# Macrofossils and their Contribution to the History of the Spermatophyte Flora in Southern Scandinavia from 13000 BP to 1536 AD

*By* HANS ARNE JENSEN

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## *Abstract*

In introductory chapters, factors affecting dispersal and deposition of prospective botanical macrofossils, seed-bank size, preservation of macrofossils, and conditions of importance for the detection of preserved macrofossils are discussed.

The composition of the spermatophyte flora in Southern Scandinavia from 13000 BP to 1536 AD is elucidated by finds of macrofossils. The finds are arranged according to plant formation within the following periods: Pollen Assemblage Zones I-IX, Pre-Roman Iron Age, Roman Iron Age, Germanic Iron Age, Viking Age, Early and Late Middle Ages.

The recorded information was further arranged according to media examined, life-form, assumed plant formation, and phytogeographical group of the recorded taxa. All media examined from Pollen Assemblage Zones I-VII were sediments, while those from Zone VIII on were mainly from contexts associated with human activities. Distribution on life-form was clearly affected by the introduction of agriculture. The life-form distribution of all recorded species was almost the same as that of the present Danish flora. Taxa from wet areas were dominant from Zone I to Zone VII. The introduction of agriculture was associated with the appearance of cultivated plants, weeds, and ruderals. Grasslands also became more frequent, mainly represented by species from natural plant formations. The number of first-recorded taxa per 100 C-14 years reflected various conditions for invasion of species:- Zones I-IV: 2.0-2.9; Zones V-VII: 1.2; Zone VIII: 3.4; Zone IX: 14.0. The first-recorded taxa for 21 families were dated to Zones I-III, for 32 families to Zones IV-VII, and for 31 families to Zone VIII or later. Comparison with finds from neighbouring countries suggests that a number of species were present in Southern Scandinavia earlier than known so far. 22% of the recorded taxa were anthropochorous. The imported species *Ficus carica*, *Juglans regia*, *Oryza sativa*, *Pinus pinea*, *Prunus persica*, *Staphylea pinnata* and *Vitis vinifera* are briefly discussed.



KEYWORDS: Macrofossils, sediments, seed-bank, carbonized macrofossils, imprints, Pollen Assemblage Zones, Pre-Roman Iron Age, Roman Iron Age, Germanic Iron Age, Viking Age, Middle Ages, media, life-forms, plant formations, phytogeographical groups, anthropochorous species, imported species.



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# Contents

# Introduction

The present paper deals with botanical macrofossils, and mainly with their contribution to the history of the spermatophyte flora in Southern Scandinavia (Denmark, Schleswig, Scania, Halland, and Blekinge). Included are finds dating from the ice withdrawal about 13000 BP (carbon-14 years before 1950 AD) to the end of the Middle Ages (1536 AD).

The Quaternary vegetation of Denmark has been explored in a great number of investigations. Earlier works were based on macrofossil analysis only, an example being the find on which the establishment of the Allerød Age was based (Hartz & Milthers 1901), while pollen-statistical analysis, founded by von Post (1916), and introduced into Denmark by Jessen (1918, 1920), has since been widely used both in describing the vegetation of different periods and for dating purposes.

Some of the published information on the ancient vegetation has been utilized in a survey of the late-glacial flora of Denmark (Iversen 1954), and in a general description of the vegetation of Denmark since the last ice age (Iversen 1967, 1973). Similar papers for Schleswig and Blekinge have been published by Overbeck (1975), Usinger (1985), and Berglund (1966a, 1966b), respectively.

Several pollen-analytical papers contain information on macrofossils as well. Most information on macrofossils, however, has been obtained directly from analysis of deposits of stored cereals, from imprints in pottery, from graves, barrows, preserved corpses, or latrine deposits, and from soil and manure samples drawn from excavated houses or towns (Jensen 1985).

In an introductory chapter, it is discussed how the results of an examination of palaeobotanical materials are influenced by factors affecting the deposition of prospective macrofossils, state of preservation, and the possibilities of different techniques for detecting the preserved macrofossils.

Then follows, period by period, a presentation of the recorded finds from Southern Scandinavia. This information has been extracted from a catalogue of late and post-glacial macrofossils of Spermatophyta, covering 505 sites in Denmark, Schleswig, Scania, Halland, and Blekinge (Jensen 1985).

For each pollen assemblage zone or archaeological/historical period, a list is given of the taxa recorded as macrofossils. The findings are grouped according to 'plant formation'.

It is briefly discussed to what extent the finds of macrofossils relate to and supplement the above-mentioned descriptions of the vegetation of the area (Iversen 1967, 1973), giving an insight into which species were actually present in different plant formations through the periods studied. As the records have been compiled from many sources and sites, only the presence and not the absence of a given species can be accorded definitive evidential value.

A thorough description of both the composition and extension of different plant formations through different periods - as carried out for the British Isles (Godwin 1975) - is considered outside the scope of the present paper, not least because a detailed survey of the pollen taxa recorded from 13000 BP-1536 AD has so far not been compiled for Southern Scandinavia.

In order to further our knowledge of the origin of the recorded macrofossils, it has been endeavoured to classify the finds according to medium examined (Jensen 1985), life form of recorded taxa (Raunkiær 1907, 1934), plant formation, and phytogeographical group (Hultén 1950).

Discussed are the establishment of new species in the area, the number of taxa recorded for each period, the period in which macrofossils of different

families first occur in the records from Southern Scandinavia, and the introduction of plants by man.

The term 'seed' includes fruits as well as seeds. The term 'macrofossil' covers seeds, fruits, leaves, bud scales, and other parts of plants, as well as imprints in pottery and other loam materials. Wood, charcoal, and wooden artifacts have not been included in the survey (Jensen 1985). 'Seed bank' is used as a term for the seed assemblage in modern soil, whether living or dead. The nomenclature follows that of "Flora Europaea" (Tutin et al. 1964-1980).

# Dispersal and Deposition of Prospective Macrofossils

In the present chapter it is discussed how the prospective plant macrofossils were dispersed to the media from which they were recovered, and to what extent they can reflect the contemporaneous spermatophyte flora.

## Sediments

Lakes and bogs are far the most important source of plant macrofossils, dating from the last glaciation to the introduction of agriculture (Pollen Assemblage Zones I-VII).

The dispersal of prospective plant macrofossils into lake sediments has been discussed in detail by Birks (1980).

Analogues for the late-glacial plant assemblage have been sought in arctic and alpine areas. Ryvarden (1971) trapped diaspores in the alpine zone at Finse, Norway. A high and constant percentage of diaspores was not dispersed beyond 5 metres. A rough estimate showed that the downfall of diaspores within 1 km of the glacier in a favourable season was about 650/m$^2$. Using traps, a considerable transport of seeds in streams was demonstrated. Ryvarden (1975) also studied the winter-dispersed species in the Finse area. He found that the winter dispersal contributes far less than the summer one to the total downfall in front of the glacier.

During the late glacial period, the soil around lakes and streams was unstable due to incomplete vegetation cover, and species from drier areas must have been washed into the lakes by erosion and landslides.

Seeds or fruits, of various origin, and dispersed by air, water, or animals (cf. p. 8-10) were deposited in lake sediments.

In temperate environments, the dispersal of dryland species into lake sediments was hampered by the vegetation cover around lakes and streams, which both reduced the erosion and caught many of the dispersed seeds from drier areas (Birks 1973). A considerable number of plants growing in wet habitats can be dispersed by water (Kølpin Ravn 1894), and the chance of such seeds and fruits being incorporated into the lake sediments is high.

Studies of the dispersal of modern potential plant macrofossils in Minnesota lakes have shown that the highest concentration of upland and wetland macrofossils was recovered close to the edge of the lakes and ponds (Birks op. cit.).

Collinson has explored the relation between vegetation and accumulation of fruits and seeds in three small sedimentary environments in Southern England. It is concluded (Collinson 1983) that a fruit and seed assemblage rich in aquatic plants may provide a more or less accurate representation of a past community.

Presence of buried seeds in freshwater marsh soils supporting six vegetation types was determined by observing seedling emergence in the greenhouse (Leck & Graveline 1979). These results were compared with those obtained from field germination. 3 to 5 times more seeds and almost 3 times as many species germinated in the greenhouse than in the field. Of the 10 most numerous species in greenhouse samples, an average of 7.2 species were also observed as seedlings at the same site in the field.

The sorting and deposition of leaves in a modern environment at Silwood Lake, England, has been studied by Spicer (1981). He found that both the vegetation immediately surrounding the basin of deposition and plant material derived from more distantly upstream vegetation were represented in the sediments.

These studies indicate that analysis of samples from sediments can provide a reasonably good pic-

ture of the plants growing in wetlands, but not of the dry-land vegetation.

## Layers affected by man

The introduction of potential macrofossils into the various media affected by man is influenced by a number of factors. The findings for each type of medium are, however, also closely related to preservation circumstances. For that reason these subjects are primarily discussed under 'medium and macrofossils' (p. 12-14).

*Seeds produced at the site*

The number of seeds produced in an area depends both on the species present and on the density and development of the plants.

The number of weed seeds produced per $m^2$ through one growth season in 44 Danish fields was examined by Overgaard (1919a, 1919b, 1921, 1922). He found an average production corresponding to 14,000 seeds per $m^2$, varying from 84 to 91,756 per $m^2$. These figures demonstrate that the number of seeds preserved from one growth season may vary widely.

Recently, Hvarregaard (1986) examined the potential weed seed production through a single growth season in 10 Danish fields under sugar-beet. She found an average of 1241 weed seeds/$m^2$ (100-4500/$m^2$). It is obvious that these fields were much cleaner than those examined by Overgaard (op. cit.).

From a dense stand of *Juncus bufonius* L., a production corresponding to 1,070,000 seeds per $m^2$ was found (Jensen 1968). This explains the large number of *Juncus bufonius* seeds frequently found in layers examined for botanical macrofossils (Kroll 1975; Jensen 1979a, 1986).

The seed production of single plants of different species has been examined by Dorph-Petersen (1906), Stevens (1932, 1957), Salisbury (1942), Korsmo (1954), and Aamisepp et al. (1967). The variation between species is excessive. For instance Dorph-Petersen (1906) reports 110,000 mericarps from a single plant of *Daucus carota* L.

In investigations of modern and palaeobotanical seed assemblages, the probability of recording is in general substantially higher for species with a high production of persistent seeds.

*Animals*

The numerous ways by which birds and mammals disperse seeds are described in detail elsewhere (Jessen & Lind 1922-23; Ridley 1930; van der Pijl 1982). Studies of the stomach content of Danish birds have demonstrated that a number of plant species are eaten by birds (Hammer et al. 1955; Bloch 1973). Several are able to pass through the bird digestive system without losing their germination capacity (Korsmo 1954). The number of seeds dispersed to an area by animals is usually limited, but is in the long term an important factor in the migration of species.

*Burnt house or deposit*

Excavated houses or deposits affected by fire contain mainly carbonized cereals and some weeds. Such finds give an indication of the crops grown in the area and of the weeds either associated with these or collected as food (Hatt 1938; Helbæk 1958b; Menke 1969; Hjelmqvist 1972).

*Graves*

Vessels found in graves have yielded information on what is believed to have been a highly esteemed drink (Gram 1911; Thomsen 1929). The finding of *Staphylea pinnata* L. in a grave from the Roman Iron Age (Mackeprang 1934) and of *Hyoscyamus* seeds in a Viking grave (Helbæk 1974) may indicate a symbolic or mystical power attributed to these species. *Staphylea pinnata* was most likely imported (cf. p. 65).

Unbiased information on the vegetation of the Bronze Age has been obtained through studies of plant remains under barrows (Iversen 1939; Kroll 1975).

*Gyttja, peat*
Gyttja and peat usually contain plants from wet habitats, but at the Muldbjerg site, cultivated and collected plants from a drier habitat have been found (Troels-Smith 1957).

*Humic culture layers*
Peat-like layers under towns have proved to contain a large number of macrofossils from cultivated plants as well as from natural plant communities (Jensen 1979a).

*Latrine*
Latrine deposits yield information on the vegetative diet of man and to some extent on other plants passing through the house (G. Jørgensen 1980).

*Manure*
Seeds of several species are able to pass through the digestive system of ruminant animals (Dorph-Petersen 1910; Korsmo 1954) and to some extent resist storage in a dunghill without losing their germination capacity (Dorph-Petersen & Holmgaard 1928). This indicates that manure and rubbish can add a substantial number of seeds to the seed bank. This was confirmed by examination of the 8th century manure layer from Ribe, in which a large number of seeds were found (Jensen 1986).

*Sowing*
The number of weed seeds added to the seed bank by sowing is limited in modern agriculture (Jensen 1969b, 1981), but before an effective screening was introduced, many weed seeds were dispersed into the fields (Korsmo 1954). From the very beginning of agriculture, many weeds were migrating along with seeds of the cultivated species and even used as food for man (Helbæk 1951, 1958a).

*Stomach*
Analyses of the stomach contents of corpses buried in peat for more than 2000 years have yielded information on the person's last meal (Helbæk 1950, 1951, 1958a; Brandt 1951).

*Storage*
Grain stored for later consumption has provided information on the cereals grown in different periods (Helbæk 1958b, 1958c, 1974). Preserved apples have been found on the island of Bornholm (Helbæk 1952).

The weed seeds mixed with cereals reflect to some extent the weed flora in the fields and harvesting method used (Willerding 1980). The crop cultivated may influence the weeds found as well. Hinz (1954) and Kroll (1975), for instance, report that a rather large number of *Cuscuta epilinum* Weihe seeds were found in samples of *Linum usitatissimum* L.

*Tools*
In modern agriculture, farm machinery is an important factor in spreading weeds both within and between fields. The simple tools used in the agriculture of former times were of minor importance as a dispersal factor.

*Wind dispersal*
The number of seeds added to the seed bank in arable soil by wind dispersal has in Denmark been examined by Sepstrup (1974) and in Scania by Zimmergren (1980). Sepstrup (1974) trapped through one season seeds dispersed from dikes running north-south in cultivated fields. The traps were placed 1, 5, 10, 25, and 50 m from the edge of the dike vegetation. East of the dikes - in the direction of the prevailing wind - a total of 843, 23, 0, 0, and 0 seeds per $m^2$ were trapped at these respective distances. These figures show that the number of seeds added to the seed bank by wind dispersal is limited when the seeds are trapped more than 5 metres from the vegetation.

Certain plants have effective anemochory, and their seeds are naturally spread to the cultivated areas. The perennial plant *Taraxacum* sp., for instance, was found growing in 25 out of 57 Danish fields, and as seed in 2 only (Jensen 1969a). As the analyses were performed in annual crops, the *Taraxacum* plants most likely originated from seeds transported to the fields by anemochory.

Higher figures can be obtained when seed dispersal is measured close to a large population of plants with effective anemochory. Lorenzen (1982) found at a distance of 40 and 80 m from a *Chamaenerion* population an invasion of 2000 and 560 seeds per $m^2$, respectively.

Despite the limited number of seeds of most species added to the seed bank within a single growth season, wind dispersal is an important factor in the migration of many species. For a considerable number of species, it is facilitated by morphological features of seeds, fruits, or vegetative parts (Ridley 1930; Harper 1977; van der Pijl 1982).

*Seeds removed by wind, water, animals, cropping, tools, etc.*

The number of seeds removed by wind, water, and tools is usually limited. Reduction caused by browsing animals may be of importance due both to removal and to the fact that most species have a reduced germination capacity after passing through the animal's digestive system (Dorph-Petersen 1910; Korsmo 1954).

Both in modern and ancient agriculture, a considerable number of seeds can be removed from the fields together with the crop.

The proportion of weed seeds removed depends, however, on the method of harvesting, in particular the height of the straw and weeds left standing after harvesting: ancient fields harvested by scythe would usually have fewer weed seeds left on the ground compared to those harvested by sickle, taller plant remains being left on the field with the latter method (cf. Willerding 1980).

Seeds produced in natural or semi-cultural plant communities have, most likely, less chance of survival compared to those produced in cultivated areas, since the latter are covered by soil during ploughing or harrowing.

*Primary or secondary position*

In an evaluation of to what extent dispersed seeds represent the original flora, it is of importance to know whether the macrofossils are in primary or secondary position.

Weed seeds found under burials and in cereal caches, for instance, may be in primary position, whereas when found in manure or together with carbonized cereals in pits or spread on the soil they must be in secondary position and can, accordingly, not serve as reliable sources of information on the composition of the weed flora.

# Preservation of Botanical Macrofossils

From deposit to analysis, the botanical macrofossils have been influenced by several factors that may have an effect on the results obtained.

## Resistance of non-carbonized macrofossils

Germination is an important factor in the reduction of the seed assemblage. Seeds of most species, however, arrive on the soil surface in dormant condition (Harper 1977). The term 'primary dormancy' is usually applied if such seeds need a period of after-ripening before germination. The term 'secondary dormancy' (or 'induced dormancy') is used if the seed loses its readiness to germinate by for instance low temperature or low oxygen tension (Mayer & Poljakoff-Mayber 1982).

A substantial part of the seeds in soil will in most cases be in secondary dormancy until they either reach the necessary conditions for germination or die.

If the soil is frequently disturbed and no new seed added, the seed bank will decrease exponentially due to germination and decay. Roberts & Feast (1973) examined the seed content in undisturbed plots and in plots dug twice and seven times per year. The number of seeds was annually reduced by 34%, 42%, and 56%, respectively.

The depth from which seeds are able to germinate varies between species. By measurement of the uncoloured part of the hypocotyl on seedlings germinated under natural field conditions, Chancellor (1964) demonstrated that seeds of *Chamomilla recutita* (L.) Rauschert germinate from the upper 0-2 cm of the soil; *Senecio vulgaris* L., *Stellaria media* (L.) Vill., and *Urtica urens* L., from a depth of 0-3 cm; *Fumaria officinalis* L., *Polygonum aviculare* L., *P. lapathifolium* L., *P. persicaria* L., and *Raphanus raphanistrum* L. from a depth of 0-5 cm, *Bilderdykia convolvulus* (L.) Dumort from a depth of 0-9 cm.

The ability to resist decomposition varies considerably between species. *Chenopodium album* proved to have the most resistant seed coat after 49 years of storage in garden soil (cf. p. 13). Accordingly, a large number of *Chenopodium* seeds have been found in seed banks from modern soil (Jensen 1969a; Lorenzen 1982) and from ancient soil samples (Behre 1983). Transient seeds disappear from the soil within one year (Grime 1980). Therefore, unless preserved under anaerobic conditions, it is rare in moist areas to find, for example, non-carbonized grasses in a palaeobotanical context.

The differences in resistance of non-carbonized seeds have without doubt a great influence on the composition of ancient seed assemblages. In dry areas, old uncarbonized seeds have been recovered. Examples include the find of 4,500-year-old emmer (*Triticum dicoccon* Schrank) from Egypt (Helbæk 1953a). Under specific conditions, ancient plant materials have been found replaced by inorganic substances. Various examples, including finds of phosphatic mineralized seeds from archaeological sites, have been published by Green (1979a, 1979b).

## Carbonization of macrofossils

A substantial part of the known history of cultivated plants, especially cereals, has been obtained by studying carbonized macrofossils. Most likely, the preserved cereals were carbonized by overheating during drying, when parched in ovens in order to facilitate threshing, or by unintentional fires in storehouses (Renfrew 1973).

Carbonized macrofossils will in most cases be the only plant remains left in mineral soil. The number of species identified at such sites is less than in corresponding uncarbonized finds (Willerding 1970; Zeist & Palfenier-Vegter 1979). Part of this

difference may be due to either destruction or alteration of the morphological detail necessary for identification.

## Imprints

A Danish teacher, Frode Kristensen, discovered in 1894 imprints of cereals in potsherds. This was followed up by G. Sarauw, who examined a great number of potsherds in Danish and foreign museums. His results have been utilized by Hatt (1937) and Brøndsted (1938) in describing the history of cereals in Denmark. Most imprints are from macrofossils which have been accidentally worked into the wet clay during the forming of the vessel. For some pottery, however, straw and other plant parts were deliberately mixed with the wet clay to temper it (Helbæk 1955, Hjelmqvist 1981-82).

Advantages of imprint studies are that the macrofossils identified can be exactly assigned to the time the vessel was made. This facilitates the dating and references to the contemporary culture (Hjelmqvist 1979).

The method is well suited for the discovery of cultivated plants, especially cereals, and weeds with rather large, characteristic seeds, while small seeds are naturally difficult to detect.

## Medium and macrofossils

Soil texture and moisture greatly influence the preservation of seed banks. Anaerobic conditions are, as mentioned, necessary for prolonged preservation of seeds.

Numerous experiments show that water provides excellent conditions for preservation of macrofossils. Famous are the finds of plant remains from prehistoric settlements in Swiss lakes (Heer 1866; Jacomet 1985). Other examples are analyses of plant remains from wells (Körber-Grohne 1979), from settlements in the wet coastal areas at Feddersen Wierde (Körber-Grohne 1967) and Elisenhof (Behre 1976), and from towns built on moist ground, e.g. Haithabu (Behre 1983), York (Kenward & Williams 1979), and Svendborg (Jensen 1979a, 1979b).

The media examined for botanical macrofossils in Denmark, Schleswig, Scania, Halland, and Blekinge (Jensen 1985) vary with regard to preservation. The following discussion of the occurrence of spermatophytes in Southern Scandinavia is based on these results. A brief description of some of the media examined is therefore given below.

*Gyttja, peat*

Due to anaerobic conditions, gyttja and peat provide excellent conditions for preservation of uncarbonized macrofossils.

*Imprints*

Imprints in vessels, potsherds and clay walls have supplied information on the occurrence of cultivated plants, especially of cereals and weeds with characteristic but not too small seeds.

*Manure*

Layers of manure from 8th century Ribe and 13th or 14th century Kolding contained a large number of uncarbonized macrofossils from cultivated and uncultivated species (Jensen 1986). In Ribe, the preservative effect must be due to the manure itself, since the manure (0.5-1.0 m thick) was found in sandy soil above the groundwater level (cf. Jensen op. cit. fig. 5).

*Pits*

Post-holes, pits and rubbish holes may contribute with both carbonized and uncarbonized macrofossils.

*Sand*

Sandy soil affected by man contains only carbonized macrofossils, unless anaerobic conditions obtain.

*Soil*

Soil may contain both carbonized and uncarbonized macrofossils, provided that anaerobic conditions have been present.

*Vessels*

Plant remains may be found on the surface of vessels. The first described find of ancient *Triticum* in Denmark was discovered on the surface of a bronze vessel incrusted with metal compounds (Rostrup 1877).

*Preservation in agricultural soil*

Several species are able to survive in soil for a shorter or longer period (Lewis 1958, 1983; Guyot 1960; Madsen 1962; Ødum 1965, 1978; Kivilaan & Bandurski 1973, 1981). It must, therefore, be assumed that a substantial part of the seed bank derives from previous years. The exact proportion, however, is not known from any experiment.

The seeds of *Tussilago farfara* L., for instance, germinate as soon as they reach moist soil, while other transient seeds lose their capacity to germinate within one year. This is, according to Grime (1980), typical of grasses with large seeds and/or elongated structure, lack of pronounced after-ripening or dormancy, and ability to germinate over a wide range of temperatures and in light and darkness.

Both types disappear from the soil. *Tussilago farfara* and *Elymus repens* (L.) Gould were, for instance, present as plants in some Danish fields, but no seeds were found in the corresponding seed bank. Other species with underground vegetative reproduction were represented in the seed bank with a limited average number of seeds per litre: *Cirsium arvense* (L.) Scop. with 0.1, *Sonchus arvensis* L. with 0.2, *Stachys palustris* L. with 0.2, *Rumex acetosella* L. with 1.2, and *Mentha arvensis* L. with 7 seeds per litre (Jensen 1969a).

More likely to be found in soil are species with a persistent seed coat, e.g. *Chenopodium* sp. The above-mentioned circumstance is reflected in ancient soil, where reports of grasses are rare, but of *Chenopodium* common (Jensen 1985).

The seed decay in soil was reflected in the seed bank in 57 modern Danish fields, which on average contained 50,258 living and 84,328 dead seeds per $m^2$ (Jensen 1969a).

The exact time between the death of the seeds of certain species and their disappearance from the soil is not known. Some information, however, has been derived from a storage experiment on buried seeds, started at the Danish State Seed Testing Station in 1934. From each of 29 cultivated and weed species, portions of 400 seeds were placed in porous clay pots filled with sterile soil and buried in garden soil 20 cm below the surface (Madsen 1962).

The germination capacity has been examined frequently through the years. Usually the pots were emptied out into boxes with sterile soil and the germinated seeds counted (Madsen op. cit.). This method, however, gave no information on the dead seeds still present in the soil. Therefore one set of pots, stored in the soil for 49 years, was washed and examined for remains of the buried seeds.

Soil from each of 29 pots was washed on a Fenwick washing apparatus provided with a 0.4 mm sieve (Jensen 1969a), and the residue examined for seed remains. The extracted seeds were germinated on a Jacobsen germinator (Anon. 1985), which in a previous experiment (Jensen 1969a) had provided higher percentage germination than the method used so far: germination in boxes with sterile soil, placed in a greenhouse. The following results were obtained for the 400 seeds of each species originally buried:

| | Number found | Percentage germination |
|---|---|---|
| *Brassica napus* L. var. *napobrassica* (L.) Reichenb. | 1 | 0 |
| *Brassica rapa* L. subsp. *rapa* (*B. campestris* var. *rapifera* Metzg.) | 1 | 0 |
| *Chenopodium album* L., sample 1 | 326 | 22 |
| *Chenopodium album* L., sample 2 | 242 | 4 |
| *Papaver rhoeas* L. | 2 | 0 |
| *Vicia hirsuta* (L.) S.F. Gray | 1 | 0 |

No remains were found of the following species:

*Agrostemma githago* L., *Centaurea cyanus* L., *Chrysanthemum segetum* L., *Cirsium arvense* (L.) Scop.,

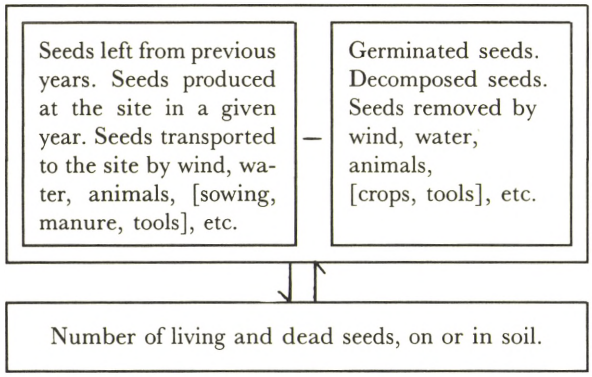
*Dactylis glomerata* L., *Daucus carota* L., *Geranium dissectum* L., *Geranium pusillum* L., *Hordeum distichon* L., *Lolium perenne* L., *Matricaria perforata* Mérat (*M. inodora* L.), *Medicago lupulina* L., *Phleum pratense* L., *Plantago lanceolata* L., *Plantago major* L., *Polygonum tomentosum* Schrank, *Rumex acetosella* L., *Rumex crispus* L., *Scleranthus annuus* L., *Sinapis arvensis* L., *Thlaspi arvense* L., *Trifolium pratense* L., *Trifolium repens* L., *Triticum aestivum* L. (*T. sativum* Lam.).

The decomposition of seeds to pieces of less than 0.4 mm (the mesh size of the sieve used) during the 49 years of storage in soil is most likely caused by the soil microfauna and microflora.

These results are relevant to the present study, since all genera and 24 of the 29 species listed are included in this publication.

*Factors affecting the assemblage of prospective plant macrofossils in agricultural soil*

In the chapter dealing with dispersal of seeds and fruits, and on the previous pages, several factors have been mentioned which either add to or subtract from the seed assemblage on or in soil:




Not all factors affecting the size of the ancient seed assemblage are known in detail, but the model presented below may describe the main factors involved. Designed for modern fields (Jensen 1969b), it is applicable to natural plant communities when factors associated with cultivation are excluded.

For ancient seed assemblages, the main part (cf. Ødum 1965) or all seeds originally dispersed to the site have lost their germination capacity. In cases where barrows were placed on the original vegetation (Iversen 1939; Kroll 1975), a considerable part of the original seed assemblage may still be present.

In most ancient seed assemblages, however, the decomposition of the seeds has continued through the years, and for that reason only a part of the original seed bank is available for analysis.

*Interaction between medium examined and results obtained*

The remarks above indicate that for all types of sites the results of macrofossil analysis depend largely on the medium examined. A similar relationship has been discussed for macrofossils found in medieval samples from Southern England, where the main part of the cereals were found carbonized, whereas the seeds from anaerobic pits, road surfaces, or ditches, were uncarbonized (Green 1979a).

The number of species obtained through studies of imprints is limited compared to that found through the examination of waterlogged materials, but the imprints can supply information which cannot be obtained elsewhere.

In general, the different aspects of the distribution and utilization of cultivated and wild plants in an area can be explored only through examinations of different types of media.

# Detecting Preserved Macrofossils

The methods applied during sampling and analysis have a great influence on the results obtained.

## Sample size

Within Southern Scandinavia the reports on macrofossil finds may vary from some additional notes taken when drawing samples for pollen analysis (S. Jørgensen 1954) to extensive examinations performed during excavation of sites (Behre 1976, 1983).

The size of the sample has naturally an effect on the number of species identified (van der Veen & Fieller 1982). During analysis of soil samples from Ribe and Viborg (Jensen 1986), each working sample was divided into two sub-samples of equal size. The average number of new taxa identified after analysis of the second set of sub-samples is shown below. The percentage increase is calculated on the average number of taxa in sets of sub-samples.

| Site | Number of working samples | Size of sub-samples | Average number of taxa in sets of sub-samples | Average number of new taxa recorded after examination of the second sub-samples |
|---|---|---|---|---|
| Sønderports-gade, Ribe | 13 | 125 ml | 17.2 | 3.3 (19%) |
| Kunstmuseet, Ribe | 5 | 250 ml | 20.8 | 5.4 (26%) |
| Viborg | 8 | 250 ml | 31.4 | 7.3 (23%) |

These figures indicate that a substantial increase in the number of species reported can be obtained by doubling the sample size. The time-consuming analytical work, however, limits the sample size. Similar findings from Southern England have been discussed by Green (1979a).

## Shape and size

The varying extent to which morphological characters have been preserved or destroyed is important for the identification of palaeobotanical macrofossils. *Carex* achenes, for instance, are in most cases found without the perigynium, which hampers species identification. In *Juncus* and other genera, the seeds of most species are difficult to identify to the species level. Although keys exist for *Carex* fruits without perigynium (Nilsson & Hjelmqvist 1967) and for seeds of *Juncus* (Körber-Grohne 1964) most authors do not go to the species level in the identification.

The size of macrofossils is important, since small seeds and especially their imprints are easily overlooked during analysis.

In many studies where seeds have been extracted from soil samples, the smallest sieve used has had 0.5 mm or even larger holes. Such sieves do not retain all seeds. Using the seed measurements published by Korsmo (1935), Brouwer & Stählin (1975), and Beijerinck (1976), it has been found that among the South Scandinavian species, at least 30 species have seeds with a width of between 0.4 and 0.5 mm, 18 species have seeds between 0.3 and 0.4 mm, and 30 species have seeds between 0.2 and 0.3 mm. Only certain species of Orchidaceae have seeds as small as 0.1 mm plus appendages.

These figures demonstrate that a lot of information may be lost if the smallest sieve used has holes larger than 0.2 mm.

It almost goes without saying that the skill of the analyst and the availability of the necessary reference seed collection, equipment and literature have

a major influence on the quality of the published results.

## Evaluation of finds

When the results presented below are studied, it must be kept in mind that the number and types of medium examined at different sites are unevenly represented through the different periods (cf. Fig. 1), and that the methods applied may vary as well. Therefore, as mentioned, only the presence and not the absence of species can be taken into account.

In the macrofossil studies available from Southern Scandinavia, most attention has been paid to sites affected by cultivation or habitation.

Accordingly, cultivated, collected, and ruderal plants have a rather high probability of representation.

The excellent conditions of preservation in deposits from wet areas mean that plants belonging to such communities are frequently reported, while plants from drier habitats have a minor probability of being recorded, uncarbonized parts of such plants rarely being preserved.

# Occurrence of Spermatophytes in Southern Scandinavia from 13000 BP to 1536 AD Elucidated by Finds of Macrofossils

The occurrence of spermatophytes in Southern Scandinavia (Denmark, Schleswig, Scania, Halland, and Blekinge) between 13000 BP and 1536 AD is in the following elucidated by finds of macrofossils. The information has been extracted from a catalogue of finds, giving name and location of the excavated sites, cited publications, dating, media examined, and for each taxon the number of finds in different periods (Jensen 1985).

The paper includes 516 taxa from the South Scandinavian flora, recorded as macrofossils in the periods considered, and 7 imported species. The accuracy of identification is as in the original publications. Taxa for which the dating has been uncertain are marked "(u)". Author designations and synonyms have been omitted here, but are listed in the catalogue (Jensen op. cit.). Macrofossils referred to genus only, or identified with uncertainty to species level, have been excluded, unless the occurrence is either the only one known, or the oldest one, from Southern Scandinavia.

For each period, the recorded taxa have been listed according to plant formation. The classification has been based on Mikkelsen (1980) and Hansen (1984), on information obtained from Vald. M. Mikkelsen (personal communication), and on the literature cited below.

The vegetation during the Late Weichselian was mainly 'tundra' and 'park-tundra'. These general terms cover a wide variety of growth conditions - as stated by Godwin (1975). Further division of the finds from Zones I-III by plant formation has, however, not been attempted, not least because conditions have varied both within and between the three periods and because they deviated from those established for the Flandrian stage. For these reasons, the findings from Zones I-III have been excluded from Fig. 3.

Macrofossils dated to the Flandrian are assigned to one or more of the following plant formations: 'lakes/ponds', 'bogs/swamps/wetlands', 'forests', 'heaths', 'grasslands', 'maritime plants', 'cultivated plants', 'weeds', and 'ruderal soils'. Since the collected information covers both a long period of time and various ecological conditions, these groups include a variety of vegetation types.

'Bogs/swamps/wetlands' includes wet forest areas and wet meadows. 'Forests' includes scrub - also coastal. 'Heath' amalgamates heath vegetation inland with that on coastal sand dunes. 'Grasslands' includes dry meadows, commons, slopes in coastal areas, etc.

'Maritime plants' is restricted to plants either known as closely associated with saline water (Iversen 1936; Mikkelsen 1949a, 1949b) or occurring along the coast only.

'Cultivated plants' includes medicinal herbs but not plants collected by ancient man in forests and hedges.

Some compromise has been necessary. Only the typical plant formation(s) for the species in question has been included: many species are listed under one plant formation only, while others occur under two or three. Findings in certain plant formations considered rare or atypical have been excluded.

The first recorded taxa are presented first and marked either "*" or "<". The latter sign indicates that records from the neighbouring countries - the British Isles, the Netherlands, Germany, Poland, Sweden, and Norway - suggest that the taxon may have been present in Southern Scandinavia in previous periods.

Each species listed in this chapter has been assigned to one of the life-forms established by Raunkiær (1907, 1934). In his system, plants are

classified according to how they survive the unfavourable season.

The allocation to the subdivisions of hemicryptophytes, geophytes, and therophytes (cf. Fig. 2) has been made in order to examine how different types of plants are affected by environmental changes during the periods studied.

The information on life-forms for the species recorded has been obtained from the latest issue of the local Danish flora (Hansen 1984). No account has been taken of the fact that many plants during Zones I and III were lower than at present. *Betula pendula* and *B. pubescens*, for instance, would most likely in most areas not have reached a height of 8 m during Zones I and III, and should accordingly have been classified as microphanerophytes for these periods.

During classification, it has been a problem that the media, life form, and plant formation could not always be assigned unambiguously. For some sites, 2 or 3 layers (media), and for some taxa 2 or 3 life forms or plant formations, were involved. When the number of media/taxa assigned to each factor were summed, the values 1/2 and 1/3 were used, respectively.

## Pollen Assemblage Zone I (13000-11800 BP)

A total of 24 taxa have been recorded as macrofossils in Pollen Assemblage Zone I. The chronozones Bølling and Older Dryas are not separated here, in accordance with older publications containing valuable information on macrofossils (referred to in Jensen 1985).

The climate changed at the beginning of the Bølling period from sub-arctic to temperate, with July temperatures a little above 10° C. Studies at the dried-up Bølling lake have disclosed a park-tundra vegetation with many plants growing in lakes and ponds (Iversen 1954).

Lately, the Bølling period at Bølling has been considered to represent the first part of the Allerød period, and accordingly to be younger than Older Dryas (Usinger 1985).

Older Dryas was cool with July temperatures of below 10° C. The vegetation was a treeless tundra, and the density of plants in lakes and ponds, gauged from pollen of *Potamogeton*, considerably lower than during the Bølling period (Iversen 1954).

Due to extensive changes in climatic and edaphic conditions during Late Weichselian, and to difficulties of comparison with later periods, the macrofossils recorded in Zones I-III are all referred to the group 'tundra/park-tundra'. Below, however, those taxa recorded from Zone I and belonging to aquatic vegetation have been listed separately from the remaining tundra and park tundra plants. All plant names are followed by an asterisk, indicating that all finds are the first recorded finds from Southern Scandinavia in the period considered:

*Zone I: Aquatic vegetation*

Callitriche hermaphroditica*, Carex cf. rostrata*, Menyanthes trifoliata*, Montia fontana subsp. fontana*, Myriophyllum spicatum*, Potamogeton compressus*, P. filiformis*, P. perfoliatus*, P. praelongus*, Potentilla palustris*, Ranunculus aquatilis*, R. cf. trichophyllus*, and Scirpus sylvaticus*.

*Zone I: Tundra/park tundra*

Arctostaphylos uva-ursi*, Betula nana*, B. pubescens*, B. pubescens subsp. carpatica*, Dryas octopetala*, Empetrum nigrum*, Salix herbacea*, S. phylicifolia*, S. polaris*, S. reticulata*, and Saxifraga oppositifolia*.

The species listed were most likely established in Southern Scandinavia during Pollen Assemblage Zone I, since it is unlikely that the recorded macrofossils were transported to Southern Scandinavia from other areas. For several species, this is supported by more than one find (Jensen 1985, Table 2). In comparison with pollen diagrams from Bølling (Jutland) and eastern Denmark (Iversen 1967, 1973), it is surprising that macrofossils of Gramineae, *Rumex*, *Juniperus*, *Helianthemum*, *Artemisia*, and *Hippophaë* so far have not been recorded from Zone I. For Gramineae, a similar relation has been

observed for the British Isles, where much grass-pollen but so far only few macrofossils have been identified from this period (Godwin 1975:440).

According to Fig. 1 (Zone I), finds from 17 different sites have been included in the review. The main part of the deposits were described as clay (59%), followed by gyttja/peat (17%), sand (12%), late glacial sediments (6%), and silt (6%). The sites examined were located in North Jutland, Schleswig, Funen, Zealand, and Bornholm.

When grouped according to life-form (Fig. 2), 45% of the recorded taxa are defined as helo- and hydrophytes, 20% as chamaephytes, 13% as nanophanerophytes, 6% as microphanerophytes, 4% as mega- and mesophanerophytes, and 4% as geophytes. These figures illustrate that most of the plants recorded from Zone I had their surviving bud well protected either below soil/water or close to the surface of the soil.

All finds were from sediments. It is therefore natural that the aquatic vegetation is well represented. Due to the incomplete vegetation cover, and erosion by water and wind, a rather high proportion of the dry land vegetation was incorporated in the lake sediments.

It is likely that further examination of deposits from Zone I, not least from areas so far not examined, would disclose that the vegetation in Southern Scandinavia during Zone I was richer in species than shown so far by finds of macrofossils. This is supported by the findings from Zone II. Among the taxa first recorded from this zone, 9 are marked "<", indicating that records from neighbouring countries suggest their presence in Southern Scandinavia during Zone I.

## Pollen Assemblage Zone II (11800-11000 BP)

Altogether, 41 taxa have been reported from Zone II (Allerød). Among these, 23 taxa have been recorded from Southern Scandinavian sites for the first time (marked * or < below).

Iversen (1954) suggested that the temperature in July during Late Allerød was 13°–14° C and that the dominating forest tree was *Betula pubescens*. During this period, humus formation was considerable, and colonization of sandy soil by the heath plants *Empetrum nigrum*, *Vaccinium uliginosum*, and *Arctostaphylos uva-ursi* was in progress (Iversen 1967). The macrofossils recorded from Zone II are listed below. Those occurring in Southern Scandinavia for the first time are listed first:

*Zone II: Aquatic vegetation*

Caltha palustris<, Carex vesicaria*, Hippuris vulgaris<, Nuphar pumila*, Oenanthe aquatica* (u), Potamogeton alpinus*, P. natans<, P. vaginatus*, P. x zizii* (u), Sparganium cf. angustifolium<.

Carex rostrata, Menyanthes trifoliata, Montia fontana subsp. fontana, Myriophyllum spicatum, Potamogeton compressus (u), P. filiformis, P. perfoliatus, P. praelongus, Potentilla palustris, Ranunculus aquatilis, R. cf. trichophyllus.

*Zone II: Woodland and scrub*

Betula intermedia* (either B. nana x B. pubescens or B. nana x B. pendula (Hartz 1902)), B. nana x B. pubescens*, B. pendula<, Juniperus communis<, Rubus saxatilis*, Salix cf. arbuscula*, S. cf. caprea*, S. cf. cinerea*, Urtica dioica<.

Betula nana, B. pubescens, B. pubescens subsp. carpatica.

*Zone II: Heaths and grasslands*

Arctostaphylos alpinus*, Rumex acetosella<, Stellaria media<, Vaccinium uliginosum subsp. microphyllum*.

Arctostaphylos uva-ursi, Dryas octopetala, Empetrum nigrum, Salix reticulata (u).

23 taxa were recorded for the first time in Zone II. Further information on these finds is given in the catalogue (Jensen 1985, Table 2), from which it appears that for several species the presence in Southern Scandinavia is supported by more than one find. *Oenanthe aquatica* is recorded with 2 finds, both referred to Zone II with some uncertainty. The species is, however, known from glacial and interglacial layers in the British Isles (Godwin 1975). It is therefore likely that the species was also established in Southern Scandinavia at that time.

*Carex aquatilis*, identified with some uncertainty by Iversen (1946), does not occur in Denmark today. The species, reported together with *C. bigelowii*, is known from the British Isles, Zones I-III, V-VIIa (Godwin 1975).

The following taxa, which might be expected according to the pollen diagrams of Bølling and eastern Denmark (Iversen 1967, 1973), have so far not been recorded as macrofossils in Zone II: Gramineae, *Pinus*, *Artemisia*, *Helianthemum*, *Hippophaë*, *Filipendula*, and *Populus tremula*.

In total, finds from 29 of the recorded sites have been dated to Zone II (cf. Fig. 1). Due to the higher temperatures, the production of organic materials was increased in lakes and ponds. There was ground cover, and the sedimentation of clay was in general reduced during the Allerød period (Iversen 1947).

Accordingly, 92% of the examined layers were described as gyttja/peat, 3% as late glacial sediments, 3% as sand, and only 2% as clay. The 29 sites were located in North Jutland, South Jutland, Schleswig, Funen, Zealand, Bornholm, and Blekinge.

The life-forms of the Zone II taxa show a distribution similar to that of Zone I (cf. Fig. 2). 46% of the genera were helo- and hydrophytes, 14% chamaephytes, 14% hemicryptophytes, 11% nanophanerophytes, 7% microphanerophytes, and 7% mega- and mesophanerophytes. The surviving bud was for most species protected by water/soil, or placed on or near the soil surface, allowing protection by snow.

All layers examined were sediments, and the plants from aquatic vegetation have a high probability of representation.

The vegetation of Zone II is most likely not fully known yet. 15 of the taxa first recorded from Zone III are marked "<", in this case signifying that they have been recorded from Zone II in the British Isles (Godwin 1975). Southern Scandinavia was during Zone II connected with Britain, and it is therefore likely that these 15 taxa were present in both areas during this period.

## Pollen Assemblage Zone III (11000-10000 BP)

From this period, 56 taxa were recorded as macrofossils, with 24 taxa recorded from Southern Scandinavia for the first time.

The temperature in Europe north of the Alps was during the Younger Dryas 3°–4° C lower than in Late Allerød. In northwestern Denmark, the vegetation was mainly tundra, while in southwestern Denmark it was an open park tundra. Throughout the area, *Betula nana*, *Juniperus communis*, *Empetrum nigrum*, *Arctostaphylos uva-ursi*, and *A. alpinus* were common (Iversen 1967). The amount of pollen from water-plants found in Zone III deposits is less than in Zone II. The heath plant *Calluna vulgaris* was of minor importance in Zone III (Iversen 1967). Macrofossils from that species have, however, been recorded from North Jutland, Funen, and Bornholm (Jensen 1985, Table 2).

The following macrofossils have been recorded:

*Zone III: Aquatic vegetation*

Carex cf. aquatilis*, Ceratophyllum demersum <, Eleocharis palustris< (u), Eriophorum vaginatum< (u), Hydrocotyle vulgaris* (u), Myriophyllum alterniflorum< (u), M. verticillatum<, Nymphaea alba<, Potamogeton friesii< (u), P. gramineus< (u), P. obtusifolius< (u), P. pectinatus*, P. pusillus* (u), P. trichoides < (u), Scirpus lacustris*, Sparganium minimum* (u), Triglochin maritima* (u), Viola palustris< (u), Zannichellia palustris<.

Callitriche hermaphroditica (u), Caltha palustris (u), Carex rostrata, Hippuris vulgaris, Menyanthes trifoliata, Montia fontana subsp. fontana, Myriophyllum spicatum, Potamogeton alpinus (u), P. compressus (u), P. filiformis, P. natans, P. praelongus (u), P. x zizii (u), Potentilla palustris, Ranunculus aquatilis (u), R. cf. trichophyllus, Sparganium cf. angustifolium (u).

*Zone III: Tundra, park tundra*

Calluna vulgaris*, Pinus sylvestris<, Potentilla erecta< (u), Rubus idaeus* (u).

Arctostaphylos alpinus, Betula nana, B. pendula, B. pubescens, B. pubescens subsp. carpatica (u), Dryas octopetala, Empetrum nigrum, Juniperus communis, Salix herbacea, S. cf. phylicifolia, S. polaris, S. reticulata, Saxifraga oppositifolia (u), Vaccinium uliginosum subsp. microphyllum (u).

*Zone III: Grasslands*
Armeria maritima<.
Rumex acetosella.

*Armeria maritima* has been found in samples from North Jutland, Funen, Zealand, and Bornholm, which indicates that the plant was rather common in Southern Scandinavia. Unfortunately, 5 of the 6 finds were not securely dated to this period. Iversen (1967) reports that pollen of *Armeria* occurs frequently in North European layers dated to Older and Younger Dryas.

The following taxa which might be expected according to the pollen spectra of Zones I-III from Bølling and eastern Denmark are so far missing from the macrofossil record: Gramineae, *Filipendula*, and *Artemisia*.

Finds from 48 sites were assigned to Zone III (Fig. 1). 55% of the media were described as clay, 25% as gyttja/peat, 10% as sand, 2% as silt, and 2% as lime. 2% of the media were described as late glacial sediments; for 4% the medium was not stated. This distribution is, as might be expected, more like the findings from Zone I than those from Zone II. Gyttja/peat is, however, well represented in this period.

The 48 sampled sites were located in all areas of Southern Scandinavia except Lolland, Falster, and Blekinge.

The distribution according to life-form (Fig. 2) shows that 51% of the taxa recorded were classified as helo- and hydrophytes, 20% as hemicryptophytes, 12% as chamaephytes, 6% as mega- and mesophanerophytes, 5% as nanophanerophytes, 4% as microphanerophytes, and 2% as geophytes.

As indicated for the previous zones, the aquatic vegetation had, due to the nature of the sites sampled, a high probability of representation. The soil was still unstable due to erosion and melting of buried ice (Iversen 1954), and several of the macrofossils from drier habitats were most likely washed into the sediments.

5 of the species first recorded during Zone IV are marked "<",suggesting that these species may have appeared in Southern Scandinavia already in Zone III.

## Pollen Assemblage Zone IV (10000-9300 BP)

From Zone IV, a total of 49 taxa have been recorded. Among these, 17 taxa have been recorded from sites in Southern Scandinavia for the first time.

At the zone border III/IV, the temperature seems to have risen so quickly that development of a dense forest could not follow the climatic improvement. The vegetation was from the beginning of the period dominated by *Filipendula*, *Juniperus*, and in North Jutland by *Empetrum nigrum*. The pollen curves for *Populus tremula*, *Betula pubescens/pendula* soon indicate an increasing density of these forest trees. *Pinus* was invading from the southeast, and as this tree is longer-lived than *Betula*, it became increasingly more important. The vegetation in water and in wet areas was rich. The average temperature for July is estimated to have been about 15°C (Iversen 1967).

Macrofossils of the following taxa, listed according to plant formation, were recorded:

*Zone IV: Lakes/ponds*
Alisma plantago-aquatica*, Cicuta virosa*, Najas marina*, Nuphar lutea<, Phragmites australis*, Ranunculus flammula<.

Ceratophyllum demersum, Hippuris vulgaris, Menyanthes trifoliata, Myriophyllum spicatum, M. verticillatum, Nymphaea alba, Potamogeton natans, P. pectinatus, P. perfoliatus, P. praelongus, Ranunculus cf. trichophyllus (u), Scirpus lacustris, Sparganium cf. angustifolium (u), S. minimum.

*Zone IV: Bogs/swamps/wetlands*
Alnus glutinosa*, Carex lasiocarpa*, C. pseudocyperus*, Cicuta virosa*, Lycopus europaeus*, Phragmites australis*, Rumex cf. maritimus<, Ranunculus flammula<, R. repens<, Solanum dulcamara*.

Betula intermedia (u), B. nana, B. pubescens, B. pubescens subsp. carpatica (u), Calluna vulgaris, Carex rostrata, C. vesicaria, Empetrum nigrum, Eriophorum vaginatum, Menyanthes trifoliata, Potentilla palustris, Salix cinerea, Scirpus lacustris, S. cf. sylvaticus, Sparganium cf. angustifolium (u), S. minimum.

*Zone IV: Forests*
Betula pendula x B. pubescens*, Populus tremula*, Prunus padus*, Solanum dulcamara*.

Betula pendula, B. pubescens, B. pubescens subsp. carpatica (u), Pinus sylvestris, Salix cf. caprea.

*Zone IV: Heaths*
Populus tremula*.

Calluna vulgaris, Empetrum nigrum, Vaccinium uliginosum subsp. microphyllum (u).

*Zone IV: Grasslands*
Hippophaë rhamnoides<, Ranunculus repens<.

Salix polaris (u).

*Zone IV: Plant formation uncertain*
Taraxacum sp.*

Several of the 17 first-recorded taxa from this period occurred at more than one site. Their establishment in Southern Scandinavia is for all species supported by finds in one or more of the subsequent zones. Most species have been recovered from the following Zone V.

According to pollen spectra for Jutland and East Denmark (Iversen 1967), *Betula* was very important in Zone IV. Macrofossils of *Betula intermedia*, *B. nana*, *B. pendula*, *B. pubescens*, *B. pendula x B. pubescens*, and *B. pubescens* subsp. *carpatica* have been recorded from 1, 5, 1, 5, 1 and 1 finds, respectively.

*Pinus* pollen became increasingly frequent. Macrofossils of *Pinus sylvestris* are known from 5 deposits dated to Zone IV. *Calluna vulgaris*, which according to pollen records was of growing importance in West Jutland, is represented by one find of macrofossils. According to the pollen curves, *Juniperus*, *Filipendula*, and Gramineae were rather important during Zone IV, but so far only one find of macrofossils (*Phragmites australis*) has been recorded from Zone IV. *Populus tremula*, rather frequent in pollen diagrams from eastern Denmark, is represented with 3 finds of macrofossils (Jensen 1985). The species has been listed for forests, and for heaths, which this pioneer tree invades, since it is able to survive heath-burning (Hansen 1976).

Finds from a total of 30 sites in all areas of Southern Scandinavia have been dated to Zone IV. 97% of the examined deposits were classified as gyttja/peat, and 3% as clay (Fig. 1). These figures reflect that water erosion was to a large extent prevented by a nearly complete vegetation cover. Melting of buried ice may, however, in certain areas have caused some landslides (Iversen 1954).

Around many lakes, reed vegetation was, as far as we know, developed, which had a reducing effect on wave erosion. Indications of reed vegetation are 1 find of *Phragmites australis*, 4 finds of *Scirpus lacustris*, 1 find of *Sparganium* cf. *angustifolium*, 1 find of *Sparganium minimum*, 2 finds of *Carex rostrata* and 1 find of *Carex vesicaria*. Godwin (1975) reports *Phragmites australis* from 3 British sites, one of which is now located in the North Sea. Due to the connection of Britain with Southern Scandinavia, the British finds support the existence of a reed vegetation in South Scandinavian lakes during Zone IV.

49% of the identified taxa were classified as helo- and hydrophytes, 13% as mega- and mesophanerophytes, 10% as chamaephytes, 9% as microphanerophytes, 7% as hemicryptophytes, 6% as nanophanerophytes, 4% as therophytes, and 2% as geophytes (Fig. 2). The increase in temperature during Zone IV is reflected in the occurrence of mega- and mesophanerophytes, microphanerophytes, and nanophanerophytes, which all showed higher frequencies compared to Zone III. The therophytes (represented by *Najas marina* and *Rumex* cf. *maritimus)*, which from Zone VIII onwards play an important part, occur here for the first time. It appears from Fig. 3 that 42% of the taxa were from bogs/swamps/wetlands, 33% from lakes/ponds, 15% from forests, 5% from heaths, and 5% from grasslands.

All the recorded finds from Zone IV were, as mentioned, from sediments, and the plants from wet areas have accordingly a high probability of being recorded. The vegetation in drier areas is, however, represented with a number of finds. Part of these were most likely brought to the sediments by erosion.

7 taxa, recorded for the first time from Southern

Scandinavia in deposits dated to Zone V, are known from British finds dated to Zone IV or earlier. Even if the sites examined were fairly evenly distributed throughout Southern Scandinavia, it is likely that further macrofossil analysis would result in a higher number of taxa than known at present.

## Pollen Assemblage Zone V (9300-c.8000 BP)

Of the total of 58 taxa that have been recorded from Zone V, 15 were recorded from sites in Southern Scandinavia for the first time.

The rise in temperature continued throughout Zone V. Iversen (1967) estimated the average temperature in July as at least 2° C above the present average for the area (c. 17° C), and the temperature in January was not below the present average(−1° C).

Trees and bushes preferring higher temperatures and able to grow in shade were invading. First came *Corylus*, followed by *Ulmus* and *Tilia*. Accordingly, the vegetation changed through Zone V from open forest to a denser growth of shade-trees (Iversen 1967).

Below, the recorded macrofossils are grouped according to plant formation:

*Zone V: Lakes/ponds*
Ceratophyllum submersum*, Najas flexilis*.

Alisma plantago-aquatica, Ceratophyllum demersum (u), Menyanthes trifoliata, Myriophyllum spicatum (u), M. verticillatum, Najas marina, Nuphar lutea, Nymphaea alba, Phragmites australis, Potamogeton alpinus, P. filiformis (u), P. natans, P. pectinatus, P. perfoliatus (u), P. praelongus, Ranunculus aquatilis, Scirpus lacustris.

*Zone V: Bogs/swamps/wetlands*
Carex riparia< (u), Cladium mariscus*, Frangula alnus* (u), Geum sp.< (u), Peucedanum palustre* (u), Potentilla anserina<, Prunella vulgaris*, Rumex hydrolapatum* (u), Scirpus lacustris subsp. tabernaemontani<.

Alnus glutinosa, Betula intermedia (u), B. nana (u), B. pubescens, B. pubescens subsp. carpatica, Calluna vulgaris, Carex lasiocarpa, C. pseudocyperus (u), C. rostrata (u), Dryas octopetala (u), Eriophorum vaginatum, Lycopus europaeus (u), Menyanthes trifoliata, Phragmites australis, Potentilla palustris, Ranunculus repens, Rumex cf. maritimus, Scirpus lacustris, S. cf. sylvaticus, Urtica dioica, Viola palustris.

*Zone V: Forests*
Corylus avellana<, Frangula alnus* (u), Stachys sylvatica< (u), Ulmus glabra*.

Betula pendula x B. pubescens (u), B. pubescens, B. pubescens subsp. carpatica, Pinus sylvestris, Populus tremula, Rubus idaeus (u), R. saxatilis (u), Salix caprea, Urtica dioica.

*Zone V: Heaths*
Calluna vulgaris, Populus tremula.

*Zone V: Grasslands*
Potentilla anserina<, Prunella vulgaris*.

Ranunculus repens.

*Zone V: Maritime plants*
Ruppia maritima<.

*Zone V: Plant formation uncertain*
Atriplex sp.*.

Taraxacum sp.

The establishment of several species is supported by more than one find. Especially the finds of *Cladium mariscus* indicate that the species was growing in nearly all parts of Southern Scandinavia.

*Carex riparia* is represented by one insecurely dated find (Mikkelsen 1954). The species has been recorded from the British Isles, Zones II-III, V-VI. An establishment in Zone V or earlier therefore seems likely.

*Frangula alnus* has according to Godwin (1975) been recorded from the Dogger Bank, Zone V, thus supporting establishment in Denmark from this period.

The British finds of *Geum rivale* or *G. urbanum* suggest that at least one of these species was present in Southern Scandinavia from Zone V.

*Stachys sylvatica*, known from one ambiguously dated find (Jessen 1916), is reported from the British Isles, Zones IV, VIIa-VIII (Godwin 1975).

According to the pollen diagrams from both Jutland and East Denmark (Iversen 1967), *Corylus*

was very frequent in Zone V. So far, macrofossils from *Corylus avellana* have been recorded from only 2 sites dated to this period.

Pollen of *Betula* occurs frequently as well, not least at the beginning of the period. *Betula intermedia*, *B. nana*, *B. pendula x B. pubescens*, *B. pubescens*, and *B. pubescens* subsp. *carpatica* are known as macrofossils from 1, 3, 1, 6, and 2 sites, respectively.

*Alnus* is rather common as pollen from this period. *A. glutinosa* has been recorded from 3 sites dated to Zone V. *Populus tremula* and *Pinus sylvestris*, both well represented as pollen, have been recorded as macrofossils from 3 and 8 sites, respectively.

Among the genera *Ulmus*, *Tilia*, and *Quercus*, whose pollen became frequent during Zone V, only *Ulmus glabra* is represented as a macrofossil from 1 site.

Pollen of Gramineae are frequently present in deposits from this period, but so far this family is represented only by *Phragmites australis*, known from 7 sites.

Finds from 48 sites dated to Zone V have been recorded (Fig. 1). 94% were gyttja/peat, 1% sand, and 1% clay. For 4% of the samples, the medium was not clearly indicated. The sites examined were located in all areas of Southern Scandinavia.

The distribution of the recorded taxa according to life-form shows that 45% of the taxa were helo- and hydrophytes, 20% hemicryptophytes, 12% mega- and mesophanerophytes, 6% microphanerophytes, 6% chamaephytes, 5% therophytes, 4% nanophanerophytes, and 2% geophytes (cf. Fig. 2).

Fig. 3 shows that 43% of the taxa were assigned to bogs/swamps/wetlands, 31% to lakes/ponds, 18% to forests, 4% to grasslands, 2% to maritime plants, and 2% to heaths.

Compared to previous periods, the plants from lakes and ponds showed a slight reduction, whereas forest plants have an increased importance.

Although the sites examined were distributed throughout Southern Scandinavia, it is likely that further examinations would disclose a greater number of taxa, since 18 taxa recorded for the first time in Zones VI-VII have been recorded from the neighbouring countries from Zone V or earlier.

## Pollen Assemblage Zones VI and VII (c. 8000-5000 BP)

From Zones VI and VII, a total of 96 taxa have been recorded. The two zones are combined here, because the definition of zone border VI/VII varies between authors (S.T. Andersen 1978). 36 taxa were recorded for the first time in these zones.

The finds of macrofossils of *Trapa natans* and of the marsh tortoise *Emys orbicularis* indicate that the rise in temperature continued and reached its peak. July temperatures were most likely 3° C higher than at present. Precipitation was greater than in the previous period, and several raised bogs were formed during Zones VI and VII. Forests were dominated by *Tilia*, *Ulmus*, and *Quercus*, and by *Alnus glutinosa* on wet soil. *Fraxinus* was of increasing importance toward the end of the period (Iversen 1967).

Macrofossils from the following plant formations were recorded:

*Zones VI-VII: Lakes/ponds*

Calla palustris*, Sparganium cf. emersum<, S. erectum< (u), Trapa natans<, Utricularia sp.*

Ceratophyllum demersum, C. submersum (u), Cicuta virosa, Hippuris vulgaris, Menyanthes trifoliata, Myriophyllum verticillatum, Najas flexilis, N. marina, Nuphar lutea, Nymphaea alba, Oenanthe aquatica, Phragmites australis, Potamogeton natans, P. obtusifolius, P. pectinatus, P. perfoliatus (u), P. praelongus, Ranunculus flammula, Scirpus lacustris, Sparganium minimum, Zannichellia palustris (u).

*Zones VI-VII: Bogs/swamps/wetlands*

Bidens cernua< (u), Carex curta*, Cirsium palustre*, Eupatorium cannabinum<, Iris pseudacorus*, Lychnis flos-cuculi <, Ranunculus sceleratus<, Scheuchzeria palustris*, Sparganium cf. emersum<, S. erectum< (u), Stachys palustris< (u), Typha sp.< (u), Vaccinium oxycoccos<.

Alnus glutinosa, Betula pubescens, B. pubescens subsp. carpatica (u), Calluna vulgaris, Carex lasiocarpa, C. pseudocyperus, C. rostrata, Cicuta virosa, Cladium mariscus, Eleocharis palustris (u), Empetrum nigrum, Eriophorum vaginatum, Frangula alnus, Geum sp. (u), Hydrocotyle vulgaris,

Lycopus europaeus, Menyanthes trifoliata, Peucedanum palustre (u), Phragmites australis, Potentilla palustris, Ranunculus repens, Rumex hydrolapathum (u), R. maritimus (u), Salix cinerea (u), Scirpus lacustris, S. lacustris subsp. tabernaemontani, S. sylvaticus (u), Solanum dulcamara, Sparganium minimum, Urtica dioica.

*Zones VI-VII: Forests*

Acer platanoides*, Actaea spicata*, Cornus sanguinea*, Fagus sylvatica< (u), Fraxinus excelsior<, Humulus lupulus* (u), Moehringia trinervia< (u), Quercus cf. petraea*, Q. robur*, Sorbus aucuparia< (u), Tilia cordata*, T. x vulgaris* (u), Viscum album* (u).

Betula pendula, B. pubescens, B. pubescens subsp. carpatica (u), Corylus avellana, Frangula alnus, Pinus sylvestris, Populus tremula, Prunus padus (u), Rubus idaeus, Salix caprea, Solanum dulcamara, Stachys sylvatica (u), Ulmus glabra, Urtica dioica.

*Humulus lupulus*, which in later periods is considered also a cultivated plant, is here assigned to forests only, since a cultivation at this early date seems unlikely.

*Zones VI-VII: Heaths*

Carex curta*.

Calluna vulgaris, Empetrum nigrum, Populus tremula, Vaccinium uliginosum subsp. microphyllum (u).

*Zones VI-VII: Grasslands*

Rumex crispus< (u).

Ranunculus repens.

*Zones VI-VII: Maritime plants*

Atriplex littoralis* (u), Ruppia cirrhosa< (u), Zostera marina*.

*Zones VI-VII: Plant formation uncertain*

Arctium sp.*, Atriplex patula< (u), Chenopodium album<, Crataegus sp.* (u), Polygonum aviculare*, Rhynchospora sp.<, Rumex crispus<.

Atriplex sp., Geum sp.

Several of the species listed as first recorded for Zones VI-VII are represented by more than one find (e.g. *Tilia cordata*).

The earlier or contemporaneous presence of *Atriplex patula*, *Bidens cernua*, and *Crataegus* sp. in the British Isles suggests that these species were present in Southern Scandinavia at least from Zones VI-VII. The establishment of *Humulus lupulus* in the area was most likely earlier than indicated by macrofossils, since pollen of this species is frequently recorded in layers dated 8000-7000 BC (Berglund 1966a; Iversen 1967).

The finds of *Moehringia trinervia*, *Rumex crispus*, *R. maritimus*, *Ruppia cirrhosa*, *Sorbus aucuparia*, *Sparganium erectum*, *Stachys palustris*, *Tilia x vulgaris*, and *Typha* sp. are all supported by finds in coeval or earlier deposits in the neighbouring countries (Jensen 1985). *Viscum album* is known from local finds of pollen from Zone VI - about 6000 BC (Iversen 1944, 1967; Mikkelsen 1949a).

Zones VI-VII are represented with records from 57 sites (Fig. 1). 96% of the examined layers were described as gyttja/peat, and 1% as silt, while for 3% the medium was not stated. The sampled sites were located in all areas of Southern Scandinavia.

Classification by life-form (Fig. 2) shows that 37% of the recorded taxa were helo- and hydrophytes, 18% hemicryptophytes, 16% mega- and mesophanerophytes, 11% therophytes, 7% microphanerophytes, 6% chamaephytes, 4% geophytes, and 1% epiphytes.

When distributed by plant formation, 41% were assigned to bogs/ swamps/wetlands, 27% to forests, 24% to lakes/ponds, 3% to maritime plants, 3% to heaths, and 2% to grasslands (Fig. 3).

Comparison with previous periods shows an increased representation of trees and bushes, and a reduction in macrofossils from lakes and ponds.

Despite a large number of macrofossil analyses from sites located in all parts of Southern Scandinavia, it is likely that further analysis would augment the list of species, since 27 of the first-recorded taxa from Zone VIII have been listed in finds from the present periods or earlier in the neighbouring countries.

## Pollen Assemblage Zone VIII (5000-2500 BP)

A total of 161 taxa were recorded from Zone VIII.

84 of these were first records for Southern Scandinavia.

The temperature was slightly lower than in the previous period, but higher than today, as the heat-demanding *Trapa natans* and the marsh tortoise *Emys orbicularis* were still living in Denmark (Iversen 1967).

The zone border VII/VIII is defined with the beginning of the decline of the pollen curve for *Ulmus*. Also the *Tilia* curve shows a marked decline for this period. The *Ulmus* fall may be explained by the beginning of agriculture. Leaves and twigs of *Ulmus* and *Tilia* were used as fodder for animals, and part of the forest was burned before cultivation of cereals.

The burning of the forest areas and the cultivation created growing possibilities for many species of bare soil and open habitats - the 'weeds'. In the interval between the cessation of cultivation and the establishment of a new cover of trees and bushes, grasses were growing in the abandoned fields. Pollen of cereals, other grasses, *Plantago major*, *P. lanceolata*, *Rumex acetosella*, and *R. acetosa*, as well as archaeological artefacts, are indicators of this development (Iversen 1941, 1967; Troels-Smith 1954, 1960).

The period covers the development of agriculture from its very inception to a rather widespread cultivation. The forest became more and more open due to cultivation and to browsing animals hampering re-growth of trees and bushes. In the forests, *Ulmus* and *Tilia* were partly replaced by *Fraxinus*, *Quercus*, and *Corylus*. *Calluna vulgaris* was expanding on sandy soil (Odgaard in Andersen et al. 1983).

The following taxa - grouped according to plant formation and into spontaneous or anthropochorous species (see p. 62) - were recorded from Zone VIII:

*Zone VIII: Lakes/ponds*

*Spontaneous*: Alisma plantago-aquatica, Calla palustris, Ceratophyllum demersum, Cicuta virosa, Menyanthes trifoliata, Myriophyllum spicatum, Najas marina, Nuphar lutea, Nymphaea alba, Phragmites australis, Potamogeton natans, P. obtusifolius, P. pectinatus, P. praelongus, Ranunculus flammula, Scirpus lacustris, Sparganium cf. emersum, Trapa natans, Zannichellia palustris.

*Zone VIII: Bogs/swamps/wetlands*

*Spontaneous*: Andromeda polifolia<, Anthriscus sylvestris* (u), Calystegia sepium*, Carex cf. acuta*, C. cf. diandra*, C. cf. echinata<, C. elata*, C. cf. flava<, Filipendula ulmaria< (u), Lythrum salicaria*, Myrica gale<, Phleum cf. pratense*, Polygonum hydropiper*, P. lapathifolium*, Ranunculus acris<, Rhynchospora alba<, Rumex acetosa<, Scirpus cespitosus<, Valeriana officinalis subsp. sambucifolia<.

Alnus glutinosa, Betula pubescens, Calluna vulgaris, Caltha palustris, Carex curta, C. lasiocarpa, C. pseudocyperus, C. cf. rostrata, C. vesicaria (u), Cicuta virosa, Cladium mariscus, Eleocharis palustris, Empetrum nigrum, Eriophorum vaginatum, Frangula alnus, Hydrocotyle vulgaris, Lychnis flos-cuculi, Lycopus europaeus, Menyanthes trifoliata, Peucedanum palustre (u), Phragmites australis, Potentilla erecta, P. palustris, Prunella vulgaris, Ranunculus repens, R. sceleratus, Salix cinerea (u), Scheuchzeria palustris, Scirpus lacustris, S. lacustris subsp. tabernaemontani, Solanum dulcamara, Sparganium cf. emersum, Urtica dioica (u), Vaccinium oxycoccos.

*Zone VIII: Forests*

*Anthropochorous?*: Lapsana cf. communis*.

*Spontaneous*: Cf. Elymus caninus*, Fragaria vesca*, Galium aparine*, Malus sylvestris*, Prunus spinosa*, Rubus cf. caesius <, R. fruticosus group*, Sorbus cf. intermedia*, Taxus baccata<.

Acer platanoides, Betula pendula, B. pubescens, Cornus sanguinea, Corylus avellana, Fagus sylvatica, Frangula alnus, Fraxinus excelsior, Pinus sylvestris, Populus tremula, Potentilla erecta, Quercus robur, Rubus idaeus, Solanum dulcamara, Sorbus aucuparia (u), Tilia cordata, T. x. vulgaris (u), Urtica dioica (u).

*Zone VIII: Heaths*

*Spontaneous*: Andromeda polifolia<, Carex pilulifera*, Danthonia decumbens*, Genista anglica et G. pilosa*, Myrica gale<, Scirpus cespitosus<.

Calluna vulgaris, Carex curta, Empetrum nigrum, Populus tremula, Potentilla erecta.

*Zone VIII: Grasslands*

*Anthropochorous*: Silene alba*.

*Spontaneous*: Achillea millefolium<, Agrimonia eupatoria*, Anthriscus sylvestris* (u), Arenaria serpyllifolia<, Bromus hordeaceus subsp. hordeaceus*, Carex pilulifera*, Cirsium vulgare <, Danthonia decumbens*, Daucus carota<, Fragaria vesca*, Knautia arvensis*, Leontodon autumnalis<, Luzula cam-

pestris*, Phleum cf. pratense*, Plantago lanceolata*, Prunus spinosa*, Ranunculus acris<, Rubus cf. caesius*, Rumex acetosa*, Scleranthus annuus*, Viola canina<, V. tricolor*.

Prunella vulgaris, Ranunculus repens, Rumex acetosella, Stellaria graminea.

*Zone VIII: Maritime plants*

*Spontaneous*: Scirpus maritimus*.

Ruppia maritima, Zostera marina.

*Zone VIII: Cultivated plants*

*Anthropochorous*: Avena sativa*, A. strigosa*, Brassica cf. nigra*, B. rapa*, Hordeum vulgare (six-rowed hulled barley)*, H. vulgare var. nudum (six-rowed naked barley)*, H. vulgare (hulled or naked barley)*, Linum usitatissimum*, Panicum miliaceum*, cf. Pisum sativum*, Spergula arvensis*, Triticum compactum*, T. dicoccon*, T. monococcum*, T. spelta*.

*Spontaneous*: Daucus carota<, Malus sylvestris*.

*Zone VIII: Weeds*

*Anthropochorous*: Avena fatua*, A. strigosa*, Bilderdykia convolvulus*, Brassica rapa*, Bromus secalinus*, Camelina alyssum*, Capsella bursa-pastoris*, cf. Euphorbia helioscopia*, Lolium cf. temulentum*, Raphanus raphanistrum*, Silene noctiflora*, Sinapis arvensis*, Sonchus oleraceus<, Spergula arvensis*, Thlaspi arvense*.

*Anthropochorous?*: Erodium cicutarium*, Lapsana cf. communis*.

*Spontaneous*: Achillea millefolium<, Arenaria serpyllifolia<, Chenopodium cf. glaucum*, Galeopsis tetrahit<, Galium aparine*, Plantago lanceolata*, Polygonum hydropiper*, P. lapathifolium*, P. persicaria<, Scleranthus annuus*, Solanum nigrum<, Stellaria media<, Viola tricolor*.

Chenopodium album, Polygonum aviculare, Ranunculus repens, R. sceleratus, Rumex acetosella.

*Zone VIII: Ruderal soils*

*Anthropochorous*: Avena strigosa*, Bilderdykia convolvulus*, Brassica cf. nigra*, Bromus secalinus*, Capsella bursa-pastoris*, Chenopodium cf. urbicum*, Lolium cf. temulentum*, Malva pusilla*, Panicum miliaceum*, Silene alba*, Sonchus oleraceus <, Thlaspi arvense*.

*Anthropochorous?*: Lapsana cf. communis*.

*Spontaneous*: Achillea millefolium<, Bromus hordeaceus subsp. hordeaceus*, Chenopodium cf. glaucum*, Cirsium vulgare<, Galeopsis tetrahit<, Galium aparine*, Polygonum lapathifolium*, P. persicaria<, Stellaria media<.

Chenopodium album, Plantago lanceolata, Polygonum aviculare, Potentilla anserina, Urtica dioica (u).

*Zone VIII: Plant formation uncertain*

*Spontaneous*: Agrostis sp.*, Holcus sp.*, Hypericum sp.<, Juncus sp.<, Lamium sp.*, Lysimachia sp.*, Mentha sp.<, Poa sp.<, Senecio sp.*

Crataegus sp.

Several of the species listed from Zone VIII are documented by more than one find. The establishment of *Myrica gale* is proven by finds of both macrofossils and pollen. According to Overbeck (1975), this species became common in Schleswig-Holstein after 1800 BC.

The following edible plants in particular were recorded from a number of sites: *Bromus secalinus* (26 sites), *Hordeum vulgare* (six-rowed hulled barley 64 sites, six-rowed naked barley 123 sites), *Panicum miliaceum* (11 sites), *Triticum aestivum* et *T. compactum* (17 sites), *T. compactum* (5 sites), *T. dicoccon* (74 sites), *T. monococcum* (65 sites), and *T. spelta* (8 sites). A review of the growing of cereals in the Nordic countries has been published by Jessen (1951), whereas the finds of cereals and other cultivated plants in Sweden have been summarized by Hjelmqvist (1979). Many details about the history of *Avena sativa*, *Triticum* sp., *Malus sylvestris*, and *Linum usitatissimum* are included in Holmboe's (1927) paper on finds of plants from the Oseberg Viking ship grave. The evolution and cultivation of *Linum* have been treated by Helbæk (1959).

*Anthriscus sylvestris* and *Filipendula ulmaria* were dated with uncertainty to Zone VIII. The latter species has been recorded in earlier finds from the British Isles and the German Federal Republic. It is therefore likely that it was present in Southern Scandinavia at least from Zone VIII.

274 of the recorded sites were dated to Zone VIII (Fig. 1), which is the greatest number for any of the periods considered. The origin of the material was as follows: 77% imprints in potsherds, etc., 14% gyttja/peat, 3% soil, 2% pits, 2% storage, 1% burnt houses or layers, and 1% plant remains found in a vessel.

The sites examined were located in all parts of Southern Scandinavia.

With a total of 86% of the sites affected by human activity (Table 4), the finds recovered from Zone VIII represent a remarkable change in relation to previous periods.

Fig. 2 shows that 31% of the recorded taxa were hemicryptophytes, 30% therophytes, 19% helo- and hydrophytes, 9% mega- and mesophanerophytes, 5% chamaephytes, 4% microphanerophytes, 1% nanophanerophytes, and 1% geophytes.

The distribution according to plant formation (Fig. 3) gave the following figures: 27% bogs/swamps/wetlands, 14% forests, 14% weeds, 11% grasslands, 10% lakes/ponds, 9% cultivated plants, 9% ruderal soils, 4% heaths, and 2% maritime plants.

The information on plant formation (Fig. 3) has been grouped into natural, semi-natural, and culturally affected plant formations (cf. Table 4, p. 62). The representation for Zone VIII was 53%, 15%, and 32%, respectively.

These figures demonstrate that - when compared with previous periods - the macrofossil composition of the samples is much influenced by their changed origin. The shift from natural plant formations to sites/media affected by human activity gives a higher representation of cultivated plants and weeds, and of plants from grasslands and ruderal soils. Plants from lakes, bogs, swamps, and wetlands, and from forests, now constitute a minor part of the recorded taxa.

A large number of the 293 taxa first recorded from one of the periods Pre-Roman Iron Age (PRIA) to Late Middle Ages (LMA) or to Zone 'IX' are marked "<", an earlier presence in Southern Scandinvia being indicated by finds in neighbouring countries. Some of these finds (e.g. *Hyoscyamus niger*, *Origanum vulgare*) are dated to Zone VIII or earlier (cf. Jensen 1985, Table 2).

## Dating of finds from Pre-Roman Iron Age to Late Middle Ages and Pollen Assemblage Zone 'IX' (2500 BP-1536 AD)

Zone 'IX' contains those finds for which a more exact dating into the periods Pre-Roman Iron Age, Roman Iron Age, Germanic Iron Age, Viking Age, and Early and Late Middle Ages was not available.

75% of the samples referred to Zone 'IX' were classified as gyttja/peat (cf. Fig. 1). As the macrofossil composition of these samples deviates from that revealed from Zone VIII and from Pre-Roman Iron Age, the Zone 'IX' finds have been listed last (i.e. after Late Middle Ages).

The zone border VIII/IX is defined by an increase in the pollen curves for *Fagus* and *Carpinus* (Jessen 1935). Recent pollen diagrams from the bog Holmegårds Mose in Zealand show that *Fagus* entered Southern Scandinavia about 1500-1400 BC and pollen counts reached exceptionally high values about 800 BC (S.T. Andersen et al. 1983). In Jutland, the *Fagus* expansion occurred around 500 AD (S.T. Andersen 1978).

Due to the difficulties in establishing a common zone border for all Southern Scandinavia, I have used the border between the Sub-Boreal and the Sub-Atlantic chronozones, dated c. 2500 BP. This border is approximately coeval with the beginning of the Pre-Roman Iron Age (cf. Iversen 1967; Mangerud et al. 1974).

At about 2500 BP, temperature probably decreased, and climate became more moist or cool. This affected the growth conditions for raised bogs, and the climatic changes are visualized as 'recurrence surfaces' in the bogs. The raised bogs indicate that the climate changed from relatively warm/dry to moist/wet at intervals of about 260 years through the last 5000 years (Aaby 1976). The magnitude of these changes is not known in detail, but some of them are recorded in several Danish bogs (Aaby, op. cit.). In spite of these changes, the greatest impact on the vegetation during Zone IX was undoubtedly made by man.

Forest clearance continued throughout the period, and the landscape became more and more open. Especially *Tilia* was reduced, mainly due to human impact and oligotrophication. The pollen curves for *Corylus* and *Fraxinus* show a simultaneous

reduction. The expansion of *Fagus sylvatica*, especially in East Denmark, was most likely affected by the agricultural activities (Iversen 1967, Aaby 1986).

## Pre-Roman Iron Age (500-1 BC)

110 taxa have been recorded from deposits dated to the Pre-Roman Iron Age. Among these, 53 have not been recorded from previous periods:

### *PRIA: Lakes/ponds*

*Spontaneous*: Phragmites australis.

### *PRIA: Bogs/swamps/wetlands*

*Spontaneous*: Carex disticha<, C. hirta*, C. cf. nigra<, C. ovalis*, C. cf. vulpina<, Deschampsia cespitosa*, Galium cf. mollugo<, G. cf. palustre<, Holcus lanatus<, Juncus bufonius<, J. cf. effusus<, J. squarrosus*, Lepidium latifolium*, Lolium perenne*, Rhinanthus cf. minor*, Stellaria cf. palustris<, Veronica serpyllifolia*.

Calluna vulgaris, Carex cf. curta, C. cf. flava, C. cf. riparia, Eleocharis palustris, Empetrum nigrum, Lycopus europaeus, Phragmites australis, Polygonum lapathifolium, Potentilla erecta, Prunella vulgaris, Ranunculus acris, R. repens, R. sceleratus, Rumex cf. acetosa, Scirpus lacustris subsp. tabernaemontani, Urtica dioica.

### *PRIA: Forests*

*Anthropochorous*: Aegopodium podagraria*.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Deschampsia cespitosa*, Poa nemoralis*.

Elymus caninus, Galium aparine, Potentilla erecta, Urtica dioica.

### *PRIA: Heaths*

*Spontaneous*: Juncus squarrosus*.

Calluna vulgaris, Carex cf. curta, Danthonia decumbens, Empetrum nigrum, Potentilla erecta.

### *PRIA: Grasslands*

*Anthropochorous*: Aegopodium podagraria*, Crepis capillaris<, Veronica arvensis*.

*Anthropochorous?*: Trifolium campestre*, T. dubium*.

*Spontaneous*: Campanula glomerata*, Carex hirta*, C. ovalis*, Cerastium fontanum subsp. triviale<, Galium cf. mollugo<, Holcus lanatus<, Lolium perenne*, Phleum pratense subsp. bertolonii*, Plantago major<, Potentilla argentea*, Rhinanthus cf. minor*, Verbascum cf. nigrum*, Veronica serpyllifolia*, Vicia cf. sativa subsp. nigra<, V. cf. tetrasperma<.

Achillea millefolium, Bromus hordeaceus subsp. hordeaceus, Danthonia decumbens, Leontodon autumnalis, Luzula campestris, Plantago lanceolata, Prunella vulgaris, Ranunculus acris, R. repens, Rumex cf. acetosa, R. acetosella, R. crispus, Scleranthus annuus, Silene alba, Stellaria graminea.

### *PRIA: Maritime plants*

*Spontaneous*: Atriplex cf. hastata<, Juncus gerardi<.

### *PRIA: Cultivated plants*

*Anthropochorous*: Camelina sativa*, Hyoscyamus niger<, Lepidium latifolium*, Papaver somniferum<, Secale cereale<, Triticum aestivum<.

Avena sativa, Brassica cf. nigra, B. rapa, Hordeum vulgare (six-rowed hulled barley), H. vulgare var. nudum (six-rowed naked barley), H. vulgare (hulled or naked barley), Linum usitatissimum, Panicum miliaceum, Spergula arvensis, Triticum dicoccon, T. monococcum, T. spelta.

### *PRIA: Weeds*

*Anthropochorous*: Aphanes arvensis*, Crepis capillaris<, C. tectorum*, Echinochloa crus-galli<, Erysimum cheiranthoides*, Fumaria officinalis<, Lolium cf. remotum*, Poa annua*, Setaria viridis*, Sonchus asper<, Urtica urens<, Veronica arvensis*, V. polita*.

Avena fatua, Bilderdykia convolvulus, Brassica rapa, Camelina alyssum, Capsella bursa-pastoris, Spergula arvensis, Thlaspi arvense.

*Anthropochorous?*: Myosotis arvensis*.

Lapsana communis.

*Spontaneous*: Cerastium fontanum subsp. triviale<, Juncus bufonius<, Matricaria perforata*, Plantago major<, Veronica serpyllifolia*, Vicia cf. sativa subsp. nigra<, V. cf. tetrasperma<, Viola arvensis<.

Achillea millefolium, Atriplex cf. patula, Chenopodium album, Galium aparine, Plantago lanceolata, Polygonum aviculare, P. lapathifolium, P. persicaria, Ranunculus repens, R. sceleratus, Rumex acetosella, R. crispus, Scleranthus annuus, Solanum nigrum, Stellaria media.

### *PRIA: Ruderal soils*

*Anthropochorous*: Aegopodium podagraria*, Echinochloa crus-galli<, Fumaria officinalis<, Hyoscyamus niger<, Lepidium latifolium*, Papaver somniferum<, Poa annua*, Sonchus asper <, Urtica urens<.

Bilderdykia convolvulus, Brassica cf. nigra, Capsella bursa-pastoris, Panicum miliaceum, Silene alba, Thlaspi arvense.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Malva sylvestris<, Matricaria perforata*, Plantago major<, Verbascum cf. nigrum*.

Achillea millefolium, Atriplex cf. patula, Bromus hordeaceus subsp. hordeaceus, Chenopodium album, Galium aparine, Plantago lanceolata, Polygonum aviculare, P. lapathifolium, P. persicaria, Rumex crispus, Stellaria media, Urtica dioica.

*PRIA: Plant formation uncertain*

Cf. Odontites sp.*.

Atriplex sp., Poa sp.

Among the 53 first-recorded taxa, 26 are marked "<", suggesting a previous presence in Southern Scandinavia. Several of these are spontaneous, belonging to the natural plant formations bogs/swamps/wetlands, forests, and maritime areas. It is quite possible that also a number of the other first-recorded taxa from these plant formations were present in Southern Scandinavia in previous periods.

The medicinal plants *Hyoscyamus niger* and *Papaver somniferum*, too, may have been present in the area earlier than demonstrated so far. The former is known from German finds dated 2500 BC, and the latter from Band Ceramic layers in Germany and the Neolithic in Poland (Jensen 1985).

Macrofossils of *Secale cereale* are known from Grauballe, Jútland (Helbæk 1958a). The finds have been radiocarbon-dated to 80 ± 55 BC (Fischer 1980). Rye is known from the Pre-Roman Iron Age onwards from the British Isles, the Netherlands, and the German Federal Republic. From Poland, records exist from the Neolithic and later (Jensen 1985). The history of rye cultivation has been discussed in detail by Helbæk (1974).

*Triticum* has been cultivated in Denmark since Zone VIII. The earlier finds have been referred to *T. compactum*, *T. dicoccon*, *T. monococcum*, *T. spelta*, and to *T. aestivum* et *T. compactum* (cf. p. 27). From PRIA, 1 find from Sylt has been identified as *T. aestivum* (Kroll 1975). This species is known from Neolithic and later finds from Poland and Sweden, and from 400 BC in the German Federal Republic (Jensen 1985).

*Camelina sativa* has been recorded from deposits at Skørbæk Hede, Jutland, dated to PRIA (Hatt 1937), from several finds dated to the Hallstatt and La Tène periods in Germany and Poland, and from the Late Bronze Age in Sweden (Jensen 1985).

A number of the first recorded taxa occur within the groups 'weeds' and 'ruderal soils'. 6 of the weeds classified as 'spontaneous' are marked "<", indicating earlier presence in the area.

The rather long list of cultivated plants, weeds, and plants from ruderal soils is an indication of the ongoing cultivation within Southern Scandinavia, carried out during the Pre-Roman Iron Age.

53% of the media examined were imprints, 20% stored material, 11% gyttja/peat, 7% derived from burnt houses or materials, 7% were stomach contents, and 2% soil. The ratio of natural to culturally affected media was 11:89 (cf. Table 4).

The sites were located in all parts of Southern Scandinavia except Funen, Lolland, Falster, and Bornholm.

The main part of the recorded taxa are therophytes (53%), followed by hemicryptophytes (36%), helo- and hydrophytes (5%), chamaephytes (3%), and geophytes (3%).

The distribution according to plant formation (Fig. 3) is as follows: 25% weeds, 20% bogs/swamps/wetlands, 19% grasslands, 14% ruderal soils, 13% cultivated plants, 4% forests, 3% heaths and 2% maritime plants. Grouped into natural, semi-cultural and culturally affected plant formations, the representation was 26%, 22% and 52%, respectively (Table 4).

The high frequency of therophytes is due to the common occurrence of cultivated plants, weeds, and ruderals. According to Fig. 2, no mega-, meso-, micro-, and nanophanerophytes have been recorded. The occurrence of helo- and hydrophytes is lower than in the other periods studied. It is striking that no plants from lakes and ponds are listed.

According to Fig. 1, only 11% of the sites have been assigned to 'gyttja/peat'. One of the three sites involved was Borremose (A. Andersen 1975), where the main part of the recorded macrofossils derived

from a fill layer in a moat, described as 'sandy gyttja'. The second site was Borup Ris (Mikkelsen 1984, 1986), with macrofossils recovered from different types of peat. The third site was Lodbjerg, where the deposit was described as sandy peat (Jensen & Liversage unpub.).

The layers examined in these three finds explain to some degree why plants from lakes and ponds are not represented.

The total absence of mega-, meso-, micro-, and nanophanerophytes in the records may be due to the composition of the samples, since such plants are rarely recorded from imprints, in burnt houses or stored material, or as stomach contents, which constituted the main parts of the media examined (see above).

## Roman Iron Age (1-399 AD)

A total of 219 taxa have been recorded from the Roman Iron Age, of which 76 have not been recorded from earlier periods. The recovered macrofossils belong to the following plant formations:

### *RIA: Lakes/ponds*

*Spontaneous*: Callitriche stagnalis<, Hydrocharis morsus-ranae*.

Alisma plantago-aquatica, Calla palustris, Menyanthes trifoliata, Montia fontana subsp. fontana, Oenanthe aquatica, Phragmites australis, Potamogeton natans, Ranunculus flammula, Scirpus lacustris, Sparganium emersum, S. erectum, S. minimum.

### *RIA: Bogs/swamps/wetlands*

*Spontaneous*: Alchemilla sp.<, Alopecurus geniculatus<, Bidens tripartita<, Bromus racemosus*, Carex cf. appropinquata<, Erica tetralix<, Festuca rubra<, Juncus articulatus<, J. cf. compressus*, Mentha aquatica<, M. arvensis<, Molinia caerulea<, Myosoton aquaticum<, Odontites verna<, Phalaris arundinacea<, Polygonum cf. mite<, Ranunculus lingua<, Rorippa islandica<, Salix repens<, Scutellaria galericulata<, Stellaria alsine<, Taraxacum officinale group<, Thalictrum flavum<, Trifolium pratense*, T. repens<, Triglochin palustris<, Vaccinium uliginosum*, Veronica scutellata*.

Alnus glutinosa, cf. Andromeda polifolia, Apium graveolens, Betula pubescens, Bidens cernua, Calluna vulgaris, Carex cf. curta, C. disticha, C. flava, C. hirta, C. cf. nigra, C. pseudocyperus, C. cf. riparia, C. rostrata, C. vesicaria, C. vulpina, Cladium mariscus, Eleocharis palustris, Empetrum nigrum, Eriophorum vaginatum, Galium mollugo, G. palustre, Hydrocotyle vulgaris, Juncus bufonius, J. cf. effusus, J. squarrosus, Lolium perenne, Lychnis flos-cuculi, Lycopus europaeus, Menyanthes trifoliata, Montia fontana subsp. fontana, Myrica gale, Phragmites australis, Polygonum hydropiper, P. lapathifolium, Potentilla anserina, P. erecta, P. palustris, Prunella vulgaris, Ranunculus acris, R. repens, R. sceleratus, Rumex cf. acetosa, R. hydrolapathum, R. maritimus, Scirpus lacustris, S. lacustris subsp. tabernaemontani, S. sylvaticus, Solanum dulcamara, Sparganium emersum, S. erectum, S. minimum, Stachys palustris, Stellaria palustris, Urtica dioica, Vaccinium oxycoccos, Viola palustris.

### *RIA: Forests*

*Anthropochorous*: Aegopodium podagraria.

*Spontaneous*: Alchemilla sp.<, Bromus racemosus*, Epilobium montanum*, Myosoton aquaticum<, Vicia cf. cracca*.

Alnus glutinosa, Betula pubescens, Corylus avellana, Galium aparine, Moehringia trinervia, Potentilla erecta, Rubus fruticosus group, R. idaeus, Solanum dulcamara, Urtica dioica, Vaccinium cf. myrtillus.

### *RIA: Heaths*

*Spontaneous*: Carex arenaria*, Erica tetralix<, Hieracium umbellatum*, Salix repens<, Vaccinium uliginosum*, V. vitis-idaea<.

Cf. Andromeda polifolia, Calluna vulgaris, Carex cf. curta, C. pilulifera, Danthonia decumbens, Empetrum nigrum, Juncus squarrosus, Myrica gale, Potentilla erecta, Vaccinium cf. myrtillus.

### *RIA: Grasslands*

*Anthropochorous*: Conium maculatum<, Medicago lupulina<.

Aegopodium podagraria, Silene alba, Veronica arvensis.

*Spontaneous*: Alchemilla sp.<, Bromus racemosus*, Carex arenaria*, Elymus repens<, Festuca rubra<, Hieracium umbellatum*, Lotus corniculatus*, Odontites verna<, Ranunculus sardous<, Taraxacum officinale group<, Thalictrum minus<, Trifolium arvense*, T. pratense*, T. repens<, Vicia cf. cracca*, V. hirsuta<.

Bromus hordeaceus subsp. hordeaceus, Carex hirta, C. pilulifera, Cerastium fontanum subsp. triviale, Cirsium vulgare, Danthonia decumbens, Daucus carota, Galium mollugo, Leontodon autumnalis, Lolium perenne, Luzula campestris, Phleum pratense subsp. bertolonii, Plantago lanceolata, P. major, Potentilla anserina, Prunella vulgaris, Ranunculus acris, R. repens, Rumex cf. acetosa, R. acetosella, R. crispus, Scleranthus annuus, Verbascum cf. nigrum, Vicia tetrasperma, Viola tricolor.

*RIA: Maritime plants*

*Spontaneous*: Ammophila arenaria*, Aster tripolium<, Carex cf. distans*, Glaux maritima<, Oenanthe lachenalii<, Plantago coronopus*, P. maritima<, Puccinellia distans<, P. maritima<, Salicornia europaea<, Spergularia marina*, S. media<, Suaeda maritima<.

Atriplex hastata, Juncus gerardi, Scirpus maritimus, Triglochin maritima.

*RIA: Cultivated plants*

*Anthropochorous*: Isatis tinctoria<, Pinus pinea (imported - see discussion p. 64)*, Setaria italica<, Staphylea pinnata (imported)*, Vicia faba<.

Avena sativa, Brassica cf. nigra, B. rapa, Camelina sativa, Hordeum vulgare (six-rowed hulled barley), H. vulgare var. nudum (six-rowed naked barley), H. vulgare (hulled or naked barley), Hyoscyamus niger, Linum usitatissimum, Panicum miliaceum, Pisum sativum, Secale cereale, Spergula arvensis, Triticum aestivum, T. compactum, T. dicoccon, T. monococcum, T. spelta.

*Spontaneous*: Apium graveolens<.

Daucus carota.

*RIA: Weeds*

*Anthropochorous*: Agrostemma githago*, Chenopodium ficifolium <, C. polyspermum<, Cuscuta epilinum*, Galeopsis ladanum<, Galium spurium<, Lamium purpureum*, Medicago lupulina<.

Avena fatua, Bilderdykia convolvulus, Brassica rapa, Bromus secalinus, Camelina alyssum, Capsella bursa-pastoris, Echinochloa crus-galli, Euphorbia helioscopia, Fumaria officinalis, Poa annua, Raphanus raphanistrum, Setaria viridis, Silene noctiflora, Sinapis arvensis, Sonchus asper, S. oleraceus, Spergula arvensis, Thlaspi arvense, Urtica urens, Veronica arvensis.

*Spontaneous*: Anagallis arvensis<, Bidens tripartita<, Chenopodium rubrum<, Cirsium arvense<, Elymus repens<, Mentha arvensis<, Odontites verna<, Ranunculus sardous<, Sagina cf. procumbens<, Sonchus arvensis<, Taraxacum officinale group<, Vicia hirsuta<.

Atriplex patula, Cerastium fontanum subsp. triviale, Chenopodium album, Galeopsis cf. tetrahit, Galium aparine, Juncus bufonius, Plantago lanceolata, P. major, Polygonum aviculare, P. hydropiper, P. lapathifolium, P. persicaria, Ranunculus repens, R. sceleratus, Rumex acetosella, R. crispus, Scleranthus annuus, Solanum nigrum, Stachys palustris, Stellaria media, Vicia tetrasperma, Viola tricolor.

*RIA: Ruderal soils*

*Anthropochorous*: Chenopodium ficifolium<, C. polyspermum<, Conium maculatum<, Lamium album<, L. purpureum*, Setaria italica<, Sisymbrium officinale<.

Aegopodium podagraria, Bilderdykia convolvulus, Brassica cf. nigra, Bromus secalinus, Capsella bursa-pastoris, Echinochloa crus-galli, Fumaria officinalis, Hyoscyamus niger, Panicum miliaceum, Poa annua, Silene alba, Sonchus asper, S. oleraceus, Thlaspi arvense, Urtica urens.

*Anthropochorous?*: Chenopodium murale<.

*Spontaneous*: Chenopodium rubrum<, Cirsium arvense<, Elymus repens<, Rorippa islandica<, Sagina cf. procumbens<, Sonchus arvensis<, Taraxacum officinale group<.

Atriplex patula, Bromus hordeaceus subsp. hordeaceus, Chenopodium album, Cirsium vulgare, Galeopsis cf. tetrahit, Galium aparine, Plantago lanceolata, P. major, Polygonum aviculare, P. lapathifolium, P. persicaria, Potentilla anserina, Rumex crispus, R. maritimus, Stachys palustris, Stellaria media, Urtica dioica, Verbascum cf. nigrum.

*RIA: Plant formation uncertain*

*Spontaneous*: Centaurium sp.<

Agrostis sp., Atriplex sp., Juncus sp., Lamium sp., Mentha sp., cf. Odontites sp., Poa sp.

Among the 76 taxa first recorded from the Roman Iron Age, 56 are marked "<", suggesting an occurrence in Southern Scandinavia in earlier periods.

The main part of the first-recorded species from the plant formations lakes/ponds, bogs/swamps/wetlands, forests, heaths, grasslands and maritime areas have been found in previous periods in the surrounding countries. It is likely that most of these species are older in Southern Scandinavia than demonstrated so far.

The number of taxa recorded from natural plant formations is extensive, not least from bogs, swamps and wetlands, and maritime areas.

The finds of some taxa, listed as cultivated, deserve some comment.

*Apium graveolens* was recovered from Tofting (Behre 1976), which is close to the sea. An origin from natural plant communities can therefore not be ruled out.

*Isatis tinctoria*, cultivated for its blue dye, is known from 5 finds from the Roman Iron Age (Jensen 1985). Later actual remains of *Isatis* have been recorded from the Oseberg Viking ship, Norway (Holmboe 1927). Holmboe's paper contains a thorough discussion of the cultivation of *Isatis*, and its

mention in old written sources. Information on finds of vegetative remains of *Isatis tinctoria* from 9th-10th century layers in York and details of the extraction of the blue dye have been published by Tomlinson (1985).

*Vicia faba* is known from Tofting, Schleswig (Behre 1976) and from a number of contemporaneous or older finds from the British Isles, the Netherlands, Germany, and Poland (Jensen 1985).

*Pinus pinea* and *Staphylea pinnata* belong to warmer climates and are thus both considered to have been imported (cf. p. 64).

The cultivated plants, weeds, and ruderals comprise indicators of farming and settlement in the Roman Iron Age. *Hordeum vulgare*, 'six-rowed hulled barley', for instance, is represented by 28 finds, and *Hordeum vulgare* var. *nudum*, 'six-rowed naked barley', by 23 finds (cf. Jensen 1985).

A total of 62 sites are dated to the Roman Iron Age (Fig. 1). Find derivation is: 60% imprints, 16% stored grain, 6% burnt houses and materials, 4% soil, 3% graves, 2% unburnt house remains, 2% humic culture layers, and 2% stomach contents of bog corpses. Gyttja/peat was represented by 3% and sand by 2% of the sites. The ratio of natural to culturally affected media was 5:95.

The sites examined were situated in all parts of Southern Scandinavia.

When classified by life-form (Fig. 2), 38% were therophytes, 36% hemicryptophytes, 12% helo- and hydrophytes, 6% chamaephytes, 6% geophytes, 1% mega- and mesophanerophytes, and 1% nanophanerophytes.

The distribution according to plant formation (Fig. 3) is: 29% bogs/swamps/wetlands, 17% weeds, 11% ruderal soils, 11% grasslands, 9% maritime plants, 9% cultivated plants, 5% lakes/ponds, 5% forests, and 4% heaths. 48% of these finds belong to natural, 15% to semi-cultural, and 37% to cultural plant formations.

Comparison of the finds from RIA with those from Zone VIII (PRIA being somewhat atypical), reveals that the representation of imprints and finds from natural plant formations was lower, and finds classified as deriving from storage, house remains, etc., higher than in Zone VIII (Fig. 1).

When the information in Fig. 2 is compared, it appears that the representation of mega-, meso-, and microphanerophytes and of helo- and hydrophytes (i.e. forest, lakes, bogs, etc.) is lower, whereas that of the hemicryptophytes and therophytes (maritime plants, weeds, and ruderal soil) was higher than in Zone VIII.

From pollen studies, it is known that from the beginning of Zone VIII to the Roman Iron Age, many forest areas were replaced by cultivated fields - the finds of macrofossils as well indicate this development.

## Germanic Iron Age (400-799 AD)

Altogether, 155 taxa were recorded from the Germanic Iron Age. 17 taxa occurred for the first time in samples dated to this period. The following plant formations were represented:

### *GIA: Lakes/ponds*

*Spontaneous*: Alisma plantago-aquatica, Menyanthes trifoliata, Najas marina, Phragmites australis, Potamogeton cf. pectinatus, Ranunculus flammula, Zannichellia palustris.

### *GIA: Bogs/swamps/wetlands*

*Spontaneous*: Carex lepidocarpa<, Pedicularis palustris<, Poa trivialis*, Potentilla reptans<, Scirpus setaceus<.

Alnus glutinosa, Alopecurus geniculatus, Andromeda polifolia, Calluna vulgaris, Carex acuta, C. cf. curta, C. disticha, C. cf. flava, C. hirta, C. cf. nigra, C. pseudocyperus, C. cf. riparia, C. rostrata, C. cf. vulpina, Eleocharis palustris, Empetrum nigrum, Erica tetralix, Galium cf. palustre, Iris pseudacorus, Juncus cf. articulatus, J. bufonius, J. cf. effusus, J. squarrosus, Lolium perenne, Lychnis flos-cuculi, Lycopus europaeus, Menyanthes trifoliata, Myosotis scorpioides, Myrica gale, Phragmites australis, Polygonum hydropiper, P. lapathifolium, P. cf. mite, Potentilla anserina, P. erecta, P. palustris, Prunella vulgaris, Ranunculus acris, R. repens, R. sceleratus, Rorippa islandica, Rumex cf. acetosa, R. hydrolapathum, R. maritimus, Scirpus cespitosus, S. lacustris subsp. tabernaemontani, S. sylvaticus, Solanum dulcamara, Stachys palustris, Stellaria palustris, Trifolium repens, Urtica dioica.

*GIA: Forests*

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Sambucus nigra<, Veronica chamaedrys<.

Betula pendula, Corylus avellana, Fagus sylvatica, Fragaria vesca, Galium aparine, Humulus lupulus, Potentilla erecta, Rubus fruticosus group (u), Solanum dulcamara, Urtica dioica.

*GIA: Heaths*

*Spontaneous*: Andromeda polifolia, Calluna vulgaris, Carex cf. curta, Danthonia decumbens, Empetrum nigrum, Erica tetralix, Juncus squarrosus, Myrica gale, Potentilla erecta, Scirpus cespitosus.

*GIA: Grasslands*

*Anthropochorous*: Silene alba.

*Spontaneous*: Artemisia campestris*, Dactylis glomerata<, Poa trivialis*, Potentilla reptans<, Veronica chamaedrys<.

Bromus cf. hordeaceus subsp. hordeaceus, Carex hirta, Cerastium fontanum subsp. triviale, Danthonia decumbens, Elymus cf. repens, Fragaria vesca, Lolium perenne, Luzula campestris, Phleum pratense subsp. bertolonii, Plantago lanceolata, P. major, Potentilla anserina, Prunella vulgaris, Ranunculus acris, R. repens, Rumex cf. acetosa, R. acetosella, R. crispus, Trifolium arvense, T. repens, Vicia cf. sativa subsp. nigra, Viola canina.

*GIA: Maritime plants*

*Spontaneous*: Zostera noltii*.

Atriplex hastata, Carex cf. distans, Glaux maritima, Juncus gerardi, Puccinellia cf. maritima, Scirpus maritimus.

*GIA: Cultivated plants*

*Anthropochorous*: Avena sativa, A. strigosa, Brassica cf. nigra, B. rapa, Hordeum vulgare (six-rowed hulled barley), H. vulgare var. nudum (six-rowed naked barley), H. vulgare (hulled or naked barley), Hyoscyamus niger, Linum usitatissimum, Secale cereale, Setaria italica, Spergula arvensis, Triticum compactum.

*Spontaneous*: Sambucus nigra<.

Humulus lupulus.

*GIA: Weeds*

*Anthropochorous*: Aethusa cynapium<, Anthemis arvensis<, Carduus crispus<, Stachys arvensis<.

Agrostemma githago, Aphanes arvensis, Avena fatua, A. strigosa, Bilderdykia convolvulus, Brassica rapa, Bromus cf. secalinus, Camelina alyssum, Capsella bursa-pastoris, Crepis tectorum, Erysimum cheiranthoides, Euphorbia helioscopia, Galium spurium, Poa annua, Raphanus raphanistrum, Setaria viridis, Sinapis arvensis, Sonchus asper, Spergula arvensis, Urtica urens, Veronica polita.

*Anthropochorous?*: Lapsana communis, Myosotis arvensis.

*Spontaneous*: Atriplex patula, Cerastium fontanum subsp. triviale, Chenopodium album, C. rubrum, Cirsium arvense, Elymus cf. repens, Galeopsis tetrahit (u), Galium aparine, Juncus bufonius, Matricaria perforata, Plantago lanceolata, P. major, Polygonum aviculare, P. hydropiper, P. lapathifolium, P. persicaria, Ranunculus repens, R. sceleratus, Rumex acetosella, R. crispus, Solanum nigrum, Sonchus arvensis, Stachys palustris, Stellaria media, Vicia cf. sativa subsp. nigra, Viola arvensis.

*GIA: Ruderal soils*

*Anthropochorous*: Aethusa cynapium<, Carduus crispus<, Rumex cf. longifolius<, R. cf. obtusifolius<.

Avena strigosa, Bilderdykia convolvulus, Brassica cf. nigra, Bromus cf. secalinus, Capsella bursa-pastoris, Hyoscyamus niger, Poa annua, Setaria italica, Silene alba, Sonchus asper, Urtica urens.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Potentilla reptans<, Sambucus nigra<.

Atriplex patula, Bromus cf. hordeaceus subsp. hordeaceus, Chenopodium album, C. rubrum, Cirsium arvense, Elymus cf. repens, Galium aparine, Galeopsis tetrahit (u), Matricaria perforata, Plantago lanceolata, P. major, Polygonum aviculare, P. lapathifolium, P. persicaria, Potentilla anserina, Rorippa islandica, Rumex crispus, R. maritimus, Sonchus arvensis, Stachys palustris, Stellaria media, Urtica dioica.

*GIA: Plant formation uncertain*

*Spontaneous*: Barbarea sp.<.

Agrostis sp., Arctium sp., Atriplex sp., Hypericum sp., Juncus sp., Lamium sp., Mentha sp., cf. Odontites sp., Poa sp.

The main part of the 17 first-recorded taxa from the Germanic Iron Age was most likely present in Southern Scandinavia from the Germanic Iron Age, since 15 of these have been recorded from previous periods in one or more of the surrounding countries.

The number of first-recorded species from natural plant formations is limited for this period. The total number of taxa from these plant formations is, however, rather extensive, not least from bogs/swamps/wetlands, and from grasslands and maritime areas.

Among the cultivated plants, *Sambucus nigra* occurs as a macrofossil for the first time. It is strange that the characteristic fruit stone has not been

discovered from earlier periods, since pollen of the species in Denmark has been recorded by Fredskild (1970) from Zone V, Zone VII, and the Iron Age. A few pollen grains of this species were furthermore recorded from Sværdborg, Zone VI (I. Sørensen 1976, personal communication), but not from the extensive examination of Åmosen material which covered Zones IV-VII (S. Jørgensen 1963). From Zone VIII, the species has been identified from Dyrholmen and Åmosen (Troels-Smith 1960). From Blekinge, the species is known from the Sub-Atlantic Zone (Berglund 1966a: 190). Although *Sambucus nigra* is insect-pollinated, it is likely that the species was rare in Southern Scandinavia during Zones V-VIII.

Macrofossils have been recorded from: the British Isles, Zone V onwards (Godwin 1975); the German Federal Republic, Neolithic and later; and Poland, Hallstatt and later (Jensen 1985).

The recorded cultivated plants, as well as the weeds and plants from ruderal soils, are indications of the continued influence of cultivation on the Southern Scandinavian landscape.

According to Fig. 1, the main part of the media examined consisted of imprints (65%), followed by samples from burnt houses (15%), soil (10%), gyttja/peat (8%), and storage (2%). The ratio of natural to culturally affected media was 8:92.

The sites were located in all parts of Southern Scandinavia except Funen, Lolland and Falster.

41% of the recorded taxa were therophytes, 33% hemicryptophytes, 10% helo- and hydrophytes, 7% geophytes, 5% chamaephytes, and 4% mega-, meso-, micro-, and nanophanerophytes (Fig. 2).

Plant formation (Fig. 3) is distributed as follows: 29% bogs/swamps/wetlands, 23% weeds, 13% ruderal soils, 11% grasslands, 7% cultivated, 5% forests, 5% maritime plants, 4% lakes/ponds, and 3% heaths. 43% of the finds were referred to natural, 14% to semi-cultural, and 43% to culturally affected plant formations.

The vegetation revealed by finds of macrofossils in the Germanic Iron Age is similar to that deduced for the Roman Iron Age.

## Viking Age (800-1049 AD)

A total of 325 taxa were recorded as macrofossils from the Viking Age. Among these, 95 taxa occur for the first time. Below, the finds are grouped according to plant formation:

### *VA: Lakes/ponds*

*Spontaneous*: Berula erecta<, Glyceria fluitans<, Lemna sp.<, Oenanthe fistulosa<.

Alisma plantago-aquatica, Menyanthes trifoliata, Myriophyllum verticillatum, Oenanthe aquatica, Phragmites australis, Potamogeton cf. pectinatus, P. perfoliatus, P. x zizii, Ranunculus flammula, Scirpus lacustris, Sparganium erectum, Zannichellia palustris.

### *VA: Bogs/swamps/wetlands*

*Spontaneous*: Achillea ptarmica*, Ajuga reptans<, Angelica sylvestris<, Berula erecta<, Carex flacca<, C. panicea<, Cirsium oleraceum<, Epilobium cf. hirsutum<, E. palustre<, Festuca cf. pratensis<, Glyceria fluitans<, G. maxima<, Hypericum tetrapterum<, Juncus filiformis*, J. cf. inflexus<, J. subnodulosus<, Linum catharticum<, Lotus uliginosus*, Poa cf. palustris<, Salix aurita<, Sonchus palustris<, Valeriana officinalis<, Viburnum opulus<.

Alnus glutinosus, Alopecurus geniculatus, Anthriscus sylvestris, Betula pubescens, Bidens cernua, B. tripartita, Calluna vulgaris, Caltha palustris, Carex acuta, C. appropinquata, C. cf. curta, C. disticha, C. echinata, C. elata, C. flava, C. hirta, C. nigra, C. pseudocyperus, C. riparia, C. rostrata, C. vulpina, Cirsium palustre, Deschampsia cespitosa, Eleocharis palustris, Empetrum nigrum, Erica tetralix, Eriophorum vaginatum, Eupatorium cannabinum, Festuca rubra, Filipendula ulmaria, Galium mollugo, G. palustre, Hydrocotyle vulgaris, Iris pseudacorus, Juncus articulatus, J. bufonius, J. cf. compressus, J. cf. effusus, J. squarrosus, Lolium perenne, Lychnis flos-cuculi, Lycopus europaeus, Lythrum salicaria, Menyanthes trifoliata, Molinia caerulea, Myosotis scorpioides, Myrica gale, Odontites verna, Pedicularis palustris, Peucedanum palustre, Phragmites australis, Polygonum hydropiper, P. lapathifolium, P. cf. mite, Potentilla anserina, P. erecta, P. palustris, P. cf. reptans, Prunella vulgaris, Ranunculus acris, R. lingua, R. repens, R. sceleratus, Rorippa islandica, Rumex acetosa, R. hydrolapathum, R. maritimus, Scirpus lacustris, S. lacustris subsp. tabernaemontani, S. setaceus, S. sylvaticus, Scutellaria galericulata, Solanum dulcamara, Sparganium erectum, Stachys palustris, Stellaria palustris, Taraxacum officinale group, Thalictrum flavum, Trifolium cf. pratense, T. repens, Triglochin palustris, Typha sp., Urtica dioica, Veronica scutellata, V. serpyllifolia.

### *VA: Forests*

*Anthropochorous*: Prunus domestica subsp. insititia<, Aegopodium podagraria.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Angelica sylvestris<, Ajuga reptans<, Brachypodium sylvaticum*, Carex strigosa<, Cirsium cf. helenioides*, Clinopodium vulgare<, Crataegus laevigata<, C. monogyna<, Geranium robertianum*, Prunus avium<, Ranunculus cf. lanuginosus*, Silene dioica<, Stellaria cf. nemorum<, Torilis japonica<, Viburnum opulus<, Viola reichenbachiana*.

Alnus glutinosa, Betula pendula, B. pubescens, Coryllus avellana, Deschampsia cespitosa, Fagus sylvatica, Fragaria vesca, Fraxinus excelsior, Galium aparine, Humulus lupulus, Malus sylvestris, Populus tremula, Potentilla erecta, Prunus spinosa, Rubus fruticosus group, R. idaeus, Salix caprea, Sambucus nigra, Solanum dulcamara, Sorbus aucuparia, Urtica dioica, Vaccinium cf. myrtillus, Vicia cracca.

### *VA: Heaths*

*Spontaneous*: Cytisus scoparius*, Juncus filiformis*, Thymus serpyllum<, Vicia orobus*.

Calluna vulgaris, Carex cf. curta, C. pilulifera, Danthonia decumbens, Empetrum nigrum, Erica tetralix, Juncus squarrosus, Myrica gale, Potentilla erecta, Populus tremula, Vaccinium cf. myrtillus.

### *VA: Grasslands*

*Anthropochorous*: Cichorium intybus<, Salvia pratensis*.

Aegopodium podagraria, Conium maculatum, Medicago lupulina, Silene alba.

*Anthropochorous?*: Trifolium cf. dubium.

*Spontaneous*: Artemisia vulgaris<, Carex flacca<, C. cf. spicata <, Centaurea jacea<, C. scabiosa<, Clinopodium vulgare<, Crataegus laevigata<, C. monogyna<, Cytisus scoparius*, Festuca cf. pratensis<, Geranium columbinum*, Hieracium pilosella*, Hypericum maculatum<, H. perforatum<, Hypochoeris cf. glabra<, Leucanthemum vulgare<, Linaria vulgaris<, Linum catharticum<, Melilotus alba*, Senecio jacobaea*, Silene vulgaris<, Thymus serpyllum<, Torilis japonica<, Vicia cf. lathyroides*.

Anthriscus sylvestris, Arenaria serpyllifolia, Bromus hordeaceus subsp. hordeaceus, Carex hirta, C. pilulifera, Cerastium fontanum subsp. triviale, Cirsium cf. vulgare, Danthonia decumbens, Daucus carota, Elymus repens, Festuca rubra, Fragaria vesca, Galium mollugo, Knautia arvensis, Leontodon autumnalis, Lolium perenne, Lotus corniculatus, Luzula campestris, Odontites verna, Phleum pratense subsp. bertolonii, Plantago lanceolata, P. major, Potentilla anserina, P. argentea, P. cf. reptans, Prunella vulgaris, Prunus spinosa, Ranunculus acris, R. repens, R. sardous, Rumex acetosa, R. acetosella, R. crispus, Scleranthus annuus, Stellaria graminea, Taraxacum officinale group, Trifolium cf. pratense, T. repens, Veronica serpyllifolia, Vicia cracca, V. hirsuta, V. sativa subsp. nigra, V. tetrasperma, Viola tricolor.

### *VA: Maritime plants*

*Spontaneous*: Cakile maritima*, Carex extensa<, Cochlearia anglica*, C. officinalis<, Elymus cf. pycnanthus*, Festuca arundinacea*, Hordeum secalinum*, Juncus anceps*, Limonium vulgare<, Samolus valerandi*, Trifolium fragiferum*.

Armeria maritima, Aster tripolium, Atriplex hastata, Carex distans, Glaux maritima, Juncus gerardi, Oenanthe lachenalii, Plantago coronopus, P. maritima, Puccinellia distans, P. maritima, Ruppia maritima, Salicornia europaea, Scirpus maritimus, Spergularia marina, S. media, Suaeda maritima, Triglochin maritima.

### *VA: Cultivated plants*

*Anthropochorous*: Angelica archangelica*, Brassica oleracea*, Cichorium intybus<, Coriandrum sativum (imported?)<, Juglans regia (imported)<, Pisum sativum subsp. sativum*, Prunus domestica subsp. insititia<, P. persica (imported)<, Saponaria officinalis<, Symphytum officinale<, Valeriana officinalis<, Vitis vinifera (imported)<.

Avena sativa, A. strigosa, Brassica cf. nigra, B. rapa, Camelina sativa, Hordeum vulgare (six-rowed barley), H. vulgare var. nudum (six-rowed naked barley), H. vulgare (hulled or naked barley), Hyoscyamus niger, Linum usitatissimum, Panicum miliaceum, Pisum sativum, Secale cereale, Spergula arvensis, Triticum aestivum, T. dicoccon, Vicia faba.

*Spontaneous*: Althaea officinalis<, Angelica archangelica*.

Apium graveolens, Daucus carota, Humulus lupulus, Malus sylvestris, Sambucus nigra.

### *VA: Weeds*

*Anthropochorous*: Anchusa arvensis*, Galeopsis segetum*, Geranium molle*, Neslia paniculata*, Papaver dubium et P. rhoeas*, Veronica cf. opaca*, Vicia villosa*.

Aethusa cynapium, Agrostemma githago, Anthemis arvensis, Aphanes arvensis, Avena fatua, A. strigosa, Bilderdykia convolvulus, Brassica rapa, Bromus secalinus, Carduus crispus, Chenopodium ficifolium, Euphorbia helioscopia, Fumaria officinalis, Galium spurium, Lamium purpureum, Lolium temulentum, Medicago lupulina, Poa annua, Raphanus raphanistrum, Setaria viridis, Silene noctiflora, Sinapis arvensis, Sonchus asper, S. oleraceus, Spergula arvensis, Thlaspi arvense, Urtica urens.

*Anthropochorous?*: Aethusa cynapium, Erodium cicutarium, Lapsana communis.

*Spontaneous*: Artemisia vulgaris<, Centaurea cyanus<, Chrysanthemum sp.*, Geranium columbinum*, Leucanthemum vulgare<, Linaria vulgaris<, Ornithopus perpusillus*.

Anagallis arvensis, Arenaria serpyllifolia, Atriplex patula, Bidens tripartita, Cerastium fontanum subsp. triviale, Chenopodium album, C. cf. rubrum, Cirsium arvense, Elymus repens, Galeopsis tetrahit, Galium aparine, Juncus bufonius, Matricaria perforata, Odontites verna, Plantago lanceolata, P. major, Polygonum aviculare, P. hydropiper, P. lapathifolium, P. persicaria, Ranunculus repens, R. sardous, R. sceleratus, Rumex acetosella, R. crispus, Scleranthus annuus, Solanum nigrum, Sonchus arvensis, Stachys palustris, Stellaria media, Taraxacum officinale group, Veronica serpyllifolia, Vicia hirsuta, V. sativa subsp. nigra, V. tetrasperma, Viola tricolor.

*VA: Ruderal soils*

*Anthropochorous*: Anthriscus caucalis*, Campanula rapunculoides <, Cichorium intybus<, Coriandrum sativum<, Descurainia sophia<, Papaver dubium et P. rhoeas*, Saponaria officinalis<, Setaria pumila<, Stachys cf. annua<, Symphytum officinale<.

Aegopodium podagraria, Aethusa cynapium, Avena strigosa, Bilderdykia convolvulus, Brassica cf. nigra, Bromus secalinus, Carduus crispus, Chenopodium ficifolium, Conium maculatum, Fumaria officinalis, Hyoscyamus niger, Lamium purpureum, Lolium temulentum, Malva pusilla, Panicum miliaceum, Poa annua, Rumex longifolius, R. obtusifolius, Silene alba, Sisymbrium officinale, Sonchus asper, S. oleraceus, Thlaspi arvense, Urtica urens.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Arctium minus<, Artemisia vulgaris<, Carduus nutans<, Melilotus alba*, Petasites hybridus*.

Atriplex patula, Bromus hordeaceus subsp. hordeaceus, Chenopodium album, C. cf. rubrum, Cirsium arvense, C. cf. vulgare, Elymus repens, Galeopsis tetrahit, Galium aparine, Malva sylvestris, Matricaria perforata, Plantago lanceolata, P. major, Polygonum aviculare, P. lapathifolium, P. persicaria, Potentilla anserina, P. cf. reptans, Rorippa islandica, Rumex crispus, R. maritimus, Sambucus nigra, Sonchus arvensis, Stachys palustris, Stellaria media, Taraxacum officinale group, Urtica dioica.

*VA: Plant formation uncertain*

*Spontaneous*: Rosa sp.<.

Agrostis sp., Arctium sp., Atriplex sp., Centaurium sp., Hypericum sp., Juncus sp., Lamium sp., cf. Odontites sp.

Among the 95 first-recorded taxa from the Viking Age, 58 are marked "<", indicating an earlier presence in at least one of the surrounding countries.

A substantial number of taxa referred to the plant formations lakes/ponds, bogs/swamps/wetlands, forests, heaths, grasslands, and maritime plants have been recorded for the first time from this period. Most of them are known from previous periods in the neighbouring countries. When taking all recorded taxa from natural plant formations into account, it appears that not least bogs/swamps/wetlands, but also forests and maritime plants are represented with a remarkable number of taxa.

*Armeria maritima*, recorded from ancient salt marsh vegetation at Elisenhof (Behre 1976), has been recorded from several inland sites, dated to Zone III (cf. p. 21).

The first-recorded cultivated plants comprise several medicinal plants: *Althaea officinalis*, *Angelica archangelica*, *Cichorium intybus*, *Saponaria officinalis*, *Symphytum officinale*, and *Valeriana officinalis*, and four imported species: *Coriandrum sativum*, *Juglans regia*, *Prunus persica*, and *Vitis vinifera* (cf. discussion p. 64).

Maritime areas cannot be ruled out as origin for *Althaea officinalis*, recorded from Elisenhof (Behre 1976), and *Angelica archangelica*, revealed at Haithabu (Behre 1983).

Some of the cultivated plants have been recorded quite frequently (cf. Jensen 1985): *Hordeum vulgare* (six-rowed hulled barley 17 finds, six-rowed naked barley 9 finds), *Secale cereale* (15 finds), *Spergula arvensis* (10 finds), *Avena sativa* (8 finds), and *Linum usitatissimum* (7 finds).

In addition, the analysis of the Viking Age materials has, as shown, also disclosed a substantial number of weeds and plants from ruderal soils.

Finds from 34 sites have been dated to the Viking Age (Fig. 1). They derived from: imprints (35%), soil (20%), pits (11%), manure (9%), storage (8%), graves (7%), gyttja/peat (4%), sand (2%), burnt houses (2%), houses (1%), humic culture layers (1%). The ratio of natural to culturally affected media was 6:94.

The sites examined are situated in all areas of Southern Scandinavia except Lolland, Falster, and Bornholm. A substantial part of the taxa recorded from the Viking Age derives, however, from the extensive studies of Haithabu (Behre 1969, 1978, 1983).

The distribution according to life-form (Fig. 2) revealed that 44% of the recorded taxa were hemicryptophytes, 32% therophytes, 10% helo- and hydrophytes, 5% geophytes, and 3% chamaephytes. Mega-, meso-, micro-, and nanophanerophytes constituted together 6%.

Distribution by plant formation (Fig. 3) is: bogs/swamps/wetlands 27%, weeds 15%, grasslands 14%, ruderals 12%, forests 9%, maritime 9%, cultivated 7%, lakes/ponds 4%, and heaths 3%. 49% of these have been assigned to natural, 17% to semi-cultural, and 34 to culturally affected plant formations.

The vegetation recorded from the Viking Age was not very different from that found in the Roman and Germanic Iron Ages.

## Early Middle Ages (1050-1299 AD)

A total of 181 taxa were recorded as macrofossils in deposits dated to the Early Middle Ages. Of these, 27 taxa have so far not been recorded from earlier periods.

The following plant formations were represented:

### *EMA: Lakes/ponds*

*Spontaneous*:: Alisma plantago-aquatica (u), Berula cf. erecta, Ceratophyllum demersum, Cicuta virosa, Hippuris vulgaris (u), Lemna sp., Menyanthes trifoliata (u), Oenanthe aquatica (u), Phragmites australis, Ranunculus flammula, Scirpus lacustris, Sparganium erectum (u), Zannichellia palustris.

### *EMA: Bogs/swamps/wetlands*

*Spontaneous*:: Blysmus compressus< (u), Cornus suecica< (u), Cyperus fuscus* (u), Montia fontana subsp. chondrosperma<, Polygonum cf. minus<.

Ajuga reptans, Alnus glutinosa, Anthriscus sylvestris, Berula cf. erecta, Betula pubescens (u), Bidens tripartita (u), Calluna vulgaris, Carex echinata, C. hirta (u), C. ovalis (u), C. vesicaria (u), Cicuta virosa, Eleocharis palustris, Empetrum nigrum, Erica tetralix, Festuca cf. pratensis, F. cf. rubra, Hydrocotyle vulgaris, Juncus bufonius, Linum catharticum (u), Lolium cf. perenne, Lychnis flos-cuculi, Lycopus europaeus, Menyanthes trifoliata (u), Myrica gale, Phragmites australis, Poa trivialis, Polygonum hydropiper, P. lapathifolium, Potentilla anserina, P. erecta, P. palustris, Prunella vulgaris, Ranunculus acris (u), R. repens, R. sceleratus, Rumex maritimus (u), Scirpus lacustris, S. lacustris subsp. tabernaemontani, S. setaceus, Solanum dulcamara, Sparganium erectum (u), Stachys palustris (u), Stellaria alsine (u), Trifolium pratense, T. repens, Urtica dioica.

### *EMA: Forests*

*Anthropochorous*: Prunus domestica subsp. insititia.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Cornus suecica< (u), Origanum vulgare<, Oxalis acetosella< (u), Rubus corylifolius*, Solidago virgaurea*.

Alnus glutinosa, Ajuga reptans, Betula pendula, B. pubescens (u), Clinopodium vulgare (u), Corylus avellana, Crataegus laevigata (u), Fagus sylvatica, Fragaria vesca, Humulus lupulus, Malus sylvestris, Potentilla erecta, Prunus spinosa (u), Rubus fruticosus group, R. idaeus, Sambucus nigra, Solanum dulcamara, Stachys sylvatica, Torilis japonica, Ulmus cf. glabra, Urtica dioica.

### *EMA: Heaths*

*Spontaneous*: Cornus suecica< (u), Solidago virgaurea*.

Calluna vulgaris, Empetrum nigrum, Erica tetralix, Myrica gale, Potentilla erecta, Vaccinium vitis-idaea (u).

### *EMA: Grasslands*

*Anthropochorous*: Anchusa officinalis*.

Cichorium intybus, Silene alba (u).

*Anthropochorous?*: Trifolium cf. campestre.

*Spontaneous*: Dianthus deltoides<, Origanum vulgare<, Polygala vulgaris<, Rubus corylifolius*, Rumex tenuifolius<.

Achillea millefolium, Anthriscus sylvestris, Arenaria serpyllifolia, Bromus hordeaceus subsp. hordeaceus, Carex hirta (u), C. ovalis (u), Clinopodium vulgare (u), Crataegus laevigata (u), Dactylis glomerata, Daucus carota, Festuca cf. pratensis, F. cf. rubra, Fragaria vesca, Knautia arvensis (u), Leontodon autumnalis, Leucanthemum vulgare (u), Linum catharticum (u), Lolium cf. perenne, Plantago lanceolata, Poa trivialis, Potentilla anserina, P. argentea, Prunella vulgaris, Prunus spinosa (u), Ranunculus acris (u), R. repens, R. sardous, Rumex acetosella, R. crispus, Scleranthus annuus, Silene cf. vulgaris, Stellaria graminea, Torilis japonica, Trifolium pratense, T. repens, Vicia sativa subsp. nigra.

### *EMA: Maritime plants*

*Spontaneous*: Blysmus rufus< (u), Bupleurum tenuissimum< (u).

Samolus valerandi, Scirpus maritimus, Triglochin maritima, Zostera marina (u), Z. noltii.

### *EMA: Cultivated plants*

*Anthropochorous*: Anethum graveolens<, Euphorbia lathyris*, Ficus carica (imported)* (u), Hordeum cf. distichon (two-rowed hulled barley)<, Prunus domestica<, Verbena officinalis<.

Avena sativa, Brassica nigra (u), B. rapa, Cichorium intybus, Hordeum vulgare (six-rowed barley), H. vulgare (hulled or naked barley), Hyoscyamus niger, Linum usitatissimum, Panicum miliaceum (u), Papaver somniferum, Prunus domestica subsp. insititia, Secale cereale, Spergula arvensis.

*Spontaneous*: Apium graveolens (u), Daucus carota, Humulus lupulus, Malus sylvestris, Sambucus nigra.

### *EMA: Weeds*

*Anthropochorous*: Arnoseris minima* (u).

Aethusa cynapium, Agrostemma githago, Anthemis arvensis, Aphanes arvensis, Bilderdykia convolvulus, Brassica rapa, Bromus secalinus, Camelina alyssum, Carduus crispus (u), Echinochloa crus-galli, Euphorbia helioscopia, Galeopsis ladanum, Lamium purpureum, Neslia paniculata, Plantago lanceolata, Poa annua, Raphanus raphanistrum, Setaria viridis (u), Sinapis arvensis (u), Sonchus asper, S. oleraceus, Spergula arvensis, Thlaspi arvense, Urtica urens.

*Anthropochorous?*: Aethusa cynapium, Lapsana communis.

*Spontaneous*: Rumex tenuifolius<.

Achillea millefolium, Anagallis arvensis, Arenaria serpyllifolia, Bidens tripartita (u), Carduus crispus, Centaurea cyanus, Chenopodium album, Cirsium arvense, Galeopsis tetrahit, Juncus bufonius, Leucanthemum vulgare (u), Polygonum aviculare, P. hydropiper, P. lapathifolium, P. persicaria, Ranunculus repens, R. sardous, R. sceleratus, Rumex acetosella, R. crispus, Scleranthus annuus, Solanum nigrum, Sonchus arvensis, Stachys palustris (u), Stellaria media, Vicia sativa subsp. nigra.

### *EMA: Ruderal soils*

*Anthropochorous*: Anethum graveolens<, Anthemis cotula<, Bupleurum rotundifolium<, Euphorbia lathyris*, Marrubium vulgare* (u), Ranunculus parviflorus< (u), Verbena officinalis<, Xanthium strumarium< (u).

Aethusa cynapium, Bilderdykia convolvulus, Brassica nigra (u), Bromus secalinus, Carduus crispus (u), Cichorium intybus, Echinochloa crus-galli, Hyoscyamus niger, Lamium purpureum, Panicum miliaceum (u), Papaver somniferum, Poa annua, Rumex obtusifolius, Setaria pumila (u), Silene alba (u), Sonchus asper, S. oleraceus, Thlaspi arvense, Urtica urens.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Achillea millefolium, Bromus hordeaceus subsp. hordeaceus, Chenopodium album, Cirsium arvense, Galeopsis tetrahit, Plantago lanceolata, Polygonum aviculare, P. lapathifolium, P. persicaria, Potentilla anserina, Rumex crispus, R. maritimus (u), Sambucus nigra, Sonchus arvensis, Stachys palustris (u), Stellaria media, Urtica dioica.

### *EMA: Plant formation uncertain*

*Spontaneous*: Pimpinella sp.< (u), Pyrus sp.< (u).

Arctium sp., Atriplex sp., Crataegus sp., Hypericum sp., Juncus sp., Lamium sp., Lysimachia sp. (u), Mentha sp. (u), Rosa sp.

19 of the 27 taxa so far not recorded from earlier periods have been recorded from the neighbouring countries in deposits dated earlier than 1050 AD. The main part of the first-recorded taxa from bogs/swamps/wetlands, forests, heaths, grasslands, and maritime areas were, as indicated, most likely present in Scandinavia in earlier periods than proven so far.

The first-recorded cultivated plants have been recorded from 1 or 2 finds. The identification of *Hordeum* cf. *distichon* (two-rowed hulled barley) was, as discussed in Jensen (1979a), encumbered with some uncertainty.

Among the cultivated plants, *Sambucus nigra* is known from 9 finds, *Spergula arvensis* from 9 finds, *Linum usitatissimum* from 7 finds, and *Hyoscyamus niger* from 5 finds (cf. Jensen 1985).

8 ruderal species were recorded for the first time. The finds from the neighbouring countries render it probable that in future several of these may be recovered from earlier deposits.

Finds from 15 sites have been dated to the Early Middle Ages, which is the lowest number for any period considered (Fig. 1). Find distribution is: 22% storage, 19% gyttja/peat, 19% humic culture layers, 16% soil, 8% houses, 7% graves, 4% sand, 3% pits, and 2% clay. The ratio natural to culturally affected media was 25:75.

The sites examined are located in all parts of Southern Scandinavia except Lolland, Falster, Halland, and Blekinge.

Distribution according to life-form gives the following percentages: therophytes (38%), hemicryptophytes (34%), helo- and hydrophytes (11%), chamaephytes (5%), geophytes (4%), mega-, and mesophanerophytes (4%). Micro-, and nanophanerophytes constitute together 4%.

20% of the taxa are assumed to belong to bogs/swamps/wetlands, 19% weeds, 16% grasslands, 14% ruderal soils, 10% forests, 9% cultivated

plants, 5% lakes/ponds, 5% maritime plants, and 2% heaths (Fig. 3). 40% of these finds are from natural, 18% from semi-cultural, and 42% from culturally affected plant formations.

Although the media examined deviated from those of previous periods (Fig. 1), the distributions according to life-form and plant formation for the Early Middle Ages are quite similar to those found for the Viking Age and the Roman and Germanic Iron Ages (cf. Figs. 2 and 3).

## Late Middle Ages (1300-1536 AD)

Altogether, 198 taxa were recorded as macrofossils in deposits dated to the Late Middle Ages. 17 taxa have not been recorded for previous periods.

Below, the finds are distributed by plant formation:

### *LMA: Lakes/ponds*

*Spontaneous*: Butomus umbellatus< (u), Elatine hydropiper< (u), Polygonum amphibium<.

Alisma plantago-aquatica, Ceratophyllum demersum, C. submersum (u), Cicuta virosa (u), Hippuris vulgaris (u), Lemna sp., Menyanthes trifoliata, Najas marina (u), Nuphar lutea (u), Nymphaea alba, Oenanthe aquatica (u), Phragmites australis (u), Ranunculus flammula, Scirpus lacustris, Sparganium emersum (u), S. erectum (u), Zannichellia palustris.

### *LMA: Bogs/swamps/wetlands*

*Spontaneous*: Eleocharis quinqueflora<, Glechoma hederacea<, Polygonum amphibium<, Rumex conglomeratus<.

Alnus glutinosa, Anthriscus sylvestris, Betula pubescens, B. pubescens subsp. carpatica (u), Bidens cernua, B. tripartita, Blysmus compressus (u), Calluna vulgaris, Carex curta, C. diandra, C. disticha, C. echinata, C. flacca, C. hirta (u), C. lasiocarpa, C. nigra, C. pseudocyperus (u), C. rostrata, C. vesicaria, Cicuta virosa (u), Cirsium palustre (u), Cladium mariscus (u), Eleocharis palustris, Erica tetralix, Filipendula ulmaria, Frangula alnus (u), Holcus lanatus (u), Juncus bufonius, Linum catharticum, Lychnis flos-cuculi, Lycopus europaeus, Mentha arvensis, Menyanthes trifoliata, Myrica gale, Odontites verna, Pedicularis palustris, Peucedanum palustre (u), Phragmites australis (u), Polygonum hydropiper, P. lapathifolium, Potentilla anserina, P. erecta, P. palustris, P. reptans, Prunella vulgaris, Ranunculus acris, R. repens, R. sceleratus, Rumex cf. acetosa, R. hydrolapathum (u), R. maritimus (u), Salix cinerea, Scirpus lacustris, S. setaceus, S. sylvaticus, Solanum dulcamara, Sparganium emersum (u), S. erectum (u), Stachys palustris, Taraxacum officinale group, Trifolium repens, Urtica dioica.

### *LMA: Forests*

*Anthropochorous*: Prunus cerasus<, Pyrus communis<.

Prunus domestica subsp. insititia.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Glechoma hederacea<.

Betula pendula, B. pubescens, B. pubescens subsp. carpatica (u), Corylus avellana, Fragaria vesca, Frangula alnus (u), Galium aparine, Humulus lupulus, Malus sylvestris, Moehringia trinervia, Potentilla erecta, Prunus avium, P. spinosa, Rubus caesius, R. fruticosus group, R. idaeus, Sambucus nigra, Solanum dulcamara, Stachys sylvatica, Torilis japonica, Urtica dioica.

### *LMA: Heaths*

*Spontaneous*: Calluna vulgaris, Carex curta, Danthonia decumbens, Erica tetralix, Myrica gale, Potentilla erecta, Vaccinium vitis-idaea (u).

### *LMA: Grasslands*

*Anthropochorous*: Silene alba.

*Spontaneous*: Glechoma hederacea<, Ranunculus cf. bulbosus <, Verbascum thapsus*.

Achillea millefolium, Anthriscus sylvestris, Arenaria serpyllifolia (u), Carex flacca, C. hirta (u), Centaurea jacea, Cerastium fontanum subsp. triviale, Cirsium vulgare (u), Danthonia decumbens, Daucus carota, Fragaria vesca, Holcus lanatus (u), Knautia arvensis, Leontodon autumnalis, Linum catharticum, Odontites verna, Plantago lanceolata, Potentilla anserina, P. argentea, P. reptans, Prunella vulgaris, Prunus spinosa, Ranunculus acris, R. repens, R. sardous, Rubus caesius, Rumex cf. acetosa, R. acetosella, R. crispus, Scleranthus annuus, Silene vulgaris, Stellaria graminea, Taraxacum officinale group, Torilis japonica, Trifolium repens, Vicia hirsuta, V. sativa subsp. nigra.

### *LMA: Maritime plants*

*Spontaneous*: Scirpus maritimus (u).

### *LMA: Cultivated plants*

*Anthropochorous*: Brassica cf. napus<, Chelidonium majus<, Lactuca sativa*, Oryza sativa (imported)<, Prunus cerasus<, Pyrus communis<.

Anethum graveolens, Avena sativa, Brassica nigra (u), B. rapa, Coriandrum sativum (imported?), Ficus carica (imported) (u), Hordeum vulgare (six-rowed hulled barley), H. vulgare var. nudum (six- rowed naked barley), H. vulgare (hulled or naked

barley), Hyoscyamus niger, Linum usitatissimum, Papaver somniferum, Pisum sativum, P. sativum subsp. sativum, Prunus domestica, P. domestica subsp. insititia, Secale cereale, Spergula arvensis, Verbena officinalis, Vitis vinifera (imported) (u).

*Spontaneous*: Apium graveolens (u), Daucus carota, Humulus lupulus, Malus sylvestris, Prunus avium, Sambucus nigra.

*LMA: Weeds*

*Anthropochorous*: Galeopsis cf. speciosa*, Lamium amplexicaule<, Papaver argemone<.

Aethusa cynapium, Agrostemma githago, Anchusa arvensis, Anthemis arvensis, Aphanes arvensis (u), Bilderdykia convolvulus, Brassica rapa, Capsella bursa-pastoris, Carduus crispus, Echinochloa crus-galli, Euphorbia helioscopia, Fumaria officinalis, Galium spurium, Lamium purpureum, Neslia paniculata, Raphanus raphanistrum, Setaria viridis, Sinapis arvensis, Sonchus asper, S. oleraceus, Spergula arvensis, Stachys cf. arvensis, Thlaspi arvense, Urtica urens.

*Anthropochorous?*: Lapsana communis.

*Spontaneous*: Polygonum amphibium<.

Achillea millefolium, Anagallis arvensis, Arenaria serpyllifolia (u), Bidens tripartita, Centaurea cyanus, Cerastium fontanum subsp. triviale, Chenopodium album, Cirsium arvense, Galeopsis cf. tetrahit, Galium aparine, Juncus bufonius, Mentha arvensis, Odontites verna, Plantago lanceolata, Polygonum aviculare, P. hydropiper, P. lapathifolium, P. persicaria, Ranunculus repens, R. sardous, R. sceleratus, Rumex acetosella, R. crispus, Scleranthus annuus, Solanum nigrum, Sonchus arvensis, Stachys palustris, Stellaria media, Taraxacum officinale group, Vicia hirsuta, V. sativa subsp. nigra, Viola arvensis.

*LMA: Ruderal soils*

*Anthropochorous*: Chelidonium majus<, Lamium amplexicaule<, Papaver argemone<.

Aethusa cynapium, Anethum graveolens, Anthemis cotula, Anthriscus caucalis (u), Bilderdykia convolvulus, Brassica nigra (u), Capsella bursa-pastoris, Carduus crispus, Coriandrum sativum, Echinochloa crus-galli, Fumaria officinalis, Hyoscyamus niger, Lamium album, L. purpureum, Marrubium vulgare (u), Papaver somniferum, Rumex cf. longifolius, R. obtusifolius, Silene alba, Sonchus asper, S. oleraceus, Thlaspi arvense, Urtica urens, Verbena officinalis.

*Anthropochorous?*: Aethusa cynapium, Anthriscus caucalis, Lapsana communis.

*Spontaneous*: Glechoma hederacea<, Verbascum thapsus*.

Achillea millefolium, Chenopodium album, Cirsium arvense, C. vulgare (u), Galeopsis cf. tetrahit, Galium aparine, Plantago lanceolata, Polygonum aviculare, P. lapathifolium, P. persicaria, Potentilla anserina, P. reptans, Rumex crispus, R. maritimus (u), Sambucus nigra, Sonchus arvensis, Stachys palustris, Stellaria media, Taraxacum officinale group, Urtica dioica.

*LMA: Plant formation uncertain*

*Spontaneous*: Primula sp.<.

Arctium sp. (u), Atriplex sp., Hypericum sp., Juncus sp., Lamium sp., Lysimachia sp. (u), Mentha sp. (u), Primula sp. (u), Pyrus sp. (u), Rosa sp.

Among the 17 first-recorded taxa listed above, 14 have been recorded from previous periods in at least one of the surrounding countries.

The samples dated to the Late Middle Ages comprised a rather long list of taxa referred to natural plant formations. Not least bogs, swamps and wetlands are represented by a large number of species.

The cultivated plants first recorded from the Late Middle Ages were recovered from 1 or 2 locations, all situated in towns or monasteries.

The cultivated plants most frequently recorded were: *Sambucus nigra*, 9 finds; *Hyoscyamus niger*, 7 finds; *Linum usitatissimum*, 7 finds; *Humulus lupulus*, 6 finds; *Spergula arvensis*, 6 finds (cf. Jensen 1985).

The distribution of finds (Fig. 1) is: 35% humic culture layers, 17% gyttja/peat, 12% soil, 8% storage, 7% houses, 5% sand, 4% burnt houses, 4% latrine, 3% clay, 2% pits, 2% imprints, and 1% manure. For 22% of the sites the seed content was revealed by germination (cf. Ødum 1965). These sites are included in 'humic culture layers'. The ratio of natural to culturally affected media was 25:75.

The sites examined are situated in all parts of Southern Scandinavia.

38% of the recorded taxa were therophytes, 31% hemicryptophytes, 14% helo- and hydrophytes, 5% microphanerophytes, 5% geophytes, 3% mega- and mesophanerophytes, 3% chamaephytes, and 1% nanophanerophytes (Fig. 2).

The distribution according to plant formation is: 25% bogs/swamps/wetlands, 20% weeds, 14% ruderals, 12% grasslands, 10% cultivated plants, 8% lakes/ponds, 8% forests, 2% heaths, and 1% maritime plants (Fig. 3). The representation of natural, semi-cultural, and cultural plant formations was 42%, 14%, and 44%, respectively.

Despite some deviation with regard to medium, the distributions according to life form and plant formation were quite similar to those from the previous periods.

## Pollen Assemblage Zone 'IX' (2500 BP - 1536 AD)

A total of 88 taxa have been referred to Zone 'IX' (cf. p. 28). 8 taxa have not been recorded for prior periods.

*Zone 'IX': Lakes/ponds*
*Spontaneous*: Calla palustris, Cicuta virosa, Hippuris vulgaris, Menyanthes trifoliata, Najas marina, Nuphar lutea, Nymphaea alba, Phragmites australis, Potamogeton natans, P. obtusifolius, P. praelongus, Ranunculus flammula, Scirpus lacustris, Sparganium emersum, S. minimum, Trapa natans.

*Zone 'IX': Bogs/swamps/wetlands*
*Spontaneous*: Carex cespitosa*, C. elongata*, C. cf. paniculata<, Eriophorum angustifolium<, Lysimachia thyrsiflora*, Myosotis cf. scorpioides<.

Alnus glutinosa, Andromeda polifolia, Betula pubescens, Bidens cernua, Calluna vulgaris, Carex acuta (u), C. curta, C. diandra, C. lasiocarpa, C. pseudocyperus, C. rostrata, C. vesicaria, Cicuta virosa, Cirsium cf. palustre, Cladium mariscus, Eleocharis palustris, Empetrum nigrum, Eriophorum vaginatum, Frangula alnus, Hydrocotyle vulgaris, Iris pseudacorus, Lychnis flos-cuculi, Lycopus europaeus, Menyanthes trifoliata, Molinia caerulea, Myrica gale, Peucedanum palustre, Phragmites australis, Potentilla anserina, P. erecta, P. palustris, Ranunculus repens, Rhynchospora alba, Scheuchzeria palustris, Scirpus cespitosus, S. lacustris, S. lacustris subsp. tabernaemontani, Solanum dulcamara, Sparganium emersum, S. minimum, Vaccinium oxycoccos, Viola cf. palustris.

*Zone 'IX': Forests*
*Spontaneous*: Carpinus betulus<, Vaccinium myrtillus<.

Acer platanoides, Betula pendula, B. pendula x B. pubescens, B. pubescens, Corylus avellana, Fagus sylvatica, Frangula alnus, Fraxinus excelsior, Galium aparine, Juniperus communis, Oxalis acetosella, Pinus sylvestris, Potentilla erecta, Quercus robur, Rubus idaeus, Solanum dulcamara, Sorbus aucuparia, Tilia cordata.

*Zone 'IX': Heaths*
*Spontaneous*: Vaccinium myrtillus<.

Andromeda polifolia, Calluna vulgaris, Carex curta, Empetrum nigrum, Juniperus communis, Myrica gale, Potentilla erecta, Scirpus cespitosus.

*Zone 'IX': Grasslands*
*Spontaneous*: Juniperus communis, Potentilla anserina, Ranunculus repens, Rumex acetosella.

*Zone 'IX': Maritime plants*
*Spontaneous*: Scirpus maritimus.

*Zone 'IX': Cultivated plants*
*Anthropochorous*: Hordeum vulgare (six-rowed hulled barley), H. vulgare var. nudum (six-rowed naked barley), H. vulgare (hulled or naked barley), Linum cf. usitatissimum, Secale cereale, Camelina sativa, Triticum dicoccon, T. spelta.

*Zone 'IX': Weeds*
*Anthropochorous*: Bromus secalinus.
*Spontaneous*: Chenopodium album, C. cf. glaucum, Galium aparine, Ranunculus repens, Rumex acetosella.

*Zone 'IX': Ruderal soils*
*Anthropochorous*: Bromus secalinus.
*Spontaneous*: Chenopodium album, C. cf. glaucum, Galium aparine, Potentilla anserina.

*Zone 'IX': Plant formation uncertain*
*Spontaneous*: Mentha sp.

5 of the first-recorded taxa are marked "<", indicating previous presence in Southern Scandinavia.

*Carex cespitosa* and *C. elongata* are each represented by one find only. Although not demonstrated so far, it is likely that these species were present in Southern Scandinavia in earlier periods.

Altogether, finds from 45 sites were dated to Zone 'IX' (Fig. 1). All parts of Southern Scandinavia but Lolland and Falster are represented in the material. 75% of the samples were from gyttja/peat, 22% were imprints, and 3% were from silt deposits. The high representation of samples from natural plant formations is due to the arrangement of the samples (cf. p. 28). Most of the samples from gyttja/peat were dated by pollen analysis.

The distribution of the recorded taxa according to life-form (Fig. 2) revealed that 28% were helo- and hydrophytes, 27% hemicryptophytes, 16% therophytes, 15% mega- and mesophanerophytes, 7% chamaephytes, 4% geophytes, 2% microphanerophytes, and 1% nanophanerophytes.

Plant formation was as follows: 45% bogs/swamps/wetlands, 18% forests, 14% lakes/ponds, 9% cultivated plants, 5% heaths, 3% weeds, 3% ruderal soils, 2% grasslands, and 1% maritime. Listed according to natural, semi-cultural, and cultural plant formations, the findings were 78%, 7%, and 15%, respectively.

Compared with the finds referred to Zone VIII, the finds from Zone 'IX' contained fewer therophytes and a higher percentage of helo- and hydrophytes. This underlines once more the effect of the media examined (cf. p. 12).

# Recorded Macrofossils Grouped According to Various Factors

In the present chapter, the recorded information has been arranged according to media examined, life-form, assumed plant formation, and phytogeographical groups.

The aim of these classifications of ancient macrofossils has been to examine, from different points of view, the heterogeneous material assembled from each of the periods studied, and to establish whether these systems, when applied to material covering a long span of time, is capable of yielding information of value.

The results of these classifications are briefly commented upon below. Some of the differences between periods can be explained by vegetational changes, others may be ascribed to the fact that the information derives from available publications and not from representative, equally examined samples from each period.

## Media examined (Fig. 1)

From previous studies it is known that the media examined have great influence on the macrofossils recovered (see p. 12). Attempts have therefore been made to classify the sites examined for macrofossils with respect to this factor (cf. Fig. 1).

The media gyttja/peat, late glacial sediments, clay, silt, lime and sand are in general considered to be sediments. A deviant origin for clay and sand from RIA-LMA cannot be ruled out. Other media have been affected by human activities.

Fig. 1 shows that all finds of macrofossils from Zone I were from truly sedimentary layers, clay being the most frequently represented. After the withdrawal of the ice from Southern Scandinavia, the soil was incompletely covered by vegetation, and clay, silt, and sand were washed or blown into the lakes (Iversen 1967).

During Zone II (Allerød), the temperature rose, and the organic production in lakes and ponds increased. The main part of the media examined has been described as gyttja or peat. Due to a more complete vegetation cover, the possibility for inwash of macrofossils from the drier areas into the lakes was accordingly reduced.

For Zone III, the distribution is, as might be expected, more like that from Zone I than that from Zone II. For Zone III there was, however, a somewhat greater representation of gyttja/peat. This is in agreement with Iversen (1947), who pointed out that it is only in areas rich in clay that Zone III sediments consist of pure clay.

The media examined for Zones IV-VII were with few exceptions represented by gyttja/peat.

From Zone VIII onwards, the percentage representation of media examined for macrofossils shows a remarkable change. The number of sites from Zone VIII described as sedimentary was lower than in the previous two periods, whereas media influenced by man now occur for the first time and represent as much as 86% of the samples. Most of these were imprints, which mainly provide information on cereals and characteristic weeds (p. 11).

The media from sites dated to Pre-Roman Iron Age, Roman Iron Age, and Germanic Iron Age show an approximately equal distribution. In comparison it must be kept in mind that the finds from burnt houses, imprints, and storage in general originate from dwellings.

Samples from the Viking Age deviate mainly with regard to a decreased number of imprints, and with an increased number of samples from soil, pits, and manure. This reflects the fact that findings from several urban sites now appear in the survey, e.g. Haithabu (Behre 1983), Odense (Jensen 1986), and Lund (Hjelmqvist 1963, 1964).

The media examined from Early and Late Middle Ages show a roughly equal distribution.

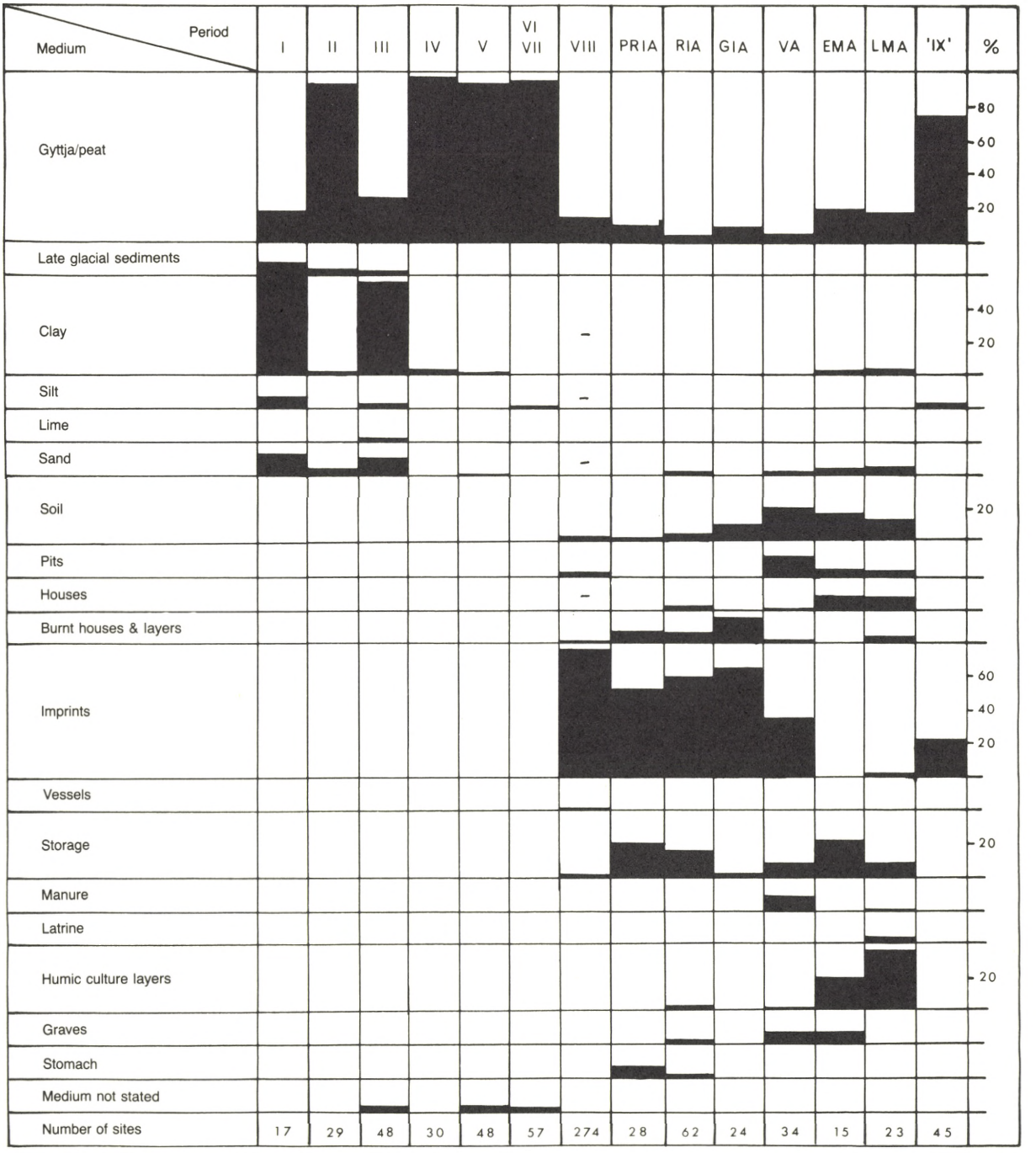



Fig 1. Recorded sites from each period distributed according to medium examined.
– : < 0.5 %.

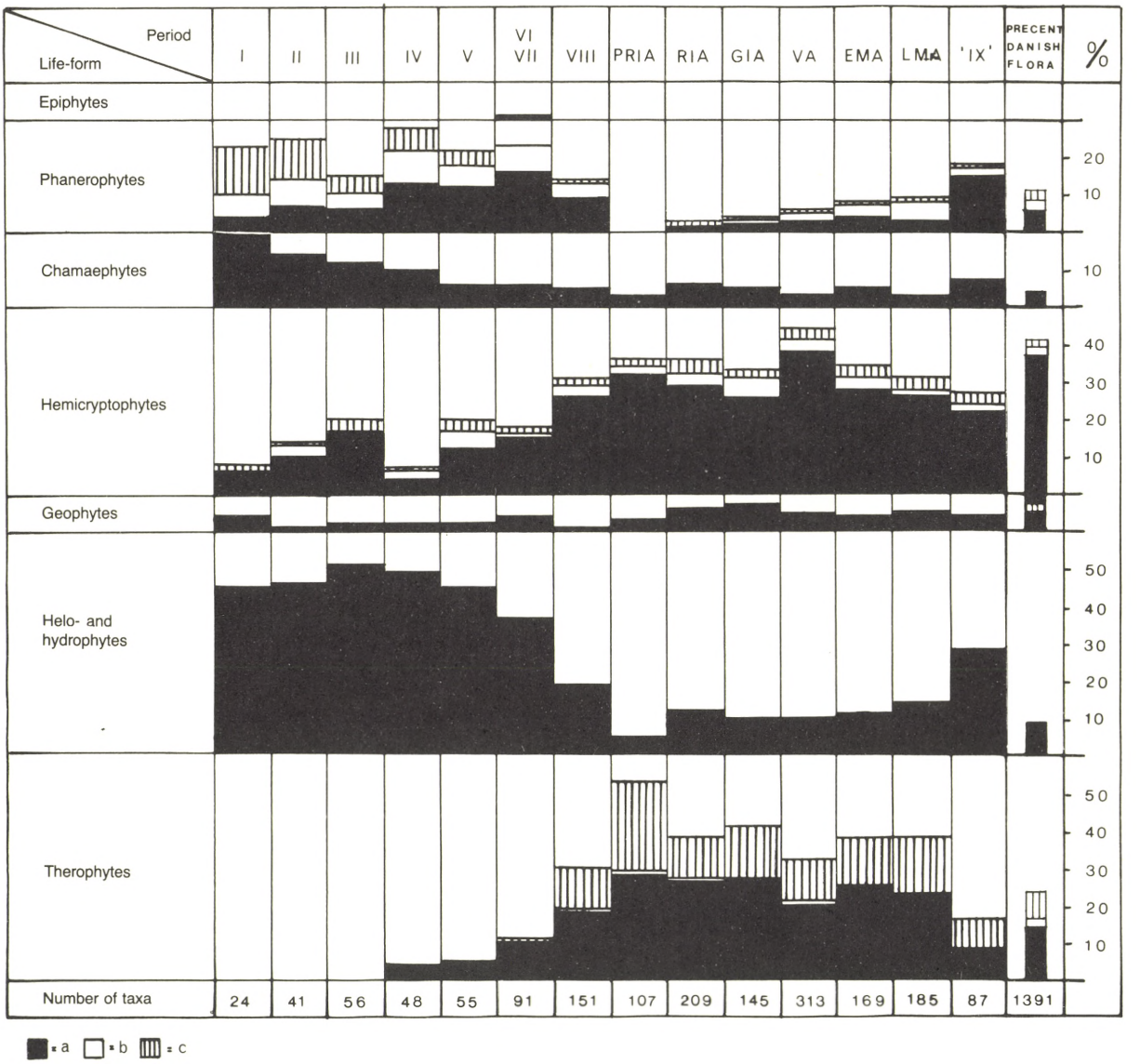



Fig. 2. Recorded taxa from each period distributed according to life-form (all finds), supplemented by information on life-forms of the present Danish Flora.
Phanerophytes *a:* Mega- and mesophanerophytes (>8 metres), *b:* Microphanerophytes (2-8 metres), *c:* Nanophanerophytes (0.25-2 metres). Hemicryptophytes *a:* Biennial and perennial without vegetative dispersal, *b:* With epigeal stolons, *c:* With subterranean stolons or root buds. Therophytes *a:* Summer annuals, *b:* Winter annuals, *c:* Summer or winter annuals.

Samples from storage were, however, more often examined from the Early Middle Ages (Helbæk 1953b; Hjelmqvist 1963, 1968), whereas humic culture layers became more common in samples from the Late Middle Ages.

Most of the samples referred to Zone 'IX' were dated by pollen analysis and classified as gyttja/peat.

## Life-forms (Fig. 2)

Raunkiær's (1907, 1934) life-form system is defined below with brief comments on representation in each period. When the height of the plant is mentioned, it signifies the average maximum height at which the buds and apical shoots destined to survive the unfavourable season are placed.

*Epiphytes*
This group includes phanerophytic parasites (Raunkiær 1934: 33), and is represented by one species only - *Viscum album* from Zone VI-VII.

*Mega- and mesophanerophytes* (> 8 m)
The mega- and mesophanerophytes show an increased relative importance from Zone I to Zones IV-VII. The diagram indicates the arrival of forest species during Zone IV. The values given for Zones I and III may be too high, due to reduced plant height during the cold periods.

For Zone VIII the percentage representation is somewhat lower than in the previous periods, due partly to a higher number of identified taxa, and partly to the frequent representation of imprints (cf. Fig. 1), among which macrofossils from trees are extremely rare.

Mega- and mesophanerophytes played a minor part among the species referred to PRIA-LMA, mainly due to the fact that most of the sites examined were associated with human dwellings, where the chance of recording phanerophytic macrofossils is substantially lower than in gyttja/peat. Mega- and mesophanerophytes were rather frequent in Zone 'IX', where 75% of the media were described as gyttja/peat (cf. Fig. 1).

*Microphanerophytes* (2-8 m)
The microphanerophytes were rather evenly represented from Zones I to VII. During the periods VIII to EMA, their relative importance was generally somewhat lower. This reflects the fact that the chance of recording such macrofossils is limited in sites associated with dwellings.

*Nanophanerophytes* (0.25-2 m)
The nanophanerophytes played a relatively important part during Zones I-IV. During the remaining periods, plants having this life-form were of limited frequency. This development indicates the importance of snow protection during harsh winters.

*Chamaephytes* (Surviving buds and shoot-apices are situated on or close to the surface of the ground)
Chamaephytes are favoured by snow cover during cold winter periods and played an important part during Zones I-III. During the remaining periods with milder climate, the percentage representation was reduced. The woody chamaephytes were the most frequent in all periods, whereas herbaceous chamaephytes have so far not been recorded from Zones I-III. In the remaining periods, their representation did not exceed 2%.

*Hemicryptophytes* (Surviving buds and shoot-apices are situated in the soil surface)
The hemicryptophytes have a great ability to survive various unfavourable climatic conditions. It appears from Fig. 2 that this life-form represents an important part of the recorded taxa, not least from Zone VIII on. This increase is coeval with the introduction of agriculture. According to Fig. 3, this resulted in increased frequencies of species from grasslands, cultivated plants, weeds, and ruderals. A grouping of the hemicryptophytes with respect to plant formations showed that grassland represented 23%, cultivated plants 6%, weeds 3%, and ruderals 9% of the species classified as hemicryp-

tophytes. These figures partly explain the increased frequencies. The hemicryptophytes are, however, also of importance in natural plant formations: 33% of this group belong to bogs/swamps/wetlands, 13% to forest, and 10% to maritime areas. The hemicryptophytes are most likely underrepresented in Zone IV. The deviation cannot be explained by variation in types of media, all finds from Zones I-VII being described as sedimentary, and more than 90% of the samples from Zones II and IV-VII being gyttja/peat (cf. Fig. 1).

Among the subdivisions shown in Fig. 2, plants without vegetative dispersal were most important throughout all periods.

*Geophytes* (Surviving buds and shoot-apices are situated below ground)

The geophytes played only a limited part in all periods. Their representation was independent of climatic conditions. Most important were geophytes with rhizomes. Geophytes with stem-tubers or with root-buds were present in small numbers in some periods, whereas those with root-tubers or with bulbs have not been recorded as macrofossils.Geophytes with root-tubers occur in the South Scandinavian flora in Orchidaceae. Seeds from this family are very small (cf. p. 15) and have so far not been recorded from Southern Scandinavia (cf. Jensen 1985, Table 3).

Geophytes with bulbs are represented by *Allium*, *Gagea*, *Ornithogalum* and other members of the Liliaceae, but so far not as macrofossils in the South Scandinavian material. From the British Isles the only record refers to seeds of *Allium schoenoprasum* (Godwin 1975). As several taxa within the Liliaceae produce a substantial number of seeds, and relic plants from this family can be referred back to Medieval monasteries (Tillge 1972), it is likely that the presence of such plants may be revealed in future analysis of samples from suitable sites.

*Helo- and hydrophytes* (Surviving buds are placed in water or in mud at the bottom of streams or lakes)

The helo- and hydrophytes from Zones I-VII were the life-form most frequently represented. All samples from these periods were from sediments (cf. Fig. 1), where remains of the helo- and hydrophytes have a high chance of preservation. From Zone 'IX', with 78% of the samples being described as sedimentary (cf. Fig. 1), helo- and hydrophytes were frequently present as well.

In Zone VIII and the periods PRIA-LMA, the helo- and hydrophytes showed somewhat lower frequencies, most of the sites examined being associated with human dwellings (cf. Fig. 1), at which macrofossils from helo- and hydrophytes occur less frequently.

*Therophytes* (Surviving the unfavourable season as seeds)

Therophytes have so far not been recorded as macrofossils from Zones I-III. From Zone IV, 2 taxa were recorded; from Zone V 3 taxa; from Zones VI-VII 9 taxa.

During Zone VIII and PRIA-LMA, the therophytes, especially cultivated plants and weeds, played an important part.

Summer annuals or winter and summer annuals were by far the most important therophytes. Few of the recorded taxa are considered true winter annuals.

*Conclusion*

In the samples from sediments (Zones I-VII), the phanerophytes, chamaephytes, hemicryptophytes, and not least the helo- and hydrophytes played the most important part.

The introduction of agriculture (Zone VIII onwards) resulted in reduced frequencies for phanerophytes, and helo- and hydrophytes, and in increased frequencies for hemicryptophytes and therophytes.

The phanerophytes, chamaephytes, geophytes, and helo- and hydrophytes were, however, of importance in several periods after the introduction of agriculture.

*Comparison of life-forms of the ancient and present Danish flora*

Fig. 2 (right column) shows the distribution of life-forms of the present Danish flora (Hansen 1984). The calculation is based on 1391 species of Spermatophyta (also cultivated plants and weeds). In a comparison of the percentage distribution by life-form in the various periods with that of the present Danish flora, it must be taken into account that only 491 taxa, or 35%, of the present Danish flora have been recorded as macrofossils. This figure does not include taxa known from Zones I-III only, those identified to genus level only, and imported species.

Compared to the present Danish flora, the phanerophytes were overrepresented in Zones I-VII. From these periods only samples from sediments have been recorded. In such media the chance of recording phanerophytes is high. The phanerophytes were underrepresented in PRIA and onwards. In these periods a high proportion of the sites were culturally affected, where the chance of recording phanerophytes is less than at natural sites.

The chamaephytes were, as mentioned, frequent in Zones I-IV. For the remaining periods the distribution is in agreement with that of the present Danish flora.

The hemicryptophytes are underrepresented in all periods but VA, which may be due to inherently reduced representation of such plants from grasslands and forests.

The geophytes are underrepresented in all periods, which in part is due to the fact that macrofossils from bulb plants and geophytes with root tubers have not been recorded so far.

The helo- and hydrophytes are overrepresented in all periods but PRIA. Not least the representation in Zones I-VII and 'IX' is far above that for the present Danish flora.

The therophytes were not present in Zones I-III, and the representation in Zones IV-VII is far below that of the present Danish flora. It is likely that some therophytes actually were present on disturbed soil during Zones I-III, but they have not been discovered yet. There was only limited space for these plants in the atlantic climax forest, which covered most of Southern Scandinavia from Zones V-VII. The therophytes were overrepresented in VIII-LMA, most likely due to a large number of sites associated with agriculture and human dwellings being included in the survey.

If the life-forms of *all* first-recorded taxa (excluding those known from Zones I-III only, those identified to genus only, and imported species) are compared with those of the present Danish flora (cf. Fig. 2), the distribution is as follows: phanerophytes 9 and 11%, chamaephytes 4 and 4%, hemicryptophytes 39 and 41%, geophytes 5 and 11%, helo- and hydrophytes 13 and 9%, and therophytes 30 and 24%.

When the heterogeneity of the materials collected and the new species added to the Danish flora since 1536 AD are kept in mind, the distribution on life-form of the taxa recorded as macrofossils from Zone VIII to LMA is fairly well in agreement with that of the present Danish flora. The reason for this similarity is, most likely, that when all periods are taken into account, a rather large number of diverse materials are included, which improves the chance of representation of various types of vegetation.

## Plant formations (Figs. 3 & 4)

The recorded taxa are in the previous chapter listed according to the plant formation from which they are assumed to have originated. A distribution according to plant formation is for each period shown in Fig. 3. The records include all referred finds from Zone IV onwards except imported species.

In order to illustrate the arrival of plants from various plant formations in Southern Scandinavia, the first recorded taxa have been assigned to plant formation, and accumulated (Fig. 4). It is assumed that when a taxon has been recorded, it has been growing in Southern Scandinavia at least from that period.

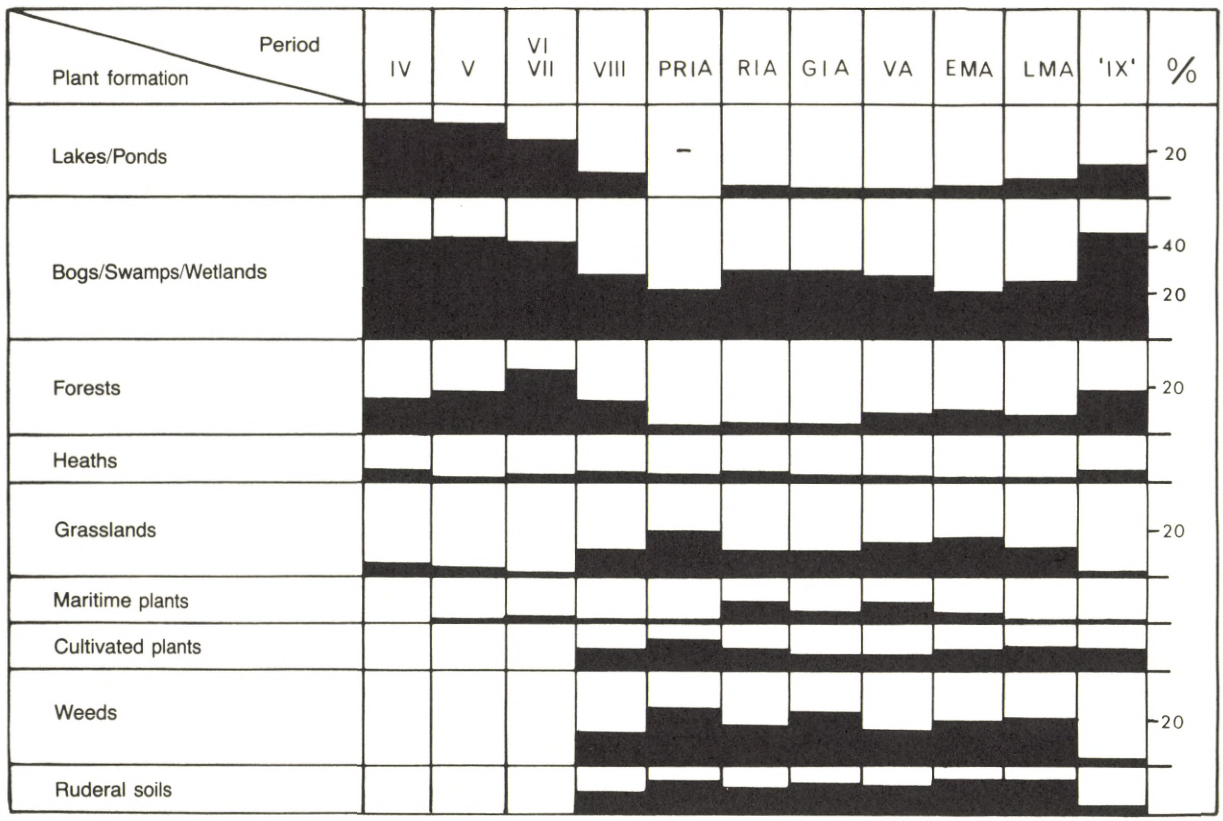



Fig. 3. Recorded species from Zone IV onwards distributed according to plant formation (all finds).

Excluded are 18 taxa known from Zones I-III only, 19 taxa not referred to any plant formation, and 7 imported species.

Most of the taxa recorded from Zones IV-VII and 'IX' originated from lakes/ponds and bogs/swamps/wetlands (Fig. 3). Taxa from these wet plant formations were important, also in the remaining periods, represented mainly by finds from dwellings, etc. (Fig. 1). Some of these plants may have grown at the site; others have most likely been transported to the dwellings as fodder, fuel, thatching materials, etc. (Jensen 1986).

According to Fig. 4, 20 (54%) of the 37 taxa assigned to lakes/ponds were recorded during Zones I-III. 30 (81%) were recorded at the end of Zone VII and 32 (86%) by the end of the Germanic Iron Age.

The corresponding figures for the taxa referred to bogs/swamps/wetlands were: Zones I-III, 18 (14%); VII, 46 (37%); GIA, 95 (75%).

Suitable growth conditions have most likely been present since Zones I-IV for a number of species recorded from the later periods. Other species may have invaded when damp forest areas during Zone VIII onwards were cleared and converted into pasture. Therefore we must assume that a large proportion of the species from damp areas were present in Southern Scandinavia earlier than proven so far.

The taxa occurring in forests and scrubs were

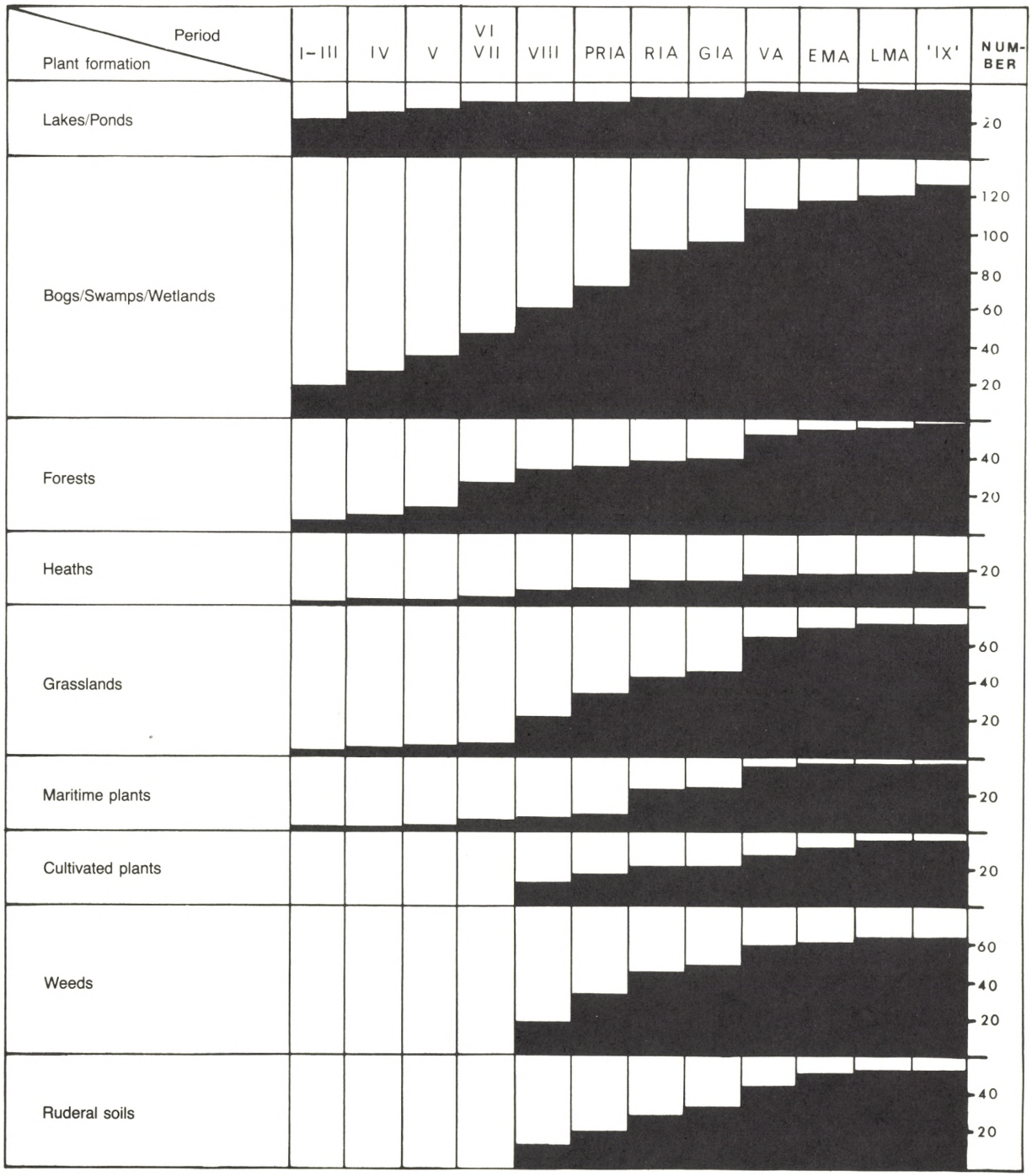



Fig. 4. Number of first-recorded taxa distributed according to plant formation and accumulated throughout the periods.

rather frequently discovered from Zones IV-VII and Zone 'IX', and less represented from PRIA-LMA (Fig. 3). The probability of recording such macrofossils is naturally higher in the sediments examined from Zones IV-VII and 'IX' than in media associated with dwellings (cf. Fig. 1).

6 (10%) of the forest species were recorded from Zones I-III, 26 (45%) from Zones VI-VII, and 39 (67%) from GIA or previous periods (Fig. 4).

The first-recorded taxa assigned to forest show a remarkable increase also after Zone VII, and several taxa from the atlantic climax forest have most likely not been recovered yet.

Throughout all periods, the number of species belonging to heaths was small (Fig. 3). Among the 19 taxa assigned to heaths, 3 (16%) were recorded from Zones I-III, 5 (26%) from Zones VI-VII or earlier, and 14 (74%) by the end of GIA (Fig. 4).

Grassland species were rather common in Zone VIII, and in PRIA-LMA, with fewer species being recovered from the remaining periods (Fig. 3). These results indicate that forest clearing from Zone VIII onwards created space for such plants. In the pollen diagrams, the curve for grasses increases around 500 BC (Iversen 1967).

3 (4%) of the 'grasslands' taxa were recorded from Zones I-III, 7 (10%) by Zones VI-VII, and 45 (63%) before the end of GIA (Fig. 4).

The maritime vegetation constituted 9% of the recorded taxa from RIA and VA, 5% from GIA and EMA, and 3% or less from the remaining periods (Fig. 3). The higher figures from RIA and VA are due to extensive analysis from coastal areas in Schleswig (Behre 1975, 1976, 1983).

The accumulated finds of maritime plants are (Fig. 4): Zones I-III, 2 (6%); VII, 6 (17%); GIA, 23 (64%).

An earlier dating of the species from heaths and not least from grasslands and maritime areas should be possible in future.

Plants classified as cultivated are recorded from Zone VIII onwards with frequencies varying between 7 and 13% (Fig. 3). Only *Humulus lupulus* was recorded from Zones VI,VII, where the species occurred in forest areas. A cultivation at this early date is unlikely.

13 (37%) of the 35 recorded cultivated plants have been recorded from Zone VIII, and 21 (60%) were known by the end of GIA.

Many analyses have elucidated the cultivation of cereals in various periods (cf. Jensen 1985). Our knowledge of cultivation of vegetables and utilization of medicinal herbs is, however, somewhat limited, since the number of suitable sites examined is restricted, and an earlier dating in future for some of these plants seems probable.

The groups 'weeds' and 'ruderal soils' have been established from Zone VIII onwards. Some dwellings earlier than Zone VIII had, most likely, ruderal plants growing close by. In the reviewed papers, all media earlier than Zone VIII were described as sediments, in which the occurrence of ruderal plants is rare and impossible to separate from those originating from natural plant communities (e.g. *Urtica dioica*).

It appears from Fig. 3 that weeds and plants from ruderal vegetation constitute an important part of the recorded macrofossils from Zone VIII to LMA. The samples dated to Zone 'IX' originated mainly from wetlands (Fig. 1) and contained, accordingly, fewer weeds and ruderal plants.

The cumulative curve for the first-recorded taxa (Fig. 4) shows that 18 (29%) of the weeds are known from Zone VIII and 48 (76%) by the end of GIA.

12 (23%) of the taxa assigned to ruderal soils are known from Zone VIII and 32 (64%) by GIA.

The number of weeds and plants from ruderal soils from, for instance, PRIA is rather limited compared to the total number recorded. Several of these species were, most likely, growing in Southern Scandinavia earlier than known so far.

## Phytogeographical groups (Table 1)

The Nordic flora has been divided into groups with regard to the phytogeographical distribution of species (Hultén 1950).

*Table 1*
First-recorded species distributed according to phytogeographical groups (Hultén 1950)

| Phytogeographical group (Hultén 1950) | Period | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI, VII | VIII | PRIA | RIA | GIA | VA | EMA | LMA | 'IX' |
| Arctic (Hultén 1-2) | | | | | | | | | | | | | | |
| Arctic-montane (Hultén 4-9, 11) | 5 | 2 | | | | | 1 | | | | | | | |
| Boreal-montane (Hultén 12-17) | 5 | 2 | 1 | 1 | | | 3 | | | | 3 | | | 2 |
| Boreal-circumpolar (Hultén 24, 29-33) | 10 | 8 | 11 | 5 | 2 | 8 | 6 | 7 | 15 | 2 | 8 | 2 | 1 | 2 |
| Eurasiatic s. l. (Hultén 23, 25-28) | 1 | 5 | 6 | 8 | 8 | 12 | 28 | 24 | 23 | 8 | 33 | 7 | 7 | 2 |
| Continental (Hultén 34-40) | | | 2 | 1 | 1 | 3 | 4 | 2 | 4 | 1 | 7 | 1 | | 1 |
| Atlantic and subatlantic (Hultén 19-20) | | | 1 | | | 3 | 5 | 4 | 9 | 2 | 21 | 4 | 2 | 1 |
| Miscellaneous (Hultén 3, 10, 18, 21-22, 41-48) | 2 | 2 | 2 | 2 | 3 | 7 | 21 | 10 | 19 | 3 | 13 | 4 | 1 | |

The extensive changes in climatic and other ecological conditions from the time of the ice withdrawal to the end of the Middle Ages have naturally affected the composition of the vegetation. In order to examine whether Hultén's grouping could throw any light on the information collected in this paper, the first-recorded species from each period have been assigned to 48 enumerated groups, established by him.

The number of first-recorded species in each of Hultén's groups is shown in Table 1. For clarity, his groups have here been formed into 8 classes, following the division applied by Berglund (1966b: 146).

The most frequently recorded macrofossils from Zones I-III were the boreal-circumpolar species (Table 1). For Zone I the arctic-montane and the boreal-montane, and for Zones II-III the Eurasiatic species, were relatively important as well. From Zone IV onwards, the relative importance of the boreal circumpolar element became reduced, whereas the Eurasiatic plants were most frequently represented in all periods but Zone 'IX'.

The frequent representation of the Eurasiatic plants from Zone IV onwards indicates that an essential part of the new species invading Southern Scandinavia came from south-east, south, and south-west of the area.

The number of continental plants was limited in most periods. It is of interest that the atlantic and sub-atlantic plants occur mainly from Zones VI-VII onwards. A rather large number was recorded from RIA and VA, due to extensive analysis in coastal areas in Schleswig (Behre 1976, 1983).

A classification according to Hultén's phytogeographical groups can provide some information on the origin of the recorded species. The value of this information is, however, reduced by the fact that in a number of cases the macrofossils have first been recorded considerably later than the period in which the species must have arrived in Southern Scandinavia. Among the arctic-montane species, for instance, *Rumex acetosa* has been recorded from Zone VIII. In the boreal-montane group, the following species have been recorded from Zone VIII: *Filipendula ulmaria*, *Taxus baccata*, *Valeriana officinalis* subsp. *sambucifolia*; from Zone 'IX': *Carex cespitosa*, *Vaccinium myrtillus*; from VA: *Angelica archangelica*, *Cirsium* cf. *helenioides*, *Silene dioica*, *Vaccinium myrtillus*.

All arctic-montane plants and boreal-montane plants should, if correctly grouped, have been recorded from periods earlier than Zone IV, since such plants must be assumed to be well adapted to the low temperatures obtaining during Zones I and III. In comparison between past and present phytogeographical distributions, it is furthermore a problem that a large number of species have so far not been recorded as macrofossils in ancient deposits.

# Changes in the Flora at Various Periods

(Figs. 5 & 6, Tables 2 & 3)

In order to describe the arrival of the South Scandinavian flora, the number of first-recorded taxa from each period is shown in Fig. 5.

Excluded from the cumulative curve are the species with either northern or arctic-montane distribution: *Salix herbacea*, *S. phylicifolia*, *S. reticulata*, and *Saxifraga oppositifolia*, all first recorded from Zone I, and *Potamogeton vaginatus* and *Salix* cf. *arbuscula* first recorded from Zone II. Imported species (cf. p. 64) have not been included either.

The number of first-recorded species varies between periods (cf. Fig. 5). Not least the samples dated to Zone VIII, Roman Iron Age, and Viking Age yielded a large number of taxa not described from earlier periods. From Zone VIII, a large number of sites associated with agriculture, which provided a large number of cultivated plants and weeds, were examined. The large number from RIA and VA is mainly due to extensive analysis from Schleswig (Behre 1976, 1983).

## Number of recorded taxa per century

As the periods covered by the various zones differ in length, the number of recorded and the number of first-recorded species per 100 C-14 years have been calculated (cf. Table 2). Period length is to the nearest whole century.

The number of first-recorded taxa during Zones I-IV varied between 2.0 and 2.9 per 100 C-14 years. This indicates that due to change in the climatic and ecological conditions, circumstances for invasion of new species were continuously created. Furthermore, due to erosion, a number of taxa from dry habitats were washed into the sediments.

From Zones V-VII the number of first-recorded taxa was 1.2, only about half the number recorded from the previous periods. Even though the number of examined sites per 100 years was less than in the previous periods, the results reflect the limited room for invasion of new species, because Southern Scandinavia during this time span was covered by an atlantic climax forest (Iversen 1960). It must be added that the inwash of species from drier areas was limited, due to the vegetation cover around ponds and lakes.

Zone VIII shows a remarkable increase in the number of new taxa. This is not least due to the fact

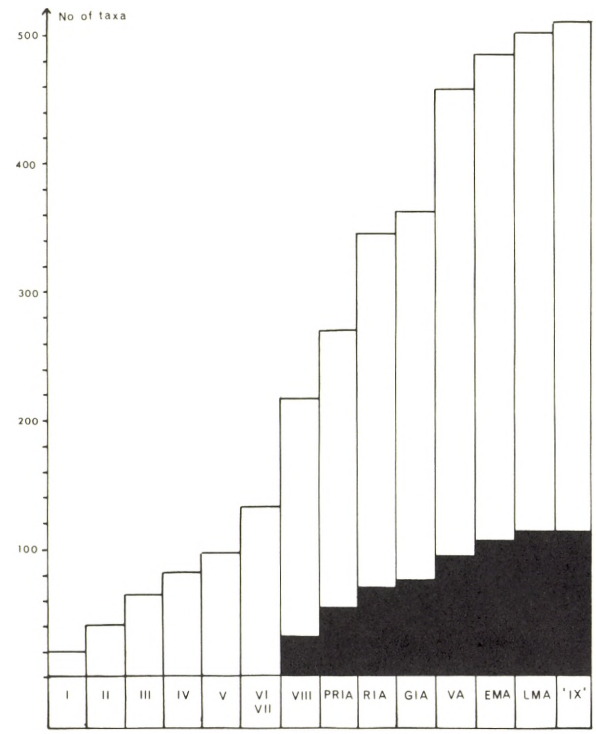



Fig. 5. Number of first-recorded taxa accumulated through periods. Excluded: 6 arctic-montane and 7 imported species. The solid area represents the anthropochorous species.

Table 2
Number of taxa registered per 100 C-14 years for different pollen zones

| Pollen assemblage zone | Number of sites | | Length of period in C-14 years | Number of taxa recorded | Number of taxa first recorded | Number of taxa per 100 C-14 years | |
|---|---|---|---|---|---|---|---|
| | Total | Per 100 C-14 years | | | | All taxa | Taxa first recorded |
| I | 17 | 1.4 | 1200 | 24 | 24 | 2.0 | 2.0 |
| II | 29 | 3.6 | 800 | 41 | 23 | 5.1 | 2.9 |
| III | 48 | 4.8 | 1000 | 56 | 24 | 5.6 | 2.4 |
| IV | 30 | 4.3 | 700 | 48 | 17 | 6.9 | 2.4 |
| V | 48 | 3.7 | 1300 | 57 | 15 | 4.4 | 1.2 |
| VI-VII | 57 | 1.9 | 3000 | 92 | 36 | 3.1 | 1.2 |
| VIII | 274 | 11.0 | 2500 | 152 | 84 | 6.1 | 3.4 |
| IX* | 231 | 11.0 | 2100 | 462 | 293 | 22.0 | 14.0 |

*Includes all finds from Pre-Roman Iron Age to Late Middle Ages and Zone 'IX'

that the number of examined sites per 100 years was much greater than in the previous periods and that finds from agricultural sites were frequently represented in the material (cf. Fig. 1). Most frequent were imprints which, however, only yielded a few species per site.

Even though fewer samples were examined in Zone IX compared to Zone VIII, Zone IX has yielded by far the largest number of new taxa per 100 C-14 years. The figure includes the finds from Pre-Roman Iron Age (PRIA) to Late Middle Ages (LMA). The high figures are, according to Fig. 4, due to a considerable number of first-recorded taxa occurring from PRIA onwards that belong to bogs/ swamps/wetlands, forests, grasslands, maritime areas, cultivated plants, weeds, and ruderal soils. The introduction of agriculture with its influence on grasslands and heaths accounts for the greatest increase in new species, but also the discovery of a large number of first-recorded species from natural plant formations played an important part.

When all finds are included, Zone IX provides also the highest number of taxa per 100 C-14 years.

The period 500 BC - 1536 AD is of great archaeological/ historical interest, and a large number of finds dated to PRIA, RIA, VA, and EMA, and less to GIA and LMA have been recorded. In order to facilitate comparison between these periods, the total number of finds and the number of first-recorded finds per 100 calender years have been calculated for each period (cf. Table 3).

The highest number of all taxa and of taxa first recorded was found in deposits dated to the Viking Age, which in part is due to the large number of taxa recorded from Haithabu (Behre 1983). The differences compared to other periods became even greater when the number of sites examined is taken into account.

Also from the Early Middle Ages and Late Middle Ages a substantial number of taxa were revealed. The number of first-recorded taxa from these periods was, however, not particularly large,

Table 3
Number of taxa registered per 100 calendar years for each archaeological/historical period

| Period | Number of sites | | Length of period in calendar years | Number of taxa recorded | Number of taxa first recorded | Number of taxa per 100 calendar years | |
|---|---|---|---|---|---|---|---|
| | Total | Per 100 calendar years | | | | All taxa | Taxa first recorded |
| PRIA | 28 | 5.6 | 500 | 107 | 53 | 21.4 | 10.6 |
| RIA | 62 | 15.5 | 400 | 211 | 76 | 52.8 | 19.0 |
| GIA | 24 | 6.0 | 400 | 147 | 17 | 36.8 | 4.3 |
| VA | 34 | 13.6 | 250 | 316 | 95 | 126.4 | 38.0 |
| EMA | 15 | 6.0 | 250 | 171 | 27 | 68.4 | 10.8 |
| LMA | 23 | 9.7 | 236 | 186 | 17 | 78.8 | 7.2 |

demonstrating that the Middle Ages were not the great age of plant introduction they were previously thought to be. Many of the plants formerly believed to have been introduced by the monks were actually present in Southern Scandinavia before the Middle Ages (cf. Jensen 1985).

## Time of arrival of various families elucidated by finds of macrofossils

The records presented in the catalogue, Table 3 (Jensen 1985), indicate remarkable differences in the time at which the various families were first represented by finds of macrofossils. In order to facilitate a comparison, the number of first-recorded taxa from each period (excluding imported species) is shown (Fig. 6). The families have been arranged alphabetically within 3 groups:

A: First finds recorded from Zones I-III
B: First finds recorded from Zones IV-VII
C: First finds recorded from Zones VIII and later.

Looking at the curves in Fig. 6, it must be kept in mind that they are based on finds of macrofossils only and represent present knowledge.

In group A, Cyperaceae are represented by 45 taxa, Rosaceae by 31, Caryophyllaceae and Umbelliferae by 22 each, Polygonaceae by 17, and Ranunculaceae by 15 taxa.

The shape of the diagrams discloses the time of discovery of macrofossils from the families listed.

For some families, all taxa known as ancient macrofossils were recorded from Zones I-IV: Betulaceae, Cupressaceae, Empetraceae, Haloragaceae, Hippuridaceae, Menyanthaceae, Nymphaceae, Potamogetonaceae, Saxifragaceae, and Zannichelliaceae.

In other families, new taxa have been recorded from most periods, especially from Zone VIII onwards. Part of this increase is due to the taxa introduced by man (cf. p. 62). In the following families, some of the recorded taxa have been considered anthropochorous (defined p. 62): Caryophyllaceae (5 taxa), Polygonaceae (3 taxa), Ranunculaceae (1 taxon), Rosaceae (7 taxa), Umbelliferae (7 taxa), Urticaceae (1 taxon).

The missing records of species from earlier periods (Zones I-VII) may be due to the media examined, the analysis technique, or problems of identification (cf. discussion p. 15-16).

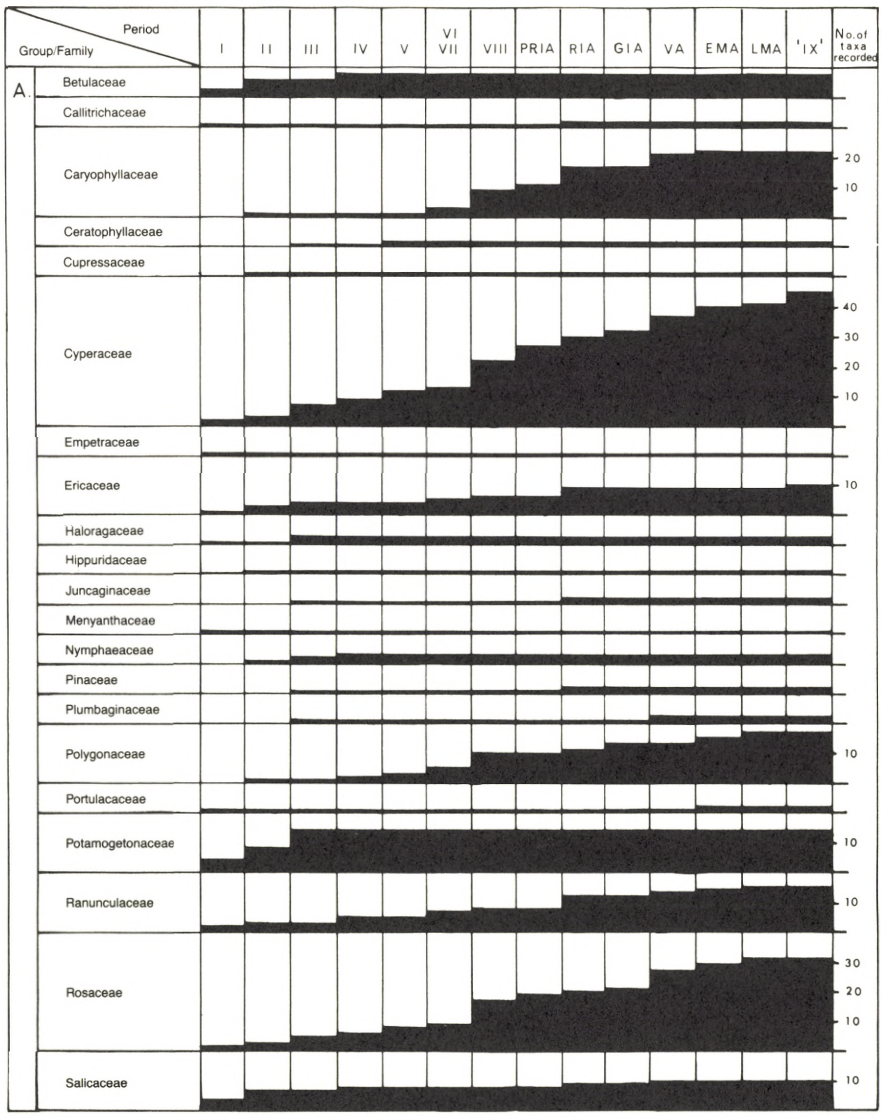



Fig. 6. Number of first-recorded taxa distributed according to family and accumulated through periods.
Included: Arctic-montane species. Excluded: Imported species. Group A: First records from Zone I-III. Group B: First records from Zone IV-VII. Group C: First records from Zone VIII onwards.

Fig. 6. (Continued)

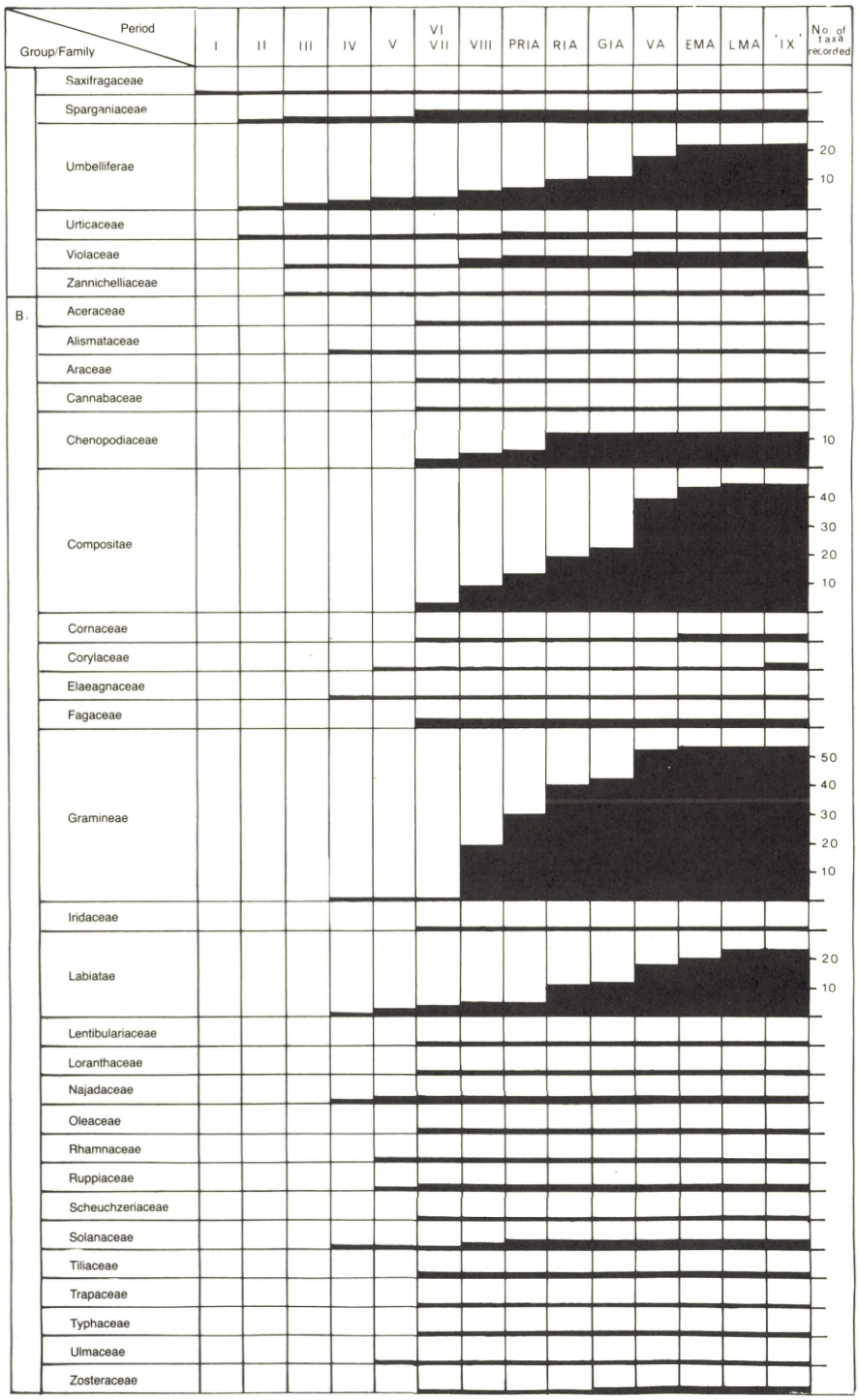
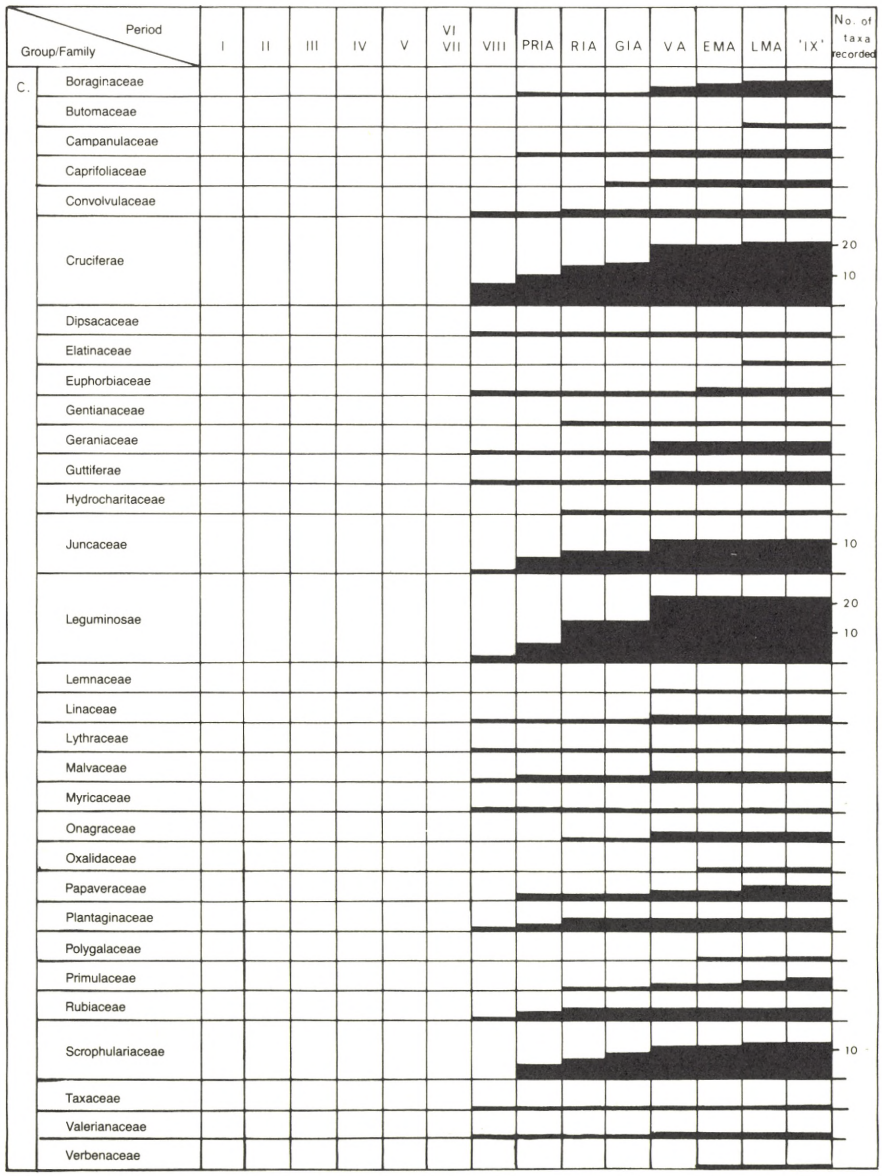


Fig. 6. (Continued)




For Cyperaceae, growth conditions during Zones I-VII were as far as is known favourable to a considerably greater number of taxa than revealed so far. As plants from the media bogs/swamps/wetlands are frequently represented at the recorded sites (cf. Fig. 3), and only a few of the Cyperaceae fruits will pass the sieves usually used (cf. p. 15), it is likely that the lack of species from Zones I-VII is in part due to identification problems. Several finds from these periods have been referred only to *Carex* sp., *C.* sect. Distigmaticae, *C.* sect. Tristigmaticae, *Rhynchospora* sp., and *Scirpus* sp. (Jensen 1985, Table

2). Another reason may be that samples for pollen analysis have frequently been taken from the central part of the lakes, whereas the greatest concentration of macrofossils is close to the edge of the lake (Birks 1980).

Most frequently represented in group B were Gramineae with 53 taxa, Compositae with 44 taxa, and Labiatae with 23 taxa.

Pollen studies have shown that Gramineae were rather important in Zones I-IV. In spite of this, the finds of macrofossils from these periods are so far limited to one species (*Phragmites australis*). The distinct increase from Zone VIII on is in part due to the introduction of agriculture. 23 of the taxa first recorded are considered anthropochorous.

The representation of anthropochorous species in other families was as follows: Chenopodiaceae (4), Compositae (13), Labiatae (10), Solanaceae (1).

The main part of the taxa within the families listed in group B belong to natural plant formations. A previous presence in Southern Scandinavia seems likely for several taxa of for instance Compositae, Gramineae, and Labiatae.

Within group C, Leguminosae are represented by 22 taxa, Cruciferae by 21 taxa, and Scrophulariaceae by 12 taxa.

An earlier dating should be possible for several taxa, since the following families in group C were represented only by taxa belonging to natural plant formations: Butomaceae, Caprifoliaceae, Dipsacaceae, Elatinaceae, Gentianaceae, Guttiferae, Hydrocharitaceae, Juncaceae, Lemnaceae, Lythraceae, Myricaceae, Onagraceae, Oxalidaceae, Plantaginaceae, Polygalaceae, Primulaceae, Taxaceae, Valerianaceae.

All recorded taxa have been considered anthropochorous for the following families: Boraginaceae, Euphorbiaceae, Papaveraceae, and Verbenaceae. These taxa were, most likely, introduced during Zone VIII or later. Other spontaneous taxa from these families, so far not recorded as macrofossils, may have been present before Zone VIII.

The remaining families were represented by some taxa designated as anthropochorous: Campanulaceae (1), Convolvulaceae (1), Cruciferae (15), Geraniaceae (2), Leguminosae (6), Linaceae (1), Malvaceae (1), Rubiaceae (1), and Scrophulariaceae (3). Several of the spontaneous taxa belonging to these families may have been present prior to the period when their presence has been demonstrated.

# Impact of Man on Vegetation

(Table 4)

Throughout history, man has played an important part in the dispersal of plants. Before the introduction of agriculture, collected plants were a substantial part of human food, and a number of taxa were most likely spread by man at this early date. It is, however, in most cases impossible to separate such finds from those dispersed by animals, birds, wind, etc.

Since the introduction of agriculture, the influence of man on vegetation is striking. In this paper it is illustrated by an increase in the number of macrofossils recovered from Zone VIII onwards (cf. Figs. 3-5).

In order to clarify the situation, the percentages of various media (Fig. 1) have been grouped into natural (gyttja/peat, late glacial sediments, clay, silt, lime, and sand) and culturally affected media (soil, pits, houses, burnt houses and layers, imprints, vessels, storage, manure, latrine, humic culture layers, graves, and stomach). The results are listed in Table 4.

The information on plant formations (Fig. 3) has been referred to natural (lakes/ponds, bogs/swamps/wetlands, forests, and maritime plants), semi-cultural (heaths, grassland), and culturally affected plant formations (cultivated plants, weeds, ruderals).

The media examined from Zones IV-VII were all classified as natural. The impact of man on vegetation was most likely limited. Only between 5 and 10 per cent of the taxa were assigned to the semi-cultural plant formations grasslands and heaths. The life-forms most frequently represented were helo- and hydrophytes, and phanerophytes (cf. Fig. 2.

From Zone VIII onwards, the introduction of agriculture had a distinct influence on the results obtained. The media examined from Zone VIII to VA were mainly classified as cultural (86-95%). For EMA-LMA, the representation of natural media was higher due to the fact that such layers occurred in connection with excavations of towns and monasteries. The distribution for PRIA deviates with regard both to plant formation and to life-form (cf. Fig. 2). It must be ascribed to the fact that the material has been assembled from finds that happen to have been published for each period, and not from homogeneous and equally representative samples.

The distribution of natural, semi-cultural, and culturally affected plant formations was to some extent alike for Zone VIII and RIA-LMA. The highest values for natural plant formations were recorded from Zone VIII, RIA, and VA. For Zone VIII this is due to higher frequencies of phanerophytes, and of helo- and hydrophytes (Fig. 2). For RIA and VA, the frequent occurrence of plants from natural plant formations reflects the large number of such taxa recorded from Elisenhof and Haithabu (Behre 1975, 1976, 1983).

The semi-cultural plant formations heaths and grasslands were more frequently represented after the introduction of agriculture, and constituted in the periods Zone VIII to LMA between 14% and 22% of the recorded finds.

The cultural plant formations constituted 32-52% from Zone VIII on, which clearly demonstrates the influence of cultivation on the materials recorded.

For 78% of the samples dated to Zone 'IX', the media were classified as natural, which had a distinct effect on the distribution according to plant formation and life-form.

It is concluded that with regard to media examined, life-form (cf. p. 46), and plant formation, the introduction of agriculture and the extended connection with other areas had a very distinct influence on the results obtained.

*Table 4*
Comparison of media examined and plant formations of all recorded macrofossils from various periods

| | | Period | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | IV | V | VI, VII | VIII | PRIA | RIA | GIA | VA | EMA | LMA | 'IX' |
| Media (sites) examined | Natural | 100 | 100 | 100 | 14 | 11 | 5 | 8 | 6 | 25 | 25 | 78 |
| | Cultural | | | | 86 | 89 | 95 | 92 | 94 | 75 | 75 | 22 |
| Plant formation | Natural | 90 | 94 | 95 | 53 | 26 | 48 | 43 | 49 | 40 | 42 | 78 |
| | Semi-cultural | 10 | 6 | 5 | 15 | 22 | 15 | 14 | 17 | 18 | 14 | 7 |
| | Cultural | | | | 32 | 52 | 37 | 43 | 34 | 42 | 44 | 15 |

## Anthropochorous species

(Fig. 5 & Table 5)

In order to examine to what extent the taxa recovered from Zone VIII onwards owe their distribution to man, the finds have furthermore been grouped into spontaneous and anthropochorous species (cf. Fig. 5).

The term 'anthropochorous' is here used in its wider sense, which includes plants that in some respects owe their distribution to man (van der Pijl 1982). The group 'spontaneous' includes the 'apophytes', i.e. weeds and ruderals not dispersed by man in Southern Scandinavia. The information has been obtained from Jessen & Lind (1922-23), supplemented by Hansen (1984), and Godwin (1975).

The following species may owe their distribution to man (Jessen & Lind op. cit.; Hansen op. cit.) and have been listed as 'anthropochorous?': *Chenopodium murale*, *Erodium cicutarium*, *Lapsana communis*, *Myosotis arvensis*, *Trifolium campestre* and *T. dubium*. These species have been counted as anthropochorous in Fig. 5 and Table 5.

The following species listed as anthropochorous by Jessen & Lind (op. cit.) have been considered spontaneous, because finds earlier than Zone VIII have been recorded from either Southern Scandinavia or the British Isles: *Anagallis arvensis*, *Carduus nutans*, *Centaurea cyanus*, *Daucus carota*, *Malva sylvestris*, *Odontites verna*, *Polygonum persicaria*, *Scleranthus annuus*, *Solanum nigrum*.

It appears from Fig. 5 that 31 of the first recorded taxa from Zone VIII have been considered anthropochorous. From each of the succeeding periods, new anthropochorous species were revealed. Of the 510 taxa assumed present in LMA, 113 taxa (22%) were classified as anthropochorous. These plants thus constituted an important, although not dominant part of the recorded flora.

In order to elucidate the occurrence of anthropochorous species, all finds from Zone VIII onwards have been grouped into spontaneous or anthropochorous species and related to plant formation (Table 5). The first-recorded finds are listed in parenthesis. Imported species are excluded.

According to Table 5, all recorded taxa referred to lakes, ponds, bogs, swamps, wetlands and heaths have been classified as spontaneous.

Most of the species occurring in forests are naturally spontaneous. Listed as anthropochorous from Zone VIII is *Lapsana* cf. *communis* (cf. p. 26), which also appears as a weed and ruderal plant (see p. 27). From PRIA and later *Aegopodium podagraria* and *Lapsana communis*, from VA *Prunus domestica* subsp. *insititia*, from EMA *Pyrus* sp., and from LMA *Prunus cerasus* and *Pyrus communis* have been recorded.

Table 5
All recorded taxa from Zone VIII onwards classified as spontaneous or anthropochorous and grouped according to plant formation (figures in parenthesis indicating number of first-recorded taxa)
Spt: Spontaneous species An: Anthropochorous species - : <0.5

| Plant formation | Spt/An | Period | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | VIII | PRIA | RIA | GIA | VA | EMA | LMA | 'IX' |
| Lakes/ponds | Spt | 16 | 1 | 10 (2) | 5 | 11 (3) | 9 | 16 (2) | 12 |
| | An | | | | | | | | |
| Bogs/ swamps/ wetlands | Spt | 41 (14) | 22 (11) | 61 (20) | 42 (4) | 84 (18) | 34 (4) | 46 (3) | 39 (6) |
| | An | | | | | | | | |
| Forests | Spt | 21 (7) | 3 (2) | 10 (3) | 8 (1) | 27 (12) | 16 (3) | 13 (-) | 16 (2) |
| | An | - (-) | 1 (-) | - | - | 1 (1) | 1 | 2 (1) | |
| Heaths | Spt | 6 (4) | 3 (1) | 8 (4) | 5 | 8 (3) | 4 (1) | 4 | 4 (1) |
| | An | | | | | | | | |
| Grasslands | Spt | 16 (13) | 16 (9) | 21 (8) | 15 (3) | 41 (18) | 23 (4) | 21 (2) | 2 |
| | An | 1 (1) | 4 (3) | 2 (1) | 1 | 4 (1) | 3 (1) | 1 | |
| Maritime plants | Spt | 3 (1) | 2 (2) | 17 (13) | 7 (1) | 29 (11) | 9 (2) | 1 | 1 |
| | An | | | | | | | | |
| Cultivated plants | Spt | 1 (1) | | 1 (1) | 1 (-) | 5 (3) | 2 | 3 | |
| | An | 12 (12) | 14 (4) | 18 (3) | 10 | 18 (3) | 12 (4) | 16 (4) | 8 |
| Weeds | Spt | 8 (6) | 12 (4) | 16 (6) | 12 | 22 (4) | 14 (1) | 17 (-) | 2 |
| | An | 12 (12) | 15 (11) | 20 (6) | 21 (3) | 26 (7) | 18 (1) | 20 (2) | 1 |
| Ruderal soils | Spt | 6 (5) | 8 (3) | 11 (3) | 10 (1) | 16 (4) | 7 | 9 (-) | 1 |
| | An | 7 (7) | 7 (4) | 13 (6) | 9 (3) | 21 (7) | 17 (7) | 17 (2) | 1 |

The taxa referred to grasslands are mainly spontaneous. The anthropochorous species include from Zone VIII: *Silene alba*; from PRIA: *Aegopodium podagraria*, *Crepis capillaris*, *Trifolium campestre*, *T. dubium*, and *Veronica arvensis*; from RIA: *Conium maculatum*, *Medicago lupulina*; from VA: *Cichorium intybus*, *Salvia pratensis*; and from EMA: *Anchusa officinalis*.

Similar results have been obtained by analysis of roadside vegetation in Denmark. 83% of the species belong to the natural flora of grasslands and 2% to forests. Only 11% are weeds and 4% ruderal plants (Mikkelsen 1981).

Maritime plants are represented by spontaneous species only.

The cultivated plants consisted by definition mainly of anthropochorous species. The following spontaneous species have, however, been recovered:- Zones VI-VII: *Humulus lupulus*; Zone VIII: *Daucus carota*, *Malus sylvestris*; RIA: *Apium graveolens*; GIA: *Sambucus nigra*; VA: *Althaea officinalis*.

For both weeds and plants from ruderal soils, the anthropochorous species were slightly more frequent than the spontaneous ones.

It appears from Table 5 that the representation of anthropochorous species was limited in natural plant formations. In the plant formations closely associated with the activity of man, the anthropochorous species were naturally predominant. The spontaneous species constituted the dominant part of grasslands and played a rather important part in the plant formation weeds and ruderal soils.

## Imported species

The following species are held to have been imported: *Ficus carica*, *Juglans regia*, *Oryza sativa*, *Pinus pinea*, *Prunus persica*, *Staphylea pinnata*, and *Vitis vinifera*.

*Coriandrum sativum*, which may have been imported, was most likely able to fruit in Southern Scandinavia. It is therefore included in Figs. 2-4 and Table 5. Macrofossils of *Coriandrum sativum* have been recorded from the Viking fortress at Fyrkat (Helbæk 1974), and from a latrine in Svendborg, dated approximately 1350-1400 AD (G. Jørgensen 1980). *Coriandrum sativum* has furthermore been recovered from the Late Bronze Age and Roman Britain (Godwin 1975; Willcox 1977; Wilson 1979), and in BRD (Knörzer 1967a; Körber-Grohne 1979; Kučan 1981). Dispersal of *Coriandrum sativum* into Southern Scandinavia before VA seems therefore likely.

*Ficus carica* has been recovered from Copenhagen in deposits from EMA and LMA. Remains of imported figs have been identified from Medieval deposits in Oslo, Norway (Griffin 1979). The fruit is also known from Roman and Medieval finds in the British Isles (Willcox 1977; Dickson et al. 1979; Kenward & Williams 1979), Germany (Knörzer 1967a, 1967b; Körber-Grohne 1979; Lynch & Paap 1982), Poland (Wieserowa 1979), and in Sweden (Påhlsson 1983). These finds indicate that *Ficus carica* was traded in Scandinavia and in the British Isles over a long span of years.

*Juglans regia* was found at Viking Age Haithabu. As both pollen and wood of *Juglans* are missing from the site despite the extensive excavation and analysis, the fruits are thought to have been imported from Central and South Germany (Behre 1983). Remains of walnuts have been recovered from Viking Age deposits in Lund (Hjelmqvist 1963). These and an extensive list of other finds cited in the relevant papers suggest that fruits of *Juglans regia* were rather commonly traded in Northern Europe throughout the Viking Age. Cultivation in Southern Scandinavia cannot be ruled out, since pollen of *Juglans* has been recorded from Bornholm in layers dated RIA-VA (Mikkelsen 1954).

*Oryza sativa* has been identified in a small cereal cache from Landskrona, Sweden, dated to the Late Middle Ages (Hjelmqvist 1968).

*Pinus pinea* was recovered from a Roman Iron Age grave at Brænde Lydinge, Funen (Mackeprang 1934). Seeds, bracts, and whole cones of *Pinus pinea* have been identified from several Roman sites in London (Willcox 1977), and at a temple of Mithras

at Carrawburg on the Antonine Wall, suggesting use as an altar fuel (Richmond et al. 1951). *Pinus pinea* is native to the Mediterranean region, where the cones were the object of trade in the Roman Period (Willcox 1977).

*Prunus persica* is represented by only 2 fruit stones from the extensive excavations at Haithabu (Behre 1983). The plant has been cultivated along the Rhine from the 1st century AD (Knörzer 1970). As transportation of fresh fruit across Germany must have been difficult, cultivation as far north as Haithabu cannot be completely ruled out.

Fruits of *Staphylea pinnata* have been found in a Roman Iron Age grave at Brænde Lydinge, Funen (Mackeprang 1934). A similar find has been made at Mahndorfer Düne, Bremen, BRD, in a woman's grave, dated c. 400 AD (Baas 1975). From Poland the species has been revealed from the Early Medieval Period (Gluza & Wasylikowa 1977). The symbolic or mystical power attributed to this fruit in connection with burials may be due to the fact that the loose seeds within mature capsules rattle when shaken. The bush occurs in Southern Germany and other parts of Central Europe (Hegi 1965, V, 1: 259), and we must assume that the dried fruit has been imported from these areas.

A few macrofossils of *Vitis vinifera* have been recorded from Haithabu. They are most likely from cultivated plants, the occurrence of wild plants being unlikely here. Even if viticulture cannot be completely precluded, finds of barrels, written information, etc., render it probable that the macrofossils recovered were either remains left in wine or from raisins (Behre 1981, 1983). *Vitis vinifera* has furthermore been recorded from Late Medieval deposits in Copenhagen (Rostrup 1906; Jessen & Lind 1922-23).

The presence of *Vitis* is very rare in pollen diagrams. It was, for instance, not recorded from the Maglemosian period in Åmosen - Zones IV-VII (S. Jørgensen 1963). A few grains of *Vitis* pollen have been recorded from the beginning of Zone VIII by Mikkelsen (1949a). As these pollen grains were from deposits dated to a period contemporary with or shortly after the first land occupation, it is possible that the plant was brought into the country by immigrants (Mikkelsen, op. cit.).

Seeds of *Vitis* have in Britain been recovered from Roman sites (Godwin 1975), from 1st-4th century AD (Willcox 1977), and from 4th-5th century AD (Greig 1976); in BRD from 12-8 BC (Kučan 1981), and 1st-2nd century AD (Knörzer 1967b, 1973); in Poland from 9th-10th century (Wasylikowa 1978); and in Norway (imported) from 1200-1250 AD and 1400-1500 AD (Griffin 1979). Most of these finds are, with all probability, from cultivated plants.

# Concluding Remarks

The information assembled in the present paper discloses that the occurrence of macrofossils in ancient deposits depends both on the dispersal of prospective macrofossils to the media and on the preservation circumstances.

Macrofossils are usually well preserved in sediments, which provide a reasonably good picture of the plants growing in wet areas, whereas species from dry land are represented with relatively few species.

For the layers affected by man, the content of macrofossils depends on a number of factors which influence dispersal and preservation. For imprints in pottery and carbonized seeds, for instance, it is usually possible to identify only cultivated plants and some weeds with rather large seeds. In layers preserved under buildings or in waste (e.g. manure), extensive numbers of macrofossils, representing a large number of taxa, have been found.

For non-carbonized macrofossils, the ability to resist decomposition is of great importance. *Chenopodium album*, for instance, occurs frequently, whereas it is rare to find non-carbonized grasses in such deposits.

Many of the excavated sites have been affected by agriculture. For that reason, a number of factors which either add to or subtract from the macrofossils present in such layers have been discussed.

In the detection of preserved macrofossils, the size of the samples and the methodology used are of importance. Studies of seed measurements have shown that valuable information may be lost if the smallest sieve used for extraction has holes larger than 0.2 mm.

Review of published finds of macrofossils has provided information on the occurrence of more than 500 taxa present in various periods and areas within Southern Scandinavia.

The arrangement of the recorded macrofossils according to periods disclosed that considerable differences exist with respect to the number of taxa recorded. Also the listing of the revealed taxa according to plant formation demonstrated great differences between periods.

Attempts have been made to arrange the recorded information on macrofossils according to media examined, life-form, assumed plant formation, and phytogeographical groups.

It was found that a close relationship existed between the media examined and the macrofossils found. Information on media examined should, therefore, be an indispensable part of reviews of finds of botanical macrofossils.

Information on life-form provided valuable information on the nature of the macrofossil assemblage from various periods. The introduction of agriculture, for instance, is clearly demonstrated in the diagram (Fig. 2). Comparison of the distribution on life-form of ancient materials with that of the present Danish flora disclosed differences for most periods. If, however, comparison is made between all species recorded as macrofossils, the distribution is fairly well in agreement with that of the present Danish flora. It is therefore recommended that information on life-form be included in similar studies on macrofossils.

From the analyses of find distribution according to plant formation (Fig. 3), the origin of the macrofossils recovered from various periods is visualized. It is evident that such information can provide knowledge essential to the understanding of the life of man and the composition of the flora at and around the examined area.

The time of arrival of various plant formations has been illustrated by grouping the first-recorded species from each period according to plant forma-

tion (Fig. 4). This has disclosed that even if the natural plant formations lakes/ponds, bogs/swamps/wetlands, forest, and maritime plants were represented fairly well from Zones I-VII, a large number of species, not least from forests and wet areas, were recovered after the introduction of agriculture. These findings suggest that a number of species were present earlier than known so far.

The listing of the recorded taxa according to Hultén's phytogeographical groups (Table 1) proved to be less suited to throwing light on the reviewed finds of macrofossils.

The arrival of species into Southern Scandinavia has been illustrated with a cumulative curve showing the first-recorded species from each period (Fig. 5), and by calculation of the number of first-recorded species per century (Tables 2 & 3). The highest values were obtained after the introduction of agriculture (Zone VIII onwards). As mentioned, some of the first-recorded species from these periods belong to natural plant formations.

Arrangement of the families according to the first-recorded find disclosed that for 21 families the oldest finds were dated to Zones I-III, for 32 families to Zones IV-VII, and for 31 families to Zone VIII or later. This distribution supports the view that an earlier dating is probable for several taxa of most families.

The influence of man has been specifically discussed (Table 4). It is concluded that with regard to media examined, life-form, and plant formation, the introduction of agriculture and the enhanced connection with other areas had a very distinct influence on the results obtained.

The anthropogenic influence has been illustrated by grouping the recorded species into spontaneous (78%) and anthropochorous (22%). The latter group thus constituted an important but not dominant part of the material. The anthropochorous species were mainly found within the groups cultivated plants, weeds, and ruderals (Table 5).

When discussing the influence of man on vegetation after the introduction of agriculture, knowledge of the occurrence of anthropochorous species is essential.

The occurrence of 7 species considered imported has indicated that plant materials were brought into Southern Scandinavia from warmer areas. Similar findings have been reported from neighbouring countries.

I hope that the materials assembled can inspire to further study of the subject, since the work has revealed that records of macrofossils from a number of species are still lacking.

Using the information presented in this and previous publications (Jensen 1985, 1986), it should be possible in future studies to select samples from specific media, localities, and periods, in which the content of macrofossils could add significantly to the history of the flora in our area.

The present study has been primarily devoted to information obtained from botanical macrofossils. The information gathered does, however, invite a thorough use of all available information on pollen as well: a combined treatment of pollen and macrofossil records would furnish a more detailed picture of the fascinating history of the South Scandinavian flora.

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# Abbreviations

*Dating*

| | |
|---|---|
| I-VIII | Pollen assemblage zones (Jessen 1935). |
| IX | Pollen assemblage zone (including finds dated to PRIA, RIA, GIA, VA, EMA, and LMA). |
| 'IX' | Pollen assemblage zone (excluding finds dated to PRIA, RIA, GIA, VA, EMA, and LMA). |

*Periods*

| | |
|---|---|
| AD | Anno Domini. |
| BC | Before Christ. |
| BP | Before present. |
| EMA | Early Middle Ages (1050-1299 AD). |
| GIA | Germanic Iron Age (400-799 AD). |
| LMA | Late Middle Ages (1300-1536 AD). |
| PRIA | Pre-Roman Iron Age (500-1 BC). |
| RIA | Roman Iron Age (1-399 AD). |
| VA | Viking Age (800-1049 AD). |

*Miscellaneous*

| | |
|---|---|
| An. | Anthropochorous. |
| Anon. | Anonymous. |
| BRD | Bundesrepublik Deutschland, German Federal Republic |
| C. | Centigrade. |
| cf. | Confer. In connection with plant names: identification uncertain. |
| I | Imported. |
| sp. | Species. |
| spt. | Spontaneous. |
| subsp. | Subspecies. |
| u | Uncertain dating. |
| var. | Varietas. |
| * | Species first recorded. |
| < | Species first recorded; finds from neighbouring countries suggest an earlier dating. |

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