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Analysis of wood charcoal remains from the Pitt Rivers Archive, The Salisbury Museum: Rotherley, Wiltshire

Zoë Hazell and Gill Campbell

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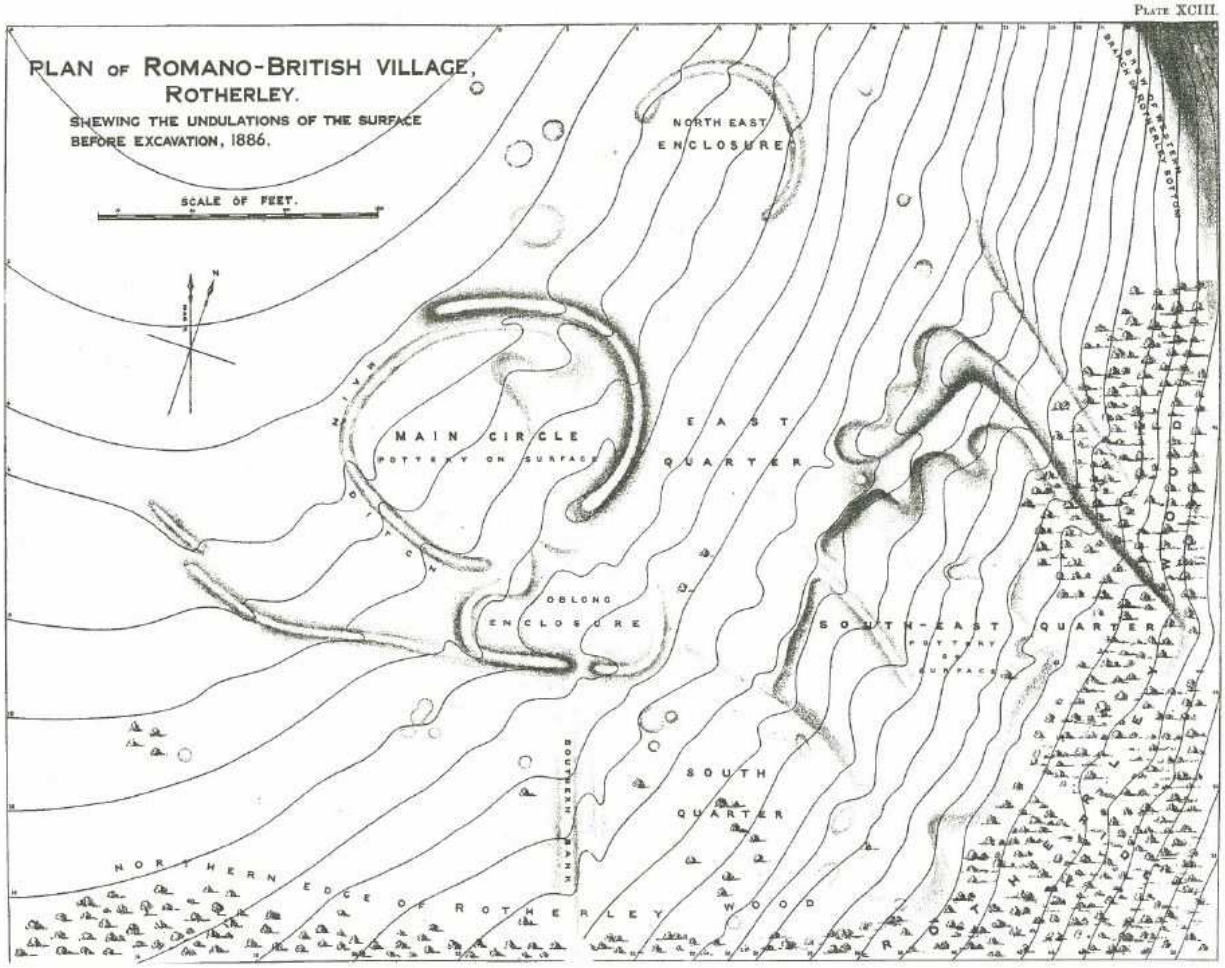

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ROTHERLEY
CRANBORNE CHASE
WILTSHIRE

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SUMMARY
During excavations in the late 1880s led by General Pitt Rivers at the Romano-British villa of Rotherley, Wiltshire, wood charcoal was recovered; examination of the material at the time included identifications of sweet chestnut (*Castanea sativa* Mill.). As part of a wider project investigating the history of the species in the British Isles, detailed analysis and recording of the charcoal remains (held in archive at The Salisbury Museum) were undertaken. The remains originally identified as sweet chestnut have now been re-identified, resulting in no secure identifications of sweet chestnut. Given that Rotherley (together with Woodcutts, Dorset) has long been cited as one of the principal sites providing evidence of sweet chestnut as a Roman introduction, these revised results necessitate re-evaluation of the status of sweet chestnut in this country.

ACKNOWLEDGEMENTS
Thanks to Rob Jarman (University of Gloucestershire) for locating and sourcing the material; and thanks to Valerie Goodrich (The Salisbury Museum) and to Janet Ellis-Schön (formerly of The Salisbury Museum) for their interest and support, facilitating the research.

ARCHIVE LOCATION
The wood charcoal is part of the Pitt Rivers Collection, held at The Salisbury Museum.

DATE OF RESEARCH
2015 to 2016

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Cover image: Site plan of Rotherley, from Pitt Rivers (1888).

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1 INTRODUCTION

1.1 Background to the study

It is widely regarded that in the British Isles *Castanea sativa* Mill. (sweet chestnut) is an archaeophyte[1] introduced by the Romans. This evidence for sweet chestnut's status as an archaeophyte was largely based on charcoal identifications from archaeological contexts of apparent Romano-British age, including material recovered during late 18th-early 19th century excavations. These results have been cited, for example, by Godwin (1956, 1975), and the theory of it being a Roman introduction is still held, unquestioned, by vegetation historians including Rackham (1990, 4).

Work by Jarman *et al* (in press) has reviewed primary sources and relocated archive material (where available) for sites from which 'sweet chestnut' remains are purported to have been recovered. As part of determining the reliability of the early records, some of this archived charcoal material – namely that which has been retained in museum archives and subsequently located – has been re-examined. The results of the analysis of material from one of the sites (Rotherley) are presented here in detail. For results relating to similar material from another site (Woodcutts Common, Dorset) see the accompanying report by Hazell and Campbell (2018).

1.2 Site details

The charcoal material discussed here came from the excavation the Romano-British villa site at Rotherley, Wiltshire, led by General Pitt Rivers in the 1880s (see Table 1 for details). The material was passed to the Salisbury and Wiltshire Museum in 1975 by HM Treasury as part of the Wessex Collections.

Table 1. Summary information of Woodcutts Common and its excavations. NRHE = National Record of the Historic Environment. Also see: https://www.pastscape.org.uk/hob.aspx?hob_id=209777

Site name	County	Monument number	NMR number	Location (from NRHE record)	Excavation dates	Excavation report
Rotherley	Wiltshire	209874	ST 91 NW 11	ST 949 195	1886-87	Pitt-Rivers (1888)

[1] According to Preston et al (2004: 259) an archaeophyte is "a plant which was brought to Britain by [people], intentionally or unintentionally, and became naturalized there between the start of the Neolithic period (c. 4000 BC) and AD 1500."

1.3 Previous analyses

At the time of the original excavations, the wood charcoal remains were examined and identified by Mr Carruthers, FRS. Table 2 shows the original reporting conventions and levels, and the associations within the assemblages.

Table 2. Summary table of the wood charcoal types recorded at Rotherley. Numbers in brackets refer to "the order of their occurrence in point of number" (Pitt-Rivers 1888, 229). * Pit 49: the remains were "Found with bones of new-born infant on step" (*ibid*).

	Site details	
	Reference	Pitt Rivers (1888: 229-230)
	Site name	Rotherley
Wood type (original taxonomic reporting)	**Contextual information**	Pits 1, 39 and 49*
Castanea vulgaris Lam. (Edible/Spanish Chestnut/Chesnut)		✓ (4) (Pits 1, 39 and 49)
Corylus avellana L. (Hazel)		✓ (6)
Fagus sylvatica L. *(*Beech)		✓ (7)
Fraxinus excelsior L. (Ash)		✓ (2)
Juglans regia (Walnut)		✓ (8)
Quercus robur L. (Oak)		✓ (1)
Salix sp. (Willow)		✓ (3)
Ulmur [sic] *campestris* L. (Elm)		✓ (5)

2 METHODS

2.1 Archive material

A full inventory of the archive material was undertaken; counting the total number of charcoal fragments in each wood category.

All the fragments identified originally as 'chesnut' and as 'walnut' were re-examined. In addition, 15 of the oak fragments (selected at random) were examined.

2.2 Taxonomic identifications

Wood identifications were carried out on each of the charcoal fragments, using a combination of the texts and keys by Schweingruber (1990), Hather (2000) and Gale and Cutler (2000). Reference material from Historic England's Wood and Charcoal Reference Collection (held at Fort Cumberland, Portsmouth) was also consulted. The main wood anatomical features required for identification are as follows:

Betulaceae family (includes *Alnus, Betula, Carpinus* and *Corylus*); here, only *Alnus* sp. (alder) (Betulaceae) is relevant, identified by: diffuse/semi-ring porous vessel pattern, with vessels in radial chains, aggregate rays, uniseriate rays (biseriate in aggregate rays) and scalariform perforation plates (10-20 narrowly spaced bars).

Castanea sp. (chestnut) (Fagaceae); this wood is identifiable by: a ring porous (earlywood) vessel pattern, with a flame-like pattern of the smaller, latewood vessels. Only uniseriate rays are present, and the perforation plates are simple.

Fraxinus sp. (ash) (Oleaceae); this wood is identified by the combination of: ring porous vessel structure, with radially-paired vessels in the early and latewood. It has rays 2-3 cells wide, and simple perforation plates.

Juglans sp. (walnut) (Juglandaceae); this wood has solitary and short radial chains (2-4) of vessels, in a diffuse to semi-ring porous pattern, with simple perforation plates and rays mostly 2-4 cells wide.

Quercus sp. (oak) (Fagaceae); typically this wood is characterised by: the ring porous (earlywood) vessel pattern, with a flame-like pattern of the smaller, latewood vessels[2], together with the occurrence of uniseriate and wide, multiseriate rays, and simple perforation plates.

Secure identifications were only made where all the required features were clearly seen. If there was any degree of uncertainty (eg where only a 'possible' multiseriate ray could not be seen) 'cf' was used. Where it could not be determined categorically that it was *Quercus* (or cf *Quercus*) then the group *Quercus/Castanea* was used.

All the wood charcoal fragments (n = 76) were examined using an Olympus BHX high power, light-reflecting microscope, at magnifications of between x100 and x500. Usually, freshly-broken, clean planes would be examined, however, given the 'heritage' of this archival material, and it being on display in The Salisbury Museum, the fragments were examined without breaking them[3]. In

[2] Evergreen oaks (none of which are native to the British Isles) have a diffuse porous vessel pattern, rather than the ring porous vessel pattern of deciduous oaks.
[3] If the fragments had been broken then subsequently they would have had to have been stored in separate sealed sample bags (in order to keep all the fragments from the same original fragment together), making them unsuitable for display.

practice, it was nearly always possible to see the necessary features from the fragments' outside edges; in particular the Transverse Section (TS) and the Transverse Longitudinal Section (TLS).

2.2.1 Taxonomic inferences

According to Stace (2010), in the British Isles:

- the only native alder is *A. glutinosa* (alder),
- *C. sativa* is introduced-naturalised[4] (i.e. not native, but established and self-regenerating),
- the only native ash is *F. excelsior* (ash),
- both *Juglans regia* (walnut) and *J. nigra* (black walnut)[5] are introduced-naturalised,
- the native oaks (both deciduous) are *Q. robur* (pedunculate oak) and *Q. petraea* (sessile oak), with the hybrid *Q. rosacea* possible where both species are present.

2.3 Other characteristics

As well as the taxonomic identifications of the wood, additional features were recorded (incorporating methods from Marguerie and Hunot, 2007):

- overall fragment size (measuring the perpendicular 3-dimensions of the fragment ie 'width, depth and height')
- number of growth rings
- a radial measurement across the counted growth rings (in order to calculate average ring width, if desired)
- presence/absence of: bark, pith, radial cracks, general vitrification
- recording whether the fragment was eg a complete, small diameter roundwood
- curvature of the rings
- physical character of the fragment (rounded, angular)
- any evidence of wood degradation (eg insect galleries, wood decay, fungal hyphae)
- any evidence of wood working marks

[4] Stace's note (2010: page xix) states "…where a plant is *known* to have been introduced by [people] before 1500 (eg *Castanea*) [it is treated] as introduced" – rather than as an archaeophyte (a plant closely associated with human activities, but for which it is not known whether it is native or not).
[5] Walnut is native to SE Europe and Asia, and black walnut is native to N America.

The distance measurements were recorded using Mitutoyo CD-8”CW digital callipers (mm; 2dps). Degree of light reflectance (as a proxy for degree of ‘vitrification’) was not recorded because freshly broken planes were not examined.

2.4 Imaging

Photographs of the fragments were taken using a Nikon Coolpix 4500, with the camera fixed to the microscope’s trinocular attachment, as necessary.

No images were taken using a Scanning Electron Microscope (SEM) because although it is not destructive, the method used to mount the sample (involving carbon) could affect subsequent radiocarbon dating of the sample itself.

3 RESULTS

3.1 Rotherley archive material

A description of the samples is given in Table 3. Each taxon has been stored in separate compartments of a glass-lidded wooden presentation box (Figure 1). The storage and labels are thought to be original (Ellis-Schön pers comm).

Table 3. Details of the charcoal archival material of the Rotherley excavations. Names have been emboldened here for emphasis. Fragment counts are only given for those taxa examined as part of this study.

The Salisbury Museum archive reference	**Original box label**	**Box description**	**Contents**	**Additional notes**
SBYWM:DR.3.6	"SPECIMENS OF WOOD FOUND IN THE EXCAVATIONS, ROMANO-BRITISH VILLAGE ROTHERLEY"	Larger wooden display case, with sliding glass lid.	Multiple compartments each containing charcoal fragments of a single wood type. "**OAK**" (c200+ fragments), "**CHESNUT**"[sic] (59+ fragments), and "**WALNUT**" (2+ fragments)	It is thought that fragments of the same taxa, but from different archaeological contexts were amalgamated when originally prepared for display. The other compartments are the wood types: "ASH", "BEECH", "ELM","HAZEL" and "WILLOW"

Figure 1. Image: R Jarman (University of Gloucestershire), reproduced with kind permission of The Salisbury Museum.

There appeared to be no differentiation made for 'chestnut' fragments recovered from different samples, features or contexts; they had all been grouped together regardless of provenance.

3.2 Analysis of the specimens

Each charcoal fragment was individually numbered, with the prefix RO (Rotherley). After examination, each fragment was individually stored in a numbered, sealed plastic sample bag. This meant that it would be possible to identify and return to a specific individual fragment, if necessary.

Summary results of the re-identification of the charcoal fragments, compared with their original identifications, are presented in Table 4. In total, four identifiable wood types were recorded at this site: cf *Alnus*, *Fraxinus*, *Quercus* and *Quercus/Castanea*, plus an Indeterminate (unidentifiable) category. All identifications to genus level were secure. Only one fragment was questionable *Quercus/Castanea*; this group was used where no multiseriate ray was observed – not even a 'possible' multiseriate ray.

During handling of the material, it was noted that a couple of the fragments had relatively fresh, cleanly broken faces, from which it was inferred that some fragmentation had occurred since they were originally sampled. It was possible to refit these two fragments back together (see Table 4). It is also possible (based on the similarity of the microscopic wood structure) that the two 'walnut' fragments fit together – this can easily, and should be, verified.

Table 4. Results of the re-examination and revised identifications of charcoal fragments from Rotherley. Fragment numbers are those allocated during this study. Note that some of these fragments fit together; the totals in (…) take account of refitting.

Rotherley			
Original identification by Carruthers	**Fragment numbers**	**Revised identification (this study)**	**Number of fragments**
Chestnut (n = 59)	RO: 1 to 4, 6 to 10, 12 to 26, 28, 29, 31 to 42, 44, 46, 47, 50 to 54, 56 to 58 [18=19]	*Quercus*	49 (48)
	RO: 30, 59 and 60	cf *Quercus*	3
	RO: 27	*Quercus/Castanea*	1
	RO: 45	*Fraxinus*	1
	RO: 49	cf *Alnus*	1
	RO: 55	Indeterminate	1
	RO: 11 and 43	Indeterminate (knotwood)	2
	RO: 48	Indeterminate (too small)	1
Walnut (n = 2)	RO: 5 and 76	Indeterminate (knotwood)	2
Oak (n = 15)	RO: 61 to 65, 67, 69 to 75	*Quercus*	13
	RO: 68	cf *Quercus*	1
	RO: 66	cf *Fraxinus*	1
TOTAL			**76 (75)**

3.3 Summary of identifications

3.3.1 *Castanea* or *Quercus*

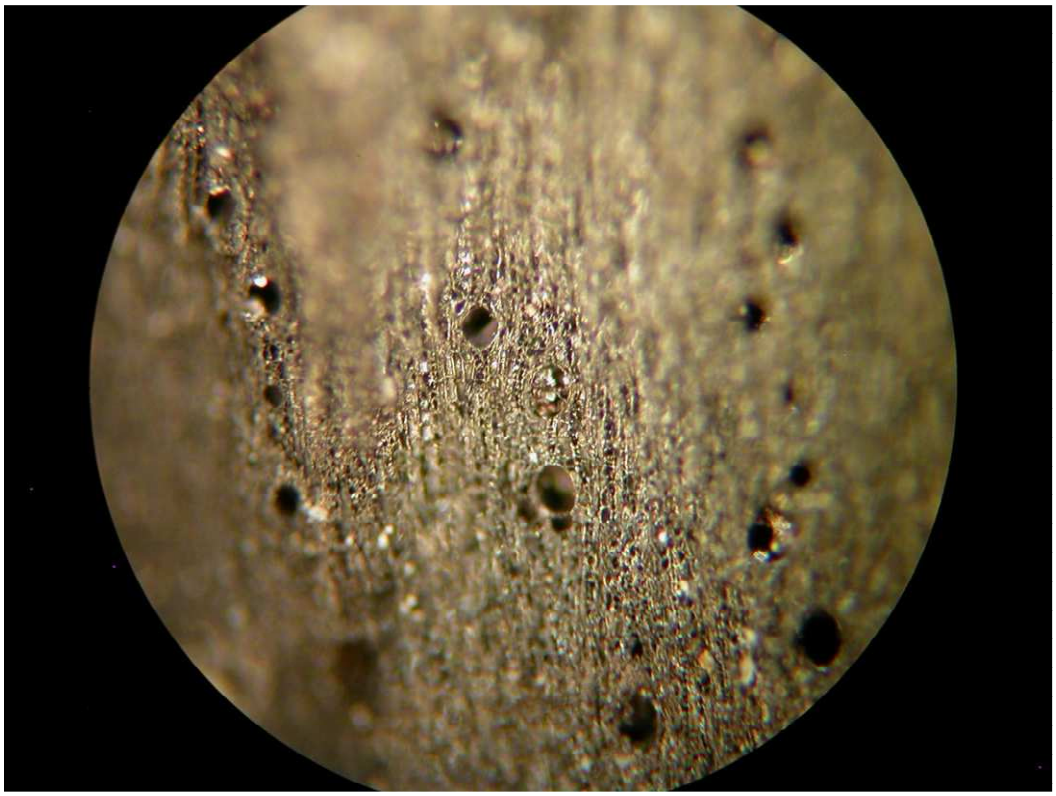
On the basis of the main wood anatomical criterion for separating *Castanea* from *Quercus* (that is, the absence/presence of multiseriate rays), the majority of 'chestnut' fragments were reidentified as (cf) *Quercus* (n = 52; two of which can be refitted), single fragments of other taxa (*Fraxinus* and cf *Alnus*) were identified. Only one fragment could not be distinguished as being either *Castanea* or *Quercus* and so has been reported here as *Quercus/Castanea*, however, it is most likely to be *Quercus* given the dominance of secure oak identifications. A few Indet. fragments were also recorded.

3.3.2 Other taxon

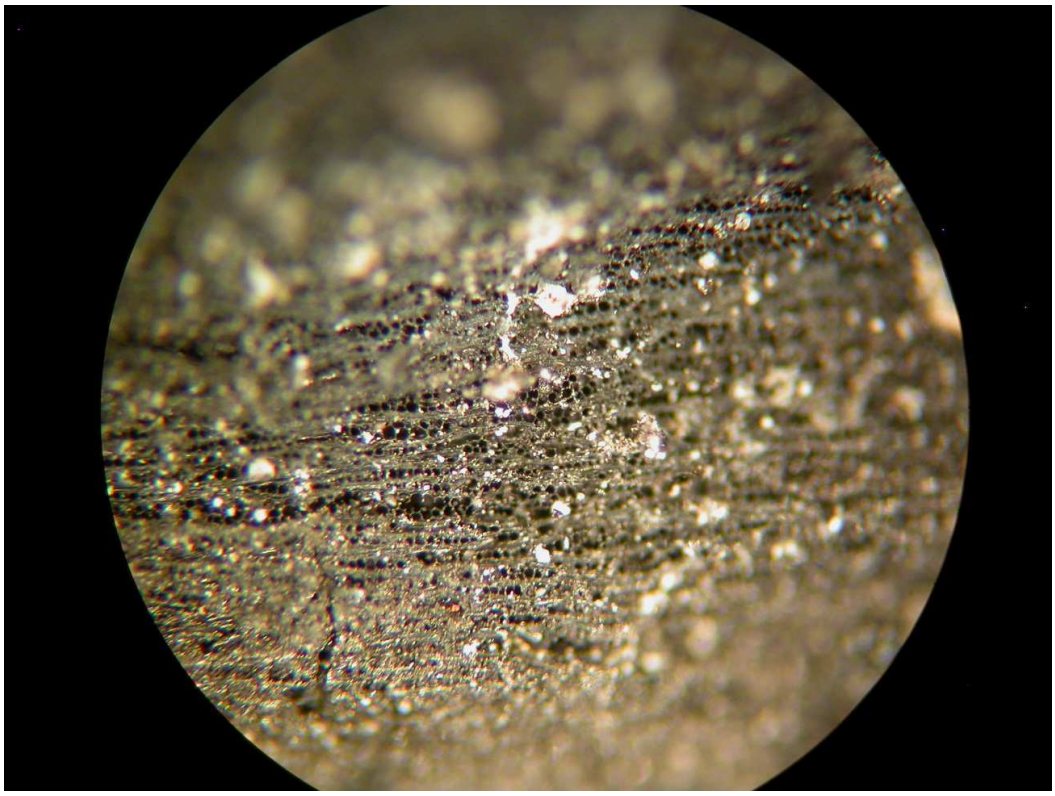
In terms of the additional wood category [walnut], both fragments have been re-identified as Indet. knotwood based on atypical wood growth. The two fragments (RO5 and RO76) did not show the wood anatomical features consistent with normal xylem growth, particularly with those of walnut. Instead, they showed an unusual growth pattern, with numerous, discrete rays situated very close together, as if forming 'proto-(multiseriate) rays' (Figure 2). As a result, the two fragments have been re-identified as Indeterminate knotwood.

Figure 2. Images of fragment RO5, showing (a) the overall structure (TS) showing the rays running from top to bottom across the image, and (b) detail of the numerous, proximal rays (TLS). In both images the FOV = 1.68mm. Photos: Z Hazell © Historic England. Reproduced by kind permission of The Salisbury Museum.

(a)



(b)



The two fragments had very similar wood structures and growth patterns, and it is highly likely that these are two parts of the same fragment.

3.3.3 Other features

Table 5 summarises the additional characteristics of the charcoal fragments, recorded where possible.

No fragments from Rotherley had both the pith and bark present, so it was not possible to determine absolute age at death of any of the wood charcoal remains. But RO67 (*Quercus*) – looks to be a small diameter roundwood.

In terms of the *Quercus* [previously 'chesnut'] fragments there were no complete small diameter roundwoods. However, there were some fragments that looked to derive from such roundwoods, with strong/moderate ring curvatures, suggesting they were from smaller tree elements, i.e. twigs.

Four fragments were knotwood and therefore were not identifiable. This included the two fragments (RO5 and RO76) (which might refit together) originally identified as *Juglans*.

RO16 (*Quercus,* previously 'chesnut') had a tangential crack visible on the TS plane.

Of the long-growing taxa (*Quercus* and *Fraxinus*) that produce tyloses in their heartwood, it was possible to make some inferences about the maturity of the wood. The two *Fraxinus* fragments seemed not to have tyloses present (although they were sediment covered), which, if so, would indicate sapwood. The majority of the *Quercus* fragments (both those originally identified as oak and those as 'chesnut') had no tyloses, indicating sapwood. Two of the *Quercus,* (previously 'chesnut') fragments (RO26 and RO31) appeared to contain the heartwood/sapwood boundary.

Both the fragments of *Fraxinus* had holes or voids present, indicating evidence of degradation. The presence of sediment cover made it hard to see the detail, but fragment RO66 looked to be very degraded wood.

No fragments seemed to show evidence of possible working.

It was not possible to determine any season of felling, as bark was not present (or clearly identified as present) on any of the fragments.

Fragments of *Quercus* (both those originally identified as oak and those as 'chesnut') showed evidence of vitrification, resulting in a distorted wood structure and/or radial cracks along the MS rays in particular (Figure 3).

Figure 3. Image of the TS of fragment RO9 (*Quercus,* previously 'chesnut') showing the multiseriate ray running vertically across the centre of the image. The lower section of the ray has split radially. The FOV = 3.30mm. Photo: Z. Hazell © Historic England. Produced with kind permission of The Salisbury Museum.

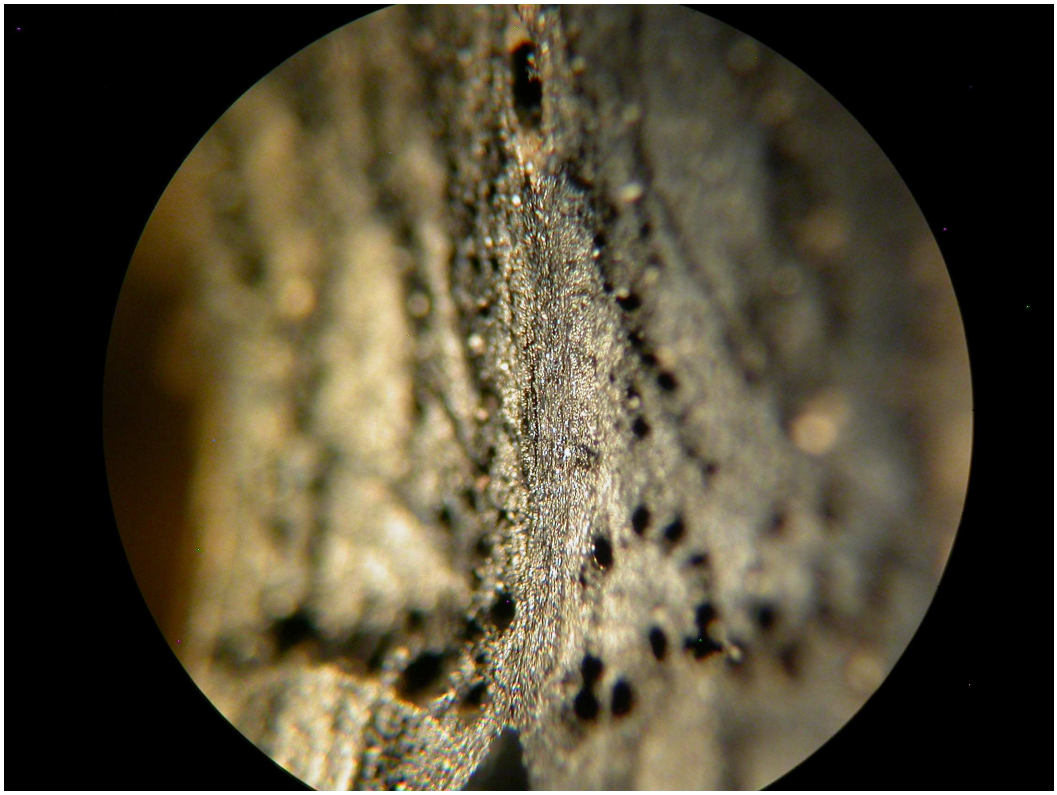


Table 5. Additional characteristics of the fragments from Rotherley (excluding Indeterminate fragments). Absence or presence is indicated by: N = no, or Y = yes. sw = sapwood. n/r = not recorded.

Wood type	*Quercus* [previously 'chesnut']	*Quercus*	*Quercus/ Castanea*	cf *Alnus*	(cf) *Fraxinus*
No. of fragments	52(51 - refitted)	14	1	1	2
No. of rings (range)	Indet, 1 to 10	Indet, 2 to 22	5	3	4 to 5
Average ring width (mm) (range)	0.53 to 7.78	0.46 to 4.28	1.6	1.6	0.9 to 2.1
Ring curvature	Weak/none (18), Weak (2), Moderate (4), Strong (5), Indet. (22)	Weak/none (1), Mod (2) = Strong (2), Indet. (4), Weak (5)	Moderate (1)	Indet. (1)	Mod (1) = Strong (1)
Vitrification	I; some with III; some MS rays fused Most n/r	I(4), II(1), I with II(2), II with III(6), I with III(1)	n/r	n/r	I
Radial cracks	Y (37): a few; lots,	Y (14): a few; along MS rays; lots	Y: lots	N	Y = N
Tyloses present	Indet. (4), N (40)(sw), Y-occ(3), Y&N(2)(hw-sw boundary), Y(2)(hw)	Y (2), Y&N (2), N(sw)(10)	N(sw)	-	N = ?N
Degradation	-	Holes present (1)	-	-	Holes present (2)
Season of felling	-	–	-	-	
Evidence of working	–	–	-	-	
Small diameter roundwoods	No complete small diameter roundwood remains. Some partial roundwood fragments(5)	?Complete small diameter roundwood(1): RO67	?twig	-	?root(1)
Notes	Some fragments with sediment cover. Vitrified, degraded and/or distorted.	Vitrified, degraded and/or distorted.	Vitrified, deformed.	-	Lots of sediment cover. Very degraded (1)

4 DISCUSSION

4.1 The (re)-identifications

The archived 'sweet chestnut' charcoal fragments at Rotherley have nearly all been re-identified as oak, based on the observation of multiseriate rays. As well as this, the original identifications of 'walnut' have been revised to Indeterminate. Possible reasons for the confusion during the original investigation could be one or more of the following:

- (irregular) characteristics of the wood growth, including:
    - knotwood – resulting in unusual, twisted growth patterns fast growth – forming wide growth rings, with uneven growth within rings in places
    - young wood – Schweingruber (2007, 57; citing Huber 1961) describes how, as oak wood ages, the medullary rays widen; and Tansley (1911) outlines studies[6] which observed how uniseriate rays in juvenile wood 'compound' to finally produce the multiseriate rays typical of mature oak. These fragments, therefore, could derive from juvenile wood where the multiseriate rays have not yet fully developed.
- preservation conditions /alterations of the wood
    - vitrification – distorting the alignment of the general wood structures preserved, and fusing of ray cells
    - radial splitting down the multiseriate rays – obscuring/destroying the diagnostic features themselves (Figure 3)
- past (superficial) approaches to wood identifications
    - past reliance on examining the TS only – where the multiseriate rays were not readily visible in the TS, it was necessary to scan the TLS. Yet this was not always the case (see Figure 3, showing the MS clearly visible in the TS)
    - inadequate microscopes/magnifications/resolutions

It is not as surprising that *Castanea* and *Quercus* were confused, given that their wood anatomical structures are very similar to each other; both are ring porous, with flame-like vessels patterns in the latewood, and with uniseriate rays present. However the additional presence of multiseriate rays in *Quercus* can reliably distinguish the two wood types. Unfortunately, no methods were reported in the original publications. The original confusion of *Fraxinus* for *Quercus* and for *Castanea* likely results because all three are ring porous; indicating that the original identifications were made based on not examining the fragments in sufficient resolution.

[6] On American white oaks.

Some of the fragments had a considerable layer of sediment obscuring features, which would have been their original state. So, it is unclear how identifications could have been made at the time of the original investigations.

Given the strong similarity between sweet chestnut and oak wood at a microscopic, anatomical scale, it is not always possible to differentiate between the two. On small fragments and/or fragments of young wood, although it is possible to determine whether something is definitely oak (by the presence of multiseriate rays) it is not always possible to say whether something is definitely sweet chestnut (in the absence of multiseriate rays). Given that archaeological charcoal remains are often small in size, this is especially problematic. Secure identifications of sweet chestnut are only possible from large timbers where it is clear that the multiseriate rays are absent. It is better to report any uncertain identifications as *Castanea/Quercus* (or *Quercus/Castanea*) rather than have 'cf's or '?'s that can become mis-understood and/or omitted in citations.

4.2 Previous reporting

Also to be noted is the inconsistent reporting of the plant types to i) genus level for the common names, but to ii) species level in the Latin names (Table 6). For example, Carruthers refers to *Quercus robur* simply as 'oak', when it is specifically pedunculate oak, and *Betula alba* (since reclassified to *Betula pendula*) which is specifically silver birch. It is not thought that this level of resolution is possible from wood taxonomic features, in which case it is spurious detail of false precision. Where there is only one species native to the British Isles (eg *Fraxinus excelsior* or *Corylus avellana*) it is more understandable why the Latin binomial might have been used. The only taxon that was consistently reported with regards to its Latin and common names, was *Salix* sp. (willow); however, on the basis of its wood anatomy, it is rarely distinguished from *Populus* (poplar) as the characteristic for their distinction (ray cell morphology) is not always reliable (Gale and Cutler, 2000, 193 and 241).

Table 6. Original reporting and plant names, with their equivalent, modern conventions. From Stace (2010) and [b] = indicates from The Plant List online resource (http://www.theplantlist.org/). [a] = no authorities given in the original report. S = single, M = multiple

Original taxonomic reporting		**Current taxonomic reporting**		**Number of native species**
Latin name	**Common name**	**Latin name**	**Common name**	**B Isles**
Castanea vulgaris Lam.	Edible Chestnut/ Chesnut	*Castanea sativa* Mill.	Sweet chestnut	-
Corylus avellana L.	Hazel	*Corylus avellana* L.	Hazel	S
Fagus sylvatica L.	Beech	*Fagus sylvatica L.*	Beech	S
Fraxinus excelsior L.	Ash	*Fraxinus excelsior* L.	Ash	S
Juglans regia[a]	Walnut	*Juglans regia*	Walnut	-
Quercus robur L.	Oak	*Quercus robur* L.	Pedunculate oak	M
Salix sp.[a]	Willow			M
Ulmur [sic] *campestris* L.	Elm	*Ulmus glabra*[b]	Wych Elm	M

5 SUMMARY AND CONCLUSIONS

This work has re-visited wood charcoal samples from the Romano-British villa at Rotherley, and has re-identified what had originally been identified/labelled as 'sweet chestnut', as *Quercus*. It has also refuted original identifications of *Juglans* (walnut), which are now reported as Indeterminate. The original (mis-) identifications could have been due to a combination of: unusual growth characteristics, together with alterations of the material (notably vitrification, fusing diagnostic features and/or causing splitting of fragments). Together with the corroborative results of similar analyses from the nearby Romano-British villa at Woodcutts Common (see Hazell and Campbell, 2018), the results have significant implications for understanding the taxon's history in the British Isles, most notably as an archaeophyte of Roman introduction.

In addition, the research demonstrates:

- the importance of re-examining archaeological remains in order to review the original identifications,

- the significance and value of ‘environmental archaeology’ materials (here wood charcoal) and the role they have in answering research questions of national and international importance,
- the importance of taking such samples in the first place, and keeping them stored in archives (so that they can be re-examined), clearly accessioned and in conditions to ensure for their long term preservation, and
- the relationship between archaeological investigations and museum displays; this re-identification of the ‘sweet chestnut’ material will require a re-evaluation of how the remains are exhibited from now on.

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