

TREE-RING RESEARCH IN THE NETHERLANDS

D. ECKSTEIN

Institute for Wood Biology
University of Hamburg

J. A. BRONGERS

State Service for Archaeological Investigations
Amersfoort, the Netherlands

J. BAUCH

Institute for Wood Biology
University of Hamburg

ABSTRACT

Two independent local tree-ring chronologies of oak in the Netherlands are described. Chronology I contains recent wood, wood from mills, and paintings. This chronology begins in A.D. 1973 and goes back to 1385 and is thought to be from inland areas of the Netherlands and the adjacent German area. Chronology II is built up from paintings and sculptures and ranges from A.D. 1623 to 1140; the origin of the wood is presumed to be from a coastal site in the Netherlands.

Es werden zwei voneinander unabhängige Jahrringchronologien für Eichenholz der Niederlande beschrieben. Chronologie I besteht aus rezentem Holz sowie aus Holz von Mühlen und Gemäldetafeln. Sie beginnt 1973 und geht zusammenhängend zurück bis 1385 n. Chr. Das Holz stammt vermutlich aus den östlichen Niederlanden und angrenzenden deutschen Waldgebieten. Chronologie II wurde mit dem Holz von Gemäldetafeln und Skulpturen aufgebaut und reicht von 1623 bis 1140 n. Chr.; die Holzherkunft dürfte mehr im niederländischen Küstengebiet anzusetzen sein.

INTRODUCTION

The idea of dendrochronology in the Netherlands has been evident since the beginning of the 20th century. The Dutchman J.C. Kapteyn (1908) should be counted, with the Russian O. Švedov (1892) and the American A.E. Douglass (1919), among the pioneers of tree-ring research. A long time passed, however, until dendrochronology began to be used systematically in the Netherlands. Hardly any interest in this type of research existed until the dating of oak wood panels of pictures by 17th century Dutch painters was started in 1965 (Bauch 1968; Bauch and Eckstein 1970). It became apparent then and in the subsequent years that this research was a valuable secondary aid to art historians (Bauch, Eckstein, and Meier-Siem 1972; Eckstein and Bauch 1974). Brongers (1973) attempted at about the same time to estimate the geographical range of chronologies of habitats with the aid of recent oak trees from different locations. Munaut (1966) and Munaut and Casparie (1971) studied for an ecological evaluation tree rings of stumps of subfossil (*Atlanticum*) pines from peat bogs.

In the following study a summary of the progress of the dendrochronological activities in the Netherlands is presented.

MATERIAL AND METHODS

Selection of Oak Material

The material used for a Dutch regional chronology consists of 27 slices of up to 294-year-old oak trees from six different habitats as given in Figure 1 and Table 1. In addition, samples obtained with a hollow drill and segments from oak beams were taken from 13 mills; nine could be dated, and their locations are also noted on Figure 1 and Table 1.

Mills have been built in the Netherlands from the end of the 13th century up to the present day. They served several industrial purposes, such as the milling of cereals, ore, paint, mustard or linseed, and rags for paper-making. An important application was the draining of land situated below sea-level. As one mill can only cope with a maximum of 1.50 m level difference, it is imperative that several mills be systematically arranged. The

Table 1. Source of wood included in the master chronologies for the Netherlands.

Dendrochronological objects	Number of dated samples	Site	Artist
Oak trees	10	Amersfoort	
Oak trees	2	Geldrop	
Oak trees	4	Groningen	
Oak trees	4	Haarlem	
Oak trees	1	Helmond	
Oak trees	1	Heeze	
Oak trees	3	Hoog Soeren	
Oak trees	2	Oele/Twivel	
Mills	3	Haaksbergen	
Mills	5	Hellouw	
Mills	4	Kinderdijk	
Mills	5	Lienden	
Mills	11	Malle	
Mills	1	Zeddam	
Mills	4	Zevenhuizen	
Paintings (Chronology I)	31		Dusart, Ph. v.Dyk, Maes, W.v.Mieris, Molenaer, Rembrandt, Rubens, Schelfhout, Sorgh, unknown master, v.d.Werff, Wouwerman, Verschuring
Paintings (Chronology II)	151		v.AIkmaar, Doomer, v.Dyk, Engelbrechtsen, Geertgen, v.Goyen, Hals, v.Heemskerck, de Heusch, Holbein, Jordaens, L.v.Leyden, Memling, Mostaert, Rembrandt, Rubens, Regters, D.Seghers, H.P.Seghers, Tooren- vliet, eight unknown masters, v.d.Werff, de Wouters, Wouwerman
Sculptures	2		unknown Dutch masters
Excavations	60	Dordrecht	
Excavations	171	Dorestad	

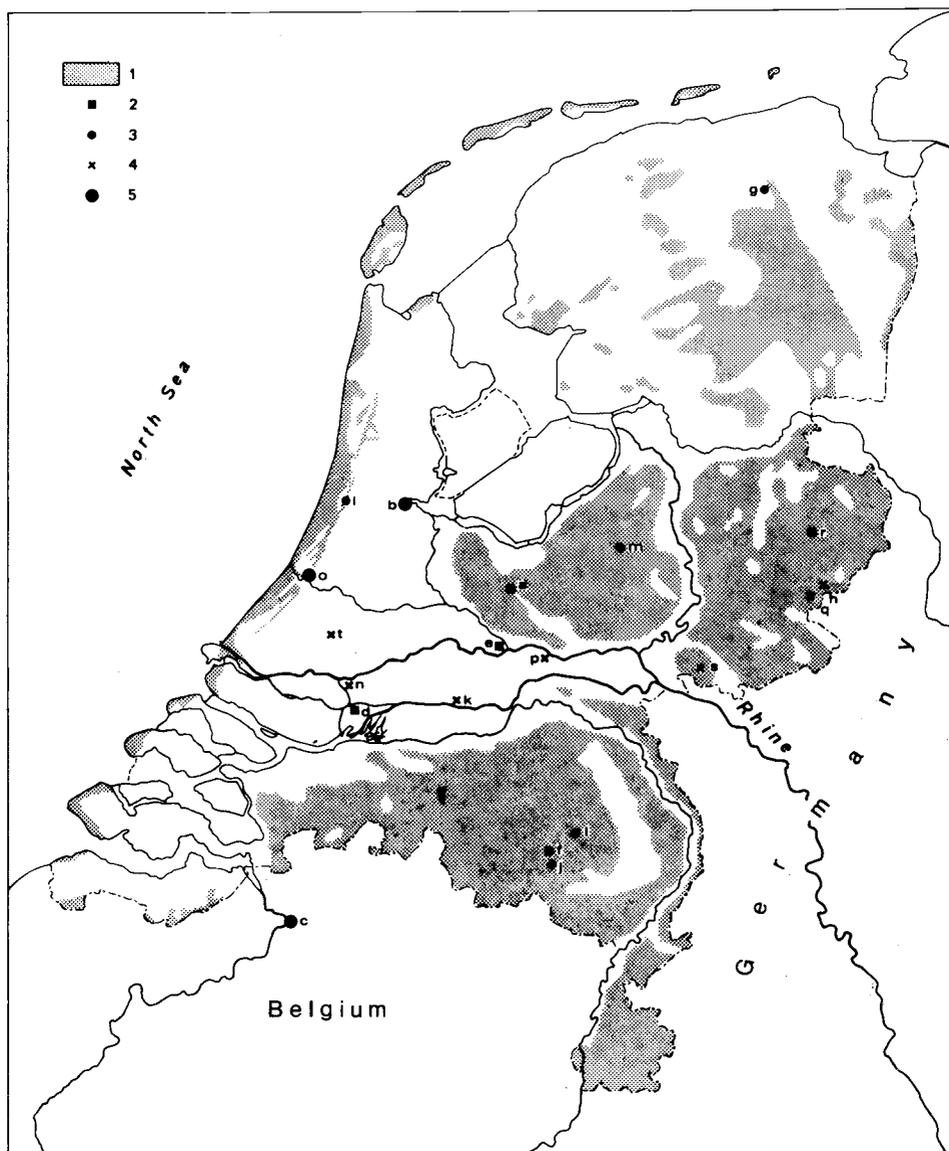


Figure 1. Map of the Netherlands with the sources of recently felled, medieval and post medieval oak timbers: (1) natural habitat of *Quercus* sp.; (2) excavation; (3) recent samples of *Quercus* sp.; (4) mills; (5) working-places of painters. (a) Amersfoort; (b) Amsterdam; (c) Antwerp; (d) Dordrecht; (e) Dorestad; (f) Geldrop; (g) Groningen; (h) Haaksbergen; (i) Haarlem; (j) Heeze; (k) Hellouw; (l) Helmond; (m) Hoog Soeren; (n) Kinderdijk; (o) Leiden; (p) Lienden; (q) Malle; (r) Oele/Twicken; (s) Zeddam; (t) Zevenhuizen (3 mills).

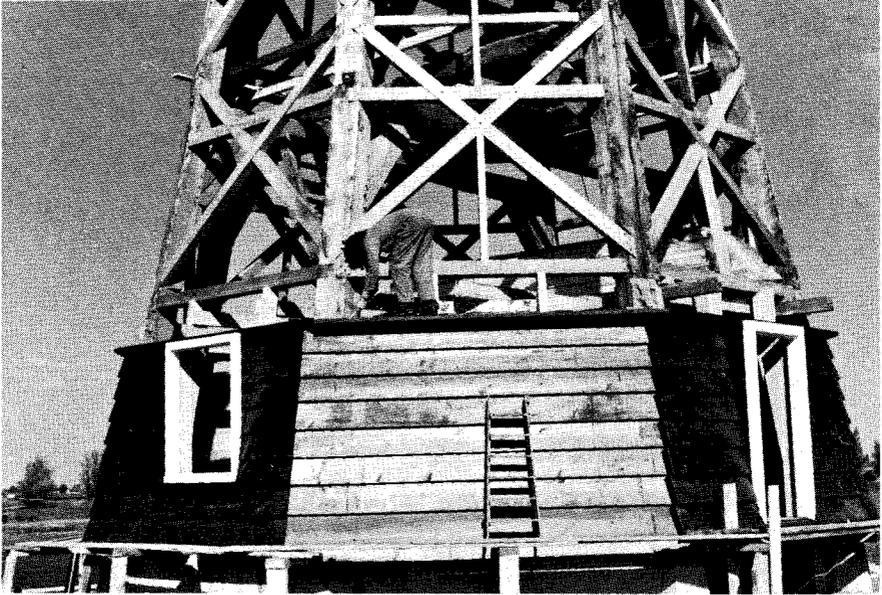


Figure 2. Wood construction of a mill (Photo: De Hollandsche Molen; Soc. of the Preservation of Mills in the Netherlands).

photograph of a windmill shown in Figure 2 provides some insight into a mill's wood construction. The Netherlands still has about 900 mills, of which 40% are in working condition; this is all that remains of a total of 9000 that were in use in and around A.D. 1850.

Another source for the research of oak tree rings was supplied by oil paintings by Dutch masters on oaken panels, a practice which can be traced from the beginning of the panel-painting technique until the end of the 17th century. As carriers of paintings, these panels were mostly radial sections cut from oak trunks and frequently contain more than 200 tree rings; in some exceptional cases more than 300. Figure 3 shows the chronological use of various carriers; it is apparent that only after around A.D. 1650 was oak replaced by other woods, mostly of tropical origin, and particularly by canvas. The paintings by Dutch masters are to be found in museum collections in and outside Europe. The paintings subjected to dendrochronological investigation are listed in Table 1, together with two sculptures carved in oak wood.

The current research included not only the construction wood of the mills and the oaken panels of paintings but also wood finds from two archaeological excavations (Figure 1; Table 1). One group of samples originates from the excavation of the town center of Dordrecht (Figure 4). The wood comes from an extensive construction which obviously prevented soil from being washed away by the river (Sarfatij 1972). The other group derives from the early medieval settlement Dorestad on the lower Rhine; due to unfavourable local conditions for conservation of organic material, the construction material of the wooden wells only was analysed (Eckstein and Van Es 1972).

Dendrochronological Procedure

In addition to the many recent publications (Stokes and Smiley 1968) about dendrochronological principles, much has been written about the different methods based

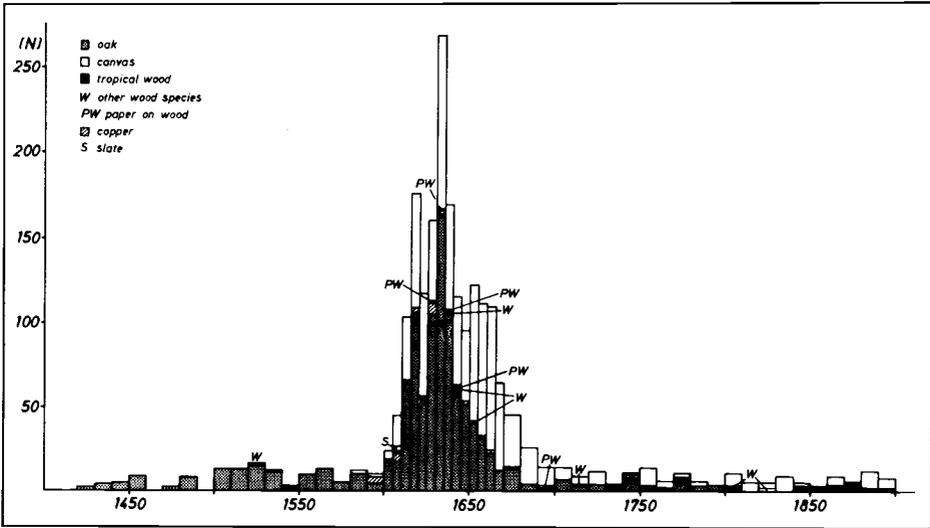


Figure 3. Number of various carriers of paintings out of 2066 paintings by 368 Dutch masters from A.D. 1400 to 1900.



Figure 4. Wood construction in the excavation at Dordrecht (Photo: Rijksdienst voor het Oudheidkundig Bodemonderzoek, Amersfoort).

thereon (Eckstein and Bauch 1969; Ferguson 1970; Kolčín and Bitvinskas 1972; Baillie and Pilcher 1973). The method introduced by Huber (1943) in central Europe was used with several modifications (Eckstein and Bauch 1969) during the investigations described here. Borings and sawn-off slices were used as samples. The tree-ring widths were measured with help of an Addo tree-ring measuring apparatus. This procedure was, of course, impossible in the case of the paintings from which no samples could be taken. They were measured directly in the museum by means of a measuring loupe (Figure 5). The tree-ring curves were drawn on semi-logarithmic graph-paper. They are synchronized on the basis of the *Gleichläufigkeits* coefficient (coefficient of parallel run) with help of a computer program.

THE DEVELOPMENT OF THE MASTER CHRONOLOGIES

Modern and Extended Chronologies

All dendrochronologically investigated material – recent oak, wood from mills, wooden panels from paintings, wooden sculptures, and wood from excavations – are included in a summary diagram (Figure 6). The abscissa is the time axis. The number of tree rings is indicated by horizontal bars, while the number of samples constituting a given bar is represented by the number at its right side, except for the mills for which the timbers are presented individually. The overlapping bars ranging from A.D. 1972-1385 represent a regional tree-ring chronology of 588 years. All included tree-ring series possess a characteristic similar to that in southwest Germany. The chronology of that type is called No. I and it contains in the bar for the panels paintings executed by Wouwerman (1619-1668), Van der Werff (1659-1722), Rembrandt (1606-1669), and others.

Another group embodies a tree-ring curve from A.D. 1325-1036 based on the construction wood of the excavation in Dordrecht. The curve of the Dorestad wood extends from A.D. 817 to A.D. 458, but it is not incorporated in Figure 6. It was not possible to couple the two latter curves to the master curve of the Dutch local chronology ranging from A.D. 1972-1385. The absolute dating was possible, however, with help of the southwest German standard chronology (Hollstein 1965, partly unpublished).

The two dotted bars represent curves derived only from 151 paintings and two sculptures. The tree-ring series range from A.D. 1629-1140 and are independent of the other curves. In the following discussion, they will be considered as one homogeneous group called Chronology II, which contains paintings by Rembrandt, Wouwerman, and others.

The Determination of the Origin of Wood

Three of the recent Dutch curves and some from neighbouring regions (southwest Germany by Hollstein 1965; Weser-Leine upland by Delorme 1973, coastal region of Niedersachsen by Schwab 1975) are compared over 200 years in Table 2. A similar comparison was done for the period A.D. 1650-1450, the Netherlands being represented by the wood of the mills and the wood of paintings (Chronology I). Tendencies in this comparison only will be indicated here. The slight similarity of the two curves from the coastal area (Haarlem and Groningen) of recent trees to the curve of southwest Germany is striking. In contrast, the curves of the Amersfoort oaks, which grow on sandy hills, correspond very well to the southwest German curve. All three recent Dutch chronologies are very similar to that in the coastal area of Niedersachsen, even more similar than



Figure 5. A panel of a Wouwerman painting is investigated for its tree-ring characteristics.

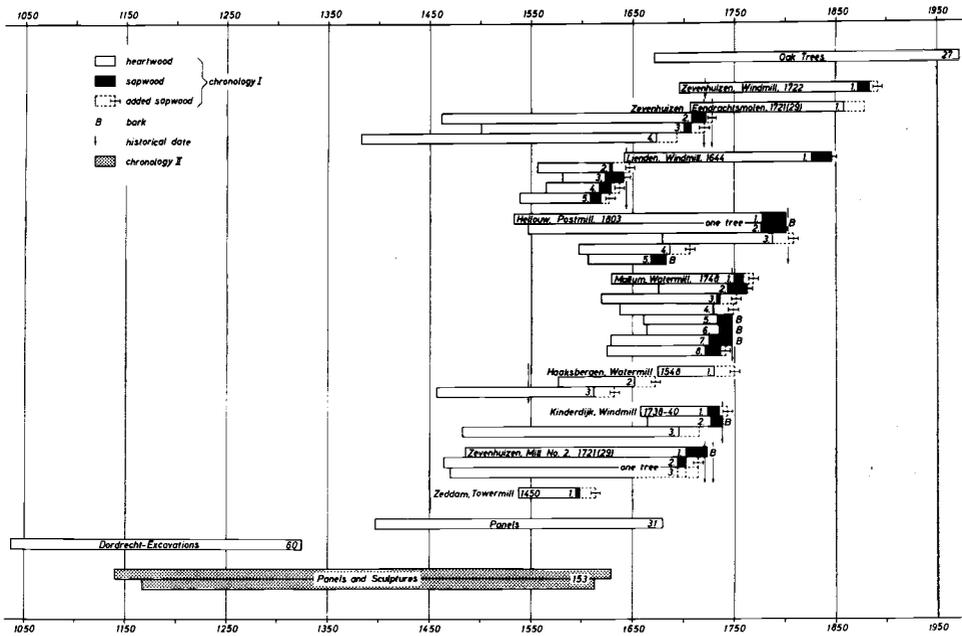


Figure 6. Synchronized tree-ring series of modern oaks, construction timbers of mills and excavations, and wood from panels and sculptures.

compared to the habitats of the Weser-Leine upland. A different picture emerges when the earlier parts of the curves are matched. The similarity of the tree-ring characteristics of the Netherlands and the coastal area of Niedersachsen has decreased, whereas the similarity to the chronologies of the Weser-Leine upland and of southwest Germany has increased.

Table 2. Comparison of different Dutch and German tree-ring chronologies by means of the coefficient of parallel run.

	Groningen	Haarlem	Southwest Germany	Weser-Leine upland	Coastal region Niedersachsen
Amersfoort	64.5	63.5	61.5	60.5	64.5
Groningen		63.5	55.0	62.3	61.8
Haarlem			54.8	60.0	66.3
Mills (Chronology I)			72.0	68.0	59.3
Paintings (Chronology I)			71.0	69.3	56.0
Southwest (1764-1964) Germany (1450-1650)				67.0 72.8	59.8 63.0
Weser-Leine (1764-1964) upland (1450-1650)					62.3 60.0

Apart from the samples dealt with until now, there is one group with curves derived from paintings and sculptures (Chronology II). The differentiation into Amsterdam-Leiden region and Antwerp region represents the working-place of the artist when the painting was made. The curves have no marked similarity to those of the Dutch mills and paintings of Chronology I, or to any of the neighbouring German chronologies. Until now it was possible to attribute 151 paintings of Dutch painters to this particular group. J.M. Fletcher (personal communication) investigated several paintings of English masters showing the same tree-ring characteristic. The latest-known felling year of an oak in this group lies about A.D. 1650. Paintings from later periods were made on oak panels that were related to the oak of Chronology I, on panels of tropical wood, or on canvas. When a painter used oak panels of the type in question (Chronology II) in around A.D. 1700, it turns out to be a secondary use of an oak panel dating from before A.D. 1650. Attempts to find this wood of unknown origin in 17th century or later buildings failed. It turned out also that it was impossible to find pre-1650 oak panels with a Chronology I characteristic.

APPLICATIONS FOR DATING

The Mills

All nine mills, datable with help of dendrochronology, are also well datable with help of archival documents, so there was no primary interest in dating these objects. The main purpose of the sampling was to build up a local tree-ring chronology (Figure 6). In most cases the historical dating was confirmed. It transpired, however, that the original building material was often replaced by new wood used for repairs: for example, the samples from the tower mill of Zeddum (1450), the water mill of Haaksbergen (1548), and the mill of Tweemanspolder (1722) contained no original wood. The historical date of two mills at Zevenhuizen (Eendrachtsmolen and mill no. 2) is ambiguous, it could be 1721 or 1729; dendrochronologically, a date about 1729 must be preferred. In the post mill of Hellouw (1803), one of the balks which bear the millhouse in the upper floor (no. 5) was cut in 1683, and thus had been clearly used for a second time. Samples of four mills contained bark; in three of these cases there is only a difference of zero to two years between cutting date and historical building date. Only in the case of mill no. 2 of Zevenhuizen there is a time lapse of six years if the questionable date 1729 is taken as the

right one. The samples of the water mill at Mallem (1748) are worthy of note: six balks, of which three with bark (nos. 5, 6, 7), support the historical date exactly; two balks (one in the cellar (no. 2) and one roof-balk of the ground floor (no. 1), however, were inserted about 20 years later.

The Paintings

Art-historical questions are the main impetus for dendrochronological investigations of paintings. On the one hand, a differentiation is required between pictures made during the lifetime of a painter and those made after his death. On the other, a seriation is often wanted of the total *oeuvre* of a painter, especially of those paintings which bear no date. Figure 7 gives, for example, the tree-ring chronology of 20 paintings by the Dutch painter Phil Wouwerman; the life and active period of the painter are also included (Bauch, Eckstein, and Brauner 1974). The paintings are listed according to the most probable cutting-year of the tree, as far as this was recognizable in the wood of the panels. When no sapwood was present the earliest possible cutting date was used. Because of the proved close relation between cutting-date and date of the painting, the seriation of the wood-datings approximately reflects the seriation of the *oeuvre*. The paintings represented by dotted bars belong to Chronology II, the others to Chronology I.

Figure 7 presents in a similar way some paintings by the Dutchman A. van der Werff. Despite the lapse of time between cutting and painting, in van der Werff's case an exceptional one of several years, some interesting observations can be made. For example, painting MP 251, dated 1702, and painting MP 263, dated 1705, were cut from the same tree. There exists also a partial copy (MP 14 196) of MP 251 signed: 'A van der Werff 1714'. Dendrochronological investigation established this painting to be on a panel from about 100 years earlier with a tree-ring characteristic like Chronology II; the secondary use of the panel was confirmed afterwards by X-ray photography.

The Sculptures

In contrast to the dating of paintings, the possibilities for the dendrochronological dating of sculptures are limited, as sculptures often have a small diameter and are hollowed out so that too few tree rings are left. As examples of successful attempts may serve the dating of two sculptures which, on art-historical basis, were put 'at the end of the 15th century'. One is shown in Figure 8. They were dendrochronologically dated A.D. 1487 \pm 5 and 1491 \pm 5. In this case also it turned out that the lapse of time between cutting and use was a short one.

The Archaeological Objects

The samples taken during the excavation in the town center of Dordrecht originated from a very large wooden construction in the soil in the neighbourhood of the river. Of about 200 oak samples 60 pieces were datable. Most of them were driven into the soil during the second half of the 13th century and first quarter of the 14th century. The exact dating of the wooden subsoil construction presents an opportunity of arriving at a more precise dating of medieval ceramics found between the different construction phases. There is still a gap of about 60 years between the local Dordrecht curve and the Dutch master curve (A.D. 1272-1385).

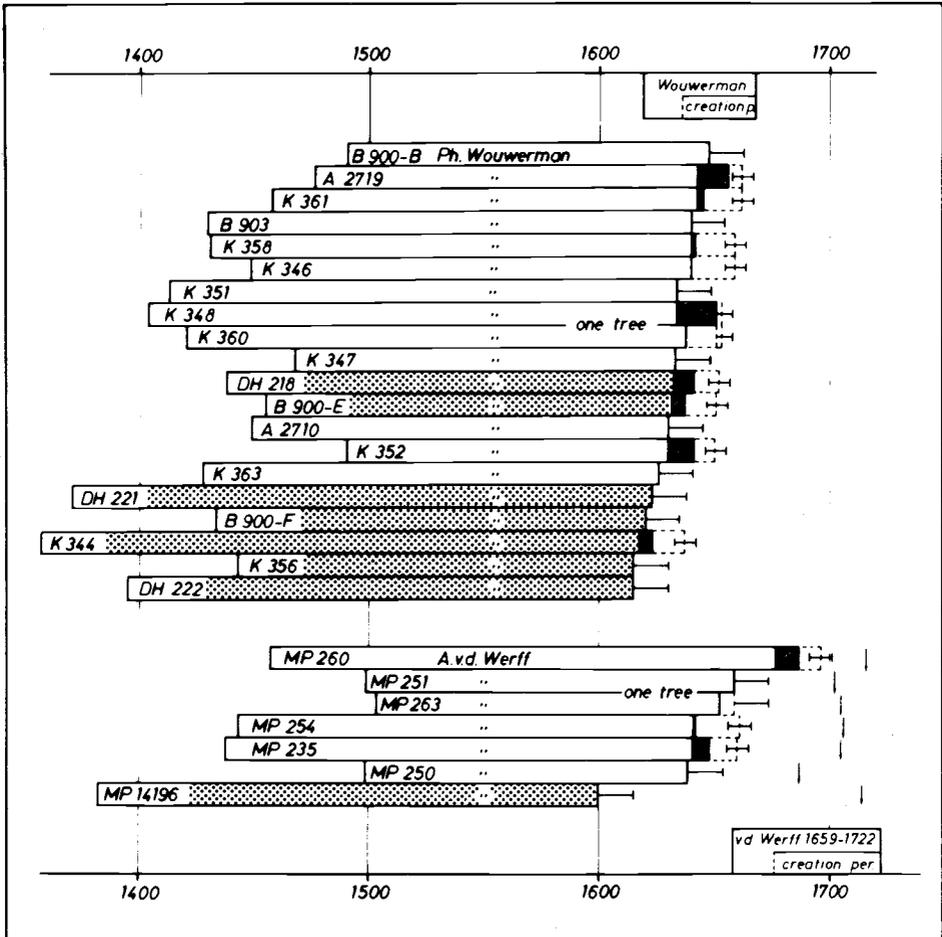


Figure 7. Relative and absolute dendrochronological synchronization of the tree-ring series of 20 panels of Wouwerman and 7 panels of van der Werff. Dotted bars symbolize a tree-ring characteristic of Chronology II, the others belong to Chronology I; an arrow indicates the time signature on a painting.

Apart from the previously mentioned work, there is the investigation into the local chronology of Dorestad. Until now, 16 lined wells have been dated. The oak staves give cutting-dates between A.D. 837 and 691. A problem which arises is whether the wood was used primarily or secondarily. The question concerning the origin of the wood — local or imported from Germany — will be dealt with in a special publication. There is a high probability that the wood was imported from the middle Rhine area (Hollstein, unpublished) and so the results will not assist in the construction of a longer Dutch regional chronology.

CONCLUSIONS

Detailed investigations into oak of different origins in the Netherlands has resulted in the construction of two local chronologies. The one representative for the eastern parts

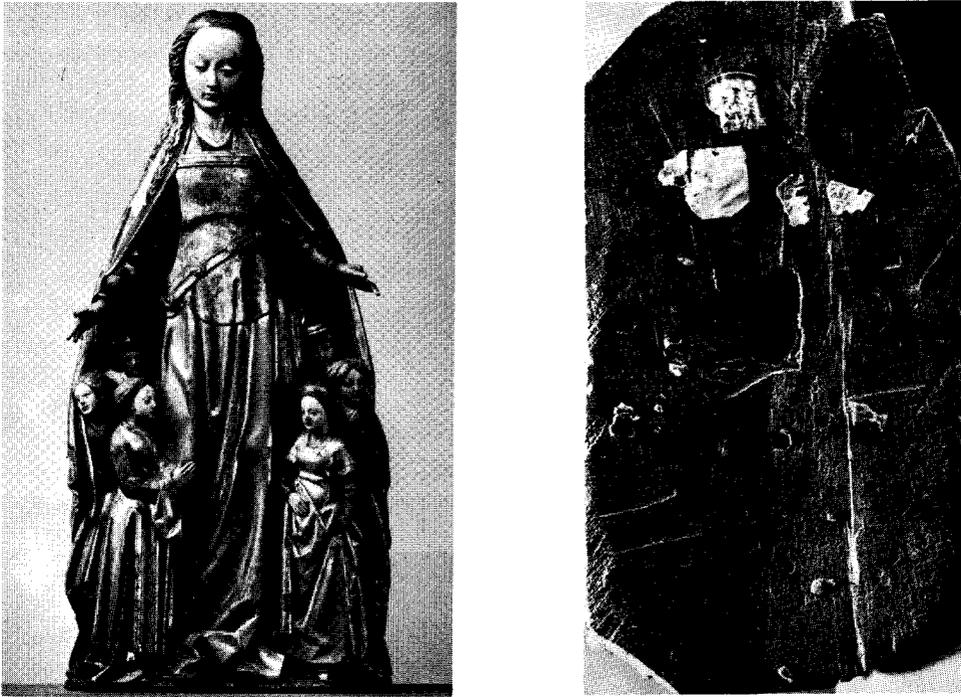


Figure 8. "St. Ursula", 56 cm high, dendrochronologically dated to around A.D. 1490. Left: the total group; right: a view of the foot (Photo: Stiftung Preussischer Kulturbesitz, Staatliche Museen, Skulpturenabteilung, Berlin).

of the country is named Chronology I. This chronology, which extends to A.D. 1385, consists of tree-ring curves from slices of recent oak, from wood used in mills, and from panels of paintings. The exact origin of recent oak is known. The provenance of the wood from mills is difficult to determine as one has to take into consideration the fact that imported wood played a major role in the 18th century. An indication of an increasing shortage of native wood is that many water-pumping mills were mainly constructed from softwoods; the more resistant oak was used only where construction parts were in direct contact with water. However, in the case of well-dated mills there are only zero to two years between felling date and the building year. This indicates shortish transport and presumes an origin of the wood from the eastern higher parts of the Netherlands and the adjacent German area. Nowadays, these regions are still the oak's natural habitat.

Problems concerning the provenance of the wood are more complex in paintings and sculptures. A minor part of the wood of the investigated paintings may be attributed to the region of origin of Chronology I on the strength of the tree-ring characteristic. A striking feature is that wood with this characteristic occurs only after A.D. 1650.

Before A.D. 1650 painters and sculptors used oak with a completely different tree-ring characteristic, which is named Chronology II. The use of wood with this provenance is demonstrable back to A.D. 1450. All attempts to find oak of this characteristic after A.D. 1650 ended in failure. Apparently the habitat with this characteristic was too intensely exploited or perhaps the area was denuded completely for the purposes of building ships. As this tree-ring characteristic occurs also in wood used by

English painters, a coastal habitat on both sides of the North Sea is assumed. The possibility that the wood does not originate from a habitat inside the Netherlands is improbable; continuous importation of wood of the same provenance for over 200 years is hard to imagine. In the future, an extension of Chronology II to modern times will perhaps be possible with help of English paintings.

In the Netherlands two local chronologies for dendrochronological dating purposes are available. As wood imports can never be excluded in the Netherlands, an early deforested country, good use may be made of the chronologies of southwest Germany (Hollstein 1965), the Weser-Leine upland (between Hannover and Kassel in central west Germany; Delorme 1973), and the Niedersachsen North Sea coastal area (Schwab 1975).

ACKNOWLEDGEMENTS

The authors wish to thank Mrs. G. Brauner and Mrs. Ch. Matern, Hamburg, for their assistance in the measuring of tree rings; the society 'De Hollandsche Molen', especially Mr. A.J. de Koning and Mr. C.A. van Hees; Professor W.A. van Es and Mr. H. Sarfatij of the Dutch State Service for Archaeological Investigations. We express our gratefulness to Professor Dr. H. Gerson, University of Groningen, and to the members of the Rembrandt Research Group, Amsterdam, supporting the investigations of paintings. Further, the staff of the following galleries are thanked for their help: Rijksmuseum, Amsterdam; Lakenhal, Leiden; the Mauritshuis and Museum Bredius, The Hague; Herzog-Anton-Ulrich Museum, Braunschweig; Staatliche Museen Preussischer Kulturbesitz, Berlin; Kunsthalle, Hamburg; Hessisches Landesmuseum, Kassel; Alte Pinakothek, München; Hermitage, Leningrad; National Gallery and the Wallace Collection, London; National Gallery, Melbourne; Kunsthistorisches Museum, Vienna.

REFERENCES

- Baillie, M.G.L. and J.R. Pilcher
1973 A simple crossdating program for tree-ring research. *Tree-Ring Bulletin* 33:7-14.
- Bauch, J.
1968 Die Problematik der geographischen Reichweite von Jahrringdatierungen an Beispielen aus der norddeutschen Tiefebene. *Kunstchronik* 21:144-145.
- Bauch, J. and D. Eckstein
1970 Dendrochronological dating of oak panels of Dutch 17th century paintings. *Studies in Conservation* 15:45-50.
- Bauch, J., D. Eckstein, and M. Meier-Siem
1972 Dating the wood of panels by a dendrochronological analysis of the tree-rings. *Nederlands Kunsthistorisch Jaarboek* 23:485-496.
- Bauch, J., D. Eckstein, and G. Brauner
1974 Dendrochronologische Untersuchungen an Gemäldetafeln und Plastiken. *Maltechnik-Restaur* 80:32-40.
- Brongers, J.A.
1973 Dendrochronological investigation of recent oak (*Quercus* sp.) in the Netherlands. *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 23:456-459.
- Delorme, A.
1973 Aufbau einer Eichenjahrringchronologie für das südliche Weser- und Leinebergland. *Forstarchiv* 44:205-209.
- Douglass, A.E.
1919 Climatic cycles and tree-growth, Vol. 1, *Carnegie Institution of Washington Publication* 289.
- Eckstein, D. and J. Bauch
1969 Beitrag zur Rationalisierung eines dendrochronologischen Verfahrens und zur Analyse seiner Aussagesicherheit. *Forstwiss. Centralblatt* 88:230-250.
1974 Dendrochronologie und Kunstgeschichte, dargestellt an Gemälden holländischer und altdeutscher Malerei. *Mitteilungen der Deutschen Dendrologischen Gesellschaft* 67:247-256.

- Eckstein, D. and W.A. van Es
 1972 Dendrochronologische Untersuchungen von Daubenbrunnen aus der frühmittelalterlichen Siedlung Dorestad, Holland. *Kunde* 23:220-226.
- Ferguson, C.W.
 1970 Concepts and techniques of dendrochronology. In *Scientific Methods in Medieval Archaeology*, edited by R. Berger, pp. 183-200. University of California Press, Berkeley and London.
- Hollstein, E.
 1965 Jahrringchronologische Datierung von Eichenhölzern ohne Waldkante. *Bonner Jahrbücher* 165:12-27.
- Huber, B.
 1943 Über die Sicherheit jahrringchronologischer Datierung. *Holz als Roh- und Werkstoff* 6:263-268.
- Kapteyn, J.C.
 1908 Complete authorized text of a lecture. *The Pasadena Star*, 19 December, pp. 11-12.
- Kolčín, B.A. and T.T. Bitvinskás
 1972 Sovremennye problemy dendrochronologii (Contemporary problems of dendrochronology). In "Problemy absolutnogo datirovanija v arheologii", Akademija nauk SSSR, Izdatel' stvo "Nauka", Moskva, pp. 80-92.
- Munaut, A.V.
 1966 Recherches dendrochronologiques sur *Pinus silvestris*, 2. Première application des méthodes dendrochronologiques à l'étude de pins sylvestres subfossiles (Terneuzen, Pays-Bas). *Agricultura* 14:361-389.
- Munaut, A.V. and W.A. Casparie
 1971 Étude dendrochronologique des *Pinus silvestris* L. subfossiles provenant de la tourbière d'Emmen (Drenthe, Pays-Bas). *Rev. Palaeobot. Palynol.* 11:201-226.
- Sarfatiĵ, H.
 1972 Dordrecht; opgravingen in Hollands oudste stad. *Spiegel Historiae* 7:620-627; 659-667.
- Schwab, F.
 1975 Aufbau einer Jahrringchronologie für den niedersächsischen Küstenraum. Dipl.-Arbeit Univ. Hamburg, pp. 59 (unpublished).
- Stokes, M.A. and T.L. Smiley
 1968 *An introduction to tree-ring dating*. University of Chicago Press, Chicago.
- Švedov, O.
 1892 Derevo, kak letopis zasuh (Tree as a chronicle for dry periods). *Meteorologičeskij vestnik* 5:163-178.