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REVIEW

Changes in cereal cultivation during the Iron Age in southern Sweden: a compilation and interpretation of the archaeobotanical material

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Abstract Macrofossil data from 73 sites dating to the south Swedish Iron Age (500 B.C.–A.D. 1100) have been compiled and analyzed in order to elucidate long term changes in cereal cultivation. The analyses indicate that "permanent field" agriculture was established at the end of the Bronze Age utilizing *Hordeum vulgare* var *vulgare* as a primary crop and *Triticum aestivum* ssp *vulgare/compactum, Triticum spelta/dicoccum/monococcum*, *Avena sativa* and *Secale cereale* as secondary crops. An observed change towards the end of Roman Iron Age (1–A.D. 400) is the expansion of *Secale cereale* and *Avena sativa* cultivation. Evidence also suggests that winter sowing of the former commenced at the latest during the eighth, ninth and tenth centuries A.D. The introduction of winter sowing possibly coincided with the establishment of crop rotation agriculture. During most of the Iron Age southern Sweden displays significant regional variations with regards to cereal cultivation practice. There is however evidence that a more homogenous agriculture appeared across the investigated area from the beginning of the Viking Age (A.D. 800–1100) onwards.

Keywords Southern Sweden · Iron Age · Cereal cultivation · Regional compilation · Plant macrofossil material

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Introduction

During the last decades the amount of investigated archaeobotanical material in Sweden has expanded significantly, creating a situation where for individual researchers the large amounts of data are becoming increasingly difficult to survey. This situation is primarily due to a lack of attempts to summarize and compile the results of archaeobotanical investigations into comprehensive formats. Currently archaeobotanical data can only be accessed through a small selection of published articles and, more problematically, a very large collection of internal documents, appendices to excavation reports and other forms of "grey" literature. This makes the process of relating one's own research to a wider regional context difficult and time consuming.

The main purpose of this article is therefore to contribute toward a better foundation for continued archaeobotanical research by compiling a selection of relevant materials from the counties of Skåne, Halland, Småland, Blekinge and Öland (Fig. 3) in one condensed publication. The secondary objective is to provide a platform for comparing the general developments in cereal agriculture in Sweden and Denmark, respectively.

These aims are pursued by attempting to answer three primary questions:

1. Does the selection of cultivated crops or the organization of agricultural practice (such as can be

identified using archaeobotanical material as a proxy) change over the course of the Iron Age?

2. How does the investigated material compare internally within the investigated area? Are there regional variations or is southern Sweden an agriculturally homogenous entity during the Iron Age?
3. How do the results from southern Sweden compare to those from nearby Denmark?

The PhD project of which this article is a part is carried out in close corroboration with *The Strategic Environmental Archaeology Database* (SEAD), currently being developed at the Environmental Archaeology Laboratory at Umeå University in Sweden. The SEAD project aims at creating an easily accessible, internet based, database which will include empirical data from a large number of archaeological and quaternary geological sites, including archaeobotanical data from investigations performed by the Environmental Archaeology Laboratory in Umeå (Buckland et al. 2010).

The development of cereal agriculture in southern Scandinavia as documented by earlier research

Sweden

Archaeobotany as a discipline involved with the study of past societies through the evidence stored in material culture is, in Denmark and Sweden, over a century old (Robinson 1994a; Viklund 2004). Although early archaeobotany in these two countries developed in close connection with each other, Swedish archaeobotany is currently lagging behind its Danish counterpart in attempts to compile, organize and summarize significant finds from recent investigations. Publications from Denmark are both better updated with regards to recent finds, and generally cover larger quantities of investigated material (e.g. Robinson 1994a, b; Robinson et al. 2009).

Early Swedish attempts at compiling existing archaeobotanical material in summary publications include the works of Hjelmqvist (1955, 1960, 1979), primarily presenting materials from Skåne, and summaries of finds from the Baltic islands of Öland and Gotland by Helbæk (1955, 1966, 1973, 1979).

More recent compilations from Skåne include Roger Engelmark's (1992) article covering the archaeobotany of the Ystad project (a major interdisciplinary, vegetation historical project involving the disciplines of quaternary geology, palaeoecology, plant ecology and prehistoric as well as medieval archaeology. Berglund 1991; Larsson et al. 1992), Gustafsson's (1995) work on material from the Malmö area, primarily the Fosie IV site, and Regnell's (2002) compilation of twelve sites excavated during the 1990s by UV Syd (The southern office of the Swedish National Heritage Board—*Riksantikvarieämbetet*).

The remaining counties within the investigation area are much more sparsely covered by archaeobotanical publications in general and regional compilations in particular. Viklund has however, in a series of publications (Ängeby and Viklund 2000; Viklund 1998, 2003a, b, 2004, 2005) presented several recent and significant finds from the county of Halland. Together with a publication by Regnell (1993) these sources have greatly extended our knowledge of prehistoric agriculture in south-western Sweden.

Öland has been the subject of limited archaeobotanical investigations and publications, initially, (as mentioned above) by Helbæk (1966, 1979), and more recently by Hansson (Hansson et al. 1993; Hansson and Bergström 2008). In nearby eastern Småland, on the opposite side of the Kalmar strait, Engelmark has conducted and published investigations of prehistoric archaeobotanical material obtained in connection with the E22 road development project (Engelmark and Olofsson 2001). The rest of Småland is essentially unpublished in formats that can be compared with the other counties. Limited investigations have taken place in areas with fields of stone clearance cairns (Torsensdotter-Åhlin et al. 2002, p. 7f), but these investigations have produced little carbonized material that can be used for studies of cereal cultivation development.

Blekinge has not been subject to any archaeobotanical investigations relevant to the survey presented in this article.

All of the abovementioned publications and compilations have allowed for the establishment of chronological models of the developments in cereal cultivation in prehistoric southern Sweden. Already during the 1950s Hjelmqvist could postulate a hypothetical chronological overview of the introduction and succession of various crops in the region. Interestingly, and despite being based on rather limited material which primarily consisted of pottery imprints, the essential parts of his chronology have over the decades remained largely intact, subject mainly to minor adjustments and elaboration of details by more recent research (e.g. Engelmark 1992; Regnell 2002; Viklund 1998).

Cereal agriculture appeared in southern Scandinavia during the early Neolithic, seemingly corresponding with the first appearances of Funnel Beaker-culture remains, dating to 3900–3800 B.C. (Welinder 2004; all B.C. /A.D. dates refer to calibrated calendar years, all B.P. dates to uncalibrated ^{14}C-dates). During the initial period two species of hulled wheat—emmer (*Triticum dicoccum*) and to a lesser degree einkorn (*Triticum monococcum*)—as well as naked barley (*Hordeum vulgare* var *nudum*) dominated the cereal agriculture. A third species of hulled wheat, namely spelt

(*Triticum spelta*), was introduced during the late Neolithic, the first occurrences dating to approximately 2200 B.C. (Engelmark and Viklund 2008).

During the following period, the Early Bronze Age (ca. 1800–1100 B.C.), several new crops were introduced but not all were adopted to the same degree. Spelt, emmer and naked barley remained as the dominating crops but there also seems to have been significant ongoing "experimentation" with crops such as broomcorn millet (*Panicum miliaceum*) and gold-of-pleasure (*Camelina sativa*), cultivars which turned out to be passing occurrences in south Swedish agriculture, as well as hulled barley (*Hordeum vulgare* var *vulgare*) which eventually became a staple crop (Welinder 2004).

During the second half of the Bronze Age the variety of cultivated species was reduced significantly as southern Sweden experienced the introduction of a new type of agriculture based on the use of permanent fields. The introduction of this type of agriculture appears to have been completely accomplished by the time of the shift from later Bronze Age- to Pre-Roman Iron Age. A significant increase in nitrophilous weeds such as goosefoot (*Chenopodium* spp) and common chickweed (*Stellaria media*) in the archaeobotanical material from this period indicates that agriculture on these fields was sustained through intensive use of manure (Engelmark 1992, 1993; Gustafsson 1995).

In this new agriculture hulled barley became the primary crop. It is somewhat unclear why this particular barley variation was selected as the primary crop. Traditionally, models focusing on hulled barley's tolerance to climatic deterioration have been dominant in the archaeobotanical debate (Helbæk 1957; Hjelmqvist 1955, 1979). However these have over the last decades been complemented by explanations taking into account the favourable response of this crop to manuring, its suitability as animal fodder and its lower loss of grains when harvested with forceful techniques utilizing metal sickles (Engelmark 1992; Gustafsson 1995).

During early Iron Age two new crops emerge in the archaeobotanical assemblages, flax (*Linum usitatissimum*) during Pre-Roman Iron Age and rye (*Secale cereale*) during Roman Iron Age. Neither of these crops is directly suitable for cultivation within the agricultural system described above. Flax is highly sensitive to even moderate competition from weeds, and rye, being hardier and significantly less dependent on high nutritional content in the soil than hulled barley, would probably not have been the first choice of crop for cultivation on intensively manured fields. Engelmark argues, however, that the two species could have nonetheless been incorporated within the permanent field system by growing flax on newly cleared fields and rye on fields that were about to be put to fallow. The rye in this case would grow off the nutrients left over from the previous season's barley cultivation (Engelmark 1992).

During the latter centuries of the Iron Age cereal cultivation in southern Sweden changed once more. Hulled barley remained a principal component, but rye and oats (*Avena sativa*) also became increasingly important during this period. In Skåne in particular the appearance of rye in larger quantities appears to correspond with the first significant finds of winter annual weeds such as corn cockle (*Agrostemma githago*) (Engelmark 1985, 1992). Engelmark interpreted this to indicate the establishment of a two or three field rotation for crop agriculture (possibly winter rye, spring barley and fallow), similar to that which became the most common praxis of cereal production during the Medieval Period throughout most of southern Scandinavia (Engelmark 1992; Pedersen and Widgren 2004). The exact time at which rotation agriculture was established in the area is still an unresolved issue. The introduction of winter rye is also an issue of debate. Engelmark (1992) and Regnell (2002) have both stated that an indication of an established crop rotation which includes winter rye and barley is the occurrence of these two species in equal quantities in the archaeobotanical assemblages. As seen in the material from the Ystad project (Fig. 1) this does not occur until the Viking Age, indicating an establishment some time after 800 A.D. However, there was no material dating to the Migration Period in the samples from the Ystad project, and the Vendel Period was very sparsely represented, making such a conclusion perilous because of the lack of material from interpretatively critical periods preceding the Viking Age.

The general changes in cereal agriculture during the Iron Age seem to happen across the entire investigation area but there are also variations.

The most significant of these appears to be the higher than average occurrence of oats throughout the Iron Age, in archaeobotanical material from Halland (Viklund 2004). The possible causes for this are elaborated upon in the discussion section of this article.

The studies presented above clearly show that, over the last century, archaeobotany in Sweden has been able to present many aspects of prehistoric agriculture and that it remains an archaeological discipline with good potential to enhance our understanding of some of the most important aspects of past societies, particularly issues relating to the nature of the local subsistence economies. To continue this trend however archaeobotanists need to work consciously towards easily accessible and comprehensive presentations of their data.

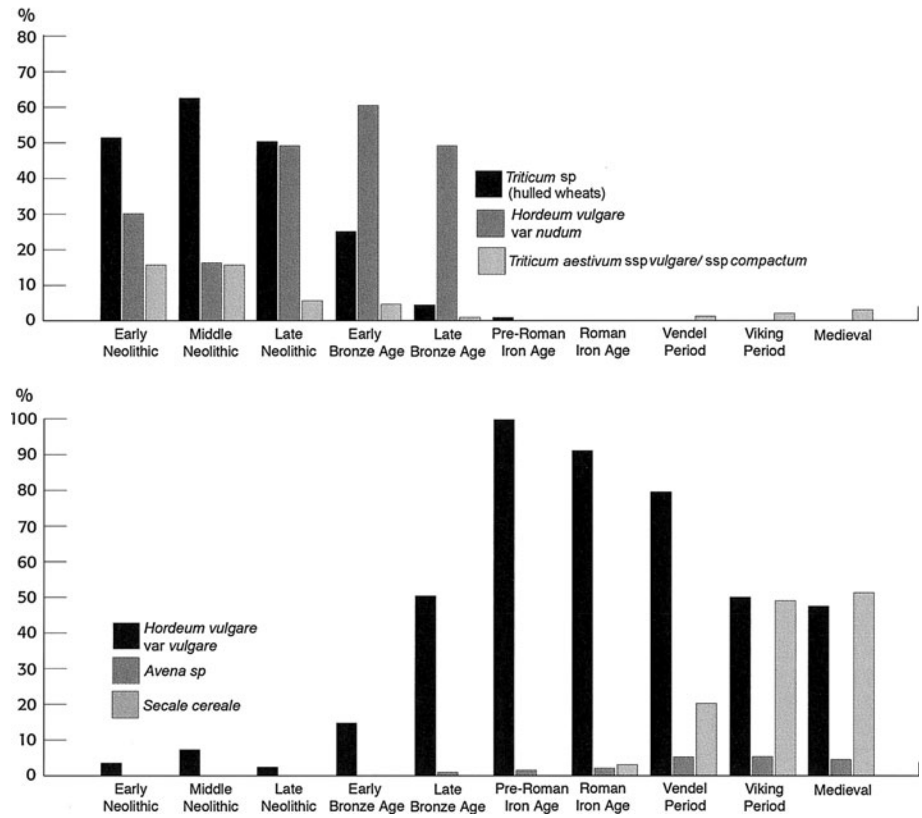

Fig. 1 Engelmark's (1992) summary of the archaeobotanical material from southernmost Skåne (including material from the Ystad project). The material is presented as percentages of the total amount of identified grains. Modified from Regnell (2002)

Denmark

As previously mentioned, the history of archaeobotany is just as old in Denmark as it is in Sweden, dating back to the last decades of the 19th century. Since then several compilations of Danish archaeobotanical materials have been published, beginning with Gudmund Hatt's (1937) *Landbrug i Danmarks Oldtid*. An informative list of the earlier Danish compilations can be found in Robinson's (1994a) article *Dyrkede planter fra Danmarks forhistorie*.

The general knowledge of cereal development during the Iron Age in the Danish area is comparatively up to date due to the publication of a recent article compiling a total of 74 significant assemblages analyzed prior to 2000 (Robinson et al. 2009).

At a very general level the Danish material appears to reflect a development similar to that of southern Sweden. The material from eastern Denmark (Sjælland and Fyn) is somewhat sparse but seems to correspond to that found in Skåne. The Jylland area on the other hand displays several important differences (Regnell 2002; Robinson et al. 2009), the most important being:

1. Longer retention of naked barley, which in Sweden is phased out towards the end of the Bronze Age while remaining in use in Jylland until the early centuries of Roman Iron Age.
2. Presence (cultivation?) of oats is more common in Denmark throughout the entire Iron Age (although, as Viklund has shown, Halland may be an exception, Ängeby and Viklund 2000; Viklund 2003a, b, 2004, 2005).
3. Cultivation of rye commences earlier and more intensively in Denmark. This crop already appears to be a fundamental component of the local agriculture from Roman Iron Age onwards while it does not achieve the same status in most Swedish assemblages until the early Viking Age (Regnell 2002)—the settlement of Vallhagar on Gotland being the most notable exception (Helbæk 1955).

The level and complexity of discussion concerning the cultivation of rye has been more developed in Denmark than Sweden, owing initially to Helbæk's (e.g. 1957, 1958, 1971, 1977) pioneer works on rye cultivation, and more recently to Mikkelsen and Nørbach's (2003) research on material from iron smelting furnaces from southern Jylland. These archaeological features, originally partially packed with unthreshed straw uprooted from cereal fields, have provided a unique proxy source for the study and comparison of unprocessed material from individual fields representing single cultivation seasons.

Mikkelsen's investigations have shown that the weed composition in barley versus rye fields varies considerably

(Mikkelsen and Nørbach 2003, p. 185ff). Speculating that the weed flora would remain more or less intact in spring rye cultivation on fields previously used for barley, the significant variation in weed composition is interpreted by Mikkelsen as possible evidence for winter rye cultivation. The absence of "typical" winter rye weeds such as corn cockle and cornflower (*Centaurea cyanus*) is explained by a hypothesis that these species, which are not native to southern Scandinavia, should not necessarily be classified as indicators for the beginning of local winter rye cultivation, but rather as indicators for the beginning of rye import from the Baltic area, a trade most probably commencing in the Baltic Sea/North Sea region during the Viking Age and developing fully during the Medieval Period (Hjelle 2007). To support this hypothesis Mikkelsen refers to investigations of the large rye find from Fyrkat, which Helbæk (1977) interpreted as imported because of the considerably larger grain size compared to other contemporary Danish finds. In the find, consisting of tens of thousands of cereal grains, only 280 weeds were identified. The purity of the find has been interpreted by both Helbæk (1977) and Robinson (1991) as an indication that the find represents a bulk import of highly processed, high quality grain. The weed species further support this interpretation since the 280 identified seeds contained no less than 19 "exotic" taxa not previously known in Denmark.

Thus Mikkelsen suggests that winter rye cultivation commenced in Denmark during the later Roman Iron Age and was, at first, limited to cultivation of rye that had previously migrated to Denmark as a weed. This initial winter rye cultivation did prompt a transformation of the weed flora, but the initial changes did not lead to an appearance of new species, or the disappearance of old ones, but rather significantly changed relations between the species already existing within the agricultural flora. Some weeds, such as perennial ryegrass (*Lolium perenne*), sheep's sorrel (*Rumex acetosella*) and knotgrass (*Polygonum aviculare*)—the majority of which are spring germinating—coped with the new conditions better than others and became more numerous. However, the import of rye from eastern Europe brought with it species more adapted to winter rye cultivation and this, together with the effects of the mouldboard plough, introduced around the same time, meant that these local species were unable to compete and the weed flora that was to become typical of winter rye cultivation in historical times was established (Mikkelsen and Nørbach 2003, p. 217ff).

The archaeobotanical research in both Sweden and Denmark has shown that the shift from permanent field cultivation to an agricultural system incorporating field rotation techniques and cultivation of winter rye probably was a very complex process that will require considerable attention from future archaeobotanical research before reasonably secure interpretations can be arrived at for the greater south Scandinavian area.

Materials and methods

The layout of the study presented in this article has been modelled after Robinson et al. 2009. The reasons for using the principles outlined in that particular publication were twofold. The primary factor was comparability, while the second was the fact that Robinson, Mikkelsen and Malmros present a workable approach to the problem of assessing the importance of various cultivated crops over time despite the comparability issues inherent in most archaeobotanical material due to its complex taphonomy, formation processes and highly variable initial composition.

During the material gathering process a large number of reports from archaeobotanical investigations were assessed. Many of these have been left out of the compilation due to one or more of three governing principles; chronological control, quantity of individual plant remains per assemblage and interpretative potential. The first two of these factors are purely quantitative while the third required a qualitative assessment.

Attempting to keep a balance between the desire for high chronological resolution against both the availability of individual finds from the various periods of the Iron Age and the "bluntness" of the common dating methods all material has been sorted into one of five chronological periods (Fig. 2).

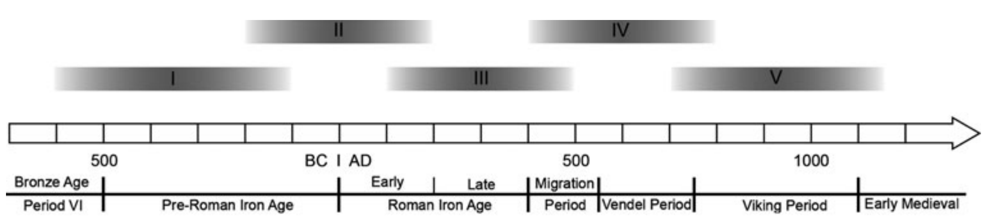

Fig. 2 The chronological categorization used in the study (*top*) related to calendar years (*middle*) and the established south Swedish Iron Age chronology (*bottom*)

Period I covers the end of late Bronze Age and the beginning and first centuries of Pre Roman Iron Age (c 600 B.C.–100 B.C.). *Period II* covers the transition from Pre-Roman to Roman Iron Age (c 200 B.C.–A.D. 200), *Period III* the latter part of Roman Iron Age (c A.D. 100–A.D. 500), *Period IV* the Migration and Vendel Periods (c A.D. 400–A.D. 800) and *Period V* the Viking Age and the very beginning of the Medieval Period (c A.D. 700–A.D. 1100).

Finds from a total of 72 sites have been used as empirical material. Several sites contained finds dating to more than one period resulting in a total of 97 individual units, henceforth referred to as *site assemblages*.

For a site assemblage to be assigned to one of the chronological periods it required a dating that was reasonably secure, directly applicable to the actual find and free of potential disturbances. Well dated sites with a short settlement continuity could on some occasions be dated in their entirety, even if some archaeobotanical material was derived from features that were only connected to dated ones by spatial and/or typological association.

On sites with longer settlement continuity stricter rules were applied. Most of the investigated finds derived from house remains and associated pits, hearths and other deposits related to "daily" activities. On sites dating to several periods, or where the inter-feature associations were uncertain, only the material from the chronologically secure contexts was used while undated features were discarded. Overlapping features, dating to two or more periods, were also disqualified because of the significant risk of contamination due to re-deposition of archaobotanical remains.

Discussions concerning acceptable minimum quantities of botanical remains per find for interpretation of pre-historic agricultural systems appear in most existing south Scandinavian regional compilations (e.g. Engelmark 1992; Regnell 2002; Robinson 1994a; Robinson et al. 2009). Robinson et al. (2009) argue in their publication for a minimum of 400 remains per assemblage as a statistically secure minimum. Unable to achieve this quantity without excluding a large amount of available Danish assemblages the minimum quantity used in that publication is a compromise of 50 remains per assemblage. In Sweden Regnell (2002) used a minimum of 25 cereal remains per site in order to balance the representativity of each find against geographic coverage. Engelmark's compilation from the Ystad project used all available remains in order to create a chronological and interpretative model with no lower minimum. The latter investigation does however also cover a comparatively smaller area than the former two, significantly reducing the risk of small assemblages, with uncertain representativity, being misinterpreted as regional variations.

The issues inherent in establishing an acceptable minimum size for the inclusion of an archaeobotanical assemblage in a regional compilation will however always be problematic, potentially in need of revision and adjustment by numerous exceptions. A storage assemblage consisting of several hundred thousand individual remains, for example, will usually provide secure evidence about the single harvest that produced the find. It will however provide considerably less information about the overall composition of the local agriculture than a "randomly" accumulated deposit in the postholes of a house, a type of deposit that represents "average drop off" from activities that are ongoing for several years or even decades. Large assemblages may also, if they are insufficiently dated, provide less relevant information about cereal cultivation development in an area than a single well dated remain.

The lower limit for including a find in this compilation was set as 25 cultivated plant remains per assemblage. The number was decided upon in order to balance the representativity of the individual finds against regional coverage.

The minimum used in this compilation is lower than that of the Danish compilation (Robinson et al. 2009) on which the study is modelled. This particular quality is however likely to be partially countered by the higher inter-assemblage comparability of the Swedish material. The Danish compilation includes finds of carbonized plant remains—distributed among storage deposits, straw packing in iron smelting furnaces and randomly accumulated settlement deposits—as well as pottery imprints, waterlogged deposits and stomach/gut contents of bog bodies. The Swedish material is, in comparison, relatively homogeneous. All material used in this study is carbonized and the material is also comparatively uniform, consisting mainly of "randomly" accumulated settlement deposits (posthole-finds, hearths, activity layers, rubbish pits and wells).

All finds were also, prior to inclusion in the study, assessed qualitatively. Several finds with numerous botanical remains were disqualified due to poor documentation, insecure dating background or insufficiently precise identification of the plant remains.

Once the available material was sorted according to the principles outlined above each site assemblage was assessed individually and each cultivated crop species was assigned a value corresponding to its interpreted importance in relation to the entire site assemblage. It should be noted that this approach to quantification is qualitative and interpretative. It is more dependent on the overall composition and make up of each site assemblage than specific percentages which often bias the material more than the subjectivity of an experienced archaeobotanist. The evaluation was made according to a five-graded scale that is unmodified from Robinson et al. (2009):

1 = single occurrence within the site assemblage
2 = few remains
3 = relatively numerous remains
4 = the remains are part of one of the main components
5 = the remains dominate the assemblage.

This form of qualitatively-interpretative categorization has its drawbacks as taxa with low occurrence will possibly tend to have a higher impact than if a site assemblage was analysed using raw counts. The approach may also be considered to be subjective.

The complexities of archaeobotanical formation processes, taphonomy, sampling strategies, extraction methods, identification issues etc. do however effectively negate the use of raw counts for site-scale compilations in any case. A solution may be to use individual samples rather than site-wide assemblages as the main unit during analysis but such an approach brings with it the same set of complex issues mentioned above, only in a different configuration.

By using quantification arrived at through qualitative interpretation however some of these issues can possibly be minimized and, in fact, it is the opinion of the author that most archaeobotanical deductions are in the end arrived at in this manner. When archaeobotanical results from a site are reported, the raw counts and the precise assemblage size is usually of secondary importance to the final interpretation, the primary one being the experience of the archaeobotanist in relating the material to previously performed analyses. Archaeobotanical data requires interpretation if it is to enhance our knowledge of past people and societies in any way. The method of quantification used in this study can thus be seen as a way of introducing conscious interpretation at an early stage in the investigative process.

A number of analyses presented in this article also include data on various species of arable weeds found in the site assemblages. Weeds are much more varied than cultivated crops in their environmental preferences, growth patterns and dispersal as well as preservation properties (Engelmark 1985). In this study no attempt was made to quantify their importance for the individual site assemblages and the documentation was limited to establishing presence or absence (Table 1).

Results and interpretation

The distribution of the 72 investigated sites is very uneven (Fig. 3). This situation is primarily the result of varying modern infrastructural development pressure in southern Sweden with a majority of sites belonging to one of three main clusters; one along the coast of Halland (the E6 motorway and West Coast Railway), one in the Malmö area (the Malmö City Tunnel and the Öresund bridge connections) and one around the town of Ystad (the Ystad project).

This situation makes regional comparisons difficult between areas other than Skåne (45 sites) and Halland (14 sites). Öland (including the Kalmar area) has produced a mere four sites and these are limited to periods III and IV. From Småland nine sites were investigated, with no sites dated to period I and only a single site from periods IV and V, respectively. Because of the uneven distribution of the available material severe limitations are put on the analyses and comparisons presented in this article. The discussion is therefore highly focused on the counties of Halland and Skåne. The Halland material, although covering the entire Iron Age, is considerably less than that of Skåne and should be interpreted carefully and critically.

Correspondence analyses were performed on the data quantified according to the principles outlined in the methodology section of the article. The first of these analyses was performed with the site assemblages categorized according to their region of origin. Using only cultivated crops in the analysis resulted in no distinguishable patterns. When both the cultivated crops and the accompanying arable weeds were used however (Fig. 4) a slight but distinguishable patterning could be identified, with samples from Halland and Skåne appearing as separate clusters (the patterning of site assemblages from the other areas being difficult to interpret due to the small amount of material).

A possible explanation for this difference might be the comparatively homogenous nature and small quantity of cultivated taxa, in contrast to the relatively large quantity of arable weed species, many of which are highly indicative of local soil conditions and agricultural techniques (Engelmark 1985). Including the latter proxy source in correspondence analyses may be a key to accessing variations in the material which mirror varying pre-existing natural conditions and agricultural practice.

In Fig. 5 another correspondence analysis is presented, showing the site assemblages from Skåne categorized according to chronology.

Danish analyses of this type have previously indicated significant differences in the composition of assemblages from early and late Iron Age, respectively (Robinson et al. 2009). Contrary to the Danish results however when this type of analysis was performed on the entire south Swedish material, it showed few distinguishable patterns.

As mentioned earlier though, the Danish material is primarily made up of finds from Jylland, thus meaning that the Swedish material, although dominated by finds from Skåne, is covering a much larger geographical area. It is

Table 1 Occurrence of cultivated crops in the investigated site assemblages, presented using the interpretative quantification described in the methodology section above

No	Site	Period	Area		*Avena* sp	*Camelina sativa*	*Hordeum vulgare* var *nudum*	*Hordeum vulgare* var *vulgare*	*Linum usitatissimum*	*Panicum miliaceum*	*Secale cereale*	*Triticum aest.* ssp *vulg./ssp comp.*	*Triticum dicoccum*	*Triticum monococcum*	*Triticum spelta*	*Triticum* sp (hulled wheats)	*Triticum* sp	*Pisum sativum*	*Vicia faba* var *minor*	Assemblage quantity	Total
8	Skrea 162	1	H	Hr			4	4								1				>25	
9	Skrea 177	1	H	H/Set	1			5	1							1				>100	
10	Stafsinge	1	H	H/Set	1		5	1		4							2	1		>100	
11	Skrea 194	1	H	H/Set	2			4				1				4				>400	
12	Landa	1	H	H/Set, Hr	4		4	4	1				4			4	1			>100	
13	Fjärås	1	H	H/Set	2		1	5	1								1			>400	
19	Fyllinge	1	H	H/Set		2	2	5	2				2							>100	
4	Petersborg 6	1	M	H/Set	4		1	4				2				4				>25	
18	Bunkeflo (ct, då2)	1	M	H/Set	1			5				2					2			>25	
27	Bageritomten	1	M	H/Set				5			1	1								>25	
29	Vintrieleden	1	M	H/Set				5				2				2				>100	
38	Tullstorp/Fortuna	1	M	H/Set				5				2								>25	
39	Södra Sallerup 15F	1	M	H/Set				5				3								>100	
40	Burlöv 20C	1	M	H/Set	2			5				2				2				>100	
41	Svågertorp 8B-C	1	M	H/Set	2		1	5		2						2				>25	
42	Svågertorp 8A	1	M	H/Set	2			5	1		2									>100	
43	Almhov (ct, då1)	1	M	H/Set		1	1	5	1							2				>25	
48	Vintrie	1	M	H/Set				4				3				3	3			>100	
53	Käglinge 5:24	1	M	H/Set		3		5	3			2								>400	
31	Lilla Köpinge	1	SK	H/Set, Hr				5								1				>400	
33	Norra Bellevue	1	SK	H/Set, Hr		1		5												>25	
34	Stora Herrestad 68	1	SK	H/Set, Hr				5												>25	
	Total				21	7	19	101	10	6	3	20	6	0	0	26	9	1	0		229
	% total				9.1	3.1	8.3	44.1	4.4	2.6	1.3	8.7	2.6	0	0	11.4	3.9	0.4	0		100
7	Tröinge	2	H	H/Set, Hr	5				1								1			>25	
19	Fyllinge	2	H	H/Set		1	4	4												>25	
4	Petersborg 6	2	M	H/Set	4	4		5	4			1			1					>400	
18	Bunkeflo (ct, då2)	2	M	H/Set	2			5	2			2				2				>25	
24	Lockarp 7B	2	M	H/Set	2	2	3	5			2	3				2	3			>100	
26	Lockarp 7D-E	2	M	H/Set	3	2		5	2			3				3				>400	
27	Bageritomten	2	M	H/Set	1	2	2	5	2	1	1	1				2	2			>400	
28	Hyllie station	2	M	H/Set				5												>100	
29	Vintrieleden	2	M	H/Set			2	5	2			3				2	2	2		>400	
37	Sunnanå 19A-F	2	M	H/Set				5			1					2		1		>100	
38	Tullstorp/Fortuna	2	M	H/Set				5				4					4			>25	
44	Lockarp (ct, då7)	2	M	H/Set				5				1					1			>25	
58	Nya Annetorpsvägen	2	M	H/Set	2	5		4	4			2		1		3				>400	
22	Klörup	2	SK	H/Set			1	4	1			3				1	1			>400	
54	Stora Herrestad 60	2	SK	H/Set, Hr	1			4				3	2		3	4				>100	
59	Lacklänga	2	SK	H/Set			3	3				2	1			4	1			>100	
71	Löddeköpinge 12	2	SK	H/Set	2		1	4		1	4	4	2			2	2			>400	
68	Ramlösagården	2	SK	H/Set		3		4				1								>25	
49	Åkarp- Rogberga	2	SM	H/Set				4				2								>25	
52	Gränna 339	2	SM	H/Set, Hr				4	4			2								>25	
55	Åkarp	2	SM	H/Set				4				2								>25	
	Total				22	19	16	89	22	2	8	39	5	1	4	27	17	3			274
	% total				8	6.9	5.8	32.5	8	0.7	2.9	14.2	1.8	0.4	1.5	9.9	6.2	1.1			100
3	Skrea 195	3	H	H/Set	4			4			3						1			>100	
6	Nydala	3	H	H/Set	3	4		4		1	1	1				3	2			>400	
9	Skrea 177	3	H	H/Set	3	1		4	1		4						1			>100	
1	Uppåkra	3	M	H/Set, Hr	2	2	2	5	2			2	2			2				>400	
18	Bunkeflo (ct, då2)	3	M	H/Set	2			5	1				1			2				>25	
26	Lockarp 7D-E	3	M	H/Set				5								2				>25	
27	Bageritomten	3	M	H/Set	1	2		5	1		1	1				2	1			>400	
28	Hyllie station	3	M	H/Set		1	3	5								3	3			>400	
29	Vintrieleden	3	M	H/Set				5				2				2	2			>100	
32	Fosie IV	3	M	H/Set	1	2	1	5			1	1								>400	

Table 1 continued

No	Site	Period	Area		*Avena* sp	*Camelina sativa*	*Hordeum vulgare* var *nudum*	*Hordeum vulgare* var *vulgare*	*Linum usitatissimum*	*Panicum miliaceum*	*Secale cereale*	*Triticum aest.* ssp *vulg.*/ssp *comp.*	*Triticum dicoccum*	*Triticum monococcum*	*Triticum spelta*	*Triticum* sp (hulled wheats)	*Triticum* sp	*Pisum sativum*	*Vicia faba* var *minor*	Assemblage quantity	Total
67	Lockarp (ct, då6)	3	M	H/Set	1	2		5				2								>100	
21	Möre- Gunnarstorp	3	Ö	H/Set	1	4		4	1		4		4							>400	
51	Skäftekärr	3	Ö	H/Set				5			1									>400	
63	Påarp	3	SK	H/Set	2			4				2	4			3				>400	
71	Löddeköpinge 12	3	SK	H/Set				4				4					1			>25	
56	Rökinge	3	SM	H/Set	1	4		4				1				1				>100	
57	Öggestorp	3	SM	H/Set		1		4				1								>25	
60	Hamneda 66	3	SM	H/Set				4			1	4								>100	
61	Hamneda 76-77	3	SM	H/Set, Hr				4			3	4								>100	
	Total				21	23	6	85	6	1	19	25	11	0	0	20	11	0	0		228
	% total				9.2	10.1	2.6	37.3	2.6	0.4	8.3	11	4.8	0	0	8.8	4.8	0	0		100
2	Elestorp	4	H	H/Set		4									4	3				>100	
14	Slöinge	4	H	H/Set	2			4			2						2	1		>400	
1	Uppåkra	4	M	H/Set	1		1	5			2		2							>400	
20	Fredriksberg 13D	4	M	H/Set	2			5			2	3								>100	
26	Lockarp 7D-E	4	M	H/Set	2			5			3									>25	
32	Fosie IV	4	M	H/Set		2	1	5			3	2								>400	
37	Sunnanå 19A-F	4	M	H/Set				5			3									>100	
42	Svågertorp 8A	4	M	H/Set	3		1	5			3	1					1	1		>400	
46	Skabersjö	4	M	H/Set, Hr	4	2		4			1	2								>25	
67	Lockarp (ct, då6)	4	M	H/Set	2			5				2								>100	
70	Hjärup	4	M	H/Set, Hr	2		1	4			2	3					1			>400	
5	Övra Wannborga	4	Ö	H/Set	1			5			1						1			>400	
69	Eketorp	4	Ö	H/Set	3	3		5	3		4	2								>400	
30	E6 6:1	4	SK	H/Set	2			5			3	3								>400	
71	Löddeköpinge 12	4	SK	H/Set				4				4	1				1			>100	
64	Växjö, kv Prefekten	4	SM	H/Set				4	1		1	4	1			1				>400	
	Total				24	11	4	70	4	0	30	26	4	0	4	4	6	2	0		189
	% total				12.7	5.8	2.1	37	2.1	0.7	15.9	13.8	2.1	0	2.1	2.1	3.2	1.1	0		100
15	Varla	5	H	H/Set	2			5			2									>100	
23	Ösarp	5	H	H/Set	4			4			1									>400	
17	Fosie by	5	M	H/Set	3			5	2		3	2					2			>100	
26	Lockarp 7D-E	5	M	H/Set				5			3									>25	
29	Vintrieleden	5	M	H/Set				5								1	2		1	>100	
36	Burlöv 20A	5	M	Hr				5				1					1			>400	
37	Sunnanå 19A-F	5	M	H/Set				5			3									>100	
45	Brågarp	5	M	H/Set	3		3	4									2			>25	
62	Kyrkheddige Bytomt	5	M	H/Set				4			1	3								>25	
66	Lockarps bytomt	5	M	H/Set	2	1		5	1		4						2	2		>25	
16	Kabusa	5	SK	H/Set, Hr	1			5			1									>100	
25	Västervång	5	SK	H/Set	2		2	4	2		4									>400	
30	E6 6:1	5	SK	H/Set	3			4	1		4	1	1							>400	
31	Lilla Köpinge	5	SK	H/Set, Hr	3			3			4	1								>400	
35	Mossby	5	SK	H/Set	2	2		5	2		2	2								>400	
50	Lilla Tvären	5	SK	H/Set	1			4			4								1	>25	
65	Stora Köpinge	5	SK	H/Set	2	1	1	4			1	2				2		2		>100	
72	Löddeköpinge 23	5	SK	H/Set, Hr	2			4			2	2								>100	
47	Bredestad	5	SM	H/Set, Hr	1			4			2	1	1							>25	
	Total				31	4	6	84	8	0	41	15	2			3	9	4	2		209
	% total				14.8	1.9	2.9	40.2	3.8	0	19.6	7.2	1			1.4	4.3	1.9	1		100

The assemblages are sorted primarily by chronology and secondly by area of origin. *H* Halland, *M* Skåne (Malmö area), *Ö* Öland, *SK* Skåne (excluding Malmö), *SM* Småland. *H* House deposit, *Hr* Hearth, *Set* settlement activity context (i.e. pits, wells, ditches, etc.)

therefore possible that the regional variations, indicated by Plot 4, may be affecting the analysis in a way that masks chronological patterns.

To test this hypothesis correspondence analyses were performed using only regional data. The analysis of the Halland material did not show any clear patterns with

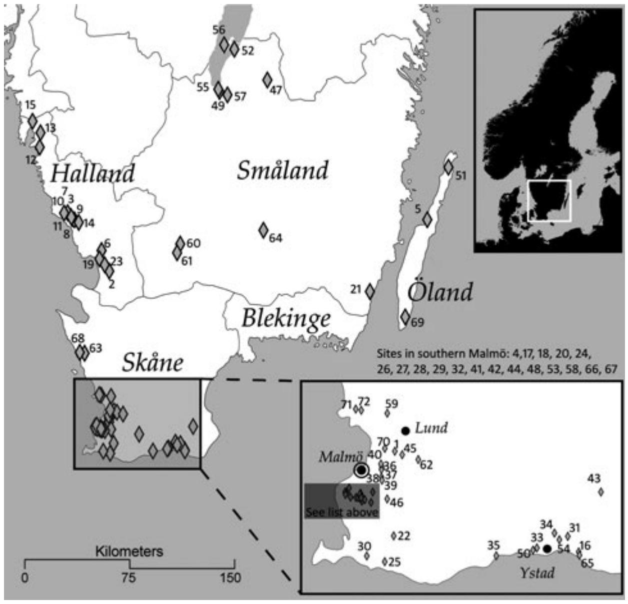

Fig. 3 Map of the area studied in the compilation presented here, showing all investigated sites

regards to chronology. This material is however rather sparse, making interpretation difficult.

The Skåne plot on the other hand (Fig. 5) resulted in a rather distinct grouping of sites dating to periods IV and V in the lower left hand side of the projection.

To summarize; the two types of correspondence analyses thus appear to indicate that:

1. There are regional variations in the composition of the archaeobotanical material, at least between Halland and Skåne.
2. At least in the Skåne material, there is evidence of changes in agricultural practice dating to the beginning of the Migration Period and onwards.

In order to further shed light on the details of the changes indicated by the analyses above, the quantified data on the occurrences of crops from the investigated sites have been illustrated in Figs. 6a–c. The first Fig. 6a shows the material representing the entire investigation area while the latter two (Fig. 6b, c) represent Halland and Skåne, respectively.

Figure 6a, representing the entire investigation area, shows hulled barley as the dominant crop throughout the Iron Age. Naked barley was in use to a smaller extent during the beginning of the Iron Age but decreased steadily in importance throughout the period. Wheat cultivation is a minor, but constant, component of Iron Age agriculture. However, speltoid wheats, which are seemingly of equal importance to that of bread/club wheat during the first three periods, are phased out during the Migration and Vendel Periods and are virtually non-existent during the Viking Age. Oats and rye appear in small quantities during the Pre-Roman and Roman Iron Age and then increase sharply following the transition from Roman Iron Age to the Migration Period. The interpretation of the importance of both species is however somewhat problematic as both can appear as weeds in barley and wheat fields. It is thus possible that at least a portion of the rye and oat finds from the earlier periods do not directly relate to intentional cultivation. During the latter periods, especially period IV and V, the occurrence of both species increases significantly, thus indicating that they have become integrated components of agriculture in southern Sweden.

Cultivation of oliferous species, namely gold-of-pleasure and flax, also appears to be a constant throughout the Iron Age. The relative significance of the two species appears to fluctuate greatly in Fig. 6a but this result must be seen in light of two factors that cause great problems in any interpretation of their occurrence. Firstly, both species have a taphonomy that differs from the other cultivated taxa as the oil rich seeds tend to combust rather than carbonize when exposed to heat (Viklund 1998, p. 31). When they do appear in carbonized form it is often as “cakes” or “lumps” which are fused together by the oil (e.g. Hansson et al. 1993). Since these “cakes” often consist of a great number of individual seeds their occurrence in a site assemblage tends to result in a disproportional impact on its final composition. Secondly, gold-of-pleasure can remain in circulation as a weed in flax even if it is no longer purposely cultivated (Welinder 2004, p. 75), meaning that an unknown amount of gold-of-pleasure finds in the site assemblages may in fact be a reflection of flax cultivation. Although it is difficult to judge the respective importance of the two species the results of the study do show that cultivation of crops for oil production was a constant and probably important addition to crop cultivation. At the end of the investigated period, during the Viking Age, this cultivation appears to decrease in importance.

Millet is a species that occurs sporadically during Pre-Roman and Roman Iron Age on a small selection of sites but disappears completely towards the end of the period.

Celtic beans (*Vicia faba* var *minor*) and peas (*Pisum sativum*) do appear constantly throughout all periods although in very small quantities, possibly indicating limited garden cultivation, perhaps as a complement to a cereal dominated diet.

Looking to the individual regions, Skåne appears to display three significant variations:

1. The occurrence of naked barley is very sporadic indicating very limited cultivation, even during the earliest periods of the Iron Age.
2. Cultivation of wheat seems to have been more extensive in Skåne during the Pre-Roman and Roman Iron Age than in southern Sweden in general.

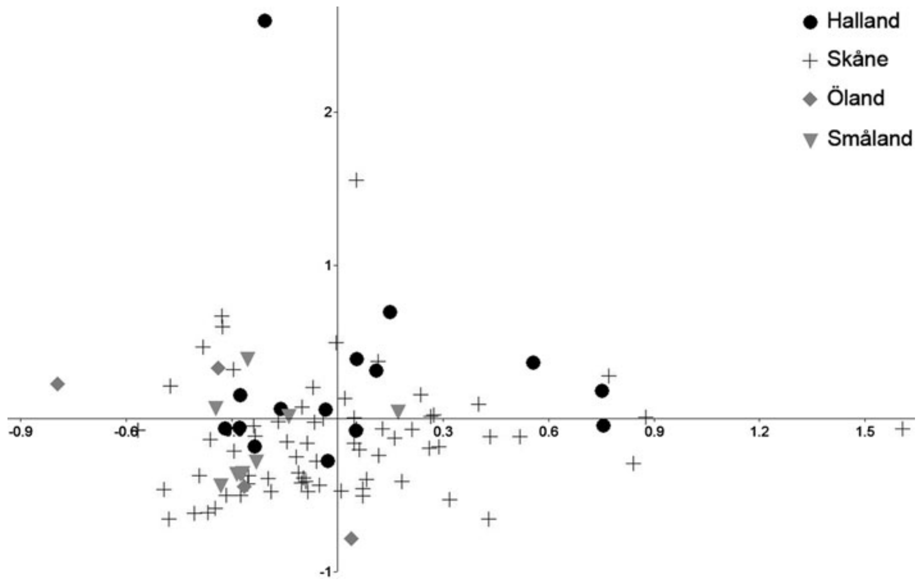

Fig. 4 Correspondence analysis showing the quantified data presented in Table 1, with all site assemblages categorized according to region of origin

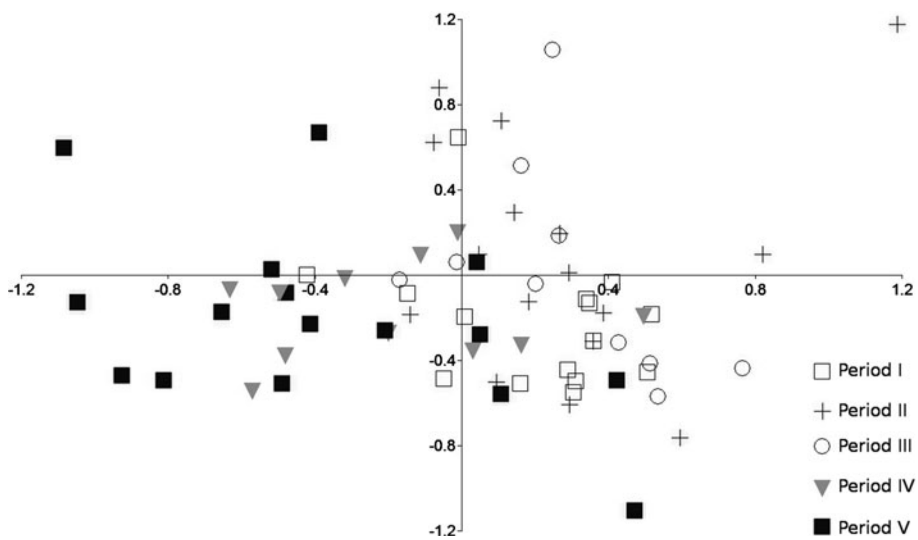

Fig. 5 Correspondence analysis showing the quantified data from Skåne with all site assemblages categorized according to chronology

3. The introduction of rye appears more distinctly in Skåne than the other areas, with a very sharp increase during the Migration Period. This introduction also appears to occur slightly later than in the neighbouring areas.

Halland, as opposed to Skåne, appears to differ quite significantly from the regional average. Oats appear in large quantities as early as during the Roman Iron Age, and even during the preceding Pre-Roman Iron Age this crop makes up a large portion of the qualitatively categorized material. Rye already appears in significant quantities during period III, i.e. the latter part of the Roman Iron Age, while naked barley is not phased out until the beginning of the Roman Iron Age, remaining in cultivation far longer in this part of Sweden than in Skåne. Wheat cultivation in Halland appears to be, as in the other areas, a significant component, but is almost entirely dominated by speltoid wheats rather than free-threshing ones. Unfortunately wheat finds are absent from periods II and V, hampering further interpretation. This absence is probably an effect of the relatively sparse quantity of material from Halland and future finds may significantly develop the interpretation of wheat cultivation in this region.

The regional variations between Halland and Skåne are also evident in Fig. 7, where the investigated site assemblages have been plotted onto a map of the area showing the relation between rye, oat, naked barley and hulled barley for each investigated site and period.

Halland stands out clearly with much higher than average occurrences of oats during the first two periods and continues to differ during period III with a higher occurrence of both oats and rye.

Discussion of the remaining areas, mainly Småland and Öland, is very difficult because of the scarcity of finds from these areas. Småland does however seem to conform to the general development seen in Skåne, although with a slightly earlier introduction of rye during the late Roman Iron Age.

The material from Öland only covers period III and IV but it seems to conform to that of nearby Småland with an introduction of rye cultivation dating to the end of the Roman Iron Age. Similarly to Halland however there is also a significant presence of oat.

Lastly the geographic illustration in Fig. 7 indicates a homogenization of agricultural praxis during the Viking Age when hulled barley and rye make up the main components with oats as a secondary crop.

Discussion

The results of the analyses presented above are, to a large extent, coherent with previously proposed hypotheses for the development of cereal cultivation development in south Sweden during the Iron Age by, among others, Hjelmqvist, Engelmark, Viklund and Regnell.

At the same time the analyses also raise some questions concerning the details of these interpretations and illuminate research areas that require further attention and study before well founded interpretative models can be proposed.

Early Iron Age, 500 B.C.–A.D. 400

As presented above, the early Iron Age agriculture in southern Sweden has been interpreted as dominated by the use of permanent fields, primarily for the cultivation of barley.

There are no indications in the material herein investigated that contradict this hypothesis. The analyses do however indicate that permanent field agriculture was probably not a uniform phenomenon throughout southern Sweden but rather subject to significant regional adaptations.

Such adaptations were more than likely the result of complex sets of interacting ecological, technological and social factors.

The most significant differences between the two counties that have produced the majority of the material are the more frequent occurrences of oats, the earlier introduction of rye and the longer retention of speltoid wheats and naked barley in Halland compared to Skåne.

Regarding oats, palynological studies have previously indicated that Halland was subject to soil depletion and spread of *Calluna* heathland at the end of the Bronze Age

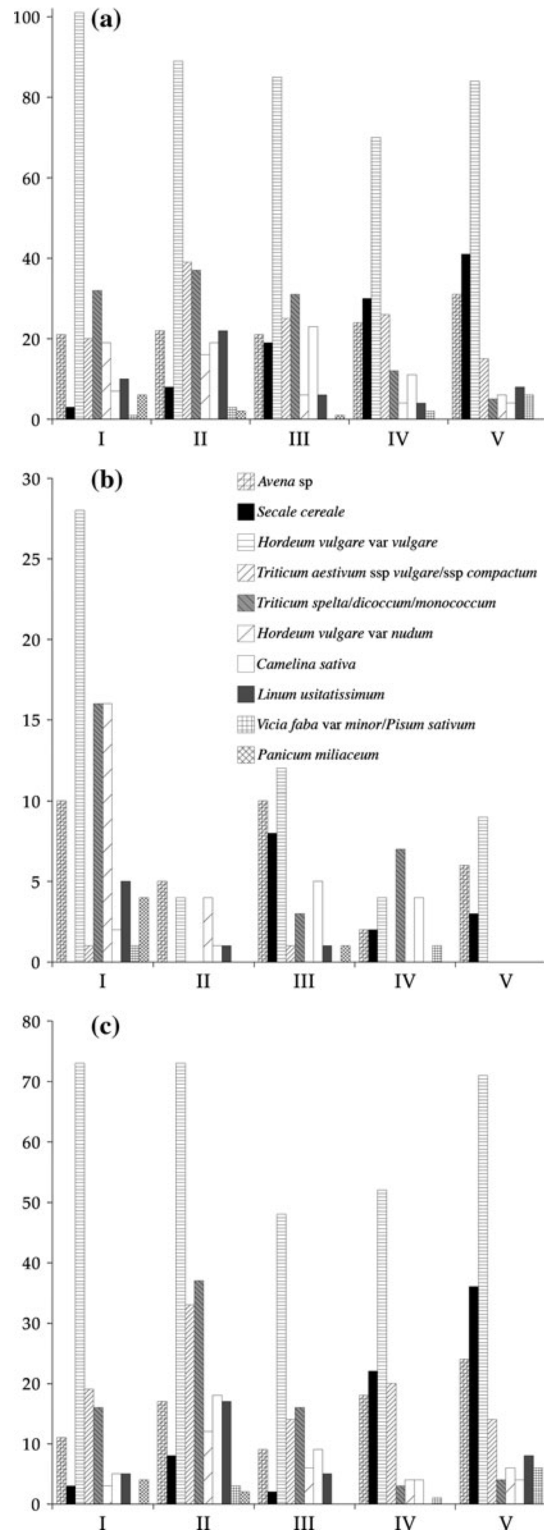

Fig. 6 a–c Changes in the composition of the archaeobotanical material, with regard to the most important crops, over the course of the Iron Age. The graphs are based on the quantified data presented in Table 1. Graph **a** shows the results for the entire investigation area. Graphs **b** and **c** show the results from Halland and Skåne, respectively

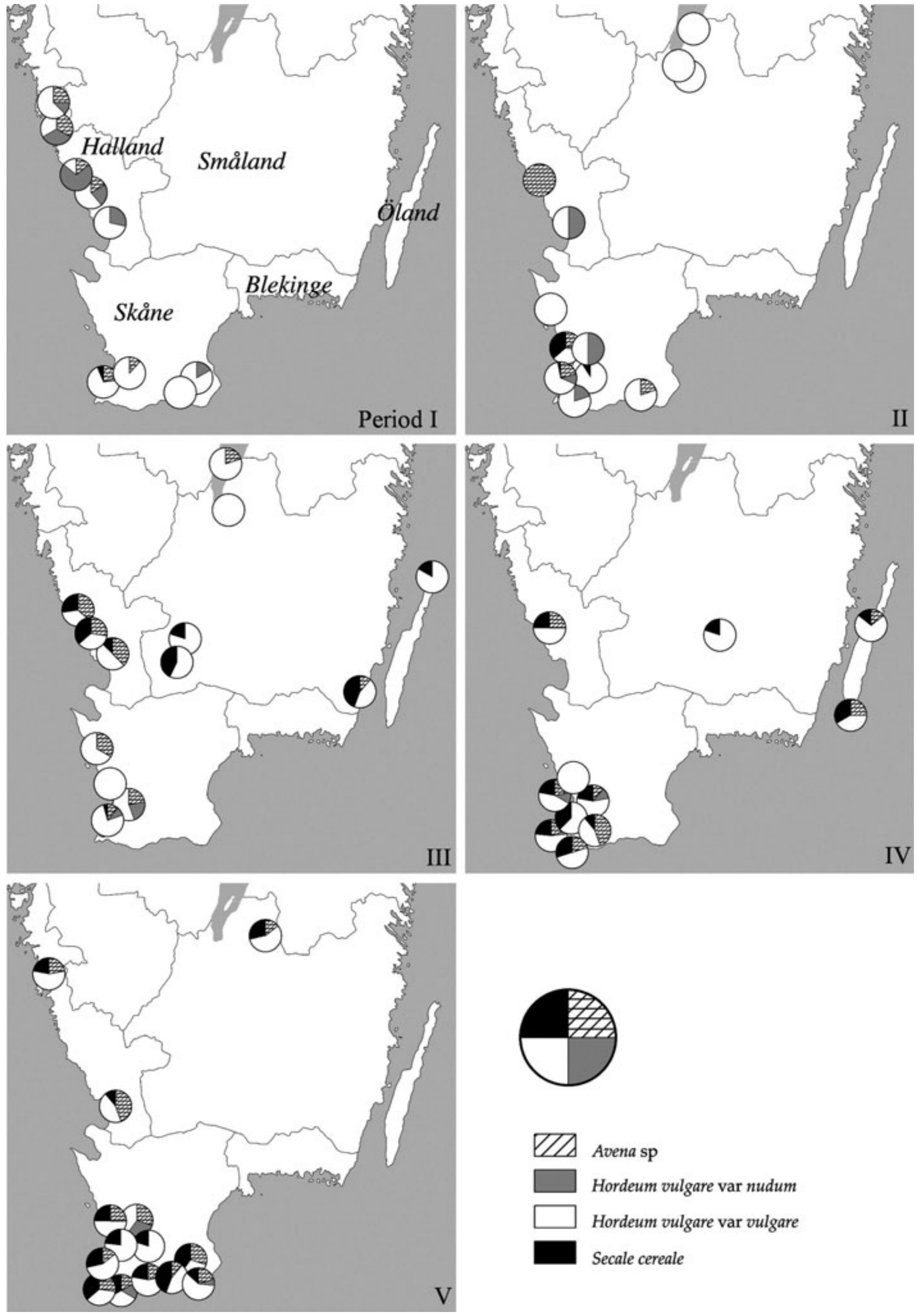

Fig. 7 Map showing the relations between *Avena* sp, *Hordeum vulgare* var *nudum*, *Hordeum vulgare* var *vulgare* and *Secale cereale* based on the quantified data presented in Table 1. For presentation purposes several closely adjacent sites in the Malmö area have been combined into single pie-charts

and beginning of the Pre-Roman Iron Age (Wallin 2004). Viklund has noted in her research (e.g. Viklund 2004) that oats appeared in Halland at around the same time and that many finds of oats occur together with larger finds of indicator species for nutrient poor soils, such as corn-spurrey (*Spergula arvensis*) and rye-brome (*Bromus secalinus*). On basis of this evidence Viklund argues that the occurrence of oats in the archaeobotanical material may be a result of soil depletion. The oats in the investigated samples cannot be differentiated as either cultivated *Avena sativa* or the wild *Avena fatua* and *Avena strigosa*. Nevertheless since oats occasionally appear in comparatively numerous and pure finds Viklund argues that they were utilized as a resource, regardless of whether they were purposely cultivated or occurred as a weed due to suitable growing conditions on marginal, nutrient poor, soils used for cultivation of the securely established crops.

Such utilization of oats as a resource may have been further influenced by Halland's differing natural ecology as the climate there is more maritime and humid than in adjacent Skåne, and Skåne's clayey moraines are contrasted in Halland by tracts of sandy soils (Welinder 2004).

From historical sources we can assume that oat cultivation on permanent fields should not have been impossible utilizing the agricultural techniques known to have existed during the Iron Age. In fact oats were the last crop cultivated in Sweden in this fashion and in Nordisk Familjebok, an encyclopaedia dating to the late 19th and early 20th century, one can read that: "[permanent field agriculture], being the oldest form of agriculture, is now abandoned in most parts of Sweden, except where it is used on wet soils that year after year are cultivated with oats [authors translation]" (Juhlin-Dannfeldt 1904, p. 655). Another written source, closer in time to the investigated period, is Gaius Plinius Secundus. In Naturalis Historia he writes about oats, which he considered to be a degenerative disease in wheat and barley: "The people of Germany are in habit of sowing it and make their porridge of nothing else […] The degeneracy is owing more particularly [to] humidity of soil and climate…" (Bostock and Riley 1855, book 18, chap. 44).

These two sources are only examples of others and it is therefore plausible that the climatic tolerance, the nutritional potential and the compatibility of oats with the existing mode of agriculture were all well known to farmers in Iron Age Halland, making an adoption of this species comparatively easy when the need for it arose.

On the basis of the fact that several large finds identified during the course of the study presented here contained large quantities of oats, and referring to the reasoning above, I would like to suggest oats as a cultivated crop in Halland during the Iron Age. This interpretation is however presented with the reservation that the finds have not been securely identified as cultivated *Avena sativa*.

Similarly the earlier introduction of rye in Halland, during the later Roman Iron Age, may have been prompted by the slightly more marginal conditions experienced there than in Skåne. It may also have been a partial consequence of the already existing experience of cultivating a secondary (complementary?) crop on marginal soils.

Both with regards to oats and rye it is difficult to discuss the role of technological and social factors behind their respective introduction into south Swedish agriculture. The study herein is an aerial shot of the situation on the ground, providing a good view of the whole, but not much resolution about particular details. There is however one crop which may be easier to assess on grounds other than ecology.

The compilation presented in this study shows clearly that wheat, either bread wheat or speltoid, appears in almost all investigated site assemblages, although almost always in comparatively small quantities. From archaeological finds of bread (Bergström 2007) as well as specific passages of Icelandic sagas (von Hofsten 1957, p. 53) a hypothesis can be formed that wheat was something of a luxury product during the Iron Age. The limited occurrence of wheat alongside the dominating barley across the entire area may thus have been an effect of social convention in the region, with most households cultivating this particular product for specific (possibly festive and/or ritual) types of consumption. The fact that wheat finds from Halland consist almost exclusively of spelt and emmer may however also indicate that the socially/traditionally prompted desire for a particular product was balanced against the natural potential of each region. Hulled wheats, particularly spelt, are more tolerant than bread wheat to the humid climate of Halland (Renfrew 1973, p. 40ff; van der Veen 1989) and may have been selected for that reason.

Late Iron Age, A.D. 400–1100

Looking to the latter part of the Iron Age two interrelated issues stand out as particularly important for archaeobotanists to address; when does permanent field agriculture change into the crop rotation based cultivation known to have existed during the Medieval period, and when is winter rye incorporated into this agriculture?

The traditional consensus in Sweden has so far been that a rotation type agriculture can be proposed once the material from investigated archaeological contexts displays more or less equal quantities of rye and hulled barley (Regnell 2002, p. 30) with winter rye being indicated by "classical" indicator species such as corn cockle and cornflower (Engelmark 1985, 1992).

In Denmark Mikkelsen and Nørbach (2003) has argued that these species are exotic to the south Scandinavian flora and can not be seen as indicators for the introduction of early winter rye cultivation but rather for the beginnings of grain import from areas where these "exotic" species were already naturalised. Mikkelsen proposes instead a series of locally available species that react positively to early winter rye cultivation as proxies for early winter rye cultivation. Since these species, among others sheep's sorrel, knotgrass and perennial ryegrass, already existed in the preceding permanent field agriculture they are however difficult to interpret. Only through analysis of material from the rather unique type of archaeobotanical remains from iron smelting furnaces is Mikkelsen able to distinguish patterns with interpretative potential.

This type of material does not exist for the south Swedish area and a survey of the weed finds from the sites presented in this article shows no patterns with regard to Mikkelsen's indicator species.

Looking to the "typical" indicator species for winter rye cultivation, three species occur in the south Swedish material analyzed in the course of the study presented here: rye brome, corn cockle and false cleavers (*Galium* *spurium*); the latter suggested by Hillman (1981, p. 146) as an indicator for autumn sowing. All three of these species show a significant increase in site assemblages dating to the transition between period IV and V. Of the three species corn-cockle is the only one that does not occur in the materials from southern Sweden prior to the sharp increase mentioned above and is therefore probably the best indicator for the new type of agriculture. Unfortunately the occurrences of corn cockle are sparsely dated, with only two sites displaying comparatively securely dated contexts in which this species was found. Site E6 6:1 (Lagerås 2009—unpublished report) displayed finds of corn-cockle together with rye from two separate *grubenhäuser* dated to A.D. 770–970 (cal. 2σ, 1162 $\pm$ 35 B.P.) and A.D. 660–870 (two datings, cal. 2σ, 1264 $\pm$ 38 B.P. and 1270 $\pm$ 43 B.P.), respectively. The second site, Lockarps Bytomt (Heimer et al. 2006), excavated in connection with the Malmö City Tunnel construction produced an early find dating to A.D. 890–1160 (cal. 2σ, 1015 $\pm$ 40 B.P.). Although the date from the latter site is later than the first one corn cockle finds become comparatively numerous at Lockarps Bytomt postdating the first occurrence. Therefore the latter site might indicate a more secure "latest" introduction of this species in south-western Skåne.

Accepting the above outlined premises that the increase in the three indicator species reflects winter rye cultivation would thus mean that the earliest date that can be suggested for its introduction to southern Sweden, and quite possibly also the introduction of "medieval type" crop rotation, would be the end of the Vendel Period and the beginning of the Viking Age.

This interpretation is however proposed with reservation on the basis of the rather insecure available material. The introduction could have taken place earlier, in the same way that has been suggested for parts of Denmark by Mikkelsen, a possibility that will remain unresolved until suitable material becomes available for analysis.

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