Dendrochronological dating on oak in Skåne and Blekinge, Southern Sweden
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Dendrochronological Dating on Oak in Skåne and Blekinge, Southern Sweden

by Thomas S. Bartholin and Björn E. Berglund

Introduction

A necessary condition for using dendrochronology is that a measurable zone of increment, a tree ring, is registered in the growth of the trees every year.

The formation of the tree ring within the same species must further be influenced by a number of increment-regulating factors that dominate individual and local growing conditions, so that we get a uniform and typical variation of the tree rings in a large area.

The tree ring in oak (Quercus robur and Q. petraea) is characterized by the formation of large, visible vessels immediately before the spring, and by a homogeneous late wood zone with only small vessels. Every year is registered by the formation of a ring with large vessels. Anomalies of double rings or missing rings, occurring often in conifers and other deciduous trees, are seldom seen in the oak.

These conditions having been fulfilled, the dendrochronological working methods are rather simple: The width of each tree ring in the samples is measured. A diagram is then drawn, showing the ring-width variation from the innermost to the outermost tree ring. The samples are dated by comparing the diagrams with a standard chronology in which the characteristic mean ring-width per year is known, as far back as the chronology exists at the present time. If the tree, from which the sample was taken, has grown in the time covered by the chronology, there will be one position where the two diagrams fit together, namely at the point where the two series of tree rings have grown simultaneously. We then have the date of the tree rings of the sample. This so-called cross-dating assumes a certain minimum number of tree rings in the sample in order to avoid individual deviation from "normal" growth. Therefore there must be at least 70–100 rings in each sample.

The basis for the chronology is living trees in which the absolute dates of the rings are known. By finding samples from old objects that overlap in time those for which ring patterns have been dated, one can go back in time and obtain a still longer record of the tree ring fluctuations. This method is illustrated in fig. 1. Even for periods not yet covered by standard chronologies, useful information about relative datings of particular objects can be gained by dendrochronology by dating the samples in relation to each other. A so-called floating chronology can be constructed using such datings.

The background of the dendrochronological project in Southern Sweden is the positive results from Northern Germany and Denmark. In 1967 investigations on modern trees showed that dendrochronology on oak was possible in Northern Germany (Bauch, Liese and Eckstein, 1967).

When Eckstein (1969) attained good results by a dendrochronological investigation of the Viking town at Hedeby, at the same time presenting methods for a practical treatment of samples, an investigation of the possibilities in Denmark was started.

Results of this investigation showed that the southern part of Jutland and the
northernmost part of Germany can be covered by one chronology, which would, also be representative of the greater part of the rest of Denmark (Bartholin, 1973).

The valid area for a chronology for Northern Germany was therefore larger than expected, and when the Swedish project was started in 1973, we expected to be able to use the German experiences and methods to a great extent. The goal was firstly to discover a valid area for a chronology in Southern Sweden (the provinces of Skåne and Blekinge), and secondly to establish a chronology from the present time back to the Iron Age.

Results from Skåne have been published (Bartholin, 1975) from which could be concluded that Skåne is a dendrochronological unit. The new investigations in Blekinge make it necessary to look at the results once more. The most recent results of work on the construction of a chronology based on sub-fossil samples will also be dealt with here.¹


The research in Denmark (1970–73) was supported by the Danish Natural Science Research Council under the guidance of "The dendrochronological Committee".

The research in Sweden started in 1973 and is supported by the Swedish Natural Science Research Council. The authors are jointly responsible for the research plan but the first author has performed the research work.

Methods

To "date" modern samples was to be made possible by means of visual synchronization of the tree ring curves, supported by the values of agreement.

The tree ring curves are drawn on semi-logarithmic paper as suggested by Huber (1941). The years are plotted on a linear scale on the abscissa axis and the ring width on a semi-logarithmic scale on the ordinate axis. This transformation means that differences between ring widths only become dependent on proportions between them and not on their absolute values, and comparisons between series with a narrow mean ring width and series with a broad mean ring width are then possible.

The method for calculating the value of agreement was also suggested by Huber (1943), and it is now used in a rationalized form for computer-treatment (Eckstein
and Bauch, 1969). These calculations give numerical values for how well two curves match, taking into consideration only whether the growth of one year is greater or smaller than that of the preceding year. When two curves are compared at a certain position, the value of agreement is calculated by counting the number of cases where the curves in the interval between two years are at the same time either falling or rising. If one or both curve-intervals are horizontal, the value of agreement is increased by 1/2. The higher the value of agreement, the better the agreement between the curves expressed in this way. The value of agreement is normally referred to in percent of the number of intervals of years during the overlapping period. The mean value of the percentage of agreement of any position between two curves is thereby 50.

A high value of agreement is not tantamount to the synchronization of two curves, as it can, though not often, be seen in asynchronous positions as well. A computer can without difficulty give the position or the positions of high values of agreement, making the final, decisive visual synchronization much easier. When there is a large number of local samples with almost the same historical age, a visual synchronization is often sufficient.

Values of agreement can also be used as a guide when investigating the geographical extension of a uniform dendrochronological area as demonstrated in the following section.

**Sample collection**

It was practical to collect the modern samples from as old trees as possible for the forthcoming chronology. In Skåne there are many oaks that are, by tradition, very old, "a thousand years old", and they were already mapped out. But inspection showed that these oaks, in all cases, had obtained their considerable size thanks to good growing conditions or had hollow trunks. Some of these big trees were examined and here are some examples of their ages: A tree at Torsebro Krutbruk has a girth of c. 700 cm and an age of probably not more than 300 years. A tree at Uddarp with a girth of 690 cm has a maximum age of 250 years and a tree with a girth of 620 cm at Torup has the same maximum age. The oldest oak (fig. 2) so far with certainty found in Skåne (Sweden) growing in Fulltofta forest, has 414 tree rings and a hollow trunk proving that it is about 500 years old. Its girth is 590 cm. Yet another tree in the same stand is of the same age.

The samples were then taken from single trees in regular forest stands. Good places for old trees were found at the four localities marked on the map (fig. 3). These localities are also supposed to have a situation representative of the whole region.
Fig. 3. Localities with dendrochronological investigations on modern oaks. G, Germany, forests around Schleswig (Bauch, Liese and Eckstein, 1967.) D, Danish localities: D1-8, Bartholin (1973). *-marked localities (D1-7) form the chronology for Southern Denmark, fig. 5; D9, Holmsgaard (1955); S, Skåne localities; S1, Böringe Kloster and Torup; S2, Bosjö Kloster and Fulltofta; S3, Uddarp and Torsebro Krutbruk; B, Blekinge, forests at Johannishus. — Platser där dendrokronologiskaundersökningar gjorts på nutida ekar.

At each place at least 10 trees were selected. The distance between the trees could be as much as c. 10 km. At a height of about one metre above ground one core was taken with an electric borer. The tree rings were measured on an ADDO electronic measuring machine.

**Chronology based on modern oak trees**

Based on the results of the measurements, 4 local chronologies could be calculated. They are shown in fig. 4 for the period 1800–1973 A.D. The similarity between the curves is sufficient for making a visual synchronization within the whole area, although it is clearly better between S1–S2 and between S3–B. The similarity of the curves is further partly underlined by their high percentage of agreement as shown in table 1.

The percentage of agreement with local chronologies from Denmark and Northern Germany is shown in table 2. These figures do not disclose any regular differences between the local chronologies in Skåne but show a somewhat lower mean value for the Blekinge chronology. The average of percentages of agreement of curves from Denmark and Northern Germany is 67.5. The figures here show a falling value of the percentage of agreement with increasing distance, which was to be expected, and in Denmark seen at even shorter distances (Bartholin, 1973). The percentages of agreement are calculated for the period 1840–1949 as fixed by the shortest chronology, D9.

The investigation shows that Skåne and Blekinge could be a dendrochronological unit served by one chronology, but that the best results would be obtained if we made two chronologies: one for South-East Skåne and one for North-East Skåne and Blekinge. Thanks to modern computer technique this would be no problem.

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**Table 1. Percentages of agreement between the local chronologies from Skåne and Blekinge, calculated for the period 1840–1949 A.D.**

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<td>S3</td>
</tr>
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<td>S1</td>
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<tr>
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<td>68.3</td>
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<tr>
<td>S3</td>
<td></td>
<td>72.9</td>
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**Table 2. Percentages of agreement between Swedish and Danish-German chronologies, calculated for the period 1840–1949 A.D.**

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<th>Blekinge</th>
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<td>S2</td>
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</tr>
<tr>
<td>Mean</td>
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<td>64.6</td>
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</tbody>
</table>
Fig. 4. Chronologies from the 3 localities in Skåne and Blekinge, see fig. 3. – Kronologiska serier från de undersökta områdena i Skåne och Blekinge, jfr fig. 3.

Chronologies based on modern samples are, for these regions, shown in fig. 5, together with a chronology from the Southern Danish localities, D1–7, (Bartholin, 1973). Here we see that the South-West Skåne chronology is almost identical with that of Denmark, and that the chronology for North-East Skåne and Blekinge only diverges from them in its lower mean level, particularly in certain “years of minimum”, for example in 1812, 1813, 1840–41 and 1862–63.

Between the chronologies there are the following percentages of agreement: S-W S.–S D.: 75.2; S-W S.–(N-E S.+B.): 75.2; and (N-E S.+B.)–S D.: 69.7.

Compiling chronologies for Skåne and Blekinge would therefore be facilitated by the possibility of making control datings on a chronology covering Northern Germany and Southern Denmark. Datings on material from North-East Skåne and Blekinge will be easier when a chronology for South-West Skåne also exists.

A floating chronology based on medieval material
The dendrochronological method for dating oak has proved valuable for practical purposes, too.

A number of samples from a current excavation in the medieval town of Lund have been dated, and on these a floating chronology is being constructed. At present it covers a period of 518 years, pre-
sumably 700–1200 A.D. This dating is based on historical information and a synchronization with the floating chronology from Hedeby, Northern Germany.

The floating Lund chronology is today based on samples from St. Drotten Stave Church and especially from coffins in its cemetery. (The Kattesund excavation, the spring and summer of 1974.)

The primary results of this dendrochronological investigation are given here as an example of how the method works, especially when extensive material of very good quality is used.

Thirty out of thirty-one investigated staves could be dated and their position in the floating chronology is shown in fig. 6. The surfaces of the staves had been worked on by man and the outermost tree rings had rotted away, making an exact dating of the cutting year impossible.

Oakwood is composed of dark brown heartwood with an outer light ring of sapwood that rots very easily and is therefore cut away. Investigations by Hollstein (1965) show that the zone of sapwood is, on an average, composed of about 20 tree rings with a standard deviation of the mean value of ±6 years. When there is no sapwood, we must add at least 20±6 years in order to estimate the cutting year of the tree, and when sapwood can be seen, we must add 20±6 years to the last heartwood ring in order to date the cutting year. When there is bark on the sample, the outermost ring is identical with the ring of the year of the cutting of the tree which therefore can be estimated exactly.

The oldest stave with remains of sapwood, no. 242, dates the church to the relative year 375±6. Several other staves, nos. 129, 130, 238, 170 and 122, could have the same cutting year, which experience shows is very often identical with the year the timber was used. If we therefore assume this year to be the year the church was built, it can be dated at the earliest to 1060 A.D. (cf. Blomquist in Blomquist and
Mårtensson, 1963). This would agree with the information we have at present on Hedeby.

Fig. 6 shows further a continuous renovation of the staves, which has surely been one of the reasons why the stave church existed for a relatively short time. There are indications that it was pulled down during the latter half of the 12th century (Blomquist and Mårtensson, 1963). The dendrochronological examinations of the coffins from the cemetery seem to show the same.

Samples from 33 coffins were suitable for dendrochronological treatment. 29 of them could be dated on the relative chronology at the same time extending it, as shown in fig. 7. Often very advanced decay was caused by a burial close to the surface of the earth, and the sapwood was therefore often gone. (There is, however, bark on coffin no. 12!) The oldest coffin dated by means of sapwood, no. 14, is nearly 40 years younger than the supposedly oldest part of the church. The youngest coffin, no. 3, was interred about the time when the church is supposed to have been pulled down. Coffins nos. 51 and 61 belong to a younger cemetery of a stone church.

These results are only tentative as the excavations have not yet been completed, and therefore decisive absolute dating is not yet possible.

Conclusions and final remarks
This report is written as an introduction to the theoretical working method of dendrochronology and to establish the practical usage of this dating method.

Examination of samples from modern oaks in Skåne and Blekinge shows that there are good conditions for using dendrochronology in this area.

It is proposed that the area be covered by one chronology for South-West Skåne and one chronology for North-East Skåne and Blekinge.

Compiling chronologies for Skåne and Blekinge would further be facilitated by the possibility of making control datings on a chronology covering Northern Germany and Southern Denmark.

The dendrochronological method has proved valuable for practical purposes, too. Based on samples from the medieval town of Lund, a floating chronology, covering a period of 518 years, presumably 700–1200 A.D., is constructed. The dating of a stave church and a number of coffins is demonstrated.

Dendrochronological work will be continued in Southern Sweden along the following lines:

1. Utilizing the unique medieval material from the present excavation in Lund in order to construct a strong chronology for the Viking Period as well as for the Middle Ages.
2. Collecting samples from the Late Middle Ages and from more recent times in order to connect the floating and the absolute chronology, as well as making the chronology as long as possible. At present the absolute chronology goes back to 1274 A.D.
3. Enlarging the geographical examination area by investigating samples from modern oaks.

Literature

Forstännen 70
Dendrokrönologisk datering grundad på ek i Skåne och Blekinge, Sydsverige