TREE-RING ANALYSIS OF THE ODELL OAK TIMBERS

by Jennifer Hillam, Sheffield University,

April 1980.

Tree-ring dating in England is confined almost exclusively to the analysis of oak timbers. Oak (Quercus sp.) is ideal for dendrochronology as it has distinct annual rings which can be easily measured under a low-power microscope. In addition, it was commonly used as a building timber because of its hardness and durability, and hence it occurs abundantly in waterlogged archaeological sites or in standing buildings. This has made it possible to construct many oak tree-ring chronologies throughout Europe by synchronising the patterns of wide and narrow rings from successively older and older wood samples; these chronologies are then used to date oak timbers of unknown age. In England, no other species occur in archaeological sites with such frequency, making the construction of reference curves so far impossible for species other than oak. Thus, although various species of timber and brushwood were found at Odell, only the oak timbers were examined dendrochronologically.

THE TIMBER

Apart from three samples from two adjacent pits associated with the later Iron Age and early Roman farms, all the timbers came from five Saxon wells. Most of the samples were roughly-hewn planks which had been radially split

(Table 1). The average widths of their annual rings varied from very narrow, eg Lii 35, to wide, eg Lii 45, suggesting that the trees grew under dissimilar conditions, perhaps in different woodlands. It is most likely that they were subject to varying degrees of crowding from other trees.

Preliminary examination of the samples appeared to indicate that the majority would be unsuitable for dendrochronological work, since they contained only a few tree-rings. However, the most substantial were selected and taken to the DoE dendrochronology laboratory in Sheffield. Although Lii 45 and Lii 52 had to be rejected as they had less than 35 rings, the remainder were measured and produced useful results.

METHOD

The samples were deep-frozen to give a firmer cross-sectional surface on which to work. They were cleaned with a surform plane, whilst still frozen; this produced a smooth section in which the individual rings were clearly visible. The wood was allowed to thaw slightly before it was measured. The apparatus used for this process consists of a binocular microscope over a travelling stage, on which the sample is placed; the latter is linked, by a transducer, to a display panel which shows the ring widths in 0.1mm. The widths are represented as a tree-ring curve by plotting the widths against time, in years, on transparent semi-logarithmic recorder paper. The curves can be compared visually by sliding one graph over another until the position of best fit is found. In addition, a computer program can be used to compare two tree-ring curves. It compares two sets of data and calculates the value of Student's t at each position of overlap between the two curves (Baillie & Pilcher, 1973). Values of 3.5 are statistically significant at the $P < 0.001$ level, whilst a t-value of, for example, 6.5 would be highly significant and would almost certainly indicate crossmatching. Thus, use of the computer saves much time and gives a measure of the quality of the similarity between two curves, but it is not infallible and results must always be checked visually before a match is accepted (Hillam, 1979).

The crossmatching of a curve with a dated reference chronology gives the calender date of the sample's outer ring. This is not always equivalent to either the felling date of the timber or the construction date of the building or structure. If bark is present, the latter is true and it is possible to determine from the amount of growth in the outer ring whether a tree was felled in summer or winter. In the absence of bark, the sample may retain some sapwood rings, ie the outer part of the tree which is distinguishable from the heartwood by its colour. The felling date can then be calculated since the number of sapwood rings in an oak tree is relatively constant. When the timber consists only of heartwood, an estimate of the terminus post quem is all that can be deduced for the felling date. As it was rare that much heartwood was removed during the conversion of the timber, this estimate is still reasonably accurate: much more so than radiocarbon dating.

The relationship between felling date and construction date is not always simple. Usually timber was felled as required and used almost immediately; it was only seasoned if the wood was needed for furniture or panelling (Hollstein, 1965). Without seasoning, the felling date and construction date are the same. However, timber was often re-used which would make the tree-ring date earlier than the actual construction date. This may be particularly true for timber which lines or supports the sides of wells, or for timber which is thrown down to form a firmer approach to a well. These problems must be taken into account during the interpretation of any tree-ring date.

RESULTS

1. Late Iron Age/early Roman timbers

Three samples were examined from this period. Lii 43 and Lii44 were sections of two large timbers which formed a platform for access to well F824. Lii 48 came from well F836; this was a later feature than F824, through which it partially cuts. F824 and F836 had radiocarbon dates of 70±90 bc and ad 20±100 respectively.

When the tree-ring curves from the three timbers were compared together, the sequences from Lii 43 and Lii 44 appeared to be very similar, suggesting that the timbers came from the same tree. A *t*-value of 10.43 between them supports this view. There was no crossmatching between Lii 43/44 and Lii 48, nor could the Odell curves be crossdated with other reference chronologies from that period. Since Lii 43/44 and Lii 48 have only 87 and 62 rings respectively (Table 1), these sequences will probably never produce tree-ring dates. The fact that there is no matching between Lii 43/44 and Lii 48 is not surprising as F824 is known to be earlier than F836.

All the samples contained sapwood. The bark edge was present on Lii 43 and the amount of growth in the outer ring indicated that the tree was felled in winter. This deduction was made because the outer ring was complete, ie felling had taken place after the annual growth had stopped in autumn. When a tree is cut down in summer, the outer ring is incomplete. The tree from which timbers Lii 43 and Lii 44 were converted must have been 90-100 years old when felled, whilst Lii 48 was possibly 70-80 years old.

2. Saxon timbers

An assortment of timbers from the five Saxon wells were analysed. Lii 35, 36, 38 and 42 were sampled from a platform of planks which were rammed into the sides and bottom of pit F123, next to the well proper. The feature was dated by a series of radiocarbon dates to the 6th to 8th centuries. Two of the timbers, Lii 35 and Lii 42, contained narrow rings whilst Lii 36 and Lii 38 had only a few wide rings (Table 1).

Well F868, dated to ad 590$\pm$80, produced a series of timbers which were set against the sides of the well-pit. Of these, Lii 40, Lii 52 and Lii 53 were sampled. Lii 52 had only 31 rings and could not be used for tree-ring dating. It was important, however, in that it retained its full complement of sapwood rings. Since the other Saxon timbers consisted of heartwood, the number of sapwood rings in Lii 52 was used to calculate the felling date of these samples. It contained 11 rings, a comparatively low number for oak (compare, for example, Baillie, 1973; Hollstein, 1965), and was felled in winter. Thus, 11 years was taken as the minimum number of sapwood rings likely to be missing from the other timbers.

The 'Saxon well' was made up of four oak piles driven into the natural gravel at the base of a deep circular pit. A roughly square timber frame had been constructed around them. The only timber sampled was Lii 45 and this proved to have less than 40 rings, making it unsuitable for dendrochronology. Thus, the dating of the 'Saxon well' relies on radiocarbon analysis which produced a result of ad 720±70.

F283, dated to ad 580±80, was wattle-lined, but access to the well was at one side where large pieces of timbers provided a firm footing. One of these timbers, Lii 47, was sectioned for tree-ring work.

Well F861 contained large upright timbers driven into one side to provide a narrow ledge or platform. Lii 50 was an object found within the well; this was the only timber considered suitable for dendrochronology. It was dated by radiocarbon to ad 450±80 (HAR-3629).

Visual comparison of the Saxon tree-ring curves showed up many agreements between the sequences. The relative time spans, covered by the rings of the samples, are indicated in Figure 1 in the form of a block diagram. *t*-values between the individual samples ranged from 2.89 to 6.12. At first, only Lii 35, 36, 40, 42, 50 and 53 could be crossmatched. Their ring widths were averaged together to produce a site mean curve of 151 years. The ring width data were first standardized to eliminate bias from wide-ringed samples by conversion to indices. This was done using the INDXA computer package (Fritts *et al*, 1969); this program was later used to produce the mean curve (Table 2). Any unmatched curves were compared with the mean; Lii 47 gave a *t*-value of 3.58 and so was dated relative to the other samples. Lii 38 appeared to match the mean in two positions and thus could not be reliably dated. This illustrates the problem of using samples with only a few rings: the fewer the number of rings, the less unique is the ring pattern. Since other timbers from F123 had been dated, the lack of success with Lii 38 was not important. However, it does emphasise the need to sample as many timbers as possible from each feature. If only Lii 38 had been sectioned, F123 could never have been dated dendrochronologically.

Absolute dating of the Odell timbers was simplified because two floating tree-ring curves of the same period had recently been absolutely dated by comparison of one of them with two unpublished dated German chronologies (Hillam, forthcoming). Until then, there were no dated curves from England prior to the 8th century; the oldest was a timber from Tudor Street in London which dated to AD 682-918 (Hillam, unpublished). Thus, there were now two reference curves by which to date Odell: REF 8, constructed using timbers from Old Windsor and Portchester (Table 5 in Fletcher, 1977), covers the period AD 416-737 and the mean curve from Mersea Strood in Essex (Hillam, forthcoming) dates to AD 445-661. Odell crossmatched well with both these chronologies (Figure 2), the visual agreement being supported by <u>t</u>-values of 5.94 and 4.20 with REF 8 and Mersea respectively. The Odell mean curve was thus dated to AD 473-623. The years spanned by the individual timbers are given in Table 3. Lii 47, which crossmatched with the Odell mean (<u>t</u> = 3.58), also matched with REF 8 (<u>t</u> = 4.59) and was dated to AD 467-513. The <u>terminus post quem</u> for the felling date of each timber was estimated by adding 11 years onto the date of the outer ring (Figure 1, Table 3), this being the number of sapwood rings in Lii 52, the only Saxon timber with sapwood (see above).

The dating of the outer rings of the Odell Saxon timbers is exact to the year and 100% reliable. The estimation of the terminus post quem for the date of felling is accurate to within a few years. What is not so clear is interpretation of the dates in respect to the construction and use of the wells (Table 3).

The three dated samples from F123 have felling dates varying by up to 80 years. As the timber cannot have come from the same tree (see sketches in Table 1), some of the wood may have been used previous to its incorporation into the well. Thus, F123 was constructed some time after AD 607, but how long after cannot be deduced.

Similarly with F868, the dated timbers are contemporary with the well's construction, but they may have been used before in another context. This particularly true of Lii 53, which was felled c 100 years prior to Lii 40. Construction of the well must have occurred after AD 634, but again it is not known how long after.

Lii 47 and Lii 50, from F283 and F861 respectively, were not structural timbers used in the actual construction of the two wells. Lii 47 was a timber, felled after AD 524, which was placed at the edge of the well to give additional support at some time in its history. Thus, the well was in use some time after AD 524.

Lii 50 was a wooden object which could have been placed in the well at any time during its life-span. Hence, the well must have been open after AD 573, which is the earliest date of felling for Lii 50.

CONCLUSION

Odell is one of the first sites of this period to be absolutely dated. The study shows that even timbers with short ring patterns can be used successfully for tree-ring dating. The results provided by this method are far more accurate and reliable than those gained from radiocarbon or archaeological dating. Any uncertainty in the results, with respect to construction dates and re-use of timber, arises from problems of interpretation, not from the dating itself. The only solution to this would be to sample more timbers per structure, but the quality of the wood at Odell did not allow this.

ACKNOWLEDGEMENTS

The author is grateful to the DoE who established the dendrochronology laboratory at Sheffield and continue to finance the work there.

REFERENCES

Baillie M.G.L. 1973, A recently developed Irish tree-ring chronology. Tree Ring Bulletin 33, 15-28.

Baillie M.G.L. & Pilcher J.R. 1973, A simple crossdating program for tree-ring research. Tree Ring Bulletin 33, 7-14.

Fletcher J.M. 1977, Tree-ring chronologies for the 6th to 16th centuries for oaks of southern and eastern England. Journ. Arch. Sci. 4, 335-52.

Fritts H.C., Mosimann J.E. & Bottorff C. 1969, A revised computer program for standardizing tree-ring series. Tree Ring Bulletin 29, 15-20.

Hillam J. 1979, Tree-rings and archaeology: some problems explained. Journ. Arch. Sci. 6, 271-8.

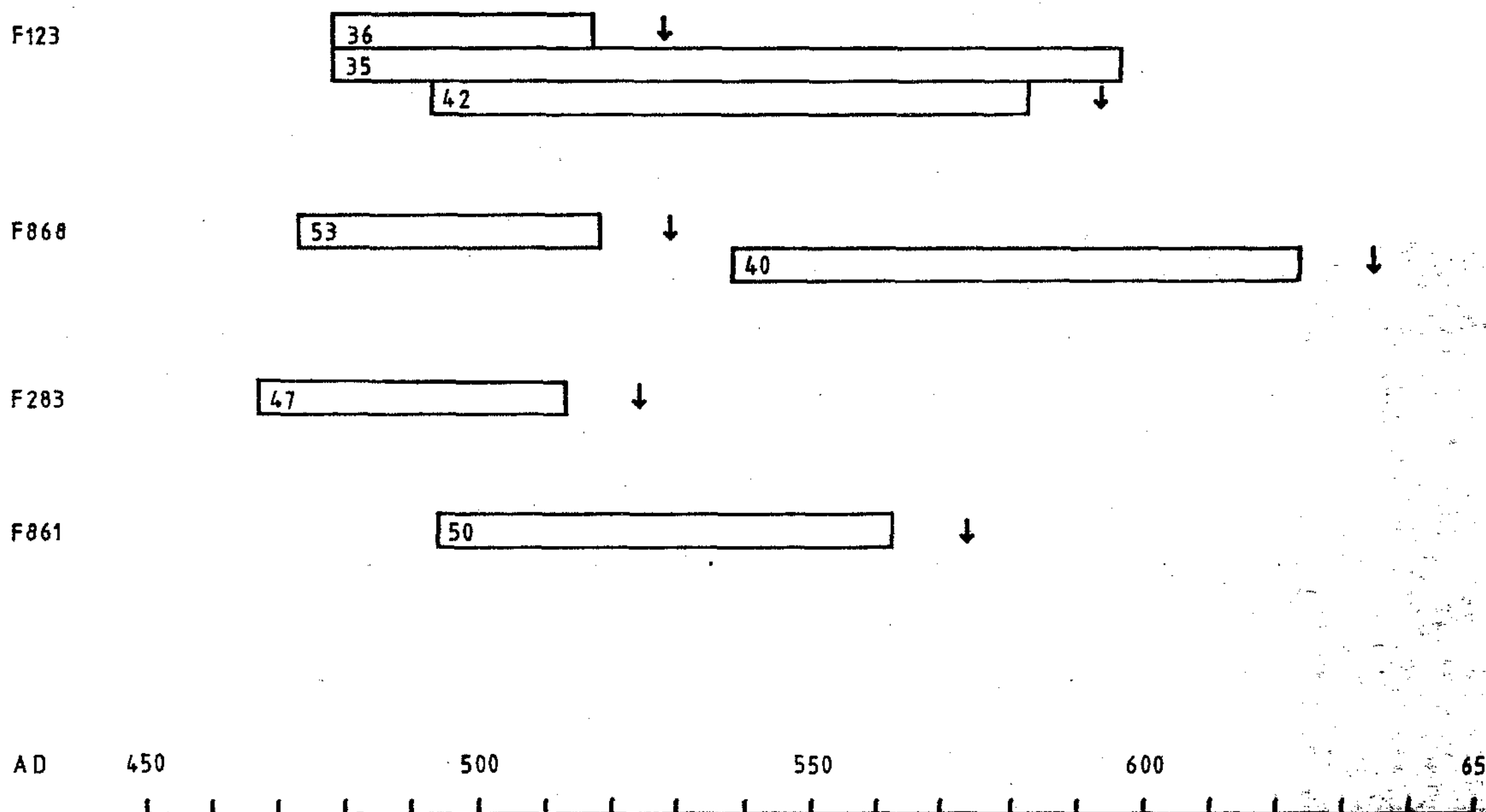
Hillam J. forthcoming, The dating of the Mersea Strood timbers. Essex Transactions.

Hollstein E. 1965, Jahrringchronologische Datierung von Eichenhölzern ohne Waldkante. Bonner Jahrbuch 165, 12-27.

Legends to the figures

Figure 1: Block diagram illustrating the years spanned by the rings of the dated timbers. Arrows indicate the estimated *terminus post quem* for the time of felling.

Figure 2: Comparison of the Odell chronology with tree-ring sequences from Mersea Strood in Essex (Hillam, forthcoming) and Old Windsor/Portchester (REF 8 in Fletcher, 1977) over the period AD 490-580. All the curves are plotted as mean ring widths, rather than indices, since this was the form in which REF 8 was published. Vertical lines are included as an aid to visual comparison.


F123
36
35
42
F868
53
40
F283
47
F861
50
AD
450
500
550
600
650

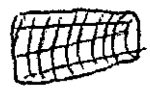
o.	Feature	Date	No. of rings	Sapwood rings	Average width (mm)	Sketch	Dimensic (cm)
35	F123	6th AD	119	-	0.96		3-5 x 11-
36	F123	6th AD	40	-	3.21		3-5 x 14
38	F123	6th AD	40	-	2.76		2-4 x 13
40	F868	6th AD	86	-	1.50		7 x 14
42	F123	6th AD	90	-	1.55		3-4 x 15
43	F824	1st BC	87	24, bark edge	1.74		14 x 17
44	F824	1st BC	84	16	1.99		3-7 x 17
45	'Saxon well'	8th AD	33	-	4.00		10 x 14
47	F283	6th AD	47	-	1.97		9 x 9
48	F836	1st AD	62	14	2.02		7-9 x 14
50	F861	5th AD	69	-	1.53		2-4 x 18
52	F868	6th AD	31	11, bark edge	2.74		9 x 22
53	F868	6th AD	46	-	1.79		9 x 11

Table 1: Details of the samples examined for tree-ring analysis. The dates are based on radiocarbon results from the timbers or associated features. The sketches are not drawn to scale.

Year	Index										Number of samples									
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
473				149	102	96	106	83	92	103				1	1	1	1	1	3	3
480	75	84	96	108	120	118	123	128	72	59	3	3	3	3	3	3	3	3	3	3
490	56	84	96	128	141	108	109	112	86	128	3	3	3	4	5	5	5	5	5	5
500	126	117	94	78	91	77	81	133	128	103	5	5	5	5	5	5	5	5	5	5
510	95	104	110	73	125	95	75	138	145	98	5	5	5	5	5	5	5	5	4	3
520	55	68	77	85	126	91	72	103	72	64	3	3	3	3	3	3	3	3	3	3
530	80	123	88	106	118	109	74	80	100	142	3	3	3	3	3	3	3	3	4	4
540	94	74	67	101	126	98	110	93	60	95	4	4	4	4	4	4	4	4	4	4
550	135	93	97	105	83	86	64	76	113	123	4	4	4	4	4	4	4	4	4	4
560	91	98	77	68	74	65	90	127	131	141	4	4	4	3	3	3	3	3	3	3
570	124	105	87	62	89	83	76	93	140	139	3	3	3	3	3	3	3	3	3	3
580	121	108	130	121	159	130	120	135	118	109	3	3	3	2	2	2	2	2	2	2
590	109	72	103	127	93	91	76	57	43	51	2	2	2	2	2	2	2	1	1	1
600	44	81	52	68	68	54	85	94	110	119	1	1	1	1	1	1	1	1	1	1
610	176	129	146	130	107	107	91	116	108	109	1	1	1	1	1	1	1	1	1	1
620	101	101	67	109							1	1	1	1						

Table 2: Odell tree-ring chronology, AD 473-623.

Feature	Sample number	Date span of tree-rings	Estimated felling date	Date of feature
F123	35	AD 478-596	AD 607	Constructed after AD 607
	36	AD 478-517	AD 528	
	42	AD 493-582	AD 593	
F868	40	AD 538-623	AD 634	Constructed after AD 634
	53	AD 473-518	AD 529	
F283	47	AD 467-513	AD 524	Well in use after AD 524
F861	50	AD 494-562	AD 573	Well in use after AD 573

Table 3: The dating of the individual timbers and their associated features. The felling date is an estimate of the *terminus post quem*, since sapwood was absent from all the dated samples.