Sowing the seed ? : human impact and plant subsistence in Dutch wetlands during the Late Mesolithic and Early and Middle Neolithic (5500-3400 cal BC)

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10. Evidence of human impact and plant subsistence from macroremains: potential arable weeds

10.1 Introduction

Cultivation practices can partly be reconstructed by the analysis of finds of crop plants, but also by the analysis of finds of arable weeds. Analysis of weeds can theoretically give information on the characteristics of the soil where crops were cultivated, the intensity of cultivation (the input of labour per unit area), permanency of plots, sowing period, harvesting methods, threshing methods and the storage product (Bogaard 2004; Hillman 1981; Jones 1984). These cultivation characteristics are hardly known for the Swifterbant culture and Hazendonk group. It is therefore expected that the analysis of arable weeds may provide information on crop cultivation as practised by the occupants of the Neolithic Dutch wetland sites and to investigate local crop cultivation.

A major problem for the reconstruction of cultivation practices and the application of weed analysis is that it is unclear which taxa found at the sites studied represent field weeds of the Swifterbant culture and Hazendonk group, since taxa of eutrophic, disturbed terrain and ruderals do not necessarily all represent field weeds (Andersen 1989; *cf.* Behre 1981). As long as the status of taxa as arable weeds is unclear, we will speak of potential arable weeds. The group of potential arable weeds of this study includes both apophytes (taxa that originally were part of the natural vegetation) and anthropochores (taxa that were spread by people and that are likely to have functioned as arable weeds) since some taxa that are known as anthropochoures were present at the Dutch wetlands already before the (known) introduction of crop plants (see paragraph 2.8.4.3). This early presence indicates that taxa that are known as anthropochores from other studies and regions did not necessary function as arable weeds at the sites of the Swifterbant culture and Hazendonk group. Therefore, all taxa will be considered as potential arable weeds until evidence from the studied sites strongly supports that they represent true field weeds. It would be expected that the weeds of the Swifterbant culture and Hazendonk group are very similar to those of earlier and/or contemporaneous Neolithic cultures in Northwestern Europe since weeds were spread together with crops (see also Colledge *et al.* 2004 who show a reduction of variation in the weed assemblage during spread of arable farming into Europe). The knowledge about assemblages from earlier cultures could then be applied to distinguish the weeds of the Dutch wetland sites. There are however two reasons to be very careful with the comparison of weed assemblages of cultures. Firstly, the introduction of crop cultivation in the Dutch environment may have resulted in a change of cultivation practices and in a change of the weed assemblage. Secondly, taxa that are generally considered as weeds in the fully Neolithic cultures are part of the natural vegetation of the Netherlands and were already present before introduction of crop cultivation and did not necessarily function as field weeds (both apophytes and anthropochores).

The analysis of arable weeds has several goals: in the first place to reconstruct which taxa represent arable weeds, and in the second place to translate the information of weeds into information on cultivation practices and/or the dispersion of crop cultivation. The analysis will focus on potential weeds of cereals since cereals are the dominant crops at the Dutch wetland sites. This chapter was written in 2006 and only data from sites available to the author at that time are included in the analysis.

10.2 Analysis of arable weeds of the Dutch wetland sites: methods

Firstly, the analysis of arable weeds has been approached in the classical way (Hillman 1981; Jones 1984), which is based on various assumptions. Uncontaminated concentrations of carbonised remains of crop plants are likely to represent a crop product (a grain product or a waste product that is the result of crop processing). The carbonised remains of non-crop plants found in the same concentration are likely to represent arable weeds, carbonised in the same step of crop processing. The analysis will show that this classical approach does not give

representative results since the number of concentrations of carbonised cereal remains from closed contexts at the sites studied is very low. The analysis will therefore be extended with other investigation methods.

Secondly, it has been investigated which taxa are present in a carbonised state in samples that contain carbonised cereal remains. It is expected that carbonised taxa are more likely to represent arable weeds than waterlogged (uncarbonised) taxa since the carbonisation state of macroremains is a considerable indication of human handling. The carbonisation of taxa is presumed to have occurred during the crop processing and/or food preparation.

Sites with more than ten samples containing carbonised cereals remains are Brandwijk-Kerkhof, the Hazendonk, Schipluiden, Wateringen 4 and Ypenburg. For the Hazendonk only the oldest layers dating to the Swifterbant culture and Hazendonk group were included and only samples that were collected at the excavation (no core samples). The analysis method consisted of frequency analysis and the results are presented in classes. The frequencies were calculated for each site separately because of differences between sites. For each site only those taxa are presented that are found in a relative high frequency. A high class indicates that a taxon was found in a carbonised state in many of the samples that contain carbonised cereal remains.

Thirdly, it has been investigated by non-statistical methods whether there is a pattern in the presence and absence of potential arable weeds at sites with and without cereals, and between regions. In this analysis, finds of taxa in a carbonised state receive more attention than finds in a waterlogged state. The selection of taxa that are considered as potential arable weeds includes taxa of habitats that are thought to be suitable to be transformed into arable fields. It is expected that arable fields were primarily located in dry to humid terrain, *i.e.* open terrain, cleared dryland woodland patches or the high salt marshes, but not very moist habitats (alder carr, marshes, heathland, fens, bogs and lower salt marshes). The selection is furthermore based on the auto-ecology of the species (Statistics Netherlands 2003). As a result the group of potential arable weeds includes modern-day arable weeds (taxa of nutrient-rich arable fields, taxa of calcareous arable fields, taxa of non-calcareous fields, taxa indicative of trodden paths, taxa indicative of nutrient-rich ruderal terrain, taxa indicative of calcareous ruderal terrain) but also taxa that are not necessarily recognised as arable weeds nowadays, such as taxa of grasslands and taxa of woodland edges, shrub vegetation and woodland vegetation. The selection includes only herbs and no trees and shrubs. The selection of sites used for the comparison of sites with and without cereals includes Hardinxveld-Giessendam Polderweg, Hardinxveld-Giessendam De Bruin, Brandwijk-Kerkhof (early phases), Zijdeweg, Randstadrail CS and Bergschenhoek (all without cereals although evidence of absence is not always available) and Brandwijk-Kerkhof (late phases), the Hazendonk, Meerdonk, Rechthoeksdonk, Barendrecht 20.126 and 20.125, Hillegersberg, Schipluiden, Ypenburg (new data included), Rijswijk-A4, Wateringen 4, Swifterbant-S3, Schokland-P14, Schokkerhaven-E170 and Urk-E4 (all with cereal remains). The sites Nijmegen-Oosterhout ‘t Klumke and Doel Deurganckdok-sector B were not included in the group of sites with cereals since the amount of data on weeds from these sites is small. The number of sites with cereals is larger than the number of sites without cereals, which is expected to influence the results. The selection of sites used for the comparison of regions is based on the same selection, except for Barendrecht 20.126 and 20.125, Bergschenhoek, Hillegersberg and Randstadrail CS. The data set of this group of sites is too small for comparison with other regions.

All steps in the weed analysis are based on macroremains and tubers only. Carbonised and waterlogged macroremains are analysed separately. The data set does not include identifications of taxa that potentially represent a variety of habitats or taxa that possibly represent contamination with recent material. Identifications with the addition *con forma* were included in the data set. If various remains of a single species are found, these are grouped together (stones and parenchyma of *Prunus spinosa* are grouped together as *Prunus spinosa*). Some identifications are not on species level and therefore some identifications may correspond with each other (*e.g.* *Chenopodium album*, *Chenopodium* sp. and Chenopodiaceae).

10.3 Results

10.3.1 Concentrations of carbonised cereals

Concentrations of carbonised cereals were found at the Hazendonk (phase 1, Swifterbant culture). This material was investigated by analysis of several samples (see appendix III). The samples contained hundreds of cereals grains and chaff remains, as well as other taxa that may represent weeds. The taxa found in a carbonised state other than crop plants are listed and discussed in appendix III (table III.16). It concerns 31 taxa that represent woodland of dry terrain, woodland of wet terrain, dryland and wetland herbs, and water plants. There are various indications that the concentrations probably were not derived from a closed context and do not represent a single crop product. The taxa in the cereal concentrations that are likely to represent potential arable weeds (as discussed in the paragraph on methods above) are *Bromus secalinus*-type, *Capsella bursa-pastoris*, *Chaerophyllum temulum*, *Chenopodium album*, *Elytrigia repens*, *Fallopia convolvulus*, *Persicaria maculosa*, *Poa annua*/*Phleum* sp., *Rumex cf. crispus*, *Rumex* sp., *Solanum nigrum* and *Urtica dioica*. For most taxa it is unclear in this stage of the analysis whether they represent arable weeds or not.

At Schipluiden the finds included three samples each containing *c.* 120 remains of carbonised glume bases and spikelet forks of *Triticum dicoccon* (Kubiak-Martens 2006a). The original crop product present in these samples probably represents a waste product since the number of chaff remains is high and the number of grains is low. The ecological range of the taxa present in one of the samples is so large that it is unlikely that it represents a pure assemblage. The ecological range of the other two samples is more restricted than in the first sample and it is therefore possible that the samples represent a crop product from a closed context. These two samples contain carbonised macroremains of *Malva* sp., *Persicaria mitis*, *Hordeum marinum*, *Trifolium repens*, *Poa* sp. and stem fragments of Poaceae, which may represent weeds. The samples contain however also two taxa (*Prunus spinosa* and *Schoenoplectus lacustris/tabernaemontani*) that cast some doubts on whether the samples were indeed derived from closed contexts.

At Ypenburg there are also two samples that contain relatively large quantities of chaff remains of *T. dicoccon* (Van Beurden 2008a). These samples do not contain any other identified taxa in a carbonised state. At Swifterbant furthermore at least one single small concentration of carbonised cereal remains was found (Van Zeist and Palfenier-Vegter 1981, 142). It is however unknown whether and which other taxa were present in this concentration.

10.3.2 Taxa present in a carbonised state in samples that contain carbonised cereal remains

Table 10.1 shows the potential arable weeds that were found at five sites in a relatively high frequency in a carbonised state in samples that contained carbonised cereal remains. The only taxa found in a high frequency at more than one site are *Galium aparine* and *Solanum nigrum*. Several other taxa found in a high frequency are macroremains from trees and shrubs that probably represent food plants rather than arable weeds, and *Phragmites australis* that is not likely to represent a weed either (not shown in table 10.1). This indicates that the samples that contain carbonised cereal remains do not represent pure crop products but instead plant food products and/or mixed settlement waste. Gathered food plants and use plants are discussed in chapter 9.

10.3.3 Comparison of potential arable weeds between sites with and without cereals

The results of the comparison of potential arable weeds between sites without and with cereals are shown in table 10.2 (at the end of the chapter). The interpretation of the likeliness that taxa functioned as arable weeds depended on their preservation state and of their presence at sites with cereals. There are several groups of taxa that probably do not represent field weeds. This firstly concerns the *c.* 15 taxa that are only found at sites without cereals. This secondly concerns *c.* ten taxa that are only found in a carbonised state at sites without cereals (but not in such a state at sites with cereals). The absence of these taxa in a carbonised state at sites with cereals

site	Brandwijk-Kerkhof	Hazendonk	Wateringen 4	Schipluiden	Ypenburg
number of samples	14	17	31	52	11
taxon					
Galium aparine	**	**	**	**	-
Solanum nigrum	**	**	-	-	-
Bromus secalinus-type	-	****	-	-	-
Fallopia convolvulus	-	***	-	-	-
Persicaria maculosa	-	***	-	-	-
Persicaria lapathifolia	-	-	**	-	-
Hordeum marinum	-	-	-	***	-
Malva sp.	-	-	-	**	-
Malva neglecta	-	-	-	-	*
Poa sp.	-	-	-	***	-

* = less than 5% *** = 26-50%
** = 5-25% **** = 51-75%
- = not present in a high frequency in a carbonised state in relevant samples

Table 10.1
Selection of sites of the Swifterbant culture and Hazendonk group, frequency classes of carbonised macroremains of potential arable weeds that were found in a relative high frequency in samples with carbonised cereal remains. The selection of sites includes only sites with more than 10 samples with carbonised cereal macroremains. In the calculations of the Hazendonk, the Vlaardingen material and core samples are excluded.

may for some taxa indicate changing plant use, but this needs further investigation. There are thirdly *c.* 15 taxa found both at sites with and without cereals in a waterlogged state only that probably do not represent arable weeds and were not dispersed together with crop plants into the Dutch wetlands. There are fourthly *c.* 10 taxa found both at sites with and without cereals in a carbonised state and in many cases also in a waterlogged state. These were not primarily introduced into the studied regions with crop cultivation, but nevertheless may have become arable weeds afterwards (in which case they would represent apophytes). There are finally *c.* 60 taxa that are only found at sites with cereals, but only in a waterlogged state, that are not considered to represent arable weeds.

Besides the taxa that probably do not represent weeds, there are *c.* 50 taxa found in a carbonised state at sites with cereals only. These taxa may represent arable weeds, although it cannot be excluded that their carbonised state is related to other changes that occurred contemporaneous with the introduction of cereals at these sites (increasing sedentism, changing site function, *etc.*). It should be realised that sites without cereals are not known from the Vecht region and not from the coastal region and that the amount of data from sites without cereals is relatively small.

The group of *c.* 50 taxa present from the introduction of crop plants onwards includes *c.* 20 taxa that are only found in a carbonised state. This would indicate that these taxa represent arable weeds, introduced together with crop cultivation. More than half of the taxa are however taxa that do not remain preserved under waterlogged conditions or are difficult to specify on species level in case of waterlogged preservation: tubers of *Beta* sp., grasses and Fabaceae (*Vicia* sp. and *Trifolium* sp.), and in lesser degree *Veronica* sp. and *Galium* sp. The remaining taxa are only found once or twice at single sites. The unique status of these taxa is therefore overrepresented.

Finally, the group of *c.* 50 taxa present from the introduction of crop plants onwards includes seven taxa that were present in a waterlogged state but not in a carbonised state before the introduction of crops, and have been found in waterlogged and carbonised states after the introduction of crops. The shift from the absence to the presence of these taxa in a carbonised state after the introduction of crop plants suggests that these taxa functioned differently after the introduction, *i.e.* presumably as arable weeds. Most taxa are known as common field weeds from comparable Neolithic cultures or grow under ecological conditions that are comparable with those of arable weeds, except for *Circaea lutetiana* that is a species of shaded terrain.

10.3.4 Comparison of potential arable weeds between regions

Table 10.3 (at the end of the chapter) shows the presence of macroremains of potential arable weeds in carbonised and waterlogged state for each of the studied regions. [1] There are *c.* 80 taxa found in a waterlogged state only, of which the majority is found in a single region only. These taxa are not considered here due to the limited indications of human handling. There are *c.* 30 taxa that are found in a single region only and in a carbonised state, and there is a group of *c.* 20 taxa that has been found in more than one region in a waterlogged state, but only in a single region in a carbonised state. Some of these taxa may represent arable weeds that are restricted to a single region. Differences in the natural vegetation or differences in the amount of data between regions may however also play a role. For example, the region with most unique taxa is the coastal region, where the natural vegetation was substantially different from other regions (see chapter 7).

There are *c.* 20 taxa that are found in a carbonised state in two or more regions. This group contains several taxa generally considered as weeds but this certainly does not hold true for all taxa. When using the presence of macroremains in a carbonised state in a high number of regions as an indication that taxa functioned as weeds, it is most probable that these taxa represent common arable weeds. Some taxa may however (also) have functioned as food plants or use plants, since macroremains and leaves of several of these taxa are edible (see chapter 9). *Galium aparine*, *Vicia* sp. and *Urtica dioica* were found in most regions in a carbonised state.

The differences between regions are generally restricted. An exception comes from seven taxa found in a carbonised state in more than one region, which were found in the central river area and the coastal region, *i.e.* the southern regions only (*Persicaria lapathifolia*, *Capsella bursa-pastoris*, *Chenopodium album*[2], *Persicaria maculosa*, *Solanum nigrum*, *Fallopia convolvulus* and *Brassica rapa*). This difference between the north and the south is remarkable since it concerns a group of taxa that are commonly regarded as weeds. It does not primarily reflect differences in the environment and natural vegetation since four of the taxa (all except for *Fallopia convolvulus* and *Brassica rapa*) were found in a waterlogged state in the Vecht region. This difference is furthermore very interesting since it corresponds with the distinction of a northern and a southern group of the Swifterbant culture, based on subtle differences of pottery and flint (Raemaekers 1999). Two hypotheses can be put forward. 1) The differential presence of seven potential weed taxa in the north and the south of the

1 During the analysis, data of a group of southern sites nearby Rotterdam became available (see paragraph 10.2 and chapter 6). Relevant results are the presence of *Bromus* sp., *cf. Phleum* sp. and *Stellaria neglecta* in a carbonised state. These results are not included in table 10.3 and the discussion below.

2 However, the presence of *Chenopodium album* in a carbonised state in the Eem and Vecht regions is not excluded since *Chenopodium* sp. was found in a carbonised state at Hoge Vaart.

Netherlands is caused by a different contact route that enabled the introduction of crop plants in the north and the south of the Netherlands, or by different crop cultivation practices. This hypothesis corresponds with the distinction between cultural groups in the north and the south. However, the differences between the cultural groups are small while the crop assemblage is highly similar in the north and the south. 2) The difference in the weed assemblage is caused by unrepresentative (incomparable) data from especially the Vecht region. The unrepresentativity is caused by the selection of waterlogged remains on the one hand (Swifterbant-S3) and the small data set on the other hand. This second hypothesis can be tested with data of future excavations in the northern Netherlands.

10.4 Discussion

10.4.1 Which taxa represent arable weeds?

In order to obtain a final list of probable arable weeds, the results of the various methods are combined. This concerns the presence in concentrations of carbonised cereals, the relatively high frequency in samples with carbonised cereals calculated per site, the taxa found in a carbonised state at sites with cereals only, and the taxa found in a carbonised state in two or more regions.

There are six taxa that meet to three or four of the conditions: *Bromus secalinus*-type, *Hordeum marinum*, *Fallopia convolvulus*, *Malva* sp., *Persicaria maculosa* and *Solanum nigrum*. These taxa most likely represent the most common arable weeds. The list of probable weeds cannot be applied to all regions in the same way since differences between regions do exist. The taxa *Hordeum marinum* and *Malva* sp. are only found in the coastal region (sites of the Hazendonk group) while *Fallopia convolvulus* is not found in the northern Netherlands (northern group of the Swifterbant culture). None of the common probable weeds are found in a carbonised state in the Eem and Vecht regions. This may related to differential representativity of the data sets of different regions, to differences in the natural vegetation or with differences in cultivation practices between regions, while for the Eem region it may be related to absence of crop plants as well.

The difficulties to distinguish these taxa indicate that the list should be considered as a preliminary result that remains to be tested by comparison with new data. It is furthermore important to realise that this list of weed taxa cannot be complete in view of the small number of taxa. Many of the taxa that do not meet more than two of the criteria may therefore also represent field weeds, although they may be less common, producing less macroremains before harvesting, having smaller chances to get harvested, to remain present at the site and in the crop product and to get preserved in a carbonised state, *etc*. For example, despite not being distinguished, the find of *cf. Avena* sp. is considered as a weed as well (see paragraph 11.2.1).

Hordeum marinum and *Malva* sp. were not found as weeds during agricultural experiments on the salt marsh by Körber-Grohne (1967) or in the experiments by Van Zeist *et al.* (1976). This difference may be related to differences in the natural vegetation and in agricultural practices, or with the methodology of the weed analysis presented here. It would therefore be relevant to investigate the status of *Hordeum marinum* and *Malva* sp. as arable weeds in the coastal region in further detail.

There are *c.* 15 species that meet two of the conditions: *Brassica rapa*, *Capsella bursa-pastoris*, *Cerastium* sp., *Chenopodium album*, *Elytrigia repens*, *Galium aparine*, *Malva neglecta*, *Persicaria lapathifolia*, *Poa annua/Phleum* sp., *Poa* sp., *Trifolium repens*, *Trifolium* sp., *Urtica dioica* and *Vicia hirsuta/tetrasperma*. These taxa may also represent weeds, at least from introduction from crop plants onwards.

The presented analysis of weeds is based on the combination of the available data from all sites and regions together, aiming to identifying the arable weeds of the Swifterbant culture and Hazendonk group. This combination of the data improves the validity of the results due to the high number of samples. However, the analysis of the combined data set assumes that cultivation methods at all sites were that uniform that a general

weed assemblage could be recognised by analysis, while this assumption is not proven. The weakness of the weed analysis therefore is that possible variation in cultivation practices within and between sites, regions, cultural groups, crop plants or other factors is not sufficiently taken into account.

Apart from the weed analysis in this chapter, it was already investigated for individual sites and regions whether the data indicate that certain taxa functioned as arable weeds (see chapters 2 and 3). The strength of these results was limited since the conclusions were based on a relatively small amount of data, all with their specific restrictions. The results of both methods can now be compared. Weed analysis on a regional scale distinguished Chenopodiaceae, *Brassica* sp. (*B. rapa*), *Bromus secalinus*-type, *Elytrigia repens*, *Galium aparine*, *Hordeum marinum*, *Malva* sp., *Persicaria lapathifolia*, *Poa* sp., *Polygonum aviculare*, *Stellaria media* and *Veronica hederifolia*. The special status of some of these taxa is indeed supported or confirmed by the presented analysis of all available data since several of these taxa are found in different regions and are associated with crop plants. For some other taxa such a status is however not confirmed at all, especially not for taxa that are scarce (*E. repens* and *V. hederifolia*). These taxa may have been weeds as argued in the relevant chapters, but were probably not common weeds in the Swifterbant culture and Hazendonk group, although it cannot be excluded that they are underrepresented for a variety of reasons.

10.4.2 Information on cultivation practices derived from probable weeds

Assuming that the weed analysis has given representative results, the group of six probable common arable weeds will be used to reconstruct agricultural practices, such as cultivation intensity, harvesting methods, and how weed taxa arrived at the sites studied. The resulting conclusions are incorporated in chapter 11 that also discusses cultivation practices.

Most taxa of the probable weeds are annuals, although *Bromus secalinus*-type and *Malva* sp. may represent biennials or perennials. A weed assemblage of annuals is indicative of long-lasting cultivation of the same plot of land where perennials do not get a chance anymore due to ongoing cultivation (Behre 1981; Bogaard 2002, 2004, 96-99; Bogaard and Jones 2007 though see Kreuz *et al.* 2005, 251). The importance of annuals therefore indicates that the major part of the arable plots was continuously located at the same spot, and that shifting cultivation was generally not practised.

The height of most probable common weeds is of medium length between 50-80 cm, while there are two low species that are especially found in the coastal region (*Hordeum marinum* and *Malva neglecta*). This indicates that only the upper half of the cereal plants was harvested in most regions, while there are indications of harvesting lower on the culm for the coastal region. This implies that small weeds that only reach a limited height may be poorly distinguished by the weed analysis.

The small group of probable arable weeds does not contain taxa that are indicative of specific soil conditions and as a result they do not give information on the location of the arable fields. Only *Hordeum marinum* indicates cultivation in the coastal region since it prefers brackish conditions. The absence of other halophilous taxa distinguished as arable weeds however indicates that the arable plots in the coastal region were generally not located on the salt marshes. Overall, the ecology of the weeds does not argue against crop cultivation at the sites studied (local cultivation). The list of potential arable weeds as initially selected contains few taxa that could not have grown in the environment/vegetation around the sites studied either. Therefore, the weed analysis indicates that local crop cultivation is possible. The import of crop products is however not excluded either for all regions other than the coastal region.

Theoretically, weeds can give information on the sowing season, since some taxa are part of the Chenopodietea, nowadays associated with spring-sown root/row-crops and some taxa are part of the Secalinetea, associated with autumn-sown cereals. The data should however be interpreted with caution since taxa are not always part of a single class only and since this division of classes is based on the modern-day vegetation and it is commonly recognised that this classification cannot be applied to prehistoric weeds directly

(Schaminée *et al.* 1998, 206). Indicators of autumn sowing moreover tend to be overrepresented in final crop products while indicators for spring sowing tend to be overrepresented in waste products (Bogaard *et al.* 2005). The group of probable arable weeds from the Swifterbant and Hazendonk sites contains some summer annuals, but also a potential winter annual (*Bromus secalinus*-type, see Kreuz *et al.* 2005), and also taxa that are indifferent. The importance of weeds indicative of spring sowing indicates that summer cultivation is most likely for most sites. This corresponds with the suitability of the wetland regions for arable farming during summer due to reduced risk of flooding. This result does not contradict local cultivation. *Bromus secalinus*-type, indicative of autumn-sowing, was mainly found at the Hazendonk (phase 1 for which import of crop plants is suggested, see chapter 11). It may indicate autumn sowing for the crop from this site and phase, but spring sowing cannot be excluded.

Most taxa that probably represent arable weeds are anthropochorous taxa, *i.e.* spread by people (based on Kreuz *et al.* 2005). The anthropochorous state supports that the taxa were dispersed as weeds together with crop cultivation. Indeed, *Bromus secalinus*-type, *Malva* sp. and *Hordeum marinum* were not present at sites without cereals. For the last two species this is not confirmed by data from the sites studied since sites without cereals are not known from the coastal region. In contrast, *Fallopia convolvulus*, *Persicaria maculosa* and *Solanum nigrum* were already present at the studied sites before introduction of crop plants, although only in a waterlogged state. Their presence before the introduction of crop plants and the indications that they functioned as weeds indicates that these taxa probably represent apophytes.

10.4.3 Comparison with weeds of other relevant Neolithic cultures

Table 10.4 (at the end of the chapter) provides a list of arable weeds known from Neolithic cultures that may have played a role in the introduction of crop plants into the wetlands inhabited by people of the Swifterbant culture (based on Arora and Zerl 2004; Bakels 1990, 2003, 2007; Bakels and Rousselle 1985; Bakels *et al.* 1993; Heim 1979; Heim and Hauzeur 2002; Hopf 1981; Knörzer 1971; Päffgen and Zerl 2005; Schreurs 1992; Vanmontfort *et al.* 2004; the list of taxa is not meant to be complete). Most information on weeds is known from the LBK and Rössen culture since a considerable number of botanical assemblages is available of these cultures. In contrast, representative data of weeds of the Blicquy group, Bischheim group and Michelsberg culture from Northwestern Europe are scarce.

Bromus secalinus-type, *Fallopia convolvulus*, *Malva* sp. (if representing *Malva sylvestris*), *Persicaria maculosa* and *Solanum nigrum* are typical Neolithic weeds known from other Neolithic cultures such as the LBK, Blicquy group, Rössen culture and Michelsberg culture. Only *Persicaria maculosa* is known to the author from the LBK only, but it seems improbable that it wasn't a weed in later Neolithic cultures in Northwestern Europe. The general similarity of the weed assemblage of the sites studied with assemblages of Neolithic cultures is as expected and can be explained by spread of agriculture into Northwestern Europe by a single culture, the LBK. In contrast to the common weeds, *Hordeum marinum* is less well-known from other cultures. The indications that this species functioned as arable weeds in the coastal region only can be related to local arable farming in the coastal region, where the vegetation differed from the vegetation in the inland of Europe from where we know (earlier) fully Neolithic cultures.

The weed analysis does not give indications that contact with a specific culture resulted in the introduction of crop plants in the Netherlands. There are some differences in the weed assemblage between the southern and the northern regions. If these differences appear to be representative results, they may represent the influence of southern cultures on the neolithisation process in the southern part of the Netherlands (see also chapter 11). It is however not possible to compare in detail the assemblage of potential arable weeds of the Swifterbant culture and Hazendonk group with that of the (Belgian) Michelsberg culture, since there are not enough data on weed assemblages of the Michelsberg culture, as far as known by the author.

10.5 Suggestions for further research

Subjects for future research are the testing of the obtained results with data from future excavations and analyses, the application of correspondence analysis, the application of the FIBS method (Functional Interpretation of Botanical Surveys; Bogaard *et al.* 2005; Jones *et al.* 2005), interpretation of the size of macroremains in relation to crop processing, calculation of densities in relation to crop processing and the calculation of the numbers of taxa per ecological group for alternative investigation of the permanency of plots. Finally, the list of probable and potential arable weeds could be compared with taxa known as field weeds from other Neolithic communities in Northwestern Europe (Belgium, France, Britain and Denmark).

cereals present / category / taxon	- C	- W	+ C	+ W
Do not represent arable weeds				
Cerastium sp.	●			
Trifolium arvense/campestre/ dubium	●			
Vicia sepium	●			
Anagallis sp./Glaux sp.	●			
Stellaria neglecta	●	●		
Chelidonium majus	●	●		
Lotus pedunculatus	●	●		
Atriplex sp./Suaeda sp.		●		
Chenopodium murale		●		
Clematis vitalba		●		
Lychnis sp./Silene sp.		●		
Poa chaixii		●		
Lamium album/maculatum		●		
Stellaria graminea		●		
Stachys arvensis/sylvatica		●		
Echinochloa crus-galli	●		●	
Lapsana communis	●		●	
Rumex obtusifolius	●		●	
Arenaria serpyllifolia ssp. serpyllifolia	●	●	●	
Atriplex littoralis/prostrata	●	●	●	
Atriplex sp.	●	●	●	
Chenopodium sp.	●	●	●	
Fallopia dumetorum	●	●	●	
Lychnis flos-cuculi	●	●	●	
Silene dioica	●	●	●	
Alliaria petiolata		●	●	

cereals present / category / taxon	- C	- W	+ C	+ W
Do not represent arable weeds (cont.)				
Anthriscus sylvestris		●		●
Arctium sp.		●		●
Carex disticha		●		●
Cirsium sp.		●		●
Daucus carota		●		●
Galium spurium		●		●
Juncus gerardii		●		●
Glechoma hederacea		●		●
Poa annua		●		●
Ranunculus acris		●		●
Silene sp.		●		●
Sonchus sp.		●		●
Torilis sp.		●		●
Urtica urens		●		●
Valeriana officinalis		●		●
May have become arable weeds				
Atriplex patula/prostata	●	●	●	●
Capsella bursa-pastoris	●	●	●	●
Chenopodium album	●	●	●	●
Galium aparine	●	●	●	●
Moehringia trinervia	●	●	●	●
Persicaria lapathifolia	●	●	●	●
Urtica dioica	●	●	●	●
Ajuga reptans	●		●	●
Chenopodiaceae	●		●	●
Vicia sp.	●		●	●
Ranunculus ficaria, tubers	●		●	
Trifolium sp.	●		●	

Table 10.2 part 1.

taxon	cereals present category	- C	- W	+ C	+ W
Do not represent arable weeds					
Aethusa cynapium				●	
Alopecurus myosuroides/ pratensis				●	
Alopecurus pratensis				●	
Anagallis arvensis				●	
Anthoxanthum odoratum				●	
Arctium lappa				●	
Artemisia vulgaris				●	
cf. Avena sp.				●	
Brassica sp.				●	
Bromus mollis/secalinus				●	
Cardamine hirsuta				●	
Cardamine pratensis				●	
Cardamine sp.				●	
Carduus crispus				●	
Carduus sp./Cirsium sp.				●	
Carex arenaria				●	
Carex brizoides				●	
Carex cf. distichia				●	
Carex cf. strigosa				●	
Carex divulsa				●	
Carex elongata				●	
Carex remota				●	
Chaerophyllum bulbosum/ temulum				●	
Cirsium arvense				●	
Cirsium arvense/palustre				●	
Cirsium oleraceum/vulgare				●	
Cirsium vulgare				●	
Do not represent arable weeds (cont.)					
Conium maculatum					●
Elytrigia atherica/repens					●
Euphorbia helioscopia					●
Glaux maritima					●
Hyoscyamus niger					●
Hypericum perforatum					●
Hypericum tetrapterum					●
Lamium album					●
Linaria vulgaris					●
Nepata cataria					●
Oenanthe lachenalii					●
Persicaria bistorta					●
Persicaria lapathifolia/maculosa					●
Physalis alkekengi					●
Poa compressa/nemoralis					●
Prunella vulgaris					●
Rumex acetosella					●
Scrophularia nodosa					●
Senecio vulgaris					●
Silene latifolia ssp. album					●
Silene otites					●
Sonchus arvensis					●
Sonchus asper					●
Sonchus oleraceus					●
Stachys sylvatica					●
Stellaria cf. nemorum					●
Taraxacum officinale s.l.					●
Thalictrum minus					●
Valerianella locusta					●
Verbena officinalis					●
Viola arvensis-type					●

Table 10.2 part 2.

cereals present	-		+	
category	C	W	C	W
taxon				
Some may represent arable weeds				
Brassica rapa			●	●
Luzula sp.			●	●
Apium graveolens			●	●
Atriplex littoralis-type			●	●
Atriplex sp./Chenopodium sp.			●	●
Brassica sp./Sinapis sp.			●	●
cf. Bromus sp.			●	●
Carex distans			●	●
Cerastium sp.			●	●
Galium sp.			●	●
Malva sp.			●	●
Malva neglecta			●	●
Medicago lupulina			●	●
Plantago major			●	●
Galium tricornutum			●	●
Hordeum marinum			●	●
Veronica hederifolia			●	●
Sisymbrium officinale			●	●
Polygonum aviculare			●	●
Trifolium repens			●	●
Torilis japonica			●	●
Althaea sp./Malva sp.			●	
Asparagus officinalis			●	
Beta vulgaris ssp. maritimus, tubers			●	

cereals present	-		+	
category	C	W	C	W
Some may represent arable weeds (cont.)				
Bromus secalinus-type			●	
Chaerophyllum temulum			●	
Claviceps purpurea			●	
Elytrigia repens			●	
Galium cf. mollugo			●	
Galium odoratum			●	
Lathyrus palustris/Vicia cracca			●	
Lathyrus sp./Vicia sp.			●	
Phleum sp./Poa annua			●	
cf. Phleum sp.			●	
Trifolium campestre			●	
Veronica arvensis			●	
Veronica austriaca/chamaedrys			●	
Vicia hirsuta			●	
Vicia hirsuta/tetrasperma			●	
Vicia sativa			●	
Probably represent arable weeds				
Chenopodium ficifolium		●	●	●
Fallopia convolvulus		●	●	●
Persicaria maculosa		●	●	●
Solanum nigrum		●	●	●
Stellaria media		●	●	●
Circaea lutetiana		●	●	●
Galeopsis bifida-type		●	●	●

C = carbonised W = waterlogged ● = present

Table 10.2 The sites of the Late Mesolithic, the Swifterbant culture and the Hazendonk group, presence of macroremains of potential arable weeds in a carbonised and waterlogged state at sites without and with cereals. See the text for the selection and assignment of sites. The headings indicate the probability that the taxa represent true arable weeds, based on the comparison of sites without and with crop plants, part 3.

region	Eem		Vecht		Central river		Coastal	
category	C	W	C	W	C	W	C	W
taxon								
Taxa nowhere present in carbonised state								
Clematis vitalba		●						
Alopecurus pratensis				●				
Anagallis arvensis				●				
Artemisia vulgaris				●				
Bromus mollis/secalinus				●				
Carduus crispus				●				
Cirsium arvense				●				
Persicaria bistorta				●				
Ranunculus acris				●				
Sonchus arvensis				●				
Sonchus oleraceus				●				
Stellaria cf. nemorum				●				
Alliaria petiolata						●		
Alopecurus myosuroides/ pratensis						●		
Anthoxanthum odoratum						●		
Cardamine pratensis						●		
Chaerophyllum bulbosum/ temulum						●		
Chenopodium murale						●		
Galium spurium						●		
Lamium album						●		
Lamium album/maculatum						●		
Nepata cataria						●		
Poa chaixii						●		
Silene latifolia ssp. album						●		
Lychnis sp./Silene sp.						●		
Stachys arvensis/sylvatica						●		
Stellaria graminea						●		
Torilis sp.						●		
Atriplex sp.								●
cf. Avena sp.								●

Table 10.3 part 1.

region	Eem		Vecht		Central river		Coastal	
category	C	W	C	W	C	W	C	W
taxon								
Taxa nowhere present in carbonised state (cont.)								
Brassica sp.								●
Brassica sp./Sinapis sp.								●
Cardamine hirsuta								●
Cardamine sp.								●
Carduus sp./Cirsium sp.								●
Carex arenaria								●
Carex brizoides								●
Carex divulsa								●
Carex elongata								●
Cirsium arvense/palustre								●
Cirsium oleraceum/vulgare								●
Cirsium vulgare								●
Echinochloa crus-galli								●
Elytrigia atherica/repens								●
Glaux maritima								●
Hyoscyamus niger								●
Hypericum perforatum								●
Linaria vulgaris								●
Oenanthe lachenalii								●
Physalis alkekengi								●
Poa compressa/nemoralis								●
Prunella vulgaris								●
Scrophularia nodosa								●
Senecio vulgaris								●
Silene otites								●
Stachys sylvatica								●
Thalictrum minus								●
Valerianella locusta								●
Verbena officinalis								●
Viola arvensis-type								●
Aethusa cynapium				●				●
Carex disticha				●				●
Conium maculatum				●				●

Table 10.3 part 2.

region	Eem		Vecht		Central river		Coastal	
category	C	W	C	W	C	W	C	W
taxon								
Taxa nowhere present in carbonised state (cont.)								
Persicaria lapathifolia/maculosa				●				●
Anthriscus sylvestris				●		●		●
Arctium lappa				●		●		●
Sonchus asper				●		●		●
Poa annua				●		●		
Rumex acetosella				●		●		
Sonchus sp.				●		●		
Daucus carota		●		●				●
Juncus gerardii		●		●				●
Urtica urens		●		●		●		
Valeriana officinalis		●				●		
Arctium sp.						●		●
Carex remota						●		●
Cirsium sp.						●		●
Glechoma hederaceae						●		●
Hypericum tetrapterum						●		●
Silene sp.						●		●
Taxa present in a single region and in carbonised state								
Anagallis sp./Glaux sp.	●							
Lotus pedunculatus	●	●						
Trifolium arvense/campestre/dubium	●							
Vicia sepium	●							
Claviceps purpurea			●					
Bromus secalinus-type					●			
Chaerophyllum temulum					●			
Elytrigia repens					●			
Galium odoratum					●			
Lathyrus palustris/Vicia cracca					●			
Phleum sp./Poa annua					●			
Veronica austriaca/chamaedrys					●			
Apium graveolens							●	●

Table 10.3 part 3.

region	Eem		Vecht		Central river		Coastal	
category	C	W	C	W	C	W	C	W
taxon								
Taxa present in a single region and in carbonised state (cont.)								
Atriplex littoralis-type							●	●
Atriplex sp./Chenopodium sp.							●	●
cf. Bromus sp.							●	●
Carex distans							●	●
Galium tricornutum							●	●
Hordeum marinum							●	●
Malva neglecta							●	●
Malva sp.							●	●
Medicago lupulina							●	●
Sisymbrium officinale							●	●
Althaea sp./Malva sp.							●	
Asparagus officinalis							●	
Beta vulgaris ssp. maritimus, roots							●	
Galium cf. mollugo							●	
Lathyrus sp./Vicia sp.							●	
Trifolium campestre							●	
Veronica arvensis							●	
Vicia hirsuta							●	
Vicia sativa							●	
Taxa present in more than one region, carbonised in a single region only								
Chenopodium sp.	●	●		●		●		●
Fallopia dumetorum	●					●		●
Stellaria neglecta	●					●		
Silene dioica	●							●
Rumex obtusifolius	●							●
Chelidonium majus	●					●		
Arenaria serpyllifolia ssp. serpyllifolia	●							●
Atriplex littoralis/prostrata	●	●		●				●
Lychnis flos-cuculi	●	●		●				●
Lapsana communis	●			●		●		●

Table 10.3 part 4.

region	Eem		Vecht		Central river		Coastal	
category	C	W	C	W	C	W	C	W
taxon								
Taxa present in more than one region, carbonised in a single region only (cont.)								
Veronica hederifolia					●			●
Chenopodium ficifolium				●		●	●	●
Polygonum aviculare				●		●	●	●
Stellaria media				●		●	●	●
Trifolium repens				●			●	●
Plantago major				●			●	●
Galeopsis bifida-type				●		●	●	●
Torilis japonica						●	●	●
Galium sp.						●	●	
Luzula sp.						●	●	
Circaea lutetiana						●	●	●
Taxa present in carbonised state in more than one region								
Galium aparine	●		●	●	●	●	●	●
Vicia sp.	●		●	●			●	
Urtica dioica	●	●		●	●	●	●	●
Moehringia trinervia	●	●		●		●	●	●
Atriplex patula/prostata	●			●		●	●	●
Cerastium sp.	●						●	●
Chenopodiaceae	●						●	●
Trifolium sp.	●						●	
Ajuga reptans	●				●	●		●
Ranunculus ficaria, tubers	●				●			
Vicia hirsuta/tetrasperma			●				●	
Persicaria lapathifolia		●		●	●	●	●	●
Capsella bursa-pastoris				●	●	●	●	●
Chenopodium album				●	●	●	●	●
Persicaria maculosa				●	●	●	●	●
Solanum nigrum				●	●	●	●	●
Fallopia convolvulus					●	●	●	●
Brassica rapa					●	●	●	●

C = carbonised W = waterlogged ● = present

Table 10.3 The regions studied, presence of macroremains of potential arable weeds in a carbonised and waterlogged state, part 5.

cultural group taxon	LBK	Blicquy	Rössen	Bischheim	Michelsberg
Anagallis arvensis	-	-	-	-	+
Anthemis-type	-	-	-	-	+
Aphanes sp.	-	-	+	-	-
Atriplex patula/prostrata	-	-	-	-	+
Atriplex prostrata	-	-	-	-	+
Brassica sp./Sinapis sp.	+	-	-	-	-
cf. Brassicaceae	-	-	-	+	-
Bromus secalinus-type	+	-	+	+	+
Bromus sp.	+	-	-	-	+
Bromus sterilis-type	+	-	+	-	+
Chenopodium album	+	+	+	+	+
Chenopodium cf. urbicum	-	-	-	+	-
Chenopodium glaucum/rubrum	-	-	+	-	-
Chenopodium polyspermum	+	-	+	-	-
Chenopodium sp.	+	-	-	-	-
Echinochloa crus-galli	+	-	-	-	+
Fallopia convolvulus	+	-	+	+	+
Galeopsis segetum	-	-	+	-	-
Galeopsis sp.	+	-	-	-	-
Galium aparine	+	-	-	-	+
Galium cf. palustre	-	-	-	+	-
Galium cruciata	+	-	-	-	-
Galium sp.	-	-	-	-	+
Galium spurium	+	-	+	-	+
Galium aparine/spurium	-	-	+	-	-
Knautia arvensis	-	-	-	+	-
Lapsana communis	+	-	+	+	+
Lolium sp.	-	-	-	+	-
cf. Lotus uliginosus	-	-	-	+	-
Malva sylvestris	+	-	-	-	-
Malvaceae	-	-	-	+	-
Melandrium cf. rubrum	-	-	+	-	-
Melandrium sp.	-	-	-	+	-
Moehringia trinervia	-	-	+	-	-
Moehringia trinervia	-	-	+	-	-
Persicaria hydropiper	-	-	+	-	+

Table 10.4 part 1.

cultural group / taxon	LBK	Blicquy	Rössen	Bischheim	Michelsberg
Persicaria lapathifolia	+	-	+	-	-
Persicaria maculosa	+	-	-	-	-
Phleum sp.	+	-	+	-	+
Poa annua	-	-	-	-	+
Poa cf. trivialis	-	-	+	-	-
Poa sp.	-	-	-	+	-
Poa sp. (non annua)	-	-	+	-	-
Poaceae	-	-	+	-	+
Polygonum aviculare	+	-	-	-	-
Ranunculus repens	+	-	-	-	-
Rumex acetosella	+	-	+	-	-
Rumex sanguinea	+	-	+	-	-
Rumex sp.	+	-	-	-	+
Scleranthus annuus	-	-	-	-	+
Setaria viridis-type	+	-	-	-	-
Sherardia arvensis	-	-	-	-	+
Silene sp.	+	-	-	-	+
Silene nutans/vulgaris	+	-	-	-	-
Sisymbrium officinale	-	-	+	-	-
Solanum nigrum	-	+	+	-	+
Stachys arvensis/sylvatica	+	-	-	-	-
cf. Stachys sp.	-	-	-	+	-
Stellaria media	+	-	+	-	-
Trifolium pratense	-	-	-	-	+
Trifolium sp.	-	-	+	-	+
Veronica hederifolia	-	-	-	-	+
Vicia hirsuta	+	-	+	-	-
Vicia hirsuta/tetrasperma	+	-	+	-	+
Vicia cracca/hirsuta/tetrasperma	-	-	+	-	-
Vicia sepium	+	-	-	-	-
Vicia sp.	-	-	-	-	+
Vicia tetrasperma	-	-	-	-	+

+ = present - = not present

Table 10.4 Neolithic cultural groups in the Lower Rhine Basin, Northwestern Europe that predate or are contemporaneous with the studied sites, presumed arable weeds (see paragraph 10.4.3 for sources and the selection of data), part 2.