.*	3	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	2	D	23
Juncus	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	4	-	-	-	8	-	3	B	2989
Juncus bufonius	5	-	9	-	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-	-	4	D	6129
Juncus gerardi	8	10	8	8	8	5	6	8	10	4	8	6	8	10	8	10	10	10	9	10	-	20	D	1160857
Agrostis	6	2	-	4	4	-	-	4	7	4	10	8	7	8	4	7	7	-	4	8	-	16	B	39461
Alopecurus geniculatus	-	-	6	-	-	-	-	-	4	-	4	-	-	-	-	-	3	-	-	-	-	4	D	315
Bromus	-	-	-	3	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	D	9
Elymus athericus/repens	-	-	-	-	-	-	-	2	4	-	-	-	-	2	2	3	2	-	-	4	-	7	D	108
Festuca rubra	2	-	-	-	-	-	-	-	3	-	5	-	-	-	1	2	3	-	-	-	-	6	D	95
Gramineae	2	-	-	-	2	-	-	-	4	-	3	4	-	4	1	4	-	-	4	7	-	10	D	780
Gramineae trib. Cerealeae	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	D	2
Hordeum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	D	3
Hordeum vulgare	-	-	-	-	-	-	-	-	4	-	-	-	-	-	2	5	6	-	-	3	-	5	B	290
Lolium perenne	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-	-	2	D	3
Molinia caerulea	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	3	-	-	-	-	-	2	D	25
Phalaris arundinacea	-	-	-	-	-	-	-	-	4	-	2	-	-	-	-	3	1	-	8	-	-	5	B	1059
Phragmites australis	2	-	-	3	-	-	-	-	-	-	-	2	4	4	-	6	4	-	4	4	-	9	D	588
Poa annua	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-	2	D	11

Table 2 (Continued).

Taxon	Sample 10	11	12	14	15	16	19	20	25	26	27	28	29	30	33	35	36	37	40	41	42	F	P	N
Poa palustris	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	1	D	337
Poa pratensis/trivialis	1	-	-	-	-	-	-	-	4	4	8	6	4	5	4	4	4	-	5	-	-	11	D	1628
Puccinellia distans	-	2	-	6	1	-	-	-	6	-	-	-	-	4	-	6	5	-	2	-	-	8	D	529
Puccinellia maritima	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	-	4	D	32
Lemna minor	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	1	O	8
Carex acuta/nigra	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	D	2
Carex cuprina	-	2	4	-	-	-	-	-	2	-	3	-	2	-	-	1	-	1	-	3	-	8	D	40
Carex distans	1	-	3	-	-	-	-	-	-	-	-	2	2	-	-	-	2	-	-	-	-	5	D	20
Carex ovalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	D	9
Carex riparia	-	-	-	2	-	-	-	-	-	3	5	-	-	2	-	2	1	-	6	3	-	8	D	.190
Carex subg. *Vignea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	2	-	-	-	-	2	D	20
Carex subg. *Carex*	-	-	1	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	3	D	4
Eleocharis palustris	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-	3	-	-	-	-	3	D	11
Eriophorum vaginatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	D	5
Scirpus lacustris ssp. *tab.*	-	-	-	-	-	-	-	-	2	-	2	-	-	2	-	2	-	-	-	4	-	5	D	25
Scirpus maritimus	4	4	4	3	4	1	1	4	4	2	4	2	4	6	2	5	6	4	2	10	-	20	D	13666

Table 3. Taxa of Heveskesklooster preserved by uncharred macro-remains from period 2. F. Sample frequency; P. Plant parts; N. Total number of plant parts. For other abbreviations, see table 2.

Taxon	Sample 3	4	5	6	7	8	9	13	17	18	21	22	24	31	34	38	39	44	45	52	53	54	55	58	F	P	N
Thelypteris palustris	2	-	-	-	-	-	-	-	-	2²	-	-	-	3	1	-	-	-	-	-	-	-	-	1	5	O	16
Salix	-	-	-	-	-	-	-	-	-	-	-	-	4	2	-	-	-	-	-	-	-	-	-	-	2	O	18
Betula	-	-	-	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	D	13
Cannabis sativa	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	12
Urtica dioica	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	19
Urtica urens	-	-	-	-	-	-	-	7	-	-	1	-	-	-	-	-	-	2	-	1	-	1	1	-	6	D	854
Polygonum aviculare	8	-	2	-	4	4	6	4	3	5	6	8	7	5	4	1	-	2	5	1	3	-	2	-	19	B	7590
Polygonum convolvulus	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	4	D	5
Polygonum hydropiper	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	-	2	D	12
Polygonum lapathifolium	6	1	3	3	1	-	-	2	2	3	2	4	6	4	4	-	-	1	2	1	2	-	3	-	18	D	834
Rumex	-	-	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	B	3
Rumex acetosella	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	1	-	4	-	3	D	60
Rumex crispus	-	-	-	-	-	-	-	4	-	2	-	-	1	-	2	-	-	-	-	-	-	-	-	-	4	D	27
Rumex obtusifolius	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Chenopodiaceae	-	-	-	-	-	-	-	5	-	-	-	7	-	-	-	-	-	3	-	-	-	-	-	4	4	D	947
Beta vulgaris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Chenopodium	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Chenopodium album	-	-	-	-	-	-	-	6	2	4	2	6	5	4	1	-	3	2	1	2	1	-	-	-	13	D	666
Chenopoditum ficifolium	5	-	-	-	-	-	-	3	-	-	-	7	-	4	-	-	-	2	-	-	1	-	1	1	8	D	719
Chenopodium glaucum/rubrum	-	-	-	-	-	-	-	-	2	-	-	8	-	-	3	2	-	2	1	-	-	1	-	-	7	D	1198
Atriplex litt./prostrata	4	1	2	-	1	-	-	1	-	4	-	7	5	1	4	1	-	-	-	-	2	-	-	1	13	D	900
Atriplex patula/prostrata	10	2	1	4	8	9	7	6	6	8	6	10	10	8	8	3	8	6	5	4	5	2	6	5	24	D	420539
Salicornia europaea s.l.	6	-	1	8	-	-	6	4	2	8	2	6	8	6	6	-	6	1	4	-	2	-	6	2	18	D	8965
Suaeda maritima	8	2	1	9	2	-	6	-	4	8	4	8	8	8	5	-	6	4	3	-	4	1	4	4	20	D	17794
Stellaria media	-	-	-	-	-	-	-	7	-	2	1	-	6	4	5	2	3	2	3	1	4	2	3	2	15	D	816
Cerastium arvense/fontanum	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	2	D	38
Spergula arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	D	3
Spergularia maritima/salina	7	-	2	8	6	6	8	6	4	9	4	8	8	8	6	4	7	4	6	1	5	2	5	4	23	D	18650
Agrostemma githago	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-	1	-	-	-	-	2	1	1	-	6	D	32
Silene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	D	1
Silene latif. (ssp. *alba*)	-	-	-	-	-	-	-	-	2	-	-	-	5	2	4	-	-	-	-	-	-	-	-	-	4	D	96
Ceratophyllum	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Ranunculus flammula	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	38
Ranunculus repens	-	-	-	-	2	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3	D	6
Ranunculus sardous	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	15
Ranunculus sceleratus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	D	1
Cruciferae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	D	1

Table 3 (Continued).

Taxon	Sample																								F	P	N
	3	4	5	6	7	8	9	13	17	18	21	22	24	31	34	38	39	44	45	52	53	54	55	58			
Descurainia sophia	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	1	D	19
Cochlearia	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	10
Cochlearia officinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	D	24
Capsella bursa-pastoris	-	-	-	-	-	-	-	6	-	-	-	4	-	-	-	-	-	-	-	1	-	-	-	-	3	D	380
Thlaspi arvense	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	1	-	4	D	7
Brassica nigra	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	2
Brassica rapa	-	-	-	-	-	-	-	3	2	-	1	-	-	2	4	-	-	1	-	-	-	-	-	-	6	D	48
Sinapis arvensis	4	2	4	4	2	4	4	1	3	4	1	7	7	6	6	1	-	3	2	-	1	-	4	2	21	B	1916
Raphanus raphanistrum	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	2	D	47
Rosaceae	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	3
Rubus fruticosus s.l.	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	4
Potentilla anserina	5[2]	-	-	6	4	2	4	3	-	-	1	4	4	4	5	-	-	-	-	-	-	1	1	-	13	B	443
Potentilla erecta	-	-	-	-	-	-	-	-	-	-	1[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Vicia crac./sat. ssp. *nigra*	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	2
Vicia faba var. *minor*	-	-	2	-	-	-	-	-	-	2	-	1	4	1	2	-	-	-	-	-	-	-	-	-	6	D	39
Medicago lupulina	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	1	D	6
Trifolium repens	-	4	2	-	6	-	-	-	-	4	1[1]	-	4	-	4	-	6	1	-	-	-	-	1	-	10	B	460
Linum usitatissimum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	D	1
Euphorbia helioscopia	-	-	-	-	-	-	-	2	-	2	-	5	3	-	1	-	-	-	-	-	-	-	-	-	5	D	88
Viola	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	D	1
Hydrocotyle vulgaris	-	-	-	-	-	-	-	5	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	2	D	61
Berula erecta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Conium maculatum	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Bupleurum tenuissimum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	D	1
Erica tetralix	-	-	-	-	-	-	-	-	-	-	-	4	-	3	-	-	-	-	-	-	-	-	-	-	2	O	27
Calluna vulgaris	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	O	14
Andromeda polifolia	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	1	D	19
Glaux maritima	5	-	-	9	-	5	-	5	-	6	2	-	5	6	6	1	4	-	2	4	3	2	4	-	16	B	8796
Anagallis arvensis	-	-	-	-	-	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	2	D	21
Armeria maritima	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	3	-	-	-	-	-	-	-	3	O	15
Galeopsis bif./spec./tetr.	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	1	-	3	D	6
Lamium amplexicaule	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	88
Lamium purpureum	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	12
Stachys palustris	-	-	-	-	-	-	-	-	-	-	1	5	-	1	1	-	-	-	-	-	-	-	-	-	4	D	71
Prunella vulgaris	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	21
Mentha aquatica/arvensis	-	-	-	-	-	-	-	-	-	-	-	4	-	-	2	-	-	1	-	-	-	-	-	-	3	D	25
Hyoscyamus niger	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Solanum dulcamara	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	2	D	2
Solanum nigrum	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3	D	4
Odontites vernus	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	10
Plantago major	6	-	1	5	6	6	6	4	1	-	-	6	1	5	5	1	-	3	1	-	3	2	2	2	19	D	1043
Plantago maritima	8	-	-	8	1	6	5	-	-	7	1	-	7	8	6	2	5	-	3	-	3	3	3	1	17	B	7661
Sambucus nigra	-	-	-	-	-	-	-	1	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	3	D	6
Dipsacus fullonum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	D	1
Compositae	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	1	D	6
Aster tripolium	6	1	-	8	-	-	6	4	1	7	2	4	6	6	4	2	6	2	3	-	-	2	2	2	19	B	6119
Bidens tripartita	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1
Matricaria maritima	9	-	2	-	-	-	6	4	-	6	2	10	7	6	5	1	-	4	3	1	3	-	2	2	17	D	21014
Matricaria recutita	-	-	-	-	-	-	-	-	-	-	-	5	-	3	-	-	-	-	-	-	-	-	-	-	2	D	94
Carduus crispus	-	-	-	-	-	-	-	-	-	-	-	2[2]	-	-	2	-	-	-	-	-	-	-	-	-	2	D	5
Cirsium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Cirsium arvense	-	-	-	-	-	-	-	-	-	4	-	-	4	-	-	-	-	-	-	-	-	-	1	-	3	D	44
Centaurea cyanus	-	-	-	-	-	-	-	-	-	-	-	-	2[1]	-	-	-	-	-	-	-	1	-	-	-	2	D	3
Leontodon autumnalis	-	2	-	-	-	-	-	2	-	3	-	-	-	2	4	1	4	-	-	-	2	2	2	-	10	D	95
Leontodon saxatilis	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	14
Sonchus arvensis	5	-	1	-	4	-	-	-	-	4	-	8	6	4	4	-	-	1	1	1	-	-	2	-	12	B	3476
Sonchus asper	-	-	-	-	4	2	-	2	1	4	-	6	6	3	2	1	-	1	-	-	-	-	2	-	12	D	407
Sonchus oleraceus	5	-	-	-	-	2	-	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1	-	6	D	100
Triglochin maritima	9	6	6	10	7	8	10	4	5	8	5	6	10	9	8	4	7	6	5	2	4	4	5	4	24	B	108499
Potamogeton pectinatus	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1	D	8
Juncus	-	2	-	-	-	-	-	6	-	-	-	5	7	6	-	-	-	-	-	1	-	3	1	3	9	B	1618
Juncus acut./artic./bulb.	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1016
Juncus bufonius	-	-	-	-	-	5	-	6	-	-	-	-	-	1	-	4	-	1	-	-	-	5	4	4	8	D	319
Juncus gerardi	10	-	-	10	8	9	10	9	9	10	8	10	10	10	10	7	10	8	8	6	8	6	8	7	22	D	5548997
Gramineae	2	-	-	-	4	2	-	4	-	4	-	4	4	2	4	-	4	4	-	-	1	1	-	2	14	D	234
Festuca rubra	-	2	-	5	4	6	4	-	-	7	1	-	6	5	6	-	6	1	2	-	-	4	2	2	16	D	1851

Table 3 (Continued).

Taxon	Sample 3	4	5	6	7	8	9	13	17	18	21	22	24	31	34	38	39	44	45	52	53	54	55	58	F	P	N
Lolium	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	6
Lolium perenne	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	57
Poa annua	-	-	-	-	-	4	-	4	-	-	6	-	-	-	3	-	3	-	5	-	-	2	-	-	7	D	583
Poa palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	1	D	6
Poa pratensis/trivialis	-	-	-	-	7	7	-	3	-	5	-	-	4	4	4	-	6	-	2	-	2	4	-	-	11	D	2360
Puccinellia	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	16
Puccinellia distans	5	-	-	6	2	-	4	3	1	-	-	6	5	5	4	-	-	-	-	-	4	-	3	-	12	D	654
Puccinellia maritima	-	-	-	6	-	-	6	-	-	-	-	-	-	4	4	-	-	-	-	-	1	-	-	1	6	D	432
Cynosurus cristatus	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	2
Bromus	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	D	2
Bromus hordeaceus/secalinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	D	1
Elymus athericus/repens	2	2	2	-	4	-	4	-	1	-	-	6	5	4	2	-	4	2	1	-	-	2	1	-	15	D	618
Elymus caninus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1[2]	-	-	-	1	D	1
Hordeum	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	1	D	7
Hordeum vulgare	1	2	5	-	-	-	-	4	-	6	1	8	4	2	5	-	2	1	-	-	-	1	4	1	15	B	2659
Avena	-	-	1	-	2	-	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	4	D	9
Holcus lanatus	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	19
Agrostis	7	2	1	10	8	9	9	4	-	10	6	4	9	9	8	4	7	-	5	4	6	6	4	4	22	D	72726
Alopecurus geniculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	D	1
Phragmites australis	-	-	-	-	-	4	6	-	1	-	-	-	6	5	6	4	-	-	5	-	-	-	-	-	8	D	521
Danthonia decumbens	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	144
Gramineae trib. Cerealeae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	D	1
Scirpus lacustris ssp. *tab.*	-	-	-	-	-	2	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	2	D	11
Scirpus maritimus	2	-	2	4	3	-	2	6	1	4	-	4	5	5	3	-	-	2	1	-	1	-	1	1	17	D	422
Eleocharis palustris	-	-	-	-	-	-	-	6	1	1	-	-	3	3	-	-	-	-	-	-	-	-	-	-	5	D	141
Eleocharis quinqueflora	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	8
Rhynchospora alba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	D	1
Carex acuta/nigra	-	-	-	-	-	-	-	6	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	2	D	151
Carex cuprina	-	-	-	-	4	2	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	D	32
Carex distans	-	-	-	-	-	-	-	4	-	-	-	-	4	1	2	-	-	-	-	-	-	-	-	-	4	D	45
Carex disticha	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	D	19
Carex flava/lepid./oederi	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	292
Carex ovalis	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	D	5
Carex panicea	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	14
Carex riparia	-	-	-	-	4	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	2	D	54
Carex subg. *Carex*	-	-	-	-	-	-	-	4	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	D	21
Carex subg. *Vignea*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	D	1

Table 4. Taxa of Heveskesklooster preserved by uncharred macro-remains from period 3 and 4. F. Sample frequency; P. Plant parts; N. Total number of plant parts. For other abbreviations, see table 2.

Taxon	Sample and period 1	2	23	32	47	48	49	50	51	56	57	59	43	46	F	P	N
	3	3	3	3	3	3	3	3	3	3	3	3	4	4			
Salix	-	-	-	-	-	-	-	-	-	1	-	-	-	2	2	O	3
Salix viminalis	-	-	-	-	-	-	-	4	6	-	-	-	-	-	2	B	139
Betula	-	4	-	-	-	-	-	-	-	4	-	-	4	-	3	D	87
Betula pendula	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	B	49
Betula pubescens	-	-	-	-	-	6	-	-	-	-	-	-	-	-	1	D	197
Quercus	-	4	-	-	-	4	-	-	-	3	-	-	-	5	4	O	116
Ficus carica	-	6	-	-	-	-	-	-	-	-	-	-	3	8	3	D	2236
Humulus lupulus	-	4	-	-	-	-	-	-	-	-	-	-	-	-	1	D	15
Cannabis sativa	4	3	-	-	2	-	-	-	4	1	2	2	2	3	9	D	74
Urtica dioica	-	6	-	-	3	-	-	-	4	-	-	-	6	7	5	D	1113
Urtica urens	6	-	2	-	5	-	3	4	6	6	4	2	5	6	11	D	952
Polygonum	-	-	-	-	-	-	6	-	-	-	-	-	-	-	1	D	468
Polygonum aviculare	7	5	6	5	7	2	6	6	5	6	4	4	5	5	14	B	2909
Polygonum convolvulus	6	-	-	-	2	-	4	1	1	-	1	-	-	6	7	D	418
Polygonum hydropiper	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	D	64
Polygonum lapathifolium	8	5	-	6	9	3	6	6	4	4	3	4	5	7	13	D	12268

Table 4 (Continued).

Taxon	Sample and period														F	P	N
	1	2	23	32	47	48	49	50	51	56	57	59	43	46			
	3	3	3	3	3	3	3	3	3	3	3	3	4	4			
Polygonum minus	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	14
Polygonum persicaria	-	-	-	3	-	-	-	3	-	-	-	-	-	6	3	D	216
Fagopyrum esculentum	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	D	7
Rumex	2	-	-	1	-	4	-	-	-	-	-	-	-	3	4	D	24
Rumex acetosella	-	6	-	-	5	-	5	-	-	-	-	-	6	8	5	D	2598
Rumex crispus	7	-	-	-	7	-	6	6	7	4	4	3	4	4	10	B	2779
Rumex hydrolapathum	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Rumex maritimus	4	-	-	-	7	-	-	1	3	-	-	-	-	1	5	D	637
Rumex obtusifolius	-	4	-	-	-	-	-	-	-	-	-	-	-	4	2	D	45
Chenopodiaceae	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1	D	37
Beta vulgaris	-	-	-	-	-	-	-	2	-	1	-	-	-	-	2	D	3
Chenopodium album	8	6	4	-	9	4	9	6	6	4	4	5	6	8	13	D	18294
Chenopodium ficifolium	-	-	-	-	6	-	4	-	3	-	-	4	-	2	5	D	178
Chenopodium glaucum/rubrum	-	-	4	-	5	-	-	5	5	4	3	-	7	4	8	D	938
Chenopodium hybridum	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Atriplex litt./prostrata	-	-	2	4	3	-	4	-	1	-	1	-	-	-	6	D	66
Atriplex patula/prostrata	10	6	7	8	8	2	10	6	7	5	6	6	7	6	14	D	31527
Salicornia europaea s.l.	-	-	8	7	-	-	-	-	-	5	3	4	4	-	6	D	2568
Suaeda maritima	-	4	6	7	-	-	-	-	2	4	4	-	-	1	7	D	1048
Arenaria serpyllifolia	-	-	-	-	-	-	-	4	-	-	-	-	-	-	1	D	14
Moehringia trinervia	-	-	-	-	-	-	-	-	-	3	-	-	-	-	1	D	9
Stellaria graminea	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	D	6
Stellaria media	8	1	2	4	6	2	10	8	6	6	4	4	6	6	14	D	17994
Stellaria uliginosa	-	-	-	-	-	-	-	-	4[1]	-	-	-	-	-	1	D	46
Cerastium arvense/fontanum	-	-	-	-	8	-	-	7	4	5	2	-	6	1	7	D	2663
Sagina	-	-	-	-	-	-	-	6	-	8	-	-	-	8	3	D	3349
Sagina apetala/procumbens	-	-	-	-	-	-	-	-	-	-	-	-	6	-	1	D	271
Scleranthus annuus	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	O	58
Spergula arvensis	-	-	-	4	-	-	-	-	2	-	-	-	-	5	3	D	112
Spergularia maritima/salina	-	1	10	6	-	-	6	4	3	6	4	-	6	3	10	D	21345
Lychnis flos-cuculi	-	-	-	-	6	-	-	4	-	-	-	-	5	-	3	D	395
Agrostemma githago	-	-	-	-	-	-	-	-	-	-	-	-	1	8	2	D	1926
Silene dioica	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	15
Silene latif. (ssp. *alba*)	-	-	-	4	-	-	-	-	-	-	-	-	-	4	2	D	38
Silene vulgaris	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	112
Saponaria officinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	3
Ceratophyllum demersum	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	2
Nigella arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Ranunculus flammula	-	-	-	-	5	-	4	6	4	6	4	4	-	-	7	D	736
Ranunculus repens	-	-	-	-	4	1	-	5	3	4	2	2	4	3	9	D	214
Ranunculus sardous	-	-	-	-	-	-	4	-	2	1	2	2	4	4	7	D	93
Ranunculus sceleratus	-	1	-	-	3	-	4	9	5	4	2	-	4	4	9	D	7012
Ranunculus subg. *Batrachium*	4	-	-	-	-	-	-	-	4	3	2	7	-	-	5	D	621
Ranunculus subg. *Ranunculus*	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	D	3
Aquilegia	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Papaver argemone	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	41
Papaver somniferum	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	171
Chelidonium majus	-	-	-	-	-	-	-	-	-	-	-	-	-	1[2]	1	D	1
Ceratocapnos claviculata	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	D	2
Cruciferae	-	-	-	-	3	-	-	-	-	-	-	-	-	4[2]	2	D	52
Descurainia sophia	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	D	8
Barbarea vulgaris	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Berteroa incana	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	30
Cochlearia officinalis	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	D	1
Camelina sativa	-	-	-	-	-	-	-	-	2	2	-	-	-	3	3	D	11
Neslia paniculata	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	17
Capsella bursa-pastoris	-	4	6	-	6	-	4	-	-	3	5	-	4	3	8	D	634
Thlaspi arvense	-	-	-	-	3	-	-	-	-	-	-	-	-	4	2	D	30
Lepidium campestre	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	5
Coronopus squamatus	-	1	-	-	-	-	-	-	3	-	-	-	-	-	2	D	8
Brassica nigra	4[1]	7	-	-	-	-	-	8	7	4	-	-	4	6	7	B	3044
Brassica rapa	-	-	-	5	8	2	-	4	4	1	2	-	2	4	9	D	2870
Sinapis arvensis	8	2	4	7	9	3	10	7	6	4	3	2	5	6	14	B	32893
Raphanus raphanistrum	5	2	-	-	2	2	4	6	6	4	2	-	6	6	11	D	804
Ribes nigrum	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	247

Table 4 (Continued).

Taxon	Sample and period														F	P	N
	1	2	23	32	47	48	49	50	51	56	57	59	43	46			
	3	3	3	3	3	3	3	3	3	3	3	3	4	4			
Rubus fruticosus s.l.	-	-	-	-	-	3	-	-	-	4	-	2	-	2	4	D	61
Rubus idaeus	-	-	-	-	-	2	-	-	-	2	-	-	-	4	3	D	18
Potentilla anserina	-	-	-	4	3	3	3	6	4	3	3	-	6	2	10	B	454
Potentilla erecta	-	-	-	-	-	-	-	-	-	-	-	-	-	3[1]	1	D	7
Fragaria vesca	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	22
Malus sylvestris	-	-	-	2	-	-	-	-	-	-	-	-	-	6	2	D	146
Prunus cerasus	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	104
Prunus domestica ssp. *ins.*	-	2	-	-	-	-	-	-	-	-	-	-	-	4	2	D	14
Vicia	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	D	4
Vicia faba var. *minor*	6	4	4	-	5	-	4	2	2	1	-	-	2	-	9	D	521
Vicia sativa	-	-	-	-	-	-	-	-	-	-	-	-	-	1[2]	1	D	1
Medicago lupulina	-	-	-	-	5	-	-	4	-	-	4	-	-	2	4	D	123
Trifolium	4	-	-	-	-	-	-	6	-	-	-	-	4	-	3	B	473
Trifolium campestre	-	-	-	-	-	-	-	3	5	6	3	2	6	-	6	O	807
Trifolium pratense	-	-	-	-	-	-	-	5	-	4	-	-	8	-	3	O	1648
Trifolium repens	-	-	1	4	4	-	4	6	3	4	2	2	8	2	11	B	3325
Linum usitatissimum	-	-	-	-	-	-	6	6	6	6	4	-	-	1	6	D	762
Euphorbia helioscopia	1	-	-	4	1	-	-	3	2	-	-	1	-	-	6	D	28
Vitis vinifera	-	4	-	-	-	-	-	-	-	-	-	-	-	5	2	D	75
Ruta graveolens	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	4
Malva neglecta	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2	D	2
Althaea officinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	1[2]	1	D	1
Viola	-	-	-	-	1	-	2	-	-	4	1	3	-	4	6	D	55
Myriophyllum verticillatum	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Umbelliferae	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	4
Hydrocotyle vulgaris	-	-	-	-	-	-	-	4	-	6	6	2	-	-	4	D	226
Coriandrum sativum	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Oenanthe lachenalii	-	-	-	-	-	-	-	-	3	-	1	-	-	-	2	D	8
Foeniculum vulgare	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	3
Anethum graveolens	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	2
Conium maculatum	-	-	-	-	-	-	-	6	6	2	-	1	-	1	5	D	540
Bupleurum rotundifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	23
Apium graveolens	-	1	-	-	-	-	-	-	2	-	-	-	-	-	2	D	4
Petroselinum crispum	-	-	-	-	-	-	-	-	-	-	-	-	3	4	2	D	26
Pastinaca sativa	-	-	-	-	-	-	-	4	4	-	-	-	-	-	2	D	29
Daucus carota	-	-	-	-	-	-	-	-	-	1	-	-	-	3	2	D	11
Erica tetralix	-	5	-	-	6	6	-	-	6	6	3	-	-	6	7	B	1130
Calluna vulgaris	-	4	-	-	-	4	-	-	1	6	2	-	-	-	5	B	463
Vaccinium	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	221
Glaux maritima	-	-	4	6	-	-	-	-	-	4	2	-	4	-	5	B	194
Armeria maritima	-	-	-	-	-	-	-	-	-	3	-	3	-	-	2	O	15
Menyanthes trifoliata	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	D	1
Galium aparine	1	4	-	-	2	-	6	3	5	2	-	-	3	4	9	D	405
Galium palustre	-	-	-	-	-	-	-	-	-	2	-	-	-	3	2	D	8
Buglossoides arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	258
Echium vulgare	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	2
Myosotis	4	-	-	-	5	-	6	-	-	-	-	-	-	3	4	D	314
Labiatae	-	-	-	-	-	-	-	-	-	-	2	-	-	3	2	D	12
Galeopsis bif./spec./tetr.	2	-	-	-	1	-	-	2	2	-	1	2	3	6	8	D	224
Lamium amplexicaule	-	4	-	-	-	-	-	-	4	4	-	-	-	2	4	D	49
Lamium purpureum	6	1	-	-	3	-	6	-	4	-	3	3	-	3	8	D	424
Stachys palustris	4	-	1	-	5	-	5	-	2	2	2	-	-	-	7	D	177
Glechoma hederacea	-	-	-	-	-	-	-	4	-	-	-	-	-	-	1	D	12
Prunella vulgaris	5	-	-	-	6	-	5	6	4	6	4	4	-	2	9	B	1011
Hyssopus officinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Mentha aquatica/arvensis	6	-	-	-	6	-	7	4	4	3	-	-	-	3	7	D	906
Salvia verticillata	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	15
Solanaceae	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Atropa bella-donna	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	2
Hyoscyamus niger	-	-	-	-	-	-	-	4	2	2	3	-	4	4	6	D	117
Solanum dulcamara	-	-	4	-	-	-	-	-	-	-	2	-	-	-	2	D	19
Solanum nigrum	-	5	-	-	-	-	-	4	2	3	3	2	4	4	8	D	130
Scrophularia	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Veronica hederifolia	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	D	36
Odontites vernus	-	-	-	4	-	-	-	4	1	4	3	-	4	-	6	D	116

Table 4 (Continued).

Taxon	Sample and period 1 3	2 3	23 3	32 3	47 3	48 3	49 3	50 3	51 3	56 3	57 3	59 3	43 4	46 4	F	P	N
Rhinanthus	-	-	-	-	-	-	4	6	4	4	1	4	4	4	8	D	242
Plantago lanceolata	-	-	-	-	-	-	6	-	-	3	-	3	-	1	4	D	343
Plantago major	6	5	4	-	9	-	8	4	4	5	4	4	4	4	12	D	9324
Plantago maritima	-	-	4	6	3	-	-	1	3	5	2	-	6	-	8	D	523
Sambucus nigra	-	-	-	-	-	-	-	4	4	2	2	-	-	4	5	D	77
Valerianella dentata	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	48
Knautia arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	4
Compositae	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	D	42
Eupatorium cannabinum	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	D	3
Aster tripolium	-	4	4	6	-	4	-	4	4	5	2	2	6	2	11	D	518
Bidens tripartita	6	-	-	2	3	-	4	3	1	-	-	-	-	-	6	D	260
Anthemis arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	D	68
Anthemis cotula	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	139
Anthemis tinctoria	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Achillea millefolium	-	-	-	-	6	-	9	-	-	-	-	-	-	-	2	B	6026
Matricaria maritima	5	-	4	-	3	-	7	4	6	-	-	2	-	-	7	D	1039
Matricaria recutita	-	-	-	-	-	-	7	-	-	3	-	4	-	3	4	D	768
Chrysanthemum segetum	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	41
Artemisia vulgaris	6	-	-	-	-	-	-	8	8	4	-	4	-	-	5	B	3713
Senecio viscosus	-	-	-	-	-	-	-	-	6[1]	-	-	-	-	-	1	D	108
Senecio vulgaris	-	-	-	-	-	-	5	-	-	-	-	-	-	-	1	D	85
Arctium	2	2	-	-	-	-	-	4	6	2	-	1	1	1	8	B	152
Carduus crispus	-	-	-	-	-	1	6	-	2	2	-	-	-	4	5	D	142
Cirsium arvense	-	-	-	-	5	1	7	6	4	4	2	3	-	3	9	B	961
Cirsium vulgare	4	-	-	-	3	1	6	-	1	2	-	2	-	-	7	D	165
Silybum marianum	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	D	3
Centaurea cyanus	-	4	-	-	-	-	-	-	-	-	-	-	4	7	3	D	770
Cichorium intybus	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	D	9
Arnoseris minima	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	50
Leontodon autumnalis	4	-	-	1	4	-	4	5	4	4	3	3	6	2	11	D	390
Leontodon saxatilis	-	-	-	-	-	-	-	6	5	6	5	4	-	-	5	B	488
Sonchus arvensis	9	-	4	5	8	1	9	4	5	3	3	2	-	3	12	D	14515
Sonchus asper	8	-	1	-	8	1	10	6	5	5	3	4	-	3	11	D	17319
Sonchus oleraceus	7	-	-	4	6	-	8	6	6	2	3	2	3	1	11	D	4256
Taraxacum officinale s.l.	-	-	-	-	-	-	4	4	2	-	-	-	-	-	3	D	27
Lapsana communis	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	D	8
Alisma lanc./plant.-aq.	-	-	-	-	-	-	-	4	-	-	-	-	-	-	1	D	12
Triglochin maritima	5	5	5	9	6	-	4	8	4	6	6	6	8	4	13	B	16664
Triglochin palustris	-	-	-	-	-	-	-	5	-	-	3	-	-	-	2	D	88
Potamogeton pectinatus	-	-	-	-	-	-	-	-	-	-	2	1	-	-	2	D	6
Potamogeton pusillus	-	-	-	-	-	-	-	-	-	-	-	2[1]	-	-	1	D	2
Ruppia maritima	-	-	-	-	-	-	-	-	-	-	2	4	-	-	2	D	25
Zannichellia palustris	-	-	-	-	-	-	-	-	-	3	-	-	-	-	1	D	9
Zannichellia pal. ssp. *ped.*	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	5
Juncus	-	-	-	2	4	-	-	8	2	2	1	-	-	-	6	D	4732
Juncus acut./artic./bulb.	5	-	-	-	8	-	6	10	8	10	9	-	-	6	8	D	89885
Juncus bufonius	-	-	-	-	-	-	-	6	-	7	-	-	-	3	3	D	948
Juncus gerardi	6	7	10	10	10	8	9	10	9	10	10	10	10	10	14	D	197757
Gramineae	4	-	-	3	6	-	6	6	4	6	1	-	1	-	9	D	1438
Festuca rubra	-	-	1	6	-	3	-	-	-	3	1	-	10	1	7	D	11585
Lolium perenne	-	-	-	-	8	-	6	2	1	2	-	2	-	-	6	D	1667
Lolium temulentum	-	-	-	-	-	-	3	-	-	-	-	-	-	-	1	D	8
Poa annua	4	1	5	4	6	4	6	4	4	4	4	-	4	3	13	D	880
Poa palustris	-	-	-	-	-	-	4	2	-	-	-	-	-	-	2	D	44
Poa pratensis/trivialis	4	5	4	5	9	4	7	4	6	7	3	4	10	5	14	D	35536
Puccinellia distans	4	-	-	4	-	-	4	-	-	-	2	-	-	3	5	D	108
Puccinellia maritima	-	-	-	5	-	-	-	-	-	-	-	-	-	-	1	D	77
Cynosurus cristatus	-	-	-	-	6	-	4	4	3	6	2	-	-	-	6	D	464
Apera spica-venti	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	168
Bromus hordeaceus/secalinus	2	-	-	1	4	-	4	5	-	5	1	-	-	4	8	D	250
Elymus athericus/repens	-	-	4	6	6	-	8	-	3	1	-	2	4	3	9	D	1733
Secale cereale	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	D	400
Hordeum	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Hordeum vulgare	6	-	5	4	8	-	6	4	5	-	-	-	2	5	9	B	2223
Hordeum vulg. ssp. *dist.*	-	-	-	-	-	-	7	-	-	-	-	-	-	-	1	O	530

Table 4 (Continued).

Taxon	Sample and period														F	P	N
	1	2	23	32	47	48	49	50	51	56	57	59	43	46			
	3	3	3	3	3	3	3	3	3	3	3	3	4	4			
Hordeum vulg. ssp. *dist./v.*	-	-	-	-	-	-	10	-	-	-	-	-	-	-	1	O	12282
Avena	4	-	-	3	6	-	8	3	1	-	1	-	-	-	7	D	3883
Avena fatua	-	-	-	-	6	-	6	4	-	-	-	-	-	-	3	B	472
Avena sativa	-	-	-	-	7	-	6	1	2	-	-	-	-	-	4	O	959
Holcus	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	D	21
Holcus lanatus	-	-	-	-	7	-	4	5	-	6	4	-	-	4	6	D	937
Agrostis	8	5	7	8	9	-	9	10	8	8	6	4	8	8	13	D	37733
Alopecurus geniculatus	-	-	-	-	6	-	6	6	4	5	2	-	6	-	7	D	853
Phragmites australis	-	-	3	4	-	-	4	4	4	-	-	-	-	3	6	D	102
Danthonia decumbens	4	-	-	-	4	-	6	8	4	6	5	5	-	-	8	B	2267
Panicum miliaceum	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	D	25
Setaria pumila	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	D	66
Setaria verticill./viridis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1
Gramineae trib. Cerealeae	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	2
Lemna	-	-	-	-	-	4	-	7	-	-	2	-	-	6	4	D	1067
Lemna minor	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	O	1
Lemna trisulca	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	O	1
Typha angustif./latifolia	-	-	-	-	-	-	-	-	-	-	-	-	4	-	1	D	46
Scirpus lacustris ssp. *tab.*	-	-	-	-	-	1[1]	-	4	2	-	2	4	-	1	6	D	40
Scirpus maritimus	4	-	3	4	-	1	5	4	4	4	4	6	3	4	12	D	565
Scirpus rufus	-	-	-	-	-	-	-	5	-	-	-	-	-	-	1	D	51
Eriophorum angustifolium	-	-	-	-	-	2[1]	-	-	-	-	-	-	-	-	1	D	.2
Eriophorum vaginatum	-	-	-	-	-	3	-	-	-	2	-	-	-	-	2	D	11
Eleocharis palustris	4	5	-	-	6	1	4	10	4	6	6	8	4	4	12	B	15923
Eleocharis quinqueflora	-	-	-	-	3	-	-	8	2	4	4	-	-	-	5	B	2100
Carex acuta/nigra	4	5	-	-	6	-	4	8	4	5	5	3	5	4	11	B	2777
Carex acutiformis	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	D	12
Carex cuprina	4	-	-	-	6	2	6	4	2	2	1	-	4	-	9	B	364
Carex distans	-	-	-	-	-	-	-	2	4	4	4	-	-	4	5	D	103
Carex divulsa	-	-	-	-	-	-	-	-	2[1]	-	-	-	-	-	1	D	2
Carex extensa	-	-	-	-	4	-	-	-	-	-	-	4	-	-	2	D	54
Carex flava/lepid./oederi	-	-	-	-	4	4	4	8	5	6	6	5	4	4	10	B	2402
Carex ovalis	4	-	-	-	7	-	6	8	4	4	5	5	3	2	10	B	4506
Carex panicea	-	-	-	-	4	2	4	8	3	5	4	2	3	1	10	D	1852
Carex paniculata	-	-	-	-	-	4[1]	-	-	-	-	-	-	-	-	1	D	12
Carex pilulifera	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Carex pseudocyperus	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	D	6
Carex riparia	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1
Carex spicata	-	-	-	-	4	-	4	5	1	2[1]	-	-	-	-	5	D	128
Carex subg. *Carex*	-	-	-	-	-	-	-	-	4	4	4	-	-	-	3	D	48
Carex subg. *Vignea*	-	-	-	-	-	-	4	-	1	-	2	-	4	-	4	D	99
Aframomum melegueta	-	1	-	-	-	-	-	-	-	-	-	-	-	4	2	D	13

Table 5. Taxa of Heveskesklooster preserved by charred macro-remains of periods 1-4. F. Sample frequency; P. Plant parts; N. Total number of plant parts. For other abbreviations, see table 2.

Taxon	Sample and period																					
	10	11	12	14	15	19	20	25	27	30	33	35	36	37	40	41	3	4	5	7	9	13
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
Quercus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Polygonaceae	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum aviculare	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Polygonum lapathifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rumex crispus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodiaceae	-	-	-	-	-	-	-	-	-	4	-	-	-	3	-	-	-	-	-	-	-	-
Chenopodium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodium album	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Chenopodium ficifolium	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Atriplex patula/prostrata	-	-	-	3	-	-	-	4	2	-	1	4	1	-	4	-	-	-	-	-	-	-

Table 5 (Continued).

Taxon	Sample and period																					
	10	11	12	14	15	19	20	25	27	30	33	35	36	37	40	41	3	4	5	7	9	13
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
Salicornia europaea s.l.	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Suaeda maritima	-	-	-	-	-	-	-	-	-	4	-	3	-	-	-	-	-	-	-	-	-	-
Stellaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stellaria media	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus flammula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus repens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sinapis arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Raphanus raphanistrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potentilla anserina	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Pisum/Vicia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia faba var. *minor*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia sativa	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Medicago lupulina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erica tetralix	5	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Calluna vulgaris	6	-	4	6	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-
Oxycoccus palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Empetrum nigrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galium aparine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lamium amplexicaule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stachys palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantago lanceolata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantago major	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Sambucus nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Compositae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Matricaria maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Arctium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leontodon saxatilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sonchus arvensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sonchus oleraceus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Triglochin maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Juncus gerardi	-	-	-	-	-	7	-	4	-	-	-	4	2	-	-	-	-	-	-	-	-	-
Gramineae	-	-	-	-	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Festuca	-	-	-	-	-	-	-	-	1[2]	-	-	-	-	-	-	-	-	-	-	-	-	-
Festuca pratensis	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Festuca rubra	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Lolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa annua	-	-	-	-	-	-	-	-	4	-	-	-	3	-	-	-	-	-	-	-	-	-
Cynosurus cristatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromus hordeaceus/secalinus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Elymus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elymus athericus/repens	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Triticum aestivum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hordeum vulgare	-	3	-	-	1	-	-	2	2	4	4	1	4	3	-	3	6	2	3	2	2	2
Hordeum vulg. ssp. *dist.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hordeum vulg. (*nudum*)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avena	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avena fatua	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avena sativa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Phleum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia decumbens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gramineae trib. Cerealeae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scirpus maritimus	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Eleocharis palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis quinqueflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex acuta/nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex distans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex flava/lepid./oederi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex panicea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5 (Continued).

Sample and period																								Taxon			
18	22	24	31	34	44	45	52	53	55	1	2	23	32	47	48	49	50	51	56	57	59	43	46	F	P	N	
2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	O	2	QUERCSP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	11	POLGOAE
-	-	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	4	-	-	1	8	D	34	POLYNAV
-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	3	D	4	POLYNLA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	1	B	11	RUMEXCR
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	D	19	CHENOAE
-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1	CHENOSP
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	5	D	10	CHENOAL
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	24	CHENOFI
4	6	6	2	-	-	1	-	-	1	-	-	2	-	-	-	-	-	4	-	4	-	-	-	16	D	637	ATRIPPP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	7	SALICEU
-	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-	5	D	32	SUAEDMA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	D	1	STELLSP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	2	D	40	STELLME
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	D	6	RANUNFL
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	2	RANUNRE
-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	4	2	-	-	-	-	6	B	37	SINAPAR
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	2	RAPHARA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2	D	3	POTENAN
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	D	1	PISXVIC
-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	D	1	VICIASP
-	-	-	-	1	-	-	-	-	-	2	1	-	1	-	-	-	-	1	-	-	-	-	-	5	D	6	VICIAFM
-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	2^{2}	-	-	-	-	-	3	D	21	VICIASA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	D	1	MEDICLU
-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	4	-	-	-	3	-	-	4	4	8	O	203	ERICATE
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	6	-	-	-	6	8	O	2566	CALLUVU
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	O	1	OXYCOPA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	D	4	EMPETNI
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	4	GALIUAP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1	LAMIUAM
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2	D	2	STACHPA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	D	1	PLANTLA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	3	D	23	PLANTMJ
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	D	1	SAMBUNI
-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	19	COMPOAE
-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	2	D	17	MATRIMA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	D	1	ARCTISP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	-	-	-	2	D	10	LEONTSA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	D	7	SONCHAR
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	D	2	SONCHOL
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	1	D	12	TRIGLMA
-	-	3	1	1	-	-	-	-	-	-	-	2	-	-	-	-	-	5	1	-	-	-	-	7	D	112	JUNCUSP
-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	6	D	1015	JUNCUGE
-	-	2	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	5	1	3	-	-	2	9	D	84	GRAMIAE
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1^{2}	2	D	2	FESTUSP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	2	FESTUPR
2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	D	11	FESTURU
-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	D	3	LOLIUSP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	1	D	17	POASPXX
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	D	31	POAANNU
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	2	D	4	CYNOSCR
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1	BROMUHS
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3^{2}	1	D	8	ELYMUSP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	1^{2}	-	-	-	-	3	D	14	ELYMUAR
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	D	1	TRITIAE
5	7	8	5	6	3	-	2	1	2	3	1	6	4	1	-	-	2	8	6	5	2	-	3	36	D	4462	HORDEVU
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	O	3	HORDEDI
-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1	HORDEVN
-	-	-	-	2	-	-	-	-	-	2	3	-	4	1	-	-	-	4	-	-	-	-	1	7	D	48	AVENASP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	1	B	22	AVENAFA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	O	3	AVENASA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	3^{2}	3	D	1770	AGROSSP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	D	6	PHLEUSP
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	1	-	-	-	3	D	10	DANTHDE
-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	D	1	GRAMICE

Table 5 (Continued).

Sample and period																								Taxon			
18	22	24	31	34	44	45	52	53	55	1	2	23	32	47	48	49	50	51	56	57	59	43	46	F	P	N	
2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	D	2	SCIRPMA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	2	2	-	1	5	D	22	ELEOCPA
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	2	ELEOCQU
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	-	-	-	2	D	10	CAREXAN
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	D	1	CAREXDI
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	2	-	-	-	2	D	14	CAREXFL
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	D	4	CAREXPA

Salvia verticillata and *Silybum marianum*. In the following paragraphs some of these species are dealt with in detail.

The average number of taxa in 150 ml samples is about half of the larger samples, but there is a considerable overlap (150 ml: (1-)22(-42), s.d. 11 (N=16); 1-3 litre: (10-)50(-157), s.d. 31 (N=43)). The small samples yielded 80 different taxa, while the larger samples of corresponding periods 1 and 2 yielded 180 different taxa. Species found only in the small samples are: *Beta vulgaris*, *Centaurea cyanus* and *Myriophyllum verticillatum*.

Of the 288 taxa that could be positively identified, 282 taxa were preserved by waterlogging and 72 by charring. Only six species were found in a charred state of preservation. They were: *Festuca pratensis*, *Hordeum vulgare* ssp. *vulgare (nudum)*, *Oxycoccus palustris*, *Pisum/Vicia*, *Triticum aestivum* and *Vicia sativa*. However, naked barley cannot be identified in uncharred condition, which makes it uncertain whether to include it on this list.

3.2. Wild plant species

3.2.1. *Comparison of samples with respect to species composition*

The cumulative percentage of variance of the complete data matrix without data transformation, explained by the first four axes, varies between 13% for the one-dimensional solution, and 45% for the four-dimensional solution. Transformation of species data that include both waterlogged and charred remains, reduces both the total inertia, which is a measure of the total species variance, and the percentage of species variance explained by these axes (table 6). As to charred remains, data transformation reduces the percentage of species variances too, but increases the total inertia (table 7).

Both logarithmic transformation and conversion to presence/absence (1/0) cause loss of information, but minimize the extreme differences between species scores. Particularly when the 1/0-transformation is used, the percentages are relatively low and can be explained by noisy species data (ter Braak, 1988). The extreme differences in seed numbers have to be regarded as variations in dispersal strategies rather than species abundance. Because the ln-transformation reduces the range of raw data counts without eliminating its information completely, as is the case with a 1/0-conversion, this transformation is used for analyzing the samples.

The elimination of both samples with less than 10 taxa and samples that were only investigated by small

Table 6. Summary of Correspondence Analyses of both waterlogged and charred remains of Heveskesklooster.

		Cumulative percentage variance				Total
		Axis 1	Axis 2	Axis 3	Axis 4	inertia
	No samples omitted:					
1	No transformation	13.2	25.9	35.9	44.9	4.533
2	Ln-transformation	14.1	25.1	31.7	37.6	2.892
3	0/1-transformation	11.2	19.6	25.0	29.7	3.376
	Reduction of samples and ln-transformation:					
4	>10 taxa/sample[1]	14.3	25.5	32.2	38.2	2.845
5	Small volume only[2]	14.6	27.4	39.1	47.6	1.495
6	Large volume only[3]	14.7	26.2	33.2	39.4	2.764
7	Without period 4	13.7	21.4	28.7	34.9	2.735
8	Without period 3 + 4	13.0	23.5	32.2	39.2	2.588
9	Without period 3 + 4[4]	11.3	20.2	27.3	32.7	2.351

[1] Samples omitted: HK\0930 (No. 16), HK\1227 (No. 19), HK\1555 (No. 28) and HK\1961 (No. 42).
[2] Volume: 150 ml.
[3] Volume: >= 1 litre.
[4] Samples omitted: HK\0791 (No. 13) and HK\1489 (No. 27).

Table 7. Summary of Correspondence Analyses of charred remains of Heveskesklooster.

		Cumulative percentage variance				Total
		Axis 1	Axis 2	Axis 3	Axis 4	inertia
	No samples omitted:					
1	No transformation	14.7	29.0	43.1	55.2	6.557
2	Ln-transformation	11.1	21.3	30.2	38.2	7.222
3	0/1-transformation	8.1	15.8	23.2	29.5	8.381

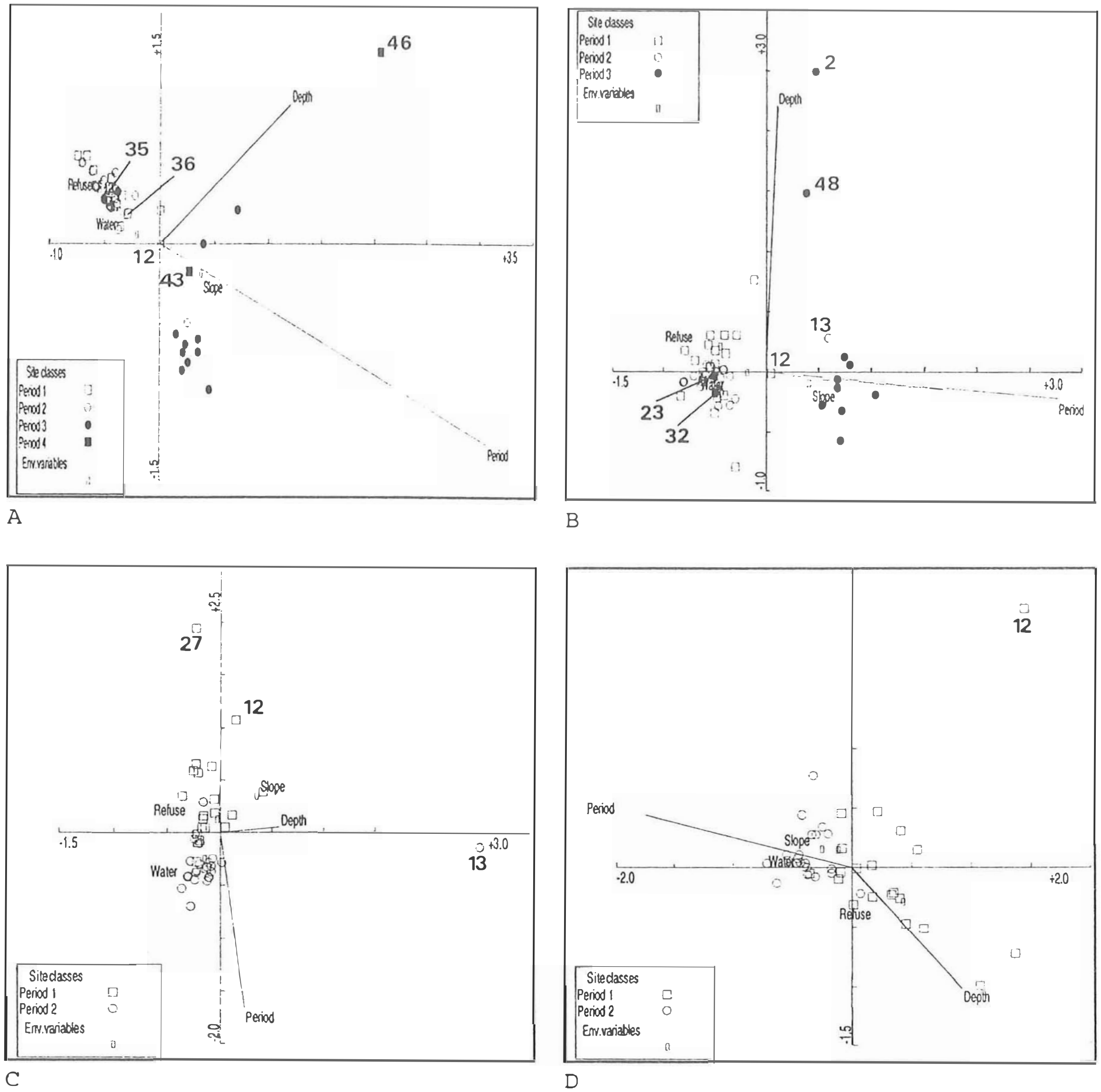
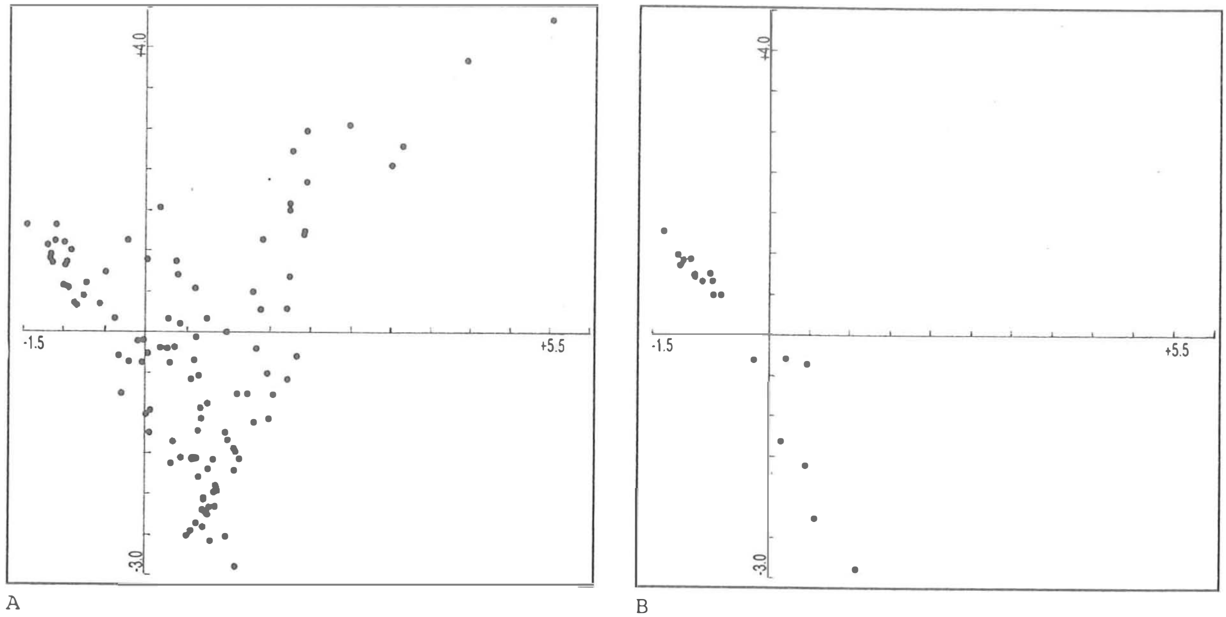


Fig. 7. A-D. Correspondence ordination diagrams of the botanical remains of Heveskesklooster, showing correlations between samples and extrinsic environmental variables. A. Samples of all periods; B. Samples of periods 1-3; C. Samples of periods 1-2; D. Samples of periods 1-2, without sample HK\0791 (no. 13) and HK\1489 (No. 27).

volumes, had little effect on the cumulative percentage of variance when compared with the complete data set. For that reason no samples were omitted in the analyses.

The ordination diagrams are separately presented for samples and species for reasons of readability (figs 7 and 8 respectively). To make a comparison between these diagrams possible, a scaling of ordination scores was chosen by which sample scores are weighted mean species scores. Thus sample points are positioned at the centroid of the points of species that are present in them. Each sample point represents the mean species scores of all species of the sample concerned; its position in the diagram measures the deviation from the mean species scores of all samples which coincides with the origin of the axes. On the other hand, species points represent the mean distribution of that particular species over all samples in which it is present. Distances between points can be interpreted only with respect to either samples or species. When samples are compared with species, the distance of the projection from object to vector must be interpreted. Isolated samples in diagrams are characterized by a different species composition, whereas species positioned far away from the origin are characterized by species scores that greatly differ from the marginal frequencies. The visualization of data in a diagram is



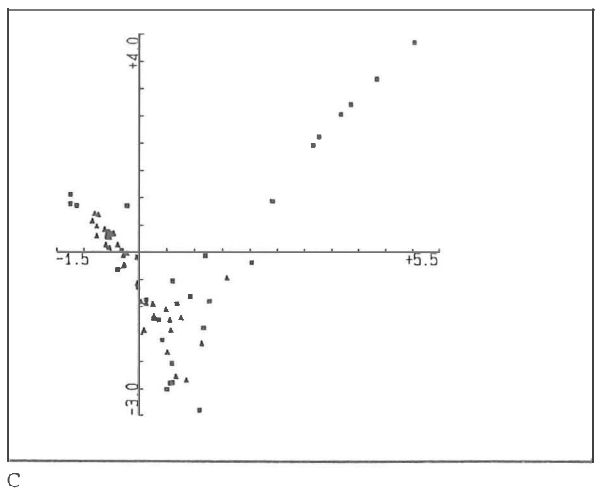


Fig. 8. A-C. Correspondence ordination diagrams of the botanical remains of Heveskesklooster, showing the distribution of the species with respect to salinity. A. Glycophytes; B. Halophytes; C. Indifferent (triangle) and not coded (square) species. A tick mark is placed after each 0.5 interval; the value belongs to the last tick mark of each axis.

limited to two dimensions and nearby points may in fact be less close than suggested. The scale of the axes corresponds with the sample and species scores, the scale of the environmental variables is multiplied by 1000.

Some of the nominal environmental variables were omitted: the location '*terp* top' because collinearity was detected when fitting variable 'refuse', as well as location 'beyond *terp*' and feature types 'well' and 'others' (viz. posthole and well casing) for they had negligible variances. The species composition of the samples is determined by period and depth in particular, and by location and feature type to a lesser extent, as can be seen by both direction and length of arrow or position of centroid of the environmental variables (fig. 7:A). Especially sample HK\2098 (No. 46) taken from a ditch dated to period 4 stands out by its isolated position due to many species that were found in this sample only. In fact, 19% of the taxa being part of the data matrix is represented only in this sample. Many of these taxa are weeds, partly occurring in winter grain fields (Secalietea), such as *Buglossoides arvensis*, *Knautia arvensis*, *Lapsana communis*, *Neslia paniculata* and *Valerianella dentata*, and other taxa in fields of summer cereals and root crops (Polygono-Chenopodietalia), such as *Chrysanthemum segetum* and *Setaria verticillata/viridis*. The other sample of the last period, HK\1995 (No. 43), is located near the origin thus indicating that its composition differs only slightly from the mean composition of all samples, represented by sample HK\0735 (No. 12) of a waste layer and dated to the first period of habitation. Species that are unique for sample HK\1995 are only

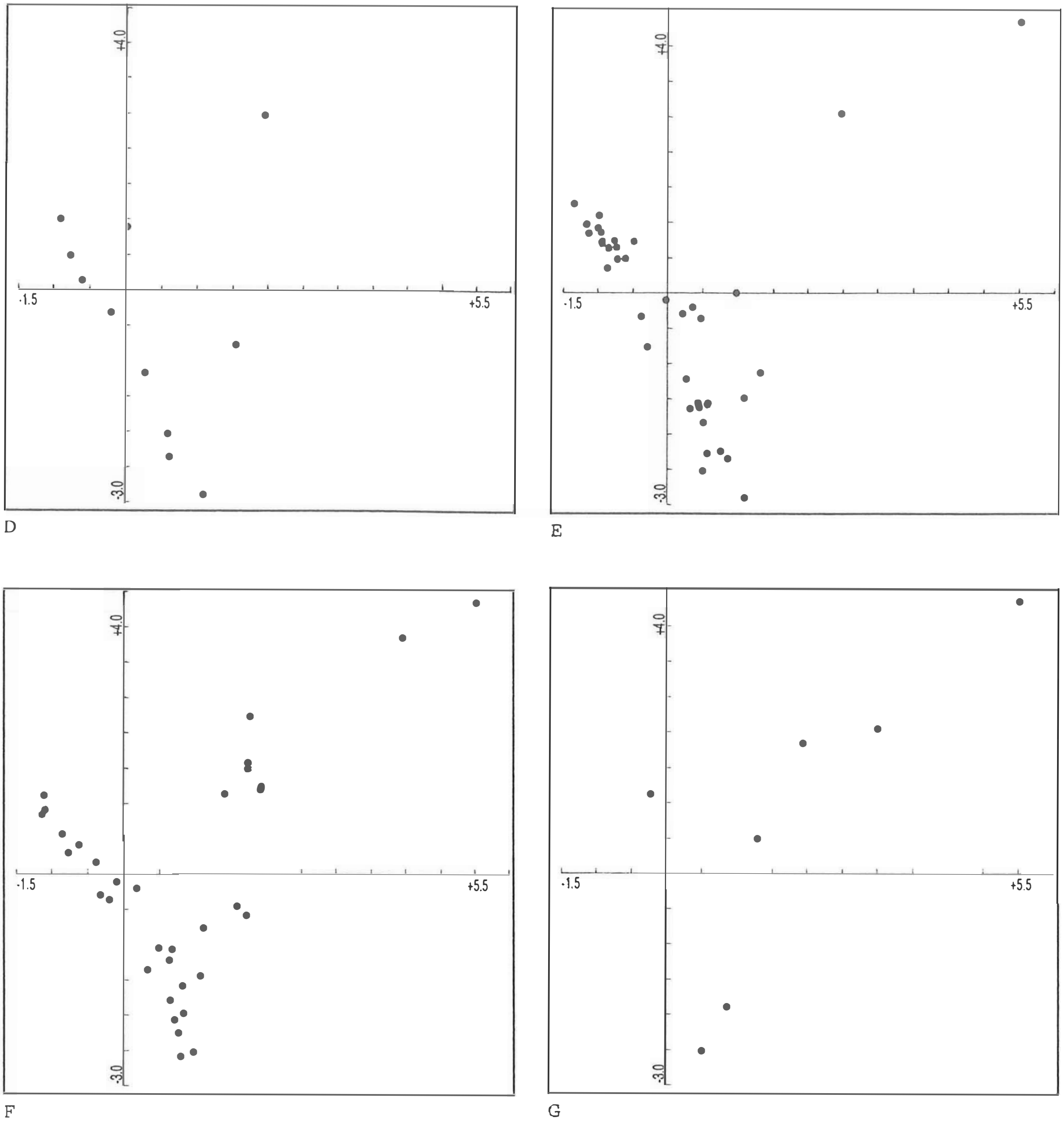


Fig. 8. D-G. Correspondence ordination diagrams of the botanical remains of Heveskesklooster, showing the distribution of the species with respect to moisture regime. D. Aquatic; E. Wet; F. Moist; G. Dry. A tick mark is placed after each 0.5 interval; the value belongs to the last tick mark of each axis.

Petroselinum crispum and *Typha angustifolia/latifolia*. Its intermediate position is the result of different species composition with respect to samples of the other three periods. Samples of periods 1, 2 and 3 are grouped into two clusters: the samples of the first two periods and samples of period 3. Environmental change, reflected in species composition, would therefore have taken place in-between the second and third habitation periods and in-between the third and fourth periods, but less information is available on the last transition. Although sample HK\1671 (No. 36) is derived from considerable depth if compared with the other samples (fig. 6), its species composition differs only slightly from other samples of the first habitation period, including HK\1670 (No. 35) collected from the same well.

When the two samples of period 4 are not included in the analysis, the cumulative percentage of variance and total inertia differs only slightly from the percen-

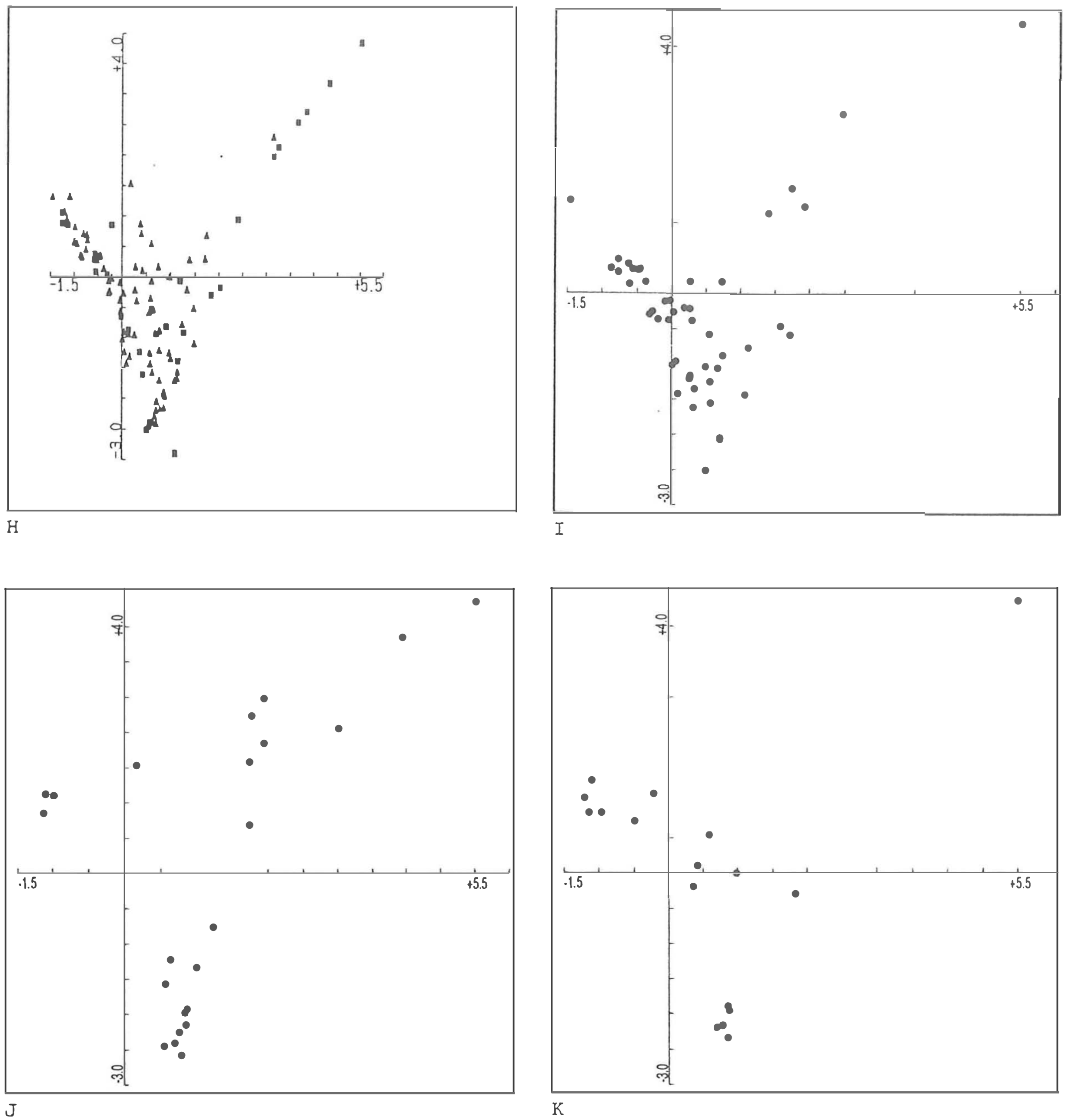


Fig. 8. H-K. Correspondence ordination diagrams of the botanical remains of Heveskesklooster, showing the distribution of the species with respect to moisture regime and nutrient availability. H. Indifferent (triangle) and not coded (square) species with respect to moisture regime; I. Rich soils; J. Moderate soils; K. Poor soils. A tick mark is placed after each 0.5 interval; the value belongs to the last tick mark of each axis.

tages of the complete data matrix (table 6). The majority of the samples of the third period are located on the right side of the second axis, while samples of the first two periods are located on the other half (fig. 7:B). Four samples of the third period take up a distinct position. The two samples that originate from a well casing, viz. HK\1294 (No. 23) and HK\1584 (No. 32), are positioned in the upper left quadrant and, therefore, resemble the species composition of samples of the first two habitation periods. Despite their dating, based on the stones used for the construction of the casing, the soil was probably mixed with the filling of the well when the casing was constructed. The two other samples are HK\0082 (No. 2) and HK\2284 (No. 48) and originate from the moat around the church. In all, seven samples were investigated from this moat. The species that are responsible for the divergent composition of both the samples are no specific water or riparian plants, but a

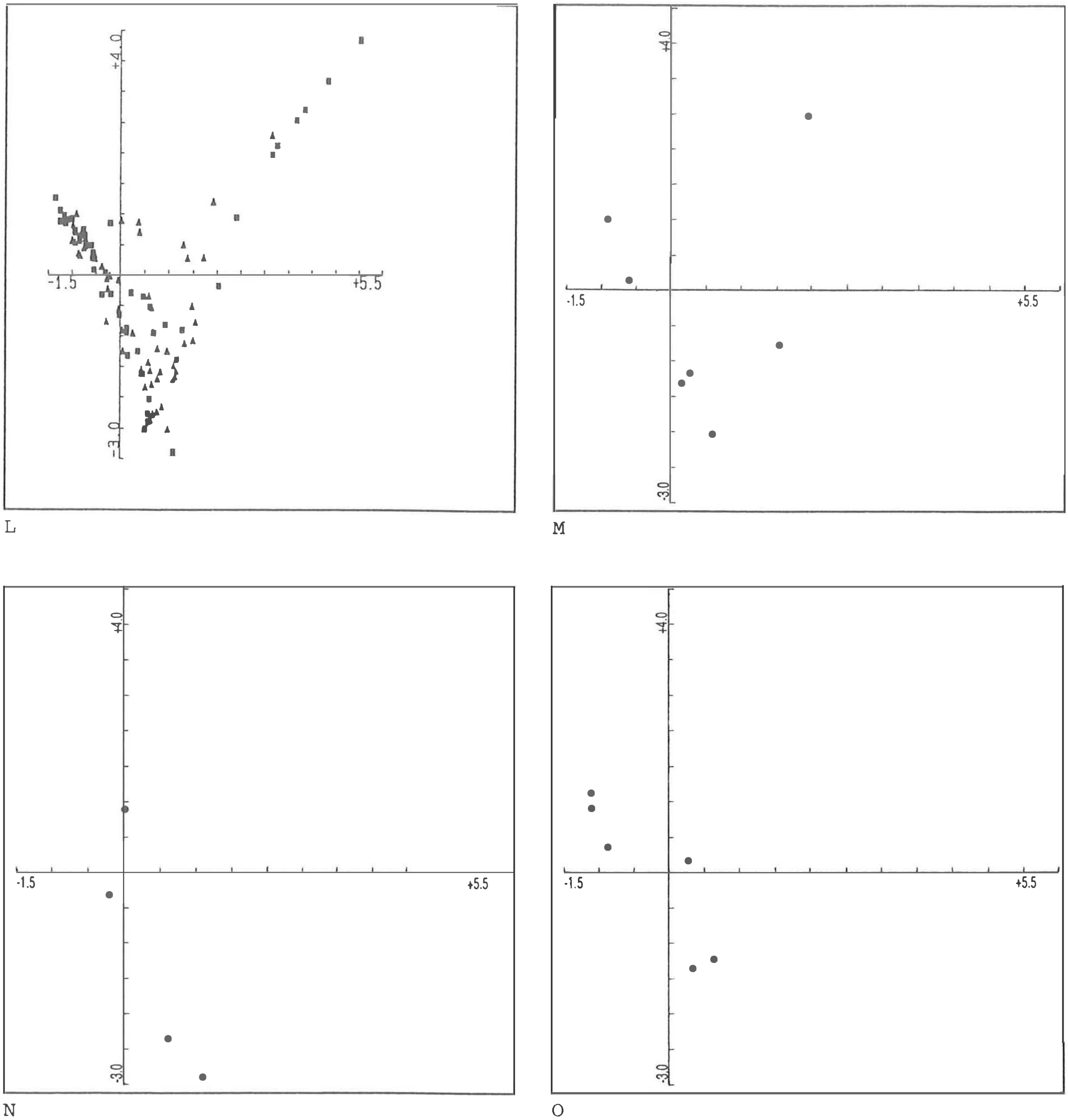
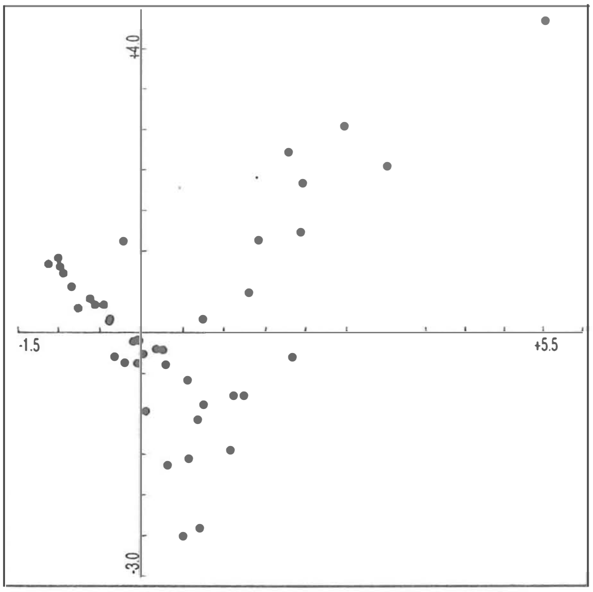


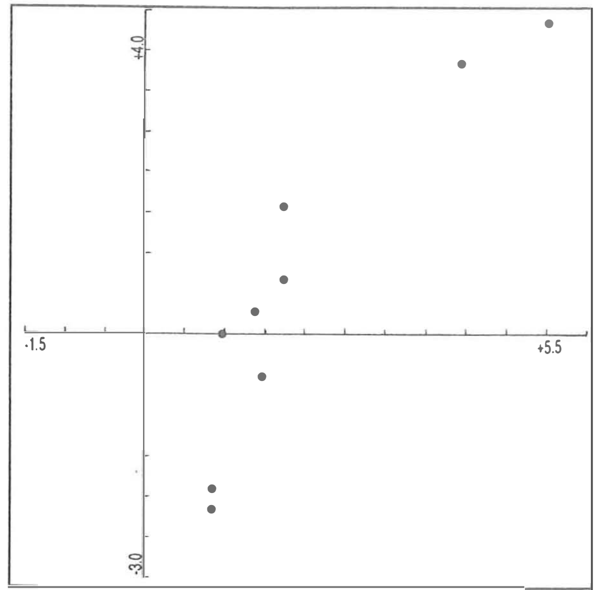
Fig. 8. L-O. Correspondence ordination diagrams of the botanical remains of Heveskesklooster, showing the distribution of the species with respect to nutrient availability and vegetation structure. L. Indifferent (triangle) and not coded (square) species with respect to nutrient availability; M. Water vegetation; N. Semi-aquatic helophytic vegetation; O. Tall herb vegetation. A tick mark is placed after each 0.5 interval; the value belongs to the last tick mark of each axis.

mixture of trees (*Betula pubescens*, *Prunus domestica* ssp. *insititia* and *Quercus*, as is the accompanying *Humulus lupulus*), plants from bogs and peats (e.g. *Empetrum nigrum*, *Eriophorum vaginatum* and *Oxycoccus palustris*) and food plants (*Aframomum melegueta*, *Ficus carica* and *Vitis vinifera*).

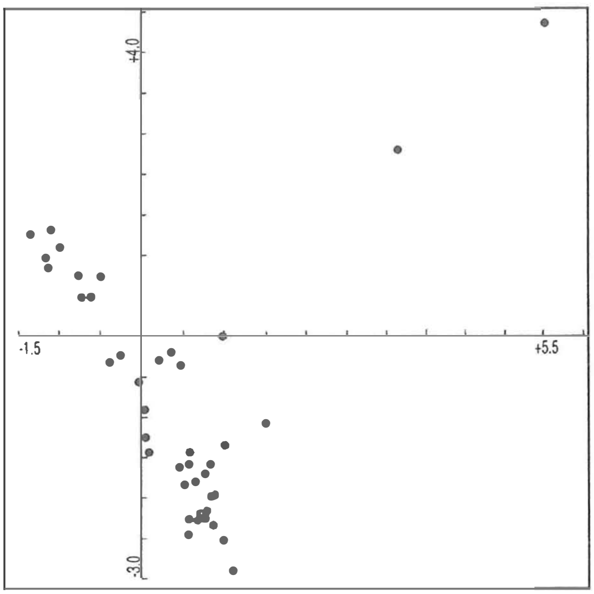
When the data matrix is reduced to species of the first two habitation periods only, depth and period remain the environmental variables with the most variance and samples from both periods become visible as two more or less separate clusters (fig. 7:C). Two samples take up a remote position: HK\1489 (No. 27) and HK\0791 (No. 13). The former originates from a waste layer dated to the first period, the latter is the only representative of one of the five wells that have been sampled of the second habitation period. As many as 29



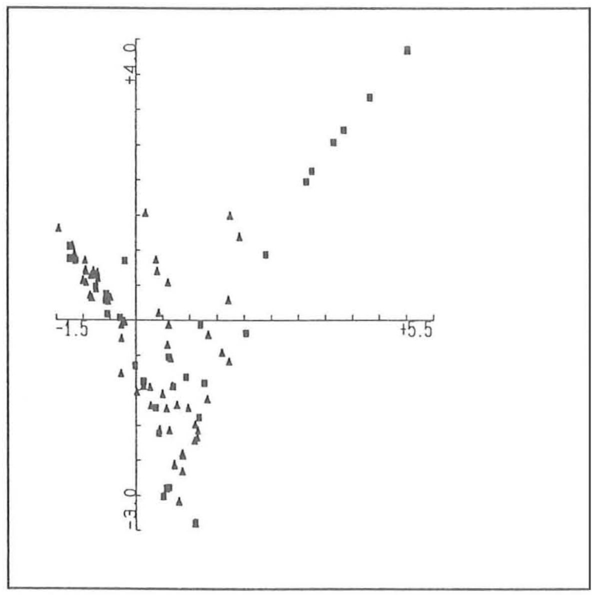
P



Q



R



S

Fig. 8. P-S. Correspondence ordination diagrams of the botanical remains of Heveskesklooster, showing the distribution of the species with respect to vegetation structure. P. Pioneer vegetation; Q. Woodland and shrub; R. Grassland; S. Indifferent (triangle) and not coded (square) species. A tick mark is placed after each 0.5 interval; the value belongs to the last tick mark of each axis.

taxa were found in this sample which were not represented in the samples taken from the other wells. Its diverse composition points to the use of dumping waste afterwards. The total number of taxa for the first and second period is the same (N=121), as is almost the number of unique taxa for each of these periods (period 1: N=37; period 2: N=39). When both remotely positioned samples are omitted, it is shown that the species composition of the other samples is mainly explained by period and depth (fig. 7:D). The only isolated sample is HK\0735(No. 12), which is positioned in the origin of the two first axes if samples of the last two periods are also taken into account (fig. 7:A,B).

3.2.2. *Environmental factors and species composition of samples*

Separate species ordination plots are presented for the various classes of each environmental characteristic (fig. 8). This way all taxa can be depicted, although one dot may represent more plants. All plots are on the same scale as the sample/environmental plots (fig. 7). Because samples scores are positioned at the centroid of the points of species that occur in them, the values on the axes in figure 8 are larger. For each habitat factor, plants characterized by a broad ecological range (indifferent) or not coded, have been presented in a separate plot. In particular, this category includes cultivated plants, partly of exotic origin.

Glycophytes are scattered in two directions (fig. 8:A). They are partly located in the upper left and lower right quadrants, a direction particularly determined by period. The second group is positioned in the upper right quadrant and indicates that these species are at least present in sample HK\2098 (No. 46). Both directions are also visible in most other diagrams of figure 8. Compared with glycophytes, the number of halophytes is less (fig. 8:B). Although sample HK\2098 (No. 46) of the last habitation period is represented by eleven obligate halophytes, these taxa are also frequently represented by many samples of other periods (table 8) and consequently the dots of these taxa coincide with the dots of samples of period 1-3. Indifferent taxa display a spacing similar to the area in which both obligate glycophytes and halophytes are present, while taxa that are not coded are also present in the upper right quadrant (fig. 8:C).

The moisture gradient shows a limited number of taxa for extreme conditions (i.e. aquatic: fig. 8:D and dry: fig. 8:G), while wet and moist conditions are represented by more taxa (fig. 8:E-F). Unique aquatic taxa are absent in period 4, which is strengthened by a shift of taxa indicative of dry soils to the recent periods. The same is true for taxa that are present during the whole habitation period: both wet and moist conditions are represented by twelve taxa, while aquatic and dry conditions have only one representative each: *Scirpus lacustris* ssp. *lacustris* and *Spergula arvensis* (table 8).

Plants indicative of low, moderate and high nutrient availability are found in all periods and show a decrease in the number of taxa from rich to poor soils (fig. 8:I-K). All three diagrams indicate that the representativeness on a species level shifts in the course of time. The number of taxa that is found in all periods is small as to low nutrient availability (i.e. *Calluna vulgaris* and *Erica tetralix*) and medium nutrient availability (i.e. *Conium maculatum* and *Spergula arvensis*), but is very well represented with 24 taxa for soils with high nutrient supply (table 8). Indifferent taxa and not coded taxa form a large part (fig. 8:L), the latter partly because they include halophytes that are not coded for this category (Runhaar et al., 1987).

Structure of vegetation and succession as a biotic environmental category is subdivided into six classes; consequently these classes are partly only scarcely represented (fig. 8:M-S). Apart from the class of indifferent and not coded taxa (fig. 8:S), the best represented classes are pioneer plants (fig. 8:P) and grassland plants (fig. 8:R). The isolated sample HK\2098 (No. 46) has clearly only few grassland species in common with the other samples, while it shares several pioneer plants. In fact, the number of grassland plants

Table 8. Taxa with small ecological range to at least one environmental category and present in all four habitation periods. Abbreviations: Sal. Salinity; Moi. Moisture; Nut. Nutrient availability; Veg. Structure of vegetation & succession (for abbreviations of classes: fig. 9); F: Sample frequency; N: Total number of plant parts.

Sal.	Moi.	Nut.	Veg.	F	N	
-	-	-	Gr	26	8	*Trifolium repens*
-	-	-	Pv	15	9	*Juncus bufonius*
-	-	-	Pv	46	10	*Plantago major*
-	-	Ri	-	33	10	*Sonchus arvensis*
-	-	Ri	-	49	10	*Scirpus maritimus*
-	-	Ri	-	14	8	*Cirsium arvense*
-	-	Ri	Pv	30	8	*Chenopodium glaucum/rubrum*
-	Mo	Ri	-	19	8	*Rumex crispus*
-	Mo	Ri	Pv	58	10	*Atriplex patula/prostrata*
-	We	Ri	-	12	8	*Alopecurus geniculatus*
Gl	-	-	-	8	5	*Rubus fruticosus* s.l.
Gl	-	-	-	15	8	*Carex acuta/nigra*
Gl	-	-	-	15	6	*Ranunculus repens*
Gl	-	-	-	14	8	*Urtica dioica*
Gl	-	-	-	10	5	*Viola*
Gl	-	-	-	9	6	*Bromus hordeaceus/secalinus*
Gl	-	-	-	12	6	*Polygonum convolvulus*
Gl	-	-	Pv	9	8	*Rumex acetosella*
Gl	-	Po	-	12	8	*Erica tetralix*
Gl	-	Po	-	10	7	*Calluna vulgaris*
Gl	-	Ri	Pv	36	10	*Chenopodium album*
Gl	-	Ri	Pv	14	8	*Capsella bursa-pastoris*
Gl	-	Ri	Pv	22	8	*Poa annua*
Gl	-	Ri	Pv	26	8	*Chenopodium ficifolium*
Gl	-	Ri	Pv	20	8	*Urtica urens*
Gl	-	Ri	Pv	38	10	*Stellaria media*
Gl	-	Ri	Pv	18	6	*Solanum nigrum*
Gl	-	Ri	Th	11	6	*Carduus crispus*
Gl	Dr	Mo	Pv	5	6	*Spergula arvensis*
Gl	Mo	-	-	13	8	*Carex ovalis*
Gl	Mo	Mo	Th	10	7	*Conium maculatum*
Gl	Mo	Ri	-	5	5	*Rumex obtusifolius*
Gl	Mo	Ri	Pv	12	6	*Lamium purpureum*
Gl	Mo	Ri	Pv	45	10	*Polygonum aviculare*
Gl	Mo	Ri	Pv	34	10	*Sonchus asper*
Gl	Mo	Ri	Pv	23	8	*Sonchus oleraceus*
Gl	Mo	Ri	Pv	34	10	*Polygonum lapathifolium*
Gl	Mo	Ri	Pv	36	10	*Sinapis arvensis*
Gl	Mo	Ri	Pv	6	6	*Lamium amplexicaule*
Gl	We	Ri	Pv	22	9	*Ranunculus sceleratus*
Ha	Aq	-	Sa	12	5	*Scirpus lacustris* ssp. *tab.*
Ha	We	-	-	40	9	*Aster tripolium*
Ha	We	-	-	30	9	*Glaux maritima*
Ha	We	-	-	53	10	*Triglochin maritima*
Ha	We	-	-	56	10	*Juncus gerardi*
Ha	We	-	-	44	10	*Spergularia maritima/salina*
Ha	We	-	-	25	8	*Puccinellia distans*
Ha	We	-	-	34	9	*Plantago maritima*
Ha	We	-	Gr	14	6	*Carex distans*
Ha	We	-	Pv	41	10	*Suaeda maritima*
Ha	We	-	Pv	37	10	*Salicornia europaea* s.l.

that are represented by all four periods is limited to two (i.e. *Carex distans* and *Trifolium repens*, while the number of common pioneer plants is 23, see table 8). Shrubs do not share common species for all periods and its taxa are plotted in connection with samples from period 3 and 4 (fig. 8:Q). *Conium maculatum* and *Carduus crispus* are the only tall herbs that are common for all periods, the scanty dots are however limited to the area of the first three periods (fig. 8:O). The ordination plots of aquatic plants (fig. 8:M) and semi-aquatic helophytes (fig. 8:N) are rather similar and display only a few taxa within the triangle area. The spread of indifferent and not coded plants for vegetation structure does not fundamentally differ from the spread as far as moisture and nutrient availability goes (fig. 8:H,L,S).

3.2.3. *Characterization of samples by indicator plants*

A different approach to the characterization of the environment is done by calculating indicator values (I_u) of the various categories for each sample. For each environmental class (e.g. halophytes or glycophytes) this indicator value is based on the character weights of the indicator taxa concerned (Cappers, 1994). Because the sum of character weights differs between the environmental factors, a comparison of absolute I_u-values is interpretative only with respect to the same environmental factor.

Values of I_u have been calculated for all classes (fig. 9). Within each period, the I_u-values of each class have been arranged separately in decreasing order. This facilitates a comparison of the I_u-range of a specific

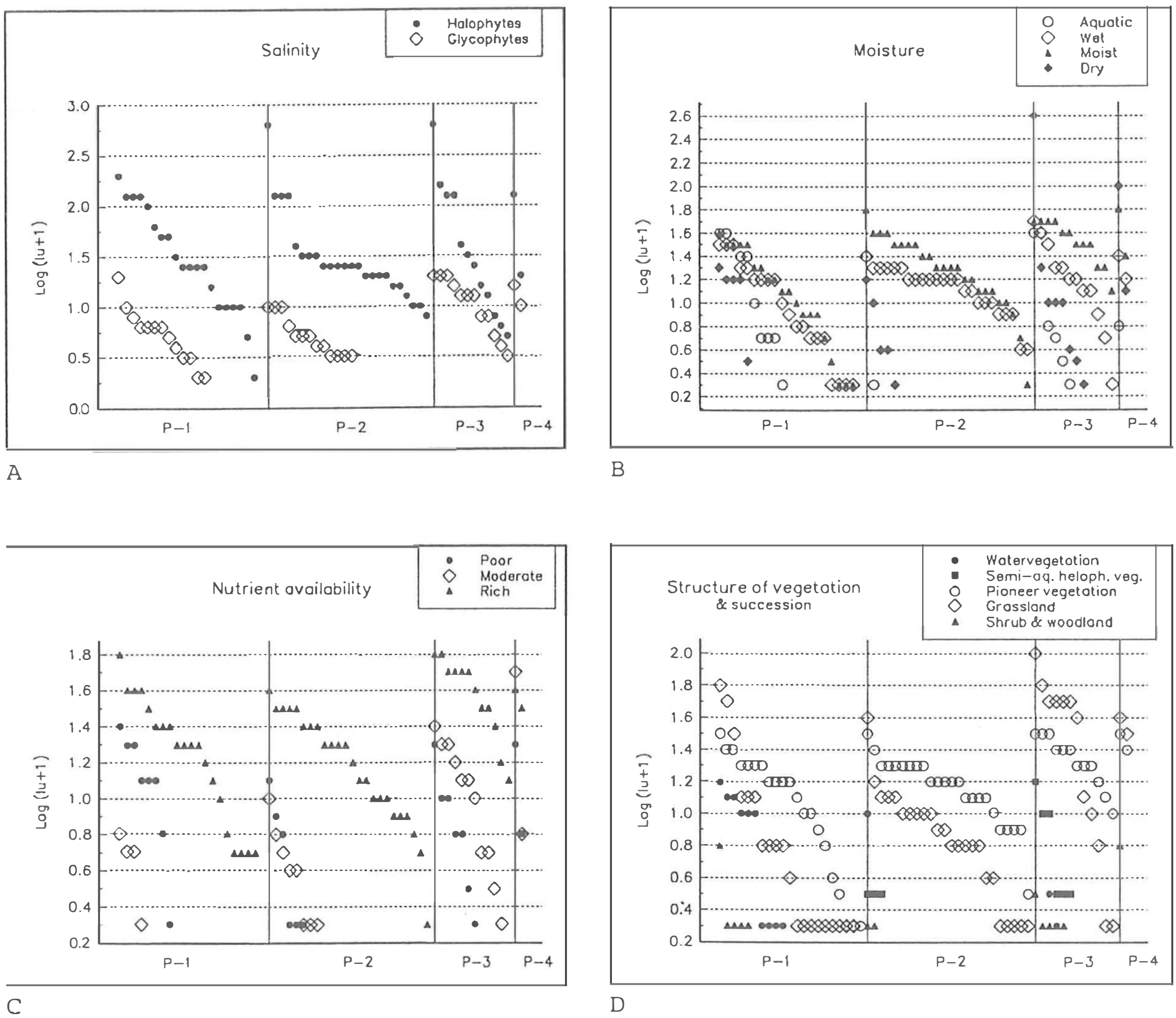


Fig. 9. A-D. Indicator values I_u of individual samples of Heveskesklooster. Within each period, the I_u-values of each class have been arranged separately in decreasing order.

environmental factor both within and between the periods. On the other hand, this arrangement does not allow a linking of different I_u-values on sample level.

All four environmental characteristics show a considerable overlap between the four periods in the range of their I_u-values. Samples that take up an isolated position due to extreme values of character weights are limited to especially halophytes and plants indicative of dry soils. For almost all samples, an indicator value I_u could be calculated for halophytes, but for glycophytes only partly for the first two periods of habitation (fig. 9:A). The I_u-values of halophytes for some samples from the first period are low, while both values of the last period are relatively high. Species responsible for the high I_u-values for saline and brackish habitats, are *Carex distans* (period 1-4) and *Cochlearia officinalis* (period 2 and 3). Both species are rare in Dutch subfossil records. *Carex distans* has been recorded for Monnickendam (Hogestijn, 1989), Rockanje (Brinkkemper, 1993) and Valkenburg (ZH) (Pals et al., 1989). Rockanje is the only site from which *Cochlearia officinalis* has been mentioned before. Both plants grow on the higher parts of salt-marshes, indicating a mesohalinic environment. On the other hand, *Salicornia europaea* s.l., which grows on bare saline mud flats (i.c. *S. procumbens*) and on saline inland stands (i.c. *S. europaea* s.s.), is represented in samples of all four periods. However, these plants produce small seeds that may easily be transported over large distances, so their presence does not necessary indicate their participation in the local vegetation. The same is probably true for the indicator plant *Juncus gerardi*, which is found in both samples from period 4, although in HK\1995 (No. 43) many unripe fruits were also found.

The I_u-values for moisture clearly show an increase for moist and dry habitats both by the number of samples that yielded indicator species and by the absolute values (fig. 9:B). Almost all samples are represented by indicator plants for wet and moist habitats. In many samples of the second period, indicator taxa indicative of both extreme moisture regimes are notably lacking. Although one sample of the third habitation period has a relatively high I_u-value for aquatic conditions, most samples of this period lack indicator plants in this class. The occurrence of *Veronica hederifolia* is responsible for the extreme value of sample HK\2332 (No. 49) for dry soil conditions in the third period. Seeds of this species have been found in the Netherlands only at De Horden (Lange, 1990), Hazendonk (Bakels, 1981) and Hekelingen (Bakels, 1988).

Indicator plants for nutrient availability differ in particular for moderate soils (fig. 9:C). Although its I_u increases with time, samples of later periods have low I_u-values or even lack indicator plants for this class of nutrient availability. Due to its broad ranges, no clear trend to poor and rich soils can be detected.

Samples of all periods are almost always represented by indicator plants for pioneer vegetations and grasslands (fig. 9:D). The I_u-values for pioneer vegetations increase in time and apply to most of the samples. Nevertheless, a part of the samples of the first three habitation periods have only a very small I_u for grasslands. The number of samples represented by indicator plants for water vegetation, semi-aquatic helophytic vegetation and shrub and woodlands is relatively low. In the course of time water vegetation apparently expanded with semi-aquatic helophytic vegetations.

3.2.4. *Environmental reconstruction for location and feature type*

The degree to which environmental factors are coupled with location and feature type for each period, is demonstrated in figure 10. As most samples of the *terp* had apparently no correlation with the various sediment layers, this variable has been left aside. Only taxa with a small ecological range are incorporated in the diagrams, and correspond with the taxa in figure 8. The occurrence of taxa is calculated in percentages; 100% equals all taxa indicative of an environmental factor for a given period and location or feature type. Thus, for salinity in period 1, 100% equals both location and feature type. As glycophytes and halophytes are complementary in percentages, only the latter is presented.

Apparently, the decrease of halophytes does not depend on the location (fig. 10:A). On the other hand, feature type shows some differences in the proportion of halophytes to glycophytes. Halophytes are mainly found in samples taken from ditches, trenches, the moat and the nearby marsh creek. Because of floodings documented up to the sixteenth century, the nearby surroundings may have become brackish now and again. Especially plants that are indicative of brackish conditions or are indifferent with respect to salinity may have grown periodically on the *terp* proper. Some of these were often found, such as *Potamogeton pectinatus* (period 1-3), *Scirpus lacustris* ssp. *tabernaemontani* (period 1-4) *Phragmites australis* (period 1-4), *Eleocharis palustris* (period 1-4) and *Scirpus maritimus* (period 1-4), while others were found at random: *Lemna trisulca* (period 3), *Myriophyllum spicatum* (period 1), *Rumex hydrolapathum* (period 1 and 4) and *Zannichellia palustris* ssp. *pedicellata* (period 1). Halophytes grew in the near surroundings; perhaps some of them temporarily on the slope of the *terp*. The plant remains of halophytes in samples of slope and central part of the *terp* may have been brought to the *terp* by men, as sods cut in the salt-marsh to heighten the *terp* or to be mixed with dung, or were partly dispersed by wind and water. Samples of the slope of the *terp* may contain a mixture of natural vegetation, dumped refuse and drift litter deposited during storm surges. Accordingly, the slope was rich in nutrient supply (fig. 10:F-H) and characterized by pioneer vegetation (fig. 10:J) and in the later periods also by grassland plants (fig. 10:I). Plants found in samples of the slope of the *terp* and may have

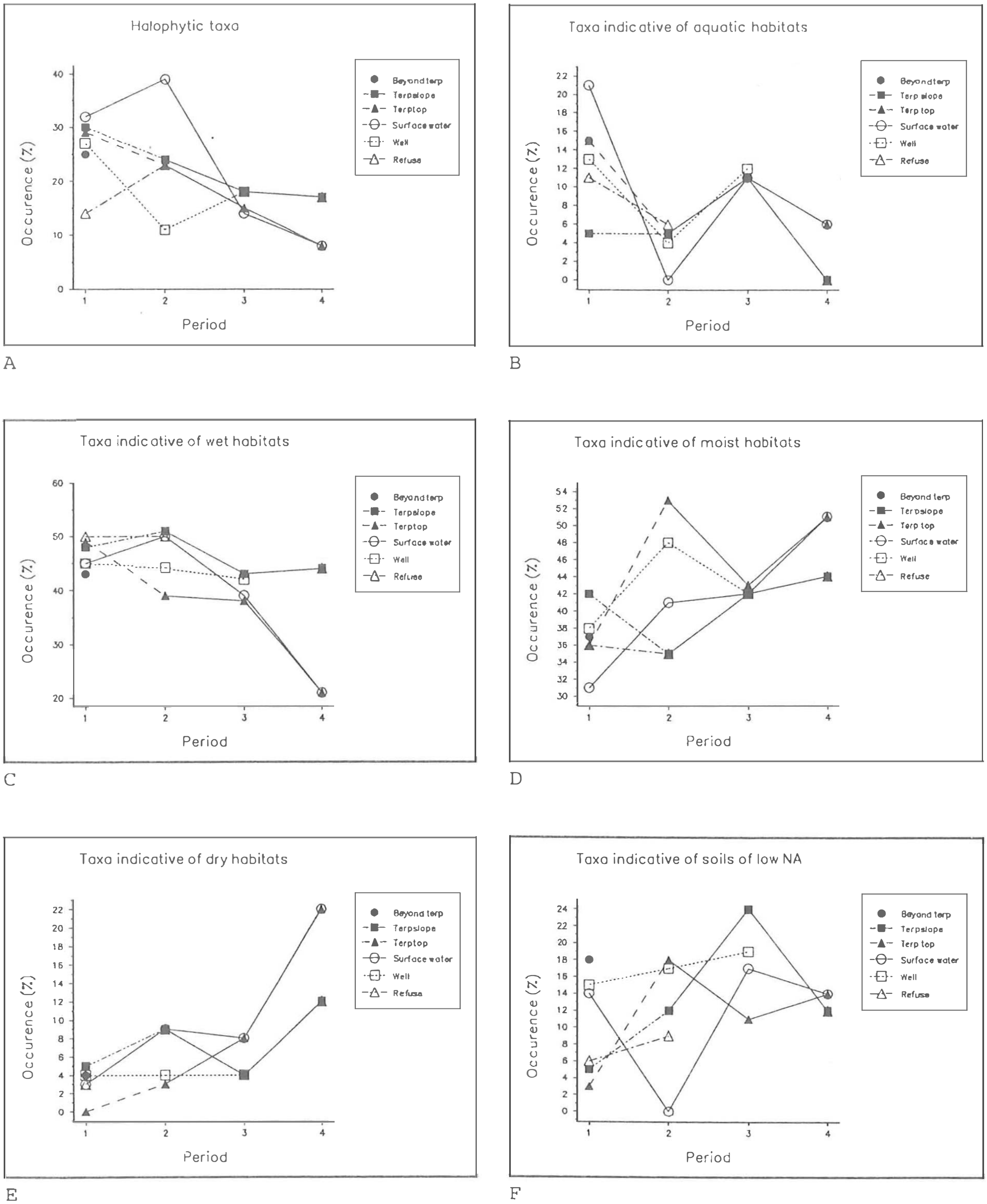
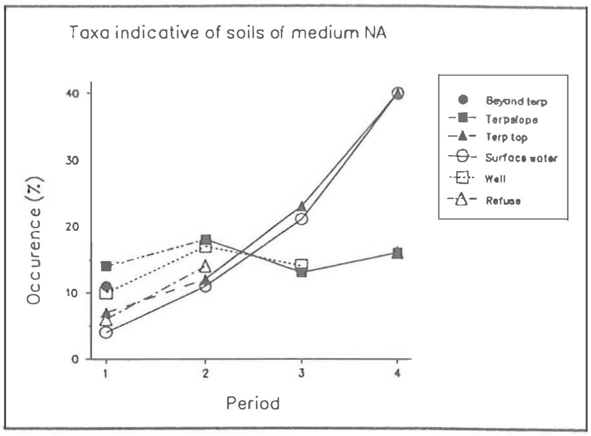
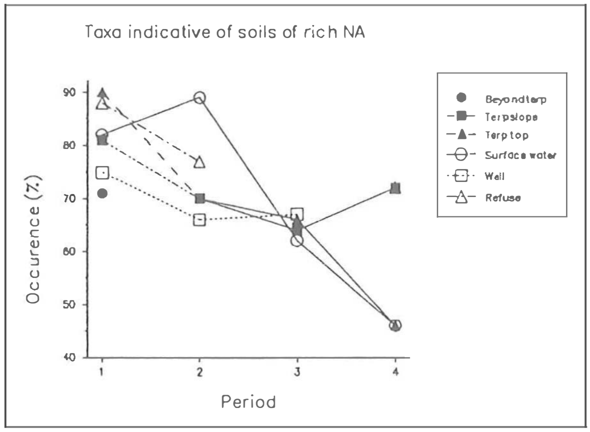


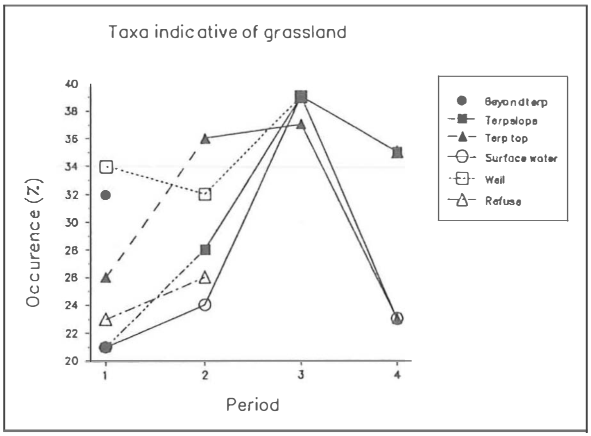
Fig. 10. A-F. Environmental characterization of samples with respect to location and feature type for each period on the basis of all taxa with small ecological range.



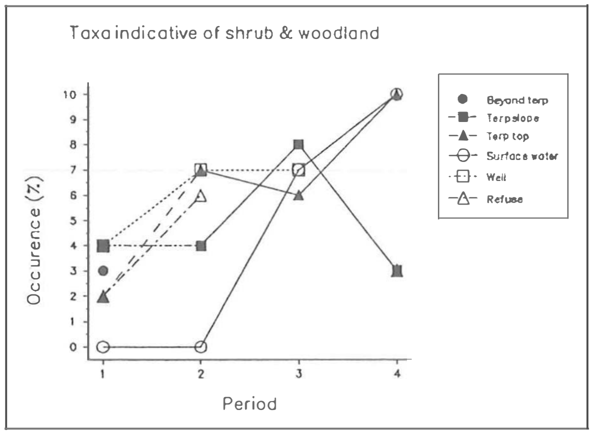
G



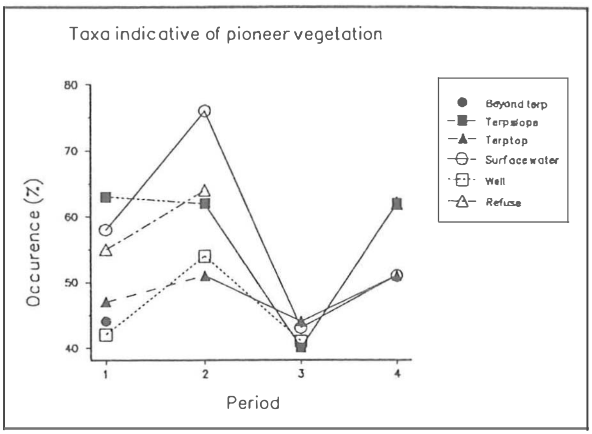
H



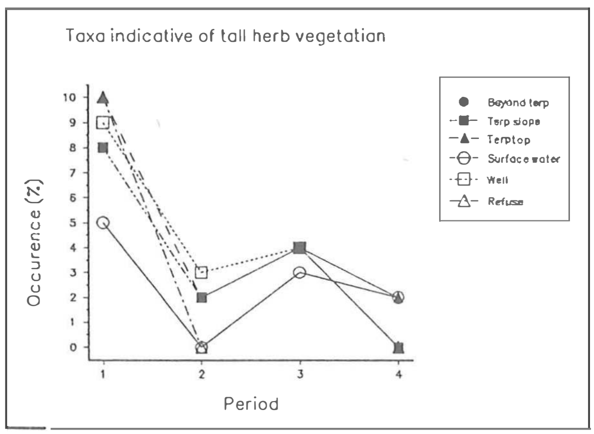
I



J

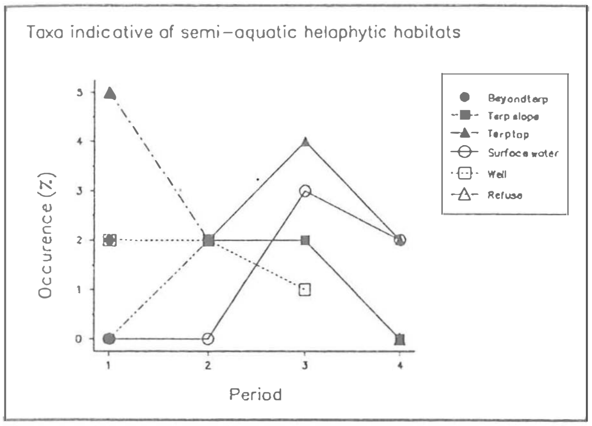


K

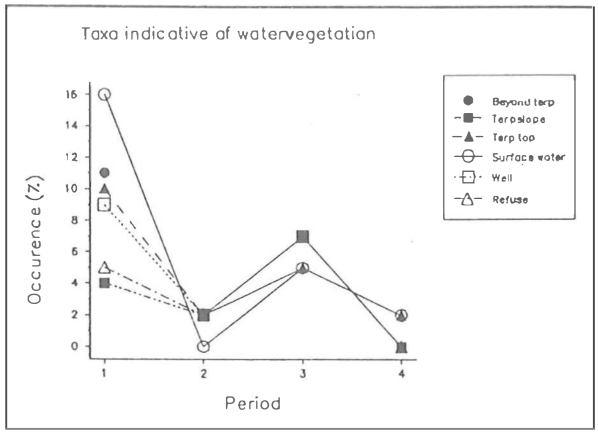


L

Fig. 10. G-L. Environmental characterization of samples with respect to location and feature type for each period on the basis of all taxa with small ecological range.



M



N

Figs. 10. M-N. Environmental characterization of samples with respect to location and feature type for each period on the basis of all taxa with small ecological range.

grown on drift litter, include: *Suaeda maritima*, *Conium maculatum*, *Althaea officinalis*, *Apium graveolens*, *Beta vulgaris*, *Matricaria maritima*, *Oenanthe lachenalii*, *Sonchus arvensis*, *Cirsium arvense*, *Atriplex littoralis/prostrata*, *Polygonum aviculare* and *Cochlearia officinalis*. *Suaeda maritima* grows on wet places with fresh drift litter that is mainly covered with algae. So it mainly grew along creeks where this kind of litter had been usually deposited. Its presence in many samples, viz. 41 of 59, can be assigned to its seed production and dispersal potential. The other species mentioned grow on tidal marks that consist of slowly decaying plants, whether or not covered with sand (Beeftink, 1965). This drift litter is deposited on higher altitudes, such as the slopes of a *terp*. Characteristic species of drift litter communities such as *Glaucium flavum*, *Cakile maritima*, *Honckenya peploides* and *Atriplex laciniata* have so far not been evidenced by subfossil remains for the Netherlands. In spite of their present distribution, their occurrence will be temporarily and consequently the chance of recovery will be small. It should be noticed that *Oenanthe lachenalii* is the only halophyte present in samples of the central part of the *terp* and its slope, but is not represented in samples beyond the *terp*. None of the samples collected from the slope of the *terp* shows evidence of included drift litter. This is no surprise, as the slopes of *terp*s take up a relatively large area. An indication of the presence of drift litter is the large percentage of charred plant remains, including non-weedy species, for large concentrations of charred weeds are obviously the result of crop processing. The only sample that did yield charred remains of many species is HK\2392 (No. 51) and was collected from the mout on the *terp* (table 5, fig. 5). Another indication for drift litter is the presence of plants that are considered to be originating from older deposits, such as *Potamogeton filiformis*. Of *Menyanthes trifoliata* and *Andromeda polifolia*, the two plants of Heveskesklooster that would qualify for this, the latter is only found once in a sample collected from the slope. The other seeds originate from samples taken from the central part of the *terp* and a location beyond the *terp*. Plants most frequently found in drift litter along the northern coast of the Netherlands where salt-marshes adjacent to the Wadden dykes are present, are: *Polygonum aviculare*, *Atriplex patula/prostrata*, *Stellaria media*, *Salicornia europaea*, *Suaeda maritima*, *Spergularia salina*, *Triglochin maritima* and *Aster tripolium* (Cappers, 1993). Although these plants were also found in samples originating from the slope, they do not show extreme values for this part of the investigated area. For the first habitation period, samples collected from the slope have only seven plants that were not found on the central part of the *terp*, while the number of unique species in samples collected from beyond the *terp*, and not present in samples from the central part, amounts to five. *Artemisia vulgaris* and *Spergula arvensis* are the only plants that are unique for the slope.

The vegetation on the central part of the *terp* seems to be not very particular about its environmental requirements. Only with respect to nutrient availability, plants seem to be predominantly indicative of rich soils, especially during the first periods of habitation (fig. 10:F-H). Although many plants were found in samples from the central part only, none of them was present in all periods. Species represented by large quantities of plant remains and found in samples of all four periods, are: *Plantago major*, *Atriplex patula/prostrata*, *Agrostis* spp., *Poa pratensis/trivialis*, *Stellaria media*, *Polygonum aviculare*, *Urtica dioica*, *Chenopodium album* and *Sonchus arvensis*, but they also occurred beyond the central part of the *terp*.

Samples collected from wells are characterized by species indicative of low nutrient supply (fig. 10:F-H) and can be attributed to species from peats and heaths: *Andromeda polifolia*, *Calluna vulgaris*, *Erica tetralix*, *Carex pilulifera, Eriophorum vaginatum, Rhynchospora alba, Rumex acetosella* and *Betula* spp. These remains are partly charred and indicate the use of fuel (table 5). On the other hand, to obtain drinking-water, wells had to be sunk till the sandy soil. Consequently, the thick layer of basal peat was dissected and would have delivered the remains of those plants. Schoute (1984) mentioned that this peat layer at Heveskesklooster mainly consists of *Phragmites* peat. Although *Phragmites* was also frequently found in samples from these wells, the above mentioned species fit in well with the description of the same peat layer in the Groningen coastal area by Roeleveld (1974). Peat for fuel, as a second source of these plants, may have been cut in the transition zone between the clay district and the Pleistocene sand district. From a report dated to 1598, it is known that the cloister was in the possession of a bog nearby Slochteren, some 10 km southwest of Heveskesklooster (Noordhuis, 1990).

Like dung layers and dung pits, unused wells may also have been utilized to dump refuge and may explain its mixed species composition. The large number of wells suggest that the well water may often had become undrinkable. Knörzer (1984) described some criteria that serve as a device for detecting the presence of human faeces: 1) evenly distributed traces of food plants including cereal bran fragments and large quantities of fragmented fruit stones and 2) fragments of weeds, particularly those of *Agrostemma githago*. Although bran fragments of *Hordeum vulgare* were regularly found in wells, they were only small in number as were the fragments of stone fruits and weeds. Wells from which samples were analyzed were indeed used afterwards for dumping refuge, but not as cesspits. The only sample that unambiguously contained human faeces is HK\2098 (No. 46) which originated from the moat. This sample contained many cereal bran fragments from both *Secale cereale* and *Hordeum vulgare* but no large numbers of rachis segments and awns of lemma, both characteristic of crop processing. Other samples that contained many waterlogged remains of cereals, especially waste layers/pits and surface water (fig. 10:K), proved to be rich in threshing remains together with weeds.

Grassland plants were frequently found in samples from wells and surface water and dominate particularly in period 3 at the expense of pioneer plants (fig. 10:I,K). In addition to cereals, 25 different grassland taxa could be demonstrated. Some of them, viz. *Poa annua, Festuca rubra, Agrostis, Bromus hordeaceus/secalinus, Elymus athericus/repens, Poa pratensis/trivialis* and *Phragmites australis* are present in several samples of all four periods, but the last mentioned species is absent in period 4. *Phalaris arundinacea* was frequently found in samples of the first period, especially in those that were taken from wells. This grass may have grown in the near surroundings in wet places and may have been collected for cattle fodder. Samples of the third habitation period are characterized by *Alopecurus geniculatus, Holcus lanatus, Lolium perenne, Danthonia decumbens* and *Cynosurus cristatus*, although these species were found also in one or two samples of the preceding period. Most of these species may have grown on the *terp*, including the slope. It is also possible that they were partly taken to the site as cattle food. The last two species are of special interest and are preserved both by waterlogging and charring. The only other Dutch records of *Danthonia decumbens* are reported from Rockanje, which is dated to the Roman Period (Brinkkemper, 1993) and Texel, which is dated to the late Bronze Age and early Iron Age (personal communication by van Zeist). At several sites in England large numbers of seeds of this species have been found in association with crop plants, reasons for Hillman (1981, 1982) to draw the conclusion that *D. decumbens* was probably a crop weed in former times, despite its present occurrence in heaths and moorlands. The chance of survival of this tufted perennial in arable fields could be supported, according Hillman, by ploughing the fields by ard, which was probably replaced by an efficient ploughing mouldboard only in medieval times. Körber-Grohne (1990) points out that *D. decumbens* would not have survived in cultivated grasslands as a result of which its subfossil presence in this type of vegetation is rare. Some of the samples of Heveskesklooster revealed large numbers of fruits, partly still enclosed by their glumes. Heathland plants, such as *Erica tetralix, Calluna vulgaris*, and *Carex pilulifera* only partly occur in samples in which *D. decumbens* is present and then only in small numbers. It is therefore likely that also for Heveskesklooster this species, which grows on rather well drained soils with low nutrient supply, should be considered as a weed, probably of *Avena sativa*.

Cynosurus cristatus is also rare in Dutch subfossil records, as it is only reported from De Horden, roughly dated to the Roman Period and early Middle Ages (Lange, 1990) and Groningen, dated to the eighteenth century (van Zeist, 1987). Although this species is present in almost the same samples from which *D. decumbens* was recovered, it would have grown on moist soils with a moderate nutrient supply, either on the *terp* on places with frequent treading or in the near surroundings in grazed areas.

3.2.5. *The salt-marsh vegetation*

The near surroundings outside the *terp* are only represented by samples of the first habitation period. Because the vegetation of mud flats and salt-marshes would hardly have changed in the course of time, they will be discussed in more detail. In all, nineteen halophytes are present in those samples, supplemented by twenty-six taxa that can grow in both brackish and fresh habitats. Submerged halophytes, viz. *Ruppia maritima, Zannichellia palustris* and *Potamogeton pectinatus*, were mostly found in samples of wells and, to a lesser degree, of trenches and waste layers. During the first habitation period, the creek was certainly subjected to tidal movements, which makes it only suitable for *Zannichellia palustris* and *Potamogeton pectinatus*. The three plants may also have been present in small water bodies isolated from the creek. On the mud flats along the marsh creek and also on places where sods were cut to heighten the *terp*, *Salicornia europaea* may have grown.

On the higher tidal flats and the lower parts of the salt-marsh that were exposed to tidal movements, the Puccinellietum maritimae is represented by *Puccinellia maritima*, *Aster tripolium*, *Suaeda maritima*, *Triglochin maritima* and *Spergularia maritima*, the latter documented as *S. maritima/salina*. Though some criteria were set to distinguish *S. maritima* and *S. salina* as to seed wing, papillae and cell pattern (van Zeist, 1974; Behre, 1976), its taxonomic value remains doubtful (Sterk, 1969a,b; Telenius & Tortensson, 1989; Telenius, 1992). For that reason no distinction was made, although the above mentioned criteria indicate that both species are present in many samples.

On the middle high salt-marsh, above mean high water, the Plantagini-Limonietum, represented by *Plantago maritima* and *Limonium vulgare*, possibly occurred where silt had accumulated. This plant community may be considered as the terminal phase of the Puccinellietum maritimae where the salt-marsh remained ungrazed (Westhoff & den Held, 1975; Roozen & Westhoff, 1985). Nevertheless, Bakker (1989) found both plants often in grazed areas of Schiermonnikoog, and should perhaps be interpreted as a transitional phase after renewed grazing. Also the Halimionetum portulacoidis, restricted to ungrazed areas and located on natural and well drained levees, may have been present along the creeks. Nowadays, its character species *Atriplex portulacoides* is more dominant in salt-marshes of south-west Netherlands, where differences between low and high tides are larger whereby desalination of the soil was limited (Mennema et al., 1985). During the first habitation period, such tidal difference may also have existed which may explain the absence of *Atriplex portulacoides* in Heveskesklooster. On the other hand, this species has so far not been recorded in the Dutch subfossil records, indicating unfavourable conditions for preservation. Moreover, analyses of recent British salt-marshes dominated by *Atriplex portulacoides* by both germination and extraction of seeds, revealed no seeds (Ungar & Woodell, 1993). But its seeds were frequently found in drift litter collected from various areas of England (Waisel, 1972). Apparently, seed production of this species is low or may change per year. This makes it difficult to decide upon the presence of the Puccinellio-Spergularion salinae that is different from the alliances Puccinellion maritimae and Armerion maritimae because of the absence of this species (Westhoff, 1987) and in spite of the presence of *Spergularia maritima/salina* and *Puccinellia distans* in many samples.

On the higher part of the salt-marsh, characterized by inundations only at high spring tides and storm tides, two associations of the Armerion maritimae are widespread along the north coast of the Netherlands: Artemisietum maritimae and Juncetum gerardii. The character species of these associations are *Artemisia maritima* and *Armeria maritima* respectively, though the latter is often also found in the Sagino maritimae-Cochlearietum danicae (Westhoff, 1987). Like *Atriplex portulacoides*, *Artemisia maritima* has never been found in any archaeological context in the Netherlands before, in contrast with the related *A. vulgaris*. The same is true for excavations of *terps* in the northern part of Germany (Körber-Grohne, 1967; Behre, 1970, 1972, 1976, 1986, 1991). In recent drift litter, *Artemisia maritima* was frequently found, though in most cases germinating and subjected to decay, explaining its absence in the subfossil record (Cappers, 1993). On the other hand, the absence of *A. maritima* may also be indicative of intensive grazing (Bakker, 1989) and the presence of agricultural fields on the ridges along the creeks. *Armeria maritima* is not necessarily present in the Artemisietum maritimae and was only found in samples dated to the second and third period. Species of samples of beyond the *terp* proper that are common in these associations are: *Juncus gerardi*, *Festuca rubra*, *Glaux maritima*, *Leontodon autumnalis*, *Trifolium repens*, *Carex distans*, *Potentilla anserina* and *Agrostis*. Particularly graminoids, viz. *Juncus gerardi* and *Agrostis stolonifera*, but also hemicryptophytic plants such as *Leontodon autumnalis* (Körber-Grohne, 1992) are specific indicators for grazing, which, in turn, were responsible for an increase in species diversity of Juncetum gerardii communities (Bakker, 1989). From the beginning of inhabitation onwards, livestock was an important factor in the economy of the site. Bones of the first habitation period that have so far been studied, are of cattle and horse (Prummel, 1988). Grazing was common practice on the nearby salt-marsh. The structure of the salt-marsh vegetation may therefore be comparable with the recent structure and, as pointed out by Westhoff (1985), the different vegetation composition as a result of ungrazed conditions may not be valid for this salt-marsh.

In contrast with the present-day situation, the Juncetum gerardii had covered large areas of the former salt-marshes (van Zeist, 1974). Five subassociations were described on the basis of subfossil records of sites along the northern coast of the Netherlands and Germany (Körber-Grohne, 1992). In addition to the variants that correspond to subassociations that are distinguished nowadays, viz. subass. typicum and leontodontetosum autumnalis, they are: 1) a subassociation with much *Bromus hordeaceus* and also abundant *Leontodon autumnalis* and *Trifolium repens* (Körber-Grohne, 1967; Behre, 1976), subdivided by Behre into a variant with *Bromus hordeaceus* and one without this species, 2) a subassociation with much *Eleocharis palustris* ssp. *uniglumis* and less abundance of *Leontodon autumnalis* and *Trifolium repens* (Körber-Grohne, 1967; van Zeist, 1974) and 3) an initial subassociation with *Limonium vulgare* (Behre, 1976).

The distinction between these subassociations was established on the basis of samples that proved to be relatively pure in its species composition. Besides diaspores, stems were frequently present indicating local deposition. The samples of Heveskesklooster did not reveal a clear clustering with these Juncetum gerardii subassociations. In general, samples from the first and, to a lesser degree, of the second period contain a large number of *Juncus gerardi*, while dominant species of the other subassociations are lacking. On the contrary, samples of the last two habitation periods are characterized by the occurrence of the above mentioned species, in which *Juncus gerardi* is still represented by a large number of seeds. Nonetheless, many samples contain several of them and a clear pattern is lacking.

One of the last halophytes to be mentioned is *Scirpus rufus*. In sample HK\2379 (No. 50), dated to the third period of habitation and collected from the moat on the *terp*, several fruits were found, some of them still enclosed by their glumes. This species has only been reported before from a medieval house *terp* in a reclaimed bog area near Oostzaan (van Geel et al., 1986) and from a heightening deposit at Monnickendam (Hogestijn, 1989), both of the thirteenth century. *Scirpus rufus* is a northern Atlantic species and its distribution in the Netherlands is almost limited to the Wadden district (Mennema et al., 1985). It is the character species of the Scirpetum rufi, which grows in between the salty and fresh environment and is found in places that are almost permanently brackish, although the water may become fresh now and then (Ketner, 1972). It can stand grazing and may even be favoured by trampling. Owing to its intermediate position in the halosere, it may have grown in the vicinity of both halophytes, like *Juncus gerardi*, *Triglochin maritima* and *Plantago maritima*, and glycophytes such as *Triglochin palustris*, *Agrostis stolonifera* and *Eleocharis quinqueflora*. Although *Scirpus rufus* often occurs as mono-dominant stands, *E. quinqueflora* may have been co-dominant in the association (Penford, 1989). *E. quinqueflora* was found in several samples, most of them dated to the third period. The sample in which *S. rufus* was found revealed indeed some hundreds of fruits, some of them still connected to each other. It is not likely that this species will have grown along the mout on the *terp*, for the soil would not have been brackish. The remains have probably originated from the lower part of the slope bordering the marshes where trenches were dug for drainage and some detritus was present.

A salt-marsh plant that is absent in the subfossil record from Heveskesklooster, is *Parapholis strigosa*. Today, this species is quite common in salt-marshes (both Puccinellion maritimae and Armerion maritimae) along the Dutch and German coasts, including the German border of the Ems (Mennema et al., 1985; Haeupler & Schönfelder, 1988). Subfossil seeds of *P. strigosa* are very characteristic and were recorded for several sites along the Dutch coast: Rockanje (Brinkkemper, 1993), Monnickendam (Hogestijn, 1989), Den Helder/Het Torp, Tritsum and Tzummarum (van Zeist, 1974) and Foudgum (van Zeist et al., 1987). The samples in which this species was found are dated from the Iron Age up to late medieval times and delivered only very few seeds. Correspondingly, it may still be possible that this species was present in former times, and even in sites that were thoroughly investigated.

3.2.6. *Comparison with other Dutch terps*

The botanical investigation of *terps* has a long tradition in the Netherlands. Even in the middle of the nineteenth century, seeds of *Vicia faba* var. *minor* and *Linum usitatissimum* were reported by Acker Stratingh in 1849 from the Warffum *terp* (see van Zeist, 1970). Publications of Beijerinck (1928, 1929 and 1931), van Zeist (1970, 1974 and 1988) and van Zeist et al. (1987) increased our knowledge of the botanical remains of the *terps* in the coastal area of the Netherlands. Unfortunately, many samples of early excavations available for botanical analyses were poorly dated or not dated at all. Moreover, most of the botanical records published by Beijerinck are not presented for individual samples, and a detailed analysis was not possible.

It was therefore decided to base the comparison of the *terps* with respect to the environmental characteristics on the occurrence of indicator taxa. With the exception of Oostzaan, all the selected *terps* are located in the northern part of the Netherlands (fig. 1). The data from Ezinge and Leeuwarden with respect to the Iron Age (van Zeist, 1974) do not overlap the data from Heveskesklooster and were left aside. In the event of lacking periodization, samples were dated from the middle Iron Age to the early Middle Ages (table 9). In some cases, it was possible to reduce this period on the basis of recent studies of archaeological objects (personal communication by E. Knol and W. van Zeist). As most botanical records of *terps* are not classified according to periods, the indicator value I_u for each environmental characteristic was calculated regardless of the number of samples in which the indicator plants were present (Cappers, 1994). An exception was made for the samples of Heveskesklooster, of which I_u was calculated for each period separately and for all periods together (fig. 11). It should be noted that the summing up of all indicator values of species of a certain period may give a shift of I_u as it is influenced by the number of samples investigated. For example, period 3 of Heveskesklooster has the maximum value I_u for dry soils which can be attributed to one sample containing *Veronica hederifolia*. Without this sample, its value would fluctuate between the values of the first two periods (see also fig. 9:B). To facilitate the interpretation of indicator values, the maximum value of I_u of the characteristics concerned is

Table 9. Description of the *terps* of which botanical records are analyzed for environmental characteristics and economically important plants. Heveskesklooster is mentioned also separately for the various habitation periods. The *terps* are arranged in decreasing order with respect to the number of recorded taxa. Abbreviations for the periods: IA. Iron Age; RP. Roman Period; MA. Middle Ages; MT. Modern Times; e. Early; m. Middle; l. Late.

No.	*Terp*	Period	From	To	References
1	Heveskesklooster 1-4	RP-MT	50 BC	1975	
1a	Heveskesklooster 1	RP	50 BC	400	Table 2
1b	Heveskesklooster 2	MA	800 AD	1300	Table 3
1c	Heveskesklooster 3	MA	1300 AD	1610	Table 4
1d	Heveskesklooster 4	MT	1610 AD	1975	Table 4
2	Leeuwarden	MA	800 AD	1525	Van Zeist et al., 1987
3	Ezinge	eIA-lMA	600 BC	1500	Beijerinck, 1928, 1929, 1931; van Zeist, 1974
4	Paddepoel/Groningen	lIA-eRP	200 BC	250	Van Zeist, 1974
5	Tritsum	mIA-eRP	500 BC	200	Van Zeist, 1974
6	Sneek	eRP	50 BC	270	Van Zeist, 1974
7	Foudgum	MA	800 AD	1100	Beijerinck, 1929; van Zeist et al., 1987
8	Den Helder/Het Torp	MA	900 AD	1200	Van Zeist, 1974
9	Oldeboorn	lMA	1000 AD	1200	Van Zeist, 1988
10	Tzummarum	eMA	600 AD	1000	Van Zeist, 1974
11	Oostzaan	lMA	1200 AD	1300	Van Geel et al., 1986
12	Ferwerd	mIA-eMA	500 BC	1000	Beijerinck, 1929, 1931
13	Westeremden	mIA-lMA	500 BC	1500	Beijerinck, 1929, 1931
14	Rasquert	mIA-lMA	500 BC	1500	Beijerinck, 1929
15	Houten-Bayum	mIA-eMA	500 BC	1000	Beijerinck, 1929
16	Hoogebeintum	mIA-eMA	500 BC	1000	Beijerinck, 1929
17	Jelsum	mIA-eMA	500 BC	1000	Beijerinck, 1929
18	Oosterbeintum	mIA-eMA	500 BC	1000	Beijerinck, 1929
19	Midlum	mIA-eMA	500 BC	1000	Beijerinck, 1929
20	Arum	mIA-eMA	500 BC	1000	Beijerinck, 1929
21	Eenum	mIA-lMA	500 BC	1500	Beijerinck, 1929
22	Leens	eMA	500 AD	1000	Beijerinck, 1929
23	Dokkum/Berg-Sion	lRP-eMA	300 AD	1000	Beijerinck, 1929
24	Achlum	mIA-eMA	500 BC	1000	Beijerinck, 1929
25	Tzum	mIA-eMA	500 BC	1000	Beijerinck, 1929
26	Wadwerder Wierde	mIA-lMA	500 BC	1500	Acker Stratingh, Feith & Boeles, 1870
27	Usquert	mIA-lMA	500 BC	1500	Acker Stratingh, Feith & Boeles, 1870

also presented in each diagram. As the differences in extensiveness of the botanical records are much correlated with the method of analysis, the *terps* are arranged in decreasing order as to the total number of taxa mentioned for the site, and only waterlogged plant remains that were positively identified are considered. These totals are marked with a solid line in each diagram.

On the basis of indicator species, an overall impression of figure 11 reveals that Dutch *terps* are largely characterized by both halophytes and glycophytes, wet and moist soils with a rich nutrient supply and plants of pioneer vegetations and grasslands. Irrespective of the number of taxa concerned, the botanical records of the *terps* comprise species indicative of both saline and freshwater conditions (fig. 11:A). Halophytes are very well represented in Heveskesklooster (*terp* 1). The only indicator species not found was *Parapholis strigosa*. The increase of I_u in period 2 and 3 of Heveskesklooster can be attributed to the presence of *Cochlearia officinalis*. Leeuwarden (*terp* 2) differs from other *terps* by its high I_u for glycophytes, which can be explained by the inland location along the former Middelzee, a sea arm that had be embanked only in the eleventh century, and the import of plants from the sandy hinterland (van Zeist et al., 1987; van Zeist, 1988). Oostzaan (*terp* 11) yielded many plants and is characterized by a high value of glycophytes, and the indicator value of halophytes is relatively low. This *terp* is dated to the thirteenth century and was situated in a raised bog environment which was temporarily inundated by salt or brackish water from the Zuyder Zee (van Geel et al., 1986).

Only Heveskesklooster and Leeuwarden have a high I_u for dry soil conditions (fig. 11:B). For Heveskesklooster these values increase for the two last periods. Like Leeuwarden, the increase of indicator taxa for dry soils relates partly to imported plants in connection with cereals. Remarkably, *terps* with a high I_u for the other extreme moisture condition, viz. aquatic habitats, are located in the northeastern part of the Netherlands, with the exception of Oostzaan. They are Heveskesklooster (*terp* 1), Paddepoel/Groningen (*terp* 4), Westeremden (*terp* 13) and Rasquert (*terp* 14). The Eenum *terp* (No. 21), also located in this area, is underestimated for its low number of taxa. These sites have high I_u for aquatic habitats partly because of a relatively large number of

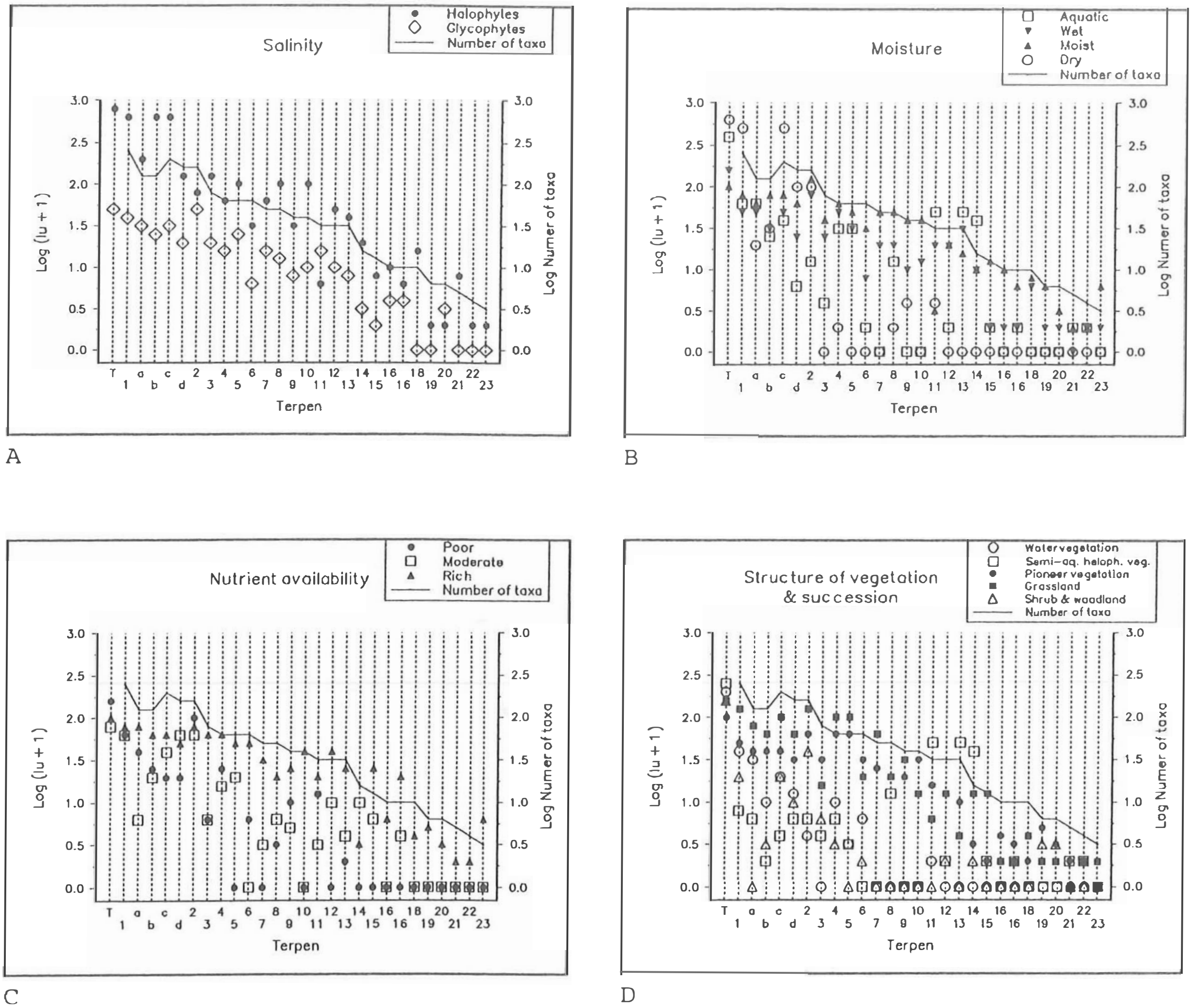


Fig. 11. A-D. Indicator values I_u of *terps* in the northern part of the Netherlands. The *terps* are arranged in decreasing order with respect to the total number of taxa (solid line) that are mentioned for the site. On the X-axis the maximum value of I_u (= T) for each characteristic is also presented. The I_u of Heveskesklooster is calculated for all samples together (= 1) as well as for each period separately (= 1a-d). The numbers of the *terps* correspond with those of table 9.

water plants, viz. Heveskesklooster and Paddepoel/ Groningen, and partly because of the occurrence of *Ranunculus lingua* which has a high weight factor.

As to nutrient availability, Heveskesklooster and Leeuwarden have much in common (fig. 11:C). Both *terps* have high indicator values for all three classes. In Heveskesklooster it is obvious that the indicator value for soils with a moderate nutrient supply increases from the first period onwards, whereas indicator values for high and low nutrient supply are decreasing. As is shown by figure 9:C, this can be explained by both the number of samples and the species composition. The other *terps* do not display a clear pattern of indicator values for poor and moderate nutrient supply. Some *terps* are characterized by a gradual increase in nutrient availability, viz. Tritsum (*terp* 5) and Foudgum (*terp* 7), while others have high indicator values for both rich and low nutrient supply, viz. Oostzaan.

The indicator values of Heveskesklooster for grassland and pioneer vegetation do not differ much with each of the four periods (fig. 11:D). Although shrub and woodland plants represent a considerable part of the Dutch flora, they are hardly represented by subfossil records of the *terps*. Again, Heveskesklooster and Leeuwarden are the only two *terps* of which samples yielded a reasonable number of these species, although the indicator values of Heveskesklooster are low in the first two habitation periods. Most of the indicator plants of semi-aquatic helophytic vegetations are also indicative of aquatic habitats, thus repeating the pattern of figure 11:B. Submerged waterplants, such as *Potamogeton* spp. are rare, while other genera such as *Ceratophyllum* spp. and *Myriophyllum* spp. are completely absent, except for Heveskesklooster.

3.3. Economically important plants

3.3.1. *Agricultural plants*

Bulk deposits of agricultural plants that are known from many sites located in the Pleistocene district have not been found in the *terps* in the coastal area. Nevertheless, the excellent conditions for both waterlogging and charring in *terps* have yielded many plant remains of agricultural plants. They are mostly deposits of threshing remains in refuge layers or pits, and human faeces possibly concentrated in cesspits. As stated before, cesspits could not be demonstrated in Heveskesklooster, whereas many samples were defined as refuse layers and pits (table 1).

The cereal most frequently encountered in Heveskesklooster is hulled barley (*Hordeum vulgare*) and is represented in all four habitation periods in considerable numbers of waterlogged and charred remains (table 10). Many samples yielded both grains and threshing remains. Waterlogged grains consist of the pericarp and the seed coat, while the endosperm was usually absent. Fruit envelopes were often complete and partly enclosed by remnants of lemma and palea. The quality of the waterlogged grains, accompanied by the presence of glumes and awn fragments, exclude the possibility that they would originate from the digestive process. Baking and the passage of bran through the digestive tract result in smaller fragments and the lack of the pericarp, as could be demonstrated for *Triticum aestivum* (Schel et al., 1980). The occurrence of threshing remains in samples of the *terp* indicate that *Hordeum vulgare* was cultivated locally and that the harvest was processed on the *terp* proper, at least partly.

The only charred grain of naked barley (*Hordeum vulgare* ssp. *vulgare*) was found in sample HK\1638 (No. 34) and was collected from a well. In the same sample charred remains of hulled barley and oats (*Avena* sp.) were also found. The single find of naked barley and the rough dating of the sample do not justify a speculation about the cultivation of this species at the site and is considered to be an admixture. Naked barley is frequently found in Dutch sites dated to the Neolithic Period and the Bronze Age. Both naked and hulled barley from the Bronze Age are frequently recorded, while naked barley has been replaced by hulled barley in the early Iron Age. The only Neolithic sites in the Netherlands that yielded some grains of hulled barley, are: Vlaardingen (van Zeist, 1970), Aartswoud (Pals, 1984) and Zijpe/Keinsemerbrug (Anonymous, 1987). Records from the Netherlands of naked barley dating to periods after the Bronze Age, are also rare: Colmschate (early Iron Age; Buurman, 1986), Ede-Veldhuizen

Table 10. Agricultural plants of Heveskesklooster per period. Numbers are represented as a range (see table 2). Abbreviations: Wl. Waterlogged; Ch. Charred; G. Grains; T. Rachis segments or top of pedicels; S. Seed; F. Fruit.

	Per. 1				Per. 2				Per. 3				Per. 4			
	Wl		Ch		Wl		Ch		Wl		Ch		Wl	Ch		
	G	T	G	T	G	T	G	T	G	T	G	T	G	T	G	T
Hordeum vulgare																
ssp. *vulgare* (hulled)	4	6	4	4	8	7	6	6	6	8	5	6	5	-	2	1
ssp. *vulgare* (naked)	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
ssp. *distichum*	-	-	-	-	-	-	-	-	-	7	-	2	-	-	-	-
ssp. *vulg./dist.*	-	-	-	-	-	-	-	-	8	9	-	-	-	-	-	-
Avena																
A. fatua	-	-	-	-	-	-	-	-	4	6	2	4	-	-	-	-
A. sativa	-	-	-	-	-	-	-	-	-	7	-	2	-	-	-	-
A. fatua/sativa	-	-	-	-	3	-	2	-	8	-	4	-	-	-	1	-
Secale cereale	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-
Triticum aestivum var. *comp.*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Panicum miliaceum	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
	Per. 1				Per. 2				Per. 3				Per. 4			
	Wl		Ch		Wl		Ch		Wl		Ch		Wl		Ch	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Linum usitatissimum	5	5	-	-	1	-	-	-	5	7	-	-	1	-	-	-
Camelina sativa	6	6	-	-	-	-	-	-	2	-	-	-	3	-	-	-
Vicia faba var. *minor*	2	-	-	-	4	-	1	-	7	-	2	-	2	-	-	-
Brassica rapa	-	-	-	-	4	2	-	-	8	-	-	-	4	-	-	-
Cannabis sativa	-	-	-	-	4	-	-	-	5	-	-	-	4	-	-	-
Fagopyrum esculentum	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-

(Roman Period; van Zeist, 1976) and Gasselte (Middle Ages; van Zeist, 1979). Only in Colmschate a reasonable amount of grains of naked barley was found in a corn-stack, together with *Triticum dicoccum*, whereas the other sites yielded only a few grains.

In two samples dated to the third period, viz. HK\2332 (No. 49) and HK\3351 (No. 56), both hulled six-row barley (*Hordeum vulgare*) and two-row barley (*Hordeum vulgare* ssp. *distichum*) were found. The latter could be identified by their small rachis segments. In sample HK\3351, only two charred rachis segments were found. In the other sample, however, many uncharred rachis segments and bran fragments were encountered, of which only the rachis segments were identified to the level of subspecies. Because of the number of rachis segments it is likely that two-row barley was also cultivated in Heveskesklooster during the third habitation period. Dorestad near Wijk bij Duurstede is the only other Dutch site from which two-row barley was recorded. In samples of this site, dated to the eighth and ninth century, many charred grains of both six-row and two-row barley were found (van Zeist, 1970, 1990).

Oats (*Avena* sp.) is another cereal frequently found in samples of Heveskesklooster, though mainly restricted to the third habitation period. In addition to the basal part of the lemma that was still present at some specimens, also on the basis of the top of the pedicels both wild oats (*A. fatua*) and cultivated oats (*A. sativa*) could be demonstrated. Although the number of pedicels of cultivated oats exceeds that of wild oats, the latter will have represented a substantial part of the cereal field. Wild oats, which has a short life cycle from spring until late summer, had probably grown together with cultivated oats and summer barley. In the two samples that yielded relatively large amounts of remains of *A. fatua*, viz. HK\2283 (No. 47) and HK\2332 (No. 49), also *A. sativa* and *H. vulgare* are well represented. On the other hand, in sample HK\3351 (No. 56) charred remains of *A. fatua* were only found together with those of *H. vulgare*. All subfossil records of the Netherlands on wild oats are accompanied at least with records on barley. Some sites also provided cultivated oats, but its limited identification distort the representativeness of cultivated oats.

One single charred grain of *Triticum aestivum* var. *compactum* was found in sample HK\2379 (No. 50). Two other cereals, viz. rye (*Secale cereale*) and broomcorn millet (*Panicum miliaceum*), were found in sample HK\2098 (No. 46) of the last period. In comparison with barley, oats and wheat, rye makes no high demands upon its environment and can withstand even low temperatures. Its absence in subfossil records from sites in marsh areas along rivers and coast as mentioned by Behre (1992), may be explained by the poor drainage of these areas in former times, causing the soil to freeze up, to which rye is sensitive (de Smet, 1961).

The occurrence of seeds of *Berteroa incana* in sample HK\2098 indicates that this sample is of recent date. In the Netherlands, this species was first collected in 1835 and was spread over a large area. Though most weed species of this sample are also documented for the province of Groningen in herbaria and written sources and correspond to the last period of habitation, it is striking that many of them were not found in samples of older periods and have become rare in this area in recent times (Wasscher, 1941; Mennema et al., 1985; van der Meijden et al., 1989). They represent both members of the Chenopodietea, e.g. *Setaria pumila* and *Chrysanthemum segetum*, and of the Secalietea, e.g. *Buglossoides arvensis*, *Arnoseris minima*, *Anthemis arvensis* and *Papaver argemone*. Apparently, the distribution of those weeds is characterized by a temporary increase during the last centuries followed by strong decline during the last decades. Many of these weeds are specifically mentioned for sites located in the coastal area as from late medieval times onwards. It is probable that the influence of the sea was for a long time responsible for preventing a successful invasion of these weeds into the agricultural fields. The temporary expansion capacity of weeds is illustrated by *A. fatua*, which expanded its area all over the country during 25 years because of the increase of the cultivation of summer grains. A shift towards root crops and the introduction of herbicides resulted in a decline of its spread during the seventies (van der Meijden et al., 1989).

In this respect, two other exotic weeds should be mentioned: *Neslia paniculata* and *Bupleurum rotundifolium*, also originating from sample HK\2098. Contrary to *Berteroa incana*, which is more or less naturalized in the Netherlands, these species are considered to be adventitious and are represented by the archaeobotanical record from the Middle Ages onwards. *B. rotundifolium* is mentioned for Dorestad (eighth-ninth century; van Zeist, 1990), Leeuwarden (tenth century; van Zeist et al., 1987) and the Oldeboorn *terp* (eleventh-twelfth century; van Zeist, 1988). *N. paniculata* is recorded from Groningen (c. 1650; van Zeist, 1987), Bourtange (c. 1650-1730; van Zeist, 1993), Kampen (c. 1475-1575; Vermeeren, 1990) and from a shipwreck in the Wadden Sea that participated in the Baltic graintrade (sixteenth-seventeenth century; Manders, 1993). Except for Dorestad, all these sites are located in the northern part of the Netherlands. Both weeds are members of the Caucalidion lappulae and characteristic for cereal fields on dry and calcareous soils. They have a continental distribution and their presence in the Netherlands indicate that grain was imported.

Non-cereal crops found in samples from Heveskesklooster are: flax (*Linum usitatissimum*), gold-of-pleasure (*Camelina sativa*), celtic bean (*Vicia faba* var. *minor*), turnip (*Brassica rapa*), hemp (*Cannabis sativa*) and buckwheat (*Fagopyrum esculentum*) (table 10). With the exception of some specimens of the celtic bean, they were preserved by waterlogging only.

Flax and celtic bean are present from the first period onwards. During the second habitation period, the cultivation of flax disappears in favour of turnip, but is grown again during the third period. Flax is often found together with seeds and capsule fragments of gold-of-pleasure. Originally, this species entered linseed fields as a weed, but was also cultivated for its oleaginous seeds from the Bronze Age until the Middle Ages. As from that period, the presence of gold-of-pleasure in the botanical records decreased, which was a common phenomenon throughout Europe (Körber-Grohne, 1988). The original weedy status of gold-of-pleasure and the development of crop mimicry resulting in resembling growth habit, branching pattern, flowering time and fruit characteristics of flax, had probably resulted in the cultivation of these species in the same fields when flax was cultivated for its seeds. In most samples with both flax and gold-of-pleasure, the number of plant remains of both species display similar fluctuations. The one sample in which gold-of-pleasure is present in the absence of flax, viz. HK\0820 (No. 14), yielded only very few seeds. Two samples of the first habitation period in which flax and gold-of-pleasure were both abundantly present, delivered also some seeds of *Cuscuta epilinum*, a weed typical for linseed fields now being extinct in the Netherlands for almost sixty years.

Although seeds of the celtic bean (*Vicia faba* var. *minor*) were found in samples of all four periods, their number is only substantial in the second and third period. This may be due to the relatively bad conditions for preservation, reducing its chance of recovery. Despite their protection against herbivores by several toxic factors (Janzen, 1981) and the widespread possession of a seed coat impermeable to water, which promotes the formation of legume seed banks (Rice, 1989), the members of the Leguminosae were badly preserved for archaeological research. In contrast to many records of celtic beans from the Netherlands, Heveskesklooster yielded uncharred seeds in many samples. Those seeds were small in size and partly fragmented, suggesting that they were mainly debris of crop processing.

Turnip (*Brassica rapa*) is frequently present in samples of the last three periods. The status of turnip as a cultivated crop in former times is somewhat obscure (Willerding, 1986; Zohary & Hopf, 1988; Körber-Grohne, 1988). It is documented that turnip is present in the Netherlands from the Bronze Age onwards. Also from *terps* in the coastal area, inhibited from the Iron Age onwards, this species is frequently recorded. Although the number of seeds in the samples of the *terps* is low, van Zeist (1974) assumes that in this area turnip was cultivated. In other parts of the Netherlands, too, the number of seeds is scarce and only for a few sites the probability of gathering or cultivation of turnip is suggested (Kuijper, 1986; Pals, 1988b; Brinkkemper, 1991). Turnip is cultivated for its storage organs, leaves and seeds. But only the oil-seed forms are detected in an archaeological context, as demonstrated by Schlichtherle (1981), who found a stock of oilseeds consisting of a mixture of turnip and *Descurainia sophia*. In contrast with animal fats, the oil of turnip is liquid due to its unsaturated fatty acids and is therefore suitable as salad oil, raw material for making soap and for burning in oil lamps (Bieleman, 1992). It should be emphasized that this species was probably present as a weed in agricultural land or grown on ruderal habitats, like other Cruciferae which were found together with turnip, viz. *Sinapis arvensis*, *Raphanus raphanistrum* and *Brassica nigra*. For Heveskesklooster, the number of seeds in all samples but one do not exceed one hundred specimens. Sample HK\2283 (No. 47) shows a peak with almost 300 seeds, and ten times as much when converted to the standard volume of 3 litres. It should be realized, however, that turnip may produce 1,000-23,000 seeds per plant (Korsmo, 1954; Katiyar & Malik, 1988) and that it is always found together with other weeds and cultivated crops in the samples of Heveskesklooster. Though its cultivation in this site is not ruled out, it is likely that it did occur as a wild plant species.

Ten samples, spread over period 2-4, yielded seeds of hemp (*Cannabis sativa*). Like flax, this species may have been cultivated for its seeds and fibres. Varieties that yield appreciable quantities of drugs are grown in hot climates (Zohary & Hopf, 1988). As a fibre and oil crop, hemp needs sufficient warmth too and avoids moist soils. The seeds may have been imported or originate from plants that may have been cultivated locally on well-drained soils. Fibres were used to make ropes, while seeds may have been used to extract oil used to produce soap and varnish (Reinders, 1893). Most Dutch subfossil records of hemp are dated to late and post-medieval times. Records of older date, originate from Uitgeest (first-second century AD; Pals, 1988a), Leeuwarden (from tenth century onwards; van Zeist et al., 1987) and Amsterdam (from thirteenth century onwards; Paap, 1983).

The last crop plant to be mentioned is buckwheat (*Fagopyrum esculentum*). This species was introduced into Europe in the late Middle Ages. This crop is sensitive to low temperatures and mainly cultivated on sandy soils and in peat bogs where ditches were dug to lower the water level and where the upper part was burnt to ashes. The first written accounts for its cultivation in the Netherlands are for Zutphen (1390 AD) and Blaarthem near Eindhoven (1391 AD). This corresponds well with an increase of the pollen records from the fifteenth century onwards (Bieleman, 1992; Leenders, 1987). Obviously, the oldest record based on subfossil seeds originates from Dommelen, located about ten kilometres south of Eindhoven, but is dated to about the seventh century AD and indicates incidental cultivation in this area (Pals, 1988b). All other subfossil macro-remains of this species do indeed originate from the fifteenth century onwards and are scattered all over the country. The sample of Heveskesklooster that yielded buckwheat, viz. HK\2098 (No. 46), is quite recent and the crop may have been imported from the peat soils and soils reclaimed from cut-over peat south-west of Heveskesklooster. During the eighteenth and nineteenth centuries buckwheat, providing high yields on poor soils, was especially cultivated during periods in which prices of cereals and potatoes increased, thus taking advantage of a need for cheap food (Slicher van Bath, 1987).

3.3.2. *Other economically important plants*

Many plants found in samples of Heveskesklooster may have been utilized by man in several ways. Determining the number of species that comes into consideration is, however, somewhat arbitrary. Plants with a potential for utilization may have grown on the *terp* or in the near surroundings without any serious application. This applies probably for species like *Beta vulgaris*, *Sambucus nigra*, *Salicornia europaea*, *Apium graveolens*, *Pastinaca sativa*, *Daucus carota* and *Chelidonium majus*. Although some of them were cultivated in the course of time, it is plausible that the plant remains of Heveskesklooster were derived from wild specimens. Plant remains may also have been transported to the *terp* by other agents than man, as is illustrated by the analysis of drift litter material (Cappers, 1993). Particularly low frequencies of economically important plants ensure by no means utilization by man and the plant remains may have been transported from remote areas and deposited on the *terp* during storm surges. Cesspits containing plant remains of edible plants indicate unmistakably the usage by man, but this could not be demonstrated for Heveskesklooster.

A compilation of non-agricultural plants with (potential) economic value is presented in table 11. This survey shows that the number of these plants increase in time. The only species present during the first habitation period, are brambles (*Rubus fruticosus* and *R. idaeus*) and *Isatis tinctoria*. Although the latter is represented by fruit remains in many samples dated to the first period, it is absent in samples of later periods. In contrast with other dye plants such as *Anthemis tinctoria*, the pigment of *I. tinctoria* becomes available only after fermentation, followed by reduction and oxidation. Nevertheless, written sources point out its use in early historical times, while archaeobotanical evidence even dates back to prehistoric times (Körber-Grohne, 1988). The presence of *I. tinctoria* in Heveskesklooster is the first archaeobotanical record for the Netherlands and also the first location beyond its present distribution in the fluviatile district (Mennema et al., 1985). Also in Germany is its distribution mainly restricted to the drainage basin of the Rhine (Haeupler & Schönfelder, 1988), while the few locations in Niedersachsen may be considered as a relic of its cultivation. The disjunct location of the *terp* with respect to the distribution of the species and the number of samples that yielded plant remains, though in

Table 11. Economically important, and for the most part non-agricultural plants of Heveskesklooster per period. Numbers are represented as a range (see table 2).

	Period 1	2	3	4
Edible fruits				
Rubus fruticosus s.l.	4	2	5	2
Rubus idaeus	2	-	3	4
Prunus cerasus	-	-	-	6
Prunus domestica ssp. *insititia*	-	-	2	4
Malus sylvestris	-	-	2	6
Fragaria vesca	-	-	-	4
Ribes nigrum	-	-	-	6
Vaccinium sp.	-	-	-	6
Ficus carica	-	-	6	8
Vitis vinifera	-	-	4	5
Condiments, vegetables and medicinal plants				
Cichorium intybus	-	-	-	3
Petroselinum crispum	-	-	-	4
Foeniculum vulgare	-	-	-	2
Anethum graveolens	-	-	-	2
Ruta graveolens	-	-	-	2
Humulus lupulus	-	-	4	-
Coriandrum sativum	-	-	-	1
Papaver somniferum	-	-	-	6
Aframomum melegueta	-	-	1	4
Atropa bella-donna	-	-	-	2
Hyoscyamus niger	-	1	4	5
Dyes				
Isatis tinctoria	4	-	-	-
Anthemis tinctoria	-	-	-	1

small number, makes it likely that the plant was indeed cultivated on the *terp*.

The number of economically important, non-agricultural plants of the second habitation period is limited, just like the agricultural plants. Only a few seeds of *Rubus fruticosus* and *Hyoscyamus niger* were found. Equal to the increase of agricultural plants, the spectrum of other economic plants is enlarged from the third period onwards. Most of these plants have been recorded from many Dutch sites, particularly from the Middle Ages onwards. Indigenous plants are sparsely recorded from pre-medieval periods, but do include settlements in the northern part of the Netherlands, such as *Humulus lupulus* in Iron Age settlement remains of Noordbarge (van Zeist, 1983), *Hyoscyamus niger* in Neolithic Aartswoud (Pals, 1984), *Malus sylvestris* in both Neolithic Aartswoud (Pals, 1984) and Swifterbant (van Zeist & Palfenier-Vegter, 1983) and *Prunus domestica* in samples of Ittersumerbroek dated to the late Bronze Age and early Iron Age (Vermeeren, 1991). On the contrary, plants found in Heveskesklooster imported in the Netherlands from the Roman period onwards, have so far not been recorded from sites north of the Dutch-Roman frontier dated to this period, although there is evidence for trade contacts with sites in the Netherlands at a relatively great distance from the

Roman frontier (Pals et al., 1989).

Despite its remote location, samples of Heveskesklooster yielded some rare species. In addition to *Isatis tinctoria* already mentioned, they are: *Ribes nigrum*, *Cichorium intybus*, *Atropa bella-donna*, *Anthemis tinctoria* and *Aframomum melegueta*. As far as they were found in other Dutch sites, these species are recorded mostly from late Middle Ages and Modern Times (van den Brink, 1985, 1988; van den Brink & de Groot, 1984; Buurman, 1989; van Dongen, 1987; Kuijper, 1986; Paap, 1983; Vermeeren, 1990; van Zeist, 1992a,b; van Zeist et al., 1987). Of special interest is *A. melegueta*, a member of the Zingiberaceae that originates from the coastal area of West Tropical Africa and, after its introduction in South America, is cultivated in Surinam and Guyana. The seed coat consists of four layers, the middle two of them containing oil and resinous elements. Not only the seeds, but also the pulp of fruits, the stem, leaves and roots are used. Their use is diverse and include the application for medicines, spices and perfumes (van Harten, 1970). Several common names are known for the seeds, among them 'grains of paradise' because of its high value and the unknown country it was imported from, and 'Melegueta pepper' referring to the sharp taste of the seeds. The first known reference to the plant dates from 1214 AD, while written sources dated to 1358 and 1871 reveal that seeds were transported to the Netherlands (van Harten, 1970). Archaeobotanical evidence of *A. melegueta* is scarce, and may partly be due to problems with identifying it. In Germany, the species is mentioned for three sites: Kiel (sixteenth century), Lübeck (sixteenth century and later) and Göttingen (sixteenth century) (Wietholt & Schulz, 1991). A same number of records of this species is known from the British Isles: Worcester (fifteenth century), Taunton (sixteenth century) and Shrewsbury (eighteenth century) (Greig, in press). The datings of these finds fit in with those of Heveskesklooster. *A. melegueta* stresses the importance of the site, not only because of the presence of a cloister which had a representative function for guests (Noordhuis, 1990), but also because of the location along the former road between Groningen and Emden, which certainly may have had some functions in the supply of exotic products.

A last category of plants is ornamental plants of which several representatives were found: *Hyssopus officinalis* (also recorded for its medical properties), *Silybum marianum*, *Nigella arvensis* and *Aquilegia* sp. These plants were found in sample HK\2098 (No. 46) only and are of recent date.

3.3.3. *Evidence from written sources*

During the third habitation period, a detailed bookkeeping was performed including information on the amount of properties, the cultivation of crops and the kind of animals that were raised. Unfortunately, most of the books and registers of the cloister were destroyed in the beginning of the sixteenth century by acts of war. The only reports that have stood the test of time are dated to 1495, 1540, 1555, 1598 and 1610, thus concerning the last phase of the third habitation period. The data obtained from these reports are taken from Noordhuis (1990) and de Crevelt (1540).

The land kept in the possession of the cloister may have amounted to some 2000 hectares during the sixteenth century. Most of it was leased out and only 200-300 hectares were for personal use. The rent may have provided a good standard of living, though some of the land did not bring in much as it was located outside the dyke nearby the Dollard or was temporarily out of use due to floodings (Noordhuis, 1990). The large landownership enabled the monastic order to use the valg to build a church and layout a churchyard. The spread of the fields and grassland, especially southwest of Heveskesklooster insofar has been documented, may have hedged sufficiently against flooding disasters that frequently affected the coastal area during the fifteenth and sixteenth centuries and resulted in the temporary loss of much land (Gottschalk, 1975, 1977; Slicher van Bath, 1987).

The land was used both as grassland and as agricultural land and included some bogs nearby Slochteren. The livestock comprised cattle, horses, pigs and sheep. The investment in four cereals is mentioned in a report of 1540: Barley (index-figure: 15), oats (index-figure: 15), rye (index-figure: 7.5) and wheat (index-figure: 1). Of both barley and oats it is reported that they were cultivated on the fields. With respect to rye and wheat only the amounts are mentioned, implying that they were probably not cultivated on the fields that were in personal use. On the other hand, it is reported that the rent was sometimes payed with oats and rye, indicating that also rey was cultivated at least irregularly on land on lease. It is striking that relatively many subfossil grains and threshing remains of barley and oats were found in samples dated to the third habitation period, whereas only one single charred wheat grain was found in a sample dated to the third period and remains of rye were found only in samples of the last period. Apparently, the chance of finding subfossil remains of cereals depends on the fact whether the crop was locally cultivation and processed within the site. Imported cereals are usually free of threshing remains and accompanying weeds, and are recovered mainly in feature types like cesspits and storage places. The recovery of remains of these species in for example dung layers or ditches, depends much on disasters and are only found in low numbers. One such disaster happened in 1583 in Heveskesklooster when soldiers, dissatisfied with their payment, plundered the cloister and set the buildings to fire, some of which stored with hay and grains (Noordhuis, 1990). It is possible that sample HK\2392 (No. 51), which contained relatively many charred seeds of a wide spectrum of species (table 5), can be related with this disaster.

In addition to differences in local cultivation versus import and to bias affected by feature type, sampling location and preservation, the discrepancy between the subfossil record and written sources as to the consumption of cereals may also be explained by the fact that samples of the third habitation period do not represent the sixteenth century. On the other hand, it seems unlikely that rye was not cultivated or imported in Heveskesklooster before, judging the amount of rye that was consumed in the fifteenth century and the subfossil records of other sites (e.g. van Zeist, 1979). Summarizing, one could say that the find of a limited number of grains do not merely indicate admixtures of other crops. Crop rotation may result in admixtures, but also implies that the contaminant crop was cultivated in alternate years. To exclude this possibility for the site concerned, a thorough sampling strategy must be carried out.

It is reported that wheat and rye were used in bread making; black rye bread was available for visitors and the poor, and white wheat bread was meant for personal use. Oats and barley were cultivated for stock-feeding and beer brewing. Although oats are mostly cultivated as forage crops for animals, it is also used in porridge and for brewing beer. Reinders (1893) mentions that in the province of Groningen a strain of oats was cultivated especially for beer. The find of seeds from *Humulus lupulus* fits in quite well with the brewing of beer. Although both *H. lupulus* and *Myrica gale* are indigenous species and are recorded on the basis of subfossil macro-remains since the Neolithic (Raven & Kuijper, 1981; van der Wiel, 1982; Gotjé, 1993), the former is only replaced by the latter in brewing in the Netherlands during the late Middle Ages (Slicher van Bath, 1987). When cultivated for brewing purposes, *H. lupulus* is preferably grown in the absence of male specimens, thus preventing seed production which, in turn, is favourable for the production of lupulin glands on the bracteoles of the female cones. According to Behre (1984), however, this practice was only introduced in Modern Times, so that the find of seeds may be indicative of the use of *H. lupulus* in brewing. The report drawn up in 1540 gives that *H. lupulus* was bought for brewing purposes by the cloister of the Johanniters in Wijtwerd, some 30 kilometres northwest of Heveskesklooster, while for Heveskesklooster itself it is registered that, besides using home-made beer, also several kinds of beer from Germany were imported.

The reports also mention the presence of trees and some nursery-gardens. Remains of *Betula* sp. were found in samples of all habitation periods. On the basis of complete fruits and bracts, *B. pubescens* could be demonstrated for the first and third period, while *B. pendula* was present in a sample of the last period. Although both fruits and bracts may have been transported by wind and water and *Betula* is not common in the clay district (Weeda et al., 1985; van der Meijden et al., 1989), it is possible that they grew on the *terp* as from the first habitation period to protect the *terp* dwellers from severe winds. From the second period onwards, remains of *Sambucus nigra*, *Salix viminalis* and *Quercus* sp. are found too. Considering ecological demands and present distribution (van der Meijden et al., 1989), it is reasonable to assume that *S. nigra* and *S. viminalis* grew on the *terp*. Although *Q. robur* is not very common in the clay district, the presence of bud scales and twigs does not rule out the possibility that this tree once grew on the *terp*. It is also possible that twigs were imported for making brooms or that the remains were deposited on the *terp* by water. The 1540 report mentions that wood was bought, though it was meant for properties in Goldhoorn. Additionally, *Prunus domestica* ssp. *insititia* is present in samples of the third and last period and may have been cultivated for its fruits.

Unfortunately, the reports do not present the names of species that were cultivated in the nursery, nor do they provide an itemized statement of plants that were obtained from the pharmacist, which makes it impossible to compare archaeobotanical records and written sources in this matter.

3.3.4. *Comparison with other Dutch terps*

The agricultural plants documented of the *terps* in the northern part of the Netherlands on the basis of archaeobotanical data are summarized in table 12. The *terps* are arranged in decreasing order as to the number of taxa recorded for each period, in which a low number corresponds with a high number of taxa (compare table 9 and fig. 11). In principle, the same *terps* and periods are analyzed as those selected for the analysis of the environmental characteristics. Two *terps*, viz. Oosterbeintum (*terp* 18) and Dokkum/Berg-Sion (*terp* 23), yielded some wild plant species but did not reveal any agricultural plants. On the other hand, only a few agricultural plants were recorded for some other *terps*, viz. Achlum (*terp* 24), Tzum (*terp* 25), Wadwerder Wierde (*terp* 26) and Usquert (*terp* 27).

The main cereal cultivated by the *terp* dwellers is *Hordeum vulgare*. Apart from the possible confusion with the wild species *A. fatua*, *A. sativa* is only mentioned for a limited number of sites. It remains doubtful whether *A. sativa* was cultivated by Dutch *terp* dwellers in pre-medieval times. *A. sativa* as well as *A. fatua* are frequently recorded only from the Middle Ages onwards for settlements along the German part of the coastal area (Körber-Grohne, 1967; Behre, 1970, 1972, 1976, 1986, 1991; Kucan, 1979). Because oats are mostly found as charred grains only, whereas other cereals were frequently recovered also by their waterlogged fruit envelopes and threshing remains, Behre (1991) points out that evidence for oats may not be representative and assumes that *A. sativa* was cultivated in the coastal area also in the Roman Period. This assumption, however, does not fit in with the use of oats for animal nutrition. Seeds of oats fed to a cow remained partly undamaged

Table 12. Agricultural plants recorded from the Dutch *terps*. The numbers of the *terps* and abbreviations of the periods correspond with those of table 9.

Species	Periods and *terps*																									
	IA-RP		RP	RP-MA	MA						IA-MA															
	4	5	6	23	2	7	8	9	10	11	22	3	12	13	14	15	16	17	18	19	20	21	24	25	26	27
	PG	Tr	Sn	DB	Le	Fo	DH	Ol	Tm	Oz	Ls	Ez	Fe	We	Ra	HB	Ho	Je	Ob	Mi	Ar	Ee	Ac	Tz	Ww	Us
Hordeum vulgare (hulled)	x	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	x	-	-	x	x	-	x	x	x	-
Avena sativa[1]	?	-	-	-	x	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-	x	-
Secale cereale	-	-	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triticum dicoccum	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triticum aestivum	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum miliaceum	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Linum usitatissimum	x	x	-	-	-	-	x	x	-	-	x	x	x	-	-	-	-	-	-	-	-	x	-	-	x	x
Camelina sativa	x	x	-	-	x	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia faba (var. *minor*)	x	-	-	-	x	-	-	-	-	x	-	-	-	x	-	-	-	x	-	-	-	-	x	-	x	-
Brassica rapa[2]	x	x	-	-	-	x	x	-	x	?	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cannabis sativa	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pisum sativum	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sinapis alba	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lactuca sativa	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Identifications to the level of genera are marked with '?'.
[2] Taxa that include B. napus are marked with '?'.

in the digestive system (Neef & Bottema, 1991). Moreover, when dung is collected and used as fuel, this may be considered an important source of charred seed assemblages (Bottema, 1984). Although restricted to the second and third habitation period, many samples from Heveskesklooster yielded waterlogged fruit envelopes, chaff and tops of pedicels (see fig. 15.8) of wild and cultivated oats. Especially in *terps*, it is assumed that those remains will have had a good chance to become preserved, but may have been overlooked. Other cereals are only rarely mentioned, not even for sites with many taxa.

Crop plants other than cereals recorded for many *terps*, are: *Linum usitatissimum*, *Camelina sativa*, *Vicia faba* var. *minor* and *Brassica rapa*. Each of those plants is represented in both the Roman Period and Middle Ages. Together with the cereals and livestock, they will have provided the *terp* dwellers with sufficient amounts of carbohydrate, protein and oil. Vegetables that were cultivated for their roots, stems and leaves are almost not represented by seeds in the archaeobotanical record. An exception is lettuce (*Lactuca sativa*) from Leeuwarden dated to the fifteenth century (van Zeist et al., 1987). Even when not cultivated, the environment of the *terps* supplied several plants that were probably gathered for nutritional purposes. A detailed discussion on this subject is given by van Zeist (1974).

Non-agricultural plants that are economically important are very well represented in Leeuwarden and are both indigenous plants, such as *Humulus lupulus*, *Hyoscyamus niger* and *Vaccinium myrtillus*, and exotic plants, such as *Vitis vinifera* and *Ficus carica*. From the other *terps*, especially fruits from trees are recorded: *Corylus avellana* (Ezinge, Ferwerd and Rasquert), *Juglans regia* (Oldeboorn), *Malus sylvestris* (Oldeboorn), *Pyrus communis* (Oldeboorn) and *Prunus spinosa* (Ezinge). These species were also mentioned for Leeuwarden, except for the last one.

Especially with respect to agricultural plants, Heveskesklooster corresponds quite well to assemblages of the other *terps*. On the other hand, samples of Heveskesklooster dated to the third period proved to be very rich in other economically important plants and its richness is equal to the Leeuwarden *terp* only. However, it should be stressed that this discrepancy may be partly the result of the rough periodization, camouflaging the differences in age, and the unbalanced number of taxa that have been recorded for the *terps*, which, in turn, is partly correlated with the volume of the samples that was investigated. Nevertheless, the botanical richness of Heveskesklooster underlines the status of the *terp* in which the presence of the commandery of the order of Johanniters was surely an important factor.

3.4. Examination of pollen

The pollen diagram of Heveskesklooster comprises the upper part of the basal peat (BP) and the clay layers belonging to Dunkerque I (DI-B 1a,c) and Dunkerque II (DII), intercalated by a *Phragmites/Scirpus* horizon (DI-B 1b) and two vegetation horizons (VH-1,2), and the lower part of the *terp* belonging to the second habitation period (fig. 12). The first habitation period coincides with the *Phragmites/Scirpus* horizon, the clay layer (DI-B 1c) and the vegetation horizon 1; the second habitation period starts with the formation of vegetation

Heveskesklooster

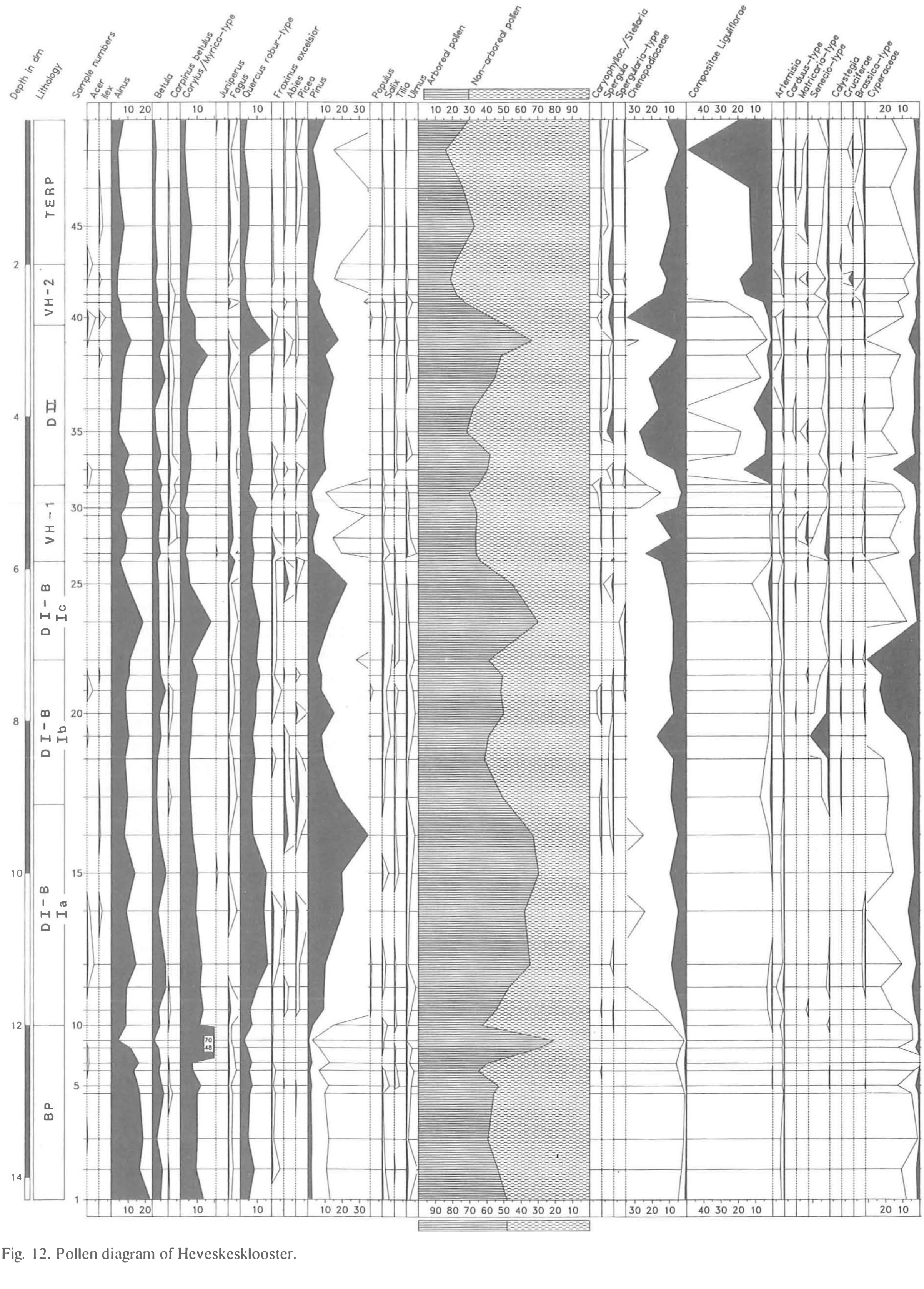
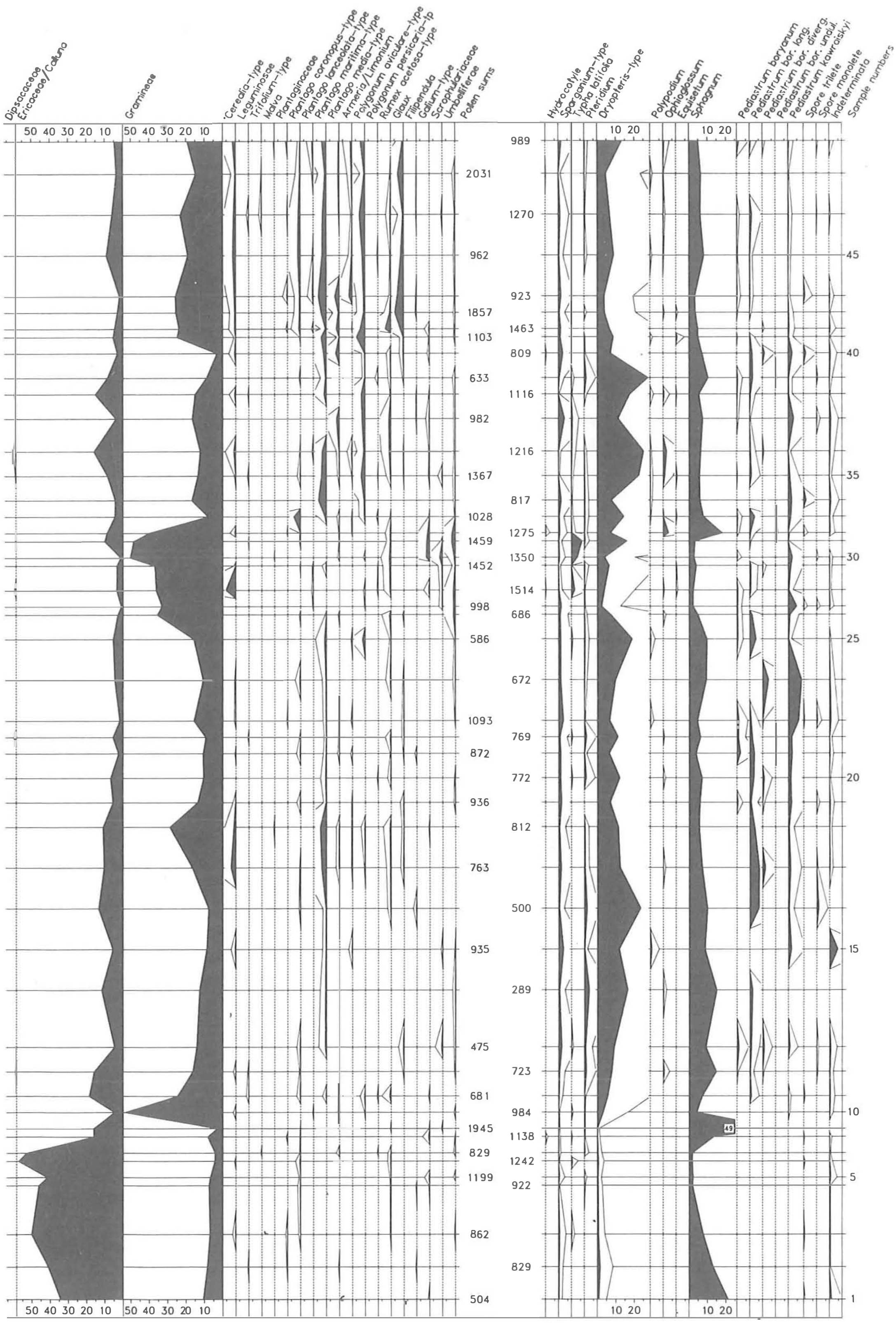


Fig. 12. Pollen diagram of Heveskesklooster.


Dipsacaceae
Ericaceae/Calluna
Gramineae
Cerealia-type
Leguminosae
Trifolium-type
Malva
Plantaginaceae
Plantago coronopus-type
Plantago lanceolata-type
Plantago maritima-type
Plantago media-type
Armeria/Limonium
Polygonum aviculare-type
Polygonum persicaria-tp
Rumex acetosa-type
Glaux
Filipendula
Galium-type
Scrophulariaceae
Umbelliferae
Pollen sums
Hydrocotyle
Sparganium-type
Typha latifolia
Pteridium
Dryopteris-type
Polypodium
Ophioglossum
Equisetum
Sphagnum
Pediastrum boryanum
Pediastrum bor. long.
Pediastrum bor. diverg.
Pediastrum bor. undul.
Pediastrum kawraiskyi
Spore trilete
Spore monolete
Indeterminata
Sample numbers
50 40 30 20 10
10 20
989
2031
1270
962
923
1857
1463
1103
809
633
1116
982
1216
1367
817
1028
1275
1459
1350
1452
1514
998
686
586
672
1093
769
872
772
936
812
763
500
935
289
475
723
681
984
1945
1138
829
1242
1199
922
862
829
504
49
45
40
35
30
25
20
15
10
5
1

horizon 2. The diagram is discussed with respect to this lithology.

The basal peat layer is dominated by *Sphagnum* and Ericaceae, including *Calluna*. Schoute (1984), who also examined an exposure of Heveskesklooster, characterized this layer as a *Phragmites* peat and the pollen of Gramineae of this zone will, therefore, partly belong to this taxon. The predominance of *Sphagnum* and Ericaceae could not be demonstrated in the basal peat layer present in the Schildmeer area (Bohncke, 1984). Nevertheless, one of the arguments presented by Bohncke to exclude the possibility of dispersal by drainage water or reworked material, viz. the independent course of both curves, is also valid for Heveskesklooster.

The change of peat layer to clay layers is characterized by: 1) the strong decrease of the Ericaceae, 2) a strong, temporarily increase of the pollen percentage of Gramineae, *Corylus/Myrica*-type and spores of *Sphagnum*, and 3) the more permanent increase of *Dryopteris*-type, *Quercus robur*-type, *Pinus*, Chenopodiaceae, Cyperaceae and Gramineae.

The temporary increase of the Gramineae is preceded by high *Corylus/Myrica*-type value. Probably most of the *Corylus/Myrica*-type is *Myrica gale* which may have grown along draining gullies in the peat. The increase in the rate of sea level rise resulted in a gradually silting up of the environment and finally the washing over of the peat by the sea. In this transition phase, particularly *Phragmites australis* may have expanded on the mud flats, resulting in vast reed marshes. It is remarkable that the *Dryopteris*-type curve becomes dominant as from that phase, though it alternates to some extent with the curves of the grasses. It is likely that this is *Thelypteris palustris* as its leaf fragments were often found in samples of the first and second habitation periods. In other *terps* too, macro-remains of this fern could be demonstrated in association with reed (e.g. Körber-Grohne, 1967; Behre, 1976), suggesting that the Thelypterido-Phragmitetum was widespread along the North Sea coast in former times.

Analysis of macro-remains revealed that only a limited number of trees may have grown on the *terp*, viz. *Quercus*, *Salix viminalis*, *Betula pendula*, *B. pubescens* and *Sambucus nigra*. With the exception of the last mentioned species, pollen of these trees are present throughout the diagram, though identified on the level of genus. Some of the other trees found through pollen may have grown in the vicinity, like *Alnus* and *Fraxinus excelsior*. Pollen from trees like *Pinus*, *Picea* and *Abies* were possibly transported over large distances.

Considering the evidence of the macro-remains, the increase of pollen percentages of Chenopodiaceae, Cyperaceae and Gramineae comprises both the expansion of halophytes, like *Salicornia europaea*, *Suaeda maritima*, *Carex distans* and *Puccinellia* spp., and of glycophytes. Halophytes of other families are also represented by pollen, viz. *Spergularia*-type, *Plantago maritima*, *Armeria/Limonium*, and *Glaux*, though their percentages remain scattered and low. They all have their counterparts in the record of macro-remains, and particularly *Spergularia maritima*, *S. salina* and *Plantago maritima* were often found.

The *Phragmites/Scirpus* horizon is characterized by four taxa. Firstly, the *Phragmites* curve increases, followed by a short predominance of Chenopodiaceae and *Senecio*-type, while the upper part in this horizon is dominated by Cyperaceae. The macrobotanical analysis of soil samples taken from the same profile, done by van Klinken (1986), provides less information about the species level of these taxa. An increase in *Scirpus maritimus* was demonstrated only in the upper part of the horizon. Although *Aster tripolium* may be responsible for the increase of the *Senecio*-type, as postulated by van Klinken, the present study shows that this species is by no means restricted to a limited number of samples.

Both vegetation horizons are characterized by an increase in the pollen percentages of Gramineae and Cyperaceae. Analysis of macro-remains by van Klinken reveals that at least *Phragmites australis*, *Poa annua* and *Poa pratensis/trivialis* represent the grasses. On the other hand, no predominance of macro-remains of the goosefoot family could be demonstrated. Although samples of the first habitation period coincide with the first vegetation horizon, and those of the second period with the upper part of the second vegetation horizon, it is not possible to establish which species were actually expanding during these phases.

Two obligate indicators of human activity are Cerealia and *Plantago lanceolata*. The analysis of macro-remains has revealed that during the first two periods *Hordeum vulgare* and *Avena sativa* were cultivated. *Plantago lanceolata*, on the other hand, has only been recovered from samples belonging to the third and fourth habitation periods. In general, this species is relatively rare in the archaeobotanical record, and it is likely that it is underrepresented in palynological research. The pollen record of *Plantago lanceolata* is mainly synchronized with the second habitation period, while the pollen record of Cerealia is present in many sections of the pollen diagram. Insofar these sections do not correspond with the occupation of Heveskesklooster, the pollen originated possibly from remote fields that were not hit by floodings.

Taxa of vascular plants demonstrated by non-arboreal pollen but are missing at all taxonomic levels of botanical macro-remains are: *Calystegia*, *Filipendula* and *Sparganium*-type. Species considered for the first mentioned, are quite rare in the Dutch subfossil record of macro-remains. These taxa, however, fit quite well with the other taxa found in samples of Heveskesklooster.

4. IDENTIFICATION REMARKS

Both archaeobotanical literature and monographs on seed and fruit morphology provide a rich source of drawings and descriptions. Therefore, it was not felt as a necessity to pay attention to diaspores that have been published frequently. A selection was made from plants that did not frequently occur in the subfossil record or were preserved by remains that are not commonly found. Measurements refer to length and breadth respectively.

Thelypteridaceae
Thelypteris palustris (fig. 13:1)
Several samples yielded leaf fragments of this species. The entire margin of the segments is obviously inrolled. The lateral veins are mostly branched nearby the midrib and usually also halfway the segment. Little hairs scattered over the underside were also still present.

Salicaceae
Salix viminalis (fig. 13:2A,B)
(3.3-)4.2(-5.1)x(1.0-)1.4(-1.7) mm (N=16; s.d. 0.44 and 0.27); fruits.
Both leaf and fruit fragments were found of *S. viminalis*. *S. viminalis* is the only Dutch species that has very small leaves and recurved margins. The lower side is densely sericeous and is also characterized by a relatively broad midrib. Fruits of *Salix* spp. are very much alike (Tomlinson, 1985) and they were attributed to this species as no other willows could be demonstrated on the basis of leaf fragments. The fruit consists of two parts, of which the upper part may split.

Chenopodiaceae
Beta vulgaris (fig. 13:3)
In some samples parts of the fruit were found. The seed was still present in only one specimen. The inner sides of the fruit parts clearly shows the impression of the seed. The edge is also marked by five scars. The fruit wall is thick and spongy, making the fruit suitable for long distance dispersal by water. Fruits of the reference collection showed no differences between fruits of wild species and cultivated ones.

Chenopodium hybridum (fig. 13:4)
1.9 mm in diameter (N=1)
The discus shaped seed is characterized by a protruding reticulate cell structure. The cells have thick cell walls radiating from the centre. On one side, there is a furrow from the centre to the edge between the radicle and the cotyledons.

Caryophyllaceae
Saponaria officinalis (fig. 13:5)
1.9-2.4x1.7-2.4 mm (N=3)
Shape, size and surface structure provide an unmistakable combination of features for this species. Elongated plates are arranged in concentric rows.

Ceratophyllaceae
Ceratophyllum demersum (fig. 13:6)
4.0-4.8x2.8-3.0 mm (N=2)
C. demersum has relatively large fruits that are characterized by two lateral spines. The basal stalk was still present in one specimen. The presence of spines differentiates this species from *C. submersum*. The fruit wall is almost 0.4 mm thick and is clearly distinguishable from the inner seed coat.

Ranunculaceae
Nigella arvensis (fig. 13:7)
One slightly damaged seed was identified as *N. arvensis*. It has two broad lateral planes and a smaller rounded dorsal plane. The entire surface is covered with translucent papillae. Where these papillae disappeared, the large isodiametric epidermal cells became visible.

Aquilegia sp. (fig. 13:8)
2.8x1.6 mm (N=1)
One seed was found in HK\2098 (No. 46) that unmistakably could be determined as *Aquilegia*, although its identification to the level of species remained uncertain. The black seed has a distinct keel, which becomes broader near the base. The opposite side is rounded and bordered by two distinct lateral ridges and in between these two ridges a weakly developed pattern of ridges is visible. These ridges, however, are lacking in *A. vulgaris*, the only native species that would qualify. Taking into account the recent date of the sample, it probably is a cultivated species.

Papaveraceae
Papaver argemone (fig. 13:9)
(0.9-)1.0(-1.3)x(0.5-)0.6(-0.7) mm (N=11; s.d. 0.10 and 0.05)
The seeds are more or less kidney shaped, the radicle often bend. The reticulate pattern differs from other *Papaver* spp. by its elongated cells, arranged in a few rows.

Cruciferae
Isatis tinctoria (fig. 14:1)
Parts of the fruit were found in several samples. Like the remnants found in the Feddersen Wierde (Körber-Grohne, 1967), they are the central part of the fruit and were identified by their spongy structure, the absence of a silicula and the coarse reticulate pattern on the eroded outsides. No seeds were found.

Berteroa incana (fig. 14:2)
(1.6-)1.8(-2.2)x(1.1-)1.5(-1.7) mm (N=22; s.d.: 0.16 and 0.15)
The seeds have an irregular shape, varying from almost round to elliptic; in some specimens the basal notch is pointed. The black surface is covered with small papillate cells, which are roundish with the exception of a strip of elongated cells in the centre of the seed and ending in a basal notch.

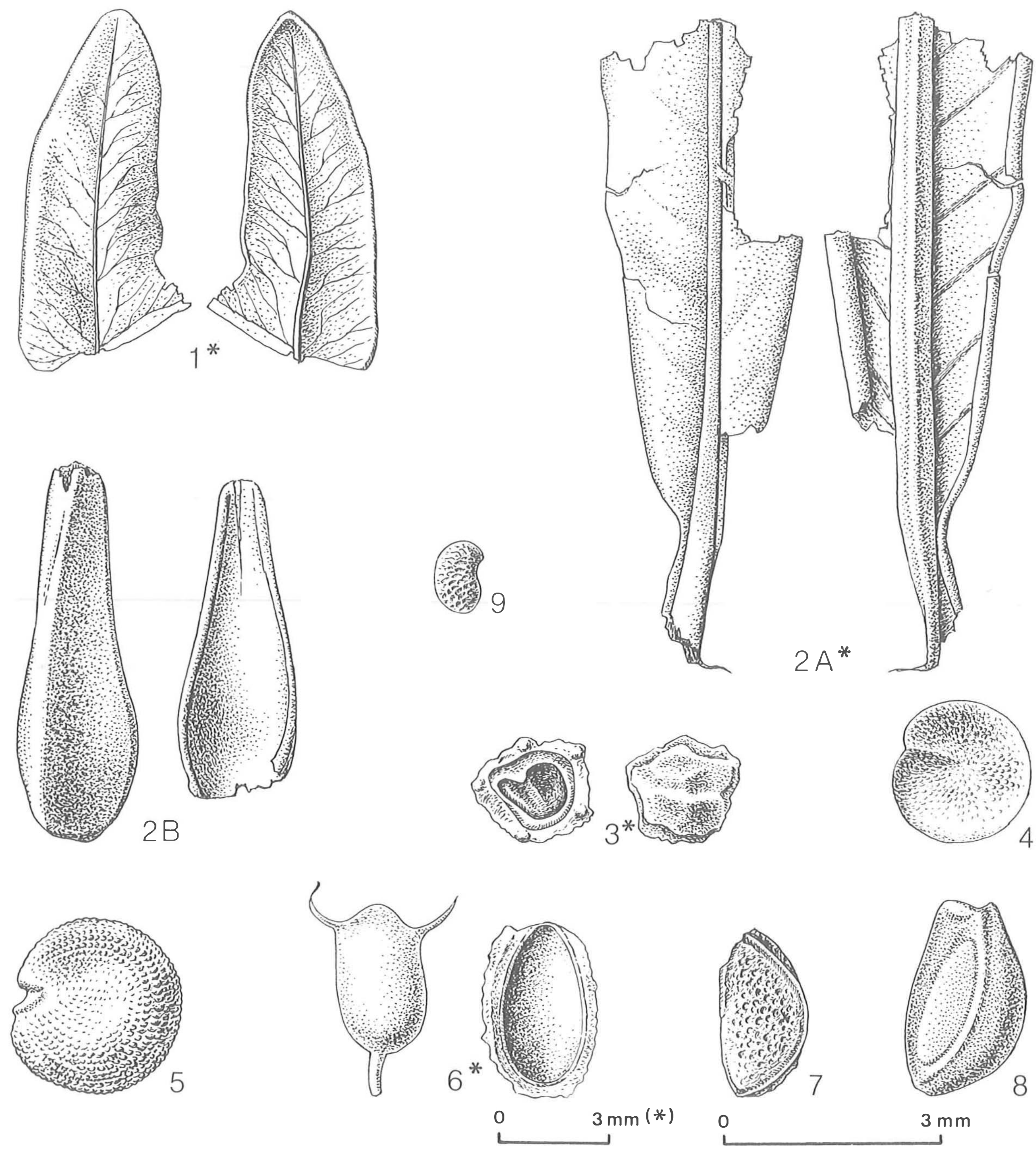


Fig. 13. 1. *Thelypteris palustris*; 2A-B. *Salix viminalis*; 3. *Beta vulgaris*; 4. *Chenopodium hybridum*; 5. *Saponaria officinalis*; 6. *Ceratophyllum demersum*; 7. *Nigella arvensis*; 8. *Aquilegia* sp.; 9. *Papaver argemone*.

Lepidium campestre (fig. 14:3)
2.6-2.7x1.5-1.8 mm (N=3)
The ovate seeds have a large radicle, the top of which is nearly as long as the cotyledons. The surface is covered with many fine papillae.

Raphanus raphanistrum (fig. 16)
Seeds of this species show a considerable range in size, reflecting differences in size of the fruit segments and probably also in populations they originate from. Nevertheless, they are larger than the more uniform seeds of *S. arvensis*. As subfossil beaks of fruits of *S. arvensis* lost their upper part in most cases and as they contain at least one seed, they resemble at first sight the siliqua portions of *R. raphanistrum*, which may lead to the misunderstanding that seeds of both species are

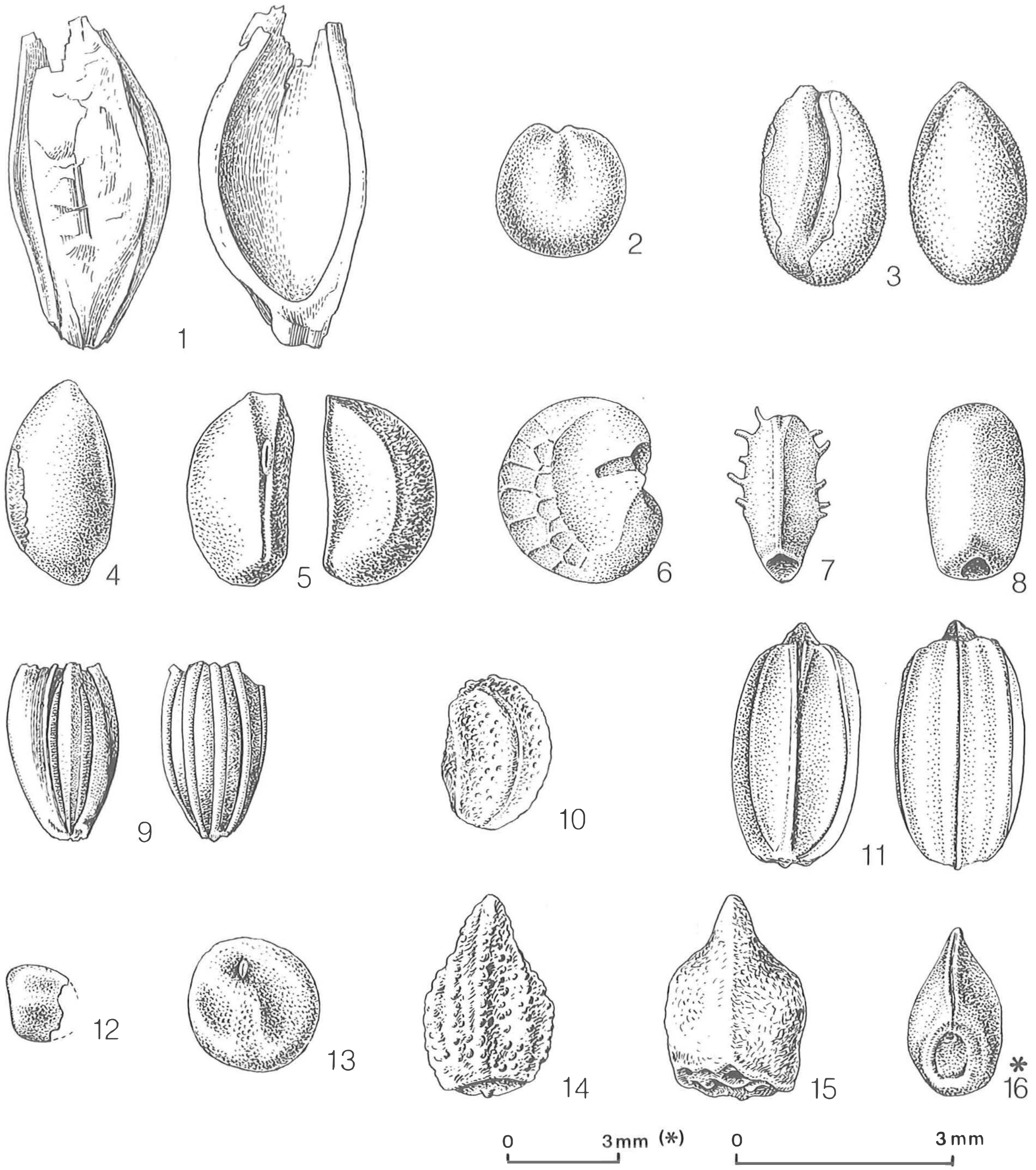


Fig. 14. 1. *Isatis tinctoria*; 2. *Berteroa incana*; 3. *Lepidium campestre*; 4. *Ribes nigrum*; 5. *Ruta graveolens*; 6. *Malva neglecta*; 7. *Myriophyllum spicatum*; 8. *Myriophyllum verticillatum*; 9. *Oenanthe lachenalii*; 10. *Bupleurum rotundifolium*; 11. *Bupleurum tenuissimum*; 12. *Andromeda polifolia*; 13. *Cuscuta epilinum*; 14. *Buglossoides arvensis*; 15. *Echium vulgare*; 16. *Symphytum officinale*.

equal. See for a comprehensive discussion van Zeist et al. (1987). Moreover, the epidermal cells of *R. raphanistrum* are more distinct and elongated and the lumina is clearly visible at a magnification of 45x.

Saxifragaceae
Ribes nigrum (fig. 14:4)
(1.9-)2.4(-3.5)x(1.0-)1.4(-1.8) mm (N=78; s.d. 0.32 and 0.21)
Most seeds were flattened, which increased its width. Remains of the fruit were still partly attached to the

seed, and some seeds contained their endosperm. Most seeds were damaged as a result of passing through the intestinal canal. Seeds of this species are smaller than seeds of *R. rubrum* and *R. uva-crispa*, as is the diameter of the small, thick-walled isodiametric cells of the seed coat. The seed is spindle-shaped and has a long hilum.

Rutaceae
Ruta graveolens (fig. 14:5)
(1.9-)2.4(-2.9)x(0.9-)1.2(-1.5) mm (N=4, s.d. 0.51 and 0.42)
The dorsal side is strongly bent, while the ventral side is either bent or straight. A double ventral ridge encloses the hilum and is somewhat widened at one end. The dorsal surface is bordered by single ridges. The surface is covered with an irregular pattern of warts.

Malvaceae
Malva neglecta (fig. 14:6)
2.3-2.5x2.2 mm (N=2)
The fruit remains were still attached to the seeds and have a distinct reticulated pattern which is more coarse than that of *M. alcea*, but lacks the raised ridges characteristic for *M. sylvestris*. The dorsal part of the fruit of *M. moschata* is covered with hairs.
Haloragaceae

Myriophyllum spicatum (fig. 14:7)
2.2-2.3x0.9-1.0 mm (N=2)
The fruits are triangular in cross-section and have several spines on the dorsal edges and on the dorsal surface but to a lesser degree. The ventral ridge is rather distinct due to the concave sides.

Myriophyllum verticillatum (fig. 14:8)
2.0-2.3x1.1-1.2 mm (N=2)
Compared to *M. spicatum*, the fruits are slightly broader and spines are lacking. The hilum seems to be more prominent, while the ventral ridge is not accentuated.

Umbelliferae
Oenanthe lachenalii (fig. 14:9)
All fruits of this species missed one or both of the characteristic broad lateral ribs. They then bear resemblance to fruits of *D. carota* for size and shape, but lack the typical spines. Specimens that lack both ventral ribs, show still three broad strips on the ventral side, contrasting with the three smaller ones on the dorsal side. The oil-bodies in between the ribs are mostly dark coloured. The fruits are much smaller than the more common *O. aquatica*, which shows some resemblance with this species.

Bupleurum rotundifolium (fig. 14:10)
(3.1-)3.3(-3.5)x(1.5-)1.7(-1.9) mm (N=8; s.d.: 0.19 and 0.14)
The black fruits have a hollow ventral side and a rounded dorsal side. There are five narrow dominant ribs and two in between those ribs. The latter are irregular in shape, tending to a zigzag design. Towards the top, the ribs often become more pronounced.

Bupleurum tenuissimum (fig. 14:11)
2.2x1.6 mm (N=1)
Although the fruit is relatively short, it is rather curved. The cross-section of the fruit is broadly ovate in outline. There are five prominent ribs and the areas in between are covered with large warts.

Ericaceae
Andromeda polifolia (fig. 14:12)
1.1-1.2x0.8-0.9 mm (N=2)
The small, broadly elliptic to ovate seeds are somewhat flattened and have rounded sides. The hilum is laterally situated at the narrow end. The somewhat spongy seed coat has a glossy, darkbrown to blackish surface. The irregular cell pattern, consisting of many-sided cells is hardly difficulty to see.

Convolvulaceae
Cuscuta epilinum (fig. 14:13)
(1.6-)1.8(-1.9)x(1.3-)1.5(-1.7) mm (N=5; s.d.: 0.11 and 0.15)
Seeds of *C. epilinum* are elliptic to circular in shape, often with some dents. They are larger than seeds of *C. epithymum* (max. 0.9 mm) and smaller than *C. lupuliformis* (min. 2.5 mm), the latter also distinguished by its irregular shape. Seeds of *C. europaea* are just as large, but differ in the height of the epidermal cells and the obviousness of the hilum. In seeds of *C. epilinum*, the epidermis cells are relatively high, which makes the outer cell layer almost transparent. Although the cells become smaller towards the hilum giving it a deviate circular pattern, this area of the seeds is less conspicuous than in *C. europaea*.

Boraginaceae
Buglossoides arvensis (fig. 14:14)
2.7x1.7 mm (N=1)
Sample HK\2098 (No. 46) yields many seeds of *B. arvensis*, all fragmented but one. The fruitwall is thick, white and irregular papillate with the exception of the smooth basal part that is connected to the gynobasis. The thin brown seed coat is still present at the inner sides of the fragments, resulting in a characteristic colourful contrast. The complete fruit is unmistakably recognized for its shape.

Echium vulgare (fig. 14:15)
2.7x1.8 mm (N=1)
The only member of the Borage family that resembles this species both in size and shape, is *Buglossoides arvensis*. Seeds of *E. vulgare*, however, are more sharp-featured and the basal part that is connected to the gynobasis is larger and surrounded by a prominent ridge. Moreover, the surface is dark coloured and warts are small.

Symphytum officinale (fig. 14:16)
4.6x2.6 mm
Seeds of this species are not easily confused with other members of the *Boraginaceae*. The hilum almost covers half of the length of the seed. Between the hilum and the top of the seed there is a prominent ridge, whereas this ridge is only visible at the top of the dorsal side. The very small epidermal cells clearly visible on recent seeds, are not conspicuous at the black, bumpy surface of the subfossil specimen.

Labiatae
Hyssopus officinalis (fig. 15:1)
One seed was found in HK\2098 (No. 46). The hilum is relatively large and the black surface is wrinkled in a typical way. The top of the seed, slightly damaged in the subfossil specimen, is variable in outline: it varies from truncate to triangular.

Salvia verticillata (fig. 15:2)
(1.7-)2.0(2.4)x(1.2-)1.4(-1.7) mm (N=16; s.d. 0.18 and 0.14)
In comparison with other *Salvia* spp., *S. verticillata* has small seeds. The largest diameter is below the middle. The surface is covered with small warts, while the weak ribs on the dorsal side are mostly not preserved.

Solanaceae
Atropa bella-donna (fig. 15:3)
1.9x1.5 mm (N=1)
Subfossil seeds of *A. bella-donna* and *Hyoscyamus niger* resemble each other more than recent seeds. Due to corrosion, the cell pattern of the seed coat becomes more pregnant in *A. bella-donna*. In contrast with *H. niger*, this cell structure is more regular and less elevated. Besides, seeds of *A. bella-donna* are slightly larger and the hilum is more protruding.

Valerianaceae
Valerianella dentata (fig. 15:4)
(1.9-)2.4(-2.6)x(1.1-)1.4(-1.6) mm (N=16; s.d. 0.22 and 0.15)
The surface of the ovate fruits is covered with small papillae. The isodiametric epidermal cells of the seed coat are irregular in size, although a bit larger than those of the fruit wall. The two sterile cells are reduced to distinct ribs that form an oval ring.

Compositae
Bidens tripartita (fig. 15:5)
Besides complete fruits, also the inner parts of fruits were recovered. The shape and colour of these eroded fruits are much like the shape and colour of grasses such as *Elymus* and *Bromus*. The absence of a distinct hilum, however, is a good diagnostic feature. Also the cell structure differs from these grasses: all over the surface, the rectangular cells are very regular in shape.

Leontodon saxatilis (fig. 15:6)
Central fruits: (2.5-)3.4(-4.8)x(0.5-)0.7(-1.0) mm (N=87; s.d. 0.44 and 0.10). Marginal fruits: (2.5-)3.2(-3.8)x(0.8-)1.0(-1.4) mm (N=36; s.d. 0.43 and 0.17).
This species has dimorphic achenes: central en marginal fruits are dissimilar, being an adaptation to different types of dispersal. The broad, curved marginal achenes have no pappus and are enclosed by the bracts. Reversely, the slender central achenes are short-beaked and do posses a pappus, although these were only partly preserved in subfossil specimens. The marginal achenes differ clearly from other *Leontodon* spp. The central achenes of *L. saxatilis* are often confused with those of *L. autumnalis*. Although there is some overlap in length, the fruits of the latter species are on average longer: (3.5-)5.0(-6.9)x(0.6-)0.7(-1.2) mm (N=25; s.d. 0.75 and 0.01) and originate from the of sample HK\3351 (No. 56) from which also fruits of *L. saxatilis* were measured. Moreover, central fruits of *L. saxatilis* have more ribs on each side, viz. 5-6, and slightly spindle-shaped (see van Zeist et al., 1986: fig. 6.11).

Gramineae
Cynosurus cristatus (fig. 15:7)
(1.7-)1.8(-2.1)x(0.6-)0.7(-0.9) mm (N=22; s.d. 0.12 and 0.10)
Fruits of *C. cristatus* were preserved by both waterlogging and charring. Charred fruits are still enclosed by their glumes that are covered with many little papilla. Waterlogged fruits are very delicate. Remnants of glumes are only present at the base, but the characteristic imprint of the two edges of the paleas proved to be a diagnostic feature. The elliptic hilum is only contrasted by its dark outline. The cell structure is badly preserved.

Avena fatua (fig. 15:8)
Subfossil fruits of both *A. fatua* and *A. sativa* can only be distinguished from one another when the basal part of the lemma is present (Körber-Grohne, 1967). Fruits of *Avena* that are preserved by waterlogging, are characterized by: 1) very fragile envelopes, as a result of which they cannot be held in a flat plane, 2) the occurrence of hairs, of which sometimes only scars can be seen, and 3) the elongated cells of the testa grouped in different orientations, as described by Körber-Grohne (1964). Although some samples yielded considerable amounts of fruits still enclosed by their glumes, the majority of glumes lacked their bases as a result of which identification to species level was in most cases not possible.

Tops of pedicels are also present in a number of samples. They were mostly preserved by waterlogging. The point of attachment differs from both species as to the basal parts of their glumes. *A. fatua* has a tongue-like extremity, while the point of attachment of *A. sativa* is more flattened. Therefore, a distinction between both species can partly be carried out also based on these plant remains.

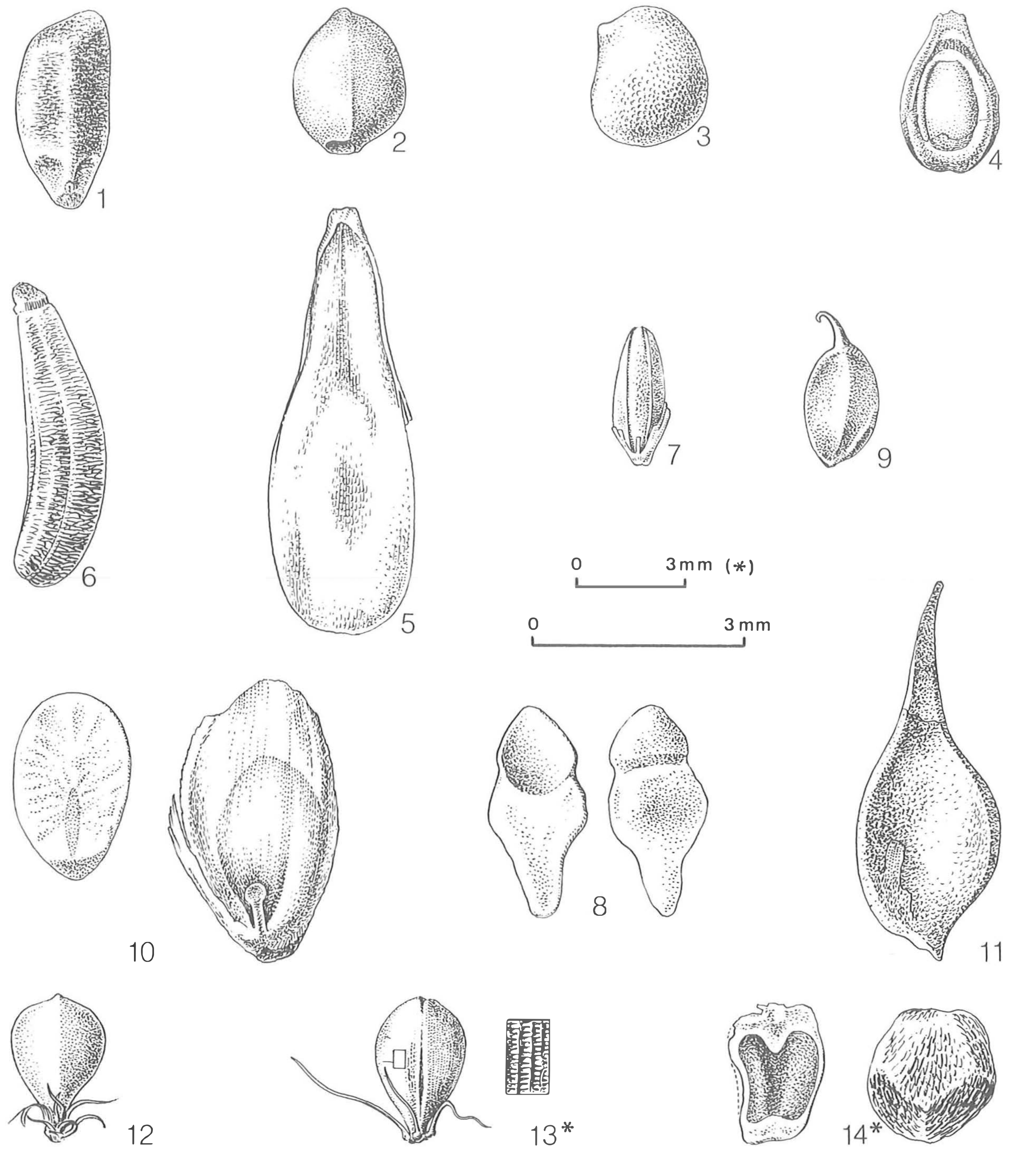


Fig. 15. 1. *Hyssopus officinalis*; 2. *Salvia verticillata*; 3. *Atropa bella-dona*; 4. *Valerianella dentata*; 5. *Bidens tripartita*; 6. *Leontodon saxatilis*; 7. *Cynosurus cristatus*; 8. *Avena fatua*; 9. *Phalaris arundinacea*; 10. *Danthonia decumbens*; 11. *Scirpus rufus*; 12. *Rhynchospora alba*; 13. *Eleocharis quinqueflora*; 14. *Aframomum melegueta*.

Phalaris arundinacea (fig. 15:9)
(1.3-)1.6(-1.9)x(0.8-)1.0(-1.1) mm (N=30; s.d. 0.17 and 0.18); length without style base.
Because there is no simultaneous development of the fruits, they are quite variable in size. Moreover, some fruits are completely white, probably the result of a fungal infection. The fruits are characterized by their long, laterally positioned hilum and the stout style which was intact in many cases. Many fruits were still enclosed by the glossy lemma and palea, from which

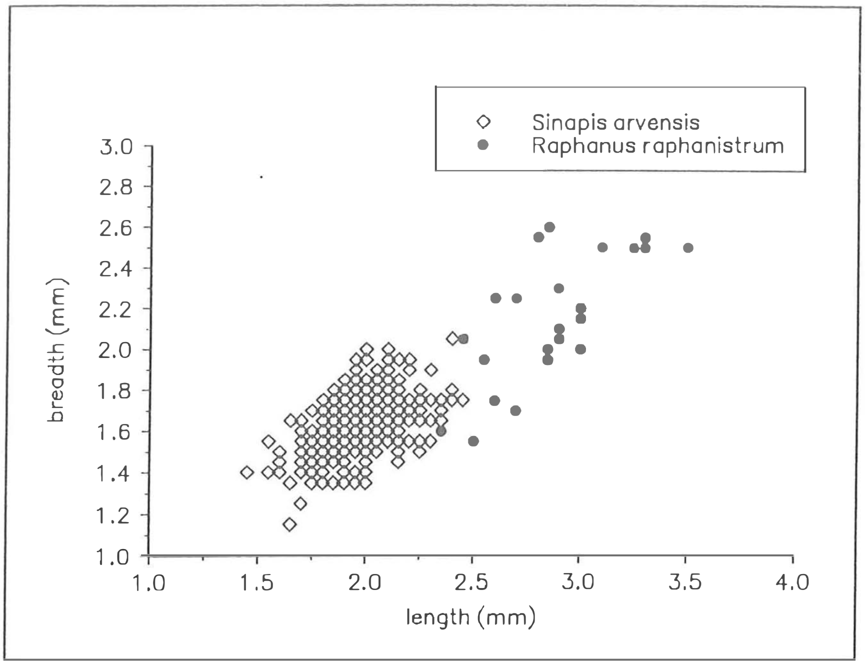


Fig. 16. Size of seeds of *R. raphanistrum* and *S. arvensis*. Seeds of *R. raphanistrum* originate from fruit segments of samples HK\2332 (No. 49; N=18) and HK\0079 (No. 1; N=7). Seeds of *S. arvensis* originate from beak fragments of sample HK\2332 (No. 49; N=336).

hairs had disappeared. Both lemma and palea have a fine striate cell structure.

Danthonia decumbens (fig. 15:10)
(2.0-)2.4(-3.1)x(1.1-)1.3(-1.7) mm (N=22; s.d. 0,21 and 0.15)
With the exception of a few specimens, most of the fruits of *D. decumbens* are preserved by waterlogging and about half of the fruits still possess their glumes. Both glumes and fruits have unique features, making their identification easy. Besides fruit shape and size, the ventral palea is swollen at the base while the fruit itself is characterized by an elongated and pale coloured hilum contrasting with the dark brown cells in the other part of the fruit. The hilum is variable in length and may reach the upper half of the fruit (0.5-)0.8(-1.2) mm (N=22, s.d. 0.17).

Cyperaceae
Scirpus rufus (fig. 15:11)
(4.9-)5.3(-5.7)x(1.7-)1.9(-2.1) mm (N=7; s.d. 0.33 and 0.12)
The relatively large plano-convex fruits have a truncate base and a tapering style, which is still present in most specimens. Both style and fruit wall have a spongy structure. The surface is black and rather glossy, while the reticulate cell structure is poorly visible.

Rhynchospora alba (fig. 15:12)
1.6-1.4 mm (N=1)
One fruit was found in sample HK\1638 (No. 34). Although this species bears close resemblance to *R. fusca*, it can be identified on the basis of both the number of perianth-bristles, viz. 11 (*R. alba*: 9-13 and *R. fusca* 4-6), and the downwards pointed hairs on these bristles (*R. alba*: basal part upwards, upper part glabrous or pointed downwards; *R. fusca*: all hairs pointed upwards) (Reichgelt, 1956).

Eleocharis quinqueflora (fig. 15:13)
(1.7-)2.0(-2.5)x(1.1-)1.3(-1.6) mm without stigma (N=30; s.d. 0.19 and 0.11)
A typical feature of seeds from *E. quinqueflora* is the combination of the 3-angled cross-section and the central cells of each surface being elongated in a transverse direction. *E. acicularis* is much smaller, less angular and all cells are elongated in a transverse direction. *E. multicaulus* is almost equal in size, but all cells are isodiametric. Frequently, parts of the stigma, bristles and bracts are still attached to the seeds.

Carex extensa
(1.7-)2.0(-2.4)x(1.2-)1.3(-1.6) mm (N=12; s.d. 0.12 and 0.13)
Both utricles and fruits were found in samples of Heveskesklooster. The fruits differ from the fruits of *C. distans* by the size of the epidermal cells, which are much smaller in *C. extensa* but visible at a magnification of 45 x. Moreover, the base of the fruit is not widened and the colour is red-brown, whereas subfossil fruits of *C. distans* are mostly grey-black.

Zingiberaceae
Aframomum melegueta (fig. 15:14)
(3.4-)3.7(-4.1)x(2.9-)3.3(-3.8) mm (N=9; s.d.: 0.24 and 0.29).

At first sight, seeds of *A. melegueta* resemble the seeds of *Agrostemma githago* and the Boraginaceae. The seeds are broadly ovate with partly truncated sides. The hilum is sunken at the top and bordered with small tufted scales. The glossy surface is covered with irregular warts, which at a high magnitude (45 X) shows a fine striate pattern.

Two samples yielded seeds from this species: HK\0082 (No. 2) and HK\2098 (No. 46). In the latter, seeds were partly fragmented. Owing to the characteristic surface, they could still easily be identified.

5. ACKNOWLEDGEMENTS

I am much indebted to the following persons for their valuable contributions to this study. The beginning of the archaeobotanical research was carried out by A.C. van Klinken who studied the pollen, and R.M. Palfenier-Vegter and W. van Zeist who examined a part of the macro-remains. Their results form a substantial part of the botanical records of Heveskesklooster.

J.W. Boersma provided much information on the samples and J.M. van Winter kindly placed her transcription of the examination reports of the Johanniters of Frisia at my disposal. The drawings were partly made by G. Delger (figs 1-5) and H.R. Roelink (figs 12-14) and R. Lutgerink prepared the final version of the pollen diagram.

The manuscript was critically read by J. van Andel, S. Bottema and W. van Zeist, and some parts also by J.W. Boersma and N. Veldhuijzen. The numerous corrections and suggestions for revision offered by them largely improved the text. M.A.G. Wennekers corrected the English text.

6. REFERENCES

ACKER STRATINGH, G., H.O. FEITH & W.B.S. BOELES. 1870. *Bijdragen tot de geschiedenis en oudheden inzonderheid van de provincie Groningen. Over boonen, vlas en haver uit onze terpen of wieren: eene eerste kleine bijdrage tot de flora dezer merkwaardige heuvelen.* Groningen, J.B. Wolters.

ANONYMUS, 1987. Botanisch laboratorium. *Jaarverslag van de Rijksdienst voor het Oudheidkundig Bodemonderzoek over het jaar 1986*, pp. 109-111.

BAKELS, C.C., 1981. Neolithic plant remains from the Hazendonk, province of Zuid-Holland, the Netherlands. *Zeitschrift für Archäologie* 15, pp. 141-148.

BAKELS, C.C., 1988. Hekelingen, a Neolithic site in the swamps of the Maas estuary. In: H. Küster (ed.), *Der prähistorische Mensch und seine Umwelt (Festschrift U. Körber-Grohne)* (= Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg 31). Stuttgart, Konrad Theiss Verlag, pp. 155-161.

BAKKER, J.A., 1992. *The Dutch Hunebedden. Megalithic tombs of the Funnel Beaker Culture* (= Archaeological series 2). Ann Arbor, International Monographs in Prehistory.

BAKKER, J.P., 1989. *Nature management by grazing and cutting. On the ecological significance of grazing and cutting regimes applied to restore former species-rich grassland communities in the Netherlands.* Dordrecht etc., Kluwer Academic Publ.

BEEFTINK, W.G., 1965. *De zoutvegetatie van ZW-Nederland beschouwd in Europees verband.* Wageningen, H. Veenman & Zonen N.V.

BEHRE, K.-E., 1970. Die Entwicklungsgeschichte der natürlichen Vegetation im Gebiet der unteren Ems und ihre Abhängigkeit von den Bewegungen des Meeresspiegels. *Probleme der Küstenforschung im südlichen Nordseegebiet* 9, pp. 13-47.

BEHRE, K.-E., 1972. Kultur- und Wildpflanzenreste aus der Marschgrabung Jemgumkloster/Ems (um Christi Geburt). *Neue Ausgrabungen und Forschungen in Niedersachsen* 7, pp. 164-184.

BEHRE, K.-E., 1976. *Die Pflanzenreste aus der frühgeschichtlichen Wurt Elisenhof.* Bern, Herbert Lang/Frankfurt/M., Peter Lang.

BEHRE, K.-E., 1984. Zur Geschichte der Bierwürzen nach Fruchtfunden und schriftlichen Quellen. In: W. van Zeist & W.A. Casparie (eds), *Plants and ancient man. Studies in palaeoethnobotany.* Rotterdam etc., A.A. Balkema, pp. 115-122.

BEHRE, K.-E., 1986. Ackerbau, Vegetation und Umwelt im Bereich früh- und hochmittelalterlicher Siedlungen im Flussmarschgebiet der unteren Ems. *Probleme der Küstenforschung im südlichen Nordseegebiet* 16, pp. 99-126.

BEHRE, K.-E., 1991. Umwelt und Ernährung der frühmittelalterlichen Wurt Niens/Butjadingen nach den Ergebnissen der botanischen Untersuchungen. *Probleme der Küstenforschung im südlichen Nordseegebiet* 18, pp. 141-168.

BEHRE, K.-E., 1992. The history of rye cultivation in Europe. *Vegetation History and Archaeobotany* 1, pp. 141-156.

BEIJERINCK, W., 1928. Tabellarisch overzicht der plantenresten in dertien, door Dr. A.E. van Giffen verzamelde grondmonsters uit de wierde van Ezinge. Bijlage I: Mededeeling omtrent systematische onderzoekingen, verricht in de jaren 1926 en 1927, ten behoeve van de Terpenvereeniging, in Friesland en Groningen. *Jaarverslag van de Vereeniging voor Terpenonderzoek* 11-12, pp. 44-48.

BEIJERINCK, W., 1929. *De subfossiele plantenresten in de terpen van Friesland en Groningen. Eerste gedeelte: vruchten, zaden en bloemen* (= Publicaties van de Stichting Fonds Landbouw Export Bureau, 2). Wageningen.

BEIJERINCK, W., 1931. *De subfossiele plantenresten in de terpen van Friesland en Groningen. Derde en laatste gedeelte: overige macro- en microscopische resten* (= Publicaties van de Stichting Fonds Landbouw Export Bureau, 7). Wageningen.

BIELEMAN, J., 1992. *Geschiedenis van de landbouw in Nederland 1500-1950.* Meppel etc., Boom.

BOERSMA, J.W., 1988. Een voorlopig overzicht van het archeologisch onderzoek van de wierde Heveskesklooster (Gr.). In: M. Bierma et al. (eds), *Terpen en wierden in het Fries-Groningse kustgebied.* Groningen, Wolters-Noordhoff/Forsten, pp. 61-87.

BOHNCKE, S.J.P., 1984. Palaeobotanical study on vegetation horizons in the young Holocene coastal plain of Groningen (northern Netherlands). *Dissertationes Botanicae* 81, pp. 221-264.

BOTTEMA, S., 1984. The composition of modern charred seed assemblages. In: W. van Zeist & W.A. Casparie (eds), *Plants and ancient man. Studies in palaeoethnobotany.* Rotterdam etc., A.A. Balkema, pp. 207-212.

BOTTEMA, S., T.C. VAN HOORN, H. WOLDRING & W.H.E. GREMMEN, 1980. An agricultural experiment in the unprotected salt marsh, Part II. *Palaeohistoria* 22, pp. 128-140.

BRAAK, C.J.F. TER, 1987. Ordination. In: R.H.G. Jongman et al. (eds), *Data analysis in community and landscape ecology.* Wageningen, Pudoc, pp. 91-173.

BRAAK, C.J.F. TER, 1988. Canoco, version 2.1 (= Technical Report: LWA-88-02). Wageningen, Agricultural Mathematics Group.

BRAAK, C.J.F. TER, 1993. Canoco, version 3.12.

BRINK, L.M. VAN DEN & H.L. DE GROOT, 1984. Dorstige Harthof e.o. *Maandblad Oud Utrecht* 9, pp. 108-113.

BRINK, W. VAN DEN, 1985. Pollen and seeds from medieval Utrecht. *Stuifmail* 3, pp. 27-30.

BRINK, W. VAN DEN, 1988. Zaden en pollen uit een 16e eeuwse beerput uit de Postelstraat. In: H.W. Boekwijt & H.L. Janssen (eds), *Kroniek van bouwhistorisch en archeologisch onderzoek 's-Hertogenbosch*. 's-Hertogenbosch, Kring 'Vrienden van 's-Hertogenbosch, pp. 113-124.

BRINKKEMPER, O., 1991. Agricultural production during the Iron Age period in the swamps of the Meuse Delta. *Acta Interdisciplinaria Archaeologica* 7, pp. 51-59.

BRINKKEMPER, O., 1993. Wetland farming in the area to the south of the Meuse estuary during the Iron Age and Roman period. An environmental and palaeo-economic reconstruction. *Analecta Praehistorica Leidensia* 24, pp. 1-226.

BUURMAN, J., 1986. Graan in IJzertijd-silo's uit Colmschate. *Nederlandse Archeologische Rapporten* 3, pp. 67-73.

BUURMAN, J., 1989. Plantenresten. In: H. Clevis & J. Kottman (eds), *Weggegooid en teruggevonden. Aardewerk en glas uit Deventer vondstcomplexen 1375-1750*. Kampen, Stichting Archeologie IJssel/Vechtstreek, pp. 67-69.

CAPPERS, R.T.J., 1993. Seed dispersal by water: a contribution to the interpretation of seed assemblages. *Vegetation History and Archaeobotany* 2, pp. 173-186.

CAPPERS, R.T.J., 1994. An ecological characterization of the Holocene flora of the Netherlands. *Acta Botanica Neerlandica* 43, pp. 145-174.

CAPPERS, R.T.J. & B.O. VAN ZANTEN, in press. Ecology and representativeness of subfossil mosses of the Heveskesklooster terp (the Netherlands). *Lindbergia*.

CREVELT, T.N. DE, 1540. Examination report of the Johanniters in Frisia. In: *Archives de l'ordre de Malta (AOM 6340)*, transcribed by J.M. van Winter (1965).

DONGEN, R. VAN, 1987. Zaden- en vruchtenonderzoek. In: J.M. Baart et al. (eds), Opgravingen aan de Oostenburgermiddenstraat. In: J.B. Kist et al. (eds), *Van VOC tot werkspoor, het Amsterdamse industrieterrein Oostenburg*. Utrecht, pp. 123-125.

FAEGRI, K. & J. IVERSEN, 1975. *Textbook of pollen analysis*, 3rd ed. Copenhagen, Munksgaard.

GEEL, B. VAN, J.M. BOS & J.P. PALS, 1986. Archaeological and palaeoecological aspects of a medieval house terp in a reclaimed raised bog area in North Holland. *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 33, pp. 419-444.

GIJN, A.L. VAN & H.T. WATERBOLK, 1984. The colonization of the salt marshes of Friesland and Groningen: the possibility of a transhumant prelude. *Palaeohistoria* 26, pp. 101-122.

GOTJÉ, W., 1993. De Holocene laagveenontwikkeling in de randzone van de Nederlandse kustvlakte (Noordoostpolder). Amsterdam (thesis).

GOTTSCHALK, M.K.E., 1971. *Stormvloeden en rivieroverstromingen in Nederland. I. De periode vóór 1400*. Assen, Van Gorcum & Comp. N.V.

GOTTSCHALK, M.K.E., 1975. *Stormvloeden en rivieroverstromingen in Nederland. II. De periode 1400-1600*. Assen, Van Gorcum.

GOTTSCHALK, M.K.E., 1977. *Stormvloeden en rivieroverstromingen in Nederland. III. De periode 1600-1700*. Assen, Van Gorcum.

GREIG, J., in press. What plants are found, what aren't and why? A new look at the taphonomy of edible and other useful plants from the 11th to the 18th century AD. *Circaea*.

GRIEDE, J.W. & W. ROELEVELD, 1982. De geologische en paleografische ontwikkeling van het noordelijk zeekleigebied. *K.N.A.G. Geografisch Tijdschrift* 16, pp. 439-455.

HAEUPLER, H. & P. SCHÖNFELDER, 1988. *Atlas der Farn- und Blütenpflanzen der Bundesrepublik Deutschland*. Stuttgart, Verlag Eugen Ulmer.

HARTEN, A.M. VAN, 1970. Melegueta Pepper. *Economic Botany* 24, pp. 208-216.

HILLMAN, G.C., 1981. Reconstructing crop husbandry practices from charred remains of crops. In: R. Mercer (ed.), *Farming practice in British prehistory*. Edinburgh, University Press, pp. 123-146.

HILLMAN, G.C., 1982. Crop husbandry at the medieval farmstead, Cefn Graeanog: Reconstructions from charred remains of plants. *The Bulletin of the Board of Celtic Studies* 29, pp. 901-906.

HOGESTIJN, J.W.H., 1989. Palaeobotanical analysis of Monnickendam and the salination of the Zuiderzee. In: H.A. Heidinga & H.H. van Regteren Altena (eds), *Medemblik and Monnickendam. Aspects of medieval urbanization in northern Holland* (= Cingula 11). Amsterdam, I.P.P., pp. 115-124.

JANZEN, D.H., 1981. The defenses of Legumes against Herbivores. In: R.M. Polhill & P.H. Raven (eds), *Advances in Legume systematics*, 2. Kew, Royal Botanical Gardens, pp. 951-977.

KATIYAR, R.K. & D. MALIK, 1988. Branching ability and its relative contribution for siliquae production and seed yield in Brassica L. species and Eruca sativa Mill. *New Botanist* 15, pp. 271-275.

KENT, M. & P. COKER, 1992. *Vegetation description and analysis. A practical approach*. London, Belhaven Press.

KETNER, P., 1972. *Primary production of salt-marsh communities on the island of Terschelling in the Netherlands*. Nijmegen, Thoben Offset.

KLINKEN, A.C. VAN, 1986. Het pollendiagram van Heveskesklooster. Doctoraal verslag. Groningen, B.A.I. (RUG).

KNÖRZER, K.-H., 1984. Aussagemöglichkeiten von paläoethnobotanischen Latrineuntersuchungen. In: W. Zeist van & W.A. Casparie (eds), *Plants and ancient man. Studies in palaeoethnobotany*. Rotterdam etc., A.A. Balkema, pp. 331-338.

KÖRBER-GROHNE, U., 1964. Bestimmungsschlüssel für subfossile Juncus-Samen und Gramineen-Früchte. *Probleme der Küstenforschung im südlichen Nordseegebiet* 7, pp. 1-47.

KÖRBER-GROHNE, U., 1967. *Geobotanische Untersuchungen auf der Feddersen Wierde*. Wiesbaden, Franz Steiner Verlag GMBH.

KÖRBER-GROHNE, U., 1988. *Nutzpflanzen in Deutschland. Kulturgeschichte und Biologie*. Stuttgart, Konrad Theiss Verlag.

KÖRBER-GROHNE, U., 1990. Gramineen und Grünlandvegetationen vom Neolithikum bis zum Mittelalter in Mitteleuropa. *Bibliotheca Botanica* 139, pp. 1-105.

KÖRBER-GROHNE, U., 1992. Studies in salt marsh vegetation and their relevance to the reconstruction of prehistoric plant communities. *Review of Palaeobotany and Palynology* 73, pp. 167-180.

KORSMO, E., 1954. *Ugras i nåtidens jordbruk*. Oslo, A-S Norsk Landbruks Forlag.

KORTEKAAS, G.L.G.A., 1988. Verslag van een kwartair-geologisch veldwerk in Heveskesklooster, prov. Groningen. Intern rapport. Groningen (RUG).

KUCAN, D., 1979. Mittelalterliche Kulturpflanzen und Undkräuter aus ostfriesischen Kirchen. *Probleme der Küstenforschung im südlichen Nordseegebiet* 13, pp. 23-38.

KUIJPER, W.J., (1984) 1986. Planten- en dierenresten in laat-Middeleeuwse beerputten op het terrein van het St. Agnietenklooster in Leiden. *Bodemonderzoek in Leiden* 7, pp. 131-142.

LANGE, A.G., 1990. *De Horden near Wijk bij Duurstede. Plant remains from a native settlement at the Roman frontier: a numerical approach* (= Nederlandse Oudheden 13). Amersfoort, R.O.B.

LEENDERS, K.A.H.W., 1987. De boekweitkultuur in historisch perspektief. *K.N.A.G. Geografisch Tijdschrift* 21, pp. 213-227.

MANDERS, M., 1993. Twee graanschepen. Een botanische studie van de lading. In: R. Reinders & A. van Holk (eds), *Scheepslading*. Groningen, Glavimans Stichting, pp. 19-31.

MEIJDEN, R. VAN DER, 1990. *Heukels' flora van Nederland*. 21e druk. Groningen, Wolters-Noordhoff.

MEIJDEN, R. VAN DER, C.L. PLATE & E.J. WEEDA, 1989. *Atlas van de Nederlandse flora 3. Minder zeldzame en algemene soorten*. Leiden, Rijksherbarium/Hortus Botanicus & Voorburg etc., Centraal Bureau voor de statistiek.

MEIJDEN, R. VAN DER, L. VAN DUUREN, E.J. WEEDA & C.L. PLATE, 1991. Standaardlijst van de Nederlandse flora 1990. *Gorteria* 17, pp. 75-126.

MENNEMA, J., A.J. QUENÉ-BOTERENBROOD & C.L. PLATE (eds), 1985. *Atlas van de Nederlandse flora 2. Zeldzame en vrij zeldzame planten*. Utrecht, Bohn, Scheltema & Holkema.

NEEF, R. & S. BOTTEMA, 1991. Mest als bron voor verkoold plantaardig materiaal uit opgravingen in het Nabije Oosten.

Waarnemingen en experimenten. *Paleo-aktueel* 2, pp. 72-76.
NOORDAM, A.P. & J.P. PALS, 1987. Zaden uit Valkenburgse waterputten. In: E.J. Bult & D.P. Hallewas (eds), *Graven bij Valkenburg, II. Het archeologisch onderzoek in 1986*. Delft, Eburon, pp. 56-67.
NOORDHUIS, G.F., 1990. *De Johannieters in Stad en Lande. Geschiedenis van de Johannieters in de provincie Groningen (13de-17de eeuw)*. Warffum, Sikkema.
PAAP, N.A., 1983. Economic plants in Amsterdam: qualitative and quantitative analysis. In: M. Jones (ed.), *Integrating the subsistence economy* (= B.A.R., intern. series 181). Oxford, B.A.R., pp. 315-325.
PALS, J.P., 1984. Plant remains from Aartswoud, a Neolithic settlement in the coastal area. In: W. Zeist van & W.A. Casparie (eds), *Plants and ancient man. Studies in palaeoethnobotany*. Rotterdam etc., A.A. Balkema, pp. 313-321.
PALS, J.P., 1988a. Milieu, landschap en landbouweconomie in Noord-Holland 1300 v. Chr.-1300 n a Chr. In: J.H.F. Bloemers et al. (eds), *Archeologie en oecologie van Holland tussen Rijn en Vlie* (= Studies in prae- en protohistorie 2). Assen etc., Van Gorcum, pp. 121-132.
PALS, J.P., 1988b. Akkerbouw in het Middeleeuwse Dommelen. Phyto-archeologische studies. Universiteit van Amsterdam (thesis).
PALS, J.P., V. BEEMSTER & A. NOORDAM, 1989. Plant remains from the Roman castellum Praetorium Agrippinae near Valkenburg (prov. of Zuid-Holland). In: U. Körber-Grohne & H. Küster (eds), *Archäobotanik* (= Dissertationes Botanicae 133). Berlin etc., Cramer, pp. 117-133.
PENFORD, N., 1989. Notes on the ecology of Blysmus rufus (Huds.) Link in north-eastern Fife. *Watsonia* 17, pp. 360-361.
PLICHT, J. VAN DER, 1993. The Groningen radiocarbon calibration program. *Radiocarbon* 35, pp. 231-237.
PRUMMEL, W., 1988. Kalver- en veulensterfte in de terpen. In: M. Bierma et al. (eds), *Terpen en wierden in het Fries-Groningse kustgebied*. Groningen, Wolters-Noordhoff/Forsten, pp. 241-249.
RAVEN, J.G.M. & W.J. KUIJPER, 1981. Calais deposits (Holocene) near Benthuizen (province of Zuid-Holland), the Netherlands, with a paleoecological reconstruction. *Mededeelingen Werkgroep Tertiair Kwartaire Geologie* 18, pp. 11-28.
REICHGELT, T.J., 1956. *Cyperaceae excl. Carex* (= Flora Neerlandica 1).
REINDERS, G., 1893. *Handboek voor den Nederlandschen Landbouw en de veeteelt*. Deel 2. J.B. Wolters, Groningen.
RICE, K.J., 1989. Impacts of seed banks on grassland community structure and population dynamics. In: M.A. Leck et al. (eds), *Ecology of soil seed banks*. San Diego etc., Academic Press Inc., pp. 211-230.
ROELEVELD, W., 1974. *The Holocene evolution of the Groningen marine-clay district* (= suppl. Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 24). Amersfoort, R.O.B.
ROOZEN, A.J.M. & V. WESTHOFF, 1985. A study of long-term salt-marsh succession using permanent plots. In: W.G. Beeftink et al. (eds), *Ecology of coastal vegetation*. Dordrecht etc., Dr. W. Junk Publ., pp. 23-32.
RUNHAAR, J., C.L.G. GROEN, R. VAN DER MEIJDEN & R.A.M. STEVERS, 1987. Een nieuwe indeling in ecologische groepen binnen de Nederlandse flora. *Gorteria* 13, pp. 277-359.
SCHEL, J.H.N., M. STASSE-WOLTHUIS, M.B. KATAN & M.T.M. WILLEMSE, 1980. *Structural changes of wheat bran after human digestion* (= Mededelingen Landbouwhogeschool Wageningen 80-14). Wageningen, Veenman.
SCHLICHTHERLE, H., 1981. Cruciferen als Nutzpflanzen in neolithischen Ufersiedlungen Südwestdeutschlands und der Schweiz. *Zeitschrift für Archäologie* 15, pp. 113-124.
SCHOUTE, J.F.TH., 1984. *Vegetation horizons and related phenomena. A palaeoecological-micromorphological study in the younger coastal Holocene of the northern Netherlands (Schildmeer Area)* (= Dissertationes Botanicae 81). Vaduz, Cramer.
SLICHER VAN BATH, B., 1987. *De agrarische geschiedenis van West-Europa: 500-1850*, 6e druk. Utrecht, Het Spectrum BV.
SMET, L.A.H. DE, 1961. *Het Dollardgebied. Bodemkundige en landbouwkundige onderzoekingen in het kader van de bodemkartering* (= Versl. Landbouwk. Onderz. nr. 67.16). Bennekom etc., StBoKa.
STERK, A.A., 1969. Biosystematic studies of Spergularia media and S. marina in the Netherlands I. The morphological variability of S. media. *Acta Botanica Neerlandica* 18, pp. 325-338.
STERK, A.A., 1969. Biosystematic studies on Spergularia media and S. marina in the Netherlands II. The morphological variability of S. marina. *Acta Botanica Neerlandica* 18, pp. 467-476.
TELENIUS, A., 1992. Seed heteromorphism in a population of Spergularia media in relation to the ambient vegetation density. *Acta Botanica Neerlandica* 41, pp. 305-318.
TELENIUS, A. & P. TORTENSSON, 1989. The seed dimorphism of Spergularia marina in relation to dispersal by wind and water. *Oecologia* 80, pp. 206-210.
TOMLINSON, P., 1985. An aid to the identification of fossil buds, bud-scales and catkin-bracts of British trees and shrubs. *Circaea* 3, pp. 45-130.
TOORN, J. VAN DER, 1972. *Variability of Phragmites australis (Cav.) Trin. ex Steudel in relation to the environment. Van zee tot land* (= Rapporten en mededelingen inzake de droogmaking, ontginning en sociaal-economische opbouw van de IJsselmeerpolders 48). 's-Gravenhage, Staatsuitgeverij.
UNGAR, I.A. & S.R.J. WOODELL, 1993. The relationship between the seed bank and species composition of plant communities in two British salt marshes. *Journal of Vegetation Science* 4, pp. 531-536.
VERMEEREN, C., 1990. Botanisch onderzoek van Middeleeuwse beerputten uit Kampen. In: H. Clevis & M. Smit (eds), *Verscholen in vuil. Archeologische vondsten uit Kampen 1375-1925*. Kampen, Stichting Archeologie IJssel/Vechtstreek, pp. 139-161.
VERMEEREN, C., 1991. Cultuurgewassen en onkruiden uit Ittersumerbroek. In: H. Clevis & A. Verlinde (eds), *Bronstijdboeren in Ittersumerbroek*. Kampen, Stichting Archeologie IJssel/Vechtstreek, [pl.v.uitg.], pp. 93-106.
WAISEL, Y., 1972. *Biology of halophytes*. New York etc., Academic Press.
WASSCHER, J., 1941. De graanonkruidassociaties in Groningen en Noord-Drente. *Ned. Kruidk. Arch.* 51, pp. 435-441.
WATERBOLK, H.T., 1979. Siedlungskontinuität im Küstengebiet der Nordsee zwischen Rhein und Elbe. *Probleme der Küstenforschung im südlichen Nordseegebiet* 13, pp. 1-21.
WEEDA, E.J., R. WESTRA, CH. WESTRA & T. WESTRA, 1985. *Nederlandse oecologische flora. Wilde planten en hun relaties 1*. Wageningen, IVN.
WESTHOFF, V., 1985. Nature management in coastal areas of Western Europe. In: W.G. Beeftink et al. (eds), *Ecology of coastal vegetation*. Dordrecht etc., Dr. W. Junk Publ., pp. 523-532.
WESTHOFF, V., 1987. Salt marsh communities of three West Frisian islands, with notes on their long-term succession during half a century. In: A. Huiskes et al. (eds), *Vegetation between land and sea*. Dordrecht etc., Dr. W. Junk Publ., pp. 16-40.
WESTHOFF, V. & A.J. DEN HELD, 1975. *Plantengemeenschappen in Nederland*, 2e druk. Zutphen, Thieme & Cie.
WIEL, A.M. VAN DER, 1982. A palaeoecological study of a section from the foot of the Hazendonk (Zuid-Holland, the Netherlands), based on the analysis of pollen, spores and macroscopic plant remains. *Review of Palaeobotany and Palynology* 38, pp. 35-90.
WIETHOLD, J. & F. SCHULZ, 1991. Pflanzliche Grossreste aus einer Kloake des 16. Jahrhunderts der Grabung Kiel-Klosterkirchhof/Hassstrasse (LA Nr. 23). *Archäologische Nachrichten aus Schleswig-Holstein* 2, pp. 44-47.
WILLERDING, U., 1986. *Zur Geschichte der Unkräuter Mitteleuropas*. Neumünster, Karl Wachholtz Verlag.
ZEIST, W. VAN, 1970. Prehistoric and early historic food plants in the Netherlands. *Palaeohistoria* 14, pp. 41-173.
ZEIST, W. VAN, 1974. Palaeobotanical studies of settlement sites in the coastal area of the Netherlands. *Palaeohistoria* 16, pp. 223-371.

ZEIST, W. VAN, 1976. Two early rye finds from the Netherlands. *Acta Botanica Neerlandica* 25, pp. 71-79.

ZEIST, W. VAN, 1979. Agriculture in medieval Gasselte. *Palaeohistoria* 21, pp. 267-299.

ZEIST, W. VAN, 1983. Plants remains from Iron Age Noordbarge, province of Drenthe, the Netherlands. *Palaeohistoria* 23, pp. 169-193.

ZEIST, W. VAN, 1987. Plantenresten uit twee beerputten in Groningen. In: A. Carmiggelt et al. (eds), *Uitgeput huisraad. Twee Groninger beerputten in historisch-archeologisch perspectief.* Groningen, Stichting Monument en Materiaal, pp. 65-74.

ZEIST, W. VAN, 1988. Archeobotanisch onderzoek van Oldeboorn. In: M. Biermaet al. (eds), *Terpen en wierden in het Fries-Groningse kustgebied.* Groningen, Wolters-Noordhoff/Forsten, pp. 190-195.

ZEIST, W. VAN, 1990. The palaeobotany of early-medieval Dorestad: evidence of grain trade. *Proc. Kon. Ned. Akad. v. Wetensch.* 93, pp. 335-348.

ZEIST, W. VAN, 1992a. De geconsumeerde gewassen. In: H.P. ter Avest (ed.), *Opmerkelijk afval. Vondsten uit een 17e eeuwse beerput in Harlingen.* Harlingen, Gemeentemuseum Het Hannemahuis, pp. 91-97.

ZEIST, W. VAN, 1992b. Cultuurgewassen en wilde planten. In: P.H. Broekhuizen et al. (eds), *Van boerenerf tot bibliotheek.* Groningen, Stichting Monument en Materiaal, pp. 525-535.

ZEIST, W. VAN, 1993. Suhfossiele zaden en vruchten. Een onderzoek naar vegetatie, akkerbouw en voeding. In: J.J. Lenting et al. (eds), *Schans op de grens. Bourtanger bodemvondsten 1580-1850.* Sellingen, Stichting Vesting Bourtange, pp. 597-619.

ZEIST, W. VAN, G.J. DE ROLLER, R.M. PALFENIER-VEGTER, O.H. HARSEMA & H. DURING, 1986. Plant remains form medieval sites in Drenthe, The Netherlands. *Helinium* 26, pp. 226-274.

ZEIST, W. VAN, R. CAPPERS, R. NEEF & H. DURING, 1987. A palaeobotanical investigation of medieval occupation deposits in Leeuwarden, The Netherlands. *Proc. Kon. Ned. Akad. v. Wetensch.* Ser. B 90, pp. 371-426.

ZEIST, W. VAN & R.M. PALFENIER-VEGTER, 1983. Seeds and fruits from the Swifterbant S3 site. Final reports on Swifterbant IV. *Palaeohistoria* 23, pp. 105-168.

ZEIST, W. VAN, T.C. VAN HOORN, S. BOTTEMA & H. WOLDRING, 1976. An agricultural experiment in the unprotected salt marsh. *Palaeohistoria* 18, pp. 111-153.

ZOHARY, D. & M. HOPF, 1988. *Domestication of plants in the Old World.* , Oxford, Clarendon Press.