

Appendix 5

Dendrochronological investigation

(by Saß-Klaassen & Vernimmen)

Foundation piles of historical buildings

Tree characteristics: tree age and mean tree-ring width

The results are summarised in Table 2D and show that both the age and mean tree-ring width of the trees that were used for foundation piles varies between species and, to lesser extent, origin of the wood. However, due to the small number of samples only tendencies can be described: most of the spruce pile are made from trees between 50 and 60 years old with the exception of two spruce piles from site 2 made from two 114 and 96 year old slow-growing spruce trees with at least one originating from South Germany. The 50 to 60 year old trees show a quite consistent average tree-ring width of about 2 mm.

The sampled pine trees that were used for foundation piles differ much more in both tree age and mean tree-ring width in comparison to spruce. However, inside one sample site the material is quite homogeneous, with young pine trees around 40 years being used in sites 4 and 6 and about 80-year old trees in site 3. In general the pines show smaller annual growth rates in comparison with the spruces, e.g. below 2 mm also in young pines (site 4 and 6).

Dating results

Dendrochronology could be successfully used to determine the felling date and season of the pine and spruce trees that were used as timber for foundation piles in historical buildings (tab. 2D).

For six out of the eight investigated historical building **dating results** were yielded. Even in case of samples with a small number of rings (sites 4 and 6) dating was possible if several samples were available which could be combined into mean tree-ring series. The young pines that were used as piles in sites 4 and 6 could be dated by using two of the newly (for this project) constructed five pine chronologies for the Netherlands (tab. 1D).

| Location | | | Co-ordinates | | Chronology | |
|--------------|----------------|------------|--------------|------|------------|-----------|
| Site | Nearest town | Forest map | North | East | no. trees | Time span |
| Amerongen | Rhenen | - | 52.00 | 5.29 | 15 | 1767-2003 |
| Eerde | Ommen | 10/17F | 52.29 | 6.27 | 20 | 1824-2003 |
| Edese Bos | Ede | 202A | 52.02 | 5.42 | 20 | 1750-2003 |
| Noord Ginkel | | | 52.02 | 5.45 | 12 | 1854-2003 |
| Mattemburgh | Bergen op Zoom | - | 51.27 | 4.19 | 20 | 1846-2001 |

Table D1. Tree-ring chronologies of *Pinus sylvestris* from four locations in the Netherlands (Morales 2004)

Possible reasons why no dendro-dates could be provided for the spruce samples from site 1 could be that the tree-ring series of the samples are heterogeneous, i.e. it was impossible to combine time series of the different samples into one or two site chronologies that could have been used for dating. From site 5 only one spruce samples was available and the fir samples could not combined into a mean time series either. Moreover only cores were available from site 5 whereas most other samples were delivered as complete stem disk. Stem-disk samples (in contrast to cores) enable to measure at least four radii and calculate a representative mean tree-ring series for each sample. In that way it is possible to adjust for intra-tree variability and increase the chance of dendro-dating.

The **felling season** can be determined by looking at the anatomical structure of the last ring. In all cases a complete last tree ring was found, i.e. consisting of earlywood and latewood and thus indicating that cutting has been taken place during a period when the trees were not growing. This is the period from late summer of the year to which the last ring was dated to early spring of the following year.

All dating results are in accordance with the information available on the construction date of the historical buildings. This means that no re-used wood is incorporated in the wooden foundations. The time of transportation and/or storage varies for the different sites from very short, i.e. several months (site 4 and 22) to about one year (site 2 and 6) up to 2 years (site 3) and in case of single stems up to about four years (site 22, td1).

Origin of wood/Dendroprovenancing

If dating is possible it is also possible to get an indication about the origin of the wood. The last column of table 2D indicates the region that is represented by the regional master chronology that yields the best match with the (mean) tree-ring series of the sample(s). Most of the spruce originates from South Germany; two piles are from Sweden. Sites 2 contains piles originating from trees from both Germany and Sweden.

Pine that has been used in foundation piles either originates from Scandinavia or is local material from the Netherlands. At site 4 where young trees provided the wood for the piles pine from Sweden and The Netherlands is combined. Site 6 exclusively contains pine from the Netherlands whereas at sites 3, 4, 22 and 23 contain only pine from Finland (site 3) and Sweden.

Pine from the Netherlands that has been used for foundation piles derives from young, on average 45-year old slow-growing trees.

Archaeological samples

In case of the archaeological material Dendrochronology is mainly used to get an indication about the time when a construction was erected that was later preserved in the soil.

Dating results

The majority of the archaeological samples could be dated by dendrochronology.

Dendrochronological dating worked very well for the oaks samples.

Sites 14, 18, 19 and 24 did not yield any dating results. The main reasons why dating failed are the species (site 18, 19, 24) often in combination with a small number of tree rings on the sample. There are no chronologies for dating *Larix* and only a few pine chronologies for wood older than 200 years. Tree-ring series shorter than 20 years (site 19, 24) are not datable.

Dating precision

Archaeological material often comprises damaged or degraded samples which mostly prevented dating to the year. Only at sites 10, 11 and 17 the felling date of oak could be exactly determined.

Origin of wood/Dendroprovenancing

Dendroprovenancing becomes less reliable the further back in time the material dates. This is due to changing environmental and ecological conditions throughout the centuries in different regions that can not be traced back. However, it is well known that in the Netherlands especially during the Roman time a lot of import of building timber has been taken place (e.g. Buis 1993). From the results of sites 11 and 26 it becomes obvious that timber from Germany was imported for the construction that was erected in the first century AD probably in combination with local oak (site 26: sample S41). Timber import from the Poland/Baltics are found in combination with German or local material at the sites 9, 20 and 21 dating in the 14th and 17th century. The oak used in site 17 proved to be local.

| Sample characteristics | | Measurement results | | | | Dating results and statistics | | | | Felling year and documented building date | | Origin of wood |
|------------------------|---------|------------------------|-----------------|----------------|-----------|-------------------------------|----------------|------|--------|---|-----------|--|
| Sample No. | species | No. rings/ tree age | Mean RW [mm] | STD RW [mm] | Last ring | Growing period | T-test | %PV | p | felling year/season | Built in | Regional chronology used for dating |
| 1a.td.1 | Piab | 50 | 1.95 | 0,72 | EW+LW | no date | - | - | - | - | 1916-1919 | - |
| 1b.td.3 | Piab | 55 | 2.12 | 0,71 | EW+LW | no date | - | - | - | - | | - |
| 1d.td.3 | Piab | 39 | 3.58 | 2,30 | EW+LW | no date | - | - | - | - | | - |
| 1c.td.1 | Piab | 58 | 1.77 | 0,38 | EW+LW | no date | - | - | - | - | | - |
| 2.td.3 | Piab | 55 | 2.31 | 1,28 | EW+LW | 1875-1929 | 3.59 | 63.9 | 0.04 | Late summer 1929 - spring 1930 | 1931 | Sweden, Gotland |
| 2.td.2 | Piab | 65 | 2.05 | 0,68 | EW+LW | 1865-1929 | 6.89 | 86.7 | 0.0001 | Late summer 1929 - spring 1930 | | S.Germany, Wuerttemberg |
| 2.td.8 | Piab | 50 | 2.41 | 0,93 | EW+LW | 1880-1929 | 5.76 | 73.5 | 0.001 | Late summer 1929 - spring 1930 | | S.Germany |
| 2.td.10 | Piab | 60 | 2.13 | 0,93 | EW+LW? | 1869-1928 | 4.78 | 72.0 | 0.001 | Late summer 1928 - spring 1929? | | S.Germany |
| 2.td.11 | Piab | 114 | 1.08 | 0,45 | EW+LW | 1816-1928 | 3.27 | 63.4 | 0.005 | Late summer 1929 - spring 1930 | | S.Germany |
| 2.td.1 | Piab | 55 | 2.23 | 0,83 | EW+LW | 1875-1929 | 2.79 | 63.9 | 0.04 | Late summer 1929 - spring 1930 | | Sweden, Gotland |
| 2.td.4 | Piab | 58 | 2,11 | 0,90 | EW+LW | 1872-1929 | 4.90 | 66.7 | 0.02 | Late summer 1929 - spring 1930 | | S.Germany |
| 2.td.5 | Pisy | 136 | 0.81 | 0,34 | EW+LW | no date | - | - | - | - | | - |
| 2.td.6 | Piab | 50 | 2.32 | 1,06 | EW+LW | 1880-1929 | 3.50 | 65.3 | 0.04 | Late summer 1929 - spring 1930 | | S.Germany, Francia |
| 2.td.7 | Piab | 96 | 1.25 | 0,68 | EW+LW | no date | - | - | - | - | | - |
| 2.td.9 | Piab | 62 | 1.84 | 1,00 | EW+LW | 1868-1928 | 4.40 | 74.2 | 0.0002 | Late summer 1929 - spring 1930 | | S.Germany, Francia |
| 2.td.12 | Piab | 69 | 1.91 | 0,65 | EW+LW | no date | - | - | - | - | | - |
| 3.te.1.1 | Pisy | 82 | 1.40 | 1,18 | EW+LW | 1842-1923 | via Mc 1.1+2.1 | | | Late summer 1923 – spring 1924 | 1926 | S.Finland |
| 3.te.2.1 | Pisy | 70 | 1.66 | 0,72 | EW+LW | 1854-1923 | via Mc 1.1+2.1 | | | Late summer 1923 – spring 1924 | | S.Finland |
| Mc 1.1+2.1 | Pisy | 82 | 1.71 | 1,06 | EW+LW | 1842-1923 | 4,43 | 62,8 | 0,001 | | | S.Finland |
| 3.te.3.1 | Piab | 60 | 1.82 | 0,92 | EW+LW | 1864-1923 | via MC 3.1+4.1 | | | Late summer 1923 – spring 1924 | | S.Germany |
| 3.te.4.1 | Piab | 46 | 2.15 | 0,78 | EW+LW | 1878-1923 | via MC 3.1+4.1 | | | Late summer 1923 – spring 1924 | | S.Germany |
| Mc 3.1+4.1 | Piab | 60 | 2.09 | 0,84 | EW+LW | 1864-1923 | 5,36 | 71,9 | 0,001 | Late summer 1923 – spring 1924 | | S.Germany |
| 4.td.1 | Pisy | 41 | 1.90 | 0,96 | EW+LW | 1864-1904 | via Mc 1+2+4 | | | Late summer 1904 – spring 1905 | 1904 | Sweden, Gotland |
| 4.td.2 | Pisy | 39 | 1.81 | 0,73 | EW+LW | 1866-1904 | via Mc 1+2+4 | | | Late summer 1904 – spring 1905 | | Sweden, Gotland |
| 4.td.3 | Pisy | 34 | 1.81 | 0,60 | EW+LW | no date | - | - | - | - | | - |
| 4.td.4 | Pisy | 41 | 1.61 | 0,87 | EW+LW | 1864-1904 | via Mc 1+2+4 | | | - | | Sweden, Gotland |
| MC 1+2+4 | Pisy | 41 | 1.79 | 0,77 | EW+LW | 1864-1904 | 4,28 | 76,3 | 0,001 | Late summer 1904 – spring 1905 | | Sweden, Gotland |
| 4.te.5 | Pisy | 46 | | | EW+LW | 1852-1897 | Via Mc 5+6+7 | | | Late summer 1894 – spring 1895 | 1895 | E.Netherlands (Ede) |
| 4.te.6 | Pisy | 44 | 1.52 | 1,22 | EW+LW | 1851-1894 | Via Mc 5+6+7 | | | Late summer 1894 – spring 1895 | | E.Netherlands (Ede) |
| 4.te.7 | Pisy | 43 | 1.59 | 1,00 | EW+LW | 1852-1894 | Via Mc 5+6+7 | | | Late summer 1894 – spring 1895 | | E.Netherlands (Ede) |
| MC 5+6+7 | Pisy | 47 | 1.56 | 0,85 | EW+LW | 1851-1897 | 6,23 | 80,4 | 0,0001 | Late summer 1894 – spring 1895 | | E.Netherlands (Ede) |
| 5.te.2 | Abal | 53 | 2.5 | 1,09 | EW+LW | no date | - | - | - | - | 1901-1905 | - |
| 5.te.3 | Piab | 51 | 2.56 | 1,24 | EW+LW | no date | - | - | - | - | | - |
| 5.te.1 | Abal | 98 | 1.29 | 0,86 | EW+LW | no date | - | - | - | - | | - |
| 6.te.3 | Pisy | 42 | 1.25 | 0,77 | EW+LW | 1894-1935 | via Mc 1+2+3 | | | Late summer 1935 – spring 1936 | 1937 | E-Netherlands (Noordginkel) |
| 6.te.1 | Pisy | 45 | 1.18 | 0,39 | EW+LW | 1891-1935 | via Mc 1+2+3 | | | Late summer 1935 – spring 1936 | | E-Netherlands (Noordginkel) |

| Sample characteristics | | Measurement results | | | | Dating results and statistics | | | | Felling year and documented building date | | Origin of wood |
|------------------------|---------|------------------------|-----------------|----------------|-----------|-------------------------------|--------------|------|--------|---|-----------|-------------------------------------|
| Sample No. | species | No. rings/ tree age | Mean RW [mm] | STD RW [mm] | Last ring | Growing period | T-test | %PV | p | felling year/season | Built in | Regional chronology used for dating |
| 6.te.2 | Pisy | 38 | 1.43 | 0,42 | EW+LW | 1898-1935 | via Mc 1+2+3 | | | Late summer 1935 – spring 1936 | | E-Netherlands (Noordginkel) |
| MC 1+2+3 | Pisy | 45 | 1.28 | 0,46 | EW+LW | 1891-1935 | 4,86 | 68,2 | 0.001 | Late summer 1935 – spring 1936 | | E-Netherlands (Noordginkel) |
| 22.td.2 | Pisy | 145 | 0.77 | 0,50 | EW+LW | 1750-1894 | 5.84 | 68.1 | 0.0001 | Late summer 1894 – spring 1895 | 1895-1905 | S-Sweden |
| 22.td.1 | Pisy | 147 | 0.91 | 0,71 | EW+LW | 1748-1890 | 8.89 | 77.1 | 0.0001 | Late summer 1890 – spring 1891 | | S-Sweden |
| 23.td.1 | Pisy | 53 | 2.33 | 0,80 | EW+LW | 1849-1901 | 5.89 | 72.1 | 0.005 | Late summer 1901 – spring 1902 | ca. 1900 | S-Sweden |
| 23.td.1 | Pisy | 52 | 2.23 | 0,78 | EW+LW | 1850-1901 | 5.81 | 69.6 | 0.005 | Late summer 1901 – spring 1902 | | S-Sweden |

Table 2D. Dating results for foundation piles of historical buildings (softwoods); results are given for sample disk closest to stem base/soil surface

Sample no.=Bacpoles sample number, Mc= mean curve; **Species:** Piab=*Picea abies*, Pisy=*Pinus sylvestris*; **No.rings=tree age:** number of measured tree rings also indicating tree age in upper pile samples; **Mean RW**=Mean ring width; **STD RW**=Standard deviation ring width; **Last ring**=characteristics of last formed tree ring under the bark, EW=earlywood, LW=latewood, EW+LW=complete ring; **Growing period**=time span of tree-ring series equals growing period of the tree, no date=tree-ring series not datable; **t-test**= The t-value resulting from a “students t-test” on the cross correlation between the measured ring-width pattern and the reference chronology at the “best match” position; **%PV**= “Gleichläufigkeit” (German) or Percentage of Parallel Variation; the percentage of rings in the measured annual ring pattern, which show identical increase and decrease in annual ring width at the position in the reference chronology which was found by dating the pattern. The significance of this percentage is a function of the length in years of the measured annual ring pattern and the reference chronology; **p**= The possibility (expressed as a fraction of 1) that the found value of %PV is just accidental; **felling year/season**=time span when the tree was felled, in case of complete tree ring (=EW+LW): after growing period (late summer) of year to which last tree ring is dated to beginning of growing season (spring) of following year; **Built in**=documented year when the building was constructed; **Region represented by chronology used for dating**=country, region or area that is represented by the regional chronology that yielded the best match with the tree-ring series and thus indicates the origin of wood.

| Sample characteristics | | | Measurement results | | | | | | Dating results and statistics | | | | | Origin of wood |
|------------------------|---------|---------------------|---------------------|--------------------|------------------------|------------------------|-----------------------|-----------|-------------------------------|---------------|---------------|--------|--|--|
| Sample No. | species | find no./element no | No. rings | No. sap-wood rings | Miss. rings until bark | Miss. rings until pith | Estim. Tree age [yrs] | Last ring | Growing period | T-test | %PV | p | Estim. felling year/season | Region represented by chronology used for dating |
| 8.td.1 | Qusp | 5 | 61 | 17-18 | 1 or more | 0 | >62 | - | 1402-1467 | 6.17 | 62,3 | 0.05 | 1468 AD or later | via MC timberNL |
| 8.td.4 | Qusp | 6 | 28 | 6? | Ca. 14 | 0 | 42 | - | no date | - | - | - | - | - |
| 8.td.7 | Qusp | 7 | 69 | 16-22 | ? | 0 | >69 | - | 1390-1458 | - | - | - | after 1458 AD | via MC 1+3 |
| 8.td.5 | Qusp | 2 | 76 | 36? | Ca. 1 | ? | >77 | EW+LW | 1404-1479 | 5.52 | 78.0 | 0.0001 | 1480 AD or later | C.-S.Germany |
| 8.td.2 | Qusp | 1 | 23 | 8 | Ca. 1 | 0 | 24 | - | no date | - | - | - | - | - |
| Mc 1+7 | Qusp | 5+7 | 78 | | 1 or more | | | - | 1390-1467 | 6.11 | 67,5 | 0.0005 | 1468 AD or later | Netherlands+NW.Germany |
| 9.td.5 | Qusp | 10 | 196 | - | >15+9/-6 >26 ±8 | ? | >207 >214 | - | 1180-1375 | 5.74/ 5.34 | 63.8/ 64.9 | 0.0001 | after 1390 AD +9/-6/ after 1401 AD ±8 | C.Poland/ Netherlands+ NW.Germany |
| 9.td.4 | Qusp | 9 | 100 | Border | >20±6 | ? | >118 | - | no date | - | - | - | - | - |
| 9.td.3 | Qusp | 8 | 77 | 4? | 11+9/-6 | ? | >82 | - | 1292-1368 | 6.13 | 61.8 | 0.04 | 1379 AD +9/-6 | Poland-E.Pommerania |
| 9.td.6 | Qusp | 6 | 221 | - | >15+9/6 | ? | >230 | - | 1128-1348 | 8.49 | 71.1 | 0.0001 | after1363 AD+9/-6 | Poland/Baltics |
| 9.td.1 | Qusp | 5 | 143 | 6 | 14±6 | ? | >155 | - | 1256-1398 | 5.53 | 61.3 | 0.01 | 1412 AD ±8 | C.-W.Germany |
| 10.td.1 | Qusp | 520 (S112) | 66 | 13 | 0 | 0 | 66 | EW | 34-100 | 4.7 | 68.5 | 0.005 | Spring/early summer 100 AD | C.Netherlands, wet sites |
| 10.td.2 | Qusp | 521 (S134) | 75 | 18 | 0 | 0 | 75 | EW | 22-97 | 4.1 | 72.3 | 0.0002 | Spring/early summer 97 AD | via MC Roman way/ Vleuten de Meern |
| 11.td.? | Qusp | V116 | 65 | 13 | 0 | ? | >65 | EW | 35-100 | 4.5 | 63.3 | 0.04 | Spring/early summer 100 AD | via MC Roman way/ Vleuten de Meern |
| 11.td.? | Uisp | V115 | 92 | ? | 0 | ? | >92 | EW+LW | 7-99 | 4.85 | 62.6 | 0.02 | Late summer 99 – spring 100 AD | C.W.Germany |
| 12.ta.1.3 | Qusp | | 106 | - | >20 ±6 | ? | >120 | - | 1503-1608 | 5.8 | 68.0 | 0.0002 | after 1628 AD ±6 | Netherlands+ NW. Germany |
| 12.ta.2.2 | Pisy | | 114 | ? | ? | Max 10 | >124 | - | 1513-1626 | 6.4 | 66.0 | 0.0005 | after 1626 AD | S.Norway/ Flesberg |
| 13.ta.1 | Pisy | | 73 | - | ? | ? | >73 | - | no date | - | - | - | - | - |
| 13.ta.@ | Qusp | 352 | 111 | - | >20 ±6 | 2 | >123 | - | 1370-1480 | 8.1 | 66.6 | 0.0001 | after 1500 AD ±6 | C.S.Germany |
| 13.ta.@ | Qusp | 207 | 63 | 4 | 12 ±5 | 8 | Ca. 77 | - | 1566-1628 | 6.0 | 75.8 | 0.0001 | 1640 AD ±5 | NW.Germany, Lower Saxony |
| 14.ta.1 | Qusp | P27 | 32 | 5 | 0 | 0 | Ca.38 | EW+LW | no date | - | - | - | - | - |
| 14.ta.3 | Qusp | P17 | 72 | 11/12 | 0 | 0 | 72 | EW | no date | - | - | - | - | - |
| 14.ta.2 | Qusp | P25 | 36 | 6 | 0 | 0 | 36 | EW+LW | no date | - | - | - | - | - |
| 14.ta.@ | Qusp | Probe A | 72 | 10 | 0 | 0 | 72 | EW+LW | no date | - | - | - | - | - |
| 17.ta.1 | Qusp | | 71 | ? | 0 | ca.1 | 72 | EW | 1136-1065 BC | 6.38 | n.a. | n.a. | Spring 1065 BC | S.England/S.Wales |
| 17.ta.2 | Qusp | | 43 | - | >16 ±5 | ca.1 | Ca. 55 | - | 1123-1081 BC | 5.26 | n.a. | n.a. | after 1065 BC ±5 | S.England/S.Wales |
| 18.td.4 | Qusp | | 55 | 15? | 0 | 0 | 55 | EW+LW | no date | - | - | - | - | - |
| 18.tc.1 | Lade | | 52 | ? | 0 | ? | >52 | EW+LW | no date | - | - | - | - | - |
| 18.tc.2 | Lade | | 43 | ? | ? | Max 5 | >48 | - | no date | - | - | - | - | - |
| 18.tc.3 | Lade | | 49 | ? | ? | 0 | >49 | - | no date | - | - | - | - | - |
| 19.td.4 | Pisy | | 12 | ? | 1 | 0 | 13 | EW? | no date | - | - | - | - | - |

| Sample characteristics | | | Measurement results | | | | | | Dating results and statistics | | | | | Origin of wood |
|------------------------|---------|----------------------|---------------------|-------------------|------------------------|------------------------|-----------------------|-----------|-------------------------------|---------------|---------------|------------------|---|--|
| Sample No. | species | find no./ element no | No. rings | No. sapwood rings | Miss. rings until bark | Miss. rings until pith | Estim. Tree age [yrs] | Last ring | Growing period | T-test | %PV | p | Estim. felling year/ season | Region represented by chronology used for dating |
| 19.tc.1 | Pisy | | 21 | ? | 1 | 0 | 22 | EW | no date | - | - | - | - | - |
| 19.tc.2 | Pisy | | 13 | ? | 1 | ? | >14 | EW? | no date | - | - | - | - | - |
| 19.tc.3 | Pisy | | 22 | ? | 1 | ? | >23 | EW? | no date | - | - | - | - | - |
| 20.td.3 | Qusp | (bottom) | 128 | - | >15+9/-6 >20 ±6 | ? | >137-142 | - | 1487-1614 | 7.53/ 6.04 | 68.5/ 65.4 | 0.0001 0.001 | after 1629 AD +9/-6 after 1634 AD ±6 | Poland, Wollin Germany, Friesland |
| 20.td.2 | Qusp | (lid) | 113 | - | >20 ±6 | ? | >127 | - | no date | - | - | - | - | - |
| 20.td.1 | Qusp | (stave) | 123 | - | >20 ±6 | ? | >137 | - | no date | - | - | - | - | - |
| 20.td.1 | Qusp | (stave) | 112 | - | >20 ±6 | ? | >126 | - | no date | - | - | - | - | - |
| 21.ta.3 | Qusp | | 294 | 13 | 13 ±8/ 2 +9/-6 | ? | >290-299 | - | 1085-1378 | 8.50/ 7.95 | 61.1/ 65.5 | 0.0002 0.0001 | 1391 AD ±8/ 1380 AD +9/-6 | Netherlands+NW.Germany/ C.Poland |
| 21.ta.2 | Qusp | | 137 | 10? | 5 +9/-6 | ? | >136 | - | 1248-1384 | 5.16 | 63.2 | 0.005 | 1389 AD +9/-6 | C.Poland |
| 24.ta.1 | Pisy | | 29 | ? | 1 | 1 | 32 | EW | no date | - | - | - | - | - |
| 24.ta.3 | Pisy | | 155 | ? | 0 | ca.10 | 65 | EW+LW | no date | - | - | - | - | - |
| 24.ta.2 | Pisy | | 22 | ? | 0 | 0 | 22 | EW? | no date | - | - | - | - | - |
| 25.ta.1 | Qusp | | 72 | Border? | 16 ±5 | 1 | >87 | - | no date | - | - | - | - | - |
| 26.td.? | Qusp | S46 | 100 | Border? | 20 ±6 | 3 | >117 | - | 14BC-86AD | 8.04 | 69.7 | 0.0002 | 106 AD ±6 | C.W.Germany |
| 26.td.? | Qusp | S48 | 46 | - | >16 ±5 | 2 | >59 | - | 49BC-4BC | 4.56 | 66.7 | 0.025 | after 12 AD ±6 | C.S.Germany |
| 26.td.? | Qusp | S47 | 64 | - | >16 ±5 | Max 5 | >80 | - | 58BC-6AD | 8.38 | 73.8 | 0.0002 | after 22 AD ±6 | C.W.Germany |
| 26.td.? | Qusp | S43 | 121 | - | >20 ±6 | Ca. 3 | >138 | - | 37BC-84AD | 7.68 | 72.5 | 0.0001 | after 104 AD ±6 | C.W.Germany |
| 26.td.? | Qusp | S32 | 107 | - | >20 ±6 | 2 | >123 | - | 45BC-62AD | 5.17 | 65.6 | 0.0001 | after 82 AD ±6 | C.W.Germany |
| 26.td.? | Qusp | S41 | 80 | - | >20±6 | ca.3 | >97 | - | 47BC-33AD | 5.41 | 70.9 | 0.0002 | after 53 AD +/-6 | Netherlands+NW.Germany |
| 27.ta.1 | Qusp | | 41 | - | >16 ±5 | ca.3 | >55 | - | no date | - | - | - | - | - |
| 27.ta.2 | Qusp | | 70 | - | >16 ±5 | ca.3 | >84 | - | 1456-1525 | 5.34 | 69.6 | 0.005 | after 1541 AD ±5 | NW.Germany, coastal area |
| 27.ta.3 | Qusp | | 118 | 4 | 16 ±5 | Max 5 | >134 | - | 1416-1533 | 6.72 | 72.6 | 0.0001 | 1549 AD ±6 | NW.Germany, Westfalen |
| 27.ta.4 | Qusp | | 55 | - | >16 ±5 | ca.2 | >68 | - | no date | - | - | - | - | - |
| 28.ta.1 | Qusp | | 66 | - | >16 ±5 | Max 10 | >87 | - | 1503 | 6.44 | 73.6 | 0,0002 | after 1519 AD +/-5 | via MC timber NL |
| 28.ta.2 | Qusp | | 20 | 3 | 0 | ca.2 | >22 | - | no date | - | - | - | - | - |

Tab. 3D. Dating results for archaeological samples

Sample no.=Bacpoles sample number, Mc= mean curve; **Species:** Qusp=*Quercus spec.*, Ulsp=*Ulmus spec.*, Pisy=*Pinus sylvestris*, Lade=*Larix decidua*; **Find no./ element no:** sample information for archaeologists; **No.rings**= number of measured tree rings; **No. sapwood rings**= number of (remaining) sapwood rings on sample, *border* indicates sapwood/heartwood transition zone meaning that heartwood is complete; **Miss. Rings until bark**= estimated missing tree rings until bark: estim. by using diff. statistics for calculating missing sapwood rings: for C.W.Germany (trees<100 yrs: 20 ±6 yrs, trees>100: 16 ±5) and for Central Poland (15+9/-6), remaining sapwoods (see previous column) are taken into account; **Miss. Rings until pith**=estimated missing tree rings until pith; **Estim. tree age**=number of measured tree rings+number of (at least) missing tree rings until bark (calculated from sapwood statistics)+number of est. miss. rings until pith; **Last ring**=characteristics of last formed tree ring under the bark, EW=earlywood, LW=latewood, EW+LW=complete ring; **Growing period**= time span covered by tree-ring series, no date=tree-ring series not datable; **t-test**= The t-value resulting from a "students t-test" on the cross correlation between tree-ring series of the sample and the reference chronology at the "best match" position; **%PV**= "Gleichläufigkeit" (German) or

Percentage of Parallel Variation; **p**= The possibility (expressed as a fraction of 1) that the found value of %PV is just accidental; **Estim. felling year/season**=estimated felling year: calculated from last year of *growing period + missing rings until bark (column 6)*, felling season: in case of complete tree ring (=EW+LW): after growing period (late summer) of year to which last tree ring is dated to beginning of growing season (spring) of following year; in case of only earlywood present (EW): in spring of year to which last ring is dated; **Region represented by chronology used for dating** =country, region or area that is represented by the regional chronology that yielded the best match with the tree-ring series and thus indicates the origin of wood. In some cases no indication for a region could be given because the chronology that yield the best dating result is not clearly connected to a certain region in Europe, i.e *MC timber NL*=mean curve of timber found in the eastern part of the Central and Northern Netherlands and *MC Roman way/Vleuten de Meern*=mean curve from Roman Way in Vleuten de Meern.

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