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# Growing habits? Delayed introduction of crop cultivation at marginal Neolithic wetland sites

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**Abstract** This paper aims to gain a better understanding of the neolithisation process in the Netherlands after the arrival of the Linearbandkeramik Culture, focussing on local crop cultivation at Neolithic wetland sites of the Swifterbant Culture and Hazendonk Group. The debate of the past 30 years questions whether crop plants were cultivated locally in the exploitation area of wetland sites, or whether they were brought in from elsewhere. Which crop plants were introduced in the wetlands, when they were introduced and where they came from is investigated, based on published evidence from three main regions. The main crop plants introduced were emmer wheat and naked barley. Details of the introduction process are available only for the southern region. The complex discussion of botanical and non-botanical criteria supports local crop cultivation in most regions.

**Keywords** Neolithisation · Local crop cultivation · Swifterbant Culture · Hazendonk Group

## Introduction

Knowledge of the neolithisation process of most parts of the Netherlands is still restricted. The process started with arrival of the fully Neolithic Linearbandkeramik (LBK) Culture in the very southeastern part of the Netherlands, an area characterised by loess soils at ca. 5300 cal B.C. (van

Gijn and Louwe Kooijmans 2005). The LBK Culture was followed by the Grossgartach Culture in 5000 B.C., the Blicquy Group and Rössen Culture in 4900 B.C. and the Michelsberg Culture in 4300 B.C. in the regions to the south and southeast of the Netherlands. The presence of these Neolithic neighbours resulted in a gradual neolithisation process, characterised by local pottery production in the Dutch wetlands in ca. 5000 B.C., introduction of domestic animals in ca. 4700 B.C. and introduction of crop plants even later. Suggestions for the date of introduction of crop plants are 4900 B.C. (Gehasse 1995, pp. 195–198), between ca. 4600 and 4000 B.C. (Brinkkemper et al. 1999, p. 82) and at least from 4100 B.C. onwards (Raemaekers 1999, p. 191). According to the first two hypotheses, the Rössen Culture played an important role in the introduction of crop plants, while the third hypothesis suggests that the Michelsberg Culture played a key role. People of both cultures cultivated a broad range of crops including cereals and pulses (Bakels 2003; Knörzer et al. 1999).

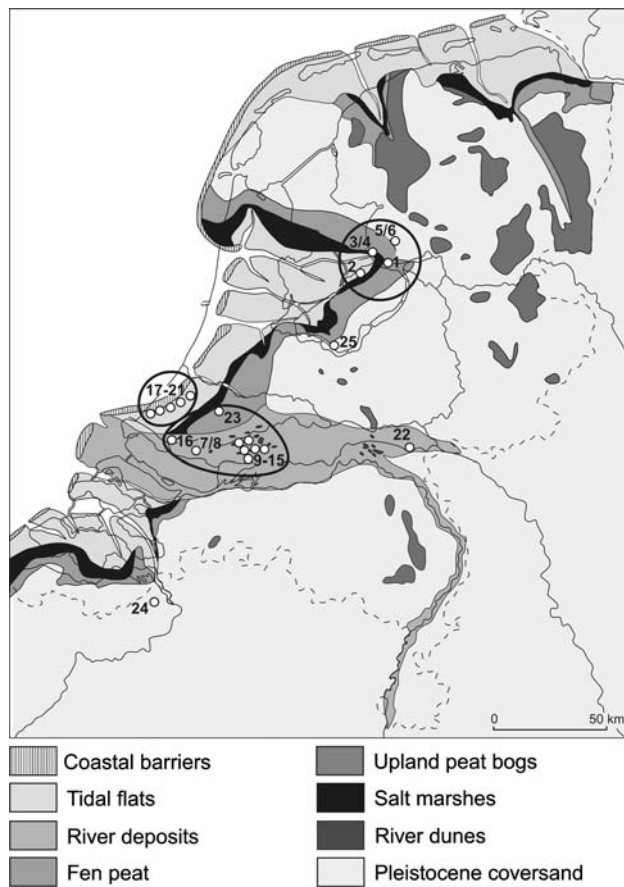
This study concerns Dutch wetland sites dating to 6000–3500 B.C., corresponding with the Late Mesolithic and the subsequent Swifterbant Culture and Hazendonk Group. The economy of the Swifterbant Culture and the Hazendonk Group was a broad-spectrum economy, based on hunting, gathering, fowling and fishing, supplemented by animal husbandry and crop cultivation in the course of time. The economy remained semi-agrarian until the Late Neolithic. The Dutch wetland sites are located in the Rhine/Meuse/IJssel river area, dominated by organic sediments (peat and clay). Three main regions can be discerned that consist of clusters of sites; the northern region, the southern region and the coastal region, while some additional sites occur outside these regions (Fig. 1). The sites are located on small patches of dry land, formed by river dunes, natural levees, coastal dunes and outcrops

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**Fig. 1** The location of the main studied sites plotted on a palaeogeographic map of the Netherlands (4200 B.C.). Table 1 shows the names of the sites

of boulder clay. Preservation of organic material at the wetland sites is usually good since sedimentation under waterlogged conditions was continuous during prehistory.

Local crop cultivation at the Dutch wetland sites has been subject of debate since the seventies (Bakels 1981, 1986; Cappars and Raemaekers 2008; Casparie et al. 1977; Louwe Kooijmans 1993; Out 2008; van Zeist and Palfenier-Vegter 1981). On the one hand, the archaeobotanical finds indicate consumption of crop plants and possibly even local cultivation in the exploitation area of the sites. In particular the chaff remains of naked barley are a convincing argument for local crop cultivation for some authors, assuming that relative heavy chaff remains of free-threshing cereals preclude long-distance transport (e.g. Kubiak-Martens 2006; van Zeist and Palfenier-Vegter 1981). Local crop cultivation would moreover probably have been inferred if the same remains were found at sites located in the middle of dry terrain.

On the other hand, environmental conditions were far from optimal for crop cultivation, at least to our modern-day view of arable farming. Most studied sites are located on patches of dry land with a surface area of only few

hectares, surrounded by wetlands. The area that was not used for domestic activities and hence remained for fields was probably small. The area of dry terrain moreover decreased through time due to the rising water level, and seasonal flooding must have occurred frequently. Most sites were additionally located on sloping terrain, where deforestation would have caused a considerable risk of erosion.

The alternative to local crop cultivation is the importation of crop products from the Pleistocene sandy soils that surround the wetlands to the north, east and south (van Gijn and Louwe Kooijmans 2005). Subsistence data from these regions are however scarce since preservation of organic material is very poor. The hypothesis of importation of crop plants from the sandy soils assumes that people of the Swifterbant Culture and Hazendonk Group lived in the sandy regions during part of the year or that a part of their community was there. Importation of crop plants could additionally be the result of exchange with people of other, possibly fully Neolithic, cultural groups since the precise cultural identity of people living on the Pleistocene sandy soils is not clear.

The aim of this study is to give an overview of the archaeobotanical data to improve our understanding of the plant economy in relation to neolithisation. The first basic questions are which crop plants were cultivated, when were they introduced, and which culture played an important role in the introduction process. A further question is whether crops were cultivated locally in the exploitation area of Dutch wetland sites or whether crops were imported from elsewhere. In order to answer this fourth question, data from botanical remains, artefacts, features and site function are investigated.

## Materials and methods

This study is based on literature research. Table 1 gives the main sites with their references. The original site investigation methods varied widely. Samples were usually collected from excavations, but occasionally only from cores, influencing the number, type and context of samples. Sample preparation usually included wet-sieving on sieves with a mesh-width down to 0.25 mm. At most sites both waterlogged and carbonised material has been found.

## Results

In the northern region, the main crop plants are emmer wheat (*Triticum dicoccon*) and naked barley (*Hordeum vulgare* var. *nudum*). At Urk-E4 only grains of einkorn (*Triticum monococcum*-type) were found. The einkorn

**Table 1** Information on the main studied sites and general information on the presence of crop plants ordered by region and time

Site	Age (cal B.C.)	Cereals	Other	References	
Northern region					
1	Schokkerhaven-E170	3950–3700	+	Gehasse (1995)	
2	Swifterbant-S3	4300–4000	+	van Zeist and Palfenier-Vegter (1981)	
3	Urk-E4 late phases	4200–3500	+	Peters and Peeters (2001)	
4	Urk-E4 early phases	7000–5050	– (?)	Peters and Peeters (2001)	
5	P14 later phases	4400–4100	+	Gehasse (1995)	
6	P14 early phases	4900–4400	– (?)	Gehasse (1995)	
Southern region					
7	Barendrecht 20.125	3660–3380	+	+	Meirsmann and Moree (2006)
8	Barendrecht 20.126	4050–3790	+		Moree (2006)
9	Hazendonk, early phases	4020–3610	+		Unpubl. data RMO/Leiden University
10	Meerdonk	4030–3910	+		Verbruggen pers. comm.
11	Rechthoeksdonk	4240–3980	+		Verbruggen pers. comm.
12	Brandwijk-Kerkhof late phases	4220–3630	+	+	Out (2008)
13	Brandwijk-Kerkhof early phases	4610–4370	– (?)		Out (2008)
14	Hardinxveld-Giessendam Bruin	5500–4550	–		Bakels et al. (2001)
15	Hardinxveld-Giessendam Polderweg	5500–5000	–		Bakels and van Beurden (2001)
16	Rotterdam-Randstadrail	5630–5380	– (?)		Guiran and Brinkkemper (2007)
Coastal region					
17	Schipluiden	3630–3380	+		Kubiak-Martens (2006)
18	Wateringen	3625–3400	+		Raemaekers et al. (1997)
19	Rijswijk-A4	Middle Neolithic	+		Unpubl. data Leiden University
20	Sion (AHR-42)	3640–3370	+		Rieffe et al. (2006)
21	Ypenburg	3860–3435	+		van Haaster (2001)
Other sites					
22	Nijmegen-Oosterhout	3770–3530	+		Out in Ball and van den Broeke (2007, 104)
23	Bergschenhoek	4300–4100	– (?)		Unpubl. data RMO/Leiden University
24	Doel Deurganckdok-sector B	4540–3960	+		Bastiaens et al. (2005)
25	Hoge Vaart	6600–4150	–		Brinkkemper et al. (1999)

The number in the first column corresponds with those in Fig. 1. Other = other crops (see text), + = present, – = no indications for presence, – (?) = no indications for presence, although the representativity of this result is questionable due to a small number of samples or remains, RMO = National Museum of Antiquities

grains may however also represent grains from the top of ears of emmer wheat (Nesbitt and Samuel 1996, p. 56). The small number of wheat grains identified down to species level from this site ( $n = 2$ ) does not permit a final conclusion. A single bread wheat grain (*Triticum cf. aestivum*) was identified at Swifterbant-S3, but this may now be considered to represent a deformed grain of emmer wheat (cf. Braadbaart 2004, 2008).

In the northern region, cereals were present from ca. 4400 to 4100 B.C. onwards (Table 1), and the precise moment of cereal introduction is not known. For P14 (occupied until the Middle Bronze Age) it was suggested that cereals were present from 4900 B.C. onwards, partly based on  $^{14}\text{C}$  dates obtained from food crusts (Gehasse 1995). However, most material from the relevant layer dates to 4400–4100 B.C. (cf. Brinkkemper et al. 1999) and

in addition dating of food encrustation on pottery may have produced dates that are too early due to the possible presence of fish remains (reservoir effect; Ten Ancher personal communication). It is therefore assumed that the cereal finds of P14 are no older than 4400 B.C. Representative data on absence of crop plants in this region are available only from the site Hoge Vaart, located in the southwestern fringe of the northern region and used until ca. 4100 B.C. At this site active search for cereals and analysis of at least 44 samples resulted in strong indications of the absence of cereals, which on the one hand can be related to initial unavailability of crop plants and on the other hand to site function (Brinkkemper et al. 1999).

In the southern region there is again evidence for the regular presence of emmer wheat and naked barley. The combined evidence from Hardinxveld, Brandwijk-Kerkhof

and Hazendonk indicates that cereals were absent before 4370 B.C. and were introduced from 4220 to 3940 B.C. onwards, or perhaps even earlier (Out 2008). Interestingly, some other crop plants are known from this region as well. Waterlogged seeds of opium poppy (*Papaver somniferum* ssp. *setigerum*) were found at the Swifterbant site Brandwijk-Kerkhof (Out 2008). Finds of opium poppy are known from three other Neolithic locations, but these are not dated precisely. Five carbonised peas (*Pisum sativum*) were found at the Hazendonk site Barendrecht 20.125 (Brinkkemper in Meirsmann and Moree 2006), and represent the first Dutch find of peas younger than those from the Michelsberg Culture and older than the Iron Age (Bakels 2003; Dutch archaeobotanical database RADAR 2005). The uniqueness of the find may, however, be not related to introduction but to the small chances of carbonisation of peas during crop processing and food preparation and poor preservation in waterlogged state. The assemblages from both Brandwijk and Barendrecht 20.126 contained a few grains of einkorn-type. The single grain from Brandwijk is interpreted as emmer wheat, while as yet the number of cereal grains from Barendrecht is too small to make a final conclusion. The large variety of crop plants in the southern region points to active exchange and to a developed stage of the neolithisation process in the south.

In the coastal region finds of emmer wheat and naked barley date to the period 3900–3350 B.C. It is not possible to reconstruct the precise moment of the arrival of cereals in this region since older sites are not known. At Ypenburg, a single seed was identified as cf. *Avena* sp., which is considered to represent *A. fatua* that functioned as a weed in cereal fields (van Haaster 2001).

At the Belgian Swifterbant site Doel Deurganckdokssector B there is a find of a single grain of bread wheat/macaroni wheat (*Triticum aestivum/durum*), interpreted as bread wheat (Bastiaens et al. 2005). At present the paucity of published archaeological data from the site and lack of other contemporaneous finds from this Belgian region hinders discussion of the significance of the species, the period of introduction and local crop cultivation (though see Crombé and Vanmontfort 2007).

Local crop cultivation has been investigated by analysis of both botanical and non-botanical site characteristics, such as cereal remains, potential arable weeds, indications of deforestation, querns, sickles, tillage marks and site function (Table 2). The evidence for the category of potential arable weeds includes both pollen and seeds. The degree of deforestation is based on information from pollen diagrams. The available pollen diagrams are used only to investigate presence of deforestation and cannot be used to conclude absence of deforestation, since deforestation may be invisible in pollen diagrams for various reasons. True absence of sickles and tillage marks is not always

**Table 2** Evidence for local crop cultivation for the northern, southern and coastal region

	North	South	Coast
Cereal grains	+	+	+
Cereal chaff	+	+	+
Cereal pollen	+	+	+
Potential arable weeds	+	+	+
Dominance of salt-tolerant crops	+/-	-	+/-
Deforestation	-	+	-
Querns	+	+	+
Sickles (cereal cutting tools)	-	-	+
Tillage marks	?	-	-
Site function	1?	1,2,?	1,?

+ = present, - = no indications of presence, +/- = present at some sites in the regions or during some phases, ? = debatable/unpublished finds. Site function: 1 = base camps, 1? = base camps?, 2 = extraction camps, ? = unknown

demonstrated since some excavation and research programs did not include such analysis.

## Discussion

Comparison with the broader range of crop plants of relevant Neolithic cultures (Bakels 2003) shows that only a selection of available crop plants was introduced in the Dutch wetlands. The main crop plants at Dutch wetland sites of the Swifterbant Culture and Hazendonk Group are emmer wheat (*T. dicoccon*) and six-rowed naked barley (*H. vulgare* var. *nudum*), usually occurring together. This corresponds with other Northwest European Neolithic sites outside the loess area, where emmer and barley were the main crops of a relatively small crop spectrum as well. The importance of einkorn in the northern Netherlands remains to be assessed. Only in the southern region are opium poppy and pea present as well, possibly indicative of active exchange processes with southern groups.

The best data on the moment of introduction are available from the southern region, indicating absence of cereals until 4370 B.C., despite the presence of fully Neolithic communities in the regions to the south and east of the Netherlands from 5300 B.C. onwards. The data for this region thus show delayed introduction of crop plants (cf. Brinkkemper et al. 1999). The available data support the introduction of cereals after 4400/4300 B.C. at the earliest in other regions as well, although precise data on the moment of introduction are less well known. Both the chronology and archaeological remains indicate that the Michelsberg Culture played an important role in the introduction of crop plants in the southern region (Out 2008; Raemaekers 1999), and archaeological finds suggest

the same for the coastal region (Louwe Kooijmans 2007). For the northern region especially, the period and the instigators of the introduction of crop plants remain poorly known.

As discussed already, the crop assemblages of the Michelsberg Culture and the Swifterbant Culture show some differences, especially in respect of naked wheat (*Triticum durum/turgidum*). These differences may be related to differences in environmental conditions, cultivation practices and/or possibly cultural/ideological preferences. The shift may be better understood when more knowledge is available on the character and cultivation practices of communities living in the sandy upland regions, who form a missing link in the reconstruction of introduction of crop plants into the wetland regions.

## Local crop cultivation

### Botanical finds

In all three regions there are finds of cereal seeds, chaff and pollen, as well as seeds and pollen of potential arable weeds. Chaff of naked barley is found at all late fifth millennium and later sites where cereal macroremains were present, where preservation of organic material was good and where research methods focused on retrieval of small botanical macroremains, suggesting it was present at all comparable sites. This indicates either that cereals were cultivated locally at all these sites or that the chaff of naked barley should play a less important role in discussion of local crop cultivation (see “[Introduction](#)” and below). The botanical finds thus at least indicate the consumption of cereals, and may indicate cultivation. However, the finds of macroremains do not necessarily demonstrate local cultivation since the presence of cereal grains and chaff remains of both emmer wheat and naked barley can be explained by transport while still on the ear, partly for protection against fungi (Bakels 2000). Although transport on the ear seems uneconomic considering the volume, the harvesting of naked barley before final ripening and its storage on the ear could have been favoured for prevention of loss of grains during harvest and for optimal ripening (Cappers 2006, pp. 435–436). The presence of pollen can be explained both by importation of cereals on the ear and/or the presence of fields, since most cereal pollen is released during threshing rather than during flowering (Robinson and Hubbard 1977). The presence of potential arable weeds has no meaning since these taxa may just represent local disturbance indicators. Many potential arable weeds were indeed present before introduction of crop plants (e.g. Bakels and van Beurden 2001; Bakels et al. 2001).

Interestingly, the ratio of emmer wheat to naked barley can be used to obtain information on local cultivation. At Swifterbant-S3 in the northern region, where minor marine influxes were occasionally present, naked barley dominates over emmer wheat (van Zeist and Palfenier-Vegter 1981). This suggests that crops were cultivated locally in the exploitation area of Swifterbant since naked barley tolerates marine conditions better than emmer wheat (Bottema et al. 1982, p. 139). At the other sites in this region the numbers of cereal grains are too small for representative ratio calculation. Interestingly, at a single site in the coastal region, Schipluiden, a shift from a brackish environment to a fresh-water environment corresponds with a shift from naked barley to emmer wheat (Kubiak-Martens 2006, p. 324). Similarly to the northern region, this dominance of naked barley during brackish conditions supports the idea of local cultivation. The ratio of emmer wheat and naked barley seems equal at two other coastal sites where the number of cereal grains allows analysis, which can be explained by local dominance of fresh-water conditions for at least one of the sites (Raemaekers et al. 1997). In the southern region, where marine influence is absent, emmer wheat is dominant, which does not per se prove local crop cultivation for this region, but which nevertheless demonstrates that naked barley was not automatically the dominant crop in all regions.

### Deforestation

Only the pollen diagrams of Brandwijk and Hazendonk in the southern region show small-scale deforestation, which may be indicative of garden-like cultivation. For the northern region there are no indications of deforestation, but this has limited meaning since relevant pollen diagrams with small sample intervals are scarce. For the coastal region there are no indications of deforestation either, but this can be related to the natural vegetation of the dunes, consisting of open dune shrub vegetation. These shrubs produce only sparse pollen, reducing the possibility of detecting the presence of vegetation and occurrence of deforestation. The absence of indications of deforestation in the northern and coastal regions does not therefore support or reject the local presence of small arable fields.

### Querns and sickles

Querns have been found in all regions, but these only indicate consumption. Sickles (flint artefacts with cereal gloss in a longitudinal direction caused by cereal cutting) until now have only been found in the coastal region (van Gijn et al. 2006). The flint assemblages from Brandwijk and Hazendonk in the southern region did not include similar artefacts, although use-wear analysis of the flint

from the Hazendonk does not exclude their presence either (van Gijn personal communication). In the northern region, there are no indications of the presence of sickles (van Gijn personal communication), although not all flint excavated has been investigated. The presence of sickles in the coastal region is a strong argument in support of local crop cultivation there. The absence of similar sickles in the other regions has limited significance, since people may have harvested their crops in ways other than by using sickles. In the Michelsberg Culture sickles are also scarce (Schreurs 2005, p. 308). If crop cultivation on Dutch wetlands was indeed introduced by the Michelsberg Culture, the cultivation methods and tool set of this culture may explain the absence of sickles at Swifterbant sites. The method of crop harvesting used in the Michelsberg Culture and Swifterbant Culture is poorly understood.

#### Ard marks

It was suggested that ard marks dating to the Swifterbant occupation phase were found at Urk-E4, which would represent the oldest ard marks in the Netherlands if not in northern Europe. These are questionable since the published features are not comparable to ard marks as known from the Funnel Beaker Culture and since the ard had presumably not been introduced in the Netherlands by the period concerned (Louwe Kooijmans 2006). It is actually unknown what kind of tillage marks to expect at sites of the Swifterbant Culture and Hazendonk Group since it is not known how these people prepared the soil for crop cultivation. This complicates the distinction between arable plots and general disturbance and reworking of the soil due to human activities. Relevant features showing traces of systematic soil digging have been excavated at Swifterbant-S4 in 2007 (Raemaekers, University of Groningen, personal communication), but these have not yet been published.

#### Site function

Site function gives additional indirect information on the possibilities for local crop cultivation. The function of sites in the northern region is poorly known due to the presence of palimpsests and the scarcity of organic material, but a function as base camp is suggested for several sites (Gehasse 1995; Peters and Peeters 2001; Raemaekers 1999). This site function is compatible with local crop cultivation. In the coastal region at least some sites also functioned as year-round occupied settlements (Louwe Kooijmans 2007). The Neolithic sites in the southern region probably functioned as extraction camps occupied repeatedly during various seasons, but the precise site function remains unclear (Louwe Kooijmans 2007), as do the resulting possibilities for crop cultivation.

#### Conclusions

Neolithisation of Dutch wetlands in ca. 4300 B.C. under the influence of the Michelsberg Culture resulted in the introduction of emmer wheat and naked barley as the main crops. Only in the south were some additional crops also introduced. For the northern and the coastal regions, it is necessary to collect more data to reconstruct the introduction process of crop plants. Furthermore, the precise process of crop plant introduction (just) before/at 4300 B.C. remains poorly understood.

The results allow conclusions on local cultivation in all regions despite the environmental conditions, although for each region a different type of evidence gives the decisive argument. For the northern region, the dominance of naked barley in relation to minor marine influence in the environment indicates local crop cultivation for at least one site. For the coastal region, the shift from naked barley to emmer in relation to environmental change, the finds of sickles and the site function strongly support local crop cultivation. For the southern region, the deforestation signal in the pollen diagrams suggests that crop plants may have been obtained by small-scale crop cultivation in the exploitation area (possibly on a scale of several square metres), while importation of cereals from the southern sandy soils remains an alternative. The positive indications for local crop cultivation in several Dutch wetland regions indicate that the presence of crop plants at sites of the Swifterbant Culture and the Hazendonk Group was the result of incorporation of cultivation in the subsistence from ca. 4300 B.C. onwards, and not just the result of frequent exchange with fully agrarian societies.

The difficulty in demonstrating local crop cultivation and the possibility of importation of cereals from elsewhere into marginal areas may also be relevant for other Middle Neolithic sites in Northwest Europe. Exchange of crop products could furthermore have been part of the very early stage of introduction of crop plants as part of initial neolithisation everywhere in Northwest Europe outside the loess area. There are two examples of comparable discussions. Firstly, availability of crop plants at the Swifterbant/Funnel Beaker site Hüde I is attested by scarce impressions of einkorn(-type) and barley. However, local cultivation is rejected because of environmental conditions and site function (Kampffmeyer 1991, p. 312). Reinvestigation of the relevant evidence may shed new light on this conclusion. Secondly, Richmond (1999, p. 34) rejects local cultivation during the Early Neolithic in Great Britain and suggests importation from other regions or from abroad instead. This argument seems to be strongly based on a post-processual interpretation that presumes a symbolic role of crop plants, while the archaeobotanical evidence shows that crop plants can also be explained as a common component of daily

subsistence (Jones and Rowley-Conwy 2007). The author is not acquainted with other discussions based on similar evidence as obtained from the studied wetland sites. Usually investigators consider the suitability of the environment for local cultivation as less problematic, or arid marks support local cultivation (Tegtmeier 1993; Thrane 1989).

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