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ORIGINAL ARTICLE

Plant subsistence and environment at the Mesolithic site Tågerup, southern Sweden: new insights on the "Nut Age"

Mats Regnell

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Abstract Pollen was analysed from a sediment sequence collected in the close vicinity of the Mesolithic settlement Tågerup, southern Sweden. Macroremains were also retrieved from numerous samples taken at the site of the archaeological excavations of Kongemose and Ertebølle settlement phases, 6700–6000 B.C. and 5500–4900 B.C. respectively. Plants and other organic remains were well preserved in the refuse layers from the settlements embedded in the gyttja. The pollen record includes no clear indications of human impact on the vegetation during the Mesolithic. The occurrence of charcoal particles and pollen of grass and herbs associated with nutrient-rich soils are contemporaneous with the Kongemose settlement. The Ertebølle settlement phase, although characterised by considerable dwelling activities less than a hundred metres from the pollen sampling site, is scarcely seen in the pollen data. Numerous finds of crushed dogwood stones from the Kongemose phase, often partly carbonised, suggest that these stones were used for the extraction of oil. Other plants found in the Kongemose refuse layers that may have been used are apples, cherries, raspberries, acorns and rowan-berries. Based on the abundance of hazelnut shells found at the studied site and in other studies of Mesolithic sites in southern Scandinavia it is proposed that these remains may testify to an important food supply rather than just use as a supplement to animal protein. It is also hypothesised that a regional decrease in hazel populations and thus hazelnut availability at the end of the Mesolithic may have motivated the adoption of Neolithic subsistence.

Keywords Plant macroremains · Pollen · Mesolithic · Environmental history · Plant subsistence · Hazelnuts

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M. Regnell (✉)
Department of Physical Geography and Quaternary Geology, Stockholm University, 10691 Stockholm, Sweden
e-mail: mats.regnell@geo.su.se

Introduction

When literature on Mesolithic plant use in Northern Europe is considered, three important aspects can be perceived. First, pollen analysis alone seems to be inadequate to gain specific information on plant use. Second, studies on plant macroremains have, when wood working is not involved, identified few intentionally used plant species. Third, hazel nuts seem to have been the most important plant food resource. Pollen analysis is a useful method to reconstruct past vegetation and landscape development, but it has obvious limitations if the objective is to investigate the past environment at community or species level. This is apparent for instance when plant usage is the focus. Plant macroremain analysis is a valuable method for supplying detailed information on local vegetation and crucial for distinguishing plants that have been collected and utilized. There are many reports on human disturbance of vegetation in northern Europe during the Mesolithic from pollen analytical studies (e.g. Vuorela 1986; Kolstrup 1990; Regnell et al. 1995; Poska 2001) and on possible pre-Neolithic agriculture (Edwards and Hirons 1984; Göransson 1988; Klassen 2004; Poska and Saarse 2006). However, few of these studies discuss the use of specific plant species and several arguments against Mesolithic agriculture in central and Northern Europe have been advanced (Behre 2006). Mesolithic use of specific species concluded from pollen analysis involves hazelnuts (e.g. Simmons and Innes 1987; Huntley 1993) and ivy (Simmons and Dimbleby 1974). In previous investigations of Stone Age sites in southern Sweden a combination of pollen and plant macroremain analyses has proved rewarding (Göransson 1983; Regnell et al. 1995). The results show, for example, that Mesolithic settlement, although relatively extensive and of long duration, had a limited impact on forest vegetation. Adjacent to the Mesolithic site Bökeberg III pollen analysis of a peat sequence revealed small changes in tree and herb pollen frequencies, although microscopic charcoal was abundant during periods of settlement. It was assumed that the habitation was established without any forest clearance or other disturbance of the vegetation (Regnell et al. 1995). Retrieved plant macro remains (excluding wood) from Scandinavian Mesolithic sites include ca. 70 species (Regnell 1998). Most of them represent contemporaneous vegetation at the archaeological sites. It can be argued that a few species were being collected and used, with hazelnut as the most obvious example. However yellow water lily, dogwood (Andersen et al. 1982), acorns and hawthorn have also been pointed out as having been consumed (Grøn 1997).

This paper presents results from one of the sub-projects within the archaeological West Coast Line project, which was launched by the Swedish National Heritage Board in connection with the construction of a new railway track. The study area is situated in Scania, the southernmost province of Sweden, at the outlet of the Baltic Sea into the Atlantic Ocean (Fig. 1). The Mesolithic site Tågerup presented here has been the focus of massive investigations. Adjacent to the Mesolithic settlement, numerous samples from marine deposits were studied using palaeoecological methods. The results from the extensive archaeological excavations and also some of the most important palaeoecological conclusions have been published in a series of books (e.g. Karsten and Knarrström 2001, 2003; Svensson 2003). In this paper, two sets of data are presented and discussed:

(1) Pollen stratigraphical investigations of a sediment sequence accumulated in close connection to the Mesolithic site at Tågerup
(2) Plant macroremains collected from a range of contexts during the archaeological excavations.

In this study, pollen analysis was used to reconstruct general vegetation changes around the settlements at Tågerup and plant macroremain analysis was used to identify specific plants that might have been used by humans.

The aims within the study have been:

- To reconstruct the vegetation around the settlements and specifically to study human impact on vegetation during the phase of significant human settlement
- To provide information on the use of plants during the Mesolithic
- To evaluate the importance of hazelnuts within consumption strategies.

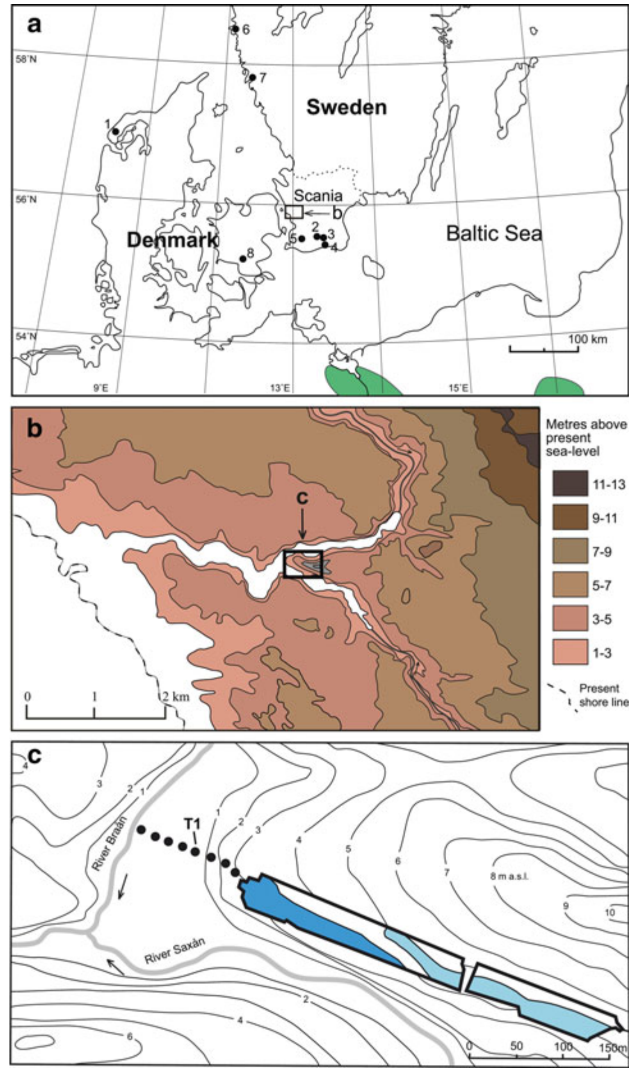

Fig. 1 Map of the study area and the investigated site Tågerup. **a** Pollen analysed sites mentioned in the text and in Fig. 5: 1—Hassing Huse Mose Bog, 2—Kurarp, 3—Lake Krageholmssjön, 4—Lake Bjärsjöholmssjön; sites with Mesolithic plant remains mentioned in the text: 5—Bökeberg, 6—Huseby Klev, 7—Balltorp, 8—Holmegard Mose; green area with settlements from the Linear Band Pottery Group dated between 5500 and 4700 B.C. (from Lüning 2000 and Larina 2009). **b** Map with the sea level shown as 1 m above the present average level, i.e. the assumed sea level at the end of the Kongemose settlement phase (Regnell and Risberg unpub.). **c** *Black dots* show the coring sites along the profile presented in Fig. 2. T1 The analysed sequence (pollen). Area of excavation shown with thick line. *Light blue area*—excavated area with in situ remains from the Ertebølle settlement phase. *Dark blue*—extension of the refuse layers belonging to the Kongemose settlement phase

Geological and archaeological settings

Scania is situated at the boundary between the Fenno-scandian archaic Baltic Shield and the central European sedimentary basin. Geologically, the north-eastern part of Scania belongs to Scandinavia and the south-western part, where Tågerup is situated, to continental Europe. The topography surrounding the site Tågerup is characterised by flat land surfaces barely reaching 20 m a.s.l. Sand is the most common Quaternary deposit along the coast; further inland clayey till dominates. The stratigraphical distribution of Quaternary deposits is complicated by complex vertical variations, e.g. thin accumulations of postglacial sand often overlying clayey till. Moreover, bodies of silt occur locally in otherwise sandy areas (Ringberg 1976; Adrielsson 1984). This three-dimensional large variation in lithostratigraphy explains the complexity of the hydrology of the area and also the environmental diversity important for plants and animals.

The minerogenic portion of the Quaternary deposits mainly originates from the southern part of the Baltic, which means chalk and limestone predominate. Around Tågerup the soils are very fertile and the area is characterised by a rich agriculture (Erlandsson 1999), an aspect that may be assumed to have been also important during prehistory.

Tågerup is located where the small rivers of Saxån and Braån converge in a larger stream. Both rivers can be followed inland about 15 km and represent together a drainage area of approximately 150 km^2. Prior to the confluence, the rivers run south and west of a hill (Fig. 1a), where abundant stray finds from all prehistoric periods have been found. The archaeological excavations at Tågerup were performed during three seasons in 1997–1999 along the southern rim of this hill, parallel to the course of the present River Saxån (Fig. 1c). The investigations have revealed Mesolithic occupations dated to two phases (all dates below are given in calibrated years B.C.):

The Kongemose phase, dated to 6700–6000 B.C., is represented by finds in aquatic and telmatic sediments, i.e. in refuse layers deposited close to the contemporary shore and below water at distances up to 20 m from the former shore-line. Finds from marine gyttja include flint and bone tools (some of them decorated), wooden leisters, prongs and fish traps, and bone remains from humans and 48 animal taxa. At about 40–60 m from the former shore-line, five graves and eight probable burials were found. One hut from the Kongemose phase was found (Karsten and Knarrström 2001, 2003).

The Ertebølle phase, dated to 5500–4900 B.C., revealed the same type of remains as the older settlement phase, although with each category generally in smaller numbers. In addition to finds in gyttja, artefact-rich cultural layers on dry land were found, including houses and huts with strikingly preserved construction details. Surface finds surrounding the excavated area at Tågerup indicate that the promontory was also inhabited after the Mesolithic, and a number of dates indicate activities at the site throughout prehistory (Karsten and Knarrström 2003).

Materials and methods

Close to the excavated area, cores with a 10 cm diameter Russian sampler were taken along an east–west profile (Fig. 1c). In this area Quaternary deposits reach a thickness of almost 20 m (Fig. 2). The deposits consist of fine and coarse minerogenic late-glacial sediments, laminated minerogenic sediments representing an early Holocene riverbed, and Mid-Holocene transgression sediments. In the central part of the profile a representative sequence (T1), was extracted and sub-sampled at 10 cm intervals and analysed for multi-proxy data. The pollen stratigraphy from T1 is presented in this paper. Analyses of plant macroremains, together with siliceous microremains, sediment chemistry and mineral magnetic parameters (Regnell et al. 2001), will be discussed in a forthcoming paper in which sea-level changes will be the focus.

Pollen analysis

Samples for pollen analysis were treated according to standard procedures (Berglund and Ralska-Jasiewiczowa 1986). The analyses were performed at ×320 and ×800 magnifications, and phase contrast was used when necessary. A minimum of 1,000 pollen grains per sample was counted. In general, pollen identifications were based on the pollen keys by Erdtman et al. (1961), Faegri et al. (1989), Moore et al. (1991) and Punt et al. (1976). In addition, the reference collection at the Department of Quaternary Geology, Lund University was consulted. Pollen taxonomy and nomenclature follows the pollen keys mentioned above. The results are presented as percentages of the sum of terrestrial taxa; aquatics, spores of Pteridophytes and *Sphagnum*, the alga *Pediastrum* and herbs of wet soil (*Typha latifolia*, *Sparganium erectum*-type and Cyperaceae) are excluded from the calculation sum. The programs TILIA and TILIAGRAPH (Grimm 1990) were used for calculation, drawing the diagram and zonation. To facilitate the description and interpretation of the pollen diagram in terms of vegetation changes, five local pollen assemblage zones were distinguished (LPAZ T1:1–T1:5), based on the CONISS cluster analysis (Grimm 1987) as implemented by the TILIA program (Grimm 1990). Each zone boundary denotes significant changes in the pollen assemblages and hence represents major changes in

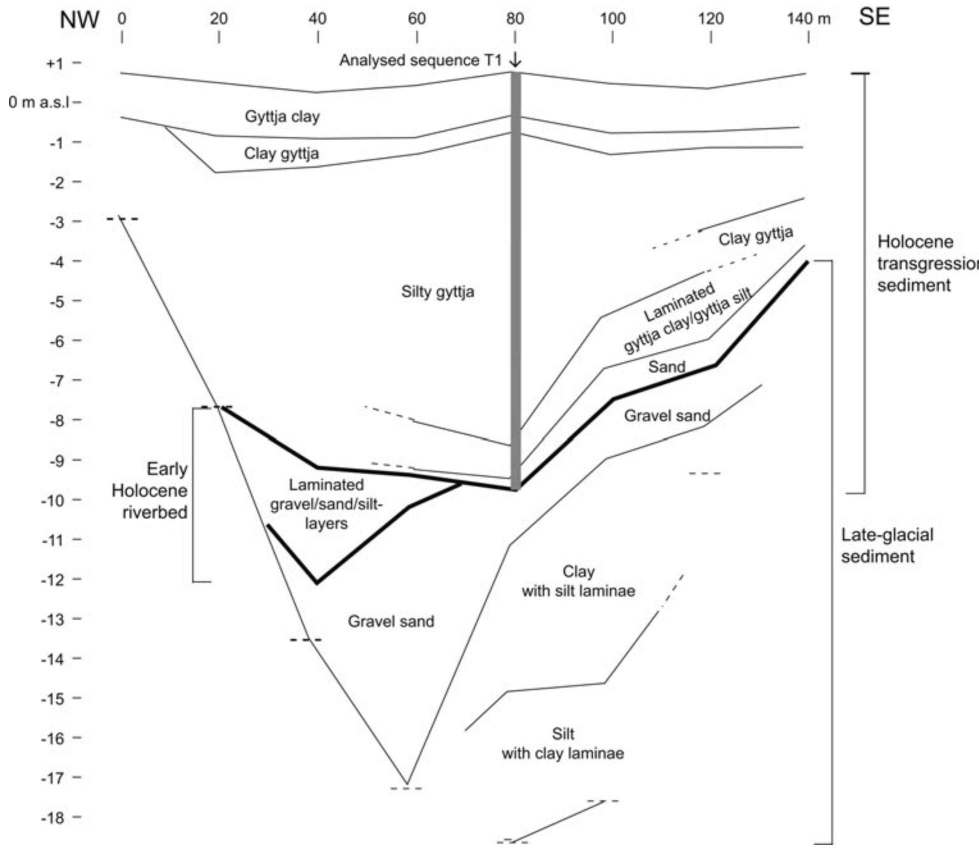

Fig. 2 The litho-stratigraphy at Tågerup T1. The section is drawn along the profile shown in Fig. 1c. Limits between stratigraphical units representing Late-glacial, Early Holocene and Mid-Holocene deposits are indicated by thicker lines

vegetation. A number of taxa with low pollen counts and of little significance to the discussion have been excluded from the diagram (Fig. 4).

Macroremain analysis

The macroremain analyses were performed on separate soil samples from the cultural layers, on various constructions from the terrestrial environment and from refuse layers in marine, waterlogged, organic sediments. Sampling was mainly performed in collaboration with the excavating archaeological staff. No sampling grid has been used, i.e. each sampling was decided on the basis of contextual aspects. Sample volume was calculated in a graduated beaker where a known volume of water was added. All samples were diluted with 1–2% NaOH. Waterlogged samples characterised by high organic content were diluted for a longer time, and/or were heated to approximately 60°C and washed through a 0.25 mm mesh sieve. Minerogenic soil samples were handled with a modified flotation method. Diluted samples were placed in a 10 l bucket. While constantly pouring water into the bucket that was inclined with slight variations in angle, smaller minerogenic particles and organic material were decanted into the 0.25 mm sieve. Originally waterlogged samples were kept in water after preparation, but minerogenic samples were dried in room temperature. Macro remains were sorted and identified under a binocular microscope at ×6 to ×80 magnification using the keys and atlases by Katz et al. (1965), Berggren (1969, 1981), Beijerinck (1947), Jacomet et al. (1989) and Anderberg (1994). The majority of samples that originated from minerogenic soils often contained fresh seeds, rootlets, insects etc. These fresh specimens were considered as recently incorporated in the soil and were not regarded as sub-fossil finds, but their presence was noted. Nomenclature and present distribution of plants are according to Den Nya Nordiska Floran [The new Nordic flora] (Mossberg and Stenberg 2003).

Dating

The chronology of the sediment sequence T1 was constructed from 11 AMS radiocarbon dates on macro remains of terrestrial origin (Table 1). The plant remains used for dating were retrieved from sequence T1, parallel to the levels that were analysed for pollen. These samples were prepared and analysed with the same methods as described above. Dating was performed at the Ångström laboratory, Uppsala University, and ^{14}C dates were calibrated using OxCal 4.1. A time-depth model was established applying a linear interpolation through the individually plotted calibration curves (Fig. 3).

Table 1 Radiocarbon dates from Tågerup 1 (T1)

Lab. no.	Material	Depth cm	^{14}C-age yrs B.P.	Cal. age yrs B.C. 1 σ-range (probability)	Cal. age yrs B.C. 2 σ-range (probability)
Ua-26047	Charcoal/*Quercus*	110–111	5,495 ± 80	4,448–4,413 (13.5%)	4,518–4,225 (89.6%)
				4,406–4,316 (39.9%)	4,205–4,162 (3.2%)
				4,298–4,262 (14.7%)	4,130–4,112 (0.9%)
					4,101–4,072 (1.6%)
Ua-25938	Wood/undiff.	160–161	4,780 ± 95	3,650–3,501 (54.4%)	3,762–3,724 (2.1%)
				3,428–3,380 (13.8%)	3,715–3,362 (93.3%)
Ua-25939	Wood/undiff.	270–271	4,960 ± 90	3,912–3,878 (9.9%)	3,964–3,632 (94.0%)
				3,804–3,649 (58.3%)	3,558–3,538 (1.4%)
Ua-25940	Wood/undiff.	550–551	6,140 ± 110	5,220–4,938 (68.2%)	5,320–4,796 (95.4%)
Ua-26048	Charcoal/*Alnus*	600–601	6,360 ± 75	5,468–5,402 (23.4%)	5,484–5,207 (95.2%)
				5,388–5,297 (42.2%)	5,088–5,084 (0.2%)
				5,241–5,232 (2.6%)	
Ua-26049	Wood/*Corylus*	670–671	6,840 ± 75	5,792–5,657 (66.3%)	5,892–5,621 (95.4%)
				5,651–5,646 (1.9%)	
Ua-26050	Wood/Pomoideae	800–801	7,360 ± 75	6,354–6,294 (17.4%)	6,393–6,069 (95.4%)
				6,266–6,202 (23.1%)	
				6,194–6,099 (27.8%)	
Ua-25941	Nutshell/*Corylus*	880–881	8,565 ± 90	7,705–7,698 (1.8%)	7,936–7,927 (0.3%)
				7,681–7,522 (66.4%)	7,916–7,900 (0.6%)
					7,866–7,860 (0.2%)
					7,840–7,454 (94.0%)
					7,392–7,381 (0.4%)
Ua-26051	Wood/*Salix*	920–921	8,755 ± 80	7,952–7,658 (68.2%)	8,200–8,110 (8.5%)
					8,093–8,072 (1.6%)
					8,066–8,039 (2.0%)
					8,006–7,597 (83.3%)
Ua-8960	Charcoal/*Quercus*	940–941	7,875 ± 65	6,981–6,975 (1.1%)	7,030–6,874 (23.1%)
				6,908–6,886 (4.5%)	6,866–6,596 (72.3%)
				6,828–6,638 (62.6%)	
Ua-26052	Wood/undiff.	1,045–1,046	8,040 ± 75	7,076–5,825 (68.2%)	7,180–6,691 (95.4%)

Results and interpretation

Chronology

The age-depth model presented in Fig. 3 was used to construct the time-scale of sequence T1 (pollen diagram, Fig. 4).

Pollen-inferred vegetation development

The size of the area for which the local pollen assemblages are representative is difficult to estimate since the studied sediments were deposited in a bay of the sea. In addition, the Braån and Saxån Rivers may have transported pollen into the bay. Therefore, it is assumed that the pollen source area is relatively large and that the pollen data therefore represent mainly the regional vegetation.

In the following description, characteristic features for each local pollen assemblage zone are indicated. Mesolithic and Neolithic periods are according to Brinch Petersen (1993) and Nielsen (1993) respectively.

Estimated accuracies for the stated ages below are in the order of ±100 years (Fig. 3).

T1:1: 1,050–885 cm, ca. 7000–6500 B.C. This zone corresponds to the Late Maglemose and Early Kongemose cultures. The pollen spectra suggest a landscape dominated by nemoral trees (*Corylus, Ulmus, Quercus* and *Tilia*). *Pinus* was present during the early part of the period and became more common in the later part. *Ulmus* was slightly less common in the younger part of the period. *Alnus* was

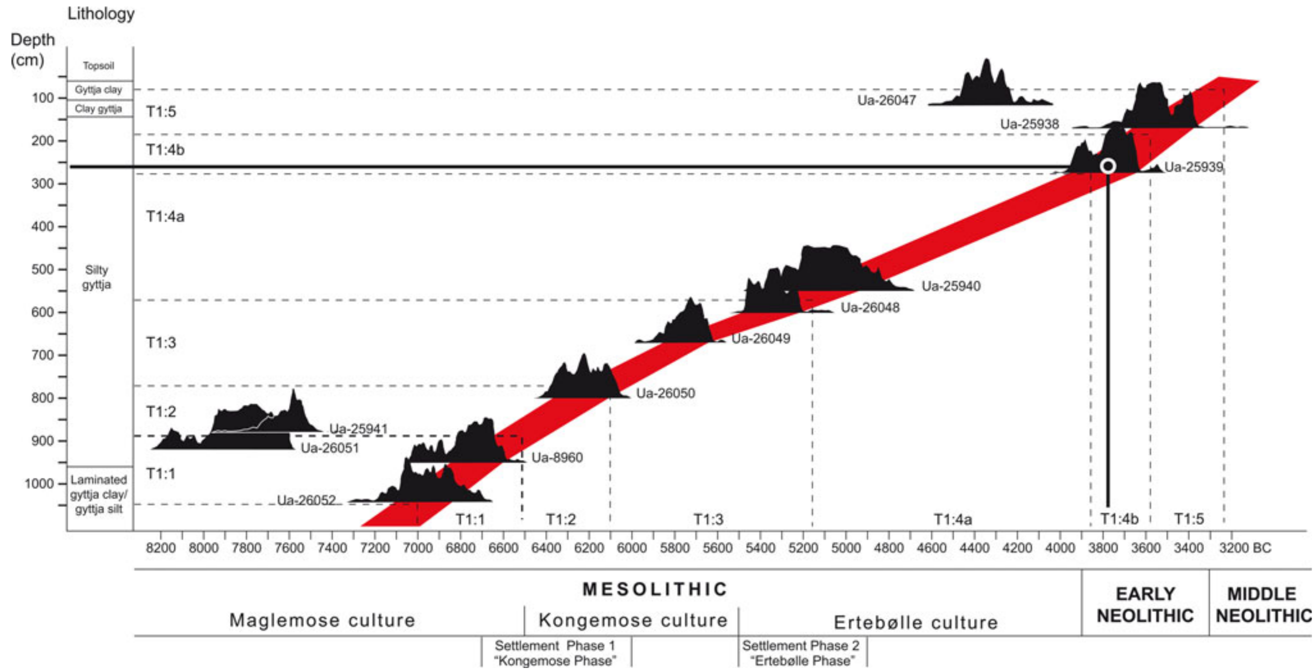

Fig. 3 Time-depth model for the sediment sequence T1. The calibration curve for each date (Table 1) is projected. A linear interpolation of the age intervals with highest density of likelihood is drawn (red). The three dates (Ua-26047, Ua-25941 and Ua-26051) are considered to represent reworked, older material and are excluded from the time-depth model. Boundaries between pollen zones are shown with hatched lines. The classical elm-decline as dated by Skog and Regnéll (1995) is indicated by a thick line and a white circle. The settlement phases at Tågerup are shown below the time axis

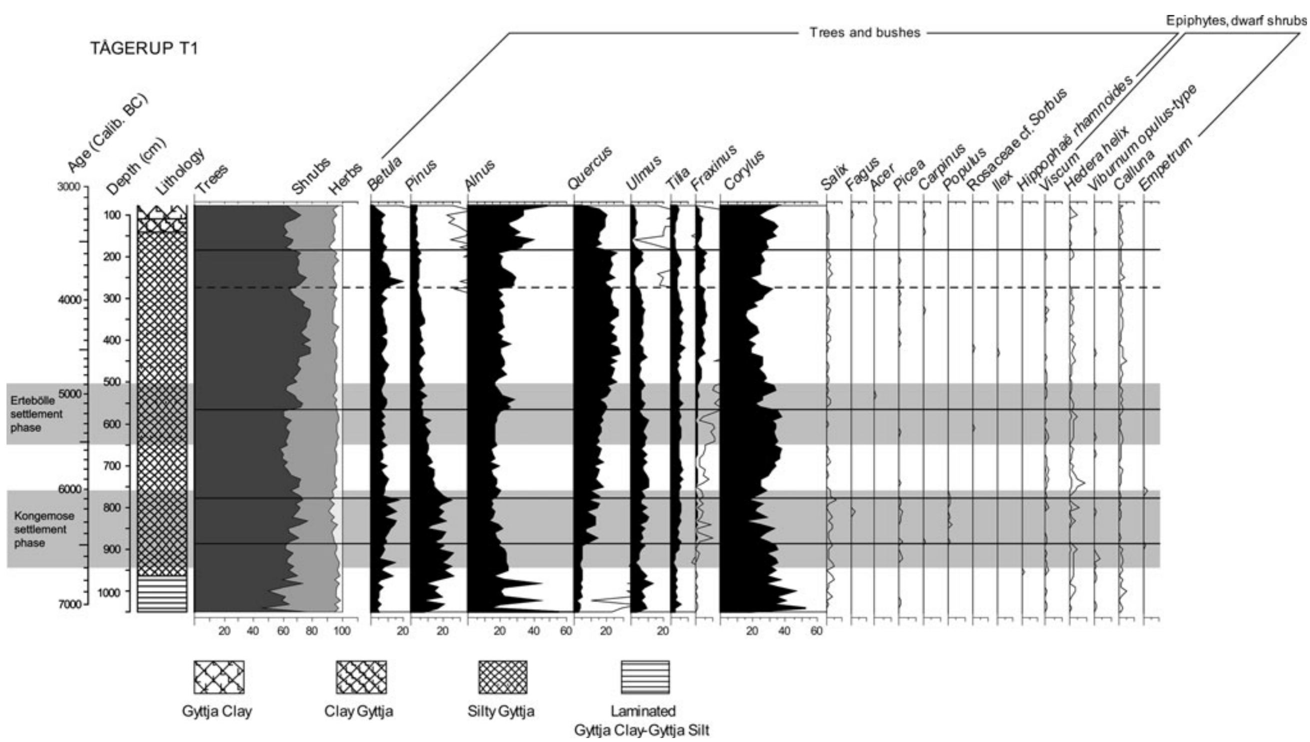

Fig. 4 Percentage pollen diagram of the sequence T1. The pollen zones are based on CONISS cluster analysis (Grimm 1987) implemented by the program TILIA (Grimm 1990)

abundant on peaty or waterlogged ground, together with some *Betula* and *Salix*. Wetland communities, represented by Cyperaceae, *Sparganium erectum*-type and *Filipendula* were probably confined to shorelines. During the oldest part of the period, highly variable values are found for taxa such as *Alnus*, *Corylus* and *Pinus*. These fluctuating values may be caused by redeposition of sediment and pollen grains, perhaps in connection with a transgression of the sea at the study site (cf. Digerfeldt 1975). Microscopic charcoal particles are present in the middle part of the zone, before the first settlement phase. These charcoal particles should be interpreted together with occasional radiocarbon datings of archaeological findings preceding the defined Kongemose phase and thus suggesting activities at the site before the main occupation.

T1:2: 885–775 cm, ca. 6500–6100 B.C. The zone corresponds to the Kongemose culture. The lower part of the zone shows an increase in *Quercus, Tilia* and *Fraxinus*. The landscape was dominated by a nemoral forest where *Corylus*, *Quercus*, *Ulmus*, *Tilia* and *Pinus* were common trees and shrubs. On waterlogged ground, *Alnus* and *Betula* were abundant, but some *Salix* shrubs also occurred. The zone corresponds to an increase of *Artemisia,* Chenopodiaceae, Poaceae undiff. <40 μm, *Sparganium erectum*-type and Cyperaceae. These taxa may, if Poaceae undiff. <40 μm is at least partly inferred as being *Phragmites*, correspond to an expansion of communities close to the shore. *Pediastrum* colonies are found in enhanced numbers through the zone, possibly indicating a stronger influence of freshwater from the small rivers Braån and Saxån. High frequencies of microscopic charcoal particles are found in the zone, correlating to the Kongemose settlement phase. The occasional presence of *Rumex acetosa/acetosella* may indicate either patches of open ground within the forest or seashore vegetation. Decreases in *Viscum* and *Hedera helix* and the presence of *Populus* also signify a more open and disturbed forest.

T1:3: 775–565 cm, ca. 6100–5100 B.C. The zone covers the Late Kongemose and Early Ertebølle cultures. Trees and shrubs such as *Corylus*, *Quercus*, *Ulmus* and *Tilia* were common. *Pinus* shows lower frequencies than in previous zones. *Alnus* was the dominant species on wet soils, but *Betula* and *Salix* shrubs may have occurred. During this period, a reduction of open vegetation communities is indicated. A continuous expansion of *Quercus* and *Fraxinus* can be seen as well as a decrease in *Corylus* frequencies. Microscopic charcoal particles occur only sporadically, most likely indicating a reduced occurrence of camp-fires. As a consequence of the change in disturbance regime, *Pinus* and grasses were disadvantaged and *Quercus* and *Ulmus* could expand. In the upper part of the zone there is an increase of *Artemisia*, *Aster* and Chenopodiaceae that may be an effect of an expansion of shoreline plants.

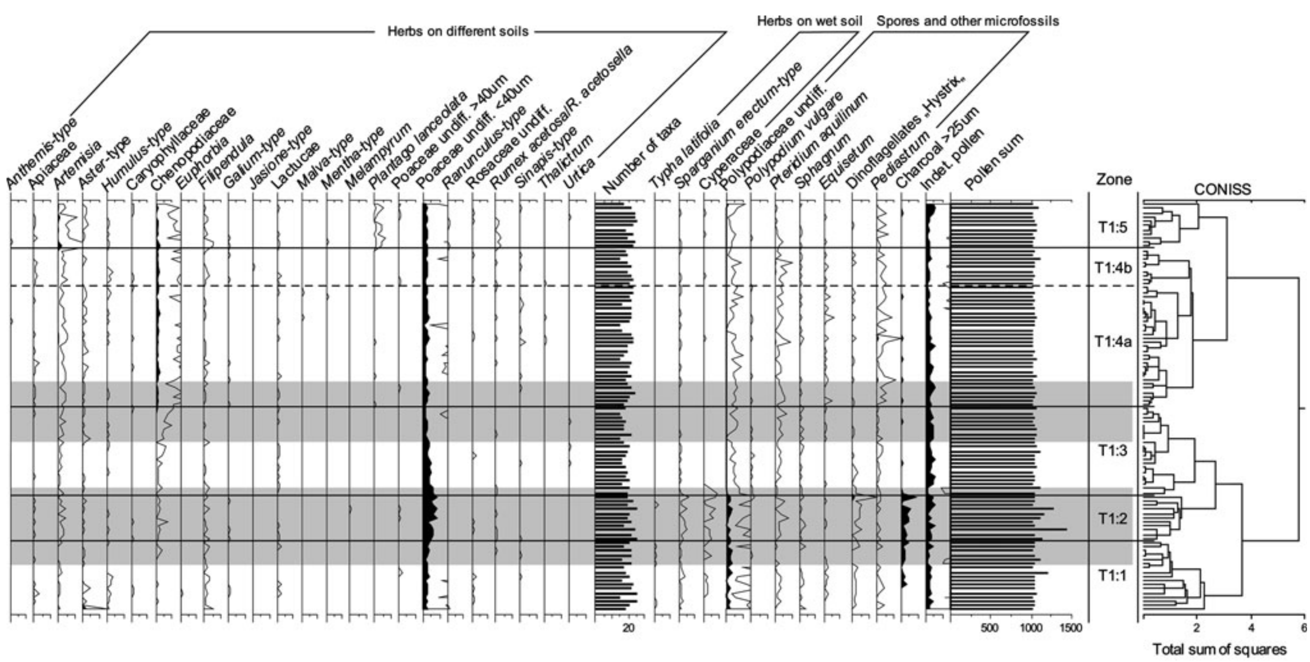

Fig. 4 continued

T1:4: 565–185 cm, ca. 5100–3600 B.C. The zone is divided into two subzones where T1:4a (565–275 cm, ca. 5100–3900 B.C.) represents the later part the Late Ertebølle culture and T1:4b (275–185 cm, ca. 3900–3600 B.C.) the earliest part the Early Neolithic culture (EN A and B according to Nielsen 1993). Just above the lower boundary there is a decrease of *Corylus* from nearly 40–25%, which is accompanied by an equivalent increase in *Alnus*. The beginning of the zone, ca. 5100–4900 B.C., corresponds to the most intense phase of Ertebølle settlement, as indicated by radiocarbon datings of archaeological finds and chronologically significant artefact types (Karsten and Knarrström 2003). In the uppermost part of zone T1:4a, *Corylus* increases again to similar values as previously. Paralleling the changes in *Corylus* percentages described above, *Quercus* and *Fraxinus* show increasing values in the lower part of subzone T1:4a while other tree pollen maintains comparable percentages through the subzone.

The lower part of subzone T1:4b is marked by the classical *Ulmus* decline recognised in many areas of north-west Europe that was dated to 3790–3745 B.C. in southern Sweden (Skog and Regnéll 1995). It is hard to infer a precise timing for the elm decline in this study, but the time-depth curve (Fig. 3) suggests one of ca. 3900 B.C. The regular occurrence of Apiaceae, Compositae/Cichorioideae (Lactucae), Caryophyllaceae and *Filipendula* may represent an expansion of open vegetation. However, the forest disturbance indicated by the decline of broad leaved trees may not have favoured an expansion of open vegetation since *Betula* appears to have responded quickly as a pioneer tree expanding in the areas of disturbed forest, maintaining a relatively dense tree cover, however with an altered species composition. Open vegetation communities were probably still confined to shorelines. Later, *Quercus* and *Tilia* may have replaced *Betula*. Microscopic charcoal particles are scarce in the sediment suggesting that probably no camp fires occurred in the closest vicinity of the study site. Therefore, it is considered that signs of human impact in T1:4b are weak, which implies that the *Ulmus* decline rather was a consequence of natural factors such as climate change and elm disease (Peglar 1993; Peglar and Birks 1993; Digerfeldt 1997). *Ulmus* and *Fraxinus* probably regained their previous abundance in the later part of the subzone, as indicated by pollen values as high as those prior to the *Ulmus* decline. The structure and composition of the forest were probably similar at the end of subzone T1:4a and at the last part of subzone T1:4b. Open vegetation communities probably had a restricted occurrence in the area.

T1:5: 185–80 cm, ca. 3600–3200 B.C. This zone represents the late Early Neolithic (ENC) and the earliest part of Middle Neolithic (MNAI-II?). The pollen record reflects a landscape dominated by a nemoral forest, where *Quercus* and *Corylus* were abundant elements and *Ulmus*, *Tilia* and *Fraxinus* occurred regularly. *Acer* was present, but it probably had a low abundance. On wetter sites, *Alnus* was dominant, possibly intermixed with *Betula*. The pollen data also indicates an increase in *Corylus*, *Tilia* and *Alnus*, and a reduction of *Quercus* and *Fraxinus* in the uppermost part of the zone. An increase in *Artemisia*, *Filipendula*, *Plantago lanceolata* and *Rumex acetosa/acetosella* clearly indicates the expansion of open vegetation. The occurrence of *Plantago lanceolata* suggests that grazing might have been introduced into the area, possibly as forest grazing. Microscopic charcoal particles are not common in the record which suggests that natural fires and forest clearance using fire were not occurring in the study area.

Plant macroremains

Nearly 50 samples representing 36 litres of gyttja from the refuse layers were analysed. The plant remains from the layers ascribed to the Kongemose occupation phase are listed in Table 2. The composition of the plant macroremains is dominated by aquatic plants. Fruits of *Ruppia maritima* and *Zannichellia palustris* and oospores of *Chara* sp. are most common. These plants, as well as different species of *Potamogeton,* grow along shores of the Öresund Strait today, while *Najas marina* is rarely found along the Scanian coasts but is more common along the Swedish eastern coast. *Apium inundatum* also has a limited occurrence along the Scanian coast today, but the plant was found close to Tågerup in the 1980s (Weimarck and Weimarck 1985). Today, it is mainly characteristic of inland lakes, ditches and ponds.

The most numerous remains from plants characteristic of shore-lines (telmatophytes) are from *Phragmites australis* and *Typha* sp.; *Glaux maritima* is also common together with *Moehringia trinervia*. A few remains of *Schoenoplectus lacustris/Bolboschoenus maritimus* and *Tripolium vulgare* were found. All these plants grow today along the shores of the Öresund Strait, although *M. trinervia* and *S. lacustris* are more commonly found along lake shores. Thus, some plant species from the Kongemose phase indicate aquatic and telmatic vegetation typical of waters with lower salinity than the modern conditions at the site. However, the occurrence of these species might also be explained by transport from upstream sources via the tributaries.

The wetland plants found at Tågerup probably derive from wet or moist soils along the seashore or from similar environments upstream. *Alnus* was the dominant wetland tree and probably grew close to the sampling site. Internodes of *Equisetum palustre* and achenes of *Eupatorium cannabinum* are relatively common in the Tågerup sediments and these species are also represented in the modern surrounding vegetation. Other frequent remains are of fruits of *Urtica dioica* and seeds of *Juncus* sp. All these wetland species are still widespread in western Scania.

Table 2 Plant macroremains from 49 samples from the refuse-layers dated to the Kongemose phase at Tågerup. The finds are diaspores if nothing else is specified

	Finds (*n*)
Aquatic species	
Apium inundatum	2
Chara sp.	9,097
Najas marina	150
Potamogeton sp.	142
Ruppia maritima	4,120
Zannichellia palustris	1,576
Wetland and shore line species	
Alnus sp.	46
Alnus sp. (flower spindles, leaf scars etc.)	>100
Bidens tripartita	3
Carex sp.	5
Crambe maritima	39
Equisetum palustre (internodes)	32
Eupatorium cannabinum	20
Galium uliginosum	2
Glaux maritima	56
Juncus sp.	117
Lychnis flos-cuculi	1
Lycopus europaeus	2
Moehringia trinervia	13
Persicaria hydropiper	1
Phragmites australis	100
Schoenoplectus lacustris/Bolboschoenus maritimus	1
Stellaria palustris	1
Tripolium vulgare	4
Typha sp.	73
Urtica dioica	100
Terrestrial species	
Betula sp.	317
Chenopodium sp.	364
Cornus sanguinea	9
Corylus avellana (no. nutshell fragments)	234
Fallopia convolvulus	4
Malus sylvestris	1
Persicaria maculosa	1
Polygonum aviculare	6
Prunus avium	2
Rubus idaeus	78
Rumex acetosa	5
Quercus sp. (no. acorn fragments)	22
Silene nutans	1
Silene vulgaris	2
Sorbus aucuparia	2
Stellaria media	1
Others	
Poaceae indet.	3
Potentilla sp.	6

Table 3 Summary of carbonised plant remains (diaspores if not otherwise specified) found in terrestrial soil samples associated with the Ertebølle phase at Tågerup

Construction	House 1	House 2	House 3	Grave A6504	Grave A40186
Vol. (l)	74.1	179.1	138.1	9.4	7.9
Cerealia indet.	1	2	1		
Hordeum vulgare coll.	2		1		
Hordeum vulgare var. *vulgare*	1				
Triticum aestivocompactum		2			
Triticum spelta		1			
Triticum dicoccum/T. spelta	1		1		
Corylus avellana (no. of nutshell fragments)	7	3	34	1	1
Arrhenatherum bulbosus (tuber)		1			
Poaceae undiff.	1	3			
Chenopodium sp.		1			
Rumex acetosa	1				

Of the terrestrial plants the highest numbers of finds are from birch *Betula* sp., *Quercus* sp., *Malus silvestris*, *Sorbus aucuparia*, *Corylus avellana* and *Cornus sanguinea*. Remains from *Chenopodium* sp., *Persicaria maculosa*, *Polygonum aviculare* and *Stellaria media* indicate nutrient rich soils probably in the moist environment along the shore. Alternatively, the occurrence of such species at the site might indicate more nutrient-rich conditions at and around the Mesolithic settlement. In addition, pollen zone T1:2, that is contemporaneous with the Kongemose settlement phase, is characterised by an increase in Apiaceae, *Artemisia*, Chenopodiaceae and *Rumex acetosa/acetosella*. These taxa also indicate nutrient-rich soils and a situation with more open vegetation.

The finds of *Fallopia convolvulus* in Mesolithic depositions at Tågerup (Table 2) should probably be interpreted as contamination from younger layers. *F. convolvulus* is probably not native to Scandinavia or the British Isles (Webb 1985) but was introduced during the Neolithic. The species has previously been found at about a dozen Stone Age sites in Scandinavia, and only one of these is Mesolithic, the rest belonging to the Neolithic (Regnell 1998). The Mesolithic finds are from a coastal site in southern Norway and although the stone tools and radiocarbon dates are indisputably of Mesolithic origin (Østmo 1976) the find description in the original report cannot rule out contamination. It should be pointed out that apart from the finds of *F. convolvulus* there could be other examples of redeposition of younger remains into the Kongemose layers.

At Tågerup the gyttja refuse-layers from the Kongemose settlement phase provided by far the largest amount of plant remains. Additional plant remains were retrieved from 519 samples originating from the terrestrial part of the younger Ertebølle settlement phase. Table 3 summarises the finds of carbonised plant remains from three houses and three graves, all of Mesolithic origin. All terrestrial deposits are related to the Ertebølle phase dating to c. 5500–4900 B.C. In relation to the large volume of soil analysed, find concentrations were low. In House 2, for example, 179 litres of soil were analysed but only 13 plant remains were found. The presence of cereal grains can be explained by post-depositional processes, as radiocarbon dating of the grains show that they are contemporaneous with an Iron Age settlement at a higher elevation. However, the presence of hazelnuts, although in low concentrations (maximum of 34 nuts in House 3), might be associated with the Mesolithic remains.

Discussion

This discussion is focused on the consumption of plants, but other uses will also be mentioned. In such a context it is very important to define what is meant by plant use and how deliberate collection and usage of plants can be inferred from palaeo-records. There are three major situations where archaeobotanical records can be interpreted in terms of utilization of wild plants; (1) occurrences in very large quantities, (2) presence in an environment in which the plant does not belong naturally (i.e. appears as 'exotic'), and/or (3) obvious signs of processing by humans.

Moreover, ethnological information usually provides further understanding. Ethnological analogies are of course important within many aspects of archaeology, and ethnobotany is perhaps an especially rich source of information on human habits and behaviour within the field of anthropology.

The Mesolithic period is highlighted as the era of hunter-gatherers and therefore wild plants are integrated in virtually all models and concepts dealing with the Mesolithic (e.g. Clarke 1976; Rowley-Conwy 1983, 1986; Price 1989; Zvelebil 1994). Food strategies during the Mesolithic are described in a large number of publications, however the references above put forward the idea that gatherers not only made a passive use of what nature provided, but also deliberately maintained plants of particular interest for them and consciously transformed the landscapes/vegetation for various purposes. Pollen and charcoal analyses from several sites in Europe suggest that people during Early and Middle Mesolithic induced forest fires (Tolonen 1985; Patterson et al. 1987; Edwards 1990; Simmons 1996). Some authors consider fire during these periods as a deliberate method of creating clearances that attracted game animals and thus made meat a more achievable food component (e.g. Mellars 1976). Nevertheless, other studies show that natural climate-induced fire was probably a major factor in the forest dynamics of the Early and Mid Holocene in southern Sweden (Greisman and Gaillard 2009; Olsson et al. 2010). During the last decades discussions have included the possibilities that plants could have been important for consumption during the Mesolithic in northern Europe (e.g. Larsson 2003). Seven species that fulfil one or several of the indicator criteria for utilization were found in the refuse layers at Tågerup.

Cornus sanguinea (dogwood)

Among the land plants found in samples from the former shore zone at Tågerup, fruit stones of dogwood (*Cornus sanguinea*) were found in spectacular numbers. In Table 3 only finds from the processed soil samples are presented, but very large quantities of dogwood stones were retrieved from wet sieving during the excavations. In total, more than 300 stones were found and, interestingly, most of these were cracked. There is also one find of a probable digging stick or soil-working tool of dogwood at the site. Dogwood has previously been documented at Mesolithic sites in southern Scandinavia (Regnell 1998). However, it is only at Bökeberg in Scania that large amounts of fragmented stones of dogwood have been found (Regnell et al. 1995). What makes the dogwood stones from Tågerup remarkable is their fragmentation, an obvious result from processing by people. One possible explanation for the fragmentation might be that the stones are a by-product of oil extraction. The dry weight of dogwood stones comprises as much as 50% oil. A simple way of extracting the oil from the fruit stones is to crush them, boil them in water and skim off the oil from the water surface. The oil is excellent as lamp-oil or as an impregnator for wood or leather, and was commonly used in later times (Nyman 1868). Dogwood is probably one of the most convenient terrestrial oil-resources of non-domesticated origin in Scandinavia. There are of course alternative oil-sources such as seal blubber in coastal areas. As with plant oil, it is difficult to prove the use of animal fat in prehistory, although biochemical analyses may provide important information (e.g. Isaksson 2000). Interestingly there are far fewer seal bones found at Tågerup, when compared to other coastal sites dated to the Mesolithic period in Scandinavia (Eriksson and Magnell 2001).

Malus sylvestris (crab apple)

A pip from apple (*Malus sylvestris*) was found in a sample from the Kongemose phase at Tågerup. It cannot be ruled out that the single, uncarbonised pip from this site could be a result of natural deposition since crab apple trees can grow adjacent to shores. The finds of crab apple from Huseby Klev and Balltorp along the Swedish west coast represent carbonised remains and should be interpreted as conscious use of the fruit (Larsson 2000). When the single remain from Tågerup is added to the collection of Mesolithic findings of crab apples in Sweden, the few records indicate that apples were not commonly used.

Prunus avium/cerasus (wild cherry/sour cherry or dwarf cherry)

Two stones of cherry (*Prunus avium/cerasus*) were found in the cultural layers. Both specimens are damaged and their shapes are hard to use for more specific determination. The distinction between the two species *Prunus avium* and *P. cerasus* is not easy. *P. avium* has previously been defined as being a natural consituent of the European decidious forest whereas *P. cerasus* should be native to West Asia (Van Zeist et al. 1994). Recent studies on distribution and genetics suggest that the two species are very closely related and that hybridisation between the species *P. avium*, *P. cerasus* and *P. fruticosa* is responsible for present phenotypes (Badenes and Parfitt 1995; Brettin et al. 2000). Although both *P. avium* and *P. cerasus* have evolved in Europe, *P. avium* is native to southern Europe and *P. cerasus* to central and northwest Europe (Dirlewanger et al. 2009; Bortiri et al. 2001). The oldest find of cherry known in Sweden (*Prunus* sp.) is from early Holocene peat from a bog in Bohuslän (Hjelmqvist 1963). Because neither of the two cherry species grows naturally on wet soils or on seashores both finds (from Bohuslän and Tågerup) may therefore be considered as 'exotics' in the sediments. The finds of cherry from Tågerup are the first documented from a Scandinavian Stone Age archaeological site. On the European continent the earliest record of cherry (*P. avium*) seems to be described from a Mesolithic site in Southern France (Vaquer and Ruas 2009). More frequent records start with the Neolithic (Zohary and Hopf 2001).

Quercus sp. (oak acorns)

In the samples from the cultural layers belonging to the Kongemose culture, 22 fragments of acorns (*Quercus* sp.) were found. All fragments were carbonised or partly carbonised. During wet sieving at the excavation site, ca. 100 whole or cracked pieces of acorns were found, half of which were carbonised. Acorns, as well as the bark of the oak, are rich in tannins, which makes them unpleasant in taste and unusable. The bitter tannins can be leached by soaking in water or denaturised by heat (Källman 1993). The fact that the acorns found at Tågerup were carbonised strongly indicates heat treatment as a means to make them edible. Acorns and hazelnuts are easily identified during archaeological excavations. They are often handled as any other artefact and included in registration, documentation and publication. This may be a reason why acorns are so rarely discussed in the literature specifically reporting archaeobotanical finds. In a compilation of plant remains from archaeological sites of the Nordic countries (Regnell 1998) astonishingly few acorns are included, i.e. from three Mesolithic and four Neolithic sites. In other parts of Europe acorns are more prominent in the archaeobotanical literature, in particular for the Mesolithic period (Mason 1995; Vencl 1996).

Rubus idaeus (raspberry)

There are numerous finds of raspberry (*Rubus idaeus*) from the cultural layers, and samples from the Kongemose refuse layers contained 78 fruit-stones. It is not conclusive that finds of raspberry indicate gathering since it normally grows on fresh nitrogen-rich soil adjacent to seashores and wetlands and may be deposited through natural processes. However, samples with high numbers of raspberry fruit-stones (e.g. 55, 16) indicate an unusual high deposit of remains at the same spot. The latter together with numerous acorns found in the same sample suggest that raspberries might well have been gathered. Fruit-stones of raspberries have been found earlier in Stone Age sites in Scandinavia. Mesolithic finds were made at Holmegaards Mose (Denmark) and Bökeberg (Scania) but also at Rognelien in southern Norway (Regnell 1998). A large number of raspberry fruit-stones were found in the stomach area of a Neolithic skeleton from a young female often referred to as 'the raspberry girl', buried in peat. It was assumed that the numerous remains were residues from her last meal (Geijvall et al. 1952).

Sorbus aucuparia (rowan)

Two pips of rowan (*Sorbus aucuparia)* were found in the Kongemose cultural layers. Rowan was found earlier in the Mesolithic sites of Balltorp in Bohuslän (Larsson 2000) and Bökeberg in Scania (Regnell et al. 1995). Rowan grows on fairly moist soils and is favoured by unshaded conditions at the edge of woodlands, and it may have grown close to the seashore at Tågerup. In historical times it has been used as a remedy for scurvy and kidney stones. Fresh berries have also been used to make cider and vinegar or dried for jam (Nyman 1868; Høeg 1974) and are recognised as an important source of vitamin C (e.g. Oberdorfer 1990; Källman 1993).

Corylus avellana (hazelnut)

In the West Coast Line project shells of *Corylus avellana* (hazelnut) are by far most abundant in samples from the Mesolithic period (Table 4). In four out of five samples of Mesolithic age where plant remains were found, hazelnut shells were present.

Table 4 Frequencies of *Corylus avellana* (hazelnut) shells within the West Coast Line project, percentages of total preserved plant remains in samples dated to different archaeological periods

Period	Hazelnut shells (%)
Mesolithic	81
Neolithic	23
Bronze age	8
Early iron age	11
Late iron age	7

Nutshells of hazel are the most common plant remains found at the Mesolithic sites of Scandinavia. Approximately 20 Mesolithic and 25 Neolithic sites with finds of hazelnut shells have been reported earlier (Regnell 1998). The Mesolithic sites are characterised by higher frequencies of hazelnut shells than the Neolithic sites, and roughly half of the sites include refuse layers with both non-carbonised and carbonised nutshells. In contrast, at the Neolithic sites the nutshells are mainly carbonised. Therefore it may be proposed that hazelnuts not only played an important role for foraging during the Mesolithic, but were also an important subsistence base. This argument has recently been put forward in relation to finds from the Early Mesolithic of northern Germany (Holst 2010). Modern hazelnuts contain about 60% fat and 20% carbohydrates and 100 g nuts equal 660–720 kcal (Amaral et al. 2006). Thus, a few handfuls of hazelnuts represent a substantial part of the daily requirement of energy uptake. Following the definitions of Zvelebil (1994), the exploitation of hazelnuts during the Mesolithic in temperate Europe was not opportunistic and incidental but systematic and intensive. At Tågerup, nutshells were present in over 80% of the samples that contained preserved plant remains and they were, with few exceptions, fragmented in a characteristic way, different from the fragmentation caused by birds or rodents. Carbonised nutshells represented only a few percent of the total amount. The occurrence of carbonised hazelnut shells in sites of the Stone Age has been interpreted as due to their being roasted for longer storage (Larsson 1983; Holst 2010), or as a result of their use as fuel (Kubiak-Martens 1999). Experiments showed that moderate roasting of hazelnuts could prolong storage without significant loss in nutritional value (Kirbaşlar and Erkmen 2003). Since osteological data suggest year-around occupation at Tågerup (Eriksson and Magnell 2001), roasting of hazelnuts might have been useful. However, the relatively low number of carbonised nutshells at Tågerup does not argue in favour of roasting as a common procedure at the site.

When hazel is cut, new shoots appear that provide a richer development of nuts. This phenomenon must have been noted by Mesolithic people. Probably humans during that time also knew that scattered hazelnuts sprouted and produced new plants. It has been suggested that the rapid expansion of hazel in Europe during early Post-glacial times was at least partly an effect of intentional spreading by humans (Iversen 1973; Bogucki 1988; Kuneš et al. 2008). The rapid expansion has also been explained by natural causes (Tallantire 2002). The benefits from induced growth in hazel stands did not only come as increased harvests of nuts but also with the production of long, slender branches sprouting from coppiced stands. Hazel branches were indeed used at Tågerup, for example in several of the fish traps.

On the basis of the present study and previous investigations it may be proposed that the hazelnut was a food product the availability of which played an important role for the introduction of farming in Scandinavia. The presence of numerous settlements of the Neolithic Linear Band Pottery (LBP) culture around the mouth of the River Oder at the southern Baltic coast, centuries before agriculture was introduced in southern Scandinavia, has long been known (Grygiel and Bogucki 1993; Lüning 2000). From these settlements and other contemporaneous ones further east in the area of Cuiavia in Poland (Czerniak 1998), there is scattered but significant evidence of farming and animal husbandry (Heussner 1989; Bogucki 2000). The Neolithic settlements in the area south of the Baltic are dated to a period between 5500 and 4700 B.C. (Persson 1999), clearly predating the adoption of farming in southern Scandinavia, which did not occur before ca. 3900 B.C. Artefacts from the same period imported from—or locally produced but influenced by—LBP culture were found in Sweden and Denmark, such as the axe-types 'Schuhleistenkeilen' and 'Breitkeilen'. Moreover, based on a thorough investigation of Swedish aurochs remains, Ekström (1993) concluded that this species became extinct in Sweden slightly after 7000 B.C. The aurochs disappeared from eastern Denmark at the same time, although it survived in Jutland, western Denmark, until the Early Subboreal (Aaris-Sørensen 1980). Therefore, the presence of aurochs tooth beads in the graves of the Scanian Mesolithic cemeteries Skateholm I and II dated to ca. 5300–4700 B.C. (Jonsson 1988) suggests import from continental Europe where aurochs populations still existed. The practice of agriculture along the southern coast of the Baltic, less than 150 km from the Scanian coast, and occurrences of artefacts in Scania with provenance from the LBP culture, indicate that the hunter-gatherers of southern Scandinavia already had knowledge of farming practices at that time, but neglected their necessity. The LBP culture disappeared from the area close to the Baltic ca. 4700 B.C. and retreated further south (Lüning 2000). When a later expansion of Neolithic people arrived at the Baltic coast of present day Germany and Poland at ca. 3900 B.C., farming and animal husbandry became rapidly introduced to Denmark and vast areas of Sweden (Ammerman and Biagi 2003; Fischer and Kristiansen 2002).

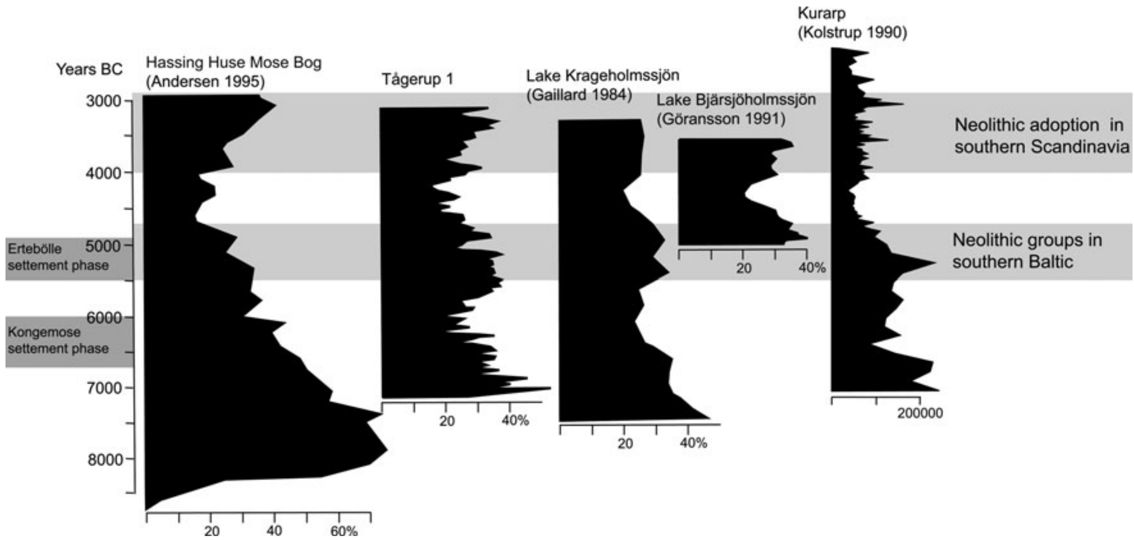

Fig. 5 Correlation of *Corylus* pollen curves from Denmark and southern Sweden. Positions of sites are shown in Fig 1. Curves represent pollen percentages except for the Kurarp diagram which is expressed as concentrations i.e. number of pollen/cm^3. See text for further explanations

There are not sufficient archaeobotanical data from Mesolithic sites in southern Scandinavia to make a precise quantification of the use of hazelnuts throughout this entire period. The marked decrease in *Corylus* in the lowermost part of zone T1:4a in the pollen diagram from Tågerup could be interpreted as a diminishing hazel population due to harvesting of nuts and especially to cutting sticks for tool-making. A substantial proportion of the wooden artefacts from the Ertebølle phase are made of hazel (Regnell and Sjögren 2006). At the end of the settlement phase *Corylus* is at first regaining its previous values but shows during the following 600–700 years a slow decrease during which the frequencies are reduced by half. However, a decrease in *Corylus* pollen during this specific period has counterparts in other investigations from southern Scandinavia. Here it is suggested that a reduced availability of hazelnuts, as interpreted from the decrease in *Corylus* pollen percentages during the later part of the Mesolithic, may have motivated adaption to farming (Fig. 5). The decrease in *Corylus* pollen may be caused by climate change. The beginning of this decrease is dated to about 4700 B.C. This coincides with indications of increased precipitation and lowered summer temperature in southern Sweden from ca. 4700 B.C., as interpreted from charcoal data inferring decrease in forest fire intensity (Greisman and Gaillard 2009; Olsson et al. 2010), as well as from stable isotope records (Hammarlund et al. 2003). Wetter and colder climate may have affected the hazel populations during this phase, since a positive correlation between temperature during the flowering season and pollen accumulation rate for *Corylus* has been found (Nielsen et al. 2010).

When Neolithic groups were present in the southern Baltic area, 5500–4700 B.C., *Corylus* show frequencies between 20 and 40% and high concentrations (Fig. 5). Pollen values decrease from 5500 B.C. reaching a minimum that occurs well after the disappearance of Neolithic groups from the region. The prominent decrease of *Corylus* pollen between c. 5500 and 4500 B.C. might be related to a reduction in nut production. When the next expansion of farming approached the coast of southern Baltic, in ca. 3900 B.C., Neolithic adaptation to farming took place rapidly and simultaneously in southern Scandinavia. At the first contact with Neolithic cultures, people in southern Sweden had an abundance of hazelnuts and perhaps relied on them as a staple food resource and, therefore, farming appeared less attractive. It is important to state that the decrease in hazel nut availability may have been one of several factors behind the adaptation to/introduction of farming in Sweden.

Conclusions

Despite considerable settlement activities at Tågerup, the pollen record does not indicate any substantial human impact on the vegetation during the Mesolithic. The presence of charcoal particles and pollen from grass and herbs associated with nutrient-rich soils are contemporaneous with the Kongemose settlement. The Ertebølle settlement phase, although characterised by considerable dwelling activities less than a hundred metres from the pollen sampling site, is scarcely seen in the pollen data. Apart from the changes in tree species composition during the Early Neolithic there is no indication of agriculture or other human impact on the vegetation during this period. In contrast the pollen composition during the latest part of the Early Neolithic and the earliest part of the Middle

Neolithic (3600–3200 B.C.) suggests a more open landscape than earlier and an increase in grazed areas (animal husbandry), however, still with no indication of agriculture.

Numerous finds of crushed dogwood stones suggest that they were used for the extraction of oil. Several other forest plants were found and some may have been specifically used for consumption, i.e. apples, cherries, raspberries, acorns and rowan-berries.

The importance of hazelnuts as a food source during the Mesolithic may have been underestimated in the literature. At the time of establishment of farming communities from continental Europe along the coasts of the southern Baltic between 5500 and 4700 B.C., *Corylus* exhibits pollen values between 20 and 40% in pollen diagrams from southern Scania and Denmark. The occurrence of imports from continental Europe (e.g. specific axe-types and aurochs beads) at Mesolithic sites in Scania implies that people in Scania might have been conscious of the farming practices in present northern Germany but did not yet adapt to a Neolithic way of life. During a later phase of the Mesolithic period, a regional decrease in *Corylus* as suggested by lower pollen percentages may indicate a decrease in the availability of hazelnuts. The latter may, in turn have led to a shortage in protein and energy resources in people's consumption, which may have forced them to alter their subsistence habits. When the next expansion of farming economy reached the Baltic coast of present day Germany, at about 3900 B.C., it led to an almost simultaneous adaption to farming and animal husbandry in Southern Scandinavia. Despite the pollen records suggesting that the hazel populations had regenerated considerably in the Early Neolithic, people had reasons to be less reliant on hazelnuts at around 3900 B.C. However, this hypothesis should be tested further through studies of the occurrence and types (carbonised, non-carbonised, fragmentation etc.) of hazelnut shells at settlements dated to the Middle and Late Mesolithic.

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