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Mid-holocene Vegetation Development at the Inland Ertebølle Settlement of Ringkloster, Eastern Jutland

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ABSTRACT

Two pollen diagrams have been produced from littoral lake sediments close to the Ertebølle settlement of Ringkloster with the aim of elucidating the development of the vegetation during the Ertebølle occupation and at the transition to the Funnel Beaker Culture. One of the diagrams, from radiocarbon-dated refuse layers containing artefacts from the Ertebølle and Funnel Beaker Cultures, provides a particularly good picture of the vegetation. Through a close stratigraphic relationship between the refuse layers and the pollen-analytical investigations, evidence for woodland disturbance contemporary with the occupation of the Ertebølle settlement can be demonstrated. The disturbance is primarily in the form of very early elm and lime declines, which in all probability are anthropogenic in origin. At the transition to the Funnel Beaker Culture, ca. 3900 cal. BC, the woodland cover is reduced and open-habitat herbs increase. At the same time there is the first occurrence of *Plantago lanceolata* and the pollen diagrams register the earliest agricultural activity, pastoral farming, in the vicinity of the Ringkloster settlement. The investigation shows, furthermore, a lowering of the water level in the lake at the Mesolithic/Neolithic transition (Atlantic to Sub-boreal), indicating a shift towards a drier climate.

INTRODUCTION

Archaeological investigations have been carried out between 1969 and 1985 at the Ertebølle settlement site of Ringkloster, which lies south of Skanderborg Sø (fig. 1). The findings have been published by the excavation director, Søren H. Andersen, Institute of Prehistoric Archaeology, University of Aarhus (Andersen 1975; 1979; 1994; 1998 - this volume). Biostratigraphical investigations were carried out in conjunction with the archaeological investigations and samples were collected with the aim of investigating the contemporary vegetation at the site. The biostratigraphical fieldwork was carried out by C. Malmros and C. Christensen of the National Museum, Natural Science Research Unit, and J. Ørnbøl, formerly attached to the Institute of Prehistoric Archaeology, University of Aarhus. All the pollen samples were prepared and counted by J. Ørnbøl.

The final processing and publication of the pollen-analytical data was transferred to the Geological Survey of Denmark and Greenland and the present author, whose presentation here is based exclusively on the already existing pollen data.

With the exception of Djursland, the Holocene vegetation development in eastern Jutland has been scantily investigated and there is in particular a lack of radiocarbon-dated pollen diagrams from this part of Denmark. The pollen diagrams nearest to the Ringkloster settlement are the very early ones from Brabrand near Århus, about 17 km from Ringkloster (Troels-Smith 1937) and Dyrholmen on Djursland, about 49 km from Ringkloster (Troels-Smith 1942) (fig. 1). Both diagrams were produced from deposits associated with archaeological settlements from the Ertebølle Culture, but without any direct correlation

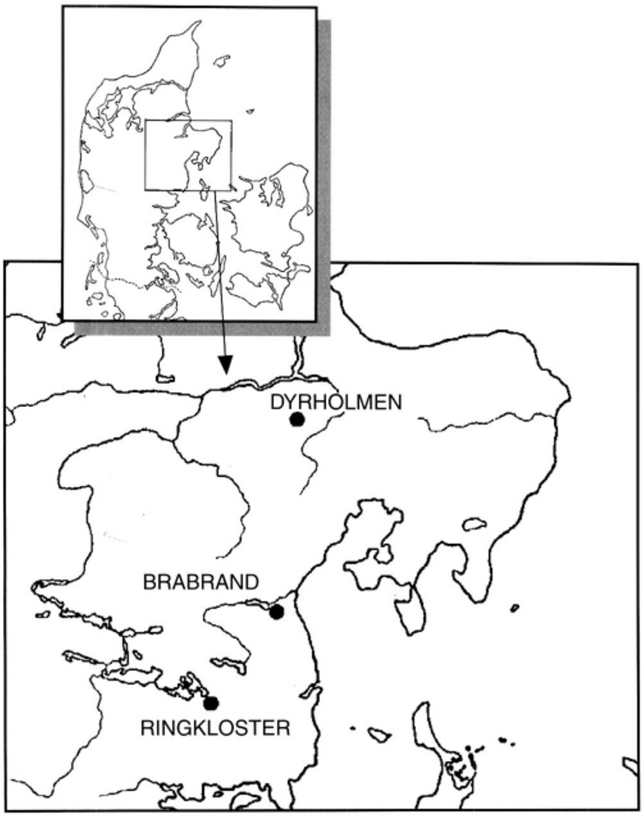

Fig. 1 Map of Denmark showing the location of Ringkloster and the sites of the nearest pollen diagrams: Brabrand and Dyrholmen (after Andersen 1975).

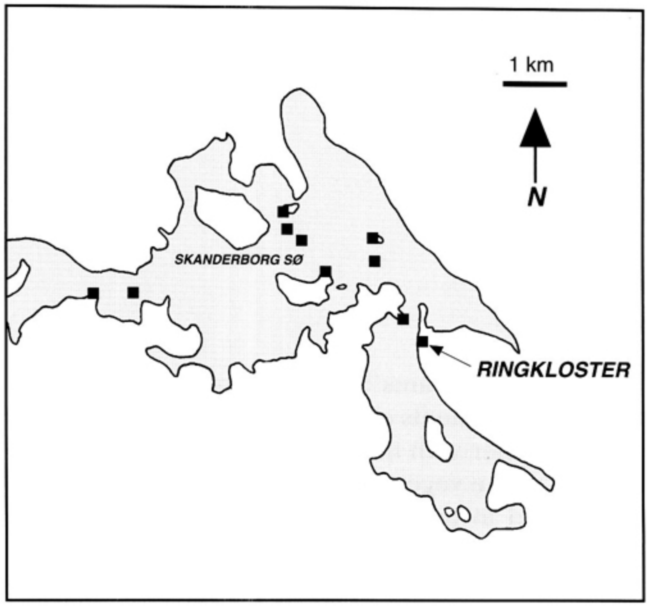

Fig. 2 Skanderborg Sø´s presumed extent in the Mesolithic period. The Ringkloster settlement and all other known Mesolithic settlements are marked (after Andersen 1975).

between the diagrams and the archaeological layers. The diagrams are not radiocarbon dated, as they were produced before the method was introduced.

Like the investigations at Brabrand and Dyrholmen, the pollen-analytical investigations at Ringkloster had, as their main aim, the description of the development of the vegetation during the Ertebølle occupation and at the later transition from the Mesolithic to the Neolithic, i.e. from the Ertebølle Culture to the Funnel Beaker Culture.

THE RINGKLOSTER SETTLEMENT

The Ringkloster settlement is situated by a now overgrown, but earlier open, arm of Skanderborg Sø, which extended about 3 km south-southeast of the present-day lake (fig. 2). The settlement lies at the foot of a clayey moraine slope, facing out over the former lake. Ringkloster is the only inland settlement from the Ertebølle Culture excavated in Jutland so far. The archaeological investigations took place partly on dry land, in the settlement area itself, and partly in the refuse layers extending out from the settlement into the adjacent lake deposits. The refuse layers contained very large numbers of archaeological artefacts which are presumed to have been thrown out into the lake from the settlement (Andersen 1975; 1979). They also contained extremely well-preserved animal remains, which is quite unique for Jutland. Analyses of the latter show that the site was used primarily in the winter (November to May) and that the economy was based primarily on hunting of wild boar (*Sus scrofa*), red deer (*Cervus elaphus*) and pine marten (*Martes martes*) while fishing and gathering was of minor importance Andersen 1975; 1979; 1994; Enghoff 1998 - this volume; Rowley-Conwy 1998 - this volume).

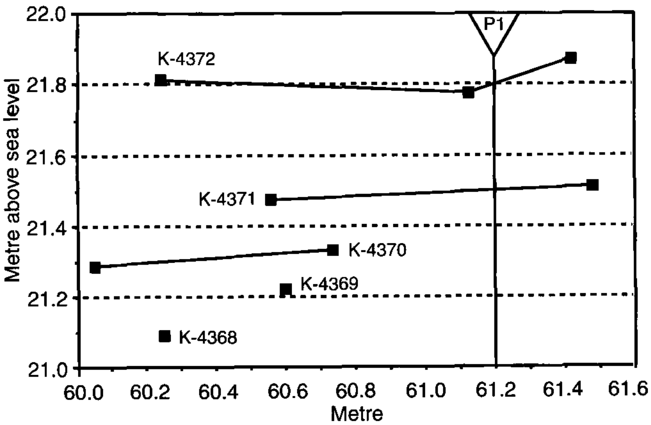

Fig. 3 Vertical and horizontal distribution of the radiocarbon-dated pieces of wood in the lake sediments in relation to the sampling site for the pollen diagram P1. The linked pieces comprise the material used for one date.

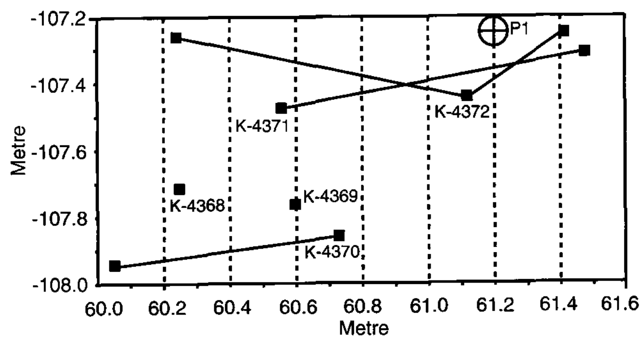

Fig. 4 Horizontal distribution of the radiocarbon-dated pieces of wood in the lake sediments in relation to the sampling site for the pollen diagram P1. The linked pieces comprise the material used for one date.

The settlement belongs primarily to the Ertebølle Culture, but occasional earlier and later finds have also been recovered from the site (Andersen 1975; 1979).

For a detailed description of the stratigraphical relationship between the pollen samples and the archaeological finds, reference is made to S. H. Andersen's paper in this volume (1998).

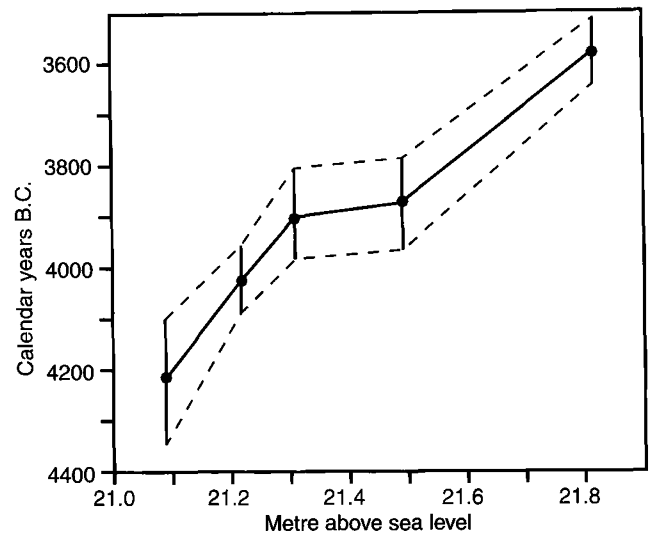

Fig. 5 Time/depth curve for section P1. The limits for one standard deviation are indicated.

METHODS

Coring and sampling

The biostratigraphical investigations were carried out in the littoral sediments immediately adjacent to the settlement, where samples were collected for pollen analysis, partly from open sections, partly by coring. Samples for the two diagrams presented in this article, P1 and B, were collected in the following way: samples for diagram P1 were taken from an open section produced during the excavation of the archaeological layers. The layers adjacent to the sampling point were drawn and described and wood samples were taken for radiocarbon dating. Samples for diagram B were taken further out in the lake basin using a Hiller corer.

Diagram P1 is from the area with archaeological deposits and diagram B is from beyond the archaeological layers. The two sampling sites lie ca. 17 metres and ca. 24 metres respectively from the former shore (see Andersen 1998, fig. 7 - this volume).

In addition to these two diagrams, which are the most important, several other sample series were taken for pollen analysis, as well as a large number of individual samples, which were collected in connection with characteristic Ertebølle artefacts. Some of these samples have been analysed (also by J. Ørnbøl) but the results will not be presented here.

Radiocarbon dating

Five conventional radiocarbon dates have been obtained for charcoal and partly-charred wood found in the lake deposits close to the sampling site for diagram P1. Fig. 3 and fig. 4 show the horizontal and vertical positions of the dated wood relative to the pollen diagram.

The radiocarbon dates were produced by H. Tauber at the Copenhagen Radiocarbon Laboratory. Calibration of the radiocarbon age to calendar years was performed using the CALIB computer programme (version 3.0.3) from the University of Washington with the 20 year averaged atmospheric curve (Stuiver & Reimer 1993).

On the basis of the calibrated dates a time/depth curve has been established for diagram P1 (Fig. 5). The construction of this curve required a single point (age) for each date; the central value in the calibration interval at one standard deviation has been chosen as this point (cf. Molloy & O'Connell 1991).

Pollen analysis

34 pollen samples were analysed from both sampling point B and P1.

The pollen samples were treated with HCl, KOH and acetolysis mixture (a few samples were also treated with HF) and mounted in silicone oil.

The number of pollen counted (pollen sum) in each sample varied greatly. In diagram B the pollen sum varies from 229 to 1266 (average 521), and in diagram P1 from 128 to 7960 (average 1420). The very high sums in the latter diagram were counted in samples dominated by *Alnus* (in the sample with a sum of 7960 pollen counted, 7610 pollen grains were of *Alnus*).

Table 1 gives a list of the plant names used in Latin, English and Danish. The plant nomenclature follows *Flora Europaea* (Tutin *et al.* 1964-1980), apart from Poaceae (= Gramineae); the English names follow Clapham *et al.* (1987), and the Danish names Hansen *et al.* (1981).

The construction of the pollen diagrams

The pollen taxa have been grouped into five categories: Trees, shrubs/dwarf shrubs, terrestrial (dry land) herbs, plants of uncertain habitat and reed swamp species/aquatics.

The pollen percentages are calculated on the basis of the sum of pollen of unambiguous terrestrial plants, i.e. trees, shrubs/dwarf shrubs and terrestrial herbs.

The diagrams have been divided up into 3 local pollen assemblage zones (R1, R2 and R3).

Pollen of *Alnus* occurs in very large numbers both in diagram B (fig. 6 and 7) and P1 (fig. 8 and 9). This is undoubtedly due to the location of the pollen sampling sites close to the shore. *Alnus* was presumably the locally dominant tree species on the wet soils of the lake margin, and as a result this taxon is over-represented in the diagrams. Analysis of the uncarbonised wood from the settlement's refuse layers reveals a great dominance of *Alnus* (Malmros 1986). Most of this wood probably became incorporated in the sediments by natural means. It can therefore be assumed to reflect the woodland composition in the area around the settlement and as such it underlines the evidence from the pollen diagrams with regard to alder's dominant role. The over-representation of *Alnus* made it difficult to choose a pollen sum for calculating the pollen percentages. If *Alnus* is included in the pollen sum it will "depress" the other pollen curves and as a consequence the diagram will give a somewhat distorted picture of the regional vegetation in the area. If *Alnus* is excluded from the pollen sum the picture will also be distorted as *Alnus* has played a role in the regional vegetation. On balance, the decision was made to include *Alnus* in the pollen sum (fig. 6 and 8). For the sake of comparison, the tree pollen curves for the two diagrams are, however, also shown with *Alnus* excluded from the pollen sum (fig. 7 and 9).

Due to the very local nature of the pollen input represented in the diagrams, there is some uncertainty regarding the habitats to which certain taxa should be ascribed. This applies not least to the wild grasses (Poaceae), which in regional pollen diagrams are normally classed as terrestrial (dry land) herbs, but which at this site could equally well come from very local wetland species (such as *Phalaris arundinaceae* and *Phragmites australis*). Accordingly, changes in the curve for wild grasses cannot unequivocally be interpreted as an expression of changes in the regional terrestrial vegetation, there could also have been local changes in the wetland vegetation around the lake.

The pollen diagrams were produced using the programmes TILIA and TILIA-GRAPH (Grimm 1990).

RESULTS

Sediments

The stratigraphy at the two sampling sites (B and P1) is described below (note that all meaurements of depth are given as metres above sea level).

Site B: Sediment core, 2.25 metres long. Description of the sediment stratigraphy and collection of pollen samples carried out by J. Ørnbøl (1984).

19.33-20.48:	Reddish-brown fine gyttja with molluscs. Scattered pieces of wood.
20.48-21.58:	Reddish-brown fine gyttja. Scattered pieces of wood.

Site P1: Open section, sampled sequence, 3.43 metres long. Description of sediment stratigraphy and collection of pollen samples carried out by C. Malmros and C. Christensen (Malmros 1972) (se also Andersen 1998 - this volume).

-20.46:	Dark grey sand with molluscs.
20.46-20.86:	Yellowish-brown fine gyttja with molluscs. Few artefacts.
20.86-20.91:	Yellowish-brown fine gyttja with molluscs.
20.91-21.41:	Dark yellow-brownish-grey coarse drift gyttja with molluscs. Charcoal and stones up to 5 cm.
21.41-21.71:	Brownish-yellow coarse drift gyttja without molluscs. Pottery, flint, charcoal and stones.
21.71-21.96:	Reddish-brown rather coarse drift gyttja.
21.96-22.36:	Reddish-brown gyttja (?) with secondary tree roots.
22.36-23.01:	Yellowish-brown alder fen peat.
23.01-23.61:	Black highly-humified alder fen peat.
23.61-23.89:	Yellowish-brown recent grass turf.

Chronology

The following is a list of the material dated and the results obtained (radiocarbon years bp) for the five samples associated with diagram P1. The identification of the charcoal and partly charred wood dated was carried out by C. Malmros (1984).

K-4372: 4800 ± 65 bp
Sample comprised three pieces of wood:
1 piece of *Fraxinus*; 1592 OBJ; level 21.86
1 piece of *Alnus*; 1592 OCP; level 21.81
1 piece of *Alnus*; 1592 OEC; level 21.77

K-4371: 5080 ± 70 bp
Sample comprised three pieces of wood:
1 piece of *Frangula*; 1592 GNE; level 21.50
1 piece of *Alnus*; 1592 GNE; level 21.50
1 piece of *Corylus*; 1592 GQO; level 21.47

K-4370: 5120 ± 70 bp
Sample comprised two pieces of wood:
1 piece of *Alnus*; 1592 GSN; level 21.33
1 piece of *Ulmus*; 1592 GRO; level 21.29

K-4369: 5200 ± 70 bp
Sample comprised one piece of wood:
1 piece of *Tilia*; 1592 GUW; level 21.22

K-4368: 5410 ± 95 bp
Sample comprised one piece of wood:
1 piece of *Corylus*; 1592 PDD; level 21.09

The five radiocarbon dates have been calibrated to calendar years and on the basis of these, a time/depth curve has been established for diagram P1 (fig. 5). In the list below the five dates are given in radiocarbon years bp, along with the calibration intervals at 1 standard deviation and the central value in the calibration interval which was used in constructing the time/depth curve.

Lab. no.	Av. level	^{14}C-age *yr bp*	Cal ± 1 std *yr BC*	Cal *yr BC*
K-4372	21.81	4800 ± 65	3650-3510	3580
K-4371	21.49	5080 ± 70	3970-3790	3880
K-4370	21.31	5120 ± 70	3980-3800	3890
K-4369	21.22	5200 ± 70	4070-3960	4020
K-4368	21.09	5410 ± 95	4350-4100	4220

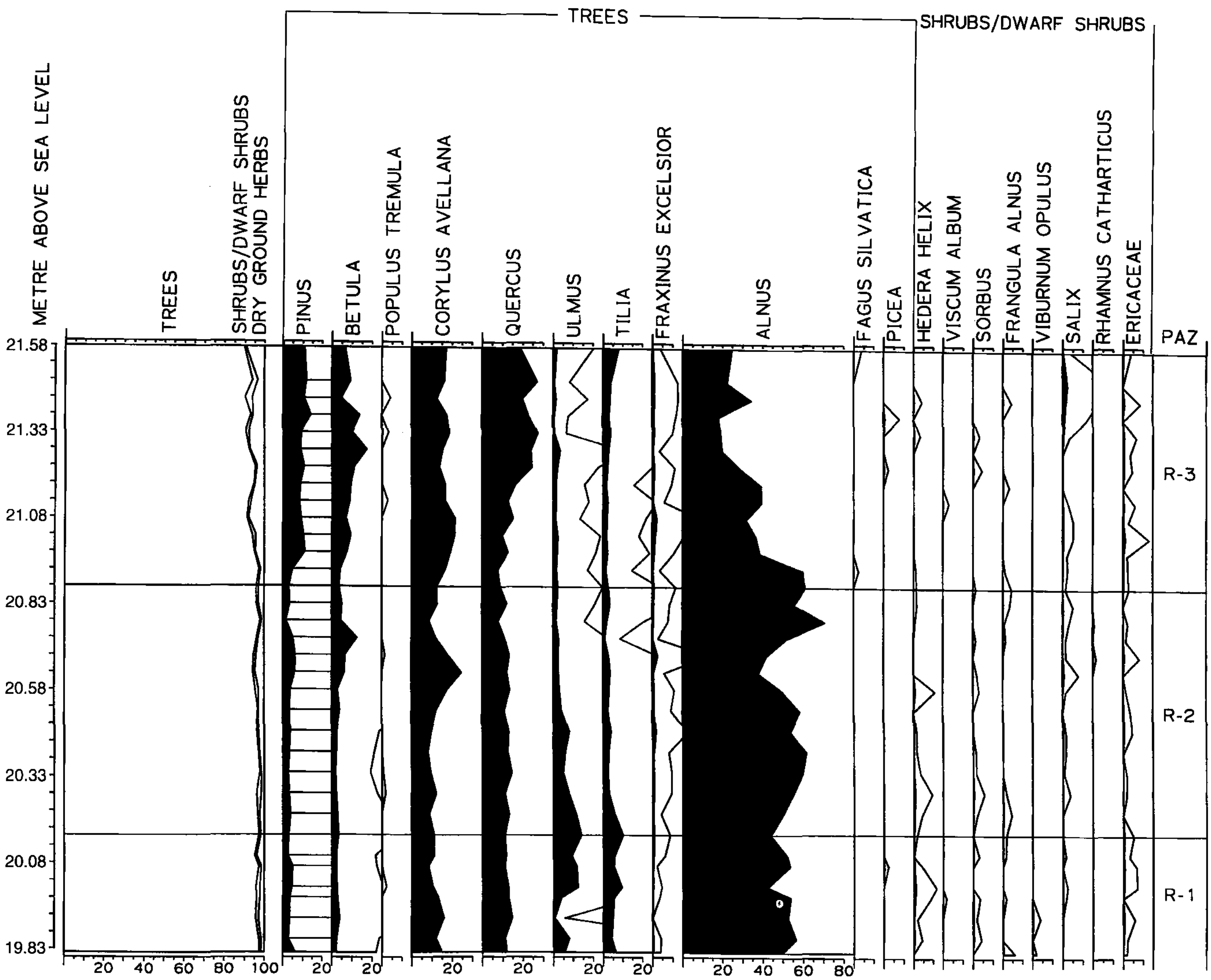

Fig. 6 Pollen diagram B. Percentage diagram calculated on the basis of pollen from the plant categories included in the summary diagram (trees, shrubs/dwarf shrubs and terrestrial (dry land) herbs). The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

The pollen diagram and the archaeological layers are dated on the basis of the time/depth curve. The ages given for the archaeological layers in this article can deviate slightly from those mentioned with respect to the same layers in Andersen's paper in this volume as in the latter, reference is exclusively made to individual radiocarbon dates.

Inferred Vegetation

Diagram B (fig. 6 and 7) The diagram is divided up into 3 zones. Zones R1 and R2 cover the Late Atlantic and zone R3 the early Sub-boreal.

Local pollen assemblage zone R-1: High percentage values of *Tilia*, *Quercus*, *Corylus*, *Ulmus* and *Alnus* show that these taxa were common. In addition, the woodland also included modest amounts of *Betula* and

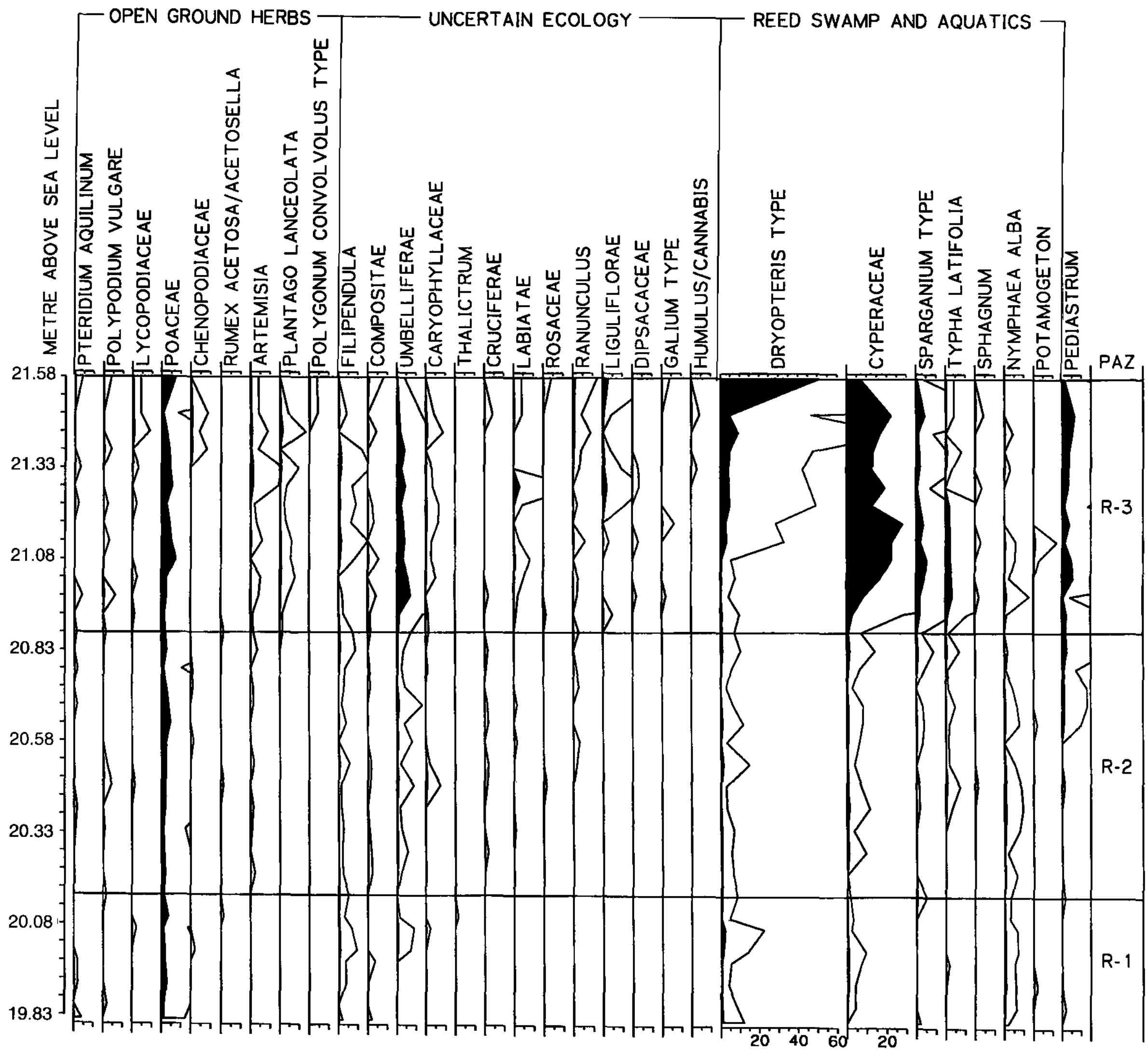

Fig. 6 continued

Fraxinus, along with occasional occurrences of *Populus*. It is difficult to say to what extent *Pinus* grew in the area at this time, as the pine pollen in the diagram could be the result of long-distance transport. *Sorbus* also grew in the woodland as did Ericaceous dwarf shrubs. *Hedera* was common, whilst *Viscum* had a scattered distribution. Total tree pollen values in the zone vary between 95.2% and 97.4% (fig. 6), which shows that the landscape was covered by dense woodland. The vegetation on the woodland floor was sparse; wild grasses were the most common herbs. There were, in addition, scattered occurrences of Chenopodiaceae and *Rumex acetosa/ acetosella*; *Pteridium*, *Polypodium* and members of the Lycopodiaceae grew on acid soils.

Woodland on wet soils close to the lake was completely dominated by *Alnus*; but *Frangula*, *Viburnum* and *Salix* presumably also grew there. The herb vegetation in the alder carr was modest, being represented by *Dryopteris*-type, Cyperaceae, *Sparganium*-type and *Typha*. Several of the herbs of uncertain habitats, such as *Filipendula* and members of the Umbelliferae, probably also grew here. Out in the lake itself there were stands of *Nymphaea* and *Potamogeton* as well as small amounts of the green alga *Pediastrum*.

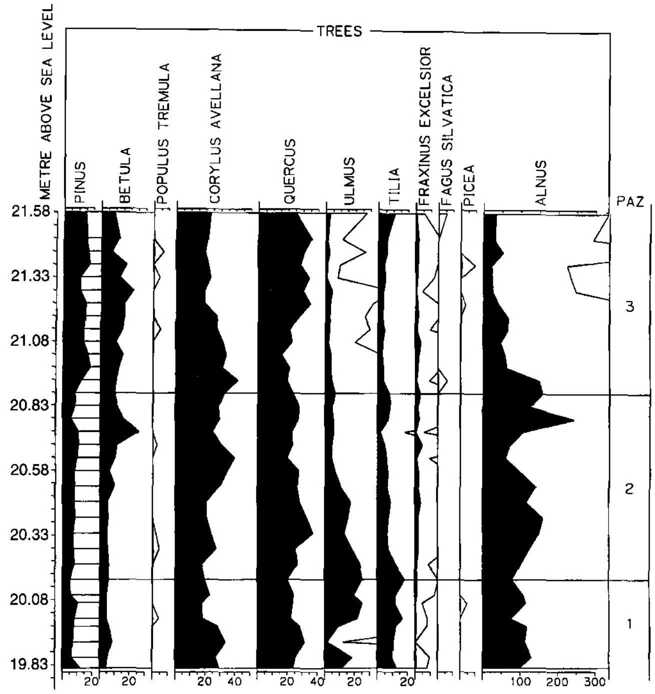

Fig. 7 Diagram B exclusively showing tree pollen curves. Percentage diagram calculated on the basis of total land plant pollen excluding *Alnus*. The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

Local pollen assemblage zone R-2: The woodland composition changes significantly in this zone. At the start of the zone there is a clear decline in *Tilia*, and at the same time an elm decline begins. The latter takes place in two stages: a) an initial decline in which values fall from 14% to 5.1%, followed by a slight regeneration, and b) a second decline in which elm values fall from 8% to 1.6% (fig. 6). In the diagram calculated with *Alnus* excluded from the pollen sum, the curves for *Tilia* and *Ulmus* show a similar sequence of events with a marked decline in *Tilia* and a two-stage decline in the elm curve (fig. 7). Contemporary with elm's final decline, *Corylus* becomes more abundant and reaches a small peak (fig. 6). A little later, when *Corylus* declines again, there is a small peak in *Betula*. The frequencies of *Quercus* and *Fraxinus* are more or less constant throughout the whole zone. Apart from the tree species already mentioned there were still occasional scattered occurrences of *Populus* in the woodland. Shrubs are represented by *Sorbus* and *Rhamnus* and dwarf shrubs by members of the Ericaceae. *Hedera* is common at the start of the zone but declines in abundance towards the end. Total tree pollen values lie between 94.3% and 97.9% (fig. 6), and woodland quite clearly still dominated the landscape, even though a slight increase in the frequency of terrestrial herbs is evident. This rise consists primarily of pollen of wild grasses. As mentioned earlier, the possibility cannot be excluded that this is due to an increase in the local input of grass pollen from the wetland vegetation. Terrestrial herbs present included *Artemisia*, Chenopodiaceae and *Rumex acetosa/acetosella*; *Pteridium*, *Polypodium* and members of the Lycopodiaceae grew on acid soils.

The wetland area close to the lake continued to be dominated totally by alder, probably with scattered *Salix* and *Frangula*. The still sparse wetland herb vegetation comprised *Dryopteris*-type, Cyperaceae, *Sparganium*-type, *Typha* and *Sphagnum*, as well as presumably *Filipendula* and members of the Umbelliferae. Aquatic plants in the lake are represented by *Nymphaea* and *Potamogeton* and the green alga *Pediastrum*, which increases in frequency towards the end of the zone.

Local pollen assemblage zone R-3: *Ulmus* declines further, particularly towards the end of the zone, at about which time *Tilia* increases. *Quercus*, *Corylus* and *Betula* all show marked increases relative to the previous zone. Values of *Fraxinus* are relatively constant. The few pollen grains of *Fagus* and *Picea* are due to long-distance transport. *Populus*, *Sorbus* and a good many Ericaceous dwarf shrubs were scattered around in the woodland. There were also scattered occurrences of *Hedera* and *Viscum*. Total tree pollen values lie between 89.8% and 97.4% (fig. 6), and in comparison with the previous zone this represents somewhat of a decline. With the decline in the woodland, there is a corresponding increase in terrestrial herbs, including a general increase in wild grasses. Values of *Artemisia* and Chenopodiaceae rise and *Plantago lanceolata* makes its first appearance. Apart from the light-demanding herbs already mentioned, there are occasional records of *Rumex acetosa/acetosella* and *Polygonum convolvulus* type. *Pteridium*, *Polypodium* and presumably also members of the Lycopodiaceae made up the vegetation on acid soils.

Marked changes are seen in the wetland vegetation by the lake. At the beginning of the zone there is a drastic reduction in the previously dense alder woodland, which is followed by a significant increase in wetland herbs. This applies in particular to Cyperaceae, but is also marked in the case of *Dryopteris*-type, *Sparganium*-type and *Typha* as well as to a lesser extent for *Sphagnum*. *Filipendula* and members of the Umbelliferae, which are presumed to have been part of the wetland vegetation, also increase markedly. *Nymphaea* and *Potamogeton* continued to grow in the lake and the amount of the green alga *Pediastrum* is more or less constant.

Diagram P1 (fig. 8 and 9). In the open section from where the pollen samples for diagram P1 were taken, ceramics and other archaeological finds were in evidence. At the base of the section there was thick-walled Ertebølle pottery. Above this were uncharacteristic sherds which could not be unequivocally assigned to an archaeological culture, but which on the basis of the radiocarbon dates must belong to the Ertebølle Culture, or possibly the Ertebølle/Funnel Beaker transition. Above this again, and separated by a horizon poor in finds, were a number of potsherds belonging to an early Neolithic funnel beaker of Volling type (Andersen this volume).

Like diagram B, the pollen diagram is divided up into 3 zones. Zones R1 and R2 cover the late Atlantic and zone R3 covers the early Sub-boreal.

Local pollen assemblage zone R-1: There are high values for almost all the woodland tree species: *Tilia*, *Ulmus*, *Quercus* and *Corylus*, although *Betula* and, in particular, *Fraxinus* are only relatively modestly represented. *Populus* occurred only sporadically in the woodland. As mentioned earlier, it is difficult to determine whether *Pinus* grew in the area or whether the pollen is present due to long-distance transport. The finding of pine wood (charcoal and uncarbonised wood) in the refuse layers, does however show that this species must have grown locally (Malmros 1986). *Hedera* is frequent throughout the zone and *Viscum* is not uncommon. Shrubs in the woodland are represented by *Crataegus* and *Ilex*, whilst *Salix*, *Frangula* and *Viburnum* were presumably associated with wetland areas close to the lake. The dwarf shrub vegetation comprised one or more species of Ericaceae. Total tree pollen values are high (96%-99.6%) (fig. 8) and the pollen diagram thus reveals a densely wooded landscape. Terrestrial herbs comprise primarily wild grasses and both *Pteridium* and *Polypodium* were present on acid soils.

Wet areas near the lake supported almost exclusively *Alnus*. The wetland herb vegetation was limited, being represented by Cyperaceae, *Dryopteris*-type, *Sparganium*-type, *Typha*, *Sphagnum* and *Lythrum*; *Filipendula* and members of the Umbelliferae almost certainly also grew here. *Nymphaea* grew in the lake where there were also small quantities of the green alga *Pediastrum*.

Local pollen assemblage zone R-2: This zone begins with a decline in both *Tilia* and *Ulmus* (fig. 8). *Tilia* declines sharply and rapidly, whereas the decrease in *Ulmus* takes place over a somewhat longer period. Parallel with the decline in *Tilia*, there is also a clear reduction in *Fraxinus*. If *Alnus* is excluded from the pollen sum, the elm decline occurs slightly later than the decline in *Tilia* and *Fraxinus* (fig. 9). The overrepresentation of *Alnus* pollen in the diagram makes it therefore difficult to place the elm decline precisely. In the diagram calculated with *Alnus* in the pollen sum, the elm decline lies at level 20.94 (fig. 8), whereas in the diagram calculated with *Alnus* excluded from the pollen sum it lies 10 cm higher up at level 21.04 (fig. 9). There are no marked changes in the curves for *Quercus*, *Corylus* and *Betula* relative to the situation in zone R1 (fig. 8). Shrub vegetation in the woodland is represented by *Crataegus*, *Ilex* and *Juniperus*, whilst *Salix* and *Frangula* would probably have been found on wet soils. Dwarf shrubs are represented by one or more species of the Ericaceae. *Hedera* becomes less abundant at the same time as the *Tilia* curve falls. Total pollen values for the woodland trees are at the same high levels as seen in the previous zone (97.2%-99.4%) (fig. 8), and the woodland was still dense with only a relatively sparse herb vegetation. Values for terrestrial herbs lie between 0.2% and 2.1%, being made up primarily of wild grasses plus modest occurrences of Chenopodiaceae, *Polygonum convolvulus*-type, *Artemisia* and *Rumex acetosa/acetosella* and some *Polypodium*. The very low values for terrestrial herbs apparent in the diagram probably do not give a true picture of the vegetation, as the increased local input of *Alnus* pollen "depresses" the other pollen curves.

On wet soils, *Alnus* became very abundant (up to 91.8%) and there is no doubt that the pollen diagram is strongly influenced by the local vegetation.

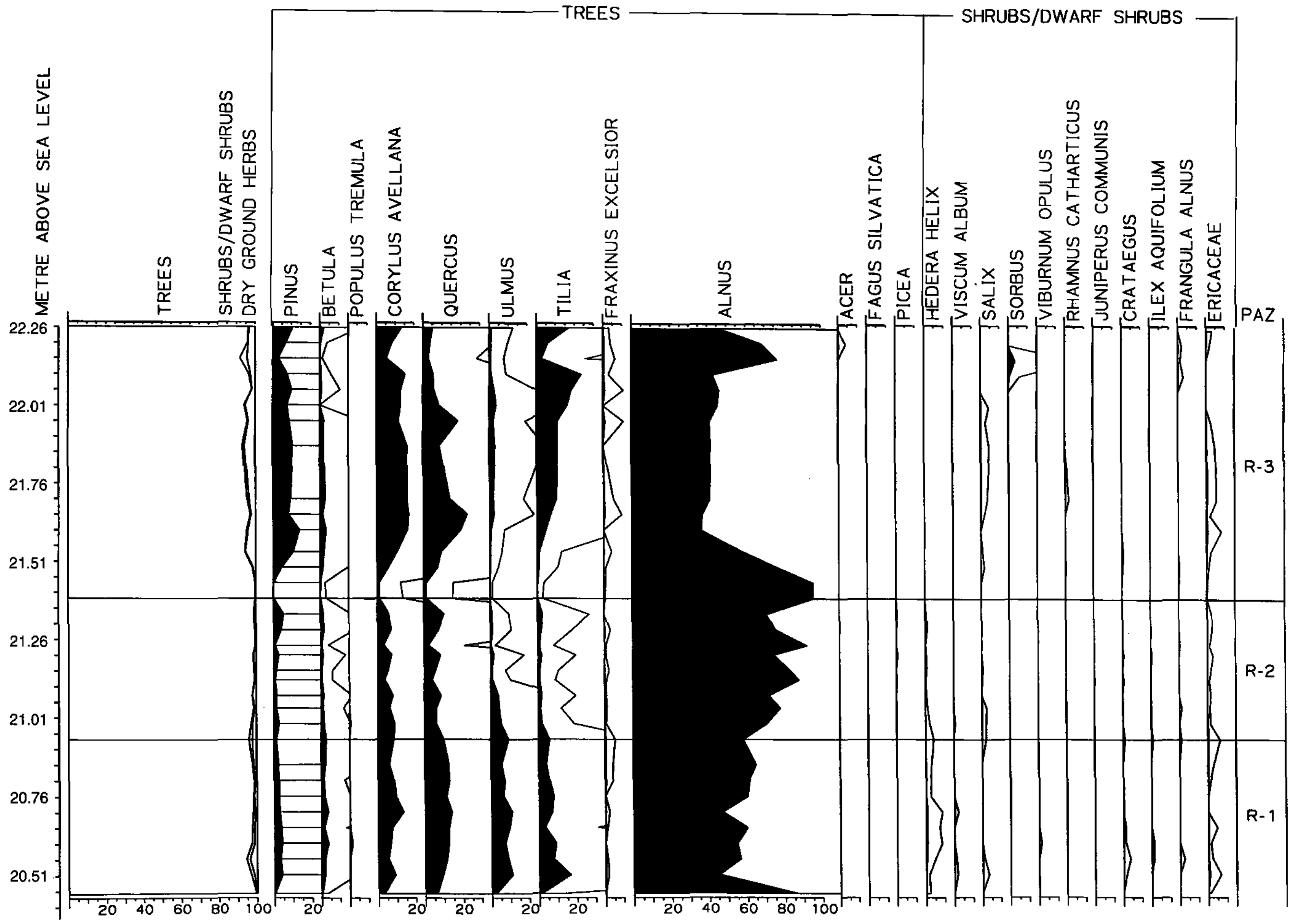

Fig. 8 Pollen diagram P1. Percentage diagram calculated on the basis of pollen from the plant categories included in the summary diagram (trees, shrubs/dwarf shrubs and terrestrial (dry land) herbs). The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

The wetland herb vegetation is relatively limited in extent and consists of *Dryopteris*-type, Cyperaceae, *Sparganium*-type, *Sphagnum*, *Typha* and *Lythrum*. *Filipendula* and members of the Umbelliferae, as mentioned earlier, probably also grew in wetland habitats. Out in the lake itself *Nymphaea* and *Nuphar* were in evidence and in the middle of the zone the amount of the green alga *Pediastrum* increases.

Local pollen assemblage zone R-3: Significant changes occur in several of the tree pollen curves. At the beginning of the zone all the pollen curves are depressed by the extremely high values of *Alnus* (up to 95.7%) (fig. 8). Some way into the zone the *Tilia* curve increases very markedly, and at approximately the same time there is a clear increase in *Ulmus*. The pollen curve for *Quercus* is somewhat irregular, reaching rather low values towards the end of the zone, where there is also a reduction in *Betula*. *Fraxinus* is rather modestly represented, whilst values for *Corylus* are relatively high and constant throughout the zone. The curve for *Pinus* rises at the beginning of the zone and maintains relatively high values throughout. In addition to the tree species mentioned above, there are occasional records of *Acer*. With regard to the shrubs, there are occasional records of *Rhamnus*, whilst *Sorbus* is very abundant in one particular spectrum. The dwarf shrub vegetation comprises one or more species of the Ericaceae. The total pollen values for the woodland trees lie between

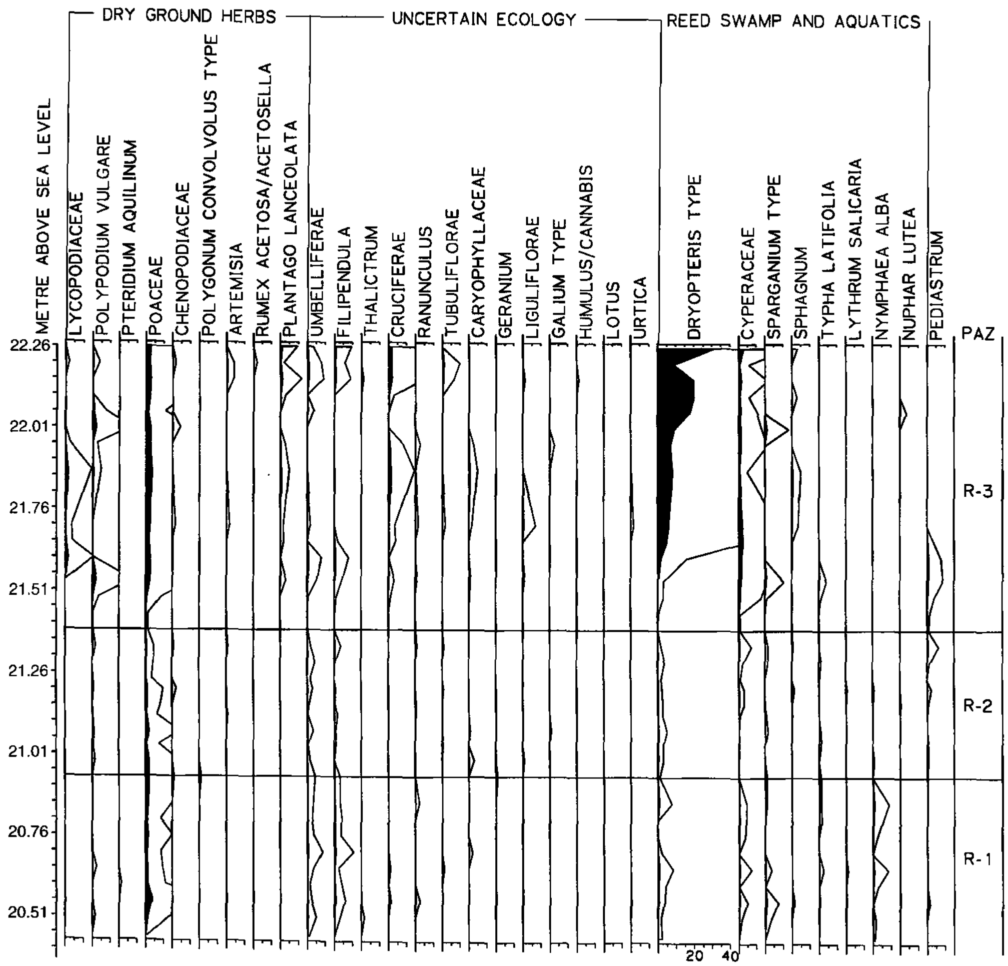

Fig. 8 continued

91.9% and 99.7% (fig. 8), which is a clear reduction relative to zones R1 and R2. There is a corresponding increase in terrestrial herbs, and the frequency of wild grasses in particular increases. *Plantago lanceolata* appear as a new species; initially with low values, but towards the end of the zone there is a small peak in the curve, which coincides with a peak in *Artemisia*. In addition to the terrestrial herbs already mentioned, there are occasional occurrences of Chenopodiaceae and *Rumex acetosa/acetosella*, as well as, in part of the zone, unusually high values of *Polypodium* and members of the Lycopodiaceae.

Significant changes occur in the wetland vegetation. At the beginning of the zone *Alnus* declines abruptly and elements in the wetland herb vegetation increase sharply. This applies in particular to *Dryopteris*-type, but also to some degree to Cyperaceae. There are, furthermore, records of *Sparganium*-type, *Sphagnum* and *Typha*. Aquatic plants in the lake are represented by a single record of *Nuphar*. The green alga *Pediastrum* occurs at the start of the zone only later to disappear completely.

Correlation of diagrams B and P1: The two pollen diagrams (fig. 6 and 8) can be correlated with one another on the basis of the elm decline and the first occurrence of *Plantago lanceolata*.

In both diagrams, zone R1 comprises the period up to the elm decline. A comparison of the length of the zone in the two diagrams is made difficult by the very dissimilar pollen curves. The curve for *Filipendula* is the only one which has an almost identical course in zone R1 in both diagrams. This is of course a very fragile basis on which to correlate, but can be cautiously interpreted as indicating that the zone is of about the same length in both B and P1.

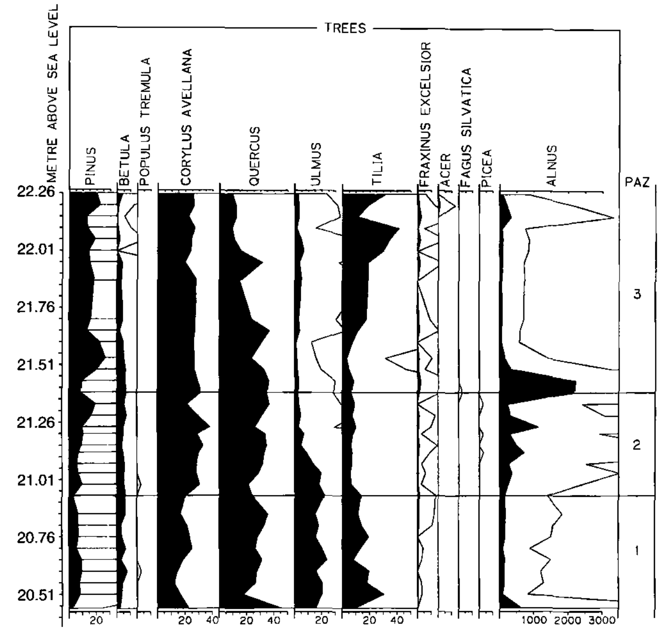

Fig. 9 Diagram P1 exclusively showing tree pollen curves. Percentage diagram calculated on the basis of total land plant pollen excluding *Alnus*. The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve.

Zone R2 covers the period from the beginning of the elm decline until the first appearance of *Plantago lanceolata*. The zone can be assumed to be of the same length in both diagrams.

Zone R3 covers the period from the first occurrence of *Plantago lanceolata* and some way into the Neolithic Period. Here too, a comparison of the length of the zone in the two diagrams is made difficult by the very dissimilar pollen curves, but if use is made of the curve for *Dryopteris*-type, which ends with a sharp rise in both diagrams, it can be cautiously assumed that the zone has approximately the same length in the two diagrams.

As the diagrams in all probability cover approximately the same time period and are located very close to one another, the development of the vegetation reflected in them can be compared directly. In some aspects there are similarities between the two diagrams, but there are also rather large differences. The most important similarities include: the elm decline and the simultaneous reduction in *Tilia*; the first occurrence of *Plantago lanceolata*; the generally high values for *Alnus* in zones R1 and R2; the decline of *Alnus* in zone R3; increased values for *Pinus* and in part *Tilia* in zone R3.

The majority of the above-mentioned similarities are of a general nature. If the pollen curves are examined in detail, great differences are seen. Some of these differences are presumably a consequence of the littoral locations of the sampling sites. This conclusion is supported by, among other things, the *Alnus* curve in the two diagrams. *Alnus* is over-represented in both diagrams, but the values for *Alnus* are very different. In diagram P1 (fig. 8) *Alnus* is much more strongly represented than in diagram B (fig. 6), which can be explained by the fact that P1 lies closest to the shore and thus closest to the alder woodland growing there.

The strongly dissimilar *Tilia* curves in the diagrams in zone 3 are difficult to explain. In the diagram furthest from land (B; fig. 6), the maximum value for *Tilia* is 8.2%, whereas in the diagram closest to the shore (P1; fig. 8) *Tilia* has a maximum value of 23.5%. This discrepancy could be a consequence of the sampling site for the latter diagram being closer to the shore where differing sedimentation conditions prevailed, but the nature of the precise mechanism is unknown.

Another factor which could be involved in the dissimilarities between the two diagrams is the human element. The Ringkloster settlement lies very close to the sampling sites and the occupants of the settlement obviously influenced the lake sediments by way of the many items of flint, stone, bone, antler and pottery which were thrown out into the lake. These activities would naturally have caused disturbances in the layers which could have contributed to the dissimilarities between the diagrams.

DISCUSSION

Diagram P1 provides the best basis for studying the correlation between the archaeological and the vegetational developments at the Ringkloster settlement as the pollen analyses were carried out directly on the archaeological layers.

In the pollen diagram P1 (fig. 10) the horizons containing finds of the various pottery types are marked with continuous lines. Other archaeological artefacts occur in these deposits, but delimitation of the horizons has been carried out solely on the basis of the pottery. Identification of the pottery was carried out by the director of the excavation, S. H. Andersen; for details see Andersen this volume. In the horizon termed *Ertebølle* (level 20.81-21.46), thick-walled pottery of undoubted Ertebølle type appears between level 20.81 and 21.12. Between level 21.27 and 21.46 the potsherds are of an uncharacteristic type which cannot be dated unequivocally archaeologically, but which, judging from the radiocarbon dates, must belong to the Ertebølle Culture, or possibly the Ertebølle/Funnel Beaker transition. In horizon *TRB* (level 21.71-21.97) there are sherds of an early Neolithic funnel beaker of Volling type. The level at which the elm decline occurs (level 20.94) is marked with a horizontal stippled line.

The timescale for the pollen diagram and the archaeological finds is based on the time/depth curve shown in fig. 5. In deposits such as these, the radiocarbon dates should be treated with a measure of caution as the sediments have been exposed to human influence (the throwing out of artefacts). The sedimentation rate cannot be expected to have been constant, and this may explain the abrupt change in the gradient of the time/depth curve. The relatively large pieces of charcoal and partly charred wood which were dated could have been washed out into the lake sediments at any time over a long period. As a consequence, the wood could have been incorporated into younger sediments. Conversely, there is the possibility that large pieces of wood could have sunk down into older sediments. Finally, some of the dated pieces of wood lay relatively far away from the sampling site for the pollen diagram, which in itself could give some uncertainty with regard to the temporal relationship between the two. Despite a series of potential sources of error it would appear however that the time/depth curve gives reliable dates; the dates arrived at for the elm decline and the archaeological finds are as follows:

TRB (Funnel Beaker) pottery:	3430-3670 cal. BC
Ertebølle:	3880-4650 cal. BC
Elm Decline:	4450 cal. BC

The date for the early Neolithic funnel beaker of Volling-type (3430-3670 cal. BC) is in agreement with the dates for other finds of this pottery type from Jutland (Madsen & Petersen 1984; Andersen & Johansen 1992).

The date of 3880 cal. BC for the youngest part of the horizon termed Ertebølle corresponds to the date for the end of the Ertebølle Period, fixed for example in the kitchen middens (køkkenmøddinger) at Norsminde (Andersen 1991) and Bjørnsholm (Andersen 1993).

The age of the oldest part of the horizon with Ertebølle pottery (4650 cal. BC) corresponds approximately to available dates for the oldest "Ceramic" Ertebølle Culture in Jutland (Andersen 1973: note 46).

On the basis of the above comparisons there appears to be good agreement between the expected age based on the archaeological finds and the age determined on the basis of the time/depth curve.

The age of the elm decline and the beginning of the Ertebølle layer must however be viewed with some caution, as they have both been arrived at by extrapolation. The extrapolated date for the elm decline is 4450 cal. BC. This is 500-600 years older than the classical elm decline in Jutland, which is dated to 3800/3900 cal. BC (Andersen 1992a: note 2; Andersen & Rasmussen 1993). As it was arrived at by extrapolation, it is impossible to determine the precision of the date for the Ringkloster elm decline, but several factors suggest that this event does occur significantly earlier here than is normal. There is, for example a radiocarbon date from above the elm decline of 4220 cal. BC. (fig. 10). Similarly, if the stratigraphical relationship between the elm decline and the archaeological finds is examined, it is clear that Ertebølle artefacts occur above the elm decline (fig. 10). This suggests that the elm decline lies prior to the end of the Ertebølle Culture, in contrast to the classical elm decline which radiocarbon dates show is contemporary with its close.

This early date for an elm decline is very unusual in Denmark, but not, however, without parallels both here and in neighbouring countries. In Denmark, a new radiocarbon wiggle-dated pollen diagram from Hassing Huse Mose (Thy) has revealed two declines in the elm pollen curve prior to the classical elm decline (Andersen & Rasmussen 1993). The classical elm decline is here dated to 3870 cal. BC and the two other declines are dated to 4130 cal. BC and 4530 cal. BC respectively. At Hassing Huse Mose the first certain evidence of agriculture (cereal pol-

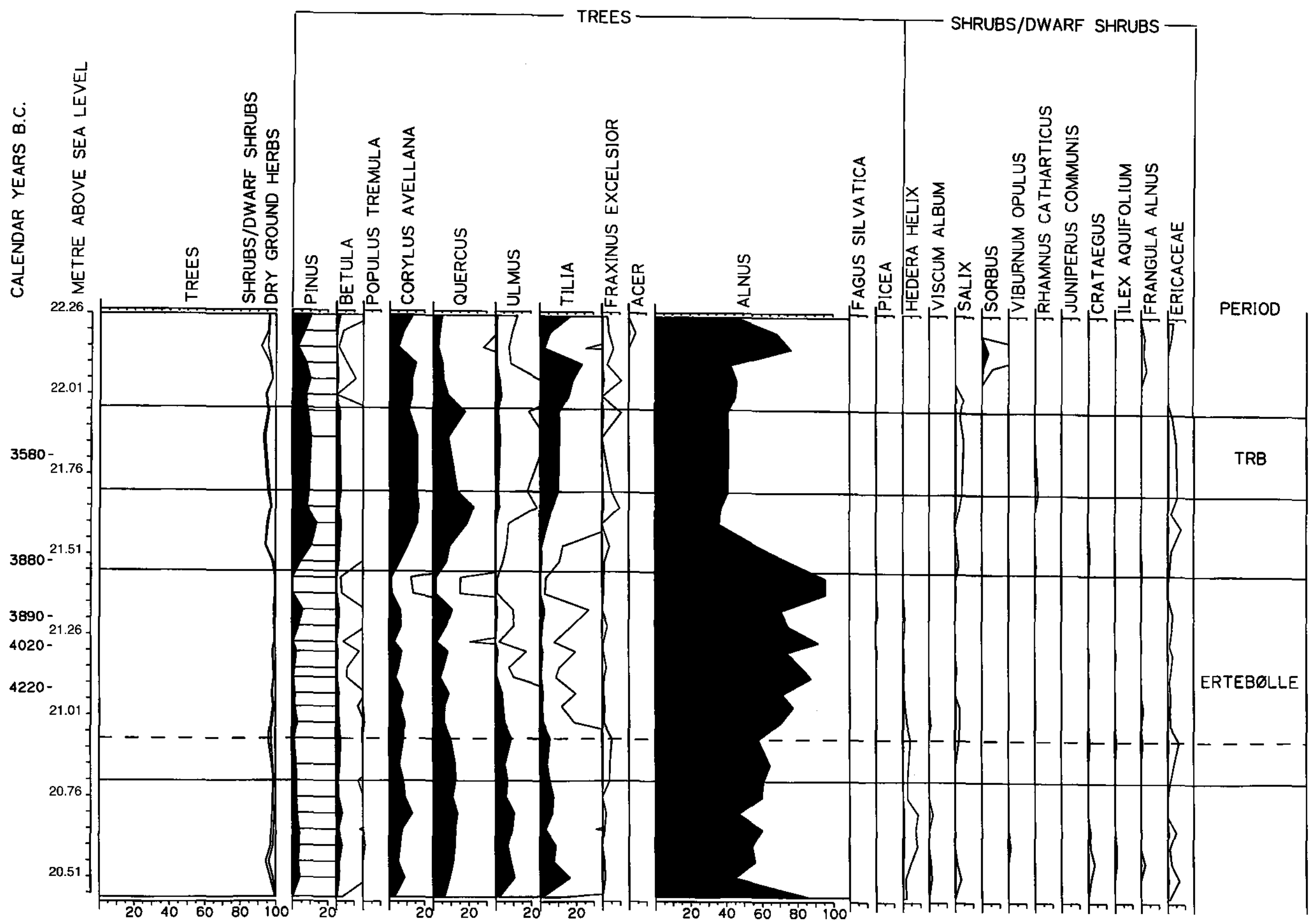

Fig. 10 Pollen diagram P1. Percentage diagram calculated on the basis of pollen from the plant categories included in the summary diagram (trees, shrubs/dwarf shrubs and terrestrial (dry land) herbs). The white silhouettes indicate percentages x10. The depths of the individual pollen sample are indicated on the *Pinus* curve. On the diagram the horizons with different types of pottery belonging to: 1) Ertebølle Culture and 2) early Neolithic Funnel Beaker Culture (TRB) are indicated. The level of the elm decline is marked with a stippled horizontal line.

len of *Hordeum*-type) occurs at the same level as the classical elm decline. Slight increases in a series of apophytes (plants present originally which are favoured by human activity) (*Rumex acetosella*, *Artemisia*, Chenopodiaceae, *Polygonum aviculare*, *Jasione* and Poaceae) are seen in connection with the two other (earlier) declines (Andersen & Rasmussen 1993).

Two declines in the elm pollen curve prior to the classical elm decline have also been demonstrated in a new pollen diagram from close to the Ertebølle site of Bökeberg III in Scania (Regnell *et al.* 1995). Here, the classical elm decline is dated to 3980 cal. BC, and the two declines prior to this, to 4340 cal. BC and 5200-5100 cal. BC, respectively. Finally, in Northern Germany an elm decline has been demonstrated at around 4900 cal. BC, i.e. contemporary with the local Ertebølle Culture (Ellerbek-group) (Kalis & Meurers-Balke 1988).

There are thus a number of parallels to the Ringkloster elm decline, but on one decisive point the latter stands apart from the sites mentioned above, namely the force of the decline and the subsequent lack of regeneration of the elm stands. The classical elm decline around 3800/3900 cal. BC is not seen at Ringkloster because by this time elm had been only sparsely represented for several hundred years.

In the period prior to the Ertebølle occupation at Ringkloster, the pollen diagram reflects dense and

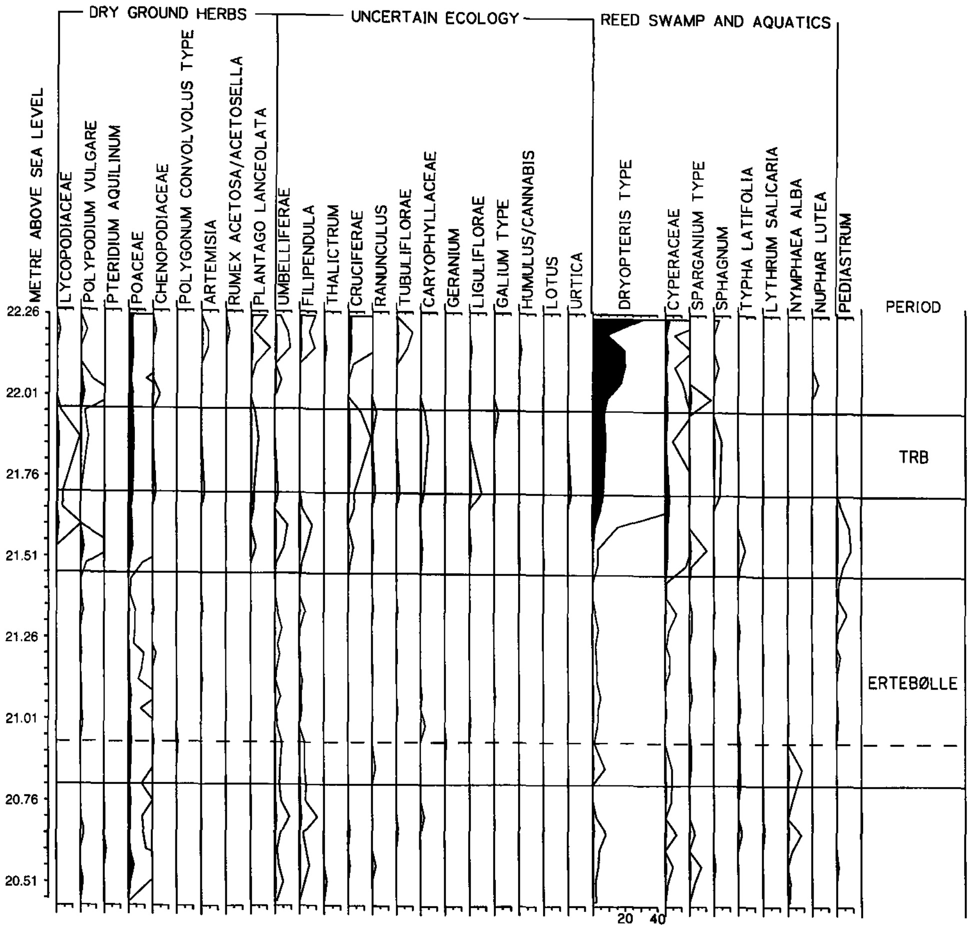

Fig. 10 continued

stable woodland with high pollen values of *Tilia*, *Ulmus*, *Quercus*, *Corylus* and *Alnus*, along with a sparse herb flora consisting primarily of wild grasses. Pollen analyses from small ponds and soil profiles show that in Atlantic times, *Tilia* was dominant on dry well-drained soils, together with *Corylus* and *Quercus*, whilst *Ulmus*, *Alnus* and *Fraxinus* could be found on damp or wet areas, presumably mixed with some *Quercus* and *Corylus* (Iversen 1969; Andersen 1978; 1984; 1991; Aaby 1983). The establishment of the first Ertebølle occupation at Ringkloster, brought about no changes in this stable vegetation, which continued virtually unaltered up until the elm decline.

The elm decline, and the simultaneous reduction in *Tilia*, is followed by a slight rise in a number of apophytes (fig. 6 and 10). In particular, the amount of *Artemisia* increases (especially in diagram B, fig. 6), but also Chenopodiaceae, *Polygonum convolvulus* type and *Rumex acetosa/acetosella* become more frequent. The increased abundance of these herbs, which typically grow on disturbed soils, including paths and ruderal areas, suggests that there was increased human activity in the area. There are no indications in the pollen diagram of agriculture contemporary with the Ertebølle Culture, and the disturbances must have been connected with everyday activities in and around the settlement.

The early Ringkloster elm decline and the simultaneous reduction in *Tilia* are difficult to explain. The causes of the classical elm decline have been discussed for decades and the following possibilities have been proposed: 1) Climatic change (Iversen 1941), 2) Soil deterioration (Iversen in Troels-Smith 1956), 3) Elm disease (Iversen in Troels-Smith 1956), 4) Pollarding of elm trees for the production of leaf fodder for domesticated animals (Fægri 1944; Troels-Smith

1953; 1960) and 5) Clearance (felling) of elm in low-lying areas to promote *Quercus* and thus produce acorns for pigs (Madsen 1982). Both climatic change and soil deterioration can, on balance, now be discounted as primary causes (see discussion in Troels-Smith 1956; 1960 and Andersen 1984). That leaves elm disease and human intervention in one form or another. New pollen analytical investigations from England identify a combination of elm disease and agricultural activity as the most likely cause (Peglar 1993; Peglar & Birks 1993; see also Rackham 1980 & Birks 1986).

The latter interpretation cannot explain the Ringkloster elm decline, as there are no contemporary indications of agriculture at the time of the elm decline. According to research on modern elm trees, elm disease can occur "passively" in an area for a long time, flaring up in periods without necessarily killing the trees (Rackham 1980; Moe & Rackham 1992). If it is assumed a) that this situation was also the case in prehistoric times, and b) that the classical elm decline was caused primarily by elm disease, then the disease could have been present long before the classical elm decline. If we extend this assumption further, it is not improbable that stands of elm in a heavily occupied area such as Ringkloster were exploited and affected to a significant degree (for example by felling or ringing of elm trees; cf. Göransson 1987). This would have created ideal conditions for the attack and spread of elm disease, as damaged elm trees appear to be the most susceptible (Rackham 1980; Moe & Rackham 1992).

The reduction in *Tilia* at the same time as the elm decline can most readily be explained in terms of the activities of the Ertebølle people. These could have taken the form of clearance of the lime woodland and/or ringing of lime trees. Lime was presumably also used for a variety of different purposes (fuel, construction and tools). The simultaneous decline in *Ulmus* and *Tilia* suggests a common cause and it is difficult to find an explanation other than the anthropogenic. In this respect, the analyses of carbonised and uncarbonised wood from the settlement's refuse layers give some interesting information (Malmros 1986). A total of 205 pieces were examined, of which 115 were carbonised. The uncarbonised material was completely dominated by *Alnus* (70%) followed by *Ulmus* (10%) and *Corylus* (9%). Among the carbonised material the four most common taxa were *Ulmus* (24%), *Corylus* (17%), *Quercus* (17%) and *Alnus* (16%) (Malmros 1986). The uncarbonised material probably became incorporated into the lake sediments by way of natural processes, and as a consequence should be seen as reflecting the composition of the woodland vegetation in the immediate vicinity of the settlement. The carbonised material, on the contrary, is evidence for human intervention, and the species composition should therefore be seen as reflecting the Ertebølle people's choice of particular tree species for fuel, tool production etc. The clear dominance of elm (24%) in the carbonised wood therefore suggests that the stands of elm trees in the Ringkloster area were exposed to selective exploitation, and it is obvious to see this as a contributory or direct cause of the low values for elm in the pollen diagrams. No corresponding connection is apparent in the case of lime, as lime is only poorly represented in the wood samples analysed (uncarbonised: 3%; carbonised 6%). Differential preservation could however have played a role here, as lime degrades and disappears much more readily than other tree species (Bartholin *et al.* 1981; Malmros 1986; Møller 1987).

It is very difficult to determine the size of the area reflected in the Ringkloster pollen diagrams. The apparently very local nature of the pollen input suggests that a relatively small area is involved and, furthermore, the Ertebølle population could hardly have had such an impact on the elm and lime woodland over a wider area. All in all, it seems reasonable to presume that the pollen diagrams reflect the vegetation within a relatively limited area around the Ringkloster settlement.

About 3900 cal. BC, i.e. at the transition from the Atlantic to the Sub-boreal, both diagrams show a marked change in the wetland vegetation (fig. 6 and 10). *Alnus* declines sharply, followed by a significant increase in wetland herbs (in particular *Dryopteris*-type and Cyperaceae). In all probability, these changes reflect a reduction in water level in the lake. With a reduced water level, wetland herbs would have been able to expand on to new areas of the lake margin closer to the pollen sampling sites, with high values of *Dryopteris*- type and Cyperaceae as a consequence. This interpretation is supported by the marked increase in *Pinus* (in both diagram B and P1; fig. 6 and 10), which begins at the same time as the above-mentioned changes. Due to its great buoyancy, pine pollen often becomes concentrated in the littoral zone, where the sediments become enriched with this pollen type (Fægri & Iversen 1989; Amman 1994). As the water level fell, the littoral zone (and the concentrations of pine pollen) would, as described above, have moved further out into the basin and thus closer to the sampling sites for the pollen diagrams, where an increased sedimentation of pine pollen took place.

Detailed investigations of sediments in several lakes in southern Sweden have demonstrated a similar reduction in water level of the same date. The phenomenon is seen in lakes over a large geographic area and as a consequence is interpreted as being the result of a shift towards a drier climate (Digerfeldt 1988; 1997; Gaillard & Digerfeldt 1991).

A reduction in water level at Ringkloster, and the subsequent changes in sedimentation linked with this, could have influenced several of the pollen curves in the pollen diagrams. For example, it is probable that the very dissimilar curves for *Tilia* pollen seen in the pollen diagrams B and P1 at this time are the result of altered sedimentation conditions.

At the same time as the above-mentioned change in water level (ca. 3900 cal. BC), a reduction in the woodland trees and an increase in light-demanding herbs (Poaceae, Chenopodiaceae, *Artemisia*, *Rumex acetosa/acetosella*, *Plantago lanceolata* and *Polygonum_convolvulus* type) is seen in both diagrams (fig. 6 and 10). These changes are evidence of an opening up of the previously very densely wooded landscape. Apart from a single earlier record of *Plantago lanceolata* (in diagram P1; fig. 10), the change coincides with the appearance of this species, values of which subsequently form a continuous curve. The occurrence of *Plantago lanceolata* documents the first agricultural activity in the area, as the species is closely linked with areas grazed by domesticated animals (Iversen 1941; Behre 1981). The reduction in the woodland can thus be presumed to be due to anthropogenic causes, i.e. the creation of open areas for agricultural purposes. After the first opening up of the woodland, the relationship between forest and open land remains virtually constant throughout the remainder of the pollen diagrams. In diagram P1 (fig. 10) there is a slight increase in *Plantago lanceolata*, Chenopodiaceae and *Artemisia*, which suggests that there was an intensification of agricultural activity at this time. This occurs at the level of the Funnel Beaker vessel and on the basis of the stratigraphical correlation between the vessel and the pollen diagram, it can be established that the agricultural activity in the area is associated with the Funnel Beaker Culture's Volling group.

The precise character of the earliest Neolithic agriculture is difficult to elucidate alone on the basis of a pollen diagram from a lake or a bog. In the case of Ringkloster, the occurrence of *Plantago lanceolata* demonstrates the presence of areas of grazing for domesticated animals. In contrast, evidence of arable farming in the form of cereal cultivation, cannot be seen in the diagrams. The lack of records of cereal pollen can not however be taken as an indication that cereals were not cultivated in the area, as the early cereal types (*Triticum* and *Hordeum*) are self-pollinating (autogamous) and have very poor pollen dispersal (Vuorela 1973; Behre & Kučan 1986). New pollen analytical investigations of old soil horizons in and below Neolithic burial mounds have given a much more detailed picture of Neolithic agriculture than it is possible to obtain from pollen diagrams from lakes or bogs. These investigations show that agriculture consisted of swidden cultivation with arable and pastoral farming, where the burning of secondary woodland (especially *Betula* and *Corylus*), played an important role in creating and fertilising open areas (Andersen 1992b). The extent to which the earliest agriculture at Ringkloster was of this type, and if so the internal relationship between arable and pastoral farming, cannot be determined on the basis of the investigations presented here.

CONCLUSIONS

Two pollen diagrams have been produced (B and P1) from lake sediments close to the Ertebølle settlement of Ringkloster with the aim of elucidating the development of the vegetation. The sampling sites for the two pollen diagrams are located close to the shore, and as a consequence they are both to a lesser or greater extent characterised by the local wetland vegetation (alder carr).

The two diagrams (B: fig. 6 and 7; P1: fig. 8, 9 and 10) cover approximately the same timespan from the end of the Atlantic until the beginning of the Subboreal. The correlation between the archaeological and the vegetational development is best shown in diagram P1 (fig. 10), which was produced from the archaeological layers in the lake deposits directly offshore from the settlement. On the basis of 5 radiocarbon dates for charcoal and partly-charred wood from the lake deposits close to the sampling site, a timescale has been established, which corresponds well with the expected dates for the archaeological finds. In the period prior to the Ertebølle settlement at the site, the landscape was characterised by stable woodland and a modest herb flora. With the establishment of the settlement, no changes are evident in the vegetation pattern. It is first some time after the founding of the settlement that changes in the vegetation become apparent in the form of a marked decline in *Ulmus* and *Tilia*, followed by a slight increase in a number of apophytes. Stratigraphical correlation between the archaeological finds and the elm decline shows that the latter here is contemporaneous with the Ertebølle Culture. The date of the elm decline cannot be established precisely, but its coincidence with the Ertebølle Culture and a radiocarbon date for wood lying above it of 4220 cal. BC, demonstrates that the decline is significantly earlier than the classical elm decline in Jutland, which is radiocarbon-dated to 3800/3900 cal. BC (corresponding to radiocarbon dates for the end of the Ertebølle Culture).

The Ringkloster elm decline and the simultaneous decline in *Tilia*, are interpreted as being the result of the activities of the Ertebølle people (clearance of the woodland and/or ringing of trees and the collection of wood for fuel, construction and tools). The reduction of elm could have been amplified by elm disease.

Around 3900 cal. BC, at the transition from the Atlantic to the Sub-boreal, there are several indications of a reduction in the water level in the lake. A similar reduction of the same age is also known from several lakes in southern Sweden. The phenomenon is seen over a wide geographic area, suggesting that it was caused by a climatic shift towards drier conditions.

From about 3900 cal. BC *Plantago lanceolata* appears as a new species in the pollen diagrams, documenting the presence of agriculture in the area. Simultaneous with the first evidence of agriculture, there is a reduction in woodland, and a general increase in terrestrial herbs. These changes are interpreted as being the result of woodland clearance with the aim of creating open areas for the purposes of agriculture. The earliest agricultural activity cannot be linked stratigraphically to the archaeological evidence. Slightly later activity (about 3600/3700 cal. BC), can be correlated with the finding of an early Neolithic funnel beaker of Volling type, which shows that it was the Funnel Beaker Culture's Volling group, which practised agriculture in the Ringkloster area at this time.

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REFERENCES

Aaby, B. 1983: *Forest development, soil genesis and human activity illustrated by pollen and hypha analysis of two neighbouring podzols in Draved Forest, Denmark.* Danmarks Geologiske Undersøgelse, II. Række, Nr. 114.

Ammann, B. 1994: Differential flotation of saccate pollen - a nuisance and a chance. In A. F. Lotter & B. Ammann (eds.), Festschrift Gerhard Lang. *Dissertationes Botanicæ* 234, pp. 101-110.

Andersen, S. H. 1973: Overgangen fra ældre til yngre stenalder i Sydskandinavien set fra en mesolitisk synsvinkel. In P. Simonsen & G. S. Munch (eds.), *Bonde-Veideman. Bofast - ikke Bofast i Nordisk Forhistorie*, Tromsø Museums Skrifter XIV, pp. 26-44.

- 1975: Ringkloster. En jysk indlandsboplads med Ertebøllekultur. (English summary). *Kuml* 1973-74: 11-108.

- 1979: Pelsjægere. *Skalk* 2: 3-8.
- 1991: Norsminde. A „Køkkenmødding" with Late Mesolithic and Early Neolithic Occupation. *Journal of Danish Archaeology* 8, 1989: 13-40.
- 1993: Bjørnsholm. A Stratified Køkkenmødding on the Central Limfjord, North Jutland. With a contribution by K. L. Rasmussen. *Journal of Danish Archaeology* 10, 1991: 59-96.
- 1994: Kød, pelsværk og skind. *Humaniora. Et magasin om humanistisk forskning* 2, pp. 27-31.
- 1998: Ringkloster. Ertebølle trappers and wild boar hunters in eastern Jutland. A Survey. *Journal of Danish Archaeology* vol. 12, 1994-95: 13-60

Andersen, S. H. & Johansen, E. 1992: An Early Neolithic Grave at Bjørnsholm, North Jutland. *Journal of Danish Archaeology* 9, 1990: 38-58.

Andersen, S. T. 1978: Local and regional vegetational development in eastern Denmark in the Holocene. *Danmarks Geologiske Undersøgelse, Årbog* 1976: 5-27.
- 1984: Forests at Løvenholm, Djursland, Denmark, at present and in the past. With a contribution by H. J. B. Birks. *Det Kongelige Danske Videnskabernes Selskab,* Biologiske Skrifter 24:1.
- 1991: Natural and cultural landscapes since the Ice Age. Shown by pollen analyses from small hollows in a forested area in Denmark. *Journal of Danish Archaeology* 8, 1989: 188-199.
- 1992a: Pollen Spectra from two Early Neolithic Lugged Jars in the Long Barrow at Bjørnsholm, Denmark. *Journal of Danish Archaeology* 9, 1990: 59-63.
- 1992b: Early- and Middle-Neolithic agriculture in Denmark: pollen spectra from soils in burial mounds of the Funnel Beaker Culture. *Journal of European Archaeology* 1: 153-180.

Andersen, S. T. & Rasmussen, K. L. 1993: Radiocarbon wiggle-dating of elm declines in northwest Denmark and their significance. *Vegetation History and Archaeobotany* 2: 125-135.

Bartholin, T. S. , Berglund, B. E. & Malmer, N. 1981: Vegetation and environment in the Gårdlösa area during the Iron Age. In B. Stjernquist (ed.), *Gårdlösa. An Iron Age community in its natural and social setting. Kungl. Humanistiska Vetenskapssamfundet i Lund,* vol. 75, pp. 45-53.

Behre, K.-E. 1981: The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores* 23: 225-245.

Behre, K.-E. & Kučan, D. 1986: Die Reflektion archäologisch bekannter Siedlungen in Pollendiagrammen verschiedener Entfernung - Beispiele aus der Siedlungskammer Flögeln, Nordwestdeutschland. In K. -E. Behre (ed.), *Anthropogenic indicators in pollen diagrams*: 95-114. Balkema, Rotterdam, Boston.

Birks, H. J. B. 1986: Late-Quaternary biotic changes in terrestrial and lacustrine environments, with particular reference to north-west Europe. In B. E. Berglund (ed.), *Handbook of Holocene Palaeoecology and Palaeohydrology,* pp. 3-65. John Wiley & Sons, Chichester.

Clapham, A. R.; Tutin, T. G. & Moore, D. M. 1987: *Flora of the British Isles.* Third edition. Cambridge University Press, Cambridge.

Digerfeldt, G. 1988: Reconstruction and regional correlation of Holocene lake-level fluctuations in Lake Bysjön, South Sweden. *Boreas* 17, 2: 165-182.
- 1997: Reconstruction of Holocene lake-level changes in lake Kalersjön, southern Sweden, with a contribution to the local palaehydrology at the Elm Decline. *Vegetation History and Archaeobotany* 6: 9-14.

Enghoff, Inge Bødker 1998: Freshwater fishing at Ringkloster, with a supplement of marine fishes. *Journal of Danish Archaeology* vil 12, 1994-95: 99-105

Fægri, K. 1944: On the introduction of agriculture in western Norway. *Geologiska Förenings i Stockholm Förhandlingar* 66, 3: 449-462.

Fægri, K. & Iversen, J. 1989: *Textbook of Pollen Analysis.* IV Edition by K. Fægri, P. E. Kaland & K. Krzywinski. John Wiley & Sons, Chichester.

Gaillard, M.-J. & Digerfeldt, G. 1991: Palaeohydrological studies and their contribution to palaeoecological and palaeoclimatic reconstructions. In B. E. Berglund (ed.), *The cultural landscape during 6000 years in southern Sweden - the Ystad Project.* Ecological Bulletins 41, pp. 275-282.

Grimm, E. C. 1990: TILIA and TILIA•GRAPH: PC spreadsheet and graphics software for pollen data. *INQUA, Working Group on Data-Handling Metods, Newsletter* 4: 5-7.

Göransson, H. 1987: Neolithic man and the forest environment around Alvastra pile dwelling. *Theses and papers in North-European Archaeology* 20. Lund University Press, Stockholm.

Hansen, K. *et al.* 1981: *Dansk feltflora.* Gyldendalske Boghandel, Nordisk Forlag A/S, Copenhagen.

Iversen, J. 1941: *Landnam i Danmarks Stenalder.* Danmarks Geologiske Undersøgelse, II. Række, Nr. 66.
- 1969: Retrogressive development of a forest ecosystem demonstrated by pollen diagrams from fossil mor. *Oikos,* supplementum 12: 35-49.

Kalis, J. & Meurers-Balke, J. 1988: Wirkungen neolithischer Wirtschaftsweisen in Pollendiagrammen. *Archäologische Informationen* 11, 1: 39-53.

Madsen, T. 1982: Settlement systems of early agricultural societies in east Jutland: A regional Study of change. *Journal of Anthropological Archaeology* 1: 197-236.

Madsen, T. & Petersen, J. E. 1984: Tidlig-neolitiske anlæg ved Mosegården. Regionale og kronologiske forskelle i tidligneolitikum. *Kuml* 1982-83: 61-120.

Malmros, C. 1972: *Ringkloster. Rapport over undersøgelsen 30/7-10/8 1970.* Unpublished report, National Museum, Natural Science Research Unit, J. nr. A5502-24. 37 p.

- 1984: *Bestemmelse af trækul fra mesolitisk boplads Ringkloster.* Unpublished report, National Museum, Natural Science Research Unit, J. nr. A5502-86. 2 p.

- 1986: *Rapport om bestemmelse af ved, trækul, bark og svampe fra Ringkloster.* Unpublished report, National Museum, Natural Science Research Unit, J. nr. A5502-92. 19 p.

Moe, D. & Rackham, O. 1992: Pollarding and a possible explanation of the neolithic elmfall. *Vegetation History and Archaeobotany* 1: 63-68.

Molloy, K. & O'Connell, M. 1991: Palaeoecological investigations towards the reconstruction of woodland and land-use history at Lough Sheeauns, Connemara, western Ireland. *Review of Palaeobotany and Palynology* 67: 75-113.

Møller, J. D. 1987: Vedanatomisk analyse af vogndele. In P. O. Schovsbo *Oldtidens vogne i Norden. Arkæologiske undersøgelser af mose- og jordfundne vogndele af træ fra neolitikum til ældre middelalder.* Med bidrag af Jette Dahl Møller og Henrik Tauber, pp. 185-193. Bangsbomuseets Forlag. Bangsbomuseet 1987.

Peglar, S. M. 1993: The mid-Holocene *Ulmus* decline at Diss Mere, Norfolk, UK: a year-by-year pollen stratigraphy from annual laminations. *The Holocene* 3, 1: 1-13.

Peglar, S. M. & Birks, H. J. B. 1993: The mid-Holocene *Ulmus* fall at Diss Mere, South-East England - disease and human impact?. *Vegetation History and Archaeobotany* 2: 61-68.

Rackham, O. 1980: *Ancient Woodland. Its history, vegetation and uses in England.* Edward Arnold, London.

Regnell, M., Gaillard, M.-J., Bartholin, T. S. & Karsten, P. 1995: Reconstruction of the environment and history of plant use during the late Mesolithic (Ertebølle culture) at the inland settlement of Bökeberg III, south Sweden. *Vegetation History and Archaeobotany* 4: 67-91.

Rowley-Conwy, Peter 1998: Meat, Furs and Skins: Mesolithic Animal Bones from Ringkloster, a Seasonal Hunting Camp in Jutland. *Journal of Danish Archaeology* vol. 12, 1994-95: 87-98

Stuiver, M. & Reimer, P. J. 1993: Extended ^{14}C data base and revised CALIB 3.0 ^{14}C age calibration program. *Radiocarbon* 35, 1: 215-230.

Troels-Smith, J. 1937: *Pollenanalytisk datering af Brabrandfundet.* Danmarks Geologiske Undersøgelse, IV. Række, Bd. 2. Nr. 16.

- 1942: Geologisk datering af Dyrholm-fundet. *Det Kongelige Danske Videnskabernes Selskab. Arkæologisk-Kunsthistoriske Skrifter*, Bd. 1, Nr. 1.

- 1953: Ertebøllekultur - Bondekultur. Resultater af de sidste 10 Aars Undersøgelser i Aamosen, Vestsjælland. *Aarbøger for Nordisk Oldkyndighed og Historie 1953*: 5-62.

- 1956: Vandstandssvingninger i indsøbassiner og havtransgressioner og -regressioner. Mødereferat. *Meddelelser fra Dansk Geologisk Forening* 13: 127-128.

- 1960: *Ivy, Mistletoe and Elm, Climate Indicators - Fodder Plants.* Danmarks Geologiske Undersøgelse, IV. Række, Bd. 4, Nr. 4.

Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M. & Webb, D. A. (eds.) 1964-1980: *Flora Europaea.* Cambridge University Press, Cambridge.

Vuorela, I. 1973: Relative pollen rain around cultivated fields. *Acta Botanica Fennica* 102: 1-27.

Ørnbøl, J. 1984: *Pollenanalytiske undersøgelser fra Ringkloster ved Skanderborg Sø.* Unpublished report.

Latin	English	Danish
Acer	Maple	Løn
Alnus	Alder	El
Artemisia	Mugwort	Bynke
Betula	Birch	Birk
Campanula	Bellflower	Klokke
Caryophyllaceae	Pink Family	Nellikefamilien
Chenopodiaceae	Goosefoot family	Gåsefodfamilien
Compositae	Composite family	Kurveblomstfamilien
Corylus avellana	Hazel	Hassel
Crataegus	Hawthorn	Tjørn
Cruciferae	Crucifer family	Korsblomstfamilien
Cyperaceae	Sedge family	Halvgræsfamilien
Dipsacaceae	Teasel family	Kartebollefamilien
Dryopteris	Male-fern	Mangeløv
Ericaceae	Heather family	Lyngfamilien
Fagus sylvatica	Beech	Bøg
Filipendula	Meadow sweet	Mjødurt
Frangula alnus	Alder buckthorn	Tørst
Fraxinus excelsior	Ash	Ask
Galium	Bedstraw	Snerre
Geranium	Cranesbill	Storkenæb
Hedera helix	Ivy	Vedbend
Hordeum	Barley	Byg
Humulus/Cannabis	Hop/Hemp	Humle/Hamp
Ilex aquifolium	Holly	Kristtorn
Iris	Iris	Iris
Jasione montana	Sheep's bit	Blåmunke
Juniperus communis	Juniper	Ene
Labiatae	Mint family	Læbeblomstfamilien
Liguliflorae	Ligulate composites	Tungeblomstrede
Lotus	Trefoil	Kællingetand
Lycopodiaceae	Clubmoss family	Ulvefodfamilien
Lythrum salicaria	Purple loosestrife	Kattehale
Nuphar lutea	Yellow water-lily	Gul Åkande
Nymphaea alba	White water-lily	Hvid Åkande
Pediastrum	Pediastrum	Pediastrum (grønalge)
Phalaris arundinaceae	Reed-grass	Rørgræs
Phragmites australis	Reed	Tagrør
Picea	Spruce	Gran
Pinus	Pine	Fyr
Plantago lanceolata	Ribwort plantain	Lancet-Vejbred
Poaceae	Grass family	Græsfamilien
Polygonum aviculare	Knotgrass	Vej-Pileurt
Polygonum convolvulus	Black bindweed	Snerle-Pileurt
Polypodium vulgare	Polypody	Alm. Engelsød
Populus tremula	Aspen	Bævreasp
Potamogeton	Pondweed	Vandaks
Prunella	Self-heal	Brunelle
Pteridium aquilinum	Bracken	Ørnebregne
Quercus	Oak	Eg
Ranunculus	Buttercup	Ranunkel
Rhamnus catharticus	Buckthorn	Vrietorn
Rosaceae	Rose family	Rosenfamilien
Rumex acetosella	Sheep´s sorrel	Rødknæ
Rumex acetosa/acetosella	Dock/Sheeps´sorrel	Skræppe/Rødknæ
Salix	Willow	Pil
Sorbus	Rowan	Røn
Sparganium	Bur-reed	Pindsvineknop
Sphagnum	Bog moss	Tørvemos
Thalictrum	Meadow rue	Frøstjerne
Tilia	Lime	Lind
Triticum	Wheat	Hvede
Tubuliflorae	Tubulate composites	Rørblomstrede
Typha latifolia	Cat's tail	Bredbladet Dunhammer
Ulmus	Elm	Elm
Umbelliferae	Umbellate family	Skærmplantefamilien
Urtica	Nettle	Nælde
Viburnum opulus	Guelder-rose	Kvalkved
Viscum album	Misteltoe	Mistelten

Table 1. List of Latin plant names used in the article and their equivalents in English and Danish.